CONTROL OF GRAPEVINE LEAF SPOT CAUSED BY PSEUDOCERCOSPORA VITIS WITH APPLICATION OF BICARBONATE

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Abstract

This study was conducted to find environmentally friendly control methods and to investigate occurrence pattern of grapevine leaf spot, major disease in ‘Campbell early’ cultivar. Grapevine leaf spot caused by *Pseudocercospora vitis* is one of the most important disease in Korea. The occurrence pattern of leaf spot for ‘Campbell early’ cultivar was conducted in organic vineyards and conventional vineyards of Sangju, the main growing region of grape from 2012 to 2013. As results, the symptom of leaf spot was observed at last-June firstly in the organic vineyards and then the occurrence rate was gradually increased. The rate of lesion area was rapidly increased to 80.2% in last-August. To control grapevine leaf spot, some materials were tested and bicarbonate was selected. The optimum concentration of bicarbonates for control of grapevine leaf spot is 0.5%, and occurrence of grapevine leaf spot by treatment of 0.5% sodium bicarbonate and ammonium bicarbonate were 6.2 or 8.2%, respectively. This result showed that bicarbonate was more effective than Lime Bordeaux mixture in control of grapevine leaf spot widely used in grape organic cultivation for disease control. But phytotoxicity was observed in the treatment of 1% sodium bicarbonate and 2% potassium bicarbonate. So, it is expected that grapevine leaf spot will be successfully controlled by application of 0.5% bicarbonate.

Keywords: ‘Campbell early’ cultivar, *Pseudocercospora vitis*, leaf spot, bicarbonates, control

1. Introduction

Grapevine is one of the most important fruit trees with apple, citrus, persimmon and peach and the cultivation area is about 13,538ha in Korea (KOSIS, 2013). The main growing regions of grapevine are Yeongcheon, Gimcheon and Sangju, etc. In Gyeongsangbuk-do Province and the major cultivar is ‘Campbell early’ up to 70%. This cultivar developed in United States is known to have cold resistance as well as resistance to downy mildew and powdery mildew. But it is very susceptible to leaf spot caused by *Pseudocercospora vitis* (Park et al., 2004). This pathogen produced considerable damage every year in Korea. This disease begins to occur mid-June at first, and the first symptom is a small brown lesion and that spreads rapidly in the rainy season (Kim et al., 2006, Park et al., 2006). To control of this disease, a fungicide is sprayed about 5-6 times but it’s so difficult to control. Recently, as environment-friendly agricultural products are of increasing concern of consumer, environment-friendly farming is increased (Kim et al., 2013). However the farmers dependent on organic material for control of diseases are experiencing a lot of difficulties because organic cultivation method is not constructed completely. Since many researchers have tried to find out effective microorganism and organic agricultural materials for control of disease, some expecting results have been reported for practice of environmentally-friendly agriculture (Kim et al., 2008). From review of these results, bicarbonate is expected to control of disease. Bicarbonates at concentrations under 2% have been widely used in the food industry to avoid fermentation, to control pH, and to develop satisfactory textures and flavors (Lindsay, 1985). Likewise, it was known as effects of bicarbonates on microorganisms are associated with CO₂ activity (De Pasquale and Montville, 1990; Montville and Goldstein, 1989). For example of fungal disease control, treatment of sodium, potassium, and ammonium bicarbonate successfully protected from fungal infections of the cucumber during preharvest (Homma et al., 1981; Ziv and Zitter,1992). Similarly, treatments with sodium and potassium bicarbonate showed effective control of *Rhizoctonia carotae* Rader in carrots during post-harvest (Ricker and Punja, 1991; Punja and Gaye, 1993), melon (Aharoni et al., 1997) and pomegranates (Lluis et al., 2007). This study was conducted to find environmental control method with bicarbonates and to investigate occurrence pattern of grapevine leaf spot, the major disease in ‘Campbell early’ cultivar.

2. Materials and methods

*Investigation of occurrence pattern of grapevine leaf spot.* This study was conducted in Sangju regions, the main grapevine producing region of Gyeongbuk, for 2 years (2012-2013). The occurrence
pattern of grapevine leaf spot was investigated the rate of infected leaves. The surveyed vineyards were fixed up three places, conventional - or organic - rain proof cultivation, respectively. The ratio of infected leaves was calculated by investigation total 100 leaves on five trees, twice a month, from June to August. Investigation trees were selected in the middle of orchard.

**Bicarbonates spraying concentration test.** The effect of bicarbonates for control against grapevine leaf spot was tested using Sodium bicarbonate (Samchun Pure Chemicals CO., LTD), potassium bicarbonate (Samchun Pure Chemicals CO., LTD) or ammonium bicarbonate (Daejung Chemicals & Metals CO., LTD). At first, four concentration liquids were prepared to find effective spraying concentration, each 0.25, 0.5, 1 or 2% (wt/vol), and each liquid were sprayed three times at 10 days intervals on labeled 10 leaves per tree with hand spray. The control effect of bicarbonates was invested at 10 days after the last spraying and ratio of lesion area (%) was calculated with following formula: (infected leaf area/total leaf area) × 100. This study was conducted in 2012.

**Effect of bicarbonate spray.** Bicarbonate liquids for control of grapevine leaf spot were sprayed 3 times at intervals of 10 days from early-July, and then those control effect was investigated in early-August and it was calculated as ratio of lesion area (%), diameter of infected leaf and the number of infected leaf per leaf. Lime Bordeaux mixture (4g lime – 4g copper sulfate/f), widely used in grapevine organic culture, was used to compare control effect. This study was conducted in 2013.

**Statistical Analysis.** The design for this experiment was a Completely Randomized Design (CRD) with three replications. Data were analyzed with the Analysis of Variance (ANOVA) and the mean values were separated by Duncan Multiple Range Test (DMRT). All analyses were performed using The Statistical Analysis Systems (SAS Institute Inc., 2013).

3. Results and discussions

3.1. *Investigation of occurrence pattern of leaf spot*

The occurrence pattern of leaf spot for ‘Campbell early’ cultivar was conducted in organic vineyards and conventional vineyards of Sangju, the main growing region of grape from 2012 to 2013. As results, the occurrence of leaf spot was started at last-June in the organic vineyards and then this disease was gradually increased. The ratio of lesion area was increased to 80.2% in last-August rapidly (Fig. 1). The occurrence pattern of conventional vineyards showed a similar tendency with the organic vineyards. But the ratio of lesion area of conventional vineyards in last-August was 64.5% and it was less than the organic vineyards. Generally, fungicides were sprayed 5-7 times for control of leaf spot in conventional grapevine cultivation. But in case of organic cultivation, it has not neither a proper manuals for disease control not environmental organic agricultural materials to substitute agricultural fungicides. Especially, Jung et al. (2009) reported that leaf spot was increased on condition of 20℃ of daily minimum temperature, 25℃ of daily mean temperature and 80% relative humidity (Jung et al., 2009), and this disease was increased from last-July rapidly (Park, et al., 2004). Therefore, we considered that an attempt to control disease by environmental friendly organic materials was not effective because leaf spot spread rapidly with heavy rain in summer season.

3.2. *The optimum concentration and the effect of bicarbonates about control of grapevine leaf spot*

To find effective concentration of each for control of grapevine leaf spot, the three kinds of bicarbonate were diluted to 0.25, 0.5, 1.0 and 2.0%, respectively, and the occurrence of disease was investigated after spraying 3 times from early-July (Table 1). Ratio of lesion area was 42.1% in 0% of bicarbonate but it was decreased in bicarbonates treatment compared with control. Also the occurrence of disease tends to decrease with decreasing of bicarbonate concentration. The ratio of lesion area was 6.5-8.2% at 0.5% concentration of two bicarbonates treatment (sodium bicarbonate, ammonium bicarbonate) and these bicarbonates had a great effect on control of leaf spot. However, the control effect was not significant among all bicarbonates at the concentration above 0.5%. The effect of potassium bicarbonate was more efficacious than control but less than sodium bicarbonate and ammonium bicarbonate. Phytotoxicity was observed in treatment of 1 or 2% sodium bicarbonate and 2% potassium bicarbonate. The symptom of damage was occurred 3 days after spraying and leaf turned to brown following the spread around from first point (Fig. 2). For field application of the bicarbonates to control of leaf spot, it is recommended that the 0.5% bicarbonate is sprayed 3 times at 10 days intervals from early-July. Ratio of lesion area in control was increased to 56.2% after 7 days from the last spraying day. But ratio of lesion area of two bicarbonates (sodium bicarbonate and ammonium bicarbonate) were 6.2 or 8.2%, respectively, and these values were not only less than control, but also the effect of these bicarbonate was better than Lime Bordeaux mixture widely used in grape organic cultivation for disease control (Fig. 3). The average number of lesion was 42.2 ea per leaf in control and 15.2 ea and 12.8 ea per leaf in ammonium bicarbonate and sodium bicarbonate treatment, respectively, but lime Bordeaux mixture treatment showed the number of lesion of 31.8 ea per leaf. Effect of lime Bordeaux mixture treatment was better than control but it was not than bicarbonate (Fig. 4A). On the diameter of lesion, two liquids
(sodium bicarbonate, ammonium bicarbonate) were each 5.0 and 7.8mm, but the diameter of lesion was 18.6mm in control and it was decreased 58.1-73.1% compared with control. Therefore, the treatments with two liquids (sodium bicarbonate, ammonium bicarbonate) were recognized as more effective than the control (Fig. 4B). It is supposed that application of bicarbonate solution on grapevine could suppress not only early infection but also mycelial growth after penetration inside grape leaf because lesion diameter was distinctively decreased by bicarbonate treatment. It was reported that carbonates inhibited spore germination of Botrytis cinerea more effectively than bicarbonates, and that sodium and ammonium bicarbonates were more effective than potassium bicarbonate in fungal growth inhibition (Anon, 1999). Depending on these results and previous studies (Ilhan et al. 2006; Jamar et al. 2007), it was suggested that this compound could be introduced in controlling grapevine leaf spot in organic farming. These compounds are non-toxic material found in nature and human food frequently implying that this simple compound is appropriate for organic production systems. But it must be considered that bicarbonates are quickly converted into ineffective compounds and are highly water-soluble resulting in removal from the leaves by a small amount of precipitation. Therefore, frequent applications of bicarbonate will be required during the infection risk period (Jamar et al., 2008). Also, it is necessary that bicarbonates are included in organic materials list, because ammonium bicarbonate is not registered with allowed materials for environmental friendly organic material.

4. Conclusions

Grapevine leaf spot by Pseudocercospora vitis is the main disease in ‘Campbell early’, the most widely grown cultivar in Korea. It was occurred from last-June in Sangju region and then increased after last-July rapidly.

The results have shown that the control working has to start at mid-June after flowering season.

The control of leaf spot by foliage spray of bicarbonates was very effective at 0.5% concentration of sodium bicarbonate or ammonium bicarbonate. Applicability of these bicarbonates with environmental friendly organic material was very high because these bicarbonates were better than the effect of lime Bordeaux mixture. But application of sodium bicarbonate needed considerable care because phytotoxicity was occurred in concentration above 1%.

References

14. Lluis, P., Carlos, H., C., David, G., 2007. Combination of postharvest antifungal chemical treatments and controlled atmosphere storage to control gray mold and improve storability of 'Wonderful'
pomegranates. Postharvest Biology and Technology 43, 133–142.

**Tables and Figures**

![Fig. 1. Seasonal incidences of leaf spot by *Pseudocercospora vitis* on grapevine at Sangju region in Korea](image)

**Table 1. Effect of difference concentration of bicarbonates against grapevine leaf spot in 2012**

<table>
<thead>
<tr>
<th>Spray Concentration (%)</th>
<th>Ratio of lesion area(%)*</th>
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<tbody>
<tr>
<td></td>
<td>ammonium bicarbonate</td>
<td>sodium bicarbonate</td>
<td>potassium bicarbonate</td>
</tr>
<tr>
<td>0</td>
<td>42.1a**</td>
<td>42.1a</td>
<td>42.1a</td>
</tr>
<tr>
<td>0.25</td>
<td>16.3b</td>
<td>21.8b</td>
<td>26.3b</td>
</tr>
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<td>0.5</td>
<td>6.5c</td>
<td>8.2c</td>
<td>18.2c</td>
</tr>
<tr>
<td>1.0</td>
<td>7.3c</td>
<td>10.5c</td>
<td>15.3c</td>
</tr>
<tr>
<td>2.0</td>
<td>6.8c</td>
<td>8.6c</td>
<td>14.2c</td>
</tr>
</tbody>
</table>

* Ratio of lesion area (%) = infected leaf area/total leaf area × 100
**Duncan's multiple range test (P≤0.05)

![Fig. 2. Phytotoxicity symptom by spray of 1% sodium bicarbonate(A) or 2% potassium bicarbonate(B) in leaf of 'Campbell early' cultivar](image)
Fig. 3. Change of ratio of lesion area by bicarbonates spraying against *Pseudocercospora vitis* in 2013.

Fig. 4. Effect of bicarbonates spraying against *Pseudocercospora vitis*. These results were taken at 21 days after the first bicarbonate spraying.

Fig. 5. Effect of ammonium bicarbonate(A) or sodium bicarbonate(B) spraying against *Pseudocercospora vitis*. These pictures were taken at 21 days after the first bicarbonate spray.