Larval Survival on Wheat Plants Carrying Resistance Genes to Hessian Fly (Diptera: Cecidomyiidae) in Morocco

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Abstract

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A growth chamber test was conducted to determine which of the wheat genes that condition resistance to Hessian fly, *Mayetiola destructor* (Say) in Morocco, allow for larval survival on resistant plants. The results showed that H7H8 genes allowed the highest larval survival (34.8%) and that H5, H11, H13, H22 and H23 genes allowed for little (<4%) or no larval survival. Theses larvae, which were significantly (P<0.05) smaller than those on susceptible "Nasma" plants, has little negative effect on plant growth. Resistance genes that allow avirulent larvae to survive on resistant plants should be deployed to reduce selection for biotype development.

Key words: *Mayetiola destructor*, resistance genes, wheat, larval survival.

Introduction

The Hessian fly, *Mayetiola destructor* (Say), is a destructive pest of wheat (*Triticum* species) throughout most of the production areas of the world. In North America, this pest has been a serious problem on wheat since its introduction in the late 1700's. Damage caused by this insect has been estimated at $100 million in a single year (3). The Hessian fly is also the major pest of wheat in North Africa and Southern Europe. In Morocco, damage caused by the Hessian fly can result in total crop loss when fall infestations are high and coincide with the young growth stages of the crop (2, 16).

One of the most practical control methods for Hessian fly has been the use of resistant wheat cultivars. In the U.S.A., 26 resistance genes that confer resistance to larvae have been identified in *Triticum* species and *Secale cereale* L. for use in cultivar improvement (5).

In Morocco, only H5, H7H8, H11, H13, H21, H22, H23, H25 and H26 genes are effective (1, 6, 9). The mechanism of Hessian fly resistance in wheat is antibiosis, i.e., first instars of avirulent biotypes die after feeding on resistant plants.

Because of the highly specific gene-for-gene relationship between wheat and the Hessian fly (14), biotypes have evolved as a result of selection pressure exerted by large scale growing of resistant cultivars with the same genes for resistance. In U.S.A., eight biotypes have been identified from field populations and are designated Great Plains (GP), A, B, C, D, E, J, and L (12, 17).

The repeated development of virulent biotypes suggests that long term strategies for deployment of resistance genes are needed that will slow Hessian fly biotype development and result in more efficient use of resistance genes. To accomplish this, a better understanding of the genetic interaction between the wheat and the Hessian fly is essential, especially the fitness (survival) of avirulent Hessian fly larvae on wheat plants carrying specific resistance genes.

The objectives of this study were to quantify Hessian fly larval survival on wheats carrying different resistance genes and determine which of these genes exert the strongest selection pressure against avirulent genotypes in heterogeneous populations.

Materials and Methods

This study was conducted in a growth chamber using a heterogeneous avirulent Hessian fly population collected from the Settat region. The experimental design was a randomized complete block with three replications repeated over time. Each treatment was a wheat line carrying the same genes for resistance. The cultivar "Nasma" was used as a susceptible check. Each wheat cultivar or line was planted in a separate pot. When plants were in the two-leaf stage, prior to infestation, they were thinned to 30 per hill. Replications were seeded one week apart to allow enough time to evaluate larval survival. Three mated females were confined in a cage placed over each hill of plants. At ten days after the infestation, a random sample of 10 plants was taken from each treatment to estimate the total number of larvae on the 30 plants. When the larvae were in the puparial (flaxseed) stage, all the plants of each pot were taken to the laboratory for examination. Susceptible and resistant plants were separated on the basis of symptoms. Susceptible plants were stunted and dark green in color, whereas resistant plants were normal and retained their light green color and contained dead first instars. The number of live larvae and their length were recorded for five randomly selected susceptible and resistant plants. Plant height was measured on a maximum of five resistant plants with live larvae and five resistant plants with dead larvae. Measurements were taken from the soil level to the tip of the longest leaf.

Results

The infestation levels of plants were high. None of the "Nasma" plants escaped infestation (Table 1).

As reported earlier (1, 6, 7), H5, H11, H13, H22 and H23 genes were highly effective against Hessin fly in Morocco. However, for the H13 gene the percentage of resistant plants in spring and winter backgrounds differed significantly (P<0.05) (Table 1). The lower percentage of resistant plants (82.3%) in H13 spring wheat may have been due to segregation of H13, since this gene was recently transferred into Moroccan spring wheats (1). H7H8 genes showed only a moderate level of resistance (68.3%).

Table 1. Hessian fly larval survival on wheat plants carrying resistance genes, growth chamber test, Settat, Morocco.

Resistance genes (Plant growth habit)	% resistant plants	% resistant plants with live larvae
H5 (Abe, Winter)	98.7 ab	2.6 b*
H5 (saada, Spring)	100.0 a	0.0 b
H7H8	68.3 d	34.8 a
H11	97.6 ab	0.0 b
H13 (Winter)	91.7 b	0.0 b
H13 (Spring)	82.3 c	3.6 b
H22	91.5 b	0.0 b
H23	95.8 ab	0.0 b
Nasma (susc. check)	0.0 e	---

* Means followed by the same letter in the same column are nor significantly different (P=0.05; LSD {SAS Institute 1985}).

There was a highly significant difference (P<0.01) between resistance genes in the percentage of resistant plants with live larvae (Table 1). H7H8 genes had the largest number of resistant plants with live larvae, 34.8%. All other genes, H5, H11, H13, H22 and H23, had less than 4% of resistant plants with live larvae.

There was a highly significant difference (P<0.01) between genes in larval survival (Table 2). In comparison to susceptible "Nasma" plants, H7H8 resistant plants allowed about one-fifth of the larval population to survive; these larvae were significantly (P<0.05) smaller than those on "Nasma" (Table 2). Larvae that survived on H7H8 resistant plants did not cause serious damage to the plants, since there was no significant difference (P>0.05) between the height of resistant plants with dead larvae and that of resistant plants with live larvae (Table 3).

Discussion

Results of the tests conducted in Morocco corroborated those in the USA that some genes such as H1H2 and H7H8 allow for larval survival on resistant plants (8). The fact that larvae that survived on resistant plants were avirulent genotypes (8) indicates that resistance genes H7H8 would reduce the selection pressure for Hessian fly populations to develop virulent biotypes. Thus, cultivars carrying these genes should be more durable. Avirulence alleles will be maintained at high frequencies in Hessian fly populations, because significant numbers of larvae will survive on resistant plants. This in turn, will dilute virulence alleles in the population and showed slow the development of virulent biotypes. Genes such as H13, H22 and H23 from wild species that condition a high level of antibiosis (10, 11, 13, 15) will probably put a high selection pressure on populations to develop virulent biotypes. However, it is likely that virulence to these resistance genes occurs at very low frequencies, since there has been little coevolution of the Hessian fly and these wheat relatives. Thus, resistant cultivars with genes from the wild wheat, *T. tauschii* and from rye, *S. cereale*, would possibly be more durable than resistance genes from cultivated wheat. On the other hand, genes such as H5 and H11, which allow for little or no larval survival and are located on chromosome 1A, may be highly selective for virulent biotypes. Cox and Hatchett (4) proposed that when neither homozygous avirulent nor heterozygous avirulent larvae survive on resistant wheat plants, virulence alleles become fixed rapidly.

Efforts should be continued to identify effective resistance genes that allow for high larval survival on resistant plants, which could help slow biotype development.

Table 2. Antibiotic effect on Hessian fly larvae that survived on resistant wheat plants carrying resistance genes, growth chamber test, Settat, Morocco.

Resistance genes (Plant growth habit)	No. live larvae/ resistant plant	Mean length (mm) of larvae
H5 (Abe, Winter)	0.5 c*	----
H5 (Saada, Spring)	0.0 c	----
H7H8	2.3 b	2.5 b
H11	0.0 c	----
H13 (Winter)	0.0 c	----
H13 (Spring)	0.4 c	----
H22	0.0 c	----
H23	0.0 c	----
Nesma (susc. check)	12.2 a	3.9 a

* Means followed by the same letter in the same column are nor significantly different (P=0.05; LSD {SAS Institute 1985}).

Table 3. Effect on plant growth of Hessian fly larvae that survived on H7H8 resistant wheat plants, growth chamber test, Settat, Morocco.

H7H8	Mean length (cm) of leaf
Resistant plants with dead larvae	38.1 a*
Resistant plants with live larvae	34.4 a

* Means followed by the same letter are not significantly different (P=0.05; LSD {SAS Institute 1985}).

الملخص

البو حسيني، مصطفى، جيمي هاتشط وسعدية لحلوي. 1995. بقاء يرقات ذبابة هس على نباتات القمح الحاملة لمورثات المقاومة لذبابة هس في المغرب. مجلة وقاية النبات العربية. 13 (2): 103 - 105

أجري اختبار داخل غرفة النمو لتحديد أيّ من المورثات التي تتحكم بمقاومة القمح لذبابة هس *Mayetiola destructor* (Say) في المغرب يسمح ببقاء اليرقات على النباتات المقاومة. وقد أظهرت النتائج أن المورثات H7H8 تسمح بأعلى نسبة بقاء (34.8%) وأن المورثات H5، H11، H13، H22 و H23 تسمح بنسبة بقاء ضعيفة (47%). وكان لهذه اليرقات، التي كانت أصغر بفارق معنوي (P<0.5%). من تلك الموجودة على الصنف الحساس "Nasma"، تأثير سلبي قليل في نمو النباتات. ولابدّ من استخدام مورثات المقاومة التي تسمح لليرقات غير الشرسة بالبقاء على النباتات المقاومة للإقلال من الانتخاب لصفة تطوّر الأنماط الحيوية للحشرة.

كلمات مفتاحية: *Mayetiola destructor*، مورثات المقاومة، قمح، بقاء اليرقات.

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