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Full Length Research Paper

Field evaluation of soybean cultivars for resistance to whitefly (*Bemisia tabaci* Genn.) infestations

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Whitefly is one of the major yield reducing insect pests of soybean in the Mediterranean region. This study was conducted to screen soybean cultivars, taken from germplasm centers and private seed companies (USA), against the whitefly in the Mediterranean region after wheat harvest in between 1976 and 2005. No artificial infestation was made since whiteflies were very abundant. The whitefly observation was made in August which is the time of the heaviest infestation. Ten plants from each plot and three leaves from each plant (lower, medium and upper parts) were taken for investigation of whitefly population. Eggs, larvae and pupae numbers were determined on the leaves. Seventy two cultivars were found to be highly resistant, 46 cultivars resistant, 43 cultivars moderately resistant, 23 cultivars susceptible and 18 cultivars highly susceptible. Understanding of genetic control of resistance to whitefly can enhance development of resistant cultivars that could be grown in whitefly infested areas.

Key words: Soybean, resistance, whitefly, whitefly infestation, screening.

INTRODUCTION

Turkey is located between 36° and 42°N latitude. Because of the suitable climate and soil conditions, soybean (*Glycine max* L. Merr.) can be grown successfully as a main and second crop after wheat harvesting in southern part of Turkey (Mediterranean area). The major insect pest of soybean in this region is the sweet potato whitefly (*Bemisia tabaci* Genn., Aleyrodidae, Homoptera). Most of the host crops had been severely infested by whitefly in the countries as the Mediterranean Basin in the early 1970s.

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 hyaline wings covered with powdery wax and it is 1.0 - 4.0 mm in size (Vaishampayan and Kogan, 1980; Musa and Ren, 2005). Whitefly needs higher than 26°C and 60% relative humidity for optimum development (Butler et al., 1983).

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 (OISAT, 2004) Whitefly reduces crop yield by direct feeding and is also a vector of numerous plant viruses (Byrne et al., 1990; Morales and Anderson, 2001; McKenzie, 2002; Jones, 2003; Mckenzie et al., 2004; Mann and Singh, 2004; Ruiz et al., 2006; Rubinstein and Czosnek, 1997; Mann et al., 2008; Sidhu et al., 2009). Whitefly nymphs and adults feed in phloem and obtain sap containing various sugars (Hendrix et al., 1992). Injury to soybeans is caused both by nymphs and adults sucking sap from leaves. Whiteflies secrete abundant honeydew. This honeydew, containing metabolized

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sugars, 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 yield reductions. Chemical control of the whitefly has proven expensive and insecticides are losing their effects rapidly (Byrne et al., 2003; Ullah et al., 2006). For this reason, the cultivars grown have to be resistant to whitefly in the area heavily infested with whitefly.

The magnitude of whitefly infestations and the nature and extent of injury vary with the cultivar characteristics. Pubescence length beside pubescence density can be effective on whitefly infestation. A significant correlation was found between pubescence density and whitefly infestation. The Glabrous soybean isolines were highly resistant while the isolines with dense pubescence were very susceptible (Arioglu et al., 1989a). 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 (Hoelmer et al., 1991; McAuslane et al., 1991; Naranjo and Henneberry, 1996; Nombela et al., 2000., McAuslane et al., 2004; Bayhan et al., 2006; Touhidul and Shunxiang, 2009). Arioglu et al. (1989a, b) reported significant seed yield decrease due to whitefly damage in the Mediterranean type of environment.

Arioglu (1987) screened 109 soybean cultivars against the whitefly between 1976 and 1986 and 42 cultivars were found to be highly resistant, 25 cultivars resistant, 16 cultivars moderately resistant, 14 cultivars susceptible and 12 cultivars highly susceptible. Lambert et al. (1997) evaluated 14 soybean genotypes in maturity groups VII-VIII for resistance to *Bemisia argentifolii* in 1993 and 1994. They observed significant differences in mean whitefly densities among the 14 soybean genotypes.

Chemical control of whitefly is difficult due to development of pesticide-resistant whitefly strains. Development of pesticide resistant strains is extremely fast, due to its short generation time (egg to adult in as little as 12 days in summer) and to the huge populations that can develop billions/ha (Denholm et al., 1996; Horowitz and Ishaaya, 1996). Therefore, breeding soybean cultivars resistant to whitefly is one of the most important traits to increase or maintain seed yield in whitefly infested soybean planting areas. The purposes of this study were to determine whitefly resistant soybean cultivars that can be planted in the infested areas and to determine soybean cultivars that can be used as parent(s) in the breeding programs.

MATERIALS AND METHODS

This study was conducted as a second crop after wheat harvesting in Mediterranean area (Adana) between 1976 and 2005 years. In this research, 208 soybean cultivars in different maturity groups which are taken germplasm center and private companies (USA) were screened against the whitefly (*B. tabaci* Genn.). The soil was a clay silt loam with pH of 7.5, 0.8% organic matter and water holding capacity of 0.34 cm3. Fertilizer was applied prior to planting at a rate of 36-92-0 kg NPK ha in each year. A typical Mediterranean climate prevails in the study area with the long term (1976 - 2005) mean annual temperature, precipitation and potential evapotranspiration of 19.1°C, 650 and 1320 mm, respectively. The temperature extremes are -6.4°C in February and 44.0°C in July. About 87% of precipitation occurs during the winter (November to May). Almost no rainfall occurred during the period from June to August in the experimental area. Average air temperature was about 28°C in the cropping period (June -/October) while the mean relative humidity was around 60 and 64%.

The experimental design was a randomized block with three replications. The seeds were planted as a second crop in June and the seeding rate was 100 plants per row. Plot sizes were 2.8 x 5.0 m and row spacing was 0.7 m. Recommended practices were used for weed control. Insecticides were not used for whiteflies over the growing period. Since whiteflies were very abundant, no artificial infestation was made.

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. According to number of whitefly, a scale was made as, 1 is very resistant (less than 10 eggs + larvae + pupae on 2.85 cm2), 2 is resistant (11- 20 eggs + larvae + pupae on 2.85 cm2) , 3 moderately resistant (21-35 eggs + larvae + pupae on 2.85 cm2), 4 is susceptible (36-50 eggs + larvae + pupae on 2.85 cm2) and 5 is very susceptible (more than 51 eggs + larvae + pupae on 2.85 cm2) to whitefly.

RESULTS

The data belonging to the whitefly infestation were summarized in Table 1, 2 and 3 according to scale 1 to 5 for the cultivars. It can be seen from the Table 1: sixty six soybean cultivars were screened against the whitefly in between 1976 and 1983. Nineteen cultivars were found to be highly resistant, 15 cultivars resistant, 14 cultivars moderately resistant, 9 cultivars susceptible and 9 cultivars highly susceptible. Also, 72 soybean cultivars were screened against the whitefly between 1986 and 1990. Thirty two cultivars were found to be highly resistant, 18 cultivars resistant, 12 cultivars moderately resistant, 5 cultivars susceptible and 5 cultivars highly susceptible (Table 2).

It can be seen from the Table 3: sixty four cultivars were screened against the whitefly in 2000 and 2001, six cultivars between 2004 and 2005. In total, 70 soybean cultivars were screened against the whitefly between 2000 and 2005. Twenty seven cultivars were found to be highly resistant, 13 cultivars resistant, 17 cultivars moderately resistant, 9 cultivars susceptible and 4 cultivars highly susceptible.

As a results, 208 soybean cultivars were screened against the whitefly between 1976 and 2005, and 78 cultivars have been observed to be highly resistant (1), 46 cultivars resistant (2), 43 cultivars moderately resistant(3), 23 cultivars susceptible (4) and 18 cultivars highly susceptible (5) to whitefly infestation.

Table 1. The results of screening soybean cultivars for resistance to whitefly between 1976 and 1983.

Screening year	Cultivar	Whitefly* scale (1 - 5)	Screening year	Cultivar	Whitefly* scale (1 - 5)
1976 - 1977	Amsoy 71	1	1976 - 1977	Davis	3
	Beeson	1		Forrest	1
	Chippewa	4		Mack	3
	Clark	5		Bossier	3
	LC-1	5		Bragg	4
	SFR-300	4		Lee 68	3
	Dare	3		Pickett 71	1
1978 - 1979	Columbus	3	1978 - 1979	Crawford	3
	Calland	1		Elf	2
	Cuttler	2		Hodgson	2
	Evans	3		Union	3
	Franklin	3		Williams	5
	Mitchell	1		Steele	2
	Corsoy	2		Swift	4
	Harcor	2		Altona	3
1981 - 1982	IE	2	1981 - 1982	Desoto	5
	Cyst-co	3		Bay	2
	Cumberland	4		Williams 79	5
	Washington	1		Centennial	2
	V	3		Celest	5
	Victoria	5		Imp. Pelican	1
	Bellati L-263	5		UVF-1	1
	B. Semi Dwarf	2		Ware	2
	Shawnee	2		Braxton	1
	Shawnee-2	2		Foster	1
	Gail	1		PK 73-94	1
	Alamo				
1982 - 1983	Lakota	1	1982 - 1983	Kent	1
	Essex	1		Century	3
	Hardin	2		Pixie	4
	Hodgson 78	2		Williams 82	5
	Amcord	1		Fayette	4
	Corsoy	1		Pella	4
	Clay	1		Sparks	4

* Whitefly scale; 1 = Highly resistant, 2 = Resistant, 3 = Moderately resistant, 4 = Susceptible, 5 = Highly susceptible.

DISCUSSION

Since 1976, the sweet potato whitefly, *B. tabaci* (Gennadius) (Hemiptera: Aleyrodidae), has become one of the most important pests of soybean in the Mediterranean region of Turkey. The direct damage of whitefly adults and nymphs leads to high yield losses in soybean production in the Mediterranean region of Turkey. According to the range from 1 to 5, it has been observed that the cultivars are determined as a highly resistant (1) and resistant (2) had never been affected by the whitefly infestation during the growing period. The cultivars which are determined as a moderately resistant (3) had been affected by the whitefly infestation during the growing period. Markedly dark sooty mold appeared on the leaves of these type cultivars. The pods and seeds were not developed normally due to sucking sap from leaves by the whitefly.

Table 2. The results of screening soybean cultivars for resistance to whitefly between 1986 and 1990.

Cultivar	Screening year	Whitefly scale (1 - 5)	Cultivar	Screening year	Whitefly scale (1 - 5)
	Hark	1		L.1808	1
	Proto	1		L.4209	1
	Villis	2		L.4256	5
	Lincoln	2		L.4104	3
	Adams	1		L.4207	2
	Vickery	1		L.4106	1
	Banas	1		L.4206	1
	ICR	2		Mitchell 450	2
	Comerto	2		Mitchell 410	1
	Clark-63	5	1986 - 1987	A.1937	1
1986 - 1987	Woodworth	5		A.2575	1
	L.4303	2		A.2943	1
	L.4208	3		A.3127	1
	L.4303	2		Semu-4	1
	L.4204	1		Semu-33	2
	L.2330	4		Semu-31	1
	L.1771	4		Semu-2	3
	L.4404	4		Semu-62	1
	L.1994	4		AP-240	1
	A.3966	1		JMS 4982	3
	S.2596	1		RHS 623	5
	P.9301	2		CX 415	3
	P.9331	2		J.396	5
	AP-3773	2		A.3935	1
	CX 345	3		S.4240	1
	Sherman 3133	3		P.9441	1
1989 - 1990	C. 1647	2	1989 - 1990	SA 88	1
	P.9272	2		MC 420	1
	P.9293	1		A.3422	1
	EX-3626	3		P.9442	1
	SGI-3307	3		P.9292	1
	SGI-3306	2		J.357	2
	J.335	2		Proto	4
	CM-384	3		HP 201	3
	J.125	2		HP 202	3
	Lawrance	1		Weber	1

* Whitefly scale; 1 = Highly resistant, 2 = Resistant, 3 = Moderately resistant, 4 = Susceptible, 5 = Highly susceptible.

In the susceptible (4) and highly susceptible (5) cultivars, whiteflies secrete abundant honeydew on the leaves of the plants. This honeydew forms a suitable medium for the development of a dark sooty mold, which inhibits light penetration and reduces photosynthesis. For this reason, the plants could not continue to grow and the seeds have not been developed normally. The plants were matured earlier than normal time.

No relation was found between the maturity group and resistance to whitefly. However, pubescences density was seen as an important factor considering resistance to whitefly (Arioglu et al., 1989a). Resistance to whitefly was an important genetically controlled trait and it is directly related to the genetic structure and phenologic characteristics of the cultivars (Perez et al., 2009). Therefore, the determined resistant cultivars (scale 1) could be used as parents in breeding programs to develop high yielding whitefly resistant cultivars. Also the

Table 3. The results of screening soybean cultivars for resistance to whitefly between 2000 and 2005.

Screening year	Cultivar	Whitefly scale (1-5)	Screening year	Cultivar	Whitefly scale (1-5)
	Inton	3		LG 90-2550	2
	HP 203	3		LN 90-4524	3
	Amcor 89	2		LN 92-11008	5
	SS 202	2		KS 3494	2
	Sloan	1		General	1
	CN 290	1		Yale	3
	Newton	1		Pana	1
	LS 201	5		Probst	1
	BSR 201	3		Maveric	1
	Erie	3		C.1945	2
	IL-1	3		Macon	1
	Hayt	4		Ohlo F.61	3
	CN 210	4		Mercury	4
	Cartter	3		Athow	4
	Pella 86	4		C.1943	3
2000 - 2001	Lincord	5	2000 - 2001	Defiance	1
	Oakland	4		Nemaha	3
	BSR 301	3		C.1945	5
	IL-2	1		Odell	2
	Franklin	1		Iroguois	1
	Morgan	1		Saturn	3
	Pyramid	2		KS 4895	3
	Pamano	1		LG 91-7350 R	3
	Pharaoh	1		LN 89-3615	3
	LN 89-3264	1		TN 4-94	1
	Apollo	1		Mustang	2
	Savay	2		Omaha	2
	LN 92-12033	4		Stressland	3
	Olympus	1		Cinse	4
	Dwight	2		KS.4694	1
	LN 92-12054	4		D 83-3349	2
	Flint	1		CF 492	2
2004 - 2005	Arısoy	1	2004-05	ATEM-7	1
	Atakisi	1		Turksoy	1
	Umut 2002	1		Nazlıcan	1

* Whitefly scale; 1 = Highly resistant, 2 = Resistant, 3 = Moderately resistant, 4 = Susceptible, 5 = Highly susceptible.

results of the current study could be used for molecular genetic analysis of whitefly resistance.

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