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Biotic stress response in maize (*Zea mays* L.)

Dan Singh Jakhar, Rajesh Singh

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ABSTRACT

Biotic stresses are a potential threat to global food security and commonly induced by diseases or by insect pests, are a primary factor in maize yield losses. The most prevalent maize diseases are northern corn leaf blight, ear rot, maize rough dwarf disease and sugarcane mosaic disease. Maize is also plagued by pests, including stem borer, pink borer, shoot fly, termites and the storage pest maize weevil. The origin of new pathogens and insect races due to climatic and genetic factors is a major challenge for plant breeders in breeding biotic stress resistant crops. Approximately 10% of the global maize yield is lost each year as a result of biotic stresses. Reduced yield due to biotic stresses and increasing food demand put international food security at risk as 70% more food will be required in 2050.

Keywords: Biotic stress, Response, *Zea mays* L.

Introduction

Maize is one of the world's most important crop plants, boasting multibillion dollar annual revenue. In addition to its agronomic importance, maize has been a keystone model organism for basic research for nearly a century. It most probably originated in Central America, specifically Mexico and spread Northward to Canada and Southward to Argentina. Biotic stress, commonly induced by diseases or by insect pests, is a primary factor in maize yield losses (Lodha *et al*., 2013). The most prevalent maize diseases are northern corn leaf blight, ear rot, maize rough dwarf disease, sugarcane mosaic disease, and aflatoxin contamination. Maize is also plagued by pests, including stem borer, pink borer, shoot fly, termites and the storage pest maize weevil. The hemi biotrophic fungus *Colletotrichum graminicola*, which induces maize anthracnose, is responsible for annual losses of up to 1000 million dollars in the USA (Balmer *et al*., 2013; Frey *et al*., 2011). Stem borer or *Chilo partellus* is a major insect pest in India and infest maize crop during the *Kharif* season all over India. Pink borer or *Sesamia inference* affects maize crop during the *Rabi* season and mainly restricted to Peninsular India. Shoot fly (*Atherigona sp.*) is a serious pest in Peninsular India, but can affect summer or spring crop in North Indian states as well. It affects the maize plants at the seedling stage and leads to drying of the seedlings or 'dead heart'. The maize weevil (*Sitophilus zeamais*) is a destructive insect that feeds on stored maize worldwide. Subsistence farmers in tropical and subtropical agro ecosystems often experience grain damage exceeding 30% during on-farm storage (Tigar *et al*., 1994). Termite (*Odontotermes obesus*) is a major problem in the some fields. If not controlled, it can cause substantial damage to the maize crop. Since they establish colonies much deep into the soil, it is very difficult to get rid of the problem completely.

Maize response to biotic stresses

Biotic stress, commonly induced by diseases or by insect pests, is a primary factor in maize yield losses (Lodha *et al*., 2013).

Dan Singh Jakhar (✉), Rajesh Singh
Department of Genetics & Plant Breeding, IAS, BHU, Varanasi – 221005
e-mail: dansingh410@gmail.com

Turcicum leaf blight

Turcicum Leaf Blight (TLB) or Northern Corn leaf blight (NCLB) is one of the most important diseases in Northern and North-eastern hills and peninsular India and is caused by *Exserohilum turcicum*. The characteristic symptoms of NCLB are 'cigar shaped' tan or grayish lesions on leaf surface (Figure 1).

Figure 1 Characteristic symptoms of NCLB: 'cigar shaped' tan or grayish lesions.

It occurs in almost all maize growing areas worldwide, particularly in cool climate regions with temperatures ranging from 20^{0}C–25^{0}C, relative humidity from 90%–100%, and low luminosity (Wu et al., 2014). If not controlled at proper time, it has the potential to cause yield reduction up to 70%. Two to four applications of Maneb or Zineb @ 2.5-4.0 gm/litre of water at 7-10 days interval provide good control of the disease.

Ear rot diseases

Gibberella ear rot

Symptoms include reddish kernel discoloration, usually beginning at the ear tip (Figure 2). Husks may rot and become cemented to the ear. Disease development is favored by cool, humid weather, particularly 2 to 3 weeks after silking. The fungus that causes Gibberella ear rot produces the mycotoxins vomitoxin (also known as DON) and zearalenone. Vomitoxin is associated with feed refusal and zearalenone has been linked with livestock breeding problems (Woloshuk and Wise, 2010).

Figure 2 Corn ears with Gibberella ear rot.

Trichoderma ear rot

Dark green fungal growth is found on and between kernels and husks, often covering the entire ear (Figure 3). The disease usually occurs on ears with mechanical or insect damage.
Infected plants tend to be widely distributed within a field.

Figure 3 An ear with blue-green mold, indicative of the fungi that cause Trichoderma ear rot.

Diplodia ear rot

Symptoms include bleached husks, white mold over kernels, and rotted ears with tightly adhering husks. Small, black fungal bodies called pycnidia are often found on husks, kernels, and cob tissues. Early infection is likely to lead to complete ear rotting and the creation of lightweight mummified ears (Figure 4). Later infections may result in partial rotting, usually beginning at the base. Infected ears can have reduced nutritive value and reduced palatability to livestock. Although there is evidence that certain isolates of the fungus that causes Diplodia ear rot can produce mycotoxins, there have been no cases of poisoning from these mycotoxins in the U.S. Caution is urged if badly affected corn is being fed to livestock (Vincelli, 2012).

Figure 4 A cross-section of a corn cob with small, black pycnidia produced by the fungus that causes Diplodia ear rot.

Aspergillus ear rot

Symptoms include olive green or yellowish-tan fungal growth on and between kernels (Figure 5). Fungal growth is frequently near the ear tip. Symptoms are often more prevalent if the husk does not cover the ear tip. This disease is favored by hot, dry weather.

Figure 5 The fungus that causes Aspergillus ear rot produces olive-green spores that are
scattered through out the ear.

It may produce aflatoxin, which is a liver toxin and carcinogen and can potentially be dangerous to livestock. Feeding damage to ears from insects can contribute to disease development and aflatoxin contamination (Woloshuk and Wise, 2011) To examine the roles of stress-related genes in aflatoxin contamination, the expression levels of 94 genes selected from previous studies were analyzed using RT-PCR in six resistant and susceptible maize lines (Jiang *et al.*, 2011).

Fusarium ear rot

Typical symptoms include scattered individual kernels or groups of kernels with whitish-pink to lavender fungal growth (Figure 6). Infected kernels may also have a “starburst” pattern of white streaks on the cap of the kernel or along the base. Infections are more frequent on damaged ear tips and kernels with pericarp injuries or insect feeding damage. Development of this disease is favored by dry weather. Fusarium ear rot may produce a mycotoxin called fumonisin, which is carcinogenic and very toxic to horses (Jackson and Ziems, 2009).

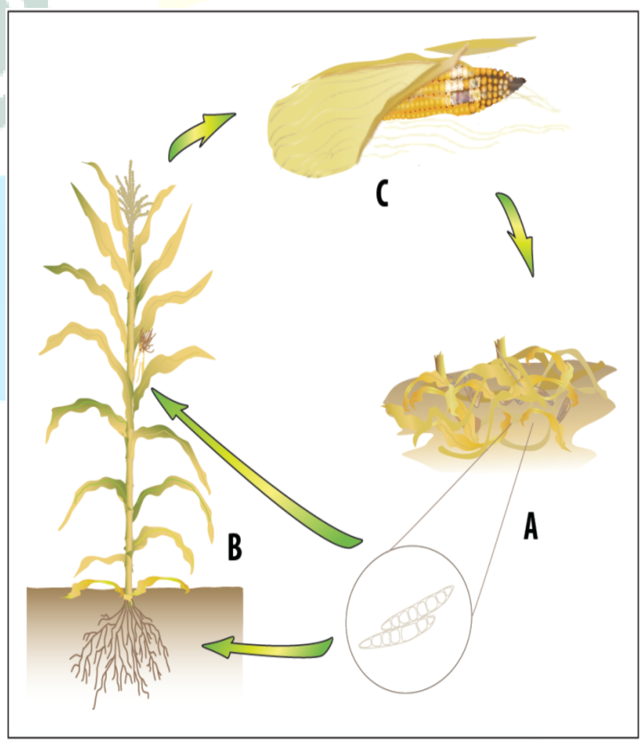

Figure 7 The Fusarium ear rot life cycle. A. Inoculum of F. verticillioides survives in corn residue. B. Airborn conidia infect ears via silks or insect injury; soil borne

conidia infect plant roots. C. White to purple, cottony mold can appear anywhere on the ear. Affected kernels are scattered and are discolored or have white streaks.

Maize rough dwarf disease

Maize rough dwarf disease (MRDD) is a destructive disease that causes great maize yield loss. MRDD is primarily caused by three pathogens: maize rough dwarf virus (MRDV), Mal de Rı ´o Cuarto virus (MRCV), and rice black streaked dwarf virus (RBSDV). MRDV and MRCV are the primary MRDD pathogens in Europe and in South America, respectively. RBSDV is considered the causal agent of MRDD in China and is transmitted by Laodelphax striatellus (Wang *et al*., 2003).

Sugarcane mosaic disease

Plant diseases caused by viruses are a severe limiting factor for food production. Sugarcane mosaic virus (SCMV) is an important viral pathogen that has caused severe losses in grain and forage yield. A high incidence of SCMV has occurred in maize in China (Xu *et al*., 2008) and Argentina (Perera *et al*., 2008).

Stem borer

Stem borer or *Chilo partellus* is a major insect pest in India and infest maize crop during the *kharif* season all over India. Spray of Cholopyriphos @ 1-1.5ml/litre of water at 10-12 days after germination provides good control. The insecticide should be mixed in 800- 1000 litre of water and evenly sprayed over the canopy per hectare. Additional 1-2 sprays after 7-10 days intervals further restricts the insect infestation. Alternatively, application of Carbofuron G 3% @ 0.6 kg a.i. / ha in the leaf whorls after 15-20 days after germination, provides protection against stem borer.

Pink borer

Pink borer or *Sesamia inference* affects maize crop during the *rabi* season and mainly restricted to Peninsular India. The larvae enter the plant at base by making a hole and damages the inside portion of the stem. This makes the plant stem weak and mild to heavy wind leads to the falling of the plants. The control measure is similar to stem borer as mentioned above.

Shoot fly

Shoot fly (*Atherigona sp.*) is a serious pest in Peninsular India, but can affect summer or spring crop in North Indian states as well. It affects the maize plants at the seedling stage and leads to drying of the seedlings or 'dead heart'. Seed treatment with Imidacloprid @ 6ml/kg of seeds provides good control of the shoot fly. Early sowing during first fortnight of February avoids build up of shoot fly population.

Termites

Termite (*Odontotermes obesus*)isa major problem in the some fields. If not controlled, it can cause substantial damage to the maize crop. Since they establish colonies much deep into the soil, it is very difficult to get rid of the problem completely. Frequent irrigation before land preparation and during the crop growth reduces its infestation. Application of Fepronil granules @ 20kg/ha followed by light irrigation controls termites to a reasonable extent. If the infestation occurs in patches, applying few granules of Fepronil on and around the patches control termite infestation.

Maize weevil

Maize weevil, *Sitophilus zeamais* Motschulsky, is a cosmopolitan pest of stored products (Longstaff 1981), and prior to the introduction of the larger grain borer, *Prostephanus truncatus*, it was reported as the most important pest on stored maize in Africa. *Sitophilus zeamais* is the dominant species on maize. These weevils are very destructive grain pests. All these weevils develop as larvae within the grain kernels. They frequently cause almost complete destruction of grain in elevators or bins, where conditions are favourable and the grain is undisturbed for some length of time. Infested grain will usually be found heating at the surface, and it may be damp, sometimes to such an extent that sprouting occurs. Prevention is the best strategy; but if resistance is suspected, first eliminates other possible causes. The only way to control these pests is fumigation. Since it is an internal pest, residual control will only kill exposed adults. To kill the internal stages (larval and pupal), you must fumigate. Heating grain to 60C can kill larvae, however, this may decrease germination and baking quality of flour.

Conclusion

Plant pathogens and insects are living entities that not only respond to plant resistance mechanisms but also evolve rapidly to avoid the plant resistance response, thus posing a serious threat to global food security. The origin of new pathogens and insect races due to climatic and genetic factors is a major challenge for plant breeders in breeding biotic stress resistant crops. Approximately 10% of the global maize yield is lost each year as a result of biotic stresses. Reduced yield due to biotic stresses and increasing food demand put international food security at risk as 70% more food will be required in 2050.

References

Balmer D, Flors V, Glauser G, Mauch-Mani B (2013) Metabolomics of cereals under biotic stress: Current knowledge and techniques. Front Plant Sci 4, 82.

Frey TJ, Weldekidan T, Colbert T, Wolters PJCC, Hawk JA (2011) Fitness evaluation of Rcg1, a locus that confers resistance to Colletotrichum graminicola (Ces.) G.W. Wils. using near-isogenic maize hybrids. Crop Sci 51, 1551–1563.

Jackson T, Ziems, A (2009) Ear rots and grain molds are common this year. University of Nebraska-Lincoln. http://cropwatch.unl.edu.

Jiang T, Zhou B, Luo M, *et al.* (2011) Expression analysis of stress-related genes in kernels of different maize (Zea mays L.) inbred lines with different resistance to aflatoxin contamination. Toxins 3, 538–550.

Lodha T, Hembram P, Basak N (2013) Proteomics: A successful approach to understand the molecular mechanism of plant-pathogen interaction. Am J Plant Sci 4, 1212–1226.

Longstaff BC (1981) Biology of the grain pest species of the genus Sitophilus (Coleoptera: Curculionidae): a critical review. Protection Ecology, 3(2):83-130.

Perera MF, Filippone MP, Ramallo CJ, *et al.* (2008) Genetic diversity among viruses associated with sugarcane mosaic disease in Tucuma´n, Argentina. Phytopathology 99, 38–49.

Tigar BJ, Osborne PE, Key GE, Flores-S ME, Vazquez-AM (1994) Insect pest associated with rural maize stores in Mexico with particular reference to Prostephanus truncates (Coleoptera: bostrichidae). J Stored Prod Res 30, 267–281.

Vincelli P (2012) Diplodia ear rot of corn and mycotoxin potential. University of Kentucky Cooperative Extension. http://www2.ca.uky.edu.

Wang ZH, Fang SG, Xu JL, *et al.* (2003) Sequence analysis of the complete genome of rice black-streaked dwarf virus isolated from maize with rough dwarf disease. Virus Genes 27, 163–168.

Woloshuk C, Wise K (2010) Gibberella ear rot. Purdue University Extension. http://www.extension.purdue.edu.

Woloshuk C, Wise K (2011) Aspergillus ear rot. Purdue University Extension. http://www.extension.purdue.edu.

Wu F, Shu J, Jin W (2014) Identification and validation of miRNAs associated with the resistance of maize (Zea mays L.) to Exserohilum turcicum. PLoS ONE 9, e87251.

Xu DL, Park JW, Mirkov TE, Zhou GH (2008) Viruses causing mosaic disease in sugarcane and their genetic diversity in southern China. Arch Virol 153, 1031–1039.