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TILLERING RESPONSE OF 'MONON' AND 'NEWTON' WINTER WHEATS INFESTED WITH BIOTYPE L HESSIAN FLY (DIPTERA: CECIDOMYIIDAE) LARVAE

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ABSTRACT

Two wheat, *Triticum aestivum*, cultivars that differed in their ability to tiller were infested by ovipositing Hessian flies, *Mayetiola destructor*, under similar controlled conditions. Since a larva typically stunts and kills the stem where it feeds and develops, tiller development of fly infested-wheat seedlings is an important plant trait relative to grain yield. 'Monon' tillered more than 'Newton' at the 0 infestation level (control). 'Monon' had about the same number of tillers at 0, 1, 2, and 3 puparia (indicative of the number of feeding larvae) per plant; and 'Newton' had fewer tillers at 0 than 1, 2, or 3 puparia per stem. However, tillering of both cultivars was less at 4 or more puparia per stem, perhaps due to the depletion of plant nutrients. In general, for both cultivars there was a decrease in leaf length, number and wet weight as the number of puparia increased per tiller.

Wheat, *Triticum aestivum*, is not as susceptible to damage by phytophagous arthropods as many other crops. It is a very resilient crop, and usually produces secondary tillers (shoots or stems). Wheat usually has eight tiller buds, but typically only three or four develop into full sized tillers (Williams et al. 1975). A few winter wheat tillers develop in the autumn or winter, but more tillers appear under warm spring temperatures (Simmonds 1987). Kirby (1983) noted that the main shoot and early formed tillers (those formed when leaves 4 to 6 emerge on the main shoot) are most likely to complete development and form grain.

An arthropod may feed on the primary tiller and destroy it, while later-developing tillers may be undamaged and produce seeds. Like other grasses, wheat can compensate for damage or injury by producing more stems per unit of area (tillering), seeds and/or heavier seeds per head, and heads per plant (Schlehuber & Tucker 1967). Wheat is thus very adaptable and tolerant of insect attack and rarely requires insecticide treatment. In dollar value in the United States in 1984 it ranked fourth among crops in acreage (Anon. 1984), while in insecticidal usage it ranked tenth (Anon. 1988).

Both biotic and abiotic conditions influence tillering. Studies of the tillering process or the production of additional culms in the Gramineae have focused primarily on cultivar differences and the effects of a wide range of

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environmental factors. The physiology of tillering has been investigated by studying the effects of various growth substances and inhibitors (Williams et al. 1975, Williams & Langer 1975). In barley, *Hordeum vulgare*, a reduction of auxin depressed tillering; however, an application of auxin naphthaleneaceticacid (NAA) to plants with destroyed apexes increased tillering (Leopold 1964).

Little information is available about the interaction of insect numbers and wheat tillering. Multi-tillering wheat varieties may tolerate heavier infestations of the wheat bulb fly, *Delia coarctata* (Fall/n), but this represents greater pest survival in the following season (Oakley 1980).

Successful Hessian fly, *Mayetiola destructor* (Say), larval infestation of the main stem usually results in stem death, and may result in the production of tillers. The economic threshold values for the Hessian fly in Central Europe are 1 to 6 larvae per plant (Wetzel and Freier 1981) and 20% larval infestation of stems in North America (Hill et al. 1943). If the infestation is severe, young plants do not tiller, but wheat cultivars that tiller freely survived better (Barnes 1956). The main resistance mechanism of wheat to the Hessian fly is larval antibiosis, resulting in the death of young larvae due to their inability to maintain sustained feeding (Gallun 1965, Shukle et al. 1990); the resistant plant continued to grow with little evidence of the previous insect infestation. However, Hessian fly biotypes able to overcome host plant resistance are becoming common.

Two cultivars that differed in tillering were evaluated under known Hessian fly puparia (larvae) numbers under controlled growth chamber conditions to evaluate the relationship between Hessian fly numbers and wheat tillering, leaf length, fresh weight, and leaf numbers.

MATERIALS AND METHODS

Test Plants. 'Newton' (less tillering) and 'Monon' (greater tillering compared to 'Newton') were selected for study, as they were found previously to differ in their tillering response under controlled conditions (authors unpublished data). 'Monon' (H3 gene for resistance, but susceptible to biotype L) and 'Newton' (H0, susceptible) seeds were germinated in moist vermiculite in single seed containers. Seedlings of each cultivar were transplanted after 5 to 7 d to soil in 24 pots (10 cm diameter), three plants per pot, and held at 15°C at 14:10 (L:D) photoperiod. The plants were provided with Hoagland's solution once weekly and watered when needed. The experiment was replicated four times.

Test Insects. Biotype L Hessian flies virulent to all Hessian fly resistant commercial cultivars currently deployed were used in this study. Hessian flies were originally collected from Indiana wheat fields and maintained by the USDA, ARS Insect and Weed Control Research Laboratory, Purdue University. In general, 26 pots per cultivar, 3 plants per pot were planted and 24 pots with plants 7 days in age were infested with biotype L Hessian flies. This design was replicated four times. Seven days after planting, virulent biotype L Hessian flies were placed to oviposit for 2–7 h on 'Monon' and 'Newton' caged wheat seedlings with the duration of oviposition dependent upon the the number of eggs observed per plant. The number of eggs per plant were recorded the day after oviposition, and if more eggs than 5–10 were found per plant, the excess eggs were removed with a brush, so that the eggs laid on plants of the two cultivars were about equal. The numbers of puparia (indicative of the previous larval infestation), tillers, and the total plant length from

Table 1. Tillering and other plant responses of 'Newton' and 'Monon' winter wheats to biotype L Hessian fly larval feeding

No. of Puparia	No. of Eggs	Puparia per Egg (%)	No. of Plants	Aerial plant responses: Tillers no.	Length mm.	Weight mg.	Leaves no.
			'Monon'				
0	0 d	0 f	24	3.8ab	343a	2056a	10.7a
1	4.7c	31.7d	57	3.8a	280b	1457b	10.2a
2	6.0b	42.5c	32	3.8a	271bc	1448b	9.9a
3	6.3b	52.2c	27	3.4ab	252cd	1113c	8.2b
4	6.7b	65.8ab	26	3.3bc	229e	834d	7.3c
5	8.9a	58.0bc	10	2.7c	238de	959cd	8.0bc
6–8[a]	9.3a	79.6a	12	3.1bc	251cde	1043cd	8.3bc
F-ratios[b]	**41****	**14****		**3***	**32****	**27****	**18****
			'Newton'				
0	0 e	0 e	24	2.6b	336a	1568a	9.0a
1	4.6d	35.4d	55	3.3a	268b	1091b	8.7a
2	5.5cd	46.9c	31	3.4a	251bc	909bc	7.8b
3	5.8c	56.7bc	45	3.2a	243cd	784cd	7.7b
4	7.1b	59.8b	24	2.7b	227e	637e	6.4c
5	6.9b	75.8a	20	2.4b	228de	680de	6.4c
6–13	8.2a	85.7a	31	2.4b	217e	597e	6.3c
F-ratios	**43****	**26****		**7****	**50****	**32****	**20****

Puparia (includes 3rd instars) were removed from the stem 21 d after oviposition.
[a]Monon: 6–8 puparia (mean=6.75), Newton: 6–13 puparia (mean=6.90), no significant difference (t-test).
[b]F-ratios from a oneway ANOVA of larval-damage levels within each cultivar; significance: *, $P \leq 0.05$; **, $P \leq 0.01$.

the crown to apex of the longest leaf per plant were recorded 21 d after oviposition.

Statistical Analysis. A one-way analysis of variance (SPSS 1988) was used to test the effects of different levels of Hessian fly infestation on the two cultivars on a per plant basis relative to number of tillers, number of leaves, plant length and weight. Differences in significance were identified at the $P < 0.05$ and $P < 0.01$ levels and separated by Least Significant Difference Tests.

RESULTS AND DISCUSSION

Based upon the greater values above ground of the four control plant parameters (leaf and tiller numbers, and plant length and weight) measured under controlled conditions, 'Monon' is a more robust cultivar than 'Newton' (Table 1). Both cultivars were susceptible to virulent biotype L larvae; within each cultivar, the number of tillers and leaves, and plant length in general decreased as the infestation level increased. An exception occurred with the plant weight of 'Monon,' where the greatest weight loss occurred at the four puparia per plant level.

The cultivars differed in their tillering response to similar Hessian fly levels, which are related to the genetics and physiology of the wheat cultivars. The numbers of tillers of 'Newton' were lower at 0, and 3 or more puparia infestation level than at 1–2 puparia per plant, indicating that Hessian fly at the 1 or 2 puparia per plant level promoted tillering in this cultivar. This was different than the tillering response of 'Monon'. For 'Monon' within the 0 to 3

Table 2. Analysis of variance of tillering and other plant responses to winter wheat cultivars 'Newton' and 'Monon' to biotype L Hessian fly larval feeding.

Sources of Variation	df	No. of Eggs F	P	Puparia per Egg in % F	P	df	Plant Response: No. of Tillers F	P	Length mm F	P	Weight mg F	P	No. of Leaves F	P
Cultivar	1	6.5	*	5.3	*	1	33.0	**	17.5	**	146.2	**	96.9	**
Puparia	5	29.6	**	32.3	**	6	7.3	**	86.6	**	73.2	**	31.9	**
Cultivar-Puparia Interaction	5	1.3	NS	1.1	NS	6	0.3	NS	1.0	NS	1.7	NS	1.9	NS
Replicate (Date)	3	7.7	**	8.2	**	3	7.1	**	33.9	**	69.1	**	33.9	**

Puparia levels: 0, control; 1, 2, 3, 4, 5-number of puparia; 6, ≥ 6 puparia. For variables no. of eggs and % puparia/ egg, only puparia levels 1 through 6 were used in the ANOVA, because controls were constant zeros. Plant weight was transformed for homogeneity.

puparia levels, tillering remained constant, but at greater than 3 puparia, there was less tillering.

Although the number of eggs and puparia for both cultivars within each replicate were similar, the percentages of puparia per egg oviposited were greater for all infestation levels on 'Newton' than on 'Monon' (Table 1). The resistance associated with the H3 gene of 'Monon' may have adversely affected virulent biotype L larvae or the 'Monon' plants may have been more tolerant to Hessian fly feeding damage. This may also reflect infestation with an impure Hessian fly biotype. The percentages of puparia per egg were lower than expected, especially at the lower infestation levels.

Stunting of the main stem due to Hessian fly larval feeding might have caused more nutrients to be available for tillering. Thus, Hessian fly feeding not only stopped elongation of both cultivars, but may have also promoted some tillering. Perhaps as the number of larvae (puparia) per plant increased more nutrients were removed (Wellso et al. 1989), and eventually the ability to tiller decreased.

The multiple analysis of variance (Table 2) shows that the cultivars and puparia factors significantly affected all of the parameters examined.' The greatest effect of Hessian fly infestation on both cultivars was on plant wet weight, portraying the detrimental effect of this insect on the growth of infested wheat. There was no significant interaction between cultivar-puparia levels; however, the replications differed significantly due to different egg deposition ranges.

Sosa & Foster (1976) evaluated the resistance of 'Arthur 71', 'Knox 62', 'Monon', and 'Seneca' (H5, H6, H3, and H7H8 genes for resistance, respectively (Gallun 1977) to Hessian fly biotypes GP (Great Plains), B, C, and D at 15 to 27°C. They noted that tillering varied with the Hessian fly biotype, cultivar, and temperature, with most cultivars exhibiting a greater fly infestation and tillering at higher temperatures. Greater tillering could be a potentially important form of tolerance in some cultivars, offsetting fly induced losses. Increased tillering might be particularly beneficial, if used in conjunction with antibiosis.

To use Hessian fly infested wheat as a forage crop because it may have more tillers may not be a valid option, as Buntin & Raymer (1989) noted that low to moderate levels of Hessian fly damage reduced wheat forage yield primarily by reducing tiller size and weight rather than tiller density.

This experiment establishes that the response of wheat to virulent Hes-

sian fly damage varied relative to the capacity of the cultivar to tiller. If an insect such as the Hessian fly infests and destroys the main stem, tillering becomes an important response for wheat survival. Tillering of these two cultivars varied in response to infestation of similar numbers of Hessian fly puparia (larvae), and plants that tiller more at lower infestation levels may have a survival and yield advantage.

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