Hessian Fly Resistant Wheat Varieties

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Summary

Production of wheat in North Africa and elsewhere, including some parts of Sub-Saharan Africa, is threatened by infestations of the Hessian fly (Mayetiola destructor), also called gall midge. This insect pest has spread across many major breadbasket areas, causing substantial losses. Damage to wheat crops is attributed to larvae from eggs deposited in grooves on the upper side of leaves. Larvae have the ability to form hardened gall structures that offer protection from natural enemies and other control agents. On seedlings of wheat, the larvae feed on the growth apex (crown), while at later growth stages of the crop larvae establish feeding sites beneath the leaf sheath. Planting wheat varieties that possess a natural defense mechanism against the Hessian fly larvae is the most effective control method and farmers can avoid severe damage by growing these resistant varieties. Crop surveillance and extension messaging ensures the best use of these varieties.

Technical Description

Resistance of wheat to the Hessian fly originates from a naturally occurring trait that activates a biochemical defense response to larvae feeding on the leaf and stem. More than 26 resistance genes have been identified in wheat that is now incorporated into local, high-yielding varieties. Common breeding techniques such as phenotyping and backcrossing are used in the development of wheat varieties that withstand Hessian fly attack. Molecular markers associated with resistance genes for the insect pest allow fast-tracking of varietal selection, reducing the cost and time for the development and release of new varieties. Hessian fly populations can overcome resistance in wheat over time because variants of the pest emerge through genetic mutation and environmental pressure, so the effectiveness of released varieties must be monitored to avoid pest outbreak.

Uses

The dispersal of the Hessian fly in Sub-Saharan Africa has not been mapped in detail but the occurrence of this insect pest has been confirmed in wheat production zones of Eritrea, Ethiopia, Kenya, Malawi, Mali, Mozambique, Niger, Nigeria, Sudan, Tanzania, Zambia and Zimbabwe. Especially during rainy seasons in tropical climates there is a large risk for severe infestations of the insect pest because the hatching of eggs and survival of larvae are favoured by high temperatures and moisture in the environment.

Genetic resistance to Hessian fly attacks is a suitable approach for protecting wheat crops in all African growing areas since the technology can be embedded into elite lines with a high yield potential and adaptations to other environmental stresses. Warmer temperatures as a result of climate change will enhance yield losses by 20% to 40% due to insect pests across Sub-Saharan Africa.

Composition

Hessian fly resistant wheat developed in Morocco, Egypt, Algeria, Syria and South Africa has been released across multiple countries in Sub-Saharan Africa. Globally, more than 200 common wheat and durum wheat varieties were developed that withstand attacks from the insect pest and offer good bread-making quality. There are ongoing efforts by breeders to incorporate resistance genes into wheat cultivars that are commonly grown in the breadbasket regions on the continent.

Means of application

The multiplication of seed for Hessian fly resistance follows the same procedures as for other improved cultivars and takes 2 to 4 growing cycles. In a first stage, early-generation of basic seed is produced by agricultural research centers, and in a later stage this is passed on to seed producers for multiplying large volumes of certified seed. In-field techniques, such as the ear-to-row method where best-performing ears are selected and replanted in single lines can be used by farmers to maintain stocks of planting material. Planting density and mineral fertilizer input for cultivation of Hessian fly resistant wheat varieties follows the same local recommendations as non-resistant varieties. Complementary practices include adherence to planting schedules, destruction of reservoir hosts (green bridges), and use of insecticides. Hessian fly control in farming systems is most effective when accompanied by pest surveillance and extension support.

Agroecologies	Dryland area, Highlands, Moist savanna.
Regions	Africa South of Sahara.
Developed in Countries	Burkina Faso, Ethiopia, Kenya, Mali, Mozambique, Senegal, Sudan, Tanzania, Zambia, Zimbabwe.
Available in	Burkina Faso, Ethiopia, Kenya, Mali, Mozambique, Senegal, Sudan, Tanzania, Zambia, Zimbabwe.
Solution Forms	Genetics.
Solution Applications	Improved variety.

Agricultural Commodities	Wheat.
Target Beneficiaries	Small-scale farmers, Commercial farmers, Agro-dealers.

Commercialization

Commercialization Category

Commercially available

Startup Requirements

Bringing this seed technology to wheat farmers in major wheat growing areas of Africa requires a set of actions: 1) Identify Hessian fly resistant wheat varieties through laboratory and field testing, 2) Demonstration with farmers to create awareness about the benefits of genetic resistance to the insect pest, 3) Engage national systems, farmer associations and private companies in seed multiplication of resistant wheat varieties, and 4) Enhance the capacity for pest surveillance, varietal selection and seed distribution in major wheat production areas.

Production Costs

Multiplying high-quality seed of Hessian fly resistant wheat varieties attracts the same costs as for susceptible varieties, and because the crop is self-pollinating there are relatively low labour costs for field operations. The price tag of certified seed for wheat that withstands the insect pest ranges between US $35 and $43 per hectare when purchased from international markets. Coordination between farmers at local and regional scale is required since devastating outbreaks can only be averted if a sufficient portion of cropland (50% to 80%) is cultivated with resistant wheat varieties. The surveillance of pest outbreak and distribution also bears a cost that must be covered by local or national authorities and incorporated into development projects and extension work plans.

Customer Segmentation

The multiplication and cultivation of Hessian fly resistant wheat varieties serves a diverse customer base, including national programs, small-scale and commercial producers, private seed companies and food processors.

Potential Profitability

Resistance to Hessian fly attack in wheat is a financially attractive solution to farmers as it results in stable production that justifies investment in certified seed. Cultivating resistant wheat in a fly-free situation has no negative effect on grain and forage yields. Lines with a natural defense against the insect pest released in Morocco have a yield

potential of 5.5 to 7.1 ton/ha, and protects from 79% to 100% of the crop. Extensive monitoring of resistant varieties in the wheat belt of Northern America found that an additional 130 to 210 kg grain per hectare is harvested for every 10% less infestation by Hessian fly larvae, and the same likely holds for Sub-Saharan Africa. The economic benefit for production of forages that is results from resistance in wheat offers producers an additional US $105 per hectare.

Licensing Requirements

Certified seed of Hessian fly resistant wheat varieties can be produced and sold by private and cooperative businesses after signing a technology transfer agreement with breeding centers that are responsible for their development. Licensing schemes and national regulators apply different standards and procedures for multiplying seed from improved wheat varieties.

Innovation as Public Good

Hessian fly resistant wheat varieties are developed and released as Regional Public Goods by the International Center for Agriculture Research in the Dry Areas (ICRARDA) and International Maize and Wheat Improvement Center (CIMMYT), which implies that no royalties have to be paid for seed production.

Solution Images



Hessian fly adult (left) and larvae and damage to wheat (right)



Performance of wheat varieties sensitive (left) and resistant (right) to Hessian fly

Institutions

ICARDA
Science for resilient livelihoods in dry areas

Accompanying Solutions

Integrated Management of Insects, Diseases and Weeds in Wheat