



# MANAGING CROP PESTS WITH CULTIVAR MIXTURES

## OVERVIEW

Plant and animal communities benefit from having higher levels of genetic diversity, and recent research has clearly demonstrated that the productivity of plant communities, as well as their resistance to stress, can increase as plant genotypic diversity increases. This evidence is particularly tantalizing for improving crop production because of the perennial desire to increase crop yield without increasing input costs while reducing susceptibility to pests, including insects, diseases, and weeds. Our ongoing research indicates there is an opportunity to achieve these goals of fewer pests and greater yield by planting fields with **cultivar mixtures**, which are blends of different genetic varieties of a crop species.

## DEFINITIONS

- **Genetic diversity:** A measure of all the genetic variation within a species.
- **Genotype:** The genetic constitution of an individual organism (in this document, variety, cultivar, and genotypes are synonyms).
- **Genotypic diversity:** Genetic variation among varieties of a species.
- **Cultivar mixture:** Mixtures of two or more crop varieties that differ in key traits, such as disease or insect resistance, but are sufficiently similar to be grown together.

## BENEFITS OF GENETIC DIVERSITY FOR AGRICULTURE

Monocultures of single crop varieties were developed to maximize growth potential of “superior” crop genotypes, and the associated genetic uniformity (e.g., similar plant height or maturity) facilitates managing, harvesting, and processing of the crop. Genetic uniformity, however, also creates disadvantages because all the plants have equal vulnerability to pests and access available resources identically. A simple solution is to increase the number of cultivars in fields to increase genotypic diversity. The resulting “cultivar mixtures” hold promise to increase yield while suppressing pests populations. Different crop varieties may express varying resistance to pest species, and a mosaic of resistant and susceptible varieties can slow spread of



*Fig. 1. Lady beetles, like this multicolored Asian lady beetle, are important aphid predators and can be more attracted to and more abundant in genotypically diverse crop plantings (Photo by Ian Grettenberger, Dept. of Entomology, Penn State).*

some pests. Wheat and barley fields in Europe and thousands of acres of rice in China, for example, have been sown as cultivar mixtures to combat serious plant pathogens. In the U.S., cultivar mixtures have been adopted on a more limited scale for soft winter wheat production in Washington, Oregon, and Kansas. In the eastern U.S., we have learned of some individual farmers who have incorporated cultivar mixtures of small grains, soybean, or even corn into their systems, but most growers do not appear aware of the benefits of the approach.

Relative to monocultures, genetically diverse fields tend to have small but meaningful increases in yield, resulting from interactions among varieties. Even in the absence of pests, this yield advantage has been determined to be 2% across all crop species, and estimated as 5% for wheat and 11% for soybeans, but specific benefits depends on the varieties and growing conditions. This effect results in part from cultivar complementarity, where the mixture as a whole is better able to exploit in-field resources, or from compensation, where varieties in the mixture do well under some environmental conditions, while others do not perform as well. A cultivar mixture also decreases annual yield fluctuations because the performance each year of different cultivars in the mix can balance each other out and create year-to-year yield stability; some growers think the stabilizing benefits of cultivar mixtures are their most appealing feature.



*Fig. 2. Two varieties of soybeans planted in alternating strips in a field in Tioga County, PA. The color pattern reflects differential senescence of the two varieties, which had different maturities. Fields containing higher levels of genotypic diversity can be more productive than fields planted with a single variety and can have fewer pest outbreaks. (Photo by J. Craig Williams, Penn State Extension).*

Some yield benefits of cultivar mixtures can also emerge from their capacity to control pests. This control typically emerges most strongly when mixtures include specific varieties containing resistance to key plant pathogens or insect pests. When pest pressure is high, these specific mixtures can yield nearly 30% better than monocultures, though support for this effect is stronger for pathogens than for insect pests. For insect pests, cultivar mixtures can suppress pests directly (e.g., altering pest resistance of plants, pest movement, or pest reproductive rate) and/or indirectly by harboring greater populations of predators, like lady beetles (Fig. 1) or spiders, which can in turn suppress the pests. In addition, transgenic, insect-resistant corn (also known as “*Bt* corn,” from *Bacillus thuringiensis*, the soil bacterium from which the insect-killing toxin was isolated) is now commonly deployed as a cultivar mixture of *Bt* and non-*Bt* seeds; these products are commonly referred to as “refuge in-the-bag,” and their purpose is to help delay evolution of resistance to this transgenic technology.

There is also some evidence that cultivar mixtures can help crops withstand drought stress. This effect occurs when varieties in the mixture differ in their ability to tolerate drought, and those that perform better in dry conditions compensate for those that suffer more from drought. Because of this possibility, some researchers have speculated that cultivar mixtures will help growers adapt to the changing climate.

## HOW TO IMPLEMENT CULTIVAR MIXTURES

Most seed companies in the eastern U.S. do not tend to sell cultivar mixtures (refuge-in-the-bag corn is an obvious exception, but there are others). In fact, some seed laws appear to discourage mixtures because companies need to assure their customers that they are purchasing 100% pure seed of a particular variety

and because patented seeds cannot be diluted with other varieties. At times, there have been seed companies or foundations selling seed blends, but they can be hard to find. Because of the lack of commercial cultivar mixtures in the eastern U.S., farmers that grow them tend to create their own, either buying seed of two to five varieties and mixing it in the drill or planter, or even alternating seed boxes with different varieties (Fig. 2). It seems that random mixtures of varieties are most common, but alternating rows or strips can also be used (Fig. 2). We have also encountered growers that plant only some of their fields as cultivar mixtures and plant the rest as monocultures. At harvest, they will save portions of each of the monoculture seeds in their grain bins, generating a mixture that they plant the next time. Anecdotally, these growers tend to believe they achieve better yields in their mixtures. We encourage growers to experiment with cultivar mixtures and incorporate genotypic diversity where possible, particularly when specific resistance is available. By mixing varieties with specific resistant traits with susceptible varieties, perhaps that are more desirable for their agronomic characteristics, the resistance traits will achieve the same purpose (helping the plants resist the pest), but the effectiveness of the trait will last longer than in the mixture.

## LIMITATIONS OF CULTIVAR MIXTURES

Managing cultivar mixtures of small grains or soybeans is very similar to managing fields planted with monocultures, but there are a few exceptions. For instance, in some years, particularly with wet springs, some wheat growers need to control *Fusarium* head blight, also known as head scab, with a fungicide application. Because timing for fungicide applications against head scab is often based on the percentage of the crop flowering, mixtures of varieties with different flowering times would seem to



*Fig. 3. Scouting with a sweep net for insect pests in a large-scale experiment planting in a commercial field in Berks County. This field was planted with monocultures of wheat or a cultivar mixture; notice the different shades of green, indicating the different plots (Photo by Andrew Aschwenden, Dept. of Entomology, Penn State).*

leave cultivar mixtures of wheat somewhat more vulnerable to head scab than monocultures that all flower at once. This and similar risks in other crop species can be mitigated by mixing together varieties with similar maturities and by incorporating varieties with resistance to key diseases into the mixture.

Our on-going research (Fig. 3) is continuing to explore the value of cultivar mixtures for Pennsylvania farmers, but at this point we can say that there appear to be some production benefits that can be derived from growing cultivar mixtures. These benefits can include lower insect or disease populations, higher natural enemy populations, higher yield, and greater year-to-year yield stability. Importantly, in our experiments thus far we have yet to measure a yield decrease from growing a mixture of soybeans or wheat—our yields have at least been equal to, if not greater than, monocultures of the constituent varieties. We encourage growers to experiment with increasing the genotypic diversity of their farms and feel free to share your experience with your fellow farmers and us.

**Authored by:**

**John Tooker, Assistant Professor & Ian Grettenberger, PhD**  
Department of Entomology The Pennsylvania State University

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