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The value of powdery mildew resistance in grapes: Evidence from California

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Abstract

Powdery mildew (PM) is a fungal disease that damages many crops, including grapes. In California, wine, raisin, and table grapes contributed over $3.9 billion to the value of farm production in 2011. Grape varieties with resistance to powdery mildew are currently being developed, using either conventional or transgenic approaches, each of which has associated advantages and disadvantages. PM-resistant varieties of grapes could yield large economic benefits to California grape growers—potentially allowing cost savings as high as $48 million per year in the subset of the industry covered by our analysis (Crimson Seedless table grapes, all raisin grapes, and Central Coast Chardonnay wine grapes), but benefits range widely across the different grape production systems.

Keywords: Powdery mildew; Resistant varieties; California grapes; Research benefits

1. Introduction

Powdery mildew (PM) is a fungal disease that damages a wide range of crops.[1] It is especially of concern to grape producers around the world. A range of fungicides can help vineyard managers keep the disease in check in most years, but these are costly and may have negative environmental and human health effects (Gubler et al., 2008; Lee et al., 2006). PM-resistant varieties are available for many affected crops, such as melons, squash, and peas (Davis et al., 2008). Work is now underway in the United States to develop PM-resistant grape varieties (e.g., the VitisGen project: http://www.vitisgen.org/). The potential value of these varieties is of interest.

In this paper, we estimate differences in costs of production between conventional and PM-resistant varieties. We do this for four types of raisin grape growing systems in the San Joaquin Valley, Crimson Seedless table grapes, also in the San Joaquin Valley, and Chardonnay wine grapes in the Central Coast region of California. The potential benefits were estimated using detailed partial budgets for hypothetical "representative" individual vineyards, given in Appendix A, which were created for this purpose based on University of California Cooperative Extension (UCCE) Cost Studies. We find that the potential benefits are large but depend critically on the lag until the resistant varieties become available as well as the subsequent rate of adoption by growers.

1.1. Literature review

The work in this paper relates to and draws on several strands of previous work. The broad context is the general literature on the economics of agricultural innovation, which was recently reviewed by Pardey et al. (2010). This literature has documented the very substantial contributions of agricultural innovation to economic growth and well-being, the high rates of payoff to public and private investments in agricultural

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[1]On most plants, powdery mildew appears as white, powdery spots on leaves, shoots, flowers, or fruit. These spots are the mycelium (fungal tissue) spores, which are the primary means of dispersal of the fungus. If untreated, the mycelium can spread over large areas of the leaves and stems and cause reduced yields and lower fruit quality (Davis et al., 2008). Grape powdery mildew, *Erisiphe necator*, can survive the winter in California in buds or as spore structures. When temperatures become warmer and moisture is adequate, the spore structures burst and fungi can spread to neighboring plants.

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R&D, and the long time lags involved. It provides a suitable frame of reference for interpreting the results from the present work as well as guidance concerning analytical and empirical methods. Previous studies have also documented a host of modeling, measurement and attribution problems and issues to be taken into account (e.g., Alston et al., 2010). The work here concerns a particular class of agricultural innovations: pest-resistant varietal technologies for perennial crops, innovations for which these general concerns are likely to be of particular relevance.

Much of the literature on agricultural R&D has pertained to crop varietal technologies, including the use of damage-abatement models as is pertinent for pest-management technologies (e.g., Lichtenburg and Zilberman, 1986). However, as can be seen in the review and meta-analysis that was undertaken by Alston et al. (2000), perennial crops and their special characteristics have been largely neglected in this literature, and very little of that work has dealt with the specific characteristics of pest- and disease-resistant varieties for perennial crops. The most closely related work is that by Alston et al. (2014), which also addresses costs and benefits of disease-mitigating varietal technology in the California wine grape industry, in this case pertaining to Pierce's Disease (see also Alston et al., 2013; Tumber et al., 2014). The work in the present paper draws in particular on insights from that prior work on modeling Pierce's Disease, and the literature on which that work draws and builds.

Several studies have modeled and measured pertinent aspects of the economics of powdery mildew and its management. Among these are Lybbert and Gubler (2008) and Lybbert et al. (2012), both of which examine how growers react to information about forecasted powdery mildew pressure. The authors found that the response of growers to forecasting information spans multiple dimensions, including fungicide choice and dose, as well as timing, which was the primary focus of the original forecasting model. In addition, growers respond to forecasting information primarily when the disease pressure is high, and grower response varies with location and crop value, with high-value grape growers being more likely to respond with more aggressive methods. Our work extends on those studies by examining the potential economic benefits if growers planted PM-resistant varieties and as a result did not have to manage powdery mildew at all.

2. Background: Grape production in California

Grapes produced in California fall into three main categories: wine grapes, table grapes, and raisin grapes. These three categories make up an industry that contributed over $3.9 billion, or 9%, of the $43.5 billion worth of agricultural production in California in 2011 (California Department of Food and Agriculture/National Agricultural Statistics Service, 2012a,b), or 91% of the $4.3 billion value of grape production in the United States (United State Department of Agriculture (USDA), 2013). The three categories of grapes have important similarities—they all use varieties of *Vitis vinifera*, and some varieties, such as Thompson Seedless, are used in all three production systems. However, the production systems differ significantly in ways that imply differences in the potential benefits from powdery mildew resistance.

2.1. Table grapes

The vast majority (90% of the bearing acreage in 2011) of California table grapes are grown in the southern San Joaquin Valley, defined as crush districts 12, 13, and 14 (CDFA/NASS, 2012a,b).[2] Many varieties are grown for table grape production—over 70 in California alone (California Table Grape Commission, 2013), but Red Globe, Crimson Seedless, and Flame Seedless dominate, making up a combined total of 54% of the total table grape acreage in 2011 (CDFA/NASS, 2012a,b).

Labor costs are large and important in table grape production—-over half of the total operating costs per acre—in particular because table grape vineyards are hand-picked three to four times during the harvest season. In the case of Crimson Seedless, which we profile in this paper, harvesting costs of $9,400 per acre (or 62% of annual operating costs) included $4,621 per acre in labor costs alone, and over $2,000 per acre in packing materials. Pruning vines and removing leaves to expose fruit to sunlight imposes labor costs of over $2,000 per acre each year (University of California Cooperative Extension (UCCE), 2007).

Over the 10 years 2002–2011, annual average real prices (in 2013 dollars) of table grapes ranged from $435 per ton in 2008 up to $832 per ton in 2011(USDA, 2003–2012).[3] Production of table grape varieties climbed slowly, from 739,000 t in 2002 to 1,031,000 t in 2011. Notably, these annual averages of production and prices of table grape varieties include between 20,000 and 55,000 t that are dried for raisins (USDA, 2003–2012). Fig. 1 shows annual average quantities and deflated prices of table grapes for 2002–2011.

2.2. Raisin grapes

Like table grapes, the vast majority (99% of the bearing acreage in 2011) of raisin grapes are grown in the San Joaquin Valley, where they are sun dried (CDFA/NASS, 2003–2012a, b). Raisin production was once very labor intensive; now much of the harvesting and pruning can be done mechanically (Boriss et al., 2013). Continuous tray dried production systems for raisins, in which grapes are mechanically harvested and dried on a continuous paper tray between rows, represent the greatest share of raisin production acreage—approximately 45% to 50% (Matthew Fidelibus, UCCE Extension Viticulture Specialist, personal communication). Labor costs for continuous tray dried raisins account for 38% of annual operating costs; and materials account for a similar share of costs (UCCE, 2006a).

[2] California has 17 grape crush districts, within which prices and production styles are considered to be similar. A map and descriptions can be found at: http://www.nass.usda.gov/Statistics_by_State/California/Publications/Grape_Crush/Final/index.asp.

[3] Nominal prices were deflated using the GDP deflator (2013; http://www.bea.gov/iTable/iTable.cfm?reqid=9&step=3&isuri=1&903=13#reqid=9&step=3&isuri=1&904=2002&903=13&906=a&905=2013&910=x&911=0).