Turkish Journal of Field Crops, 2010, 15(2): 123-127

THE RESEARCHES ON SOYBEAN (*Glycine max* Merr.) VARIETY BREEDING FOR RESISTANCE TO WHITEFLY IN TURKEY

Leyla GÜLLÜOĞLU[1] Cemal KURT[2] Halis ARIOĞLU[2*] Bihter ZAIMOĞLU[3] Mehmet ASLAN[4]

[1] *Çukurova University, Vocational School of Ceyhan, Adana- Turkey*
[2] *Çukurova University, Faculty of Agriculture, Dep. of Field Crop, Adana-Turkey*
[3] *Çukurova University, Vocational School of Kozan, Adana- Turkey*
[4] *Mustafa Kemal University, Faculty of Agriculture, Dep. of Field Crops, Antakya- Turkey*
**Corresponding Author: halis@mail.cu.edu.tr*

ABSTRACT

This study was conducted in the Cukurova University, Faculty of Agriculture, Department of Field Crops in between 1993 and 2003 in Turkey. The objective of this research was to breed high yielding whitefly (*Bemesia tabaci* Genn.) resistant soybean cultivar. Soybean cultivar S.4240 and Williams was crossed in 1993. Individual plant selection was made according to single-seed descent selection method in the segregating materials. The F_2 seeds were planted and one random F_3 seed (pod) was taken from each F_2 plant. This process was repeated until the plants were considered sufficiently true-breeding F_5 generation. All the F_5 seeds were planted as a second crop and 200 individual plants were selected among the F_5 plants according to breeding objectives at the harvesting time in 1998. The selected seeds plants were planted in separate rows in 1999 and 2000. Nine rows (lines) were selected according to breeding objectives at the end of 2000 growing season. The replicated yield test was repeated in 2001 (with 9 soybean lines), 2002 (with 7 soybean lines) and 2003 (with 7 soybean lines) seasons with selected soybean lines under double cropping conditions. At the end of 2003 growing season, three breeding lines (SW-3, SW-7 and SW-11) were determined as cultivar candidates.

Key words: Soybean, variety breeding, crossing, single-seed descent, double-cropped.

INTRODUCTION

Soybean (*Glycine max* Merr.) has been cultivated since ancient times and then it was gained great attention due to its highly valuable protein and oil as human nutrition and animal feed. The World production of soybean was 27.1 million tons in 1962 and 92.1 million tons in 1982, but now (2007) it exceeded 229.4 million tons. The 55.7 % of the world oil seed production comes from the soybean. The share of the soybean crude oil was 30 % in the total world crude oil production of 130.2 million tons.

After determining satisfactory results from the soybean double cropping projects conducted in the Cukurova (the largest plain in the eastern Mediterranean region of Turkey), soybean production was increased in 1980 and was picked in 1987 with 250.000 tons in Turkey (Anonymous, 2007). In the following years, the applied wrong agricultural policy highly decreased soybean production. The soybean production was 55 000 tons in 2007 (FAO, 2007).

Cukurova is the major soybean production area in Turkey with the 78 % production share. About 90 % of soybean has been grown as double crop after a small grain harvest, in order to increase income and improve cash flow in a wheat-soybean double cropping system (Arslan et al, 2006).

The whitefly (*Bemesia tabaci* Genn.) is a cosmopolitan pest with a worldwide distribution in different climatic zones ranging from tropical to temperate, in diverse ecosystems. The high reproductive potential, small size and high dispersal ability of this species are responsible for its pest status worldwide. The whitefly damage was one of the serious yield reducing agents in the Cukurova soybean production areas. Like most of the cultivated crop plant in the region, soybean is highly affected from whitefly damage. In addition, insecticide applications to control whitefly increased the cost of soybean production. Increased insecticide input made soybean production uneconomical for soybean growers. Therefore, whitefly resistance in soybean is one of the significant traits for soybean breeding in the region (Arioglu, 1987, Gulluoglu et al,2010).

Whiteflies lay light-yellow stalked eggs mostly on the underside of leaves. Nymphs are oval and depressed, pale to greenish yellow and 0.5 mm in size. Adults are small insect with yellow body and hialine wings covered with powdery wax and it is 1.0-4.0 mm in size (Vaishampayan and Kogan 1980).

Whitefly needs higher than 26 ^{o}C temperature and 60 % relative humidity for optimum development. The whitefly infestation starts to increase at the beginning of July and peaked in August in the Mediterranean region. A female adult lays 160 eggs in a generation and it has 11-12 generations in a year.

Injury to soybeans is caused both by nymphs and adults sucking sap from leaves. Whiteflies secrete abundant honeydew. This honeydew forms a suitable medium for the development of a dark sooty mold, which inhibits light

penetration and reduces photosynthesis. Infestation of whiteflies usually heaviest during the pod-filling period and can cause severe reductions in yield. Chemical control of the whitefly has proven expensive and insecticides are losing their effect rapidly (Ozgur and Arioglu 1992, Ozgur and Sekeroglu 1986). For this reason, the cultivars grown in whitefly infested area have to be resistant to whitefly.

Pubescence length beside pubescence density can be effective on whitefly infestation. Short pubescence isolines were affected more than long types. A significant correlation was found between pubescence density and whitefly infestation. A semi-logarithmic relation was found between whitefly infestation and seed yield. The soybean plant could not grow normally due to whitefly damage and it was forced to ripen earlier than the normal maturity. Seed yield and yield components were negatively affected by the whitefly damage (Arioglu ve ark., 1986; Arioglu et al. 1989a, Arioglu et al. 1989b).

Cultivars in maturity groups (MG) II, III, and IV are best suited for the eastern Mediterranean region and most of the high yielding cultivars are in these MG's (Isler ve Arioglu, 1989; Aslan and Arioglu, 1991; Arslan et al. 2006).

Seed yield is a complex character associated with many inter-related component factors. The optimum seed yield in a given area depends on genotypic potential of the cultivar, environmental factors and applied cultural practices. To have satisfactory seed yield in Cukurova, whitefly resistant soybean cultivars in MG II, III and IV must be chosen. Therefore, developing whitefly resistance cultivars for Cukurova region is highly important. The purpose of the current study was to develop high yielding whitefly resistant soybean cultivars for Cukurova.

MATERIALS AND METHODS

The developing of whitefly resistant soybean cultivars was started in Cukurova in 1993. Breeding whitefly resistance is still continuing in the region. Soybean cultivars S4240 and Williams were chosen as parent cultivars for their superior yielding and whitefly resistance. Cultivar S 4240 was developed by Sandoz Seed Co. USA. S 4240 has indeterminate growth habit in Maturity Group (MG) IV, tall plant height, brown pubescence, purple flower, and it is a high yielding and whitefly resistant cultivar.

Williams, a mid-maturing cultivar, was developed in USA. Williams has indeterminate growth habit, large leafed, brown pubescence, white flower, mid-tall, and it is a high yielding and whitefly sensitive cultivar.

Single-seed descent method was used to select plants in the segregating population (Fehr, 1978; Fehr, 1987; Arioglu, 2000). The flower color was used as a marker to be sure the hybridization was successful (Fehr, 1980). For this purpose, white flowered (controlled a recessive gene) Williams was used as female parent, and S 4240 was used as male parent.

The soybean lines obtained after 9, 10 and 11 years of breeding were taken cultivar performance trails in a randomized complete block design with three replications.

The whitefly observation was made in August which is the time of the heaviest whitefly infestation. Ten plants from each plot and three leaves from each plant (lower, medium and upper parts) were obtained for investigation of whitefly population. Eggs, larvae and pupae numbers were determined on the leaves per 2.85 cm^2 leaf area. According to number of whitefly a scale was made as 1 is very resistant (less than 10 eggs + larvae + pupae on 2.85 cm^2) and 5 is very susceptible (more than 51 eggs + larvae + pupae on 2.85 cm^2) to whitefly (Ozgur ve Arioglu, 1992).

The breeding program was as follow;

Season 1 (1993): Williams x S.4240 was crossed to have at least 15 pods and F_1 seeds were harvested (Fehr,1978).

Season 2 (1994): The F_1 seeds were planted to have F_2 seeds (4000 seeds).

Season 3 (1995): F_2 seeds were planted and one pod on each plant and one seed from each pod was harvested to have F_3 seeds and the F_3 seeds were bulked.

Season 4 (1996): F_3 seeds were planted to have next generation. At harvest time, again one pod on each plant and one seed from each pod was harvested to have F_4 seeds. The F_4 seeds were bulked.

Season 5 (1997): F_4 seeds were planted and F_5 seeds were harvested.

Season 6 (1998): F_5 seeds were planted as a double crop, and screened for whitefly resistance. About 200 whitefly resistant plants were selected and their seeds were harvested separately.

Season 7 (1999): The seeds of selected 200 whitefly resistant plants were planted in the separate rows. During the growing season, non-segregating whitefly resistant lines were determined and harvested separately. After inspection, 80 lines were selected.

Season 8 (2000): The seeds of selected 80 lines were planted as a double crop in a two-row micro plot yield performance and whitefly resistant test. Two rows of S 4240 and Williams seeds were planted in each 20 rows as test cultivars. The whitefly screening was done when the whitefly population was the maximum in August. Whitefly count was done with applying 1-5 scale (1 is very resistant and 5 is very susceptible). Resistant lines were separately harvested. After completing all investigations and inspections, nine high yielding whitefly resistance soybean lines were selected.

Season 9 (2001): The selected nine soybean lines were tested for their yielding performance. After having mean yield performance of nine soybean lines, seven superior high yielding soybean lines were selected (Table 1).

Season 10 (2002): The selected high yielding whitefly resistant seven soybean lines were tested for their yielding performance. The yield performance of seven lines was given in Table 2.

Season 11 (2003): Again, the selected high yielding whitefly resistant seven soybean lines were tested for their yielding performance. After three years of yield test (Table 3), three

superior soybean lines (S x W-3, S x W-7 and S x W-11) were selected and sent to cultivar registration center.

Field studies were conducted at five locations at Dogankent-Adana, Balcali-Adana, Aksu-Antalya, Beydere-Manisa, and Diyarbakir by The Ministry of Agriculture, Directorate of Variety Registration and Seed Certification Center of Turkey in the 2004 and 2005 growing seasons.

Four standard cultivars (A 3935, Umut 2002, Nazlican and Turksoy) and eight new cultivar candidates (Ataem 6, Ataem 7, 1530, 527, SxW11, SxW-7, SxW-3 and Nova) were tested in a two-year experiment. Seeds of the selected soybean cultivars and cultivar candidates were planted at a rate of 25 seeds per meter row on as double crop in 2004 and 2005. The experimental design was a randomized complete block with three replications. Plots consisted of four 6 m rows, planted 0.65 m apart, that were end-trimmed to final length of 5 m prior to harvest of the centre two rows. In both years, seed germination and plant emergence were enhanced by applying light sprinkler irrigation. Flood irrigation was applied every 15 days after emergence. Based on soil analysis and local recommendations, nitrogen and phosphorus fertilizer (36 kg/ha N and 92 kg/ha P_20_5) was applied prior to planting. Recommended practices were used for weed and insect control. Central two rows of each plot was harvested to determine seed yield.

Measured yield data was subjected to analysis of variance using the GLM procedure in the Statistical Analysis System software package (SAS Institute,1996). Means were compared by using Fisher's protected least significance difference (LSD) at type I error of 0.05.

RESULTS AND DISCUSSION

Developing high yielding soybean cultivars resistant to whitefly for double cropping, a whitefly resistant cultivar (S 4240) and a high yielding whitefly sensitive cultivar (Williams) were crossed. Nine high yielding whitefly resistant lines in 2000, and seven lines in 2001 were selected for further evaluation in 2001, 2002 and 2003. The mean seed yields of selected lines were given in Table 1.

Table 1. Yield (kg/ha) performance of selected soybean lines in 2001, 2002 and 2003.

Soybean lines	Seed yield (kg/ha)			
	2001	2002	2003	Mean
Williams x S.4240-2	2237 f	3205 b	3206 c	2883
Williams x S.4240-3	**2413 e**	**3647 a**	**3674 a**	**3245**
Williams x S.4240-5	3087 a	2882 c	2567 e	2845
Williams x S.4240-6	2877 b	3342 b	3344 bc	3188
Williams x S.4240-7	**2680 cd**	**3791 a**	**3426 b**	**3299**
Williams x S.4240-10	2590 d	2929 c	3294 bc	2938
Williams x S.4240-11	**3170 a**	**3269 b**	**3400 bc**	**3280**
Williams x S.4240-12	2777 bc	-	-	2777*
Williams x S.4240-13	2383 e	-	-	2383*
Williams	2197 f	2825 c	2869 d	2630
S.4240	2753 bc	3627 a	2880 d	3087
LSD (%5)	**130**	**223**	**179**	**-**

one year mean

Compared with parent cultivars, the higher or equivalent yielding seven whitefly resistant soybean lines were selected in the yield test conducted in 2001 (Table 1). The selected seven soybean lines were tested to determine their yielding performance and whitefly resistance in 2002 and 2003. According to the three years of yield test, the best yielding and higher whitefly resistant three soybean lines SxW-11, SxW-7 and SxW-3 were selected as cultivar candidates for double cropping systems in Cukurova. These three soybean lines were sent to the the Ministry of Agriculture, Directorate of Variety Registration and Seed Certification Center of Turkey for cultivar registration.

The three soybean lines were taken to the soybean variety yield test at five different locations in the Western Mediterranean (Aksu-Antalya), Eastern Mediterranean (Dogankent and Balcali-Adana), Southeastern Anatolia (Diyarbakir) and Aegean (Beydere-Manisa) regions of Turkey under double cropping conditions in 2004 and 2005. The results of the soybean variety yield test conducted by the Ministry of Agriculture, Directorate of Variety Registration and Seed Certification Center of Turkey were given in Table 2 and 3.

When the mean seed yield of variety test conducted at five locations in 2004 was considered, the soybean lines SxW-11 and SxW-7 had the highest seed yields than the seed yield of the standard cultivars A3935, Umut 2002, Nazlican and Turksoy. However, the seed yield of SxW-3 was close to the standard cultivars (Table 2).

When the mean seed yield of variety test conducted in 2005 at five locations was considered, there was no significant seed yield differences among soybean lines and Standard cultivars. However, the highest seed yield was obtained from soybean line SxW-11 with 3614 kg/ha (Table 3). The results of a two-year variety test conducted at five locations, cultivar candidate SxW-11 was on the first rank with 3529 kg/ha followed by SxW-7 with 3408 kg/ha. The

Table 2. Seed yield (kg/ha) of cultivars grown at Dogankent-Adana, Balcalı-Adana, Aksu-Antalya, Beydere-Manisa and Diyarbakir in 2004 (Data was taken from a multi-location cultivar-testing program being conducted by The Ministry of Agriculture, Directorate of Variety Registration and Seed Certification Center, Ankara).

		Location					
Cultivar	Maturity Group	Dogankent Adana	Aksu Antalya	Beydere Manisa	Balcali Adana	Diyarbakir	Mean 2004
A3935	IV	3583 bcd	3763	3099 ab	2645 def	3724 a	3363 ab
Umut 2002	III	3946 ab	3723	2822 abc	2939 b	3276 ab	3341 abc
Nazlican	V	4225 a	4156	3242 a	2129 g	2725 b	3295 bcd
Turksoy	III	3940 ab	4426	2191 c	2781 bcde	3305 ab	3329 abc
Ataem 6	IV	3485 bcd	3961	2324 c	2626 def	2610 b	3001 e
Ataem 7	IV	3178 cd	3992	2497 bc	2718 cdef	3458 ab	3169 bcde
527	V	3797 abc	3792	2326 c	2564 ef	-	3120 de
1530	V	3441 bcd	4079	-	2526 f	-	3349 ab
SxW-11	IV	3537bcd	3853	2854 abc	3194 a	3784 a	3444 a
SxW-7	III	3657 abcd	4030	2710 abc	2825 bcd	3830 a	3410 ab
SxW-3	IV	3791 ab	3766	3181 a	2835 bcd	2911 b	3297 bcd
Nova	III	3108 d	3615	2206 c	2879 bc	3342 ab	3030 cde
LSD (%5)	-	581	N.S.	668	218	724	254

N.S. Not significant

cultivar candidate SxW-3 was on the fourth row with 3324 kg/ha (Table 3).

CONCLUSION

According to the results of variety test conducted by the Ministry of Agriculture, Directorate of Variety Registration and Seed Certification Center of Turkey at 5 locations in 2004 and 2005, the seed yield of SxW-11 and SxW-7 had the highest than the seed yield of standard cultivars. On the other hand, whitefly resistance situations of these two soybean lines were confirmed. Therefore, the Variety Registration committee, gathered in April 2006, registered SxW-7 soybean line as ATAKISI and SxW-11 as ARISOY. These two soybean cultivars are grown and their seeds are presented in the seed markets.

Table 3. Seed yield (kg/ha) of cultivars grown at Dogankent-Adana, Balcali-Adana, Aksu-Antalya, Beydere-Manisa and Diyarbakir in 2005 (Data was taken from a multi-location cultivar-testing program being conducted by The Ministry of Agriculture, Directorate of Variety Registration and Seed Certification Center, Ankara).

		Location						
Cultivar	Maturity Group	Dogankent Adana	Aksu Antalya	Beydere Manisa	Balcali Adana	Diyarbakir	Mean 2005	Mean 2004 / 2005
A3935	IV	4124	2726 cd	4100	2675 de	2692 abc	3263	3313 b
Umut 2002	III	3931	2915 bcd	3855	3623 ab	2752 ab	3415	3378 ab
Nazlican	V	4202	3491 ab	3850	2689 de	2013 bc	3249	3272 b
Turksoy	III	3638	3255 abcd	3291	2896 cd	3370 a	3290	3309 b
Ataem 6	IV	4086	3281 abc	3640	2411 e	1982 c	3080	3041 c
Ataem 7	IV	4208	3602 a	3017	3126 c	2645 abc	3320	3244 bc
SxW-11	IV	4413	2864 cd	4781	3696 ab	2313 bc	3614	3529 a
SxW-7	III	4408	2636 d	3486	3835 a	2658 abc	3404	3408 ab
SxW-3	IV	3507	2855 cd	4150	3551 ab	2692 abc	3351	3324 ab
LSD (%5)	-	N.S.	550	N.S.	306	661	N.S.	215

N.S. Not significant

LITRATURE CITED

Anonymous, 2007. Tarımsal Yapı ve Uretim. TUİK Yayınları, Ankara (In Turkish).

Arioglu, H.H., Atakisi, I.K., Kırıcı, S, 1986. Cukurova bölgesinde 2. urun olarak yetisebilecek bazi soya cesitlerinin onemli tarimsal ve bitkisel ozelliklerinin belirlenmesi uzerinde bir arastirma. Doga Bilim Dergisi, Seri D 2, Cilt 10 (1) : 7-13 (In Turkish).

Arioglu, HH, 1987. Screening of some soybean varieties for resistance to whitefly (*Bemisia tabaci* Genn.). Soybean Genetics Newsletter 14**:** 136-139.

Arioglu, HH, 1989. The determination of soybean varieties as a second crop in Turkey. World Soybean Research Conference IV Proceedings, Vol. II, P.1036-1041, Buenos Aires-Argentina.

Arioglu, H.H., Ozgur, A.F and Isler, N, 1989a. Influence of soybean pubescence type and density on whitefly (*Bemisia tabaci* Genn.) resistance. World Soybean Research Conferance IV Proceedings III, 1235-1240, Argantinia

Arioglu, H.H., Ozgur, A.F, and Isler, N, 1989b. The effect of whitefly (*Bemisia tabaci* Genn.) damage on yield and yield

components in double-cropped Soybean production. Soybean Genetics Newsletter. 16**:** 57-61.

Arioglu,H.H, 2000. Yağ Bitkileri Yetiştirme ve Islahı. Ç.Ü.Zir.Fak.Yayınları, Genel Yayın No:220, Ders kitapları Yayın No:A-70. Adana (In Turkish)

Arslan, M., Arioglu, H.H, 1991. Screeing of new soybean varieties for Cukurova ecological conditions as a double crop. Soybean Genetics Newsletter, Vol. 18, P. 169-173, Ames-Usa.

Arslan, M., Isler, N. and Caliskan, S, 2006. Effects of cultivar maturity on growth and yield of double cropped.Soybean. Acta Agriculturae Scandinavica Section B-Soil and Plant Science, 56: 39-/46.

Cinar, O., Yılmaz, M.A. Uygun, N. Sekeroglu, E. Ozgur, F. Bicici, M. Dolar, S. and Nas, Z, 1985. Çukurova soya fasulyesi tarımında karşılaşılan hastalık, nematod ve zararlı etmenlerinin saptanması ve yaygınlıkları üzerinde araştırmalar. Doğa Bilim Dergis D 2,**10**(**1**), 33-35 (In Turkish).

FAO, 2007. FAO Statistical Databases. Available at http://faostat.fao.org/faostat/form

Fehr, WR. 1978. Breeding. Soybean physiology, agronomy, and utilization (Ed. A.G. Norman). Pp. 119-155. Academic Press, London,249 p.

Fehr, WR. 1980. Soybean. Hybridization of Crop Plants (Ed. by W.R. Fehr and H.H. Hadley), pp 589-597, ASA pub., Illinois, 765 p.

Fehr, WR, 1987. Breeding Methods For Cultivar Development.Soybean: Improvement, Production and Uses (Ed. J.R. Wilcox). pp. 249-293, Agronomy series No:16. ASA Inc. Pub., Wisconsin,888 p.

Ozgur, A.F and Sekeroglu, E, 1986. Population development of *Bemisia tabaci* (Ham. Aleyrodidae) on various cotton cultures in Cukurova, Turkey. Turkey Agriculture, Ecosystem and Environment, 17: 83-88.

Gulluoglu,L., Arioglu,H. and Kurt,C, 2010. Field evalution of Soybean cultivars for resistance to Whitefly (Bemisia tabaci Genn.) infestations. African Journal of Agricultural Research. 5(7):555-560.

Ozgur,AF and Arioglu, H, 1992. Soyada yaprak tüylülüğünün Pamuk beyaz sineği (*Bemisia tabaci* Genn.)'nin populasyon gelişmesine etkisi. Türkiye II. Entomoloji Kongresi Bildirileri. 29-36, Adana (In Turkish).

SAS Institute Inc. 1996. SAS/STAT Software: Chances and enhancements through release 6.11. SAS Inst. Inc ., Carry, NC, USA.

Vaishampayan, SH., and Kogan, M, 1980. Sampling whiteflies on soybean. Pp 305-322. In: Kogan M. and Herzog DC. (Eds). Sampling methods in soybean Entomology. Pringer-Verlag, N.Y.