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Breeding For Biotic Stresses in Wheat

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Introduction

Wheat is one of the most important cereal staple food crops grown in the world, both in terms of food production and for providing the total amount of food calories and protein in the human diet. Wheat has adapted itself to diverse climatic conditions and, as such, is grown over a range of altitudes and latitudes under irrigated, severe drought and wet conditions. India is the second highest producer of the Wheat in the world after China. Major wheat-producing states in India are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and Rajasthan. Wheat faces serious biotic stresses during different developmental stage of plant. Biotic stress in plants is caused by several living organisms namely fungi, virus, insects, nematodes, and weeds. Among biotic stresses, pathogenic fungi represent a significant challenge to wheat production globally. The major diseases in wheat involves stripe rust, stem rust, leaf rust, powdery mildew, head blight etc.Wheat seed gall nematode (*Anguina tritici*), the first plant parasitic nematodeturn wheat grains into galls, resulting in loss of grain yield. Among three rusts, leaf rust (*Puccinia triticina)* can cause grain yield losses higher than 50% under severe epidemics while stem rust (*Puccinia graminis f. sp. tritici*) and stripe rust (*Puccinia striiformis f. sp. tritici*) can cause up to 100% yield losses depending on the developmental stage of the plant. New pathogenic races are usually developed by mutation and selection for virulence against rust resistance genes in wheat. In recent years, new races of wheat leaf rusts, wheat stripe rust and wheat stem rust have been introduced into wheat growing areas in different continents. These introductions have complicated the efforts of breeders to develop wheat cultivars with durable resistance and have significantly reduced the number of the effective rust resistance genes available at present. This high degree of specificity has made for example durable rust resistance in wheat difficult to achieve because the virulence of wheat rust fungi against wheat resistance genes is highly diverse, resulting in the existence of many different pathogenic races.Till now 80, 95, 67 and 70 R genes have been identified for leaf rust, stripe rust, stem rust and powdery mildew respectively. Identified R genes has been utilized in resistance breeding for developing cultivars with high yield as well as resistance to different biotic stresses.

Currently much of the wheat genetic variability is obtained through conventional crop improvement methods involving land races and normal varieties. Hence, the germplasm base available in the form of cultivars is becoming increasingly narrow and the need for widening the gene pool is essential in view of the emerging biotic and abiotic stresses due to global warming and climate change. New and useful genetic variations exist in the wild uncultivated wheat progenitor species that can be utilized for the enhancement of the existing wheat breeding pools and improve yield stability. Wild species are the storehouse of many useful R genes and their introgression into cultivated germplasm, will provide novel source for resistance breeding. Durable resistance can be achieved by combining vertical resistance genes (monogenic/oligogenic) with horizontal resistance genes (quantitative).

The most efficient, cost-effective and environment-friendly approach to prevent the losses caused by rust epidemics is the development of genetic resistance to biotic stress. The use of cultivars with single-gene resistance permits the selection of mutations at a single locus to render the resistance effective in a relatively short time. However, due to loss of variation and selection pressure, and evolution, new virulent races of the fungus appear, which increase the need to develop durable resistance. Hence, the use of combinations of resistance genes has been suggested as the best method for genetic control of leaf and other rusts. This can be achieved by pyramiding effective resistance genes, but expression of individual resistance genes is difficult to monitor in the field. Pyramiding of R genes for multiple biotic stresses will reduces the loss in yield.

With the advent of molecular marker technology now it seems to be possible to solve such complex problems. DNA based molecular markers have several advantages over the traditional phenotype trait selection. Molecular markers can be used to tag rust resistance genes and further, they can serve for improvement of the efficiency of selection in plant breeding by so called, marker-assisted selection (MAS).The selection of genotypes with combinations of non-race specific resistance genes defining durable resistance over year as well as race specific genes at seedling stage is a task of prime importance for molecular marker assisted selection.