THE OCCURRENCE OF BARLEY STRIPE MOSAIC VIRUS IN KANSAS AND ITS CONTROL

by

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TABLE OF CONTENTS

INTRODUCTION

Barley stripe mosaic (false stripe) is a disease of barley incited by a seed-borne virus. Seed transmission of virus is rare among grasses, and it is the only known virus disease of grasses which is transmitted by the seed. The disease occurs in most of the barley-growing regions of the United States and Canada. Until recently, the disease was considered to be of minor importance, but it is now known to cause considerable yield reduction in some varieties of barley. Estimates of yield reduction vary from 17 percent (Timian and Sisler, 18) to as high as 65 percent (Hagborg, 7).

The fact that the disease is seed-borne makes control by seed certification possible. However, the occurrence of symptomless carriers among infected plants makes such a control method difficult. Some varieties of barley have been found to have a certain degree of resistance to the virus, but few of the agronomically satisfactory varieties tested so far have good resistance, and chemical and hot water seed treatments have been found to be ineffective in controlling the disease. Therefore, seed certification becomes the control method of immediate interest.

The purposes of this study were to determine the distribution and prevalence of the disease in Kansas, to determine the effect of certain environmental conditions on symptom expression in diseased plants, and to devise a seed certification method which would eliminate the more heavily infected barley seed lots.

REVIEW OF LITERATURE

History

Barley stripe mosaic has been known since about 1910, but it was thought to be a non-parasitic disease until 1951 when it was shown by McKinney (10, 11) to be caused by a seed-borne virus. Because of its resemblance to barley stripe, incited by Helminthosporium gramineum, the disease was called barley false stripe until the causal agent was determined. The disease was first collected in 1913 at the Wisconsin Agricultural Experiment Station by A. G. Johnson, who preserved several specimens which are still in existence (13).

Drayton (3) reported that barley false stripe was collected by Conners in 1924 at the Brandon Experiment Farm in Manitoba, Canada. He described the symptoms as consisting of stripes of necrotic tissue which tended to coalesce and form elongated V's. Experiments were conducted to determine if the disease might be caused by a species of Hetrosporium which was associated with the diseased plants, but the results were negative.

Christensen (1) described several non-parasitic leaf markings in barley in Minnesota. Although he did not mention barley false stripe, it seems likely that some of the conditions described by him were caused by this disease. A brief description of the disease was given by Dickson (2). He believed that the condition resulted in little yield reduction, but he noted that it was of common occurrence in barley.

Wadsworth (19) described a mosaic of barley in Oklahoma,

noting that the condition was caused by a virus which could be manually transmitted. Experiments were conducted to determine if the virus concerned was the wheat streak mosaic virus. He concluded that the virus causing the mosaic condition in barley was distinct from the wheat streak mosaic virus. McKinney (12) later expressed the opinion that the virus found by Wadsworth was probably what is now known to be the barley stripe mosaic virus. In 1951, McKinney proved that barley false stripe is caused by a virus (10, 11), and he changed the name of the disease to barley stripe mosaic. The causal agent was given the name barley stripe mosaic virus.

Distribution and Losses

McKinney (12) is of the opinion that barley stripe mosaic virus is responsible for the "running out" of many varieties of barley, and he found that yield reduction was considerable in diseased plants. Yield tests were conducted by Timian and Sisler (18) using Mars and Manchuria varieties of barley; they found yield reductions of 22 percent in Mars and 17 percent in Manchuria. Eslick (4) reported a five-year average yield reduction of 30 percent in Glacier barley in which about 95 percent of the plants were infected. Hagborg (7) reported a yield reduction of 75 percent in wheat and 65 percent in barley and found that the height of the plant, the kernel weight, and the kernel quality all were reduced by the virus. Eslick and Afanasiev (5) have shown that the stage at which plants are infected influences the yield reduction and the degree of seed transmission.

The disease seems to be common in most of the barley-growing regions of the United States and Canada. Timian and Sisler (18) reported that the disease has been found in most states in the Upper Mississippi Valley. In North Dakota, over 90 percent of the fields inspected by them were found to be infected. Walters (20) found infected fields in Northwestern and Northeastern Wyoming in Frontier, Compana, Spartan, and Glacier varieties of barley, and in Pilot wheat. In most fields observed by him. infection ranged from a trace to five percent, but in one field infection was as high as 25 percent. The disease has also been reported in Canada (3), California (6), Kansas (15), and South Dakota (17).

Host Range of the Virus

The only hosts in which the virus has been found to occur in nature are barley, and on one occasion wheat (Walters, 20). However, several other host plants have been found by artificial inoculation methods. The known host range includes barley, wheat, rye, millet, corn, Chenopodium album, Samsun tobacco, and about 20 wild grasses. Among the grasses infected are smooth brome grass (Bromis inermis) and crabgrass (Digitaria sp.). Infection is systemic in all of the hosts except tobacco and Chenopodium album, in which local lesions are produced. The host range is given by Sill and King (16).

Symptoms

In barley, crabgrass, and smooth bromegrass, the symptoms consist of light yellow to white chlorotic lines or mosaic patterns, and brown stripes occasionally occur in these hosts. The symptoms

in wheat and corn are much the same except that the brown stripe does not occur. The chlorotic patterns tend to be whiter in corn than in wheat. As mentioned previously, local lesions are produced on Samsun tobacco and Chenopodium album. The symptoms have been described by McKinney (10, 13), and others. An early description of the symptoms was given by Conners (Drayton, 3), who noted that the brown stripes tended to form V-shaped patterns on the leaves. This effect was later noted by Hagborg (8), who concluded that the V was a necrogenous reaction which delimited infection on the distal side of the V.

Eslick (4) found that symptom expression in the field varied considerably from year to year. He observed infected plants in the field for a period of five years and found that in some years symptom expression was severe and in other years was almost non-existent.

It has been noted by McKinney (14) and Sill and Hansing (15) that infected plants frequently fail to develop symptoms. In experiments conducted by Sill and Hansing (15), some infected plants developed symptoms only after vernalization, and others never developed symptoms. McKinney (14) found that a low percentage of symptomless carriers occurred in infected plants grown under adequate light and at temperatures of 75° to 100°F.

Transmission

Although the major mode of transmission is by seeds from diseased plants, McKinney (14) has shown that the virus may be transmitted by abrasive contacts between plants and by several other

mechanical means such as handling. Plant-to-plant transmission is probably important in the local spread of the virus in the field. Gold and co-workers (6) have shown that pollen transmission may occur when healthy plants are fertilized with pollen from diseased plants. However, pollen transmission resulted in only a small percentage of infected seeds.

Characteristics of the Virus

McKinney (12) and Sill and Hansing (15) recognized two distinct strains of the virus. One strain, the more severe of the two, infects oats; and the other strain does not. McKinney (12) suggests that other strains, differentiated on the basis of symptoms, may also exist. What appear to be mild and semi-mild strains were isolated by him from Union winter barley.

Gold and co-workers (6) have published electron photomicrographs of what they believed to be virus particles from infected barley. Rod-shaped particles which averaged approximately 30 mu x 130 mu were isolated from leaves, embryos, endosperm, pollen, and unfertilized pistils of infected plants. These particles were found in all infected plants examined, but they were not found in healthy plants.

McKinney (12) has determined the dilution end point of the virus in distilled water to be beyond 10,000 X, and the thermal inactivation point to be about 68°C for 10 minutes. He has also found that the inactivation time of the virus in air-dried leaves is from 35 to 40 days, but when the infected leaves are left on the plant, inactivation of the virus follows closely the death of

the tissue.

Possible Methods of Control

McKinney (14) suggested that the disease might be partially controlled by seed certification. However, he felt that the frequent occurrence of symptomless carriers made such a control method difficult. Attempts to inactivate the virus in the seed have been ineffective. Eslick (4) found that treating infected seed lots with New Improved Ceresan did not significantly reduce infection, and hot water seed treatment was found to be ineffective by McKinney (14). Timian and Sisler (18) found two varieties from the barley world collection (C. I. 3212 and C. I. 3212-1) which have some degree of resistance to the virus, and McKinney (14) found that varieties Titan and Oderbrucker are somewhat resistant. However, few of the agronomically satisfactory varieties tested have shown resistance to the virus.

MATERIALS AND METHODS

Distribution and Prevalence

Winter Barley. In order to determine the distribution and prevalence of the disease in Kansas winter barley, farmers' seed samples from the 1955 Kansas winter barley crop were indexed in the greenhouse for the presence of the virus. The seed samples were obtained from the State Seed Laboratory at Topeka, Kansas. Because of the large number of samples, it was not possible to test all of them at one time. The first test consisted of 57 samples of winter barley and was conducted in November and Decem-

ber of 1955. Twenty-five seeds from each sample were selected at random and planted individually in three-inch pots and arranged on benches in the greenhouse. The seedlings were grown at a constant temperature of 70°F in an unshaded greenhouse for a period of five weeks and observed daily for the appearance of symptoms. Infected plants were removed as symptoms were noted, and the remaining plants were cross inoculated to Pawnee wheat in the three-leaf stage to detect symptomless carriers. Inoculum for cross inoculation was prepared by grinding one leaf from each plant in the sample to be tested in a mortar with about 5 ml water. Fine carborundum was then added to the extract in the mortar, and the mixture was rubbed lightly on both surfaces of the primary and secondary leaves of the plant being inoculated by using the thumb and first finger. The hands were washed with 95 percent ethyl alcohol and rinsed in running tap water between each inoculation, and all equipment was steam sterilized. This method of inoculation is described by McKinney (9). The remaining 49 samples of winter barley were indexed in January and February of 1956. The seedlings were grown under the conditions stated above, except that the temperature varied between 70° and 85°F.

The same samples of winter barley that were indexed in the greenhouse were planted in the field in the fall of 1955, and observations were made in April and May of 1956.

Spring Barley. The 1955 spring barley samples were indexed in the greenhouse in October and November of 1955, using a method different from that used in indexing the winter barley. These samples were grown in greenhouse flats. Four rows were opened in

each flat, and 25 seeds from one sample were planted in one row. Thus each flat contained four seed samples. Using this method, it was possible to test 120 samples simultaneously, using much less space than was used in indexing the winter barley samples. The greenhouse in which the spring barley samples were grown was whitewashed on the east side only during the first three weeks of growth and completely unshaded during the last two weeks of growth. Greenhouse temperatures were maintained near 75°F, but temperatures of 80° and 90°F occurred occasionally. Infected plants were removed as the symptoms were observed, and the remaining plants were cross inoculated to Pawnee wheat.

The spring barley samples were planted in the field and observed in April of 1956, but growth of the plants was so affected by severe drought conditions that satisfactory observations could not be made.

Effect of Light and Temperature on Symptom Expression

In order to determine what environmental conditions were most favorable for the appearance of symptoms in diseased plants, plants from a known infected source were grown under different conditions of light and temperature and observed for the appearance of symptoms.

Effect of Temperature and Low Light Intensity. In this experiment, one group of 46 plants was grown at 60°F, another group of plants was grown at 70°F, and a third group of 72 plants was grown at 80°F. The light intensity in the greenhouse, as measured with a Weston sunlight meter with a quartz filter, varied from 3,000

foot candles at 12 M on overcast days to as high as 10,000 foot candles at 12 M on clear days. However, cloudy days were predominant during this period, and clear days occurred only occasionally. Thus, for the most part, the daylight intensity in the greenhouse was about 3,000 foot candles. The seedlings were grown individually in three-inch pots and observed daily for the appearance of symptoms.

Because the numbers of plants used in the first three groups were small, an attempt was made to repeat the experiment. However, it was not possible to maintain the same greenhouse temperatures as were used in the first experiment. One group of 82 plants was grown at 60°F, and another group of 121 plants was grown at 70° to 85°F. The plants were grown in the manner described above.

In order to determine the effect of light intensities of less than 1,000 foot candles on symptom expression, plants were grown in environmental control chambers lighted with fluorescent and incandescent lamps. The light intensity in the chambers was 800 foot candles, and the photoperiod was maintained at 14 hours. The temperature in one chamber was maintained at 70°F, and the temperature in the second chamber was maintained between 80° and 90°F. The plants were grown in three-inch pots in the chambers for a period of 14 days and observed daily for symptoms. At the end of the two-week period, the plants were moved to an unshaded greenhouse bench where the light intensity reached 10,000 foot candles at 12 M on clear days. The plants were observed for the further appearance of symptoms at the higher light intensity.

The experiment was repeated, using a total of 160 plants at the lower temperature and 139 plants at the higher temperature.

Effect of Temperature and High Light Intensity. This experiment consisted of growing plants at various temperatures and at light intensities which reached 10,000 foot candles at 12 M on clear days. The experiment was conducted during March and April of 1956, and most of the days during this period were cloudless. One group of 92 seedlings was grown under three layers of cheesecloth, the maximum light intensity on these plants being about 4,000 foot candles. Another group of seedlings was grown on an unshaded greenhouse bench at temperatures of from 80° to 85°F, and a third group of seedlings was grown at temperatures which ranged from 80°F at night to as high as 110°F during the day.

EXPERIMENTAL RESULTS

Distribution and Prevalence

Winter Barley. The 106 farmers' seed samples of winter barley tested were from several widely dispersed Kansas counties and were, therefore, a representative sample of the 1955 Kansas winter barley crop. Of the 1,868 plants grown from these samples, 51 were found to be infected with the virus. These infected plants were from 33 samples, and represented three percent of the total number of plants tested. Infection in individual samples ranged from four percent to as high as 29 percent. Since the samples were small, some samples containing a low percentage of infected seeds possibly escaped detection. Infected samples, including variety,

county, Seed Laboratory number, and percentage infection are listed in Table 1. Data concerning individual samples are presented in Table 2. It may be seen from Table 2 that Variety Reno was the most heavily infected variety of those tested, having a mean percentage of infection in infected samples of nine percent and an over-all infection of three percent. Variety Dicktoo was found to have a lower over-all percentage of infection, although the percentage of infected samples was only slightly lower than in Reno. The few samples of Variety B-400 which were tested did not disclose the presence of the virus in this variety. Cross inoculation to Pawnee wheat revealed the presence of only one symptomless carrier in the 106 samples tested. Symptom expression in the field was found to be considerably lower than in the greenhouse.

Plate I shows the distribution of infected samples in the 1955 Kansas winter barley crop. The numbers in the counties represent the total number of infected plants found from the county. It may be seen from Plate I that the disease was distributed throughout Kansas in the 1955 winter barley crop.

Table 1. Percentage of seed infection by barley stripe mosaic[1] virus in Kansas winter barley in 1955.

Variety	County	1955 seed lab. no.	N plants	Percentage infection
Reno	Anderson	489	23	4
"	Chautauqua	3489	13	23
"	Coffey	2929	16	6
"	Dickinson	585	14	7
"	Harvey	1671*	19	11
"	Labette	1116	16	6
"	Osage	3112	17	29
"	Reno	2235	24	8
"	Rice	3596	20	6
"	Riley	435*	17	29
"	Shawnee	3545	23	4
"	Sumner	2300	18	11
"	Woodson	2752	21	5
"	Woodson	3687	21	5
Dicktoo	Atchison	3052*	22	5
"	Decatur	1079*	19	11
"	Dickinson	2780	16	6
"	Franklin	1442*	14	7
"	Geary	246*	21	10
"	Gove	329*	18	6
"	Harper	483*	18	6
"	Kingman	598	18	6
"	Riley	3823	16	12
"	Sherman	1054*	16	6
"	Washington	703*	20	5
Mo-400	Allen	2717	14	7
Winter	Comanche	496	21	5
"	Edwards	2518	17	6
"	Ford	1003	19	21
"	Franklin	2746	19	5
"	Morris	1111	18	6
Mo. Early	Crawford	1736	18	6

*Certified seed lot.

[1]Samples with no infected seeds were excluded from the table.

Table 2. Summary of the occurrence of barley stripe mosaic virus in Kansas winter barley in 1955.

Variety	Reno	Dicktoo	B-400	Miscellaneous	Total
Total number of samples	40	31	9	26	106
Number infected samples	15	11	0	7	33
Percentage samples infected	38	35	0	27	31
Mean percentage infection in infected samples	11	7	0	8	9
Total number of plants	695	548	164	461	1,868
Percentage infected plants	4	3	0	2	3

EXPLANATION OF PLATE I

Distribution of barley stripe mosaic virus in Kansas winter barley in 1955. The figures in the counties refer to the total number of infected plants found.

PLATE I

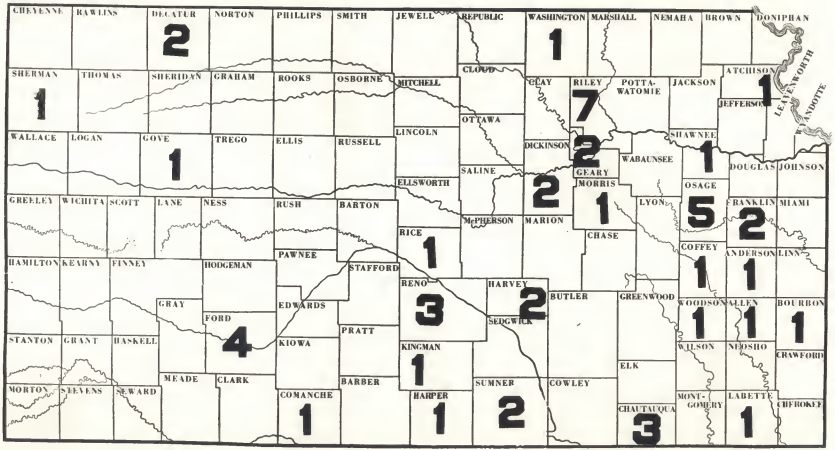

CHEYENNE
RAWLINS
DECATUR
2
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
1
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
1
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
7
POTTA-WATOMIE
JACKSON
ATCHISON
1
JEFFERSON
LEAVENWORTH
WYANDOTTE
WALLACE
LOGAN
GOVE
1
TREGO
ELLIS
RUSSELL
LINCOLN
OTTAWA
DICKINSON
2
SHAWNEE
1
WABAUNSEE
DOUGLAS
JOHNSON
GEARY
SALINE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
ELLSWORTH
2
MORRIS
1
OSAGE
5
LYON
FRANKLIN
2
MIAMI
McPHERSON
MARION
CHASE
RICE
1
COFFEY
1
ANDERSON
1
LINN
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD
RENO
3
HARVEY
2
SEDGWICK
BUTLER
GREENWOOD
WOODSON
1
ALLEN
1
BOURBON
1
GRAY
EDWARDS
FORD
4
PRATT
STANTON
GRANT
HASKELL
KIOWA
KINGMAN
1
WILSON
NEOSHO
CRAWFORD
ELK
MEADE
CLARK
BARBER
SUMNER
COWLEY
MORTON
STEVENS
SEWARD
COMANCHE
1
HARPER
1
2
CHAUTAUQUA
3
MONT-GOMERY
LABETTE
1
CHEROKEE

Table 3. Percentage of seed infected by barley stripe mosaic[1] virus in Kansas spring barley in 1955.

Variety	County	1955 seed lab. no.	N plants	Percentage infection
Flynn	Ellis	9502	21	5
"	Ford	7293	20	10
"	Harvey	9590	17	12
"	Morris	6371	19	5
"	Russell	5199	17	6
Beecher	Cheyenne	6813	20	10
"	Cloud	7540	19	16
"	Dickinson	7873	21	10
"	Dickinson	8158	18	6
"	Ellsworth	7607*	17	12
"	Osborne	8762	20	5
"	Pawnee	9863	19	6
"	Republic	7269	24	4
"	Rice	6444	21	10
"	Riley (KSC)	4826	23	13
"	Washington	8077	22	9
Custer	Dickinson	9312	15	7
"	Osborne	328*	18	6
Early Flynn	Ness	7360	21	10
Spring	Dickinson	6289	20	10
"	Dickinson	7152	19	16
"	Dickinson	7530	19	5
"	Edwards	9593	16	12
"	Edwards	9822	19	11
"	Finney	9448	18	11
"	Ford	5214	14	7
"	Ford	6650	21	5
"	Harper	6383	22	27
"	Jackson	8482	24	8
"	Jefferson	8516	17	29
"	Jefferson	9798	15	20
"	Linn	8917	18	6
"	Lyon	6949	19	11
"	Marion	7728	24	8
"	Mitchell	5626	21	24
"	Mitchell	7841	22	5
"	Osage	6581	18	6
"	Osborne	7163	21	33
"	Pawnee	9026	21	5
"	Pottawatomie	6958	18	11
"	Sedgwick	5846	20	20
"	Thomas	7470	22	9

*Certified seed lot.

[1]Samples with no infected seeds were excluded from table.

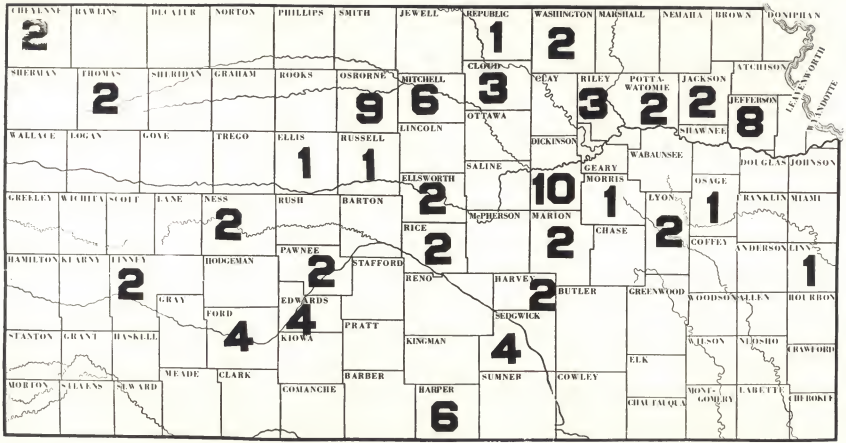
Table 4. Summary of the occurrence of barley stripe mosaic virus in Kansas spring barley in 1955.

Variety	Flynn	Beecher	Custer	Miscellaneous	Total
Total number of samples	14	30	14	62	120
Number infected samples	5	11	2	24	42
Percentage infected samples	36	37	14	39	35
Mean percentage infection in infected samples	8	9	6	13	11
Total number of plants	251	578	285	1,245	2,359
Percentage infected plants	3	4	1	5	4

EXPLANATION OF PLATE II

Distribution of barley stripe mosaic virus in Kansas spring barley in 1955. The figures in the counties refer to the total number of infected plants found.

PLATE II


CHEYENNE
2
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
1
WASHINGTON
2
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
2
SHERIDAN
GRAHAM
ROOKS
OSBORNE
9
MITCHELL
6
CLOUD
3
CLAY
RILEY
3
POTTA-WATOMIE
2
JACKSON
2
ATCHISON
JEFFERSON
8
LEAVENWORTH
WYANDOTTE
WALLACE
LOGAN
GOVE
TREGO
ELLIS
1
RUSSELL
1
LINCOLN
OTTAWA
DICKINSON
SHAWNEE
WABAUNSEE
DOUGLAS
JOHNSON
SALINE
GEARY
MORRIS
10
1
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
2
RUSH
BARTON
ELLSWORTH
2
McPHERSON
MARION
2
CHASE
LYON
2
1
FRANKLIN
MIAMI
RICE
2
COFFEY
ANDERSON
LINN
1
HAMILTON
KEARNY
FINNEY
2
HODGEMAN
2
STAFFORD
PAWNEE
RENO
HARVEY
2
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
EDWARDS
4
FORD
4
PRATT
SEDGWICK
STANTON
GRANT
HASKELL
KIOWA
KINGMAN
4
ELK
WILSON
NEOSHO
CRAWFORD
MEADE
CLARK
BARBER
SUMNER
COWLEY
MORTON
STEVENS
SEWARD
COMANCHE
HARPER
6
CHAUTAUQUA
MONT-GOMERY
LABETTE
CHEROKEE

Spring Barley. Of the 120 samples of spring barley tested in the greenhouse, 42 were found to be infected with the virus. Infection of individual samples ranged from four percent to as high as 33 percent, the average percentage of infection in infected samples being 11 percent. A total of 2,359 plants were grown, and four percent were infected. The infected samples of spring barley, including variety, county, Seed Laboratory number, and percentage of infection are shown in Table 3. Table 4 presents data concerning average infection in infected samples, total number of samples, percentage of samples infected, and percentage of plants infected for the varieties tested. As shown by this table, infection was highest in variety Beecher, in which 37 percent of the samples tested were infected. Variety Flynn was slightly less infected than Beecher, and Custer was less infected than either Beecher or Flynn, having an over-all infection of only one percent. The distribution of the disease in the 1955 Kansas spring barley crop is shown in Plate II, which shows the total number of infected plants found from each county.

Effect of Light and Temperature on Symptom Expression

Effect of Temperature and Low Light Intensity. In this experiment, plants of the same variety and seed lot were grown at 60°, 70°, and 80°F. At 60°F, symptom expression was four percent in one trial and nine percent in a second trial. At 70°F, 17 percent of the plants developed symptoms, and at 80°F, symptoms developed in 13 percent of the plants in one trial and in 16 percent of

the plants in the second trial. Symptom expression in plants grown at 60°F was delayed until 15 days after planting, whereas symptom expression in plants grown at 70° and 80°F began six days after planting. The results of this experiment are shown in Table 5.

Symptom expression in plants grown at 70° and 85°F at 800 foot candles did not differ greatly from symptom expression in plants grown at or near these temperatures at 3,000 foot candles. Symptom expression in the two groups of plants grown at 70°F at 800 foot candles was 15 percent in both groups. When these plants were moved to a higher light intensity of about 10,000 foot candles, additional plants developing symptoms brought the

Table 5. Effect of temperature and low light intensity on symptom expression.

Light	3,000 foot candles				
Temperature	60°F	60°F	70°F	80°F	80°F
N plants	82	46	47	72	121
Days from planting 6	0	0	3	0	4
7	0	0	1	4	3
8	0	0	2	1	5
9	0	0	0	1	4
10	0	0	2	0	1
11	0	0	0	0	2
12	0	0	0	3	0
15	3	0	0	0	0
16	0	2	0	0	0
22	4	0	0	0	0
% symptoms	9	4	17	13	16

total symptom expression to 22 percent in one group and 21 percent in the second group. Symptom expression in plants grown at 85°F at 800 foot candles was 14 percent in one trial and 18 percent in the second trial. When the plants were placed under a higher light intensity of 10,000 foot candles, symptom expression became 22 percent in one trial and 32 percent in the second trial. Table 6 shows the number of symptoms appearing at each temperature, the time of symptom expression, and the total symptom expression after the plants were moved to a higher light intensity.

Effect of Temperature and High Light Intensity. In 93 plants grown at a temperature of 80°F and at a light intensity of about 10,000 foot candles, 27 percent developed symptoms. By contrast, plants grown at the same light intensity but at temperatures of as high as 110°F did not develop symptoms. Of the plants grown at 80°F at 4,000 foot candles, 20 percent developed symptoms. The results of this experiment are presented in Table 7. Figure 1 shows graphically the effect of light and temperature on symptom expression, showing the percentage of infected plants which developed symptoms at various light intensities at 70° to 85°F.

Table 6. Effect of temperature and low light intensity on symptom expression.

Light	800 foot candles			
Temperature	70°F	70°F	85°F	85°F
N plants	92	68	77	62
Days from planting 5	2	0	5	6
6	6	0	6	3
7	6	7	3	0
8	0	3	0	0
10	0	0	0	0
12	0	0	0	0
14	0	0	0	0
% symptoms	15	15	18	14
% symptoms at 10,000 f.c.	21	22	32	22

Table 7. Effect of temperature and high light intensity on symptom expression.

Light	10,000 foot candles		4,000 foot candles
Temperature	80°F	80° to 110°F	80°F
N plants	93	96	92
Days from planting 8	18	0	17
12	7	0	1
22	0	0	0
% symptoms	26	0	20

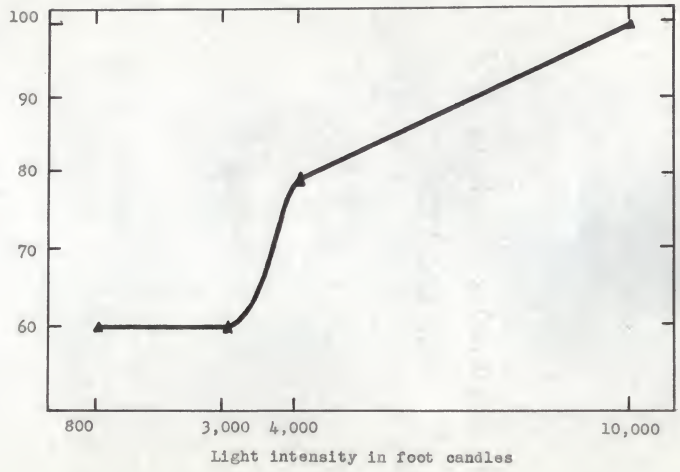


Fig. 1. Percentage of infected plants developing symptoms at various light intensities at 70° to 85°F.

DISCUSSION

Distribution and Prevalence

The data presented show that barley stripe mosaic virus was distributed throughout Kansas in the 1955 winter and spring barley crops. The over-all infection in winter barley was found to be three percent in the samples tested. Individual diseased samples of winter barley had an average infection of nine percent, as compared with an average infection in diseased samples of 11 percent in spring barley. Of the winter barley varieties tested, Reno was found to be the most heavily infected. In this variety, 38 percent of the samples and four percent of the plants were diseased. Variety Dicktoo was slightly less diseased than Reno, having 34 percent infected samples and three percent infected plants. Of the spring varieties tested, Beecher was the most heavily infected. Of the 30 samples tested, 37 percent were infected.

Although the over-all infection in winter and spring barley was not high, infection in some individual samples was as high as 29 percent in winter barley and 33 percent in spring barley. Seed lots containing such high percentages of infected seeds would no doubt result in considerable reductions in yields. Thus, the low over-all infection is not indicative of the loss incurred by individual farmers. However, the figure for over-all infection does give some idea of the total loss in Kansas barley from this disease.

Effect of Light and Temperature on Symptom Expression

That light and temperature exert a considerable influence on symptom expression in infected plants may be concluded from the data presented. Temperatures from 70° to 85°F and light intensities of near 10,000 foot candles were necessary for optimum development in all or most of the infected plants. Temperatures above and below this level and lower light intensities resulted in the more frequent occurrence of symptomless carriers, and the data indicate that at temperatures between 70° and 85°F light is the limiting factor in symptom expression. When plants were grown under favorable light intensity, temperatures below 70°F and above 85° to 90°F inhibited the appearance of symptoms. These results agree in general with those of McKinney (14).

Seed Certification

The method described above for determining distribution and prevalence of the virus in the 1955 Kansas barley crop could be used as a seed certification technique. This method would often fail to detect seed lots which contained only a low percentage of infected seeds, but heavily infected seed lots could easily be detected in this manner. Since several heavily infected seed lots were found, seed certification in Kansas would be valuable, and a program could be developed. The infrequent occurrence of symptomless carriers under the environmental conditions which were found to favor symptom expression would make cross inoculation of the samples unnecessary.

SUMMARY

Farmers' seed samples from the 1955 Kansas winter and spring barley crops were indexed in the greenhouse for the presence of barley stripe mosaic virus. Over-all infection in winter barley was found to be three percent, with an average percentage of infected plants in infected samples of nine percent. Of the 106 samples of winter barley tested, 33 were found to be infected. The over-all infection in spring barley was four percent, and the average percentage of infected plants in infected samples was 11 percent. Of the 120 samples of spring barley indexed, 42 were found to be infected. Reno was the most heavily infected winter variety, and Beecher was the most heavily infected spring variety.

Plants from a known infected source were grown under both low and high light intensities at various temperatures ranging from 60° to 110°F. At temperatures of 70° to 85°F, light was the limiting factor in symptom expression. At high light intensities of about 10,000 foot candles, temperatures below 70°F and above 85° to 90°F. resulted in few, if any, of the plants showing symptoms. The optimum conditions for symptom expression, therefore, were a high light intensity and temperatures between 70° and 85°F.

It is believed that a seed certification technique based on the method used for determining distribution and prevalence could be effectively used to eliminate the more heavily infected barley seed lots. Growing samples of seed lots under the environmental conditions which were found to favor symptom expression would make cross inoculation unnecessary except where a high degree of accuracy is desired.

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THE OCCURRENCE OF BARLEY STRIPE MOSAIC VIRUS IN KANSAS AND ITS CONTROL

by

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Barley stripe mosaic (false stripe) is a disease of barley incited by a seed-borne virus. The disease occurs throughout the barley-growing regions of the United States and Canada, and it is known to cause considerable yield reduction in some barley varieties. Chemical seed treatment and hot water seed treatment are ineffective in controlling the disease, and good resistant varieties have not been found. Since the virus is seed-borne, seed certification could be employed to control the disease. However, the occurrence of symptomless carriers makes such a control method difficult. The purposes of this study were to determine the distribution and prevalence of the disease in Kansas, to determine the effect of certain environmental conditions on symptom expression, and to devise a seed certification method in which the occurrence of symptomless carriers would be at a minimum.

The distribution and prevalence of the disease in Kansas was determined by growing farmers' seed samples from the 1955 Kansas winter and spring barley crops in the greenhouse and observing the plants for symptoms. It was found that the disease occurs throughout the state. The over-all infection in winter barley was three percent, as compared with four percent in spring barley. Of the 106 winter barley samples tested, 33 were found to be diseased. The average infection in infected winter barley samples was nine percent, with infection in some samples being as high as 29 percent. Of the 120 spring barley samples tested, 42 were diseased. The average infection in infected samples of spring barley was 11 percent, with the maximum infection being 33 percent. Reno was the most heavily diseased variety of winter barley tested, and

Flynn was the most heavily diseased spring variety.

Plants from a known infected source were grown under several different conditions of light and temperature and observed for the appearance of symptoms. Symptom expression was highest at light intensities which reached a maximum of 10,000 foot candles during the day and at temperatures of 70° to 85°F. Light intensities of 800, 3,000, and 4,000 foot candles and temperatures below 70° and above 85° to 90°F resulted in lower symptom expression.

It is believed that a satisfactory seed certification program could be developed. Growing plants from seed lots under the conditions which have been found to favor symptom expression would reveal seed lots which contain high percentages of infected seeds, but seed lots which contain low percentages of infected seeds occasionally would be undetected by this method.