5 March 1991
JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY
63(4), 1990, pp. 646-648

Resistance of Endophyte-Infected Plants of Tall Fescue and Perennial Ryegrass to the Russian Wheat Aphid (Homoptera: Aphididae)[1]

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ABSTRACT: Fewer aphids of the Russian wheat aphid, (Mordvilko), were found on tall fescue and perennial ryegrass plants harboring systemic fungal endophytes than on endophyte-free plants in laboratory tests. These results indicate that enhanced resistance in some perennial grasses to ***D. noxia*** is associated with the presence of endophytic fungi.

Fungal endophytes (family Clavicipitaceae, tribe Balansiae) occur intercellularly in the leaf and stem tissues of grasses and sedges (Diehl, 1950). Some endophytes protect grasses from grazing livestock by producing poisonous chemicals. Moreover, recent work has shown that interactions between some grasses and their insect herbivores are mediated by endophytic fungi (Clay, 1988). Among aphid species, ***Rhopalosiphum padi*** (L.) and ***Schizaphis graminum*** (Rondani) (Homoptera: Aphididae) were shown to be adversely affected by the principal tall fescue (*Festuca* ***arundinaceae*** Schreb.) endophyte, ***Acremonium coenophialum*** Morgan-Jones and Gams (Johnson et al., 1985; Latch et al., 1985).

A new and very serious threat to wheat and barley in the United States is the Russian wheat aphid, ***Diuraphis noxia*** (Mordvilko) (Homoptera: Aphididae), or 'barley aphid' as it is called in some parts of the world (Stoetzel, 1987). The objective of this laboratory study was to determine if endophyte-infected plants of tall fescue and perennial ryegrass (***Lolium perenne*** L.) are resistant to ***D. noxia.***

MATERIALS AND METHODS: Aphids used in tests (conducted October 1988–June 1989) were from colonies established from aphids collected in a commercial barley field near Prosser, Washington (Prosser colony), and in a ***Hordeum*** spp. germplasm nursery, Pullman, Washington (Pullman colony), in summer of 1988. Each laboratory colony was maintained on 'Steptoe' barley and all tests were conducted in environmental chambers maintained at 22 ±1°C with a photoperiod of 14: 10 (L:D).

Seed of perennial ryegrass and tall fescue was obtained from R. E. Welty (USDA-ARS, Corvallis, Oregon) and Jacklin Seed Co. (Post Falls, Idaho). Assessments of endophyte presence in seed and leaf sheaths of individual plants were made microscopically using methods described by Welty et al. (1986a, b). Plants used in tests were examined for endophytes when they were 7-9 weeks old.

Tests 1-4: Aphids were exposed to 'Arid' tall fescue or 'Repell' perennial ryegrass seedlings grown from endophyte-infected and endophyte-free seed (Table 1). For each test, alternating rows of seedlings from two seed lots (seedlings grown from infected and uninfected seed) of tall fescue or perennial ryegrass were established in a greenhouse flat (25 × 33.8 cm) filled with a standard soil mix to 7 cm. Ten rows of 10 seedlings or eight rows of 16 seedlings were established with uniform spacing. When seedlings were 12-14 days old (4-10 cm tall), barley leaves heavily infested with aphids were placed between rows to allow aphids to crawl to seedlings. The Prosser colony supplied aphids for tests 2 and 3, and the Pullman colony was the aphid source for tests 1 and 4. Soil in each experimental flat was water saturated at the start of each test. Live aphids on the seedlings were counted after 4 (tests 2 and 3) or 5 (tests 1 and 4) days.

Tests 5-7: Plants for tests 5 and 6 were grown in white plastic Supercells® (Ray Leech Conetainers, Canby, Oregon) (3.8 × 20.6 cm) placed in holding racks positioned over trays filled with water. Test plants were randomly arranged in the racks. Clear plastic tubes (3.6 × 30 cm) fitting tightly into the cells were used to confine the aphids. When the plants were 8 (test 5) and 2 (test 6) weeks old, 15 late-instar to adult apterous aphids were transferred with a camel's hair brush to the base of each plant. There were eight plants of each treatment group (infected or uninfected plants of 'Repell' perennial ryegrass) and 10 plants of each treatment group (infected or uninfected plants of 'Forager' tall fescue)

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Accepted for publication 30 May 1990.

Table 1. Numbers of *noxia* on groups of endophyte-infected and endophyte-free plants 4–5 days after aphid infestation.

Test no.	Source of aphids	Grass species	Treatment groups (% infected seed)	Number of aphids[b]
1.	Pullman, Wash.	Tall Fescue	Infected (48)	169*
			Uninfected (0)	447
2.	Prosser, Wash.	Tall Fescue	Infected (48)	527*
			Uninfected (0)	1057
3.	Prosser, Wash.	Tall Fescue	Infected (48)	667*
			Uninfected (0)	1171
4.	Pullman, Wash.	Perennial Ryegrass	Infected (9 1)	88*
			Uninfected (0)	153

[a] Values based on 150 seeds per lot.

[b] For comparisons among treatment groups, aphid counts for the replicates (rows) were pooled.

* Values significantly different ($P < 0.001$). Chi-square values (d.f. = 1) exceeded critical value of 10.827.

in tests 5 and 6, respectively. Plants for test 7 were grown individually in 15 cm pots in a greenhouse (15–29.4°C; natural photoperiod). For this test, six endophyte-infected and six uninfected plants of 'Repell' perennial ryegrass were 14 weeks old when they were infested by placing three aphid-infested barley leaves on each plant. Plants were placed in contact with each other so aphids could move freely between plants. The number of live aphids on each plant was recorded 6 days after infestation in tests 5-7.

Data from tests l-4 were analyzed with a Chi-square test and data from tests 5-7 were evaluated using one-way ANOVA.

RESULTS AND DISCUSSION: Aphid numbers were significantly greater ($P < 0.001$) on tall fescue and perennial ryegrass seedlings grown from endophyte-free seed than from endophyte-infected seed in tests 1–4 (Table 1). Seed infection percentages were less than 100% for the infected treatment group of each species; therefore, some aphid counts undoubtedly were taken from uninfected plants or escapes in these infected treatment groups. In test 5, the number of aphids found on uninfected plants of 'Repell' perennial ryegrass was 1.38 ± 0.71 ($\bar{x}$ ± SEM). By contrast, no aphids were found on endophyte-infected plants. In test 6, uninfected and infected plants of 'Forager' tall fescue averaged 58.30 ± 11.68 and 0.50 ± 0.31 aphids/plant, respectively (F = 208.89; d.f. = 1,18; P = 0.001). In test 7, the mean number of aphids found on uninfected and infected plants of 'Repell' perennial ryegrass was 20.50 ± 4.21 and 2.83 ± 0.48, respectively (F = 17.39; d.f. = 1,10; P = 0.001).

In summary, the results indicate that endophyte-free plants of tall fescue and perennial ryegrass are more suitable host plants for the Russian wheat aphid than are endophyte-infected plants. Moreover, these results provide evidence that some perennial grasses may be naturally resistant to *D. noxiu* and that a group of naturally occurring fungi could be of great potential in controlling this pest. Whether this enhanced resistance in endophyte-infected plants is a result of the presence of a feeding deterrent or a toxic factor has not been determined.

ACKNOWLEDGMENTS: We thank R. E. Welty and D. G. Lester for their general assistance with this study.

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