Study of Flax Rust Combat Suggests New Strategy for Plant-Disease Control

Combat between flax plants and the rust fungi that attack them, staged experimentally by USDA plant breeder H. H. Flor, working at the North Dakota Experiment Station, may provide researchers with a new approach to developing disease-resistant crops, the U.S. Department of Agriculture reports.

Dr. Flor's experiments reveal that the tiny entities known as genes within the cells of both the plant and its rust parasite (also a plant) are pitted against each other. So it's gene against gene when rust attacks flax—the genetic virulence of a rust race opposing the genetic resistance of a flax variety. Depending upon the gene interaction, a characteristic growth, or "pustule" is produced on the flax tissue, which indicates the intensity of the forces in opposition.

Both the plant and the fungus have genes in their germ plasm that determine their characters and transmit these characters from one generation to the next. Dr. Flor has found that for every rust gene affecting the parasite's attacking power, there's a flax gene that determines how the host plant will meet the threat. The outcome may depend on which of several contrasting genes occur in the rust and in the flax.

A gene for susceptibility in flax might, for example, give the plant large breathing pores (stomata) in its leaves. A corresponding gene for virulence of rust might give the fungus some characteristic that would enable it to take special advantage of the plant's large stomata in gaining a hold as a parasite.

The tactics of the rust-resistance genes in a flax plant may show breeders how to improve other plants to give them better resistance against diseases, particularly the fungi that affect every major crop.

On defense, the flax-plant cell employs five specific rust-resistance genes within four of its fifteen pairs of chromosomes (bundles of inheritance-determining genes). They include genes for susceptibility and for various degrees of resistance ranging from tolerance to immunity.

On attack, more than 25 rust genes condition the rust invasion. They're virulent or non-virulent and specialized in various ways as to mode of attack. Each opposes a specific defensive gene in the flax. Thus five of the rust genes go into action against their counterparts, the five flax defensive genes.

The rust advances simultaneously on all five of the plant's strongholds. If it meets a roadblock in any one sector, its campaign will fail. If a single rust gene for nonvirulence finds a flax gene for immunity as its counterpart, the result is no infection. If the flax gene calls for moderate resistance, the result would be moderate infection.

Rust genes for virulence will overcome flax genes of any type. Theoretically, a rust strain with all of its genes of the virulent type could parasitize any and all strains of flax. However, in nature, all known rust races contain some nonvirulent genes.

Plant breeder Flor has developed varieties of flax with known defensive characteristics that reveal the precise point of weakness in an attacking rust strain. So long as rust lacks just one factor for virulence, even if all other genes are virulent, a flax variety can be bred to resist it by incorporating a corresponding defense gene for immunity.

This theory of the complementary action of genes in the plant-pathogen conflict—each gene for virulence in the pathogen contesting directly with a corresponding defensive gene in the host—appears to strike at the root of the disease-control program. It may well aid in developing disease-resistant strains of various crops.