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Abstract: Ascochyta blight, caused by *Ascochyta rabiei* (Pass.) Lab., is the most important disease in the chickpea (*Cicer arietinum* L.) in many countries, including Turkey. Efforts to control the disease were made using host-plant resistance as the most efficient and economical way. A total of 41 exotic genotypes were evaluated for resistance to *A. rabiei* and also yield and yield criteria near Antalya in the west Mediterranean region of Turkey in the 2000-2001 and 2001-2002 seasons. After every 2 test lines, the susceptible check ILC 263 was sown. When the susceptible check was completely killed by ascochyta blight, blight severity was scored on the 1 to 9 class scale. FLIP 95-53C and FLIP 95-68C were selected for their high seed yield. FLIP 97-74C and FLIP 95-53C were selected for their high biological yield. FLIP 98-177C had the largest seeds and was selected for its high seed yield and harvest index. All of them were also resistant to ascochyta blight. It was assumed that the selected genotypes could be released directly for commercial production or be used in breeding programs.

Key Words: chickpea, *Cicer arietinum*, ascochyta blight, *Ascochyta rabiei*, seed yield, yield criteria

Nohut (*Cicer arietinum* L.) Genotiplerinin Antraknoza [*Ascochyta rabiei* (Pass.) Labr.] Dayanıklılık, Verim ve Verim Kriterleri için Seçilmesi

Özet: *Ascochyta rabiei* (Pass.) Labr.'ın meydana getirdiği nohut (*Cicer arietinum* L.) antraknozu, Türkiye'nin de yer aldığı pek çok ülkede nohudun en önemli hastalığıdır. Hastalığın kontrolü çalışmalarında, en etkili ve ekonomik yol olarak konukçu bitki dayanıklılığı kullanılmaktadır. Toplam 41 dış kaynaklı genotip *A. rabiei*'ye dayanıklılık, verim ve verim kriterleri için Türkiye'nin Batı-Akdeniz Bölgesi'nde yer alan Antalya deneme yerinde 2000-2001 ve 2001-2002 yılları arasında değerlendirilmiştir. Her iki test hattından sonra hassas kontrol ILC 263 ekilmiştir. Hassas çeşitler hastalıktan tamamen öldüğü zaman, hastalık 1-9 ıskalası üzerinden değerlendirilmiştir. FLIP 95-53C ve FLIP 95-68C antraknoza dayanıklılık ve dane verimi için seçilmiştir. FLIP 97-74C ve FLIP 95-53C genotipleri yüksek biyolojik verim için seçilmiştir. FLIP 98-177C iri dalelilik, dane verimi ve hasat indeksi için seçilmiştir. Yukarıdaki genotiplerin hepsi aynı zamanda antraknoza da dayanıklıdır. Seçilen genotiplerin doğrudan ticari üretim amacıyla tescil edilebilecekleri ya da ıslah programlarında kullanılabileceği kanısına varılmıştır.

Anahtar Sözcükler: nohut, *Cicer arietinum*, antraknoz, *Ascochyta rabiei*, dane verimi, verim kriterleri

Introduction

Cultivated chickpea (*Cicer arietinum* L.) is one of the most important cool season food legumes of dry lands and tropics in the world and produced 6,001,781 t from 8,523,168 ha cultivated land with a seed yield of 704 kg ha^{-1}. The total cultivated area, production and yield of chickpea in Turkey is 575,000 ha, 540,000 t and 939 kg ha^{-1}, respectively (FAO, 2001).

Seed yield of chickpea affected by abiotic (Singh et al., 1989, 1990; Wery, 1990; Singh and Saxena, 1993; Silim and Saxena, 1993a, 1993b; Wery et al., 1994) and biotic (Nene and Haware, 1980; Haware and Nene, 1981; 1982a, 1982b; Kaiser and Hannan, 1983; Singh et al., 1984; Singh and Reddy, 1989; Trapero-Casas et al., 1990; Kaiser et al., 1990; Kumar et al., 1991; Kaiser et al., 1993; Haware et al., 1995; Dolar, 1995, 1997; Dolar and Nirenberg, 1998) stresses is quite low, and yield is below its potential. Ascochyta blight of chickpea, caused by [*Ascochyta rabiei* (Pass.) Labr., syn *Phoma rabiei* (Pass.) Khune & J.N. Kapoor.], is considered one of the most important diseases in Turkey (Eser and Soran,

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1978; Maden, 1983; Açıkgöz and Demir, 1984) and worldwide (Singh et al., 1981; Reddy and Singh, 1984, 1993; Singh and Reddy, 1991). Yield losses from disease have been reported in 35 countries (Nene et al., 1996). Pathogenic variability of *A. rabiei* has been demonstrated since the 1960s (Aujla, 1964; Kaiser, 1973; Grewal, 1984; Nene and Reddy, 1987; Kaiser, 1997). However, there has been no consensus as to whether the variability of *A. rabiei* is due to race or aggressiveness in a single race (Mmbaga, 1997). Several researchers have reported that there were 6 races of the pathogen (ICARDA, 1993; Singh and Reddy, 1993). Races 1, 4 and 6 have been found by Dolar and Gürcan (1992a, 1992b). Furthermore, Kaiser and Kusmenoglu (1997) have reported that the teleomorph may play an important role in long-distance dissemination of the pathogen and in increasing genetic diversity in the pathogen population in Turkey. Later works showed that there were 13 different virulent isolates (Mmbaga, 1997).

Kaemmer et al. (1992) reported that there were 3 groups of isolates studied on the basis DNA techniques. Recently, *A. rabiei* isolates were classified into 3 groups (Pathotype-1, Pathotype-2, Pathotype-3) based on the reactions to a set of differentials on the host plant (ICARDA, 1998; Udupa et al., 1998; Jamil et al., 2000). Pathotype-3 is the most virulent of them (ICARDA, 1999). Similarly, it was pointed out that there were 5 groups of 48 isolates from different countries on RAPD markers (Santra et al., 2001).

Although it is possible to control ascochyta blight by the use of such inputs as agricultural chemicals, economic and environmental concerns widely restrict their use in many farmers' fields (Nene and Reed, 1994). The most economical and practical control of diseases can be achieved through an integrated management system, including host-plant resistance and improved agricultural practices. Most breeding programs are based on visual scoring in greenhouse or field conditions. Several breeders or pathologists have focused on ascochyta blight and pointed out that the fungus survives in the diseased chickpea debris and in seeds from infected plants (Maden et al., 1975; Nene, 1984; Kaiser and Hannan, 1988; Trapero-Casas and Kaiser, 1992). Fungus survives for 2 years in infected tissues. Many breeders have developed visual scoring for their breeding programs in field conditions (Vir et al., 1975; Reddy and Singh, 1984; Reddy et al., 1984). The objectives of the present study were to screen and select for resistance to ascochyta blight, seed yield and yield criteria in kabuli chickpea (ram-head-shaped, large-seeded and beige seeds) genotypes under field conditions in the lowlands (Antalya) in the west Mediterranean region of Turkey.

Materials and Methods

Plant Materials: Forty kabuli chickpea lines from the International Center for Agricultural Research in the Dry Areas (ICARDA) were used. ILC 263, susceptible to *A. rabiei*, was used for confirmation of the lines (Table 1).

Genotypes were sown in the second week of December 2000 and 2001 in Antalya in a randomized complete block design with 2 replications as a screening nursery. The experimental plots consisted of 1 row of 4 m length with 45 cm spaces and they were sown by hand. A susceptible check, ILC 263, was repeated every 2 rows. Fertilization was applied at a rate of 23 kg nitrogen and 60 kg phosphorus per hectare as diammonium phosphate. Weeds were removed by hand prior to flowering stage.

Weather conditions and soil properties: The precipitation, average moisture and temperature for the 2000-2001 and 2001-2002 cropping seasons in Antalya are presented in Figure 1. Total precipitation in 2000-2001 was 977 mm, while it was more than 1660 mm in 2001-2002. Generally, rainfall was irregular during both growing seasons in Antalya (DMI, 2002). Organic matter and macro plant nutrients were found at low levels with total nitrogen being 0.1% in the experimental area. The soil texture of the experimental area was loam with a pH of 8.05 and 30.76% $CaCO_3$.

Inoculation of plants: Infected debris and seeds are an important source of infection in subsequent seasons. We used infected debris for inoculation of the plants in the first year. In contrast, chickpea debris infected by *A. rabiei* was not used in the second year due to natural infestation. Infected tissues collected in previous years originated from Urkutlu (Bucak/Burdur) and Korkuteli (Antalya) and dispersed on the plants during initial the flowering and pod filling stages as reported (Reddy and Singh, 1984; Singh et al., 1984; Singh and Reddy, 1993; Muehlbauer et al., 1998; Toker et al., 1999).

Disease assessment: According to Toker et al. (1999), disease assessment was performed on a 1-9 class scale,

Table 1. Mean values of plant height, ascochyta blight score, pods per plant, biological yield, seed yield, 100-seed weight and harvest index of chickpea genotypes grown in the west Mediterranean region of Turkey in the 2000-2002 growing seasons. Values are mean ± standard error.

Genotypes	Plant(height (cm)	Ascochyta blight score (1-9)	Pods per plant	Biological yield (kg)	Seed yield (kg ha^{-1})	100-Seed weight (g)	Harvest index (%)
FLIP 94-90 C	45 ± 2.47	4 ± 0.85	33 ± 7.1	0.37 ± 0.1	906 ± 238	33 ± 2.6	44 ± 1.7
FLIP 95-51 C	57 ± 2.40	2 ± 0.25	38 ± 8.8	0.54 ± 0.1	1390 ± 269	30 ± 0.7	45 ± 2.5
FLIP 95-53 C	53 ± 3.86	2 ± 0.25	48 ± 16.9	0.65 ± 0.1	1676 ± 327	27 ± 0.9	49 ± 2.2
FLIP 95-58 C	46 ± 1.71	3 ± 0.40	30 ± 6.7	0.46 ± 0.1	1139 ± 221	34 ± 0.5	44 ± 1.2
FLIP 95-60 C	47 ± 1.65	3 ± 0.64	34 ± 3.0	0.45 ± 0.1	1146 ± 231	36 ± 0.7	44 ± 1.7
FLIP 95-67 C	49 ± 5.02	3 ± 0.86	41 ±10.1	0.45 ± 0.1	1138 ± 244	33 ± 1.2	45 ± 2.4
FLIP 95-68 C	47 ± 4.71	2 ± 0.00	48 ± 9.2	0.55 ± 0.1	1458 ± 192	30 ± 0.3	48 ± 0.9
FLIP 96-47 C	54 ± 1.60	3 ± 0.70	31 ± 5.9	0.42 ± 0.1	1089 ± 243	34 ± 1.1	46 ± 1.9
FLIP 96-75 C	53 ± 3.57	4 ± 0.75	45 ±10.4	0.39 ± 0.1	965 ± 260	31 ± 0.7	44 ± 2.1
FLIP 96-76 C	51 ± 1.96	4 ± 0.62	44 ±11.6	0.40 ± 0.1	1007 ± 240	30 ± 0.7	44 ± 2.6
FLIP 97-25 C	54 ± 1.19	3 ± 0.57	27 ± 4.7	0.45 ± 0.1	1046 ± 99.3	39 ± 1.0	42 ± 2.4
FLIP 97-74 C	52 ± 3.62	3 ± 0.75	47 ± 9.3	0.66 ± 0.1	1358 ± 396	40 ± 0.3	34 ± 6.3
FLIP 97-110 C	51 ± 2.10	3 ± 0.50	35 ± 6.6	0.52 ± 0.1	1235 ± 124	38 ± 1.7	43 ± 2.3
FLIP 97-121 C	53 ± 2.87	2 ± 0.25	40 ± 2.5	0.54 ± 0.1	1379 ± 134	39 ± 0.5	46 ± 1.6
FLIP 97-127 C	49 ± 1.97	4 ± 0.86	46 ±15.6	0.38 ± 0.1	871 ± 167	35 ± 0.9	42 ± 2.2
FLIP 97-132 C	50 ± 2.55	3 ± 0.40	31 ± 8.6	0.51 ± 0.1	1179 ± 195	33 ± 1.4	43 ± 4.6
FLIP 97-139 C	50 ± 2.47	3 ± 0.70	46 ± 2.8	0.45 ± 0.1	1069 ± 165	35 ± 0.4	43 ± 1.1
FLIP 97-171 C	59 ± 3.23	3 ± 0.47	44 ±12.6	0.59 ± 0.1	1476 ± 263	37 ± 1.1	45 ± 2.0
FLIP 97-191 C	46 ± 2.25	4 ± 0.64	34 ± 6.1	0.36 ± 0.1	978 ± 228	36 ± 1.8	47 ± 2.8
FLIP 97-195 C	47 ± 3.34	3 ± 0.75	33 ± 8.8	0.48 ± 0.1	1164 ± 216	36 ± 0.2	43 ± 0.4
FLIP 97-205 C	48 ± 2.50	3 ± 0.40	45 ±11.5	0.52 ± 0.1	1287 ± 226	32 ± 0.4	44 ± 0.5
FLIP 97-208 C	48 ± 0.47	3 ± 0.75	35 ± 8.5	0.53 ± 0.1	1289 ± 322	34 ± 1.4	44 ± 1.2
FLIP 97-219 C	54 ± 2.43	4 ± 0.64	31 ± 5.9	0.44 ± 0.1	1053 ± 277	36 ± 1.1	43 ± 0.8
FLIP 97-227 C	57 ± 4.07	3 ± 0.28	40 ± 8.8	0.49 ± 0.1	1322 ± 189	33 ± 0.4	48 ± 2.2
FLIP 97-229 C	40 ± 2.63	4 ± 0.86	45 ±13.5	0.43 ± 0.1	1201 ± 310	32 ± 0.8	49 ± 2.3
FLIP 97-239 C	54 ± 5.27	2 ± 0.25	36 ± 6.7	0.55 ± 0.0	1414 ± 120	35 ± 0.7	46 ± 2.5
FLIP 98-106 C	42 ± 3.03	4 ± 0.85	39 ± 6.2	0.35 ± 0.1	947 ± 207	37 ± 1.4	47 ± 2.4
FLIP 98-177 C	55 ± 2.27	2 ± 0.00	43 ± 8.9	0.56 ± 0.1	1540 ± 257	45 ± 0.3	49 ± 0.4
FLIP 98-204 C	47 ± 1.93	3 ± 0.75	39 ± 7.5	0.49 ± 0.1	1317 ± 375	42 ± 0.7	48 ± 1.8
FLIP 98-205 C	48 ± 3.97	3 ± 0.75	34 ± 8.6	0.44 ± 0.1	1057 ± 239	30 ± 0.7	42 ± 2.5
FLIP 98-224 C	56 ± 3.61	3 ± 1.08	36 ± 6.2	0.42 ± 0.1	972 ± 204	32 ± 1.5	42 ± 1.6
FLIP 98-225 C	52 ± 5.14	3 ± 0.85	26 ± 4.8	0.46 ± 0.1	1035 ± 237	36 ± 2.9	40 ± 2.1
FLIP 98-226 C	51 ± 3.50	3 ± 0.47	56 ±12.5	0.54 ± 0.1	1457 ± 267	28 ± 0.5	49 ± 0.8
FLIP 98-227 C	47 ± 3.42	3 ± 0.75	55 ±11.3	0.55 ± 0.1	1629 ± 370	29 ± 0.6	53 ± 4.1
FLIP 98-228 C	49 ± 5.68	3 ± 0.47	46 ± 9.9	0.55 ± 0.1	1336 ± 273	29 ± 0.3	43 ± 1.5
FLIP 98-229 C	45 ± 2.50	3 ± 0.75	67 ±22.0	0.50 ± 0.1	1285 ± 270	28 ± 0.5	47 ± 2.5
FLIP 98-230 C	50 ± 3.54	3 ± 0.47	59 ± 8.6	0.48 ± 0.1	1292 ± 206	29 ± 0.4	48 ± 1.9
FLIP 98-231 C	48 ± 4.05	2 ± 0.62	43 ±11.9	0.52 ± 0.1	1285 ± 278	29 ± 1.2	45 ± 2.0
FLIP 98-232 C	50 ± 3.18	3 ± 0.75	39 ± 7.0	0.38 ± 0.1	940 ± 205	31 ± 1.8	43 ± 2.3
FLIP 98-233 C	49 ± 5.18	3 ± 0.64	41 ± 9.4	0.44 ± 0.1	1121 ± 115	29 ± 0.4	46 ± 3.3
ILC 263	40 ± 0.00	8 ± 0.57	-	-	-	-	-

- data not obtained

where 1 = no symptoms on plants (Immune); 2 = (Highly Resistant); 3 = (Resistant); 4 = (Moderately Resistant); 5 = (Tolerant); 6 = (Moderately Susceptible); 7 = (Susceptible); 8 = (Highly Susceptible); and 9 = all plants dead (Very Highly Susceptible). Scoring was carried out 3 times: prior to the flowering stage, at the pod filling stage and at maturity. Ascochyta blight, in the seasons when the susceptible check was not killed, was not adequate to permit good screening, and consequently scoring in such situations under field conditions was ignored.

Characters studied: Apart from ascochyta blight score, seed yield and yield criteria were recorded. These characters were given in detail in Descriptors for Chickpea (*Cicer arietinum* L.) (IBPGR, ICRISAT and ICARDA, 1993). Plant height: from the ground to the highest point of plants at maximum growth was recorded in centimeters. Number of pods per plant: total pod number at maturity was recorded. Biological yield and seed yield of each genotype was recorded in kilograms and then seed yield was converted on a hectare basis to kg per ha. Harvest index was calculated according to the formula [(Seed yield)/Biological yield) x 100]. 100-seed weight: average of 100 seeds randomly selected twice was recorded in grams.

Statistical analyses: Recorded data were analyzed over 2 years using the MINITAB program.

Results and Discussion

Generally, analysis of variance results for genotypes were significant for all the characters except seed yield, biological yield and number of pods per plant ($P < 0.05$). However, the genotype by environment interactions were significant for the seed weight and days to maturity ($P < 0.01$).

As seen from Table 1, only 7 genotypes (FLIP 95-51C, FLIP 95-53C, FLIP 95-68C, FLIP 97-121C, FLIP 97-239C, FLIP 98-177C and FLIP 98-231C) received scores of 2 or less than 3, i.e., they were resistant over 2 years under field conditions. ILC 263, susceptible to ascochyta blight, received a score of 8 over 2 years. This genotype received a score of 9, especially in the second year as expected. Only 6 genotypes, FLIP 95-53C with 1676 kg ha^{-1}, FLIP 98-227C with 1629 kg ha^{-1}, FLIP 98-177C with 1540 kg ha^{-1}, FLIP 97-171C with 1476 kg ha^{-1}, FLIP 95-68C with 1458 kg ha^{-1} and FLIP 98-226C with 1457 kg ha^{-1}, had better performances than the remaining genotypes. FLIP 97-74C with 0.66 kg $plot^{-1}$ and FLIP 95-53C with 0.65 kg $plot^{-1}$ had the highest biological yield among all the genotypes evaluated. The highest harvest index percentage of genotypes was FLIP 98-227C with 53%. FLIP 98-177C and FLIP 98-204C had the largest seeds among the genotypes. The 100-seed weights of FLIP 98-177C and FLIP 98-204C were 45 g and 42 g, respectively. The plant heights of 17 genotypes were more than 50 cm. The plant heights of some genotypes, FLIP 97-171C, FLIP 97-227C, FLIP 95-51C and FLIP 98-224C, were 59 cm, 57 cm, 57 cm and 56 cm, respectively. The pod number per plant of genotypes is presented in Table 1. FLIP 98-229C with 67 pods, FLIP 98-230C with 59 pods, FLIP 98-226C with 56 pods and FLIP 98-227C with 55 pods had the most abundant pods per plant (Table 1).

FLIP 95-53C and FLIP 95-68C were selected for their high seed yield. FLIP 97-74C and FLIP 95-53C were selected for their high biological yield. FLIP 98-177C had the largest seeds and was selected for its high seed yield and harvest index. All of the genotypes mentioned above were also resistant to ascochyta blight and had sufficient plant height to allow harvesting by machine. It was reported that genotypes with higher plant heights could easily be harvested and threshed by machine (Singh, 1990).

Toker and Cagirgan (2003) reported that there was a strongly negative relation between yield and ascochyta blight score. They also pointed out that materials should be tested for important biotic and abiotic stresses prior to yield selection. Epidemics of the pathogen were accelerated by excessive rainfall and high moisture. Rainfall and average moisture were higher in the first season than in the second (Figure 1). The high rainfall and moisture were the more natural epidemics.

In conclusion, visual scoring can be effectively used to select resistant chickpea individuals under field conditions. Similarly, visual scorings were also used by various researchers (Vir et al., 1975; Singh et al., 1981; Reddy and Singh, 1984; Reddy et al., 1984; Haware et al., 1995). Based on the results, the following technique was developed to screen and select for resistance to ascochyta blight and evaluate for yield and yield criteria in chickpea under field conditions: (i) sow at least a susceptible check as spreader after every 2 or 4 test lines, (ii) sow at least a resistant check for confirmation, (iii) collect plant debris from various chickpea growing areas due to pathogenic

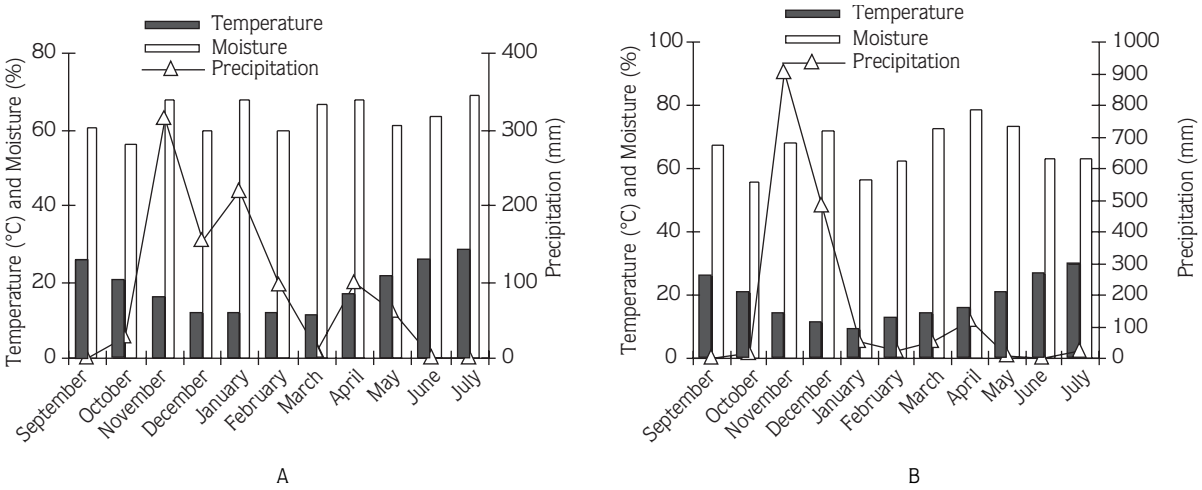

Figure 1. Monthly precipitation (mm), average moisture (%) and temperature (°C) in the 2000-2001 (A) and 2001-2002 (B) seasons in Antalya.

variability, (iv) inoculate the test lines with infected crop debris prior to flowering, (v) irrigate all entries frequently with a sprinkler irrigation system or sow all test lines as winter-sown to encourage epidemics, (vi) evaluate genotypes using the 1-9 class scale during seedling, flowering and pod filling stages, (vii) evaluate the test lines after the susceptible check is completely killed, (viii) select the test lines according to resistance to ascochyta blight and important yield and yield criteria. There are different ideotypes in different target areas because there has been no consensus on the ideotype in chickpea (Singh, 1990), (ix) repeat the field screening test over at least 2 years or confirm the screening results in greenhouse or controlled conditions owing to year and environmental effects, and (x) evaluate the resistance to the disease along with seed yield and yield criteria. Thus, the selection procedures will be shortened.

It was assumed that the genotypes possessed desirable characters that could directly be produced after release and they could be used indirectly in breeding programs.

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