MONOCOTYLEDONOUS AND LOCAL LESION HOSTS OF THE WHEAT STREAK-MOSAIC VIRUS

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B.S., Howard University, 1953

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Botany and Plant Pathology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

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INTRODUCTION

The Wheat Streak-Mosaic Virus is a disease of unknown origin. During the spring of 1929, McKinney's (3) attention was called to a mosaic which occurred on occasional wheat plants in the nurseries at Manhattan, Kansas. In 1931, his attention was again called to mosaic in the wheat plants in the Agronomy farm near Manhattan. Studies made then by McKinney indicated that the mosaic could be transmitted from plant to plant by means of needle inoculations with juice from the diseased plants. In 1949 (10) Kansas experienced a devastating outbreak of mosaic. Since that time the best efforts of several virus authorities and specialists in Plant Pathology have been devoted to the task of retarding its spread and of devising methods for its control. Losses due to this disease show that the virus is among the most threatening diseases of wheat in the country.

Other experiments have been conducted by plant pathologists interested in the effects of wheat streak mosaic virus on monocotyledonous plants (4), (6), (9), (15). Dicotyledonous plants from many families have been inoculated by manual methods by Sill and Connin (12) who concluded that they were symptomless and probably immune. The author has conducted experiments in the greenhouse with a wide range of monocotyledonous and a few dicotyledonous plants to confirm results of past experiments, to add to the host range and possibly to discover more local lesion hosts which might be suitable for quantitative virus assays.

REVIEW OF LITERATURE

Characteristics of Wheat Streak-Mosaic Virus

The nature of the virus is still unknown. Evidence indicates the infective particle to be so small that it is visible only through a high magnification of the electron microscope. However, when introduced into a susceptible host, it is capable of multiplying very rapidly and causes a diseased condition. The wheat plant may be infected any time during its growing period in the fall or spring but experiments have shown that only plants infected when young are hurt badly by the disease. The later the plant is infected during its life, the less the virus affects it (14).

Overwintering diseased wheat plants are the source from which the virus may spread to other plants and to spring wheat crops. The virus also overwinters and oversummers in some perennial grasses and volunteer wheat plants. Dead leaves from infected plants or dead infected plants or dead infected stubble harbor no virus either in the field or at room temperatures. The virus has been found to be infective for 21-30 days at room temperature when the green leaf is air dried, for eight months when kept at 4°C and for seventeen months when the green leaf is desiccated with calcium chloride and kept at 4°C (13).

Since experimental evidence was consistently negative for transmission through seed or soil, attempts were made to find an insect vector responsible for the spread of the mosaic virus. Various types of plant-feeding insects collected in wheat crops severely infected with mosaic were tested. Occasionally a small number of test plants became infected in experiments with most of the insects, but the evidence was not conclusive. Slykhuis (15) examined naturally infected wheat plants with a hand lens and with a low power microscope and revealed the presence of a tiny mite of the genus *Aceria* in the family Eriophyidae. Pieces of mosaic-infected leaves bearing the mites were placed adjacent to young wheat plants in the greenhouse. As the pieces of mite-bearing leaves dried, the mites migrated to the living plants. Within a day, he observed that margins of the leaves of some of the plants were curling upward and eventually some of them were tightly rolled. Chlrotic streak-mosaic symptoms also developed later. By manual methods, he succeded in transmitting mosaic from some of the plants showing streak symptoms thereby concluding that the mite, *Aceria tulipae* K .was the vector of the wheat streak-mosaic virus. Evidence accumulated later, that natural transmission is carried out by the Eriophyid mite, *Aceria tulipae* (15)

As the intensive search for a vector for the wheat streak mosaic virus progressed, Fellows et al (2) having in mind that some insects and other pests feed above and others below the soil surface, tested the leaves, crowns, and roots of both dormant and actively growing wheat plants for the presence of the virus and to obtain an approximate idea of the relative concentrations. It was thought that a low concentration or absence of the virus in one or more tissues might suggest the elimination of certain pests as probable or possible vectors. Two to three leaf wheat plants were inoculated by the carborundum rubbing method with yellow streak extracts. Infection from leaves of infected field plants, both dormant and those starting active spring growth, was 100 percent in all trials. Crowns and roots from dormant plants gave no infection but from plants starting spring growth 20 and 10 percent infection from crowns and roots, respectively, was obtained. One hundred percent infection resulted from the crowns of mosaic infected greenhouse plants two months old and only 16 percent from the roots. From those that were three weeks old, there were 35 percent infection from the crowns and 15 percent from the roots. Infection always approached 100 percent when leaves of greenhouse grown diseased plants were utilized. Natural transmission from plant to plant via the roots was investigated and negative results were obtained. They concluded that the low virus concentrations found in the roots, the apparent absence of natural root transmission, and the typically slow movement of exclusively root feeding wheat pests suggested that these appear to be less probable vectors for the virus than those feeding above the soil line.

Hosts

In both the spring of 1948 and 1949, McKinney (5) received collections of mosaic leaf tissue from several points in the hard red winter wheat area. He inoculated each collection into several wheat test plants at Beltsville, Maryland. Bromegrass, Golden Giant sweet corn and sugarcane seedlings were also grown in the greenhouse. The sugarcane seedlings were from seed of a selfed hybrid, Otabeite x C.P. 1161. Bromegrass and sweet corn seedlings were inoculated when they reached the second or third leaf stage. The sugarcane seedlings were inoculated when they were six to eight inches tall. The corn and sugarcane seedlings were inoculated by wiping both sides of the leaves with a gauze pad dipped in the inoculum containing carborundum. McKinney's experiments resulted in the virus inducing local chlorotic lesions on the sugarcane but no systemic infection. There was no sign of infection on Bromegrass. In wheat, the symptoms consisted of mild green mottling and/or yellowish mottling and streaking in the foliage. In sweet corn the leaves developed yellow spots and/or small rings. None of the seedlings were killed.

In 1949, McKinney (6) made a collection of varieties of wheat, barley, oats, and corn; grew them in small population in the greenhouse and inoculated them with the wheat streak-mosaic virus. He also included several wheat varieties in the test. Temperatures were maintained as near 60° to 65°F as possible during the winter but the temperatures gradually increased as the test continued through early spring. This test consisted of 39 representatives of wheats and wheat relatives, five varieties of winter barley, 24 varieties of oats and 21 varieties of field and sweet corn. The summary of the result of this test is shown in Table 1.

In 1951, McKinney and Fellows (8) devised a method suitable for rapid, large scale inoculations with the wheat streak-mosaic virus. The inoculum consisted of 80 grams of fresh turgid mosaic wheat leaves and 1440 cc of water. The tissue was clipped and chopped. The juice and chopped tissue were added to 720 cc of water and filtered through double surgical gauze. The residue was put in the Waring Blendor with the remaining 720 cc of water and the blendor was operated for two minutes. The contents were then filtered through gauze. The two batches of liquid were combined. Carborundum or celite was added to this product. When small populations were inoculated by dipping the thumb and index finger into the liquid and rubbing over the leaves, excellent results were obtained. With large populations, the inoculum was applied to the plants by means of a DeVilbiss type AG spray gun at approximately 30 pounds per square inch pressure. In each type of application, excellent results were obtained.

In 1951, Slykhuis (16) tested the following "weed grasses" as possible hosts of wheat streak-mosaic virus; Setaria glauca, S. viridis, Echinochloa crusgalli, and Panicum capillare. Of these S. viridis, which was abundant in most fields and was frequently observed with mosaic symptoms, was proven repeatedly to be carrying a virus which was rapidly transmitted to wheat by the carborundum rub method and proved to be the same virus. In reciprocal tests in the greenhouse, the yellow streak-mosaic and the green streak mosaic of wheat were transmitted to 50 to 100 percent of S. viridis plants that were inoculated in the two to three leaf stage. He concluded that it appeared probable that S. viridis provided a method of perpetuating viruses between harvest and the emergence of volunteer and fall sown wheat and that winter wheat thus infected in the fall can harbor the virus over winter.

Up until December 1953, the following were recorded as making up the known host range (12).

Table 1. The following crop plants produced reactions as indicated, when inoculated with wheat streak-mosaic virus.

Crop	Reaction	Authority
Wheats	A	McKinney, Sando, Slykhuis
Barley	B	McKinney, Slykhuis, Sill
Rye	B	McKinney, Slykhuis, Sill
Oats	B	McKinney, Slykhuis
Corn	C	McKinney, Fellows, Sill
Italian Millet	D	Slykhuis
Sorghum	E	Slykhuis, Fellows, Sill
Sugarcane	F	McKinney

Key to reactions.

A. Susceptible
B. Most - symptomless. Few - mild symptomless. Some - symptomless carriers.
C. Few - susceptible. Many - symptomless or immune.
D. Symptomless or immune.
E. All tested - immune.
F. Local chlorotic lesions.

Table 2. Annual grasses listed as susceptible to the wheat streak-mosaic virus.

Scientific name	Common name	Authority
Aegilops cylindrica	Jointed goatgrass	McKinney, Fellows
A. triuncialis	Barb goatgrass	McKinney, Fellows
Bromus japonicus	Japanese chess	McKinney, Fellows
B. secalinus	Cheat	Slykhuis
B. tectorum	Downy chess	Slykhuis, Sill
Digitaria ischaemum	Smooth crabgrass	McKinney, Fellows
Echinochloa crusgalli	Barnyard grass	Slykhuis, Connin
Eragrostis cilianensis	Stink grass	Slykhuis
Hordeum sp.	Yurasaki mochi	McKinney, Fellows
H. gussonianum	Mediterranean barley	McKinney, Fellows
Panicum capillare	Tickle grass	Slykhuis, Connin
Setaria verticillata	Bur bristle grass	Slykhuis
S. viridis	Green foxtail	Fellows, Sill
Cenchrus pauciflorus	Sandbur-Symptomless carrier	Connin

Table 3. The perennial grasses reported to be susceptible to the wheat streak-mosaic virus are as follows:

Scientific name	Common name	Reaction	Authority
Bouteloua hirsuta	Hairy grama	C	McKinney
Elymus canadensis	Canada wild rye	LCM	McKinney
E. condensatus	Giant wild rye	LP	McKinney
E. virginicus	Virginia wild rye	M	McKinney
Eragrostis trichodes	Sand lovegrass	M	McKinney
Oryzopsis hymenoides	Indian ricegrass	CP	McKinney
Poa bulbosa	Bulbous bluegrass	LM	McKinney
P. compressa	Canadian bluegrass	MP	McKinney
Stipa robusta	Sleepy grass	M	McKinney

Key to reactions.

L. Local lesions.
C. Symptomless or symptomless carrier.
M. Mosaic Symptoms.
P. Ohly part of population showing symptoms.

Table 4. Grasses reported to be naturally infected in the field with the wheat streak-mosaic virus.

Scientific name	Common name	Authority
Aegilops cylindrica	Jointed goatgrass	McKinney
Bromus japonicus	Japanese chess	McKinney
B. tectorum	Downy chess	Slykhuis
Cenchrus pauciflorus	Sand bur	Sill
Echinochloa crusgalli	Barnyard grass	Slykhuis
Eragrostis cilianensis	Stinkgrass	Slykhuis
Panicum capillare	Ticklegrass	Sill
P. dichotomiflorum	Fall panicum	Sill
Setaria viridis	Green foxtail	Fellows
Elymus virginucus	Virginia wild rye	McKinney
Sitanion hystrix	Squirreltail	Sill

Table 5. Grasses recorded as immune to the wheat streak-mosaic virus.

Scientific name	Common name	Authority
Agropyron cristatum	Crested wheatgrass	Slykhuis
A. dasystachyum	Thickspike wheatgrass	Slykhuis
A. desertorum	Desert wheatgrass	Slykhuis
A. elongatum	Tall wheatgrass	Slykhuis
A. inerme	Beardless wheatgrass	Slykhuis
A. intermedium	Intermediate wheatgrass	Slykhuis
A. repens	Quackgrass	Slykhuis
A. smithii	Western wheatgrass	Sill
A. trachycaulum	Slender wheatgrass	Slykhuis
A. trichophorum	Stiffhair wheatgrass	Slykhuis
Andropogon gerhardi	Big bluestem	Connin
A. scoparius	Little bluestem	Connin
Bouteloua	Grama grass	Connin
Bromus inermis	Smooth brome	Slykhuis
Festuca rubra	Red fescue	Slykhuis
Panicum virgatum	Switchgrass	Connin
Phalaris arundinaceae	Reed canarygrass	Slykhuis
Phleum pratense	Timothy	Slykhuis
Poa pratense	Kentucky bluegrass	Slykhuis
Sorghastrum nutans	Indiangrass	Connin
Sorghum halepense	Johnsongrass	Connin
Avena fatua	Wild oats	Slykhuis
Eleusine indica	Goosegrass	Sill
Hordeum jubatum	Wild barley	Slykhuis
Setaria lutescens	Yellow foxtail	Slykhuis

Control

McKinney and Sando (9) concluded that plants expressing local lesions may possess high resistance in the field, with the manifestation requiring further studies since the control value of the local lesion reaction in some species depends on the genotype, and on the environmental conditions, particularly temperature. High resistance in certain Agropyron x Triticum crosses has been found but much work will be required before desirable commercial wheat varieties resistant to mosaic will be available to the farmers since the final solution to the problem of this plague probably depends on resistant varieties. No tolerant or resistant wheat varieties have been reported as yet. Further evidence obtained indicates that certain cultural practices may prove valuable in controlling this virus disease. One of the most important appears to be a carefully chosen date of seeding. From the results of experiments that have been conducted, in order to escape as much fall infection as possible in areas where mosaic is a menace, winter wheat should be planted as late as sound agronomic practices permit. Certain sanitary measures may also be of considerable importance in controlling this disease. The control of volunteer wheat and weeds as well as clean tillage practice before winter wheat is planted in the fields should aid considerably in reducing primary infection of the new winter wheat.

MATERIALS AND METHODS

A wide variety of crop plants, grasses, monocotyledonous plants, and a few dicotyledonous plants, all of which were presumably virus free, were collected from various sources. Dr. Kling Anderson and Dr. Robert Pickett, both of Kansas State College, provided seeds of some grasses. Dr. E. V. Abbott, Agricultural Research Service, U.S.D.A., Houma, Louisiana, and Dr. B. A. Belcher, Agricultural Research Service, U.S. D.A., Canal Point, Florida, and Dr. S. J. P. Chilton, Department of Plant Pathology, Louisiana State University, furnished both sugarcane seeds and cuttings. Varieties of monocotyledonous plants were obtained from Dr. O. H. Elmer of Kansas State College, as well as from the Department of Botany and Plant Pathology and the Horticulture Department of Kansas State College. Dr. A. L. Hooker, Iowa State College, provided some corn varieties. Edwin James, Agriculture Research Service, U.S.D.A., Regional Plant Introduction Station Experiment, Georgia, furnished varieties of Euchlaena mexicana and Panicum. Dr. Max W. Hoover, Primary Plant Introduction Station, Ames, Iowa provided corn varieties, Dactylis collections and sorghums. Dr. R. H. Painter, Kansas State College, Department of Entomology, provided several monocotyledonous plants. Dr. Lloyd Tatum of Kansas State College furnished Kansas corn varieties, and H. H. McKinney provided Golden Giant sweet corn. The Salina strain (4) of wheat streak-mosaic virus was used in the experiments.

The method of disease transmission chiefly adopted was sap inoculation. The inoculum was prepared by grinding the leaves of infected wheat plants to a fine pulp with a small amount of water in a mortar and pestle, into which some carborundum was added to act as an abrasive. The liquid was collected, diluted with water to approximately a ratio of 1 to 25, and the pulp was discarded. Utensils, and fingers were sterilized by first washing well with soap and water and then with 95 percent ethyl alcohol. To avoid inactivation of the virus, the ethyl alcohol was removed by prolonged rinsing in water. Plants to be inoculated were grown under controlled greenhouse conditions at an average temperature of 70°F. The infectious sap was rubbed with enough pressure over the surface of the leaves so that the epidermis of the inoculated leaves was injured slightly but not enough to cause lethal injury to the leaf or to the parenchymatous cells beneath. This procedure achieved entrance of the virus with minimum leaf injury. In each experiment, two plants of each species and variety tested were set aside as uninoculated controls. One pot of wheat plants was inoculated each time also, to test the virulence of the inoculum. All inoculated plants were observed for at least one month before attempts were made to reisolate the virus from them. With slow growing plants two to four months were allowed to elapse.

EXPERIMENTAL RESULTS

Initially some important Kansas crops and varieties were tested. Ten varieties of corn were inoculated. At least ten days elapsed as the incubation period before mosaic symptoms were visible in the susceptible varieties. The symptoms consisted of faint chlorotic dashes or streaks running parallel with the leaf veins. Often, there was also a light green coloration. The variety Golden Giant Sweet Corn developed local lesions, which eventually coalesced and became systemic. All others in which symptoms were observed, proved to be systemically infected. The varieties of corn tested as well as the results obtained are listed in Table 6. Healthy wheat plants were then inoculated with extracts from the infected corn plants and the results obtained were all positive except for the varieties 1639 and Country Gentleman. These showed no symptoms and carried no infectious virus. One plant of the Midland variety finally developed only diffuse symptoms after two months. All controls remained symptomless.

Table 6. Reaction of several corn varieties to inoculation with wheat streak-mosaic virus.

Variety	No. of plants inoculated	No. of plants infected	Percentage of infection
1639	8	-	-
1830	8	1	13%
2234	8	3	38%
Country Gentleman	8	-	-
DDF2	8	2	25%
Dakota White	8	4	50%
Falconer	7	1	14%
Golden Giant Sweet Corn	7	4	57%
Midland	8	1	13%
Pride of Saline	8	2	25%

Six varieties of oats were inoculated in the same manner and the result was 100 percent systemic infection (Table 7). In this case, all the varieties developed diffuse pinkish coloration after the original diffuse mottling. Infection on the whole was mild.

Table 7. Oats varieties found susceptible to the wheat streak-mosaic virus.

Variety	No. of plants inoculated	No. of Plants infected	Percentage of infection
Cherokee CI 3327	4	4	100%
Cliton CI 3971	4	4	100%
Fulton CI 0-205	4	4	100%
Kanota CI 3846	4	4	100%
Missouri CI 837	4	4	100%
New Nortex CI 3422	4	4	100%

Four varieties of Barley as well as New Dakold Rye were inoculated and the result was 100 percent systemic infection. All plants developed mild green mosaic symptoms. (Table 8).

Table 8. Varieties of Barley and New Dakold Rye found to be systemically infected by the wheat streak-mosaic virus.

Variety	No. of plants inoculated	No. of plants infected	Percentage of infections
Beecher	4	4	100%
Dicktoo	4	4	100%
Kearney	4	4	100%
Renown	4	4	100%
New Dakold Rye	4	4	100%

The results obtained from testing fourteen varieties of millet (Table 9) indicated that a good percentage of the varieties are susceptible. Variety 183332 was the most severely affected. The yellow-green coloration was very pronounced, coupled with other mosaic symptoms and stunting. Some millets, it was concluded are so susceptible that considerable yield reductions could occur.

Table 9. Varieties of millets found susceptible to the wheat streak-mosaic virus.

Variety	No. of plants inoculated	No. of plants infected	Reaction	Percentage of infection
FC23895	25	25	CS	100%
FC23902	25	-	C	-
163300	25	-	I	-
170588	25	20	MStr	80%
173754	25	-	I	-
173803	25	25	MS	100%
177543	25	25	MS	100%
179037	25	25	StrS	100%
179388	25	25	StrSM	100%
180304	25	12	M	50%
180450	25	20	MSStr	80%
180484	25	5	M	20%
183332	25	25	MSStr	100%
PI195753	25	-	I	-

Key to reactions:

C - Symptomless carrier
I - Probably immune
M - Mottle
S - Stunt
Str - Streak

Five varieties of sorghum tested proved to be probably immune (Table 10) since they developed no symptoms and no virus could be reisolated from the inoculated plants.

Table 10. Sorghum varieties that gave negative result to inoculation with the wheat streak-mosaic virus.

Variety	No. of plants inoculated	No. of plants infected	Percentage of infection
Atlas	8	-	-
Ellis	8	-	-
Martin	8	-	-
Midland	8	-	-
Westland	8	-	-

This negative result was also true of five varieties of Sudan (Tift, K-2, Wheeler, Sweet and Greenleaf), and of <u>Sorghum</u> <u>versicolor</u> and <u>Sorghum</u> <u>almum</u>. For each variety, 25 plants were inoculated.

The inoculation of Agrotricum Nos. 6605 and 95163 gave positive local lesions. Four plants of each variety were inoculated. A few of the infected plants developed a systemic necrosis and died. Some recuperated, continued active growth, and the symptoms largely disappeared. Wheat plants inoculated with extracts from the symptomless agrotricum plants did not contract the disease.

Eight plants of <u>Euchlaena</u> <u>mexicana</u> when inoculated produced not only top necrosis in some plants (Plate I), but also local lesions on a few (Plate II), and systemic symptoms (Plate III) on at least one. The extracts from <u>Euchlaena</u> <u>mexicana</u> were also infectious to wheat plants.

<u>Teosinte</u> <u>guatemala</u>, a variety of <u>Euchlaena</u> <u>mexicana</u>, appeared to be hypersensitive to the wheat streak-mosaic virus. After inoculating four

EXPLANATION OF PLATE I

Euchlaena mexicana when inoculated with wheat streak-mosaic virus produced top necrosis. The plant on the left is normal. The other two are affected.

PLATE I

EXPLANATION OF PLATE II

Effect of wheat streak-mosaic virus on _Euchlaena mexicana_. The leaf on the right is normal. That on the left shows local lesions.

PLATE II

EXPLANATION OF PLATE III

Euchlaena mexicana

The leaf on the left is normal. The other two are systemically infected as the result of inoculation with wheat streak-mosaic virus.

PLATE III

plants, two plants developed top necrosis which killed the youngest leaf in the curl. Teosinte Chalco showed no visible symptoms. However, on inoculating wheat plants with extracts from both varieties of Teosinte, they developed severe symptoms indicating Teosinte to be a symptomless carrier. The following grasses (Table 11) are probably immune since they neither showed symptoms when inoculated with the wheat streak-mosaic virus nor induced symptoms of any kind when their extracts were inoculated later to wheat plants.

Table 11. Grasses found probably immune to the wheat streak-mosaic virus.

Family	Common name	No. of plants inoculated	Scientific name
Gramineae (Grass family)	Sugarcane	30	*Saccharum officinarum*
	Job's tears	8	*Coix lacryma-jobi*
	Tall Oatgrass	25	*Arrhenatherum elatius* F.C. 29367
	Johnsongrass	25	*Sorghum halepense*
	Western wheatgrass	25	*Agropyron smithii*
	Meadow foxtail	25	*Alopecusus pratensis*
	Smooth brome	25	*Bromus inermis*
	Orchard grass	25	*Dactylis glomerata*
		25	*Dactylis* - 189388
		25	*Dactylis* - 184040
		25	*Dactylis* - 174773
		25	*Dactylis* - PI.172879
		25	*Dactylis* - PI.170347
	Guinea grass	25	*Panicum maximum*
	Switch grass	25	*Panicum virgatum*
	Indian grass	25	*Sorghastrum nutans*
	Reed canarygrass	25	*Phalaris arundinacea*
	?	25	*Andropogon ishaemum*
	?	25	*Andropogon hallii*
	?	25	*Andropogon siberium*

The following monocotyledonous plants (Table 12) are also probably immune since they developed no symptoms and no virus could be reisolated from the inoculated plants.

Table 12. Monocotyledonous plants found probably immune to the wheat streak-mosaic virus.

Family	Common name	No. of plants inoculated	Scientific name
Typhaceae (Cat-tail family)	Common cat-tail	6	Typha latifolia
Alismaceae (Water Plaintain family)	Giant arrowhead	6	Sagittaria monte-vidensis
Amaryllidaceae		3	Amaryllis, sp.
(Amaryllis family)	Onion	8	Allium cepa
Iridaceae	Walking iris	6	Iris, sp.
(Iris family)	Gladiolus	8	Gladiolus, sp.
		4	Crocus, sp.
Cyperaceae (Sedge family)	Umbrella plant	4	Cyperus alternifolius
Araceae (Arum family)	Philodendron	4	Philodendron, sp.
Commelinaceae	Wandering jew	8	Zebrina pendula
(Spiderwort family)		4	Rheo discolor
Liliaceae (Lily family)	Madonna lily	6	Lilium candidum
	Lily of the valley	8	Convallaria majalis
	Grape hyacinth	8	Muscari armeniacum
	Ornithogalum	4	Ornithogalum sp.
	Solomon's seal	3	Polygonatum sp.
	Tulip	4	Tulipa sp.
Agavaceae (Agave family)	Bonestring hemp	4	Sansevieria thrsiflora
	Soap weed	4	Yucca glauca
Orchidaceae	Lady slipper	4	Cypripedium, sp.
(Orchid family)	Orchid	4	Orchis, sp.
Musaceae (Banana family)	Banana	2	Musa, sp.
Cannaceae (Canna family)	Canna	4	Canna, sp.

Table 13. The following dicotyledonous plants are also probably immune. They also gave negative results.

Family	Common name	No. of plants inoculated	Scientific name
Piperaceae (Pepper family)	Peperomia	4	Peperomia, sp.
Euphorbiaceae (Spurge family)	Croton	4	Codiaeum viriegatum
	Redbird-cactus	4	Pedilanthus tithymaloides
Crassulaceae (Orpine family)	Bryophyllum	4	Kalanchoe, sp.
Moraceae (Mulberry family)	Rubber plant	4	Ficus elastica

DISCUSSION

The results obtained are in accordance with those obtained by McKinney (6), Sill and Connin (12) and Slykhuis (14), save that the author experimented with a wider range of varieties. The points of disagreement are the reactions of the sugarcane and the New Dakold Rye. McKinney reported that sugarcane (Otabeite x C.P.1161), is a local lesion host, but the author found it to be immune to the yellow strain (Salina) of the Wheat Streak Mosaic Virus. The other varieties used were grown both from seeds and cuttings under controlled greenhouse conditions and inoculated by the usual manual method. They showed no symptoms. They were inoculated again after a period of one month. No symptoms developed neither did their extracts produce symptoms when used in inoculating wheat plants. If McKinney was correct in his observations, there is every possibility that quite a different strain of virus must have been used for his experiments or possibly a very different environment.

Slykhuis reported New Dakold Rye to be immune to the wheat streak-mosaic virus. The author found it susceptible to the strain of the virus used. It developed mild green symptoms and the extracts also induced symptoms when used in inoculating wheat plants.

No varieties of millet tested by Slykhuis (14) developed symptoms. Of the varieties of millet tested by the author, 79 percent, or eleven varieties were susceptible to the wheat streak-mosaic virus. A majority developed visible symptoms while the minority proved to be symptomless carriers. From both groups of plants, however, infective virus was recovered. Only three of the varieties tested were probably immune. The severe symptoms and stunting indicated that some of the susceptible varieties could be badly diseased in the field and that yields could be greatly reduced if the varieties were exposed under favorable conditions for the pathogen.

No dicotyledonous plants have yet been found to be susceptible to the wheat streak-mosaic virus. The results obtained from the few tested agree with the report made by Sill and Connin (12).

SUMMARY

From the results obtained, it can be safely concluded that the wheat streak-mosaic virus is capable of infecting all tested varieties of Oats, Barley, and Rye and some varieties of corn and millet. The characteristic mild systemic infection, the low percentage of infected plants and the consequent apparent immunity of much of the population of the corn varieties tested would suggest first, that common Kansas corn varieties very probably will never be severely hurt by the wheat streak-mosaic virus in the field and second, that breeding for complete immunity, if ever necessary, probably would be a simple genetic problem. Other important Kansas row crops and

grasses such as the various varieties of Sorghum, the Sudan grasses, Smooth brome, Reed canary grass, Western wheat grass, other wheat grasses, and a few other important Kansas grasses are apparently immune to this virus. In the case of Oats, Rye and Barley, there is no evidence yet to indicate that they are hurt appreciably by the disease. Many millets however, were susceptible enough to be regarded as potentially dangerous and under unfavorable conditions for the plants would probably be greatly hurt by the disease. No monocotyledonous plants inoculated outside of the grass family developed the disease. Hence it now appears that the wheat streak-mosaic virus is probably restricted to members of the grass family and further that wheat will probably be the only important crop severely affected in Kansas.

ACKNOWLEDGMENT

The author wishes to express his gratitude to Dr. W. H. Sill Jr., his major Professor for his assistance, criticism and guidance while performing the experiments and suggestions during the preparation of the thesis; and to the staff and members of Botany and Plant Pathology Department for the friendly atmosphere they have created, which greatly contributed to the pleasure of working in the department.

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MONOCOTYLEDONOUS AND LOCAL LESION HOSTS OF THE WHEAT STREAK-MOSAIC VIRUS

by

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B. S., Howard University, 1953

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Botany and Plant Pathology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

The Wheat Streak-Mosaic Virus is a disease of unknown origin. Its frequent occurrence and devastating results attracted the attention of several virus authorities and specialists in Plant Pathology who are now making the best of efforts to retard its spread and devise methods for its control. Losses due to this disease show that the virus is among the most threatening diseases of wheat in the country.

The purpose of the work done in the greenhouse is to confirm the results of past experiments, to add to the host range and possibly to discover more local lesion hosts which might be suitable for quantitative virus assays.

A wide variety of crop plants, grasses, monocotyledonous plants, and a few dicotyledonous plants, all of which were presumably virus free, were collected from various sources.

The method of disease transmission chiefly adopted was sap inoculation. Plants were grown under an average temperature of 70°F. All inoculated plants were observed for at least one month before attempts were made to reisolate the virus from them. With slow growing plants, two to four months were allowed to elapse.

Of the 10 varieties of corn tested, the variety Golden Giant Sweet Corn developed local lesions which eventually coalesced and became systemic. Seven of the varieties were systemically infected and the percentage of infection ranged from 13 to 57 percent. Two varieties proved to be probably immune. Six varieties of Oats tested as well as four varieties of Barley and New Dakold Rye, resulted in 100 percent systemic infection. Infection on the whole was mild. Five varieties of Sorghum, five varieties of Sudan, Sorghum versicolor and Sorghum almum tested for the reaction of the wheat streak-mosaic virus, gave negative results. Of the 14 varieties of millet tested, 11 varieties were found to be susceptible to the wheat streak-mosaic virus. Agrotricum Nos. 6605 and 95163 gave positive local lesions. Euchlaena mexicana produced not only top necrosis but also local lesions on a few and systemic infection on at least one. Euchlaena mexicana var. Teosinte guatemala appeared to be hypersensitive to the virus. It developed top necrosis which killed the youngest leaf in the curl. Euchlaena mexicana var. Teosinte chalco, proved to be a symptomless carrier. Other grasses, monocotyledonous and dicotyledonous plants tested in these experiments gave negative results.

The results obtained from the experiments indicated that wheat streak-mosaic virus is capable of infecting all tested varieties of Oats, Barley, Rye and some Corn and that the characteristic mild systemic infection typical of these would suggest that they very probably will never be severely hurt by the virus. Most of the millets by contrast could be regarded as potentially dangerous. It appears that wheat streak-mosaic virus is probably restricted to members of the grass family and further that wheat will probably be the only important crop severely affected in Kansas.