Effect of Soil Fumigation on Occurrence and Damage Caused by Soilborne Wheat Mosaic

M. G. EVERSMEYER, Research Plant Pathologist, USDA, ARS, Department of Plant Pathology, W. G. WILLIS, Professor, Department of Plant Pathology, and C. L. KRAMER, Professor, Division of Biology, Kansas State University, Manhattan 66506

ABSTRACT

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Areas of commercial fields showing only light symptoms of soilborne wheat mosaic averaged 6.6–87.9% increase in yield compared with areas with more severe symptoms in 1975. Soil fumigation of areas of 30 × 12 m in fields known to be heavily infested with wheat soilborne wheat mosaic virus with 48.8 g/m^2 66% methyl bromide and 33% chloropicrin increased wheat yields as much as 1,208% in 1977–1979. Reestablishment of soilborne wheat mosaic symptoms in fumigated plots is discussed.

Soilborne wheat mosaic virus (SBWMV), vectored by the fungus *Polymyxa graminis* Led., is the incitant of soilborne wheat mosaic (SBWM) of winter wheat (*Triticum aestivum* L.). SBWM can significantly reduce wheat yields in the central Great Plains (1,2,4,8,10). Significant reductions in yield have occurred annually in the eastern two-thirds of Kansas. Early spring temperatures below 15–17 C are a major factor in determining the magnitude of yield reduction caused by SBWM, although field topography, soil moisture, cultural practices, and wheat cultivars grown all influence SBWM severity.

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Several experimental methods have been used to determine yield losses caused by SBWM (1–3, 5–10). This study reports on yield reductions measured by comparison of paired plots in areas of a field showing severe symptoms (⩾5 on a scale of 0–9) (2) and light symptoms (⩽2) and paired fumigated and unfumigated plots in SBWM-infested areas. Reestablishment of SBWM symptoms in fumigated plots is discussed.

MATERIALS AND METHODS

Paired plots for comparison of yield reductions in severely infested and slightly infested areas of commercial fields and county agent variety trials were established in 1975. Areas with light and severe SBWM symptom expression (2) in early April 1975 were selected for disease development and yield determinations in eight central and south central Kansas counties. Plots selected for paired comparisons in each field were nearly identical for wheat production, with the exception of SBWM intensity. Four replicates of 1.5-m^2 plots of cultivars recommended for the production area were harvested for yield determination. Two to 11 cultivars were sampled in each of the eight counties. Disease severity estimates on a 0–9 scale (2) were obtained for the four replicates. Head counts per square meter, 1,000-kernel weight (KW), and yield measurements based on hectares (kg/ha) for each plot were made at harvest.

To assess the influence of soil fumigation on SBWM, five plots were established in the Kansas counties of Riley, Harvey, McPherson, and Sumner in wheat fields known to be heavily infested with the vector SBWMV. Areas of 30 × 12 m were fumigated 2–3 wk before wheat planting with 48.8 g/m^2 of 66% methyl bromide and 33% chloropicrin (Dowfume MC-33) inserted under a 4-mil polyethylene tarp. Tarps were removed after 48–72 hr. Wheat (*Triticum* *aestivum* L. em Thell.) cultivars Eagle (CI 15068) and Newton (CI 17715), susceptible and resistant to SBWMV, respectively, were planted in fumigated and adjacent unfumigated plots in 1976–1978. Disease observations were recorded on a 0–9 scale (2). Number of tillers and/or heads per square meter were obtained after emergence and at harvest. Yield estimates were obtained by harvesting areas of 1.2 × 6 m in fumigated and unfumigated plots. Residual effects of soil fumigation on disease incidence and yield were observed.

RESULTS

Average yield differences between lightly vs. severely SBWM-infected paired comparison variety plots ranged from 87.9% on Triumph 64 to 28.5% on Danne. The average percent yield increase for the most prevalent cultivars, Triumph 64, Scout, Eagle, and Centurk, was 52.6%. Comparisons of the average percent yield increase, KW, and number of heads per square meter and the difference in SBWM severities observed on the various cultivars sampled during 1975 in central and south central Kansas are given in Table 1. Significant differences among treatment means were calculated according to the new Duncan's multiple range test at the 0.05 level in all comparisons. The early-maturing cultivars (ie, Triumph 64) were more severely damaged by SBWM than the later-maturing cultivars (ie, Eagle), which seemed to recover from the SBWM infection and produce higher yields. Lightly infected areas yielded 10.7% greater KW and contained 28.2% more heads than severely infected SBWM areas, but the relative ranking of cultivars changed between locations.

Comparisons of the average percent yield increase, KW, and number of heads from paired plots in fumigated and unfumigated areas during 1977–1979 are given in Table 2. Fumigation prevented development of SBWM symptoms in all but one of the 1977 plots (Table 2). One plot showed fumigation carryover effects, taller fall growth, and increased plant numbers in the 1978 crop. Another plot that was flooded during the summer of 1977, however, was reinfected and SBWM was severe in 1978.

Fumigation increased average yields on plots planted to Eagle (SBWM susceptible) from 1,228 to 1,942 kg/ha (58%) and plots planted to Newton (SBWM resistant) from 2,536 to 3,028 kg/ha (19%) at five locations for 2 yr. In 1978, after plot fumigation in the fall of 1977, Eagle yielded 2,641 and 2,157 and Newton 4,738 and 4,657 kg/ha in fumigated and unfumigated areas, respectively, at one location.

DISCUSSION

Temperatures remained below average for an extended period during the spring of 1975. Severity of SBWM infection in Kansas was estimated in April 1975 by an aerial survey. The percentage of wheat acreage infested at that time was very close to the percentage of acreage estimated by ground-survey estimates in April and May. Based on acreage data from six Kansas crop-reporting districts and the SBWM surveys, we estimated more than 370,000 ha of wheat were moderately to severely damaged by

Table 1. Average percent increase in yield, 1,000 kernel weight (KW), and number of heads per square meter in wheat from areas showing severe SBWM symptoms and areas showing slight symptoms in central and south central Kansas in 1975

	Percent increase[x]				
Cultivar	Yield (kg/ha)	KW (g)	Heads (no./m²)	Difference in SBWM rating[x]	Percent increase per unit SBWM[y,z]
Triumph 64	87.9 a	15.0 ab	16.1 bcd	6	14.7 abc
Tam 101	67.9 b	25.5 a	20.7 abcd	6	11.3 bcd
Eagle	64.5 bc	9.2 b	40.9 ab	4	16.1 bcd
Centurk	56.8 bc	11.0 b	14.8 bcd	6	9.5 cde
Cloud	47.1 cd	12.3 b	7.5 cd	4	11.8 bcd
Scout	32.4 de	13.1 b	50.4 a	6	5.4 e
Danne	28.5 de	6.7 bc	12.0 bcd	2	14.2 abc
Buckskin	19.1 ef	−3.9 bc	36.2 abc	1	19.1 a
Homestead	6.6 f	−4.6 bc	5.3 d	1	6.6 de

[x] Means in each column followed by the same letter were not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[y] Difference in SBWM rating on the paired plots. Rating was on a 0–9 scale, where 0 = no symptoms and 9 = heaviest.
[z] Values were obtained by dividing percent yield increase by the SBWM rating difference.

Table 2. Response of wheat to soil fumigation with 66% methyl bromide and 33% chloropicrin at a rate of 48.8 g/m² in 1976–1979

Location	Year		SBWM rating[x]		Plants/m² (fall)		Heads/m (harvest)		Plants/m² (following yr)[y]		Yield[z] (kg/ha)		Yield increase
Cultivar	Fum.	Crop	Fum.	Control	Fum.	Control	Fum.	Control	Fum.	Control	Fum.	Control	(%)
Riley													
Newton	1976	1977	1	3	34	34	121	95	38	38	1,801	1,445	4.1
Eagle	1976	1977	3	9	32	26	131	18	35	29	968	74	1,208.1
Harvey													
Centurk	1976	1977	2	6	29	29	184	144	32	31	3,233	2,379	35.9
McPherson													
Eagle	1976	1977	0	3	34	34	174	162	32	29	2,473	1,922	28.7
Sumner													
Newton	1977	1978	0	0	32	30	186	164	21	21	3,152	2,688	17.3
Eagle	1977	1978	0	3	29	24	145	140	...	...	2,312	1,458	58.6
Sumner (Corbin)													
Newton	1977	1978	0	0	34	31	131	110	32	32	2,984	1,982	50.6
Eagle	1977	1978	0	2	33	28	121	112	...	...	1,976	1,519	30.1
Kiowa (Haviland)													
Newton	1977	1978	0	0	23	30	131	135	37	35	2,454 a	2,527 a	(2.9)
Eagle	1977	1978	0	1	21	29	110	130	...	...	1,539	1,653	(7.4)
Harvey (Hesston)													
Newton	1977	1978	0	2	33	31	133	114	32	31	2,466	1,908	29.2
Eagle	1977	1978	1	5	31	25	124	110	33	32	1,828	934	95.7
Riley (Hartner)													
Newton	1977	1978	0	1	43	40	141	120	42	40	4,738 a	4,657 a	1.7
Eagle	1977	1978	0	3	32	30	132	94	32	30	2,641	2,157	22.4
Harvey (Hesston)													
Newton	1978	1979	1	2	30	20	168	160	30	29	2,043	1,129	81.0
Eagle	1978	1979	2	8	26	18	150	137	28	25	1,895	773	145.1
Riley (Hartner)													
Newton	1978	1979	0	1	32	31	171	157	31	30	4,274	3,837	11.4
Eagle	1978	1979	2	5	29	24	160	109	26	22	2,843	2,224	27.8

[x] Rating was on a 0–9 scale where 0 = no visible symptoms and 9 = heaviest symptoms.
[y] Plant density taken the year after fumigation with chloropicrin.
[z] Means within each cultivar-year-location combination not followed by a letter were significantly different ($P = 0.05$) according to Duncan's multiple range test.

SBWM in 1975 (*unpublished*).

Greatest damage in 1975 occurred in the major wheat-producing counties in central Kansas. SBWM was observed in Gray and Finney counties in southwest Kansas, however, which was further west than previously reported. Symptom expression was observed in all areas of many fields instead of the typical low drainage area pattern. The pattern of SBWM development observed in 1975 indicated soil in all but the western three tiers of Kansas counties was infested with vectors carrying SBWMV.

There are several possible reasons for this apparent spread of SBWM: 1) SBWM symptoms may have been diagnosed previously as nitrogen deficiency, 2) increased acreages of susceptible cultivars (Eagle, Scout) may have allowed the vector and virus to increase to epidemic proportions, and 3) planting susceptible grain sorghum cultivars in a crop-rotation system may have caused an increase in the vector or virus by serving as a reservoir.

Severe symptom expression was evident in paired comparison plots selected for this study, but no correlation between the amount of SBWM symptom expression and percentage yield increase was observed. We believe this to be associated with cultivar/environment interactions. Significant variation in yield increase was observed among different cultivars.

Reduction of SBWM symptom expression by soil fumigation was accomplished by using 48.8 g/m^2 of 66% methyl bromide and 33% chloropicrin during 1976–1978. Our results compare favorably with earlier fumigation studies (8).

SBWM was the only obvious serious disease in the Riley County plot during 1977 through 1979. Therefore, yield differences from either fumigation treatment or resistant cultivars were probably due to SBWM infection. Newton (resistant) yields, however, were increased in some years from fumigation indicating: 1) Newton's resistance does not provide total control, 2) fumigation provided some other stimulus, or 3) other pathogens were controlled.

Losses from SBWM in Eagle (susceptible) were quite erratic, ranging from almost total loss in 1977 to only 14% in 1979. This variation apparently is related to effects of differing early spring temperatures each year. Temperatures continually below 15 C probably permit SBWMV multiplications to keep ahead of wheat growth. Periods with temperatures above 15 C, which encourage rapid wheat growth, tend to minimize losses. Specific temperatures, wheat growth stages, and the actual mechanism of this phenomenon have not been precisely documented.

Residual effects on yield the year after fumigation were minimal. Such effects of fumigation were reflected in lack of substantial yield differences and reappearance of severe SBWM symptoms in plots fumigated for the previous crop year. There also appears to be a trend toward yield reduction in plots fumigated 2 yr before the crop year, but this needs verification by future studies.

Areas fumigated in the spring supported denser stands of wheat in the fall than unfumigated areas did (Table 2), but the percent increase in plant-stand varied between years and locations. The residual effect of fumigation was more evident in fields that were not flooded or when tillage practices did not cause soil to be transported over the fumigated area.

Reappearance of SBWM symptoms in fumigated areas was extremely variable among locations, cultivars, and year combinations. Symptom expression was high in plots seeded 1 or 2 yr after fumigation, but disease severity, as measured by yield, varied from significantly higher to significantly lower than the controls in different experiments. This indicates a season-to-season residual effect of fumigation. Although the reason for variability in reappearance of symptoms among fields are not clear, it could be due to tillage practice, topography, virus strains, or some other factor.

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