APPENDIX A
PLANT RESISTANCE TO INSECTS AND DISEASES

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Selecting a plant variety that has resistance or tolerance to insects or diseases makes it possible to avoid or lessen the use of pesticides or other management tactics. Seed catalogues and cooperative extension publications should be examined carefully to find varieties of plants that have resistance, or at least some level of tolerance, to the important pests in your area. Your own experiences in the field should also help you decide what varieties to grow in the future, and what ones to avoid because of their susceptibility to insect and disease pests. Plant resistance should be considered a cornerstone for pest management for organic growers.

It may not be feasible to find varieties of plants resistant to all insects and diseases in a specific area, so it is important to identify the pests that are the most damaging in your area and find suitable varieties resistant to them.

Successful breeding for insect and disease resistance has occurred in many different crop types, including vegetables, fruits, field crops and ornamentals. Because field crops are considered low value crops compared with fruits and vegetables, control costs must be minimized and it is in these crops that host plant resistance breeding has had the most attention and success. Even as far back as the late 1700's wheat varieties resistant to the Hessian fly were used in commercial plantings and host plant resistance remains a major tactic for insect control in field crops. Disease resistance has also become the standard method of controlling fungal and viral pathogens in corn, wheat and other field crops, as well as many of the important vegetable crops.

There are many similarities in breeding for disease and insect resistance, including the ability of pests to overcome the resistance. Plants and pests interact on a physical, chemical and molecular level and changes in the genetics of either the plant or the pest may affect their interaction. In the case of resistance this results in a constant battle in which the pest evolves to overcome whatever resistance the plant may have. Depending on the

complexity of the interaction between the pest and the plant, plant resistance may break down rapidly or be long-lived.

Plant resistance to pests is based on the plant genetics and the consequential molecular interactions that occur between host and pest organism (Gebhardt and Valkonen, 2001; Pedley and Martin, 2003). There are three general types of mechanisms for resistance based on how the pest and plant interact.

Antibiosis is defined as the adverse effect that a plant may have on the pest because of chemicals or structures the plant possesses. Plants contain a wealth of chemicals some of which may be toxic to a pest or cause it to grow more slowly. The chemical commonly referred to as DIMBOA is antibiotic to the European corn borer and occurs in corn, rye and wheat varieties. There are dozens of plant chemicals that have some antibiotic effect on insects, including botanical pesticides such as rotenone and pyrethrum. Some of the chemicals, such as jasmonic acid, may be produced by plants when first attacked by insects or pathogens. However, their levels are sometimes too low to provide adequate protection. Likewise, plants may possess structures such as hairs or trichomes that may impede insects or secrete chemicals that ensnarl them and thus have an antibiotic effect.

Antixenosis resistance involves behavioral factors that cause an insect not to choose the plant for feeding or laying its eggs. This lack of selection could be the result of chemicals or colors or even the presence of structures on the plant. An example of antixenosis is the chemical coumarin, which is produced by sweet clover and deters feeding by the vegetable weevil and several other insect pests.

Tolerance is a characteristic of some plants that enable them to withstand or recover from insect or disease damage. An example of breeding for tolerance is the development of corn plants with vigorous root systems that can compensate when they are attacked by corn rootworms. Another example is breeding sweet corn with husks that inhibit the ability of insects to damage the ear. Tolerance to disease is commonly found against plant viruses, where a plant can be infected with a virus, but show few symptoms and the infection has little if any effect on yield.

Resistance to pests can be inherited in two ways:
Vertical resistance is more commonly a form of disease resistance and is generally controlled by a single gene, referred to as an R-gene. These R-genes can be remarkably effective in controlling disease and can confer complete resistance. However, each R-gene confers resistance to only one race of the pathogen. Thus, depending on the race of the pathogen present in your area a variety may appear strongly resistant or completely susceptible. Many varieties contain multiple R-genes against the same pathogen; for example, many bell pepper varieties have resistance known as X3R that confers resistance to three races of *Xanthomonas* (the pathogen that causes bacterial leaf spot).

Horizontal resistance is also known as multi-gene resistance because this type of resistance is controlled by many genes. Because of the large number of genes involved, it is much more difficult to breed varieties with horizontal resistance. Unlike vertical resistance, horizontal resistance generally does not completely prevent a plant from becoming damaged. For pathogens, this type of resistance may slow the infection process so much that the pathogen does not grow well or spread to other plants. Additionally, horizontal resistance is generally effective against all races of a pathogen.

In 1965, it was noted that 65 of 300 crop cultivars registered in the US contained some disease resistance, while only 6% contained significant levels of insect resistance. (Smith 1989) This difference can be attributed to the general tendency for multiple plant genes to be involved in insect resistance and the increased difficulty breeding such polygenic resistance requires.

Plant breeders, and the plant pathologists and entomologists with whom they collaborate, constantly look for new sources that can be utilized to develop resistant plants. Sources of plant material that can be tapped for resistant germplasm include the USDA, international research centers, foreign seeds banks, private individuals and seeds companies.

Genetic engineering is used to produce some pest-resistant crop varieties. Genetically engineered crops are not permitted under USDA organic standards and it is important that growers verify that seeds they purchase have not been developed using GE techniques.

REFERENCES

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