BARRIERS TO WIDESPREAD CONVERSION FROM CHEMICAL PEST CONTROL TO NON-CHEMICAL METHODS IN U.S. AGRICULTURE

[1]Leonard Gianessi and [2]Nathan Reigner

CropLife Foundation, Crop Protection Research Institute, 1156 15th Street NW, Washington, DC 20005; Fax: (202)463-0474; [1]Phone: (202)872-3865; Email: lgianessi@croplifefoundation.org; [2]Phone: (202)872-3866; Email: nreigner@croplifefoundation.org

Abstract

Herbicides and fungicides are widely used to kill weeds and plant pathogens in agricultural crops. CropLife Foundation assessed the value of herbicides and fungicides to U.S. farmers by evaluating crop losses to weeds and diseases and quantifying the cost and effectiveness of chemical and alternative control methods. These studies clearly identify barriers to the adoption of non-chemical methods of pest control as potential replacements for synthetic chemical pesticides. Non-chemical weed control relies primarily on tillage and hand weeding, practices which are labor intensive and expensive. Lack of available labor and high wage rates prohibit use of these techniques for production agriculture. Further, expense involved in non-chemical weed control is a significant constraint to expansion of organic agriculture in the U.S. Genetic resistance to pathogens can be an effective non-chemical disease management tool, but it cannot replace fungicides. Incorporation of disease-resistant genes into desirable varieties is difficult, and genetic resistance commonly breaks down. Under such conditions, fungicides are the only responsive and reliable disease-control method. The comparative ineffectiveness of non-chemical pest-control methods, along with their expense and instability, makes synthetic chemical pesticides the only sustainable means of agricultural weed and disease control.

Key words: crop losses, economics, fungicide, herbicides, pest management

Introduction

Herbicides and fungicides are widely used to kill weeds and plant pathogens in agricultural crops. CropLife Foundation (CLF) has released two studies that quantify the potential impacts on crop production costs and crop yields, if growers did not use fungicides and herbicides and relied on the best available alternatives. Farmers choose to use fungicides and herbicides because they are more effective and lower in cost than alternatives to prevent crop losses. Replacement of fungicides and herbicides on a large commercial scale is unlikely for the foreseeable future due to their effectiveness and low cost.

Fungicide Use

Fungicides are used on more than 90% of most fruit and vegetable crops every year. CLF study identified 231 diseases of 50 crops controlled with use of fungicide spraying. Most crops are subject to five or more diseases controlled by fungicide spraying.

Fungicides have been used for a long time in the U.S., starting with sulfur, copper, and Bordeaux mixtures in the late 1800s. In the early 1900s, powdery mildew was considered capable of destroying the entire grape crop in California if sulfur sprays were not made. By the 1920s, spraying fungicides (lime sulfur) became a universal practice in U.S. apple orchards, and it was considered to be impossible to grow apples for market without fungicide sprays.

Fungicides provide a high level of control of pathogens with properly timed sprays reducing the population of pathogens by 90% or more. Recent fungicide tests show large reductions in disease development with associated increases in yield: watermelon yields up 61% as a result of gummy stem blight control; citrus scab incidence reduced from 44% to 4%; purple spot losses in asparagus reduced 99%; mummyberrry incidence in blueberries reduced 98-99%; black rot of grapes reduced from 95% to 1%.

The primary non-fungicidal plant disease-control method that has been researched for decades is host-plant resistance, which has proven to be a durable method of disease control for several major field crops—corn, sorghum, and sugarcane. These are crops for which appearance characteristics are less important than yield and disease-resistance characteristics. The success of host-plant resistance for these crops has depended on an ongoing commitment to plant breeding since pathogen populations can evolve and overcome the resistance. As a result, in order to sustain host-plant resistance, crop breeding needs to be continuous with new resistant varieties in development at all times.

For some crops, despite decades of breeding thousands of new varieties, disease suppression with host-plant resistance has proven completely unstable because the pathogen mutates so rapidly. For example, no potato variety has been produced combining resistance genes to all late-blight races with the many genetic traits needed to produce a commercial variety. Although the search for peanut cultivars resistant to white mold originated in 1917 is ongoing, a high degree of resistance has not been found.

In many cases, resistant cultivars have been released but are not widely planted because of poor horticultural characteristics. For example, more than 20 apple cultivars bred with resistance to apple scab have been released, but none are widely-planted since they produce fruit of small size, have a tendency to ripen unevenly, and have brownish interiors. Usually, there is a tradeoff between host-plant resistance and other desirable traits that are lost in the breeding process. The tradeoff in sugarbeets is lower yield with increased cercospora resistance.

Often "resistant" cultivars are not totally resistant to the pathogen. For example, resistant peanut cultivars provide 20-40% control of leaf spot, rust, and stem rot. By contrast, fungicides provide more than 90% control. The pepper cultivar Palladin possesses excellent horticultural characteristics and exhibits excellent resistance to the crown-rot phase of phytophthora; however, it does not possess resistance to the foliar phase of phytophthora blight which requires regular fungicide applications for control.

Some examples of the breakdown in host-plant resistance which have resulted in a need to spray fungicides to control pathogens illustrate how tenuous the non-fungicidal strategy can be:

- Wheat cultivars with leaf-rust-resistance genes have been available since the 1940s. Within a few years of release, virulent leaf rust strains appear that render the varietal resistance ineffective. Most recently, resistance broke down in previously resistant cultivars in the northwest. The loss in wheat yield would have been 20% without the use of fungicides.
- Prior to 1960, downy mildew was a significant disease on lettuce in California. It was brought under control with resistance from wild lettuce. New races of the fungus appeared in 1976 and overcame the resistance. In 1989, another set of resistant cultivars were introduced, but by 1992 control slipped again and fungicides have been used ever since to manage the disease.

The importance of fungicides to fruit and vegetable production is also supported by their use by organic growers who are permitted the use of copper, lime sulfur, and sulfur, Organic grape and strawberry growers in California typically apply 66 and 45 pounds of sulfur per acre, respectively, to control powdery mildew. Organic apple growers in the

Northeast typically spray 10 gallons of lime sulfur and 12 pounds of wettable sulfur per acre for disease control.

Without use of fungicides, yields of most fruit and vegetable crops would decline by 30-70%. There are no alternatives that would control the broad spectrum of diseases that develop in most crops. Alternative controls also are typically less effective than the use of chemical fungicides. Growers will continue to use the most effective controls. The CLF study on the value of fungicides determined that growers gain $15 for every dollar spent on fungicides and their application.

Herbicide Use

Widespread herbicide use is a relatively recent development in U.S. agriculture in comparison to fungicide use. Use of chemical sprays to kill weeds began in the 1950s, resulting in rapid adoption on most crop acres. Herbicides are used on 215 million crop acres in the U.S. Herbicides largely replaced the practice of hand-weeding crops and greatly reduced the use of cultivation of fields with tractors.

Farmers have come to demand high performance from herbicides. They expect that 95-99% of the population of all the key weed species in a field (usually five or six) be killed with one or two sprays and that season-long control is maintained with no crop injury.

The problem of controlling weeds without herbicides has been cited numerous times as the single biggest obstacle that organic growers encounter. Out of 30 research areas, organic farmers ranked weed control as the number one priority in three national surveys. Organic growers rely extensively on cultivation and hand weeding to control weed populations. Hand weeding in organic crops ranges from two to 165 hours per acre, along with two to nine tillage operations. Poor weed control is often cited as a major reason for lower yields in organic production. Labor for hand weeding is expensive and scarce. Growers budget $10/hour for hand weeding which includes wages, supervision, transportation, and facilities. Because of the expense of labor and the large need for hand weeding, organic growers can spend up to $1,000/A in labor for weeding in comparison to growers who use herbicides for $50/A.

Studies have shown that crop yields need not decline without herbicides, if enough labor is used to pull weeds: corn (60 hours/A), cotton (67 hours/A), spinach (209 hours/A).

One writer concluded that to hand weed the nation's corn acres without yield loss would require a labor force of 18 million people. The CLF study estimated that 70 million workers would be required to hand weed crops in the U.S. with no loss in yield. Most simulation studies that estimate the value of herbicides forecast an increase in hand weeding that is inadequate to prevent yield loss. The American Farm Bureau estimated California lettuce yields would decline by 13% without herbicides, despite the substitution of two cultivations and 38 hours of labor. Similarly Texas onion yields were estimated to decline by 25%, despite an additional cultivation and 32 hours of labor.

In recent years, several national studies have concluded that the nonuse of herbicides would lead to significantly lower crop yields due to the substitution of less-efficacious control alternatives (hand weeding and cultivation). USDA reports on strawberries, carrots, cotton, and processed tomatoes concluded that national production would decline by 30%, 48%, 27%, and 20% respectively without use of herbicides. The Weed Science Society of America (WSSA) published estimates by state for 46 crops that estimated yield changes likely to occur without herbicide use and the substitution of alternative best management practices.

The CLF study on herbicides organized the predicted yield loss estimates from recent USDA, WSSA, and Farm Bureau studies into a comprehensive aggregate study estimating likely impacts on crop yields and production costs if herbicides were not used. The CLF study predicts a decline in overall U.S. crop production of 20% without herbicides, despite the utilization of an additional 1.1 billion hours of hand weeding (7 million workers) and an increase of 838 million acre-trips with cultivators. The need for fuel would be 337 million gallons higher, since twice as many cultivation trips would be needed to replace herbicide sprays. Cultivators use four times more fuel per trip than herbicide sprayers do.

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