



## Determination of the Reactions of Some Barley Cultivars and Genotypes to Scald Under Greenhouse and Field Conditions

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**Abstract:** The reactions of 36 barley cultivars and 683 barley genotypes to scald were investigated under greenhouse (seedling) and field (adult plant) conditions. Among the 683 barley genotypes tested 44% and 39 % were found to be resistant to moderately resistant in the seedling and adult plant stage, respectively. In the genotype resistance study, a significant ( $P=0.0001$ ) correlation was found between the seedling resistance and adult plant resistance ( $r=0.53$ ). The cultivars Çetin 2000, Avcı 2002, Erginel 90, Kırıl 97, Kaya 7794, Akhisar 98, Zafer 160 and Yeşilköy 387 were found as resistant under both greenhouse and field conditions. The cultivars Çıldır 02, Vamıkhoca and Quantum were found as susceptible under greenhouse conditions; however, they were found as resistant under field conditions. Twenty-five cultivars were susceptible under both greenhouse and field conditions.

**Key Words:** Barley, *Rhynchosporium secalis*, scald, seedling resistance, adult plant resistance

## Bazı Arpa Çeşit ve Genotiplerinin Sera ve Tarla Koşullarında Arpa Yaprak Lekesi Hastalığına Karşı Reaksiyonlarının Belirlenmesi

**Öz:** Otuzaltı arpa çeşidinin ve 683 arpa genotipinin arpa yaprak lekesi hastalığına karşı reaksiyonları sera (fide dönemi) ve tarlada (ergin bitki) incelenmiştir. Test edilen 683 arpa genotipinin %44'ü sera koşullarında, %39'u tarla koşullarında hastalığa karşı dayanıklı bulunmuştur. Genotip dayanıklılık çalışmasında fide dönemi dayanıklılığı ile olgun bitki dayanıklılığı arasındaki korelasyonun ( $r=0.53$ ) önemli olduğu tespit edilmiştir ( $P=0.0001$ ). Çetin 2000, Avcı 2002, Erginel 90, Kırıl 97, Kaya 7794, Akhisar 98, Zafer 160 ve Yeşilköy 387 çeşitleri hem sera hem de tarla koşullarında dayanıklı olarak bulunmuştur. Çıldır 02, Vamıkhoca ve Quantum çeşitleri sera koşullarında hassas olarak bulunurken tarla koşullarında dayanıklılık göstermiştir. Yirmibeş çeşit hem sera hem de tarla koşullarında hassas olarak bulunmuştur.

**Anahtar Kelimeler:** Arpa, *Rhynchosporium secalis*, arpa yaprak lekesi, fide dönemi dayanıklılığı, ergin bitki dönemi dayanıklılığı

### Introduction

Barley (*Hordeum vulgare* L. emend. Bowden) is cultivated worldwide on 57.2 million ha with total and mean productions of 132 million tonnes and 2308 kg/ha, respectively. In Turkey, it is cultivated on 3.6 million ha with a production of 8 million tonnes and a mean of 2204 kg/ha. It is the second most cultivated cereal after wheat (Anonymous, 2000). Scald, caused by the fungus *Rhynchosporium secalis* (Oudem.) J. J. Davis, reduces the yield and the quality of barley worldwide including Turkey (Zencirci and Hayes 1990, Jenkins and Jemmett 1967, Kavak 1998). Aktaş (1984) reported that the disease was common in

Turkey and losses due to this disease ranged between 1-31%. In a survey in Central Anatolia, Mamluk et al. (1997) found a severity level of 20% in more than half of the inspected fields. Kavak (1998) found that infection levels of 46.7%, 68%, 80.1% induced yield losses of 8.9%, 19.6% and 30.5%, respectively.

Using resistant cultivars is the most economical way of controlling the disease. There are some studies regarding the development of resistant cultivars to this disease (Fukuyama et al. 2000, Webster et al. 1980, Albustan et al. 1998). In Turkey,

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barley lines developed at the Central Research Institute for Field Crops (CRIFC) and resistance sources obtained from the International Center for Agricultural Research in the Dry Areas were screened for resistance to *R. secalis*. One thousand three hundred seventy nine and 1401 lines and cultivars were screened under greenhouse and field conditions, respectively. Among these genotypes, 257 and 432 were found to be resistant or moderately resistant under greenhouse and field conditions, respectively. Among the 15 cultivars tested, only the cv. Erginel 90 was found to be resistant both under field and greenhouse conditions (Albustan et al. 1998). In another study, 2481 barley lines obtained from different origins were screened for their reactions to scald. Thirty-three lines were identified as resistant (Çetin et al. 1995). Mert and Karakaya (2004) tested the reactions of 37 barley cultivars to scald isolates under greenhouse conditions. Seven cultivars (cvs Erginel 90, Şahin 91, Kırıl 97, Akhisar 98, Çetin 2000, Çumra 2001, Avcı 2002) were found to be resistant to five *R. secalis* isolates and their mixtures under greenhouse conditions. In Turkey, field resistance status of the recently registered barley cultivars is/are unknown. This study aimed at determination of the resistance status of some registered Turkish barley cultivars and 683 barley genotypes under greenhouse and field conditions.

### Materials and Methods

This study consisted of two parts: 1. Resistance studies on the 36 registered barley cultivars. This study was carried out during the 2003-2005 growing seasons under greenhouse and field conditions. A randomized block design with two replications was employed. 2. Determination of resistance status of 683 barley genotypes during the 2005 growing season under greenhouse and field conditions.

**Seedling tests:** This study was performed at CRIFC Pathology section greenhouses located at Yenimahalle campus, Ankara. A *R. secalis* isolate obtained from diseased plants collected at Haymana Research Farm was used in both greenhouse and field experiments. In the greenhouse, plants were inoculated with the fungus isolate at growth stage 11 (Zadoks et al., 1974). Inoculum concentration was 500.000 spores/ml (Mert and Karakaya 2003). Inoculation procedures were the same as reported previously (Mert and Karakaya 2004). Eighteen days after inoculation, evaluations were made on the first leaves, using a 0-4 scale (El-Ahmed 1981).

In our study, the scale values were grouped for ease of classification as followed. A scale value of 0

was considered as a highly resistant reaction and scale values 0.1–1.0, 1.1–2.0, 2.1–3.0 and 3.1–4.0 were considered as resistant, moderately resistant, susceptible and highly susceptible reactions, respectively.

**Adult plant tests:** This study was performed at Haymana-İkizce Research Farm, Ankara, Turkey. Plants were inoculated in evenings three times beginning at the tillering stage using 50 liter/decare inoculum per inoculation. Inoculum concentration in the field was 500.000 spores/ml. Cultivars/genotypes were seeded in 1.5 m rows with 30 cm spacing between the plants. After each 10<sup>th</sup> row the susceptible cultivar Tokak 157/37 was seeded as the susceptible control. Field evaluations were made at the milk development stage. The Saari and Prescott (1975) scale (0-9) was used for adult plant evaluations. In our study, the scale values were grouped for ease of classification as followed. The scale values 0 –3.0, 3.1–4.0, 4.1-6.0, 6.1-8.0, and 8.1-9.0 were considered as resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible reactions, respectively. Under field conditions, when the susceptible cultivar Tokak 157/37 exhibited a highly susceptible reaction the test materials were evaluated.

### Results and Discussion

According to three- year results, cultivar difference to pathogen isolate was evident. Also, in some cultivars, differences between the greenhouse and field results were observed (Table 1). Cultivars Çetin 2000, Avcı 2002, Erginel 90, Kırıl 97, Kaya 7794, Akhisar 98, Zafer 160 and Yeşilköy 387 were found to be resistant to moderately resistant both under greenhouse and field conditions. Cultivars Çıldır 02, Vamikhoca and Quantum were found to be susceptible to highly susceptible under greenhouse conditions; however, they were found to be resistant or moderately resistant under field conditions. Twenty-five cultivars were found to be susceptible to highly susceptible both under greenhouse and field conditions. Seedling reactions of registered barley cultivars were mostly in agreement with a previous study (Mert and Karakaya 2004) with the exception of cv. Çumra 2001. Çumra 2001 was found as resistant in the previous study, however, it was found susceptible in this study. Moreover, Mert and Karakaya (2004) by using 5 different *R. secalis* isolates and their mixture observed that some cultivars showed the same response to all isolates, however, in some cultivars, there were differences in the cultivar response to the different isolates.

Table 1. Seedling (greenhouse) and adult plant (field) responses of 36 Turkish barley cultivars to *R. secalis*

| Barley cultivars | Row type | Seedling response <sup>1</sup> |      |      |      | Field response <sup>2</sup> |      |      |      |
|------------------|----------|--------------------------------|------|------|------|-----------------------------|------|------|------|
|                  |          | 2003                           | 2004 | 2005 | Mean | 2003                        | 2004 | 2005 | Mean |
| Akhisar 98       | 6        | 0                              | 1,5  | 0,5  | 0,7  | 1                           | 1    | 0    | 0,7  |
| Anadolu 86       | 2        | 4                              | 4    | 4    | 4,0  | 8                           | 6    | 8    | 7,3  |
| Anadolu 98       | 2        | 3,5                            | 4    | 3,5  | 3,7  | 7,5                         | 7    | 7    | 7,2  |
| Angora           | 2        | 3,5                            | 3,5  | 1,5  | 2,8  | 7                           | 5    | 4    | 5,3  |
| Avcı-2002        | 6        | 0                              | 0    | 0    | 0    | 0                           | 0    | 0    | 0    |
| Aydanhanım       | 2        | 3                              | 3,5  | 3    | 3,2  | 5,5                         | 5    | 6    | 5,5  |
| Beyşehir         | 6        | 3,5                            | 3    | 2,5  | 3,0  | 6                           | 7    | 8    | 7,0  |
| Bilgi-91         | 2        | 4                              | 3    | 3,5  | 3,5  | 6,5                         | 6,5  | 8    | 7,0  |
| Bornova 92       | 2        | 3,5                            | 4    | 4    | 3,8  | 8,5                         | 8    | 8    | 8,2  |
| Bülbül 89        | 2        | 4                              | 4    | 3,5  | 3,8  | 8                           | 8,5  | 8    | 8,2  |
| Çatalhöyük 2001  | 2        | 3,5                            | 3    | 2    | 2,8  | 7                           | 8    | 7,5  | 7,5  |
| Çetin 2000       | 6        | 0                              | 0    | 0    | 0    | 0                           | 0    | 0    | 0    |
| Çıldır 02        | 2        | 3,5                            | 3    | 3,5  | 3,3  | 4                           | 3,5  | 4    | 3,8  |
| Cumhuriyet 50    | 2        | 3,5                            | 3,5  | 3    | 3,3  | 6,5                         | 7,5  | 8,5  | 7,5  |
| Çumra 2001       | 2        | 3,5                            | 3    | 2,5  | 3,0  | 6                           | 5,5  | 5,5  | 5,7  |
| Efes 98          | 2        | 3,5                            | 4    | 2,5  | 3,3  | 7,5                         | 7,5  | 7    | 7,3  |
| Efes-3           | 2        | 4                              | 4    | 4    | 4,0  | 7                           | 8    | 7    | 7,3  |
| Erginel 90       | 6        | 0                              | 0    | 0    | 0    | 0                           | 0    | 0    | 0    |
| Kalaycı-97       | 2        | 4                              | 4    | 3,5  | 3,8  | 7,5                         | 7    | 7,5  | 7,3  |
| Karatay 94       | 2        | 4                              | 3,5  | 2,5  | 3,3  | 7                           | 8    | 6,5  | 7,2  |
| Kaya 7794        | 2        | 0,5                            | 1,5  | 0    | 1,0  | 0                           | 0    | 0    | 0,0  |
| Kıral-97         | 6        | 0                              | 0    | 0    | 0,0  | 0                           | 0    | 0    | 0,0  |
| Konevi           | 2        | 4                              | 2,5  | 1,5  | 2,7  | 8                           | 5    | 8    | 7,0  |
| Obruk            | 2        | 4                              | 4    | 3,5  | 3,8  | 8                           | 7    | 8    | 7,7  |
| Orza 96          | 2        | 3,5                            | 3,5  | 3,5  | 3,5  | 7,5                         | 8    | 7,5  | 7,7  |
| Quantum          | 2        | 2,5                            | 3    | 2    | 2,5  | 2                           | 0    | 3    | 1,7  |
| Sladoran         | 2        | 4                              | 4    | 1    | 3,0  | 4,5                         | 4,5  | 3,5  | 4,2  |
| Sur-93           | 2        | 3                              | 3    | 3    | 3,0  | 5                           | 5    | 7    | 5,7  |
| Tarm-92          | 2        | 4                              | 4    | 3    | 3,7  | 8,5                         | 8    | 8    | 8,2  |
| Tokak 157/37     | 2        | 4                              | 4    | 4    | 4,0  | 8,5                         | 8,5  | 7,5  | 8,2  |
| Vamıkhoca 98     | 6        | 2                              | 4    | 3    | 3,0  | 4                           | 2    | 5    | 3,7  |
| Yerçil-147       | 2        | 3,5                            | 3    | 3    | 3,2  | 4                           | 5    | 4,5  | 4,5  |
| Yesevi 93        | 2        | 4                              | 4    | 3    | 3,7  | 7                           | 7    | 8    | 7,3  |
| Yeşilköy 387     | 6        | 2                              | 1    | 0,5  | 1,2  | 0                           | 2    | 0    | 0,7  |
| Zafer 160        | 6        | 2                              | 1    | 1    | 1,3  | 1                           | 2    | 0    | 1,0  |
| Zeynel Ağa       | 2        | 2,5                            | 3    | 3    | 2,8  | 5,5                         | 6,5  | 6,5  | 6,2  |

<sup>1</sup> For evaluation of seedling studies, a 0-4 scale was used (El-Ahmed, 1981). Inoculum concentration was 500 000 spores/ml. Numbers of each year are mean of 2 replications.

<sup>2</sup> For evaluating adult plant studies, a 0-9 scale was used (Saari and Prescott 1975). Inoculum concentration was 500 000 spores/ml. Inoculation was repeated three times. Numbers of each year are mean of 2 replications.

Kavak (1998) determined under natural and experimental conditions in the field the reactions of 20 barley cultivars to fungal isolates collected from Şanlıurfa, Turkey. Cultivar Angora was found to be highly resistant, cv. Efes 3 was resistant and cv. Kaya 7794 was susceptible. Mert and Karakaya (2004) determined the seedling reactions of these cultivars. Cultivars Angora and Efes 3 was found to be very susceptible to 5 *R. secalis* isolates and their mixtures. Cultivar Kaya 7794 was susceptible to some isolates and resistant to others. In our study, cv. Kaya 7794 was resistant both under greenhouse and field conditions. In the seedling test, cvs Angora and Efes 3 showed susceptible and highly susceptible reactions, respectively whereas in the adult plant stage they showed moderately susceptible and susceptible reactions, respectively.

Döken (1979) found the seedling reactions of cvs Tokak 157/37, Yeşilköy 387 and Cumhuriyet 50 to be susceptible and cv. Zafer 160 to be resistant. Mert and Karakaya (2004) found that cv. Cumhuriyet 50 was susceptible to all isolates, cv. Yeşilköy 387 was susceptible to one isolate and cv. Zafer 160 was susceptible to another isolate. In our study, cv. Cumhuriyet 50 was found susceptible in both greenhouse and field studies. Cultivars Yeşilköy 387 and Zafer 160 were found to be resistant in field and moderately resistant in greenhouse.

Albustan et al. (1998) found cv. Erginel 90 to be resistant in both field and greenhouse studies. Mert and Karakaya (2004) also found this cultivar to be resistant to all isolates tested in seedling studies. This cultivar also found as resistant in our study.

Among the 683 barley genotypes tested 44% and 39% were found to be resistant to moderately resistant in the seedling and in the adult plant stage, respectively (Tables 2 and 3). Albustan et al. (1998) found the seedling resistance as 19% and adult plant resistance as 31% in their experiments. In our study, out of 683 barley genotypes, 201 genotypes (29%) were found as resistant to scald both under greenhouse and field conditions.

In the genotype resistance study, the correlation between the seedling resistance and adult plant resistance ( $r=0.53$ ) during the 2005 growing season was found to be significant ( $p=0.0001$ ). Albustan et al., (1998) found the correlation as  $r=0.70$  between the seedling resistance and adult plant resistance.

Among the 719 barley genotypes used in this study, 650 genotypes were two-rowed and 69 genotypes were six-rowed. Twenty-eight percent of the

650 two-rowed barley genotypes and 92% of the 69 six rowed barley genotypes were found to be resistant at both seedling and adult plant stage. Six rowed cultivars appear to be more resistant than two rowed cultivars. These results are in agreement with those of Zencirci and Hayes (1990) and Mert and Karakaya (2004).

It appears that a large number of barley genotypes and cultivars resistant to scald are available. The resistant barley genotypes and cultivars determined in this study should be of value to plant breeders incorporating broad based scald resistance into different barley cultivars.

Table 2. Reaction of 683 barley genotypes to a *R. secalis* isolate under greenhouse conditions and their percentage values

| Total lines | Scale value <sup>1</sup> |     |    |             |     |
|-------------|--------------------------|-----|----|-------------|-----|
|             | Resistant                |     |    | Susceptible |     |
|             | HR                       | R   | MR | S           | HS  |
| 683         | 116                      | 130 | 61 | 184         | 192 |
| %           | 17                       | 19  | 9  | 27          | 28  |

For evaluation of seedling studies, a 0-4 scale was used (El-Ahmed 1981). Inoculum concentration was 500 000 spores/ml.

HR: Highly Resistant, Scale value 0

R: Resistant, scale value 0.1-1.0

MR: Moderately Resistant, scale value 1.1-2.0

S: Susceptible, scale value 2.1-3.0

HS: Highly Susceptible, scale value 3.1-4.0

Table 3. Reaction of 683 barley genotypes to a *R. secalis* isolate under field conditions and their percentage values

| Total lines | Scale value <sup>1</sup> |    |             |    |     |
|-------------|--------------------------|----|-------------|----|-----|
|             | Resistant                |    | Susceptible |    |     |
|             | R                        | MR | MS          | S  | HS  |
| 683         | 221                      | 48 | 172         | 83 | 159 |
| %           | 32                       | 7  | 25          | 12 | 23  |

<sup>1</sup>For evaluating adult plant studies, a 0-9 scale was used (Saari and Prescott 1975). Inoculum concentration was 500 000 spores/ml.

R: Resistant, scale value 0-3.0

MR: Moderately Resistant, scale value 3.1-4.0

MS: Moderately Susceptible, scale value 4.1-6.0

S: Susceptible, scale value 6.1-8.0

HS: Highly Susceptible, scale value 8.1-9.0

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