Control of Wheat Streak Mosaic Virus with Vector Resistance in Wheat

T. J. Martin, T. L. Harvey, C. G. Bender, and D. L. Seifers

Wheat breeder, entomologist, and plant pathologists, respectively. Fort Hays Branch, Kansas Agricultural Experiment Station, Hays 67601. Current address of third author, Dept. of Plant Science, South Dakota State University, Brookings 57007.

Contribution 84-263-J, Fort Hays Branch, Kansas Agricultural Experiment Station and Department of Entomology, Kansas State University.

This research was partially supported by the Kansas Wheat Commission.

Accepted for publication 14 March 1984.

ABSTRACT

Martin, T. J., Harvey, T. L., Bender, C. G., and Seifers, D. L. 1984. Control of wheat streak mosaic virus with vector resistance in wheat. Phytopathology 74:963-964.

Resistance to the wheat curl mite (WCM), *Eriophyes tulipae*, derived from cultivar Salmon wheat, reduced the incidence of wheat streak mosaic by 58% in naturally infested wheat nurseries in 1979, 1981, and 1982. The transmission of wheat streak mosaic virus (WSMV) to WCM-resistant KS80H4200 was reduced by 74% compared to WCM-susceptible cultivar Sage in greenhouse seedling tests. Reduced transmission of WSMV to WCM-resistant cultivars coupled with WCM control in WCM-resistant volunteer wheat should give effective levels of WSM control.

Wheat streak mosaic (WSM) is one of the most destructive diseases of wheat (*Triticum aestivum* L.) in the Great Plains region. Estimates of losses caused by wheat streak mosaic virus (WSMV) in Kansas include 816×10^6 kg in 1974 (9) and 571×10^6 kg in 1981 (12). Cultural practices recommended to reduce WSM losses are planting late and destruction of volunteer wheat, the major oversummering host for WSMV and its vector, the wheat curl mite (WCM) (*Eriophyes tulipae* Keifer) (13). These procedures are not always effective. In western Kansas many wheat producers do not follow either of these recommendations because volunteer wheat often is used for winter grazing and planting date usually is dictated by the availability of soil moisture rather than WSM control considerations.

Wheat cultivars with reliable WSMV resistance levels are not available. Low levels of resistance exist in several cultivars under certain conditions (6), but in many years these cultivars are damaged severely. High-level WSMV resistance was transferred to wheat from two *Agropyron* species (5,11). Due to genetic linkage between WSMV resistance and undesirable agronomic characteristics from *Agropyron*, adapted WSMV resistant cultivars have not been developed.

Control of WSMV with WCM resistance has not been investigated previously. WCM resistance is present in *Agropyron* (4) and rye (*Secale cereale* L.) (2). The WCM resistance from rye (8) is carried by the wheat-rye translocation cultivar, Salmon (14). Salmon does not have sufficient winter hardiness to survive most winters in Kansas. Therefore, it has been difficult to evaluate the effectiveness of WCM resistance in controlling WSMV under natural epiphytotics.

In 1979 and 1981, we were able to collect infection incidence data on WCM-resistant Salmon derivatives in our breeding nurseries and in 1982 from small observation plots grown at 26 locations in western Kansas. The WCM resistance reduced the incidence of WSMV compared to that in the WCM-susceptible cultivar Sage. The reduced incidence of WSMV in WCM-resistant cultivars was confirmed in greenhouse seedling tests.

MATERIALS AND METHODS

Moderate levels of WSM occurred in wheat breeding nurseries at Hays, KS, in 1979. Within one of these nurseries, segregating lines from the cross Sage/Salmon were growing in single 3-m rows. Each line was replicated three times, as was the WCM-susceptible parent Sage and the WCM-resistant parent Salmon. One of these segregates, KS78H1054, was identified previously as homozygous resistant to WCM and therefore, it was the only Sage/Salmon derivative for which WSM incidence had been determined. The WCM reaction for the remaining lines was unknown. Total number of plants in each row was determined by direct count. The number of WSMV-infected plants in each row was recorded in late May.

In 1981, WSM again occurred in the breeding nurseries at Hays. The incidence of WSM was determined on four replications of both WCM-resistant and -susceptible lines. The WCM-resistant lines were derived from the cross Sage/Salmon/3/Larned/Eagle//Sage. There were 10 WCM-resistant lines in the 1981 nursery. Data are presented for KS80H4200 only, because it was representative of all WCM-resistant lines and was used in the 1982 tests. KS80H4200 was released as germ plasm in 1982 by Kansas State University in cooperation with USDA-ARS (7). All cultivars used in these tests are susceptible to mechanical inoculation with WSMV (6).

In early September of 1981, small observation plots consisting of one 5-m row each of Sage and KS80H4200 were planted at 26 locations in Western Kansas. The plots were seeded adjacent to well established volunteer wheat. In late May of 1982, the incidence of WSM was determined on the center 2.5 m of each row. The plants in this area were removed with crowns intact, individual plants were separated, and the number of healthy and infected plants was counted.

Infected plants of each cultivar were examined visually for WCM symptoms. To determine if the WCM adapted to or reproduced on WCM-resistant plants, 10 WSMV-infected plants of each cultivar were retained from each of three locations. Leaves of each plant were cut into 2-cm pieces and placed on 10 seedlings each of Sage and KS80H4200 (6 days after planting). The test seedlings were grown in 10-cm-diameter plastic pots. A clear glass lamp chimney enclosed the seedlings and leaf clippings. The top of the chimney was covered with four layers of cheesecloth. The leaf clippings dried slowly, allowing the WCM to leave clipped leaves and infest the seedlings. WCM symptoms on the seedlings were easily recognized and recorded after 10 days of incubation in the greenhouse at 24 C.

To test the effect of resistance to WCM on WSMV transmission in the greenhouse, individual adult viruliferous WCM were transferred to Sage and KS80H4200 seedlings. Details of WCM culture and transfer techniques were as previously reported (2,8). Infested plants were incubated in a 24 C greenhouse for 12 days before being examined for WSM symptoms. The test consisted of four replications with 75 plants infested per cultivar for each

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

TABLE 1. Incidence of wheat streak mosaic (WSM) in wheat curl mite (WCM)-susceptible and -resistant cultivars resulting from natural WCM infestations

Cultivar	WCM reaction	WSM incidence (%)[a]		
		1979	1981	1982
Sage	S	32 a	14 a	52 a
Salmon	R	9 b	7 b	···
KS78H1054[b]	R	15 b	···	···
KS80H4200[c]	R	···	5 b	21 b

[a] Means followed by the same letter are not significantly different, $P=0.05$.
[b] F_4 selection from the cross Sage/Salmon.
[c] F_5 selection from the cross Sage/Salmon/3/Larned/Eagle//Sage.

replication. Each replication was infested on different days.

Data from all tests were arc sine transformed and statistically analyzed with a two-way analysis of variance.

RESULTS

In the Hays breeding nurseries in 1979 and 1981, the incidence of WSM was reduced significantly in WCM-resistant cultivars compared to WCM-susceptible Sage (Table 1). In 1982, only three of 26 locations had more than 5% WSM in Sage. The 1982 data in Table 1 are the means of those three locations where Sage ranged from 61 to 35% infected. The WCM-resistant cultivars averaged 58% less WSM than Sage during the three test years.

WCM were not recovered from 30 WSMV-infected KS80H4200 plants from the 1982 tests. All 30 infected Sage plants yielded WCM. No WCM symptoms were found on the KS80H4200 assay seedlings, but WCM symptoms did appear on the Sage assay seedlings.

Greenhouse tests where single viruliferous WCM were transferred to each Sage and KS80H4200 seedling resulted in 39 and 10% WSMV infection, respectively. Probability of a significant difference between the two cultivars was 0.01.

DISCUSSION

WSMV transmission was reduced in WCM-resistant cultivars. The WCM resistance derived from Salmon did not inhibit all WCM feeding activities, and feeding resulted in transmissions of WSMV to WCM-resistant plants, although transmission efficiency was reduced. It is not known if the WCM resistance is the result of antibiosis or nonpreference. WCM were not recovered from WSMV-infected WCM-resistant plants. This indicates WCM did not adapt and reproduce on the resistant plants in the field. It is impossible to determine the stability of the WCM resistance until large acreages of WCM-resistant cultivars are grown. The potential for adaptation by the WCM has been demonstrated in greenhouse tests (1). However, WCM that adapted to new hosts in these tests could not readily return to the original host. This may indicate that WCM adapted to this resistance may not be able to readily return and reproduce on our currently susceptible cultivars.

The greenhouse seedling test confirmed the results of the field tests. This is important because the seedling test allows evaluation of other sources of WCM resistance, including unadapted germ plasm. Natural epiphytotics of WSM are very unpredictable and we have had little success in inducing natural infection in the field. This is exemplified by the fact that in 1982 only three of 26 locations resulted in over 5% WSM in WCM-susceptible cultivars.

Since difficulties are encountered with WSM cultural control practices and with development of WSMV-resistant cultivars, WCM resistance offers a promising means of WSM control. WCM resistance should reduce WSM incidence in fall-planted wheat by reducing transmission from the incoming WCM populations. Further control should be achieved by the suppression of WCM populations in WCM-resistant volunteer wheat.

Disease control through the use of resistance to an insect vector has not often been documented. This subject was effectively reviewed by Kennedy in 1976 (3). Documented cases of disease control with insect vector resistance have involved either leaf hopper, planthopper, or aphid transmitted diseases. There are at least 15 diseases transmitted by eriophyid mites (10). This is the first report of resistance to an eriophyid mite controlling a plant disease.

LITERATURE CITED

1. Del Rosario, M. S., and Sill, W. H., Jr. 1965. Physiological strains of *Aceria tulipae* and their relationship to the transmission of wheat streak mosaic virus. Phytopathology 55:1168-1175.
2. Harvey, T. L., and Livers, R. W. 1975. Resistance to wheat curl mite, *Aceria tulipae* Keifer, in rye and wheat-rye addition lines. Environ. Entomol. 4:523-526.
3. Kennedy, G. G. 1976. Host plant resistance and the spread of plant viruses. Environ. Entomol. 5:827-832.
4. Larson, R. I., and Atkinson, T. G. 1973. Wheat-Agropyron chromosome substitution lines as sources of resistance to wheat streak mosaic virus and its vector, *Aceria tulipae*. Pages 173-177 in: Proc. 4th Int. Wheat Genet. Symp., Columbia, MO.
5. Lay, C. L., Wells, D. G., and Gardner, W. S. 1971. Immunity from wheat streak mosaic virus in irradiated Agrotricum progenies. Crop Sci. 11:431-432.
6. Martin, T. J. 1978. Procedures for evaluating wheat streak mosaic virus resistance. Plant Dis. Rep. 62:1062-1066.
7. Martin, T. J., Harvey, T. L., Bender, C. G., Seifers, D. L., and Hatchett, J. H. 1983. Wheat curl mite resistant wheat germplasm. Crop Sci. 23:809.
8. Martin, T. J., Harvey, T. L., and Livers, R. W. 1976. Resistance to wheat streak mosaic virus and its vector, *Aceria tulipae*. Phytopathology 66:346-349.
9. Niblett, C. L., Heyne, E. G., King, C. L., and Livers, R. W. 1974. Controlling wheat streak mosaic. Kansas Agric. Exp. Stn. Keeping Up With Research. 7. 3 pp.
10. Oldfield, G. N. 1970. Mite transmission of plant viruses. Ann. Rev. Entomol. 15:343-380.
11. Sebesta, E. E., and Bellingham, R. C. 1963. Wheat viruses and their genetic control. Proc. 2nd Int. Wheat Genet. Symp., Lund, Sweden, 1963. Hereditas Suppl. 2:184-201.
12. Sim, T. 1981. Summary of plant disease conditions in Kansas in 1981. Pages 26-30 in: 65th Annual Report and Farm Facts, Kansas State Board of Agriculture.
13. Slykhuis, J. T. 1955. *Aceria tulipae* Keifer (Acarina:Eriophyidae) in relation to spread of wheat streak mosaic. Phytopathology 45:116-128.
14. Zeller, F. J. 1973. IB/IR wheat-rye chromosome substitutions and translocations. Pages 209-222 in: Proc. 4th Int. Wheat Genet. Symp., University of Missouri, Columbia.