ROOT ROT OF SUGAR BEET IN THE VOJVODINA PROVINCE*

ABSTRACT: Large changes introduced in the sugar beet production technology in the Vojvodina Province over last 40 years resulted in changes in the etiology and harmfulness of different agents of sugar beet root diseases. Improvements in cultivation practices reduced the harmfulness of some diseases while increased the harmfulness of others. Some disease agents became obsolete, but others gained importance. New agents of root diseases were found. The most frequent damages, persisting over long periods of time were caused by seedling damping-off, *Fusarium* root rot, charcoal root rot, parasitic (*Rhizomania*) and non-parasitic root bearding. The parasitic damping-off, caused by several fungal species but most frequently by *Phoma betae* occurred at the time when multigerm seeds were used in combination with extensive cultural practices. The agents of seedling diseases completely lost their significance as the consequence of switching to fungicide — treated monogerm seeds, earlier planting and improved soil tillage. In the period of intensive use of agricultural chemicals, seedling damping-off occurred frequently due to the phytotoxic action of chemicals (insecticides, herbicides and mineral fertilizers). In some years, frosts caused damping-off of sugar beet seedlings on a large scale in the Vojvodina Province. Poor sugar beet germination and emergence were frequently due to spring droughts. Sometimes, they were due to strong winds. The occurrence of *Fusarium* root rot and charcoal root rot intensified on poor soils. Fusariosis symptoms were exhibited as plant wilting and different forms of root rot. In recent years, root tip rot has occurred frequently in the first part of the growing season, causing necrosis and dying of plants. Lateral roots tended to proliferate from the healthy tissue, giving the root a bearded appearance similar to *Rhizomania*. *Fusarium oxysporum* was the most frequent agent of this fusariosis. *F. graminearum*, *F. equiseti*, *F. solani* have also been identified in recent years as the agent of root rot, but its importance was much lower. Charcoal root rot and plant wilting (*Macrophomina phaseolina*) have caused extensive damages in sugar beets, especially under the conditions of severe drought and high temperatures in summer. In some years, it was the dominant agent of root rot. Mixed infections caused by fungi from the genera *Fusarium* and *M. phaseolina* were encountered frequently. The extent of damage caused by these diseases was reduced by improved pro-

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duction technology. *Rhizomania* of sugar beet (caused by *beet necrotic yellow vein virus*) was identified in Serbia in the 1970s. Results of recent investigations have shown that BNYVV is widespread in Vojvodina, since the virus was found on 36.7% (24,674 ha) of acreages from 67,213 ha of total sugar beet acreages inspected on incidence of BNYVV in the period from 1997 to 2004 year. In the last few years, the occurrence of *Rhizoctonia* root rot (*Rhizoctonia solani*) was registered in some localities in Vojvodina.


INTRODUCTION

In the last four decades, great changes occurred in sugar beet production in Vojvodina. New processing capacities were built and the areas covered with sugar beet greatly increased. Sugar beet production spread onto unfavorable, arid areas as well as on the areas characterized by poor soil conditions. The technology of sugar beet production was constantly changing. Great amounts of chemical substances were used and at one point, their uncontrollable application in agricultural production was observed. Great amounts of mineral fertilizers, soil insecticides and herbicides were applied into the soil surface. Crop rotation was narrowed, thus, beet was often cultivated in two-crop rotation. Due to such conditions, different sugar beet diseases occurred, which in some cases, significantly influenced the yield and the quality of the product (Marić and Stojšin, 2004).

MATERIALS AND METHODS

Collecting root samples

Sugar beet root rot was observed in several localities in Vojvodina and was monitored during the period of vegetation from 1998 to 2004. In order to determine and identify the agents of root rot and to study disease symptoms, root samples characterized by rot symptoms were collected from several different localities. Roots were randomly chosen and the part of roots with characteristic disease symptoms were used for isolating and determining the parasites, causal agents of rot.

Fungi isolation

Phytopathological isolations were conducted in standard way in Petri dishes on nutritive potato-decstrose agar medium and then incubated at 25°C for fungi isolation. After the colonies had been developed, transplantation of isolates was conducted in order to achieve pure cultures and determine the fungi.

Fungi determination

Pure fungi cultures belonging to *Fusarium* genus were transplanted onto the carnation medium (CLA) and exposed to special light, so called “black
light”, in order to trigger fructification. On the basis of fungi colony appearance, conidia and conidiophores as well as on the basis of chlamydospore creation, the determination of species was conducted (Nelson et al., 1983, Burgess et al., 1988, 1991).

Based on the morphological characteristics of vegetative and reproductive organs, all other fungi species were determined (Whitney and Duffus, 1989).

The investigation of NPK fertilization influence on the occurrence of root rot and bearded root were conducted on the fields of Research Institute for Field and Vegetable Crops, Novi Sad, Rimski šančevi, over a 14-year period (from 1989 to 2004, excluding 1999). Sugar beet is sown in four-year crop rotation where plant species are rotated as follows: sugar beet, corn, sunflower, and wheat. The influence of 20 variants of NKP nutritive is investigated in the trial in four replications. Each year, the same plot is given the same amount and ratio of mineral fertilizers, whereas plant species are rotated as mentioned above. Mean values of root rot and bearded root, of yield on all fertilized variants relative to control as well as the amount of precipitation relative to the vegetative period and corresponding years are presented in the paper (Table 1). The influence of NPK nutritive on the intensity of the appearance of root rot and bearded root are evaluated at the end of vegetation, during sugar beet harvesting. Ocular evaluation of 50 roots taken from each of the plots and genotypes, the intensity of the occurrence was registered.

In order to investigate the soil infestation, the occurrence and distribution of *beet necrotic yellow vein virus*, soil sampling was conducted. Samples were taken in production areas of sugar beet refineries Vrbas, Crvenka, Žabalj, Bač, Senta, Zrenjanin, Kovačica, Nova Crnja and Pećinci, meaning Bačka, Banat and Srem, three regions of Vojvodina where sugar beet is grown in our country, over the period of eight years (1997—2004). The number of hectares inspected on the presence of virus relative to years and regions is presented in Table 1. In order to determine the presence of virus and its distribution in the soil, from each 10 ha, one average soil sample was taken. Individual soil sampling was done by bin samplers at the depth of 30 cm according to the predetermined plan (chess system) at every 10 ha. Plastic dishes of the volume 1 l were filled with the collected soil samples. Then, sensitive variant, Delta was sown into these dishes. Dishes were kept in glasshouse for six weeks. After six weeks, emerged sugar beet plants were collected from the ground, the root was taken and the average sample was made in order to be tested on the presence of the virus. The presence of beet necrotic yellow vein virus was confirmed by enzyme-linked immunosorbent assay, (Clark and Adams, 1977), DAS-ELISA-test. For these tests, IgG and IgG-konjugate anti-bodies of beet necrotic yellow vein virus were used, produced by “Bioreba”, Basel. Healthy beet root grown in the same way on sterile soil was used as the negative control.
RESULTS

Seedling damping-off

Seedling damping-off and crop thinning occurs every year in Vojvodina to a higher or lesser extent, depending on the number of agroecological factors.

Parasitic damping-off

In the course of many-year studies of harmful population of phitopathogenic fungi, it was determined that on the diseased seedlings seed transmitted or soil borne fungi are dominant (Marić, 1963). Concerning the frequency and pathogenicity, Phoma betae is considered to be the most important causal agent of sugar beet seedling damping-off. The main resource of inoculum was the seed. Temperature and soil humidity are the basic pre-conditions for the occurrence of parasitic seedling damping-off. Temperatures above 20°C are extremely favorable for the development of the mentioned parasites, thus, parasitic seedling damping-off rarely occurs with early sowing. The weakening of seedlings due to droughts causes stronger fungi attacks belonging to Fusarium genus. Seed quality has a great influence on the occurrence of seedling damping-off. Healthy seed, characterized by good germination and germination viability are basic pre-conditions of achieving strong, vital seedlings which at the same time are resistant to parasitic damping-off. Technical processing of seed removes the pericarp layer and the greatest part of harmful micro flora with it (Marić and Stojšin, 2004).

Non-parasitic damping-off

With the transfer to using monogerm seed and with the intensive application of chemical substances, important changes occurred in the etiology of seedling damping-off. Non-parasitic causes of this disease like crust soil, drought, frost, toxic effect of herbicides, insecticides and mineral fertilizers are met more often (Marić and Stojšin, 2004).

Root rot

Fusarium species are dominant causal agents of sugar beet root rot in Vojvodina (65.8%). Species Macrophomina phaseolina (10,1%), Alternaria spp. (10,5%), Rhizoctonia solani (4,7%) and other fungi genera are registered in much lesser percentage (Figure 1).
Fusarium root rot (Fusarium spp.)

General opinion is that root rots in our conditions are caused by fungi belonging to *Fusarium* genus ([Marić, 1992], [Stojšin, Vera, 2001], [Jasnić et al., 2001], [Stojšin, Vera et al., 2002], [Jasnić et al., 2004], [Marić, Stojšin, Vera, 2004]). According to almost all the authors, the decisive factor influencing the occurrence of the disease are ecological conditions during vegetation. The disease is occurs more intensively in the years with dry summers. The weakening of plants in the conditions of high soil and air drought leads to the intensified appearance of parasites on root hair and side roots, especially on the poor soil types and in the conditions of low nutrition of plants. Leaf chlorosis and plant wilting are visible symptoms appearing in the second part of beet vegetation. Surface root tissues become gray-brownish in colour and soften and rot in humid conditions. Over the last years, rot of the root tail was noticed which deteriorates in the first part of vegetation. Concerning the healthy tissue, proliferation of side roots and bearded root often appears. *Fusarium oxysporum* is the dominant causal agent of root rot. Over the last years, as causal agents of rot the following species were also determined: *F. solani*, *F. equisetii*, *F. proliferatum*, *F. semitectum*, *F. graminearum*, but their importance is almost insignificant.

Charcoal root rot

*Macrophomina phaseolina* Tassi, Goidanich (sin. *Sclerotium bataticola* Taub. Butl.)

*M. phaseolina* was the dominant causal agent of beet root rot and plant wilting in Vojvodina in 1992 ([Stojšin, 1993]). Symptoms of the disease are
revealed in wilting of the diseased plants. Infested tissues are gray-brownish or black in colour with silver shine. Diseased rhizoderm gets thinner, breaks and easily divides from other parts of tissue. Within rhizoderm, numerous fungi microsclerotia are formed. Interior tissue of the infested root is of pith appearance, yellowish and eventually brown-black in colour. Highly infested root in dry conditions mummifies and in humid conditions, humid rot appears. Charcoal rot develops more intensively in the conditions of intensive drought and high temperatures during summer (Marić and Stojšin, 2004).

**Rhizoctonia root rot**

Thanatephorus cucumeris (anamorf Rhyzoctonia solani)

Based on our research, it can be seen that *Rhizoctonia solani* is present on fields where sugar beet is grown. In the last years, the intensive occurrence of this parasite is registered (4.7%) (Figure 1). The first symptoms observed on diseased plants are sudden chlorosis and leaf wilting. Later, black necrosis of leaf stands appears, most frequently near the head of the root. Wilted leaves die quickly, forming brown-black rosette from the dead leaves, which remains during the whole period of vegetation. Root rot and head rot can be complete or partial. On the infested root, brown or black areas are observed. They can unify capturing most parts of the root or the whole root. Deep cracks often appear near the head of the root. In the humid conditions, softening of tissue appears as well as the symptoms of humid rot. The second type of symptoms on the root is dry rot manifested with concentric, dark or light-brown areas. Below the lesions, mycelium of the parasite is formed with distinctive margins between healthy and infested tissue.

The influence of mineral nutrition on sugar beet root rot and bearded root

Sugar beet root rot and bearded root occurred almost regularly, in conditions of different mineral nutrition of plants as well as in the control variant. The most frequent appearance of these diseases was registered in very dry years as 2000 was when root rot in fertilized variants was 89% and in the control 96% and bearded root 41.6% and 22%, which affected root yield (fertilized treatments 44t/ha and control only 25t/ha) (Table 1). These diseases did not occur in very favorable conditions for sugar beet growth (2004), when the best yields were achieved. Root rot appeared more intensively in control variant of the trial and bearded root was more prominent on fertilized crops. In this trial, drought was the most important factor of the appearance of the diseases and low sugar beet root yield.
Table 1. Intensity of root and root bearding in condition of different mineral nutrition during 14 year investigation

<table>
<thead>
<tr>
<th>Year</th>
<th>89</th>
<th>90</th>
<th>91</th>
<th>92</th>
<th>93</th>
<th>94</th>
<th>96</th>
<th>97</th>
<th>98</th>
<th>00</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>Ave-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root rot % fertilised</td>
<td>0.0</td>
<td>5.8</td>
<td>3.3</td>
<td>19.1</td>
<td>1.4</td>
<td>2.1</td>
<td>4.3</td>
<td>0.9</td>
<td>2.1</td>
<td>89.0</td>
<td>0.0</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
<td>9.2</td>
</tr>
<tr>
<td>non fertilised</td>
<td>0.0</td>
<td>3.0</td>
<td>18.0</td>
<td>26.0</td>
<td>0.0</td>
<td>2.0</td>
<td>10.8</td>
<td>1.0</td>
<td>1.0</td>
<td>96.0</td>
<td>0.5</td>
<td>1.2</td>
<td>3.5</td>
<td>0.0</td>
<td>11.6</td>
</tr>
<tr>
<td>Bearded roots % fertilised</td>
<td>1.2</td>
<td>1.3</td>
<td>4.7</td>
<td>1.2</td>
<td>3.4</td>
<td>2.3</td>
<td>17.1</td>
<td>7.3</td>
<td>4.0</td>
<td>22.0</td>
<td>3.6</td>
<td>2.0</td>
<td>1.1</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>non fertilised</td>
<td>0.0</td>
<td>1.3</td>
<td>4.7</td>
<td>1.2</td>
<td>3.4</td>
<td>2.3</td>
<td>17.1</td>
<td>7.3</td>
<td>4.0</td>
<td>22.0</td>
<td>3.6</td>
<td>2.0</td>
<td>1.1</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Root yield t/ha fertilised</td>
<td>49.5</td>
<td>29.3</td>
<td>—</td>
<td>25</td>
<td>38</td>
<td>47</td>
<td>44</td>
<td>44</td>
<td>60</td>
<td>59</td>
<td>45</td>
<td>82</td>
<td>45</td>
<td>82</td>
<td>47.5</td>
</tr>
<tr>
<td>non fertilised</td>
<td>38.1</td>
<td>23.9</td>
<td>—</td>
<td>21</td>
<td>29</td>
<td>22</td>
<td>38</td>
<td>39</td>
<td>34</td>
<td>25</td>
<td>40</td>
<td>40</td>
<td>27</td>
<td>27</td>
<td>34.4</td>
</tr>
<tr>
<td>Precipitation IV—IX month (mm)</td>
<td>354</td>
<td>217</td>
<td>487</td>
<td>229</td>
<td>249</td>
<td>345</td>
<td>250</td>
<td>433</td>
<td>491</td>
<td>148</td>
<td>742</td>
<td>279</td>
<td>237</td>
<td>459</td>
<td>—</td>
</tr>
<tr>
<td>Annual precipitation (mm)</td>
<td>507</td>
<td>451</td>
<td>779</td>
<td>532</td>
<td>498</td>
<td>569</td>
<td>814</td>
<td>764</td>
<td>755</td>
<td>288</td>
<td>999</td>
<td>482</td>
<td>501</td>
<td>836</td>
<td>—</td>
</tr>
</tbody>
</table>

Sugar beet Rhizomania (Beet necrotic yellow vein virus)

Results concerning distribution of beet necrotic yellow vein virus in Vojvodina in the period of 1997—2004 are shown in table 2. Over eight years of investigating the infestation of soil, total area of 67.213 ha was inspected, out of which 24.674 ha was infested with Rhizomania, i.e. 36.7% of the area, on average, more than one third.

Table 2. Distribution of beet necrotic yellow vein virus relative to regions of sugar beet growing in Vojvodina over the period of 1997—2004.

<table>
<thead>
<tr>
<th>Years</th>
<th>Srem</th>
<th>Banat</th>
<th>Bačka</th>
<th>Infected (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of inspected fields (ha)</td>
<td>Sum of infected No. of hectares %</td>
<td>Sum of inspected fields (ha)</td>
<td>Sum of infected No. of hectares %</td>
</tr>
<tr>
<td>1997</td>
<td>427</td>
<td>295</td>
<td>69.1</td>
<td>2110</td>
</tr>
<tr>
<td>1998</td>
<td>348</td>
<td>100</td>
<td>28.9</td>
<td>6376</td>
</tr>
<tr>
<td>1999</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2365</td>
</tr>
<tr>
<td>2000</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2006</td>
</tr>
<tr>
<td>2001</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2176</td>
</tr>
<tr>
<td>2002</td>
<td>320</td>
<td>50</td>
<td>15.6</td>
<td>3060</td>
</tr>
<tr>
<td>2003</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>701</td>
</tr>
<tr>
<td>2004</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sum</td>
<td>1095</td>
<td>445</td>
<td>18795</td>
<td>8687</td>
</tr>
<tr>
<td>Average</td>
<td>40.6</td>
<td>46.2</td>
<td>32.9</td>
<td>36.7</td>
</tr>
</tbody>
</table>
From table 2, the tendency of virus spreading and the increase in infested areas in Vojvodina can also be seen. However, distribution of the virus in Vojvodina varies depending on the year.

**DISCUSSION**

During our investigations of causal agents of sugar beet root rot by isolating from rotten roots, *F. oxysporum* species was most commonly gained, besides *F. solani* and *R. solani* and *M. Phaseolina* fungi. Dominant distribution of *F. oxysporum* species as the causal agent of root rot is also emphasized by other authors (Snyder, Hansen, 1940, Marić, 1974, Whitney, Diffus, 1986, Ruppel, 1991, Jasnìć et al., 2001, Marić, Stojšin, Vera, 2004). Distribution of other fungi like *R. solani* (4.7%) and *M. phaseolina* (2.8%) was much lower and depended on weather conditions. According to many authors, weather conditions during the period of vegetation are decisive factors influencing the distribution of certain fungi species, causal agents of root rot (Marić, 1974, Balaz, Stojšin, Vera, 1997, Jasnìć et al., 2001, Jasnìć et al., 2004).

*Rhizoctonia solani*, causal agent of charcoal root rot appears in years with warm and humid summers. These conditions favorably influence the development of this fungus (Pometer, 1970). These conditions are rarely seen in our areas, thus, that is one of the reasons of lower incidence of *R. solani*.

By analyzing the soil samples over the period of 1997—2004, in order to determine the areas infested by Rhizomania, significant distribution of beet necrotic yellow vein virus was observed in Vojvodina (Table 2). Beside precise data about the spreading and distribution of virus in many European countries (Blunt, 1989), no data were available about the distribution of Rhizomania in Serbia (Ivanović, 1996). It is well-known that beet necrotic yellow vein virus, causal agent of Rhizomania is widespread in our country. Since it was discovered in Srem in 1977 (Šutić and Milovanović, 1978), virus has spread on significant areas in many regions where sugar beet is grown in Srem, Banat, Bačka (Šutić et al., 1986, Jasnìć et al., 1999 a, Jasnìć et al., 1999 b) with the tendency of spreading in other parts of Serbia as well.

**REFERENCES**


БОЛЕСТИ КОРЕНА ШЕЂЕРНЕ РЕПЕ У ВОЈВОДИНИ

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Резиме

У раду се дaju преглед болести корена шеђерне репе током вишегодишњег периода у Војводини и резултати испитивања њихове етиологије. Интензитет појаве ових болести зависио је од временских услова током вегетације и од примењених агroteхничких мера. Палеж клијанаца, фузариозна и угљенаста трулеж, паразитна (ризоманија) и непаразитна брадасти корена биле су најучесталије болести корена. Већина паразитних болести клијанаца се интензивније јављала у периоду примење екстензивне агroteхнике. Fusarium oxysporum je најчешћи процрвоковаћ фузариозне трулежи репа корена. Последњих година детерминисане се следеће врсте: F. solani, F. equiseti, F. proliferatum, F. semitectum и F. graminearum, али њихов значај је много мањи. Угљенаста трулеж корена и увенуће биљака (Macrophomina phaseolina) изазивају велике штете на шеђерној репи, народно у условима јаке суше и високих температура током лета. Ризоманија шеђерне репе (BNYVV) је широко распрострањена у Војводини, пошто је вирус у периоду 1997—2004. утврђен на 36,7% (24674 ha) површине од укупно 67.213 ha прегледаних. Последњих неколико година регистровање је интензивнија појава Rhizoctonia solani проузроковача мрке трулежи корена на појединим подручјима Војводине.