Evaluation of Verticillium Wilt Tolerance in Different Cotton Cultivars

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ABSTRACT
Field experiments were conducted to evaluate yield and Verticillium resistance in cotton, 6 cultivars were studied as randomized complete block design with 4 replications in Estahban Research Station, during 2005 to 2006. Disease percent, the index and severity were determined based on foliar symptoms. Results showed that Bakhtegan, 818 and B-557 had the least percent (20-29.38%), severity (1.42-1.62) and index (32.13-45.69) of disease. On the other hand, Varamin had the most percent (%85.63), severity (3.23) and index (278) of disease. Bakhtegan, 818 and B-557 were significantly differed of others in yield.

Keywords: Cotton, Cultivar, Tolerance, Verticillium

INTRODUCTION
Verticillium wilt caused by Verticillium dahlia kleb is the most serious disease in cotton production, which is the major factor influencing high yield of cotton in worldwide and Iran (Moshirabadi, 1981).

Control of Verticillium wilt is difficult under intensive cropping systems, such as those adopted in the area infested with the disease in Iran. Currently, no fungicides were registered for control of this disease on cotton. In addition, the ability of sclerotia of the fungus to survive in the soil for seven or more years (Wilhelm, 1955) and the wide host range of the fungus, make cultural control difficult, emphasizing the need for resistant cultivars (Heale, 1988).

High tannin content was reported to be associated with Verticillium wilt resistance (Singh, 1998). The original selection for Verticillium resistance was made before 1917 (Hillocks, 1992). Cultivars that have moderate to high levels of resistance to Fusarium wilt and low to moderate levels of resistance to Verticillium wilt include Deltapine 50, Deltapine 20, Stoneville 506, Stoneville 112, GC-510 and DESL 99.

465 varieties and lines including Gossypium hirsutum L. and Gossypium barbadense L. were evaluated for resistance to Verticillium wilt in field conditions and 23 varieties and lines showed resistance to disease (Chen et al., 1980).

Resistance of 32 cotton cultivars to Verticillium wilt (V. dahliae) was tested in the field and four cultivars showed high resistance to the disease (Jian et al., 2003). 28 of the most commonly grown cotton cultivars (Gossypium hirsutum L.) of Turkey were evaluated for the presence of field resistance to wilt. Most of the evaluated cultivars were susceptible. Carmen cultivar was susceptible to the defoliating but resistant to the
nondefoliating pathotype. ST-373 cultivar was moderately susceptible to both pathotypes of *V. dahliae* (Gore et al., 2009).

Four isolates of *Verticillium dahliae* were used in screening four cotton cultivars. Pimas-7 and Acalaprema gave the highest resistance reactions and Acala44 was the most susceptible (Bolek et al., 2005).

135 forms of *Gossypium arboreum* and *G. herbaceum* were studied for *Verticillium* wilt resistance in field. Both species proved resistance to race 2 of *V. dahliae* which effects *G. hirsutum* Tashkent1 (Alyamov and Kas yanenko, 1980).

The spread of *Verticillium* wilt and it’s crop loss in cotton fields of Fars, Mazandaran and Golstan provinces make it necessary to determine the susceptibility of cotton cultivars to *V. dahliae*. In view of present studies were designed to determine resistance cultivars with high yield and climate (year) effects on *Verticillium* wilt.

**MATERIALS AND METHODS**

Experiment was carried out in Estahban Research Station (south of Iran) in 2005 and 2006. Station soil was naturally infested with *Verticillium* wilt. Six cultivars of cotton (*Gossypium hirsutum* L.) were evaluated for resistance to *Verticillium* wilt. The experimental traits were randomized complete block With 4 replications. Cultivars included: Varamin, Crema, Deformeh leaf, 818, Bakhtegan and B-557.

Disease percent, index and severity were determined four months after cultivation. Disease Severity (DS) and index (DI) calculated with formula.

\[
DS = \frac{(A\times 0) + (B\times 1) + (C\times 2) + (D\times 3) + (E\times 4)}{M}
\]

Where A, B, C, D, E and M refer, respectively

A=plant No. with degree 0
B=plant No. with degree 1
C=plant No. with degree 2
D=plant No. with degree 3
E=plant No. With degree 4
M=total plant No.

*Verticillium* wilt degrees of every plant were assessed from 0 to 4 using the following degree (Booth, 1970).

0=No symptoms
1= Chlorosis of few leaves at the bottom of plant, without leaf defoliation.
2=Chlorosis of many leaves up to the top of the plant, associated with defoliation lesser than 50% of leaves and buds.
3=Chlorosis and marginal necrosis of leaves and defoliation more than 50% of leaves and buds.
4=Necrosis of the whole lamina, whole defoliation, dead plant.

DI= Disease percent×Disease severity

Data were analyzed by using of the statistical method adapted by Gomez and Gomes (Gomez and Gomez, 1984). Mean comparison were achieved by Duncan's Multiple range test using. MSTATC soft ware.

**RESULTS AND DISCUSSION**

Analysis of variance showed that disease severity was significantly different in 2005 and 2006 (Table1). Results were demonstrate climate changed *Verticillium* severity and virulance of the pathogen was increased by favourable weather conditions. Disease percent and index were not significant in 2 years of experiment. Climate did not change *Verticillium* wilt percent (Table1). Year × cultivars interaction was significant for percent, severity and index of *Verticillium* wilt at p=0.01. All cultivars were showed reaction to year (climate) and tolerant cultivars were infected in favourite year. Cultivars were infested with *Verticillium* but percent and severity of wilt disease of susceptible cultivars were increased (Table1).
The percentage and the severity of infestation depend on the environmental factors as well as cultivar and stage of plant growth. As temperature between 22 and 27°C and excessive soil moisture favour disease, there are great differences between years as well as within the same cultivar and growing period (Basset 1974; Friebertshauser and DeVay 1982, Gutierrez et al., 1983).

Results showed that Varamin had the most disease percent (85.63%) and this cultivar had the greatest infected plant. Otherwise, Bakhtegan, 818 and B-557 had the least disease percent (29.38, 23.75 and 20% respectively) and they had the least infected plants (Table 2).

Varamin had the highest disease severity. The most of plants were infected to degree 3 and 4. Vascular penetration of *Verticillium* was increased in Varamin cultivar. Probably, *Verticillium* fungus decreased seed cotton production (yield) (Table 2). Cultivars with moderate to high levels of resistance to *Verticillium* wilt have also been developed in several countries: Sahel in Iran (Moshirabadi, 1998) Albar G501 in Zimbabwe (Hillocks, 1991) and Zhong Mein12, 8004, 8010 and Laoyang 5 in China (Shen, 1985).

Bakhtegan, 818 and B-557 had the lowest disease severity (1.45, 1.625 and 1.425 respectively). Penetration *Verticillium* fungus to vascular was least and the most of plants had disease degree 1 and 2. Seedling of *Verticillium* tolerant cotton cultivar Acala 4852 were subjected to chilling at 10°C. Radicle exudates were taken after 2-5 days. Disease severity increased significantly with increase of amino acids and sugars exudation, while top dry weight decreased also significantly (Shao and Christiansen, 1982).

Varamin had the most disease index (278) and was the most susceptible to wilt disease. Bakhtegan, 818 and B-557 had the least disease index (45.69, 39.88 and 32.13 respectively).

Table 1. Analysis of variance on *Verticillium* wilt percent, severity, index and yield in 2005 and 2006

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Verticillium percent</th>
<th>Verticillium severity</th>
<th>Verticillium index</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>1</td>
<td>133.333</td>
<td>0.682*</td>
<td>928.4</td>
<td>440641.688</td>
</tr>
<tr>
<td>Error</td>
<td>3</td>
<td>115.278</td>
<td>0.063</td>
<td>836.851</td>
<td>139611.743</td>
</tr>
<tr>
<td>Cultivars</td>
<td>5</td>
<td>4773.333**</td>
<td>3.707**</td>
<td>69649.57**</td>
<td>2189000.438**</td>
</tr>
<tr>
<td>Year x cultivars</td>
<td>5</td>
<td>463.333**</td>
<td>0.227**</td>
<td>2026.318**</td>
<td>194856.438</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>79.167</td>
<td>0.038</td>
<td>630.112</td>
<td>116263.271</td>
</tr>
<tr>
<td>Cv(%)</td>
<td></td>
<td>21.35</td>
<td>10.22</td>
<td>26.63</td>
<td>10.49</td>
</tr>
</tbody>
</table>

*p<0.05 and **p<0.01
Table 2. Data means of Verticillium wilt and yield separated by Duncan's multiple range test

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Verticillium percent</th>
<th>Verticillium severity</th>
<th>Verticillium index</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varamin</td>
<td>85.63a</td>
<td>3.237a</td>
<td>278a</td>
<td>2780cd</td>
</tr>
<tr>
<td>Crema</td>
<td>51.88b</td>
<td>1.904b</td>
<td>99.68b</td>
<td>3285bc</td>
</tr>
<tr>
<td>Deformeh leaf</td>
<td>39.38c</td>
<td>1.744b</td>
<td>70.28bc</td>
<td>2404d</td>
</tr>
<tr>
<td>818</td>
<td>23.75d</td>
<td>1.625bc</td>
<td>39.88cd</td>
<td>3583ab</td>
</tr>
<tr>
<td>Bakhtegan</td>
<td>29.38cd</td>
<td>1.45c</td>
<td>45.69cd</td>
<td>3789a</td>
</tr>
<tr>
<td>B-557</td>
<td>20d</td>
<td>1.425c</td>
<td>32.13d</td>
<td>3575ab</td>
</tr>
</tbody>
</table>

Within columns, numbers followed by the same letters are non significantly different.

These cultivars were resistance to *Verticillium* disease (Table 2). Modern cultivars such as the Acola's released recently from California and New Mexico, as well as the pima's *G.barbadense* are highly resistant to *V.dahdiae*. Other upland cultivars such as paymaster HS-26, Deltapine5690 and Stoneville-495 have moderate resistance to Verticillium wilt (Zhang and Percy, 2007).

In the combination of R×S, R×R cross progeny of upland cotton, each combination showed 3R: 1S to *Verticillium dahliae*. After F1 back crossing with the resistant parent, progenies from many combinations were 1R:1S, and the progenies from combination of R×R were resistant. Therefore the cotton varietal resistance to *Verticillium* was thought to be controlled by multiple dominant gene (Kuai and Pan, 1987). major dominant gene, but it is also possible of the different genes reciprocity (Pan et al., 1994) and it is a quantitative inheritances in which the additive effect is most important and the dominat effect is second (Wang et al., 1989).

Bakhtegan, 818 and B-557 (3789, 3583 and 3575 kg/ha, respectively) were recorded the highest yield. Resistant cultivars had higher yield comparing with other cultivars. Marani and Yacobi (1976) planted the same cotton genotypes in infested and not infested fields with *V.dahliae* and difference of yield for each genotype at the two locations indicated yield loss by Verticillum wilt also resistant and susceptible cultivars indicated 31 to 45% variation in yield.

REFERENCES


