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Determination of Frequency and Distribution of Hessian Fly (Diptera: Cecidomyiidae) Biotypes in the Northeastern Soft Wheat Region

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DETERMINATION OF FREQUENCY AND DISTRIBUTION OF HESSIAN FLY (DIPTERA: CECIDOMYIIDAE) BIOTYPES IN THE NORTHEASTERN SOFT WHEAT REGION[1]

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ABSTRACT

Fifteen collections of Hessian flies from the northern soft winter wheat region of the United States were used to determine the composition and frequency of biotypes. The wheat cultivars 'Seneca' (H_7H_8), 'Monon' (H_3), 'Knox 62' (H_6, H_7H_8), and 'Abe' (H_5) were used as differentials. Biotypes J and L replaced biotype B as the prevalent biotype in Indiana, since wheat cultivars having the H_5 and the H_6 genes have been grown. Biotype GP, the least virulent of any Hessian fly biotypes, was still present in New York indicating that wheat cultivars with no genes for resistance are still being grown there. The genetic variability of Hessian fly biotypes that enables them to overcome the resistance in wheat cultivars is discussed.

The Hessian fly, *Mayetiola destructor* (Say) is one of the most serious insect pests of wheat in the United States. It is usually controlled by resistant cultivars and by planting winter wheat cultivars after the "fly-free" dates. However, the widespread use of resistant cultivars has resulted in the development of new biotypes having the ability to infest previously resistant cultivars (Gallun 1977). The frequency of biotypes is dynamic because of the selection pressure of the resistant cultivars on Hessian fly populations. The rate of change depends on the selection intensity of resistant cultivars (Gallun et al. 1961, Hatchett 1969). Biotype B replaced biotype A as the prevalent biotype in Indiana after the wheat cultivar 'Dual', having the H_3 gene for resistance, was released in 1955 and became widely grown by 1959 (Hatchett and Gallun 1968); Biotype E was found in Georgia to infest 'Georgia 1123' having the H_3 gene for resistance where this cultivar represented 75% of the wheat hectarage (Hatchett 1969); Biotypes J and L were discovered in Indiana where cultivars having the H_5 gene for resistance were being predominantly grown (Sosa 1981). These events illustrate that the Hessian fly possesses the genetic variability for virulence that is necessary to overcome the resistance in wheat.

Some individuals in a field population of Hessian flies are capable of surviving the release of a new resistant cultivar which cannot be infested by the rest of the

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individuals in the population. As the area cultivated with these resistant cultivars increases, the difference in fitness between the virulent and avirulent flies results in a shift in the biotype proportion in favor of the virulent population variant. The resistant cultivars become eventually more susceptible each year to this population, and a new biotype will be identified. Since the discoveries of biotype J in the field, several cultivars with the H_6 gene that are resistant to this biotype have been released ('Auburn', Patterson et al. 1982a; 'Caldwell', Patterson et al. 1982b; 'Fillmore', Patterson et al. 1985; and 'Adder', Shaner et al. 1986). As wider areas are grown with these resistant wheat cultivars, the frequency of biotypes that are capable of surviving on them is also expected to increase in the future. It is always necessary to monitor the occurrence of virulent biotypes in order to breed wheat cultivars resistant to them. Therefore, the objective of this study was to determine the distribution and frequency of Hessian fly biotypes in the northern and eastern areas of the soft wheat region.

MATERIALS AND METHODS

Wheat crops from 15 locations in five states in the northeast portion of the soft winter wheat region were sampled in 1986 to determine the presence of Hessian flies. Each sample consisting of at least 100 or more plants per site was brought into the Insect and Weed Control Research Unit laboratories of the U. S. Department of Agriculture, Agricultural Research Service, at Purdue University for the emergence of adult flies. Then, each sample was increased as a bulk population for one generation by caging ovipositing adult flies on susceptible 'Blueboy' wheat. When the second generation adults emerged from Blueboy, the biotype was determined according to the plant response to progenies of a single fertile female having infested four differential cultivars, Seneca (H_7H_8), Monon (H_3), Knox 62 (H_6, H_7H_8), and Abe (H_5) (Gallun et al. 1961). These four cultivars were seeded separately in 10.2 cm plastic pots divided into four sections. The location of each differential cultivar was standardized and marked, so that their sequence was the same in each pot. A minimum of 100 progenies was used to determine the biotype frequency of each location. When the seedlings were in the two-leaf stage, they were thinned to 3 seedlings per cultivar and covered by a transparent plastic cage. The top of this cage was vented with a hole covered with fine plastic screen, and a 2.5 cm diam. hole in the middle of the cage side was used for introducing a fertile fly into the cage during infestation. A dispo plug was used to prevent the fly from escaping. At the peak fly emergence, each pot of differentials was infested by placing a single mated gravid female inside the cage for oviposition. After two days, the differentials were uncovered and reviewed for eggs. Only pots with eggs on all cultivars were saved.

Two weeks after infestation, the phenotype of the fly progenies in each pot was determined according to the reactions of wheat cultivars. Susceptible plants have dark green leaves, stunted appearance, and supported live larvae; whereas the resistant plants contained dead larvae, maintained light green leaves, and grew in a normal manner (Gallun et al. 1961). All biotype determinations were conducted in environmental growth chambers set at $20 \pm 1°C$ and a 14 L:10 D photoperiod.

RESULTS AND DISCUSSION

The frequency (percentage) of the Hessian fly biotypes in the samples are listed in Table 1. Results showed that in 1986, biotype L was predominant in all counties of Indiana sampled except Tippecanoe where biotype J was most prevalent. Biotypes J and L were also the most prevalent biotypes in Indiana and nearby states (Table 1). These two biotypes occurred in 12 of 15 locations sampled. High frequency of biotype J and L in Illinois and Indiana samples indicates that these

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Table 1. — Frequency (percentage) of Hessian fly biotypes in samples collected in 1986 from the northeastern soft wheat region

States	Counties	Number of females tested	Biotype Frequencies (%)								
			GP	A	B	C	D	E	J	L	M
Illinois	Wabash	82	0	0	0	0	0	0	23	77	0
	White	73	0	0	0	0	0	0	14	86	0
Indiana	Knox	105	0	0	0	0	0	0	1	99	0
	Pike	93	0	0	0	0	0	0	0	100	0
	Posey	102	0	0	0	0	5	0	21	74	0
	Sullivan	102	0	0	0	0	0	0	20	80	0
	Tippecanoe	124	0	0	0	0	0	0	85	15	0
Michigan	Berrien	96	0	0	0	0	0	0	90	9	1
	Branch	118	0	0	65	0	0	0	35	0	0
	Calhoun	89	0	1	70	0	2	2	18	7	0
	Ingham	103	0	0	25	0	13	0	40	22	0
New York	Tompkins (1)	94	10	81	3	6	0	0	0	0	0
	Tompkins (2)	94	12	53	10	22	0	3	0	0	0
Ohio	Crawford	109	0	36	0	0	0	0	59	3	2
	Sandusky	93	0	79	0	0	3	0	17	1	0

biotypes overlap in these areas. This result is understandable because wheat cultivars susceptible to both biotypes J and L are currently grown in both states. These biotypes can stunt cultivars with the H_3, H_5, and H_7H_8 genes; however, only biotype L can survive on wheat cultivars with the H_6 gene for resistance. Thus, biotype L will most likely increase in frequency, providing that the cultivars with the H_6 gene continue to be widely grown. Currently, Caldwell, with the H_6 gene for Hessian fly resistance (Patterson et al. 1982), is the most prevalent wheat in Indiana. As a result, the frequency of biotype L has increased from 33.3% in a sample from Randolph Co. (Sosa 1981) to 100% in a sample from Pike Co. in this study.

This study showed that wheat cultivars having the H_3, H_5, and H_7H_8 genes were susceptible to the Indiana flies (Table 2). This result indicated that Hessian fly populations in these areas are evolving and are homozygous for virulence at these three loci. Only wheat cultivars having the H_6 gene provided resistance to some of the flies. The development of additional biotypes is expected in Indiana. Prior to resistant cultivars of wheat being released, biotype A was predominant (Gallun et al. 1961). When cultivars with the H_3 gene for resistance occupied a high percentage of the wheat cultivated (50%) in Indiana, biotype B became prevalent (Hatchett and Gallun 1968, Gallun 1972). After cultivars with the H_6 gene for resistance were grown, biotype J was discovered (Sosa 1981). Since 1980, several cultivars with the H_5 and the H_6 gene have been released in Indiana (Patterson et al. 1982a, 1982b, 1985, Shaner et al. 1986). These cultivars were immediately accepted and cultivated area increased. This study showed that biotype L is becoming more prevalent, further illustrating that the Hessian fly possesses the genetic variability for virulence and is evolving and overcoming the resistant genes that are incorporated into wheat. Biotype A was the predominant biotype in the New York samples along with the Great Plains (GP) biotype. Because the GP biotype will only survive on cultivars with no genes for resistance, GP is probably the original biotype; cultivars with resistant gene likes the H_7H_8 would select against it, favoring the development of biotype A.

If cultivars having other genes for resistance were grown, however, biotypes other than biotype A would be detected. This inference is reasonable because the GP biotype probably represents the original population of the Hessian fly in the eastern United States, and would have the most genetic variability for virulence to wheat. Using laboratory data, Gallun (1977) pointed out that a mating between a com-

Table 2. — Percentage of the four differential wheat cultivars susceptible to the Hessian fly collected in 1986 in different locations

States	Counties	Number of females tested	Percentage Homozygous Susceptible in			
			Seneca (H_7H_8)	Monon (H_3)	Knox 62 (H_6, H_7H_8)	Abe (H_5)
Illinois	Wabash	82	97.6	100.0	75.6	100.0
	White	73	100.0	100.0	86.3	100.0
Indiana	Knox	105	100.0	100.0	91.4	100.0
	Pike	93	100.0	100.0	100.0	100.0
	Posey	102	100.0	100.0	78.4	95.1
	Sullivan	102	100.0	100.0	77.5	100.0
	Tippecanoe	124	99.2	100.0	4.8	100.0
Michigan	Berrien	96	97.9	100.0	7.3	100.0
	Branch	118	100.0	100.0	0.0	33.1
	Calhoun	89	97.8	98.9	9.0	24.7
	Ingham	103	100.0	100.0	34.0	62.1
New York	Tompkins (1)	94	80.9	4.3	20.2	1.1
	Tompkins (2)	94	89.4	0.0	2.1	0.0
Ohio	Crawford	109	98.2	100.0	3.7	56.0
	Sandusky	93	100.0	100.0	3.2	14.0

pletely heterozygous GP female and a GP male, with maternally derived recessive alleles at the four differential loci, would theoretically produce progenies of all sixteen known biotypes when placed on four differentials. In Michigan, biotypes B and J were predominant in each county sampled, however, biotype L was found in three of four counties sampled, especially in Ingham Co. This is the first report of these three biotypes from Michigan. In Ohio, biotypes A and J were prevalent. Biotype J had not been previously reported from Ohio. In Illinois, biotypes J and L were the predominant biotypes, and this is the first report of these biotypes in this state. With the occurrence of biotypes J and L in these states, this study re-confirms that an increase in the use of cultivars with specific genes for resistance creates a change in the frequency of each biotype in the field, because the selection pressure favors individuals that can live on the specific resistant genes of wheat (Gallun et al. 1961). The high frequency of biotype L in Indiana and Illinois indicates that an outbreak of the Hessian fly could occur in these areas. The large area with wheat cultivars having the H_6 gene for resistance favors the selection for biotype L; therefore, a release of wheat cultivars resistant to this biotype is needed.

LITERATURE CITED

Gallun, R. L. 1972. Genetic interrelationships between host plants and insects. J. Environ. Quality 1:259–265.

Gallun, R. L. 1977. Genetics basis of Hessian fly epidemics. Ann. N. Y. Acad. Sci. 287:223–229.

Gallun, R. L., H. O. Deay, and W. B. Cartwright. 1961. Four races of Hessian fly selected and developed from an Indiana population. Purdue Univ. Agric. Exp. Stn. Res. Bull. No. 732, 7 pp.

Hatchett, J. H. 1969. Race E, sixth race of the Hessian fly, *Mayetiola destructor*, discovered in Georgia wheat fields. Ann. Entomol. Soc. Amer. 62:677–678.

Hatchett, J. H., and R. L. Gallun. 1968. Frequency of Hessian fly, *Mayetiola destructor*, races in field populations. Ann. Entomol. Soc. Amer. 61:1446–1449.

Patterson, F. L., G. E. Shaner, H. W. Ohm, R. E. Finney, R. L. Gallun, J. J. Roberts, and J. E. Foster. 1982a. Registration of Auburn wheat. Crop Sci. 22:161–162.

Patterson, F. L., H. W. Ohm, G. E. Shaner, R. E. Finney, R. L. Gallun, J. J. Roberts, and J. E. Foster. 1982b. Registration of Caldwell wheat. Crop Sci. 22:691–692.

Patterson, F. L., H. W. Ohm, G. E. Shaner, R. L. Gallun, J. J. Roberts, and J. E. Foster. 1985. Registration of Fillmore soft red winter wheat. Crop Sci. 25:326.

Shaner, G. E., H. W. Ohm, J. E. Foster, F. L. Patterson, R. L. Gallun, D. M. Huber, G. C. Buechley, G. G. Safranski, and J. M. Hertel. 1986. Registration of Adder wheat. Crop Sci. 26:201.

Sosa, O., Jr. 1981. Biotypes J and L of the Hessian fly discovered in an Indiana wheat field. J. Econ. Entomol. 74:180–182.