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Multiline and Mixed Cultivars: Potential Tool in Control of Plant Diseases

Samrat Saha and Riju Nath
Ph.D Research Scholar, Department of Agricultural Entomology, Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal

SUMMARY

Now-a-days the multiline and mixed cultivars are gaining popularity among researchers. Cultivar mixtures are mixtures of different cultivars having variation in many characteristics including the disease resistance, whereas multiline cultivars are mixture of a number of pureline cultivars that possess identical characters except the disease resistance gene. These cultivars suppresses plant diseases through mechanisms like density effect, barrier effect, inducing resistance due to attack of an avirulant strain and by modifying the microclimate. A number of multiline cultivars and cultivar mixtures has been developed showing more advantages over the pureline cultivars.

INTRODUCTION

Modern agriculture aims to achieve higher yield to feed the overgrowing population of the world. This high yield has been achieved through hybridization techniques or by selecting superior varieties. Monoculture is adopted for these superior types where each and every plant is genetically identical. It may enhance the yield but these genetic uniformity increase the susceptibility of the plant to different disease causing microorganisms. So if this genetic uniformity increases the vulnerability of plants to diseases, then one cost effective and potential method for disease control is to increase the genetic diversity of the crop by using cultivar mixtures (Castro, 2001).

On the other hand, when pureline varieties do not show stability in their performance year after year because of changes in environmental conditions. Furthermore in pureline cultivars they contain only one or a few major genes that provide resistance to a specific disease. So, when pureline cultivars containing a single gene for disease resistance are widely cultivated, then after a certain time new races of the pathogen will evolve and suppress the resistance mechanism in the pureline cultivars (YOKOO, 1974). For this plant breeders were forced to look for a number of different resistant genes that will effectively control the virulent races of the pathogen. To overcome these limitations, plant breeders began to give more attention to the multiline cultivars.

Cultivar mixtures

According to Wolfe (1985) cultivar mixtures are mixtures of different cultivars that have variation in many characteristics including the disease resistance, but they also have sufficient similarities so that they can be grown together. Cultivar mixtures generally enhance the stability of crop yield and in some cases they reduce use of pesticides. Except this they do not influence major changes in the agricultural system. These mixed cultivars are also cheap and to formulate and modify compared to multiline cultivars (Browning and Frey 1981).

In a mixture of cultivars, all the cultivars must contain good agronomic characteristics and they may have phenotypic similarity for certain important traits like quality and grain type, height, maturity that depends on agronomic practices and intended use. An example of phenotypically similar cultivar mixtures is barley to control of powdery mildew, whereas in Africa red- and white-grained sorghum cultivar mixtures are used which is an example of phenotypically different cultivar mixtures (Castro, 2001).

Multiline cultivars

Multiline cultivars are a mixture of a number of pureline cultivars that possess identical phenotypic characters (like similar height, seed colour, flowering and maturity dates, agronomic characteristics etc.) as well as genetic characters except one gene which is responsible for disease resistance. The purelines in the multiline cultivars must be compatible with each other so that when they are grown in a mixture they will not affect the yielding ability of each other.

Jenson in 1952 first suggested the use of multiline cultivars in oat. In 1953 Borlaug and Gibler gave the methods to develop multiline in wheat. Multiline cultivars can significantly suppress those diseases that have an airborne dispersal phase such as rust, mildews, Rhynchosporium, helminthosporium, septorioses and even *Pseudocercosporella herpotrichoides* often to the extent in which fungicide use become uneconomic.

Though disease development is slower in the multiline cultivars, but, inevitably, one line within the multiline becomes more infected compared to the remaining lines. As the line is infected, it may use fewer resources (nutrients, light, water) and less space compared to its neighbors which are resistant to the pathogen and because of this, those surplus resources are distributed to the resistant ones. So, the yield that is lost because of the disease in the susceptible plants is compensated by the higher yield provided by the more resistant plants. In a monoculture where all the plants have equal susceptibility, such compensation has not occurred (https://www.mrcseeds.com/multiline-genetics).

Mechanism of disease suppression by cultivar mixtures and multiline cultivars

Cultivar mixtures are not able to eliminate or suppress the disease completely. Instead, cultivar mixtures reduce disease progression rate through the elimination of large numbers of spores at every cycle of multiplication of the phytopathogen. As genetic differences are there in the population of plants, a number of spores are eliminated through their deposition on resistant plant individuals and also by dilution as there is a greater distance between the plants of the same genotype. Additionally, in susceptible plants the avirulent phytopathogens also activate the defense responses which delay the infection cycle of the phytopathogen. Moreover, a variety of physiological and epidemiological mechanisms influence the level of disease (Kumar *et al.*, 2021). The major mechanisms by which mixed cultivars suppress diseases are classified into four categories like: density effect or dilution effect, barrier effect, induced resistance, and alteration of the microclimate (Vidal *et al.*, 2017).

Density effect: It implies increase in the spacing between the susceptible plants will reduce the movement of spores between susceptible plants when it is compared with the single cultivar stand (Dornbusch *et al.*, 2011; Kiaer *et al.*, 2012). This mechanism is particularly applicable for those phytopathogens which for transmission of spores depend on rain splashes to a distance that is less than 1 m (Kumar *et al.*, 2021).

Barrier effect: As resistant varieties are present in the cultivar mixture, canopy of this resistant plants act as a physical barrier which interrupt the movement of the spore of the phytopathogens (Burdon *et al.*, 2016). Spores of the phytopathogen that landed on the resistant plants are not able to show any effect or show a little effect on the host plant and it also protects the susceptible plants from the pathogen. This barrier effect is influenced by the size and number of resistant plants in mixture, also by the spore dispersal physics.

Induced resistance: When a susceptible plant is attacked by an avirulent strain of the phytopathogen, the defense response of that incompatible plant gets activated which induces the resistance mechanism (Pieterse *et al.*, 2014).

Modification of the microclimate: Mixed cultivars have a variation in the characteristics like canopy structure, plant height etc. which modify the microclimatic conditions which is not favorable for plant diseases development (Barot *et al.*, 2017).

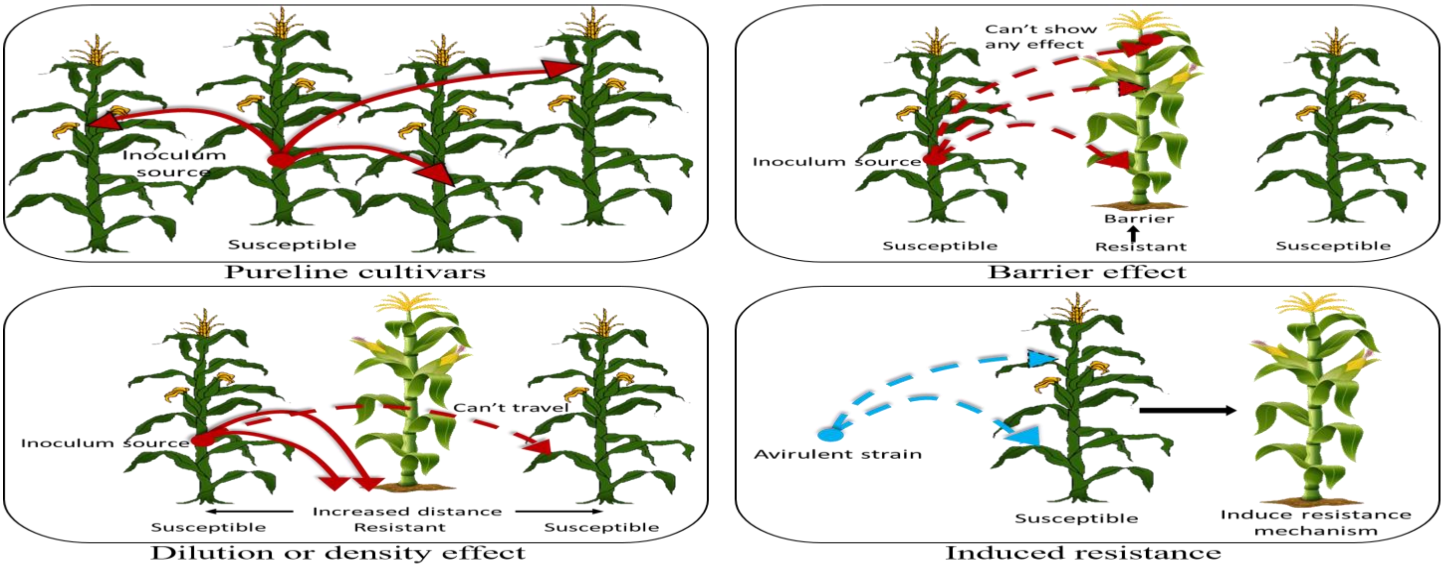

Figure 1. Mechanism of disease resistance in multiline and mixed cultivars

Example of cultivar mixtures

Cultivar Mixtures	Crops	Diseases	References
Cultivar mixture having different backgrounds of resistance	Wheat	Stripe rust	Huang et al., 2012
Mixtures of two-component	Wheat	Septoria tritici blotch	Gigot *et al.*, 2013
Four mixture	Wheat	Septoria tritici blotch	Cowger and Mundt, 2002
Mixture of two cultivar	Wheat	Septoria tritici blotch	Vidal *et al.*, 2017
Four-way mixture of cultivar	Wheat	Septoria tritici blotch	Kristoffersen *et al.*, 2020
Cultivar mixtures having variation in proportions of resistance	Durum wheat	Septoria tritici blotch	Ben M' Barek *et al.*, 2020
Mixtures of three-component	Barley	Powdery Mildew	Newton and Guy, 2011
Mixture of three cultivar	Barley	Different diseases	Newton and Guy, 2009
Mixture of susceptible and resistant cultivars	Pea	Powdery Mildew	Villegas- Fernandez *et al.*, 2021
Mixtures of two-component cultivar	Rice	Blast	Raboin *et al.*, 2012
Mixture of susceptible and resistant cultivars	Apple	Powdery mildew	Parisi *et al.*, 2013

Example of multiline cultivars

Kalyan sona which is a wheat variety is a suitable example for explaining the multiline concept. This variety was to be resistant against brown rust pathogen. Later on, evolution of new races of the pathogen make the variety susceptible. For this, several pure lines having differences in resistance genes are produced by using one recipient or recurrent parent through backcross breeding. 5-10 of such lines having different genes for disease resistance are mixed for developing multiline variety. Races of the pathogen having relevance to the area are considered to determine the lines which are to be mixed (http://www.agrilearner.com/multiline-variety).

Some other multiline wheat varieties are:

- MLKS11 (have 8 closely related lines)
- KML7404 (have 9 closely related lines)

Merits of multiline cultivars

- Due to the genetic diversity, multiline cultivars can adapt better to the environmental changes compared to the pureline cultivars.
- As in multiline cultivars pathogen can dominate only one or few lines within the mixtures. Therefore, there is relatively lower loss to the cultivator.
- Only a small proportion of the field contains the susceptible line. Therefore, pathogens can infect only a small proportion of the field. As well as disease spread slowly compared to when the entire field has a susceptible population. This will reduce the level of infection in susceptible plants as well.

Demerits of multiline cultivars

- Farmers need to change the seed of multiline cultivars after every few years by depending on the change in the pathogen race.
- There is a chance that a new strain of the pathogen can evolve and infect all the lines in the multiline varieties.

CONCLUSION

Multiline cultivars have several advantages compared to pureline cultivars. Though under normal conditions the yield of multiline cultivar can be lesser than the most productive pureline cultivar. But when adverse environmental conditions occur, then multiline cultivars give much higher yield compared to pureline cultivars.

In multiline cultivars the mixture of resistant and susceptible plants provide a buffering effect against the development of disease and thus extend the resistance gene's life. Because of the advantages of the multiline cultivars, modern plant breeders adopt multiline cultivars over the pureline cultivars.

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