A study of the effect of Cercospora leaf spot at different cultivars and fertilization level

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Cercospora leaf spot (CLS) caused by Cercospora beticola is one of the most destructive foliar disease of sugar beets in all sugar beet-growing areas worldwide (Malandrakis et al., 2006). Control of CLS in Greece and other areas in a warm climate and irrigation is based mainly on frequent fungicide applications (Karaoglanidis and Ioannidis, 2010). However, serious problems have resulted from the extensive appearance of fungicide resistant C. beticola isolates to the intensively used benzimidazoles, organotin fungicides and sterol biosynthesis inhibiting triazoles.

INTRODUCTION

Cercospora leaf spot (CLS) caused by Cercospora beticola is one of the most destructive foliar disease of sugar beets in all sugar beet-growing areas worldwide (Malandrakis et al., 2006). Control of CLS in Greece and other areas in a warm climate and irrigation is based mainly on frequent fungicide applications (Karaoglanidis and Ioannidis, 2010). However, serious problems have resulted from the extensive appearance of fungicide resistant C. beticola isolates to the intensively used benzimidazoles, organotin fungicides and sterol biosynthesis inhibiting triazoles.

Agricultural scientists are becoming aware of the potential contribution of farmers in developing integrated management of crop diseases in general (Bentley and Thiele, 1999). Much disease management practices such as the applications of fungicides and fumigant; focus on controlling pathogens is often too late to be effective, when disease symptoms are apparent. A more reliable approach is to concentrate on the period before infection occurs and encourage conditions that are unfavorable to the pathogen and favorable to the plant (Wolf and Verreet, 2002; Ghorbani et al., 2008).

Various control strategies, including host-plant resistance, resistant cultivars, integrated control and biological control have been developed. Breeding efforts to generate Cercospora resistance in sugar beet started in the 1920s by Munerati (1920). Historically, resistance was introgressed from the wild sea beet, Beet vulgaris L. spp. Maritima (Hecker and Helmerick, 1985). Additional resistant accessions were also found in other subspecies of B. vulgaris and in other sections of the genus Beta, namely Corolliniae, Nanae and Procumbentes (Asher et
al., 2001). Resistant against _C. beticola_ is a quantitative trait based on the additive effect of at least four to five major resistance genes (Smith and Gaskill, 1970). Therefore, sugar beet lines are selected for resistant against _C. beticola_ in the greenhouse using artificial inoculation or in regions where natural infection occurs annually, namely Italy and Greece in southern Europe (Byford, 1996). As the climatic conditions in these countries are different from Germany, resistance of sugar beet varieties is influenced by environmental and cultivation factors (Mähränder et al., 2003).

However, the exact number of host genes involved is unknown (Weiland and Koch, 2004). Due to highly variable climatic conditions on a single location, resistant cultivars adapted to the different sugar beet-growing areas worldwide where _C. beticola_ occurs regularly are available (Byford, 1996; Mechelke, 2000; Pfeifer and Schäufele, 2000). Host resistance is not efficient to prevent infection by _C. beticola_ entirely but reduces the pathogen’s development (Rossi et al., 2000). Therefore, sugar beet lines selected for resistant against _C. beticola_ are unreliable in different regions and variable climatic conditions in commercial breeding.

Soil conditions for plant growth can influence the occurrence and severity of plant diseases. Managing and exploiting the suppressive effects of the soil environment as part of an integrated control strategy could make a significant contribution to agricultural sustainability and environmental quality (Quimby et al., 2002).

In this study, the impact of different cultivars and fertilization levels on CLS disease severity under natural infection in Heilongjiang, China in 2010. In this study, field trials were carried out to determine the effect of CLS at different cultivars and fertilization level. Secondly, resistant against _C. beticola_ in different geographic regions were determined.

### MATERIALS AND METHODS

**Detection of disease resistant against _C. beticola_ for sugar beet varieties**

Sugar beet cultivars (KWS0142, KWS0149, KWS9145, KWS8138, KWS6167, KWS9522, KWS4121, BETA807, BETA356, BETA484, BETA812, BTO2431, Ma096, Ma097, Hi0940, Hi0166, Hi0732, Hi0474, DVA02234, IS0436) differing in the level of resistant against _C. beticola_ were used in this study. One location with severe disease occurrence in 2009 was selected to determine cultivars resistant against _C. beticola_ under natural infection in Heilongjiang, China in 2010. Three locations apart from 100 km away with severe disease occurrence were selected to determine KWS1049 and KWS4121 cultivars resistant against _C. beticola_ of different geographic area.

Field trials were sown between mid and end of April with 70 cm distance between rows. The distances between plants within rows in the natural infection trial was 40 cm, and the trials were manually thinned to a density of 49,500 to 52,500 plants ha⁻¹ in seedling trays filled with a standard soil. Weed control were carried out according to local standards.

### RESULTS

**Response of sugar beet against _C. beticola_ at different fertilization level**

Field experiments with Sugar beet cultivars KWS0149 were conducted in a location of Heilongjiang province in 2010. Soil nutrients of tested field were obtained under large of 0~15 cm. Organic matter was measured, including the contents of organic matter, available nitrogen, available phosphorus and available potassium etc. for the pre-test. The results showed that, the organic matter content is medium rate (20.18~50.20 g·kg⁻¹) in tested field soils, ranging from (118.12~204.20 mg N·kg⁻¹, 7.18~14.32 mg P·kg⁻¹, 44.75~139.57 mg K·kg⁻¹). Field trials were sown with 70 cm distance between rows. A 140 cm wide protective belt is left without fertilization by using randomized group (every group mean 5.6 m²) design with 4 replicates.

Traditional fertilization and optimized fertilization were using to analyze effect of sugar beet against _C. beticola_ at different fertilization level in this study. Nitrogen (N), phosphors (P) and potassium (K) were replaced respectively by using carbamide (N), diammonium phosphate (P), potassium (K). Fertilizer application rates of traditional fertilization were designed as the treatments of 600 kg·ha⁻¹ (240 kg N·ha⁻¹, 195 kg P·ha⁻¹, 165 kg K·ha⁻¹), 675 kg·ha⁻¹ (270 kg N·ha⁻¹, 210 kg P·ha⁻¹, 195 kg K·ha⁻¹), 750 kg·ha⁻¹ (300 kg N·ha⁻¹, 255 kg P·ha⁻¹, 195 kg K·ha⁻¹), 825 kg·ha⁻¹ (375 kg N·ha⁻¹, 270 kg P·ha⁻¹, 180 kg K·ha⁻¹), and 900 kg·ha⁻¹ (420 kg N·ha⁻¹, 255 kg P·ha⁻¹, 225 kg K·ha⁻¹).

Fertilizer application rates of optimized fertilization were N₉₀₀kg·ha⁻¹, N₇₅₀kg·ha⁻¹, N₆₀₀kg·ha⁻¹, N₅₀₀kg·ha⁻¹, N₄₀₀kg·ha⁻¹, N₃₀₀kg·ha⁻¹, N₂₀₀kg·ha⁻¹, N₁₀₀kg·ha⁻¹, N₀kg·ha⁻¹. (Detailed data refer to Table 4).

### Disease assessment

Disease index severity of all individual sugar beet plants per treatment was assessed according to the modified agronomica disease index severity (Vereijssen et al., 2003; Battilani et al., 1990), which covers a scale from 0 (healthy) to 9 (totally destroyed foliage). Disease index severity in each treatment group was estimated in the middle of August 2010 using a scale of 0 to 9: 0 = no symptoms on fully leaves; 1 = few disease spots of most leaves; 3 = most disease spots of most leaves; 5 = most disease spots of most leaves, dead lateral 1 to 3 leaves; 7 = most disease spots of most leaves, dead lateral 3 to 5 leaves; 9 = most disease spots of most leaves, all leaves and leafstalk dead or whole plant dead.

### Statistics

Analysis of variance was carried out with the programme SPSS version 13.0 (SPSS Inc., Chicago, IL, USA). Significant differences were indicated with different letters for probabilities (P<0.05).

### Detection of disease resistant against _C. beticola_ for sugar beet varieties

Disease index investigation was carried out in the middle of August. Univariate comparisons showed that level of resistance of 20 cultivars had been differed significantly (P<0.05) and were sorted KWS0149> BETA356> Hi0940 >KWS6167> KWS8138> KWS4121> Hi0166> DVA02234 > BETA807> KWS0142> Ma096> KWS9522> IS0436>
Table 1. The resistance determination of sugar beet varieties against *C. beticola*.

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Disease index</th>
<th>Cultivars</th>
<th>Disease index</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWS0142</td>
<td>17.36±0.54 (\text{abcde})</td>
<td>Ma096</td>
<td>19.01±0.89 (\text{coef})</td>
</tr>
<tr>
<td>KWS0149</td>
<td>13.08±0.49 (\text{b})</td>
<td>Ma097</td>
<td>20.86±1.01 (\text{abc})</td>
</tr>
<tr>
<td>KWS9145</td>
<td>23.95±2.85 (\text{fgh})</td>
<td>Hi0940</td>
<td>15.31±0.25 (\text{abc})</td>
</tr>
<tr>
<td>KWS8138</td>
<td>16.30±0.86 (\text{abcde})</td>
<td>Hi0166</td>
<td>16.79±0.25 (\text{abcde})</td>
</tr>
<tr>
<td>KWS6167</td>
<td>15.81±0.25 (\text{ab})</td>
<td>Hi0732</td>
<td>27.61±1.39 (\text{h})</td>
</tr>
<tr>
<td>KWS9522</td>
<td>19.14±0.81 (\text{abcde})</td>
<td>DVA0-2234</td>
<td>16.79±1.31 (\text{abcde})</td>
</tr>
<tr>
<td>BETA807</td>
<td>17.04±1.13 (\text{ab})</td>
<td>BSTO-2431</td>
<td>19.38±1.60 (\text{abcde})</td>
</tr>
<tr>
<td>BETA356</td>
<td>14.62±4.40 (\text{bc})</td>
<td>IS0436</td>
<td>19.26±1.86 (\text{abc})</td>
</tr>
<tr>
<td>BETA464</td>
<td>21.73±2.51 (\text{c})</td>
<td>Hi0474</td>
<td>25.80±2.50 (\text{gh})</td>
</tr>
<tr>
<td>BETA812</td>
<td>22.84±1.39 (\text{efgh})</td>
<td>KWS4121</td>
<td>16.54±1.38 (\text{abcd})</td>
</tr>
</tbody>
</table>

Data are treatment means of pooled data ± standard errors. Values of each column followed by different letters are significantly different at \(P < 0.05\) according to Duncan’s multiple range tests.

Table 2. The determination of sugar beet resistant against *C. beticola* from different geographic area.

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Different regions</th>
<th>Disease index</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWS1049</td>
<td>1</td>
<td>13.08±0.49 (\text{b})</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>27.66±0.25 (\text{c})</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>17.12±1.72 (\text{b})</td>
</tr>
<tr>
<td>KWS4121</td>
<td>1</td>
<td>16.54±1.38 (\text{b})</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>29.14±1.37 (\text{b})</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>19.35±3.74 (\text{ab})</td>
</tr>
</tbody>
</table>

The distance among the three zones (1,2,3) is 100 km; Data are treatment means of pooled data ± standard errors. Different letters for the same assessment date indicate significant different at \(P < 0.05\) according to Duncan’s multiple range tests. 1, 2, 3 for three locations apart from 100 km away.

BSTO-2431> Ma097> BETA464> BETA812> KWS9145> Hi0474> Hi0732 (Table 1).

Three locations apart from 100 km away with severe disease were selected to analyze relationship between KWS1049, KWS4121 cultivars resistant against *C. beticola* and different geographic area. The result showed that level of same varieties resistance from different geographic area were significant different (Table 2).

**Response of sugar beet against *C. beticola* at different fertilization level**

Traditional fertilization was designed to analyze cultivars resistant against *C. beticola*. The results showed that level of resistant against *C. beticola* from traditional fertilization were not significant different (Table 3).

Optimized fertilization was designed to analyze cultivars resistant against *C. beticola* from different fertilization level. The results showed that level of resistant against *C. beticola* from optimized fertilization were significant different (Table 4). The results showed low nitrogen reduced sugar beet resistant against *C. beticola* and level of resistance from optimized fertilization were sorted \(N_2P_1K_1 > N_2P_2K_0 > N_2P_3K_0 > N_2P_2K_2 > N_2P_1K_2 > N_1P_2K_0 > N_2P_3K_2 > N_3P_2K_0 > N_1P_2K_2 > N_3P_2K_2 > N_1P_1K_0 > N_0P_0K_0 = N_0P_0K_2\).

**DISCUSSION**

In this study, we aimed to estimate effect of different cultivars and fertilization level under natural infection against *C. beticola* in Heilongjiang, China. The 20 cultivars resistant against *C. beticola* were evaluated under natural infection in cultivar trial series. The result showed that KWS series varieties had the character of high resistance to disease in Heilongjiang, such as...
As Walters et al. (2005) pointed out; we need to pay attention to factors that are likely to influence the effectiveness of bio-controls in the field. There are evidences which show both a positive and a negative relationship between available plant nutrients and incidence of certain diseases (Ghorbani et al., 2008). Fertilizer application rates of traditional fertilization and optimized fertilization were designed to analyze cultivars resistant against *C. beticola*. The result showed that strong and weak of resistant against *C. beticola* from different fertilization level of optimized fertilization were not significantly different (P <0.05) (Table 3).

However, the results showed significant differences among different fertilization level of traditional fertilization (P <0.05) (Table 4). The results showed low nitrogen could reduce host resistant against *C. beticola*. And balance fertilizing could enhance host resistance to CLS. Fertilizer application rates were designed for enhance sugar beet resistant against *C. beticola* as the treatments of adaptive rate (N:P:K=2:1:1).

Abundant nitrogen encourages succulent growth, a prolonged vegetative period, and delayed maturity of the plant, which increases the period of susceptibility to pathogens. Deficient plants are weaker and slower growing, which are also more susceptible to pathogens (Agrios, 1997). The effect of soil nitrogen level on disease development in different agricultural crops has been shown. For example, Sharma and Kolte (1994)
suggested that the plants in pots or field plots which received NK (N 90 kg ha⁻¹) + (K 40 kg ha⁻¹) were more resistant to infection than plants which received N (alone) or P (alone) or NP and PK combinations. Such results provide interesting evidence to support the view that balanced soil fertility could lead to better sugar beet resistant against *C. beticola*.

All in all, a comparative study of resistance determination of sugar beet varieties against *C. beticola* is needed to understand better from different geographic area in order to design comprehensive control on CLS. Accumulation of more knowledge regarding control of CLS should stimulate further conversion of conventional systems of sugar beet production, which incorporate agro-ecological strategies to optimize soil fertilization, sugar beet varieties diversity management and more natural systems of disease regulation without incurring much yield.

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**REFERENCES**


