Plant Biotechnology: Current and Potential Impact For Improving Pest Management In U.S. Agriculture An Analysis of 40 Case Studies
June 2002

Viral Resistant Potato

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Financial Support for this study was provided by the Rockefeller Foundation, Monsanto, The Biotechnology Industry Organization, The Council for Biotechnology Information, The Grocery Manufacturers of America and CropLife America.
16. RASPBERRY

Viral Resistant

Production
In the U.S., red raspberries are grown primarily in Oregon and Washington. In 2000, Washington’s harvest of 9,500 acres was worth $25.9 million. Ninety four percent of utilized production went to the processing market. In Oregon in 2000, 2,900 acres of red raspberries were harvested. Ninety one percent of the utilized production went to processing, and total production for the state was worth $7.7 million. [1]

The raspberry fruit is an aggregate (results from a flower with multiple pistils that form tiny drupelets that are held together in a single mass) of 75-125 drupelets attached to a central receptacle. The receptacle remains attached to the plant when ripe fruit are harvested. Each drupelet is an entire fruit. The drupelets are held together by a dense entanglement of epidermal hairs [10].

Raspberry fruit development begins with pollination. Transfer of pollen from the stamen to the pistil in a flower results in a viable seed and formation of a drupelet. The pollen is heavy and cannot be transferred by wind, and only very limited transfer takes place within the flower. Over 90% of raspberry pollination results from flying insects, the majority of which are honeybees [11].

Raspberries have perennial roots and biennial tops. It takes 2 years for raspberry plants to reach maturity and they live for 6-30 years [2]. The roots continue to grow for the life of the planting, but new aboveground canes (primocanes) develop each year. Every year the previous season’s canes (now called fruiting canes) produce a crop of fruit and then die [10]. A plant may remain productive for 10 years or more [3].

Production of red raspberries in Washington and Oregon totaled 86 million pounds in 2000. Figure 16.1 charts the total production of red raspberries in the two states from 1973 through 2000. As can be seen, red raspberry production increased significantly in these two states. The
increase in production has been the result of a move to more mechanical harvesting of raspberries that, in turn, has resulted in lower labor costs, a change in cultivars, and an increase in acreage [5]. Further increases in acreage in the early 1990’s were due to a significant increase in prices that coincided with the war in the former Yugoslavia – formerly the world’s largest producer of red raspberries.

Prior to 1980, Willamette was the most widely planted raspberry cultivar in the region. Since the early 1980’s, Meeker has become the cultivar of choice for most growers because it outyields Willamette, has an intermediate level of resistance to root rot, has good color and fruit firmness, is compatible with mechanical harvesting, and produces a higher quality berry for the valuable whole frozen berry market [5]. Willamette is darker, smaller and tarter, requiring more sugar and processing. The Meeker variety is now planted on 80% of the raspberry acres in the Northwest.

Raspberry fruit for processing is utilized in several different ways. Much of it is frozen in bulk containers for institutional use or to be reprocessed into jams, jellies, preserves, pie fillings, yogurt, etc. Some is combined with sugar and used to fill small retail packages. High quality whole fruit is either sold in the fresh market or used for IQF processing. IQF stands for “individually quick frozen.” In this process, the whole fruit is spread out in a thin layer on belts and carried through a bath of liquid nitrogen which freezes the fruit in a few seconds. It is then packaged without sugar. Overripe, poor quality fruit is often packed in large barrels or drums to be used for juice, jam or wine. A relatively small proportion of the fruit is processed by canning [10].

Both fresh and IQF whole berries may be sold by the grower for $0.75 – $1.25 per pound. Prices for juice grade fruit average $0.25 – $0.28 per pound [15].

Raspberry Bushy Dwarf Virus

In the 1980’s, Willamette was replaced by Meeker as the most commonly planted cultivar. While Meeker is higher yielding and has a better quality berry, it does not have the resistance to raspberry bushy dwarf virus (RBDV) that Willamette does. Consequently, RBDV has become
widespread in northwest berry production, particularly in Washington [5]. The virus is pollen
borne. Bees are used to pollinate raspberry, so it is thought that they may play a role in
spreading the virus. Susceptible raspberry plants become infected within two to three flowering
seasons if located near RBDV infected plants [9].

The name Raspberry Bushy Dwarf Virus is misleading, as plants are neither dwarfed nor bushy. It reduces productivity of infected canes, but more importantly, and of more economic impact, it reduces fruit quality [6, 7]. Berries become crumbly and are not usable for whole fresh or IQF markets. There are no control measures for RBDV other than to pull out the infected plants and replant with virus free plants. Consequently raspberry production is shifting from an approximately 20 year cycle of replantings to a five or six year cycle.

Once a plant in the field is infected, it remains infected and it is not possible to eliminate the virus. The fruit produced on an infected plant will always be crumbly. New plantings usually are infected within three to five years. Research estimates are that the virus causes up to 30% yield losses [4].

A 1996 survey of commercial raspberry fields measured the incidence of raspberry bushy dwarf virus [5]. In northern Washington, 84% of the meeker raspberry fields were infected, and 63% of the fields had greater than 50% of samples testing positive for the virus.

The cost to growers of RBDV occurrence includes the cost of removing infected plants and old trellises, replanting and retrellising, the lost production during the two year plant establishment period and the revenue reduction caused by crumbly fruit in the last few years before removing diseased plants. [4]

Table 16.1 displays gross income data for a healthy planting versus a planting with RBDV. As can be seen, the loss per year caused by RBDV is estimated at $1,386 per acre. Assuming that 80% of Oregon’s and Washington’s raspberry acres will be infected soon with RBDV, it implies an aggregate potential income loss of $13.7 million per year (0.8 x 12,400 x 1,386). Incremental replanting costs of $250 per acre are included in the $1,386 per acre estimate. Thus, the potential
annual income loss consists of $2.5 million in increased production costs and $11.2 million in reduced quantity and quality.

Table 16.1 also shows annual estimates of the differences in gross income between a healthy planting and a planting with RBDV. These differences consist of yield and price received differences in years 4 through 7 and 11 through 14. In year 8, the difference is the result of yield loss of 100% and the cost of replanting. In year 9, the difference is due entirely to yield. Assuming that one-half of the gross income difference is due to differences in yield, with the exception of year 9, for which all the difference is attributable to yield and year 8 where yield is reduced by 100%, the implication is a reduction in annual yield for the RBDV planting of 15%, or 10 million pounds of raspberries (86 x 0.8 x 0.15), representing 12% of the total raspberry production in Oregon and Washington.

One of the major costs of replanting is incurred by fumigating with a combination of chloropicrin and methyl bromide prior to replanting the cleared land. Fumigation is aimed at controlling nematodes and partial control of root rot. The typical application in replanting raspberries consists of 200 pounds of methyl bromide and 60 pounds of chloropicrin per acre. Because raspberry fields are being replanted at least one extra time because of RBDV (every 7 years instead of every 14 years), a total extra application of 2.0 million pounds of methyl bromide (12,400 x 0.8 x 200) and 0.6 million pounds of chloropicrin (12,400 x 0.8 x 60) is implied. On an annual basis, it is estimated that the increased application amounts to an additional 285,000 pounds of methyl bromide and 86,000 pounds of chloropicrin.

**Transgenic Raspberries**

Developing RBDV control strategies has been among the top research priorities of the Northwest Center for Small Fruits Research for several years [8]. A collaborative effort between USDA-ARS researchers and Exelixis, Inc. in Oregon has resulted in the successful transformation of raspberry plants with RBDV resistant properties [7]. Three different mechanisms were used for conferring virus resistance to raspberry plants. The genes for resistance, all derived from the genome of RBDV, have been introduced into raspberry plants and those plants have been successfully reared in the greenhouse. Researchers produced 25 plants of each of 300
transformed lines of Meeker. These plants have been grafted with canes from RBDV-infected plants to evaluate the transgenic plants for resistance to RBDV. Approximately one third of the grafted plants remained virus-free after being grafted twice [13]. The transgenic plants have been planted in a field and are being evaluated for field resistance and fruit quality.

**Estimated Impacts**

It is assumed that a transgenic viral resistant raspberry cultivar would be planted on 80% of Oregon’s and Washington’s acreage and would eliminate the cost of replanting an extra time ($2.5 million and 371,000 pounds of fumigants). It also would prevent the current annual loss of 10 million pounds of raspberries with a value of $11.2 million. These estimates were assigned to Oregon and Washington in proportion to acreage.
Figure 16.1

Red Raspberry Production: Oregon and Washington

Source: [1, 12]
### TABLE 16.1: Gross Income Difference in Raspberry Plantings: Healthy vs. RBDV Infected

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Income Per Year ($/A)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy Planting</td>
<td>Planting with RBDV</td>
</tr>
<tr>
<td>1. (planting)</td>
<td>-3,500</td>
<td>-3,500</td>
</tr>
<tr>
<td>2. (1st crop)</td>
<td>3,750</td>
<td>3,750</td>
</tr>
<tr>
<td>3.</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>4.</td>
<td>6,000</td>
<td>5,700</td>
</tr>
<tr>
<td>5.</td>
<td>6,000</td>
<td>5,100</td>
</tr>
<tr>
<td>6.</td>
<td>6,000</td>
<td>4,500</td>
</tr>
<tr>
<td>7.</td>
<td>6,000</td>
<td>3,000</td>
</tr>
<tr>
<td>8.</td>
<td>6,000</td>
<td>-3,500</td>
</tr>
<tr>
<td>9.</td>
<td>6,000</td>
<td>3,750</td>
</tr>
<tr>
<td>10.</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>11.</td>
<td>5,625</td>
<td>5,700</td>
</tr>
<tr>
<td>12.</td>
<td>5,250</td>
<td>5,100</td>
</tr>
<tr>
<td>13.</td>
<td>4,875</td>
<td>4,500</td>
</tr>
<tr>
<td>14.</td>
<td>4,500</td>
<td>3,000</td>
</tr>
<tr>
<td>Total</td>
<td>68,500</td>
<td>49,100</td>
</tr>
</tbody>
</table>

**Difference (over 14 years)**: -19,400

**Loss per year**: -1,386

Source: [14]

**Assumptions:**

a) Year 1 – no crop in the planting year (only grow canes).
b) Year 2 – yield is only 50-75% of full production (baby crop year) (62.5% used in illustration).
c) Year 3 – full production (8,000 pounds per acre for fields in NW Washington).
d) Healthy plantings remain productive for 15 years, with yield tapering off after year 10.
e) Plantings with RBDV replanted after year 7.
f) Price paid to grower = $0.75 per pound.
g) Cost of replanting = $3,500 per acre.
References


2. USDA, Crop Profile for Raspberries in Oregon, available on the web at: http://pestdata.ncsu.edu/cropprofiles

3. USDA, Crop Profile for Raspberries (Red) in Washington, available on the web at: http://pestdata.ncsu.edu/cropprofiles


6. Oregon State University, Online Guide to Plant Disease Control, available on the web at; http://plant-disease.orst.edu


