Understanding Intermediate and High Disease Resistance in Vegetables

- Many vegetable seed companies use the designations High Resistance (HR) and Intermediate Resistance (IR) to distinguish different levels of resistance to diseases and pests.
- These designations are based on how effective the resistance traits are in helping manage diseases and pests under typical conditions of disease or insect pressure.

A plant disease results from the interaction of a virulent pathogen, a susceptible host plant, and an environment favorable for disease development, a concept known as the plant disease triangle. Changes in the host, pathogen, or environment can increase or decrease the likelihood of disease development or affect the severity of the disease.[1,2] The use of plant hosts with genetic resistance to a disease is one way to affect the disease triangle, and using resistant varieties is considered one of the most sustainable methods for helping to manage plant diseases.[3]

The International Seed Federation (ISF) defines resistance as "the ability of a plant variety to restrict the growth and development of a specified pest or the damage that they cause when compared to susceptible plant varieties under similar environmental conditions and pathogen pressure. Resistant varieties may exhibit some disease symptoms or damage under heavy pest pressure."[1] ISF recognizes two levels of resistance; High Resistance (HR) and Intermediate Resistance (IR). **High Resistance** is described by the ISF as "the ability of a plant variety to restrict the growth and/or development of the specified pest, and/or the symptoms and/or damage it causes, to a high degree. HR varieties may still exhibit minor symptoms or damage under heavy pest pressure and should not be confused with immune plants that are defined as unable to support any pest growth and development." The ISF describes **Intermediate Resistance** as "the ability of a plant variety to restrict the growth and/or development of the specified pest, and/or the symptoms and/or damage it causes, to a moderate degree. IR varieties may exhibit a greater range of symptoms or damage compared to HR varieties under similar environmental conditions and pest pressure. However, IR plant varieties will still show less severe symptoms or damage than susceptible plant varieties when grown under similar environmental conditions and/or pest pressure."

For consistency across the industry, many vegetable seed companies use the HR and IR designations to indicate levels of resistance in their varieties. The designations of HR and IR are usually based on pathogenicity tests using well-characterized pathogen strains under controlled conditions. Greenhouse pathogenicity tests are often used to speed up the process of screening large numbers of test plants. However, the accuracy of the test for identifying resistant varieties is evaluated by correlation with the varietie's field performance. Resistance claims can be based on inoculated trials or field tests conducted under natural, uncontrolled, but carefully monitored conditions. These tests usually include varieties with various levels and types of characterized resistance or susceptibility for comparison. Because different crop varieties within the same resistance class can show different ranges of symptoms under similar conditions (especially in the IR class), the seed industry often uses defined "example varieties" in their resistance evaluations for comparison and consistency.[1]

Resistance Outcomes vs. Mechanisms

Designations of HR and IR are based on the performance of a crop variety with a resistance trait, and evaluation of the outcome – asking the question "how well does it work in preventing or reducing disease symptoms?" When developing variety information, seed companies keep customer expectations in mind for claims of disease resistance. While a resistance trait may technically fit the definition of HR, a company may choose to use the IR designation because pathogen variations or certain environmental conditions may result in higher-than-expected disease levels in some situations. A designation of IR also may be used if a company feels that a pathogen may adapt and reduce the efficacy of the resistance over time.

Plant breeders and pathologists also characterize disease/pest resistance based on the genetics and physiological mechanisms that convey a resistance trait. Understanding the genetic basis of resistance helps breeders in their efforts to create new resistant varieties. Understanding the underlying mechanisms of resistance helps plant pathologists predict how long those resistance traits will remain effective and how to employ them to help manage diseases most effectively.[2]

Plant pathologists and breeders characterize disease resistance into the categories of specific resistance and broad resistance. Specific forms of resistance are usually effective against certain strains or races of a pathogen. Specific resistance often provides high levels of resistance against certain strains of the pathogen but may provide no resistance against other strains. New races may develop that are not affected by that form of resistance.[1] Specific resistance is often (but not always) monogenic, conveyed by a single gene. Some forms of specific resistance may break down under certain conditions, such as high temperatures.[2,3,4] Some forms of specific resistance result in no or minimal symptom development, and these reactions may be suitable for an HR designation. However, there are instances where specific resistance is classified as IR. For example, specific, single gene resistance is available for several species of root-knot nematodes (RKN) in pepper and tomato. This resistance is very effective against certain biotypes of the nematodes, but the populations of RKN in a field can be a mix of biotypes that may include strains not controlled by that resistance gene. Therefore, that form of resistance may only provide an intermediate level of resistance under field conditions.[5]

By contrast, broad resistance, also known as partial resistance, is effective against all strains or races of a pathogen. However, broad resistance is usually not complete resistance, meaning that the disease can develop on resistant varieties but causes less severe symptoms or the disease develops more slowly. Broad resistance is usually conveyed by the presence of several resistance genes (polygenic resistance). Broad resistance may not provide acceptable levels of disease control under conditions of high disease pressure, and broad resistance can also be sensitive to environmental conditions.[2,3] The expression of symptoms seen on plants with broad resistance can warrant an IR designation.

Because specific resistance is often controlled by a single gene, it is easier to transfer the trait from one plant variety to another. However, this form of resistance is also more susceptible to pathogens adapting and overcoming the resistance, and the resistance may become less effective over time. Broad resistance can be more difficult to transfer because several genes are involved, but the polygenic nature of the resistance tends to make it more durable, and resistant varieties can remain effective for many years.[3]

Seed companies decide on designations of HR, IR, or no claims of resistance based on their understanding of field performance, estimated durability, and grower expectations of performance over a range of conditions. Sometimes, one company may decide on a designation of HR while another may decide on a designation of IR for the same form of resistance, especially if that resistance is new and now well characterized. Seed companies do cooperate with each other through organizations such as ISF, Euroseeds, and the Collaboration for Plant Pathogen Strain Identification (CPPSI) to help standardize resistance claims among companies to better serve the needs of growers. There may also be differences in resistance claims for regulatory vs. grower expectation purposes.

Resistance Coding

The International Seed Federation (ISF) Expert Group on Disease Resistance Terminology "establishes a set of rigorous policy guidelines aimed at standardizing the inclusion, naming, and codification of pests relevant to the international vegetable seed sector."[6] These guidelines set the principles for how pests are listed, which pest names are used, and how pest name changes are managed when establishing the codes for resistance in crop varieties. The use of ISF resistance codes within the seed industry helps provide clarity for growers when looking at variety descriptions from different seed companies.[6,7]

Codes for resistance to plant viruses are in upper-case letters, except in cases where lower-case letters are used to distinguish viruses with similar names, for example, tobacco mosaic virus (TMV) and tomato mosaic virus (ToMV).

Codes for fungi, bacteria, nematodes, and insects usually consist of two letters corresponding to the first letters of the genus and species names of the organism, with the first letter of the genus in upper-case. For example, the code for the fungal pathogen *Fusarium oxysporum* is Fo. In cases where two organisms with the same letter combinations occur on the same plant host, additional relevant letters will be used. For example, *Corynespora cassiicola* and *Cladosporium cucumerinum* are two different pests of cucumber, and the assigned codes are Cca and Ccu, respectively.[6] Additional letters are also used to designate different subspecies, pathotypes, and formae speciales within a pest species, such as Fol for *Fusarium oxysporum* f. sp. *lycopersici*.

In some cases, there may be differences in how pathogen strains are designated in different regions. For example, Europe and the US use different designations for strains of *Verticillium albo-atrum* and *Verticillium dahliae*, and the corresponding resistance codes are Va:0/Vd:0 (EU) = Va:1/Vd:1 (US).[7]

Sources

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Websites verified 10/21/2025

For additional agronomic information, please contact your local seed representative.

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