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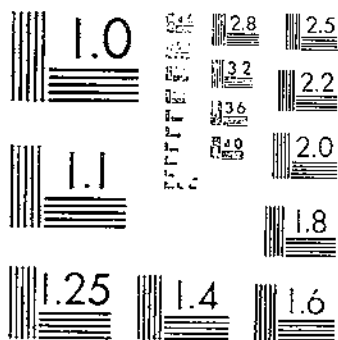
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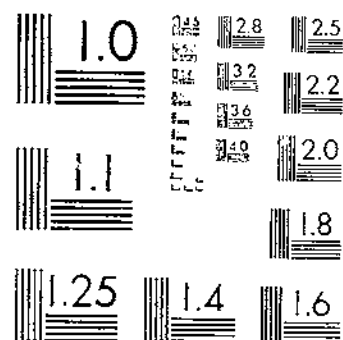
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EFFECTS OF CERTAIN ENVIRONMENTAL FACTORS ON STRIPE DISEASE OF BARLEY
LEUKEL, R. W. DICKSON, J. G. JOHNSON, A. G. 1 OF 1

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UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

EFFECTS OF CERTAIN ENVIRONMENTAL FACTORS
ON STRIPE DISEASE OF BARLEY AND THE
CONTROL OF THE DISEASE BY SEED
TREATMENT¹

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In Cooperation with the Wisconsin Agricultural Experiment Station

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INTRODUCTION

Stripe disease of barley, caused by *Helminthosporium gramineum* Rabh., occurs in nearly all countries where barley is extensively grown. It varies in severity from a mere trace to as much as 75 per cent infection. Drechsler (4)² reviewed the reports of its occurrence up to 1922 in the following countries: Sweden, Denmark, Germany, Netherlands, England, Ireland, Russia, United States, Canada, Argentina, Japan, China, and India. A report from Scotland (1) states that in 1919 the disease was present to some extent in nearly every barley field in Scotland, especially in the 4-row and 6-row varieties.

In 1923 Gram and Rostrup (10) reported its general occurrence in Denmark, but Gram and Thomsen (11), in 1925, and Gram, Jørgensen,

¹ The investigations here reported were conducted by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, in cooperation with the plant pathology department of the Wisconsin Agricultural Experiment Station.

² Italic numbers in parentheses refer to Literature Cited, p. 37.

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and Rostrup (9), in 1928, stated that it was declining in intensity in Denmark as a result of the widespread practice of seed treatment. Wahl (39) reported that stripe disease was severe in Austria in 1925. Porter³ stated in 1926 that it was prevalent in eastern China.

Dorph-Petersen (3) observed in 1926 that out of 500 barley fields in Zeeland (Netherlands) about 50 per cent showed infection. Novák (24) reported in 1926 that stripe disease was of considerable economic importance in Czechoslovakia.

Numerous references to the occurrence of stripe disease are found in German literature. According to Gisevius and Straib (8), heavy infection was observed for a number of years in the Hessian Ried, while in Rhemhessen, a region of extensive barley cultivation, the disease was less in evidence.

The occurrence of stripe disease in Russia was mentioned by Geschele (?), in Tunis by Chabrolin (2), and in Japan by Nisikado (22). Smith and Rattray (36) mention the wide distribution of stripe disease as well as net blotch and spot blotch in South Africa.

While on trips to various countries of Europe and western Asia in 1930 one of the writers (Dickson) made observations on the occurrence of barley stripe disease at various points. The disease was found to be more prevalent in the northern sections of Europe. In the spring-barley sections of the countries along the Baltic Sea and in northern Russia barley stripe disease was considered of major importance. Southward it was much less prevalent except at the higher elevations, as, for example, in the Transcaucasian and Armenian Mountains, where barley was heavily infected with stripe disease at the higher elevations, yet only a trace of the disease was found at the lower elevations, even in the winter-barley sections. The same condition was found in the Balkan States of south-central Europe. The distribution of the disease seemed to be correlated with and largely determined by regional conditions, especially of temperature and moisture.

H. V. Harlan,⁴ of the Bureau of Plant Industry, states that he found stripe disease of economic importance in the various dry-land farming sections along the Mediterranean Sea in western Egypt. He observed very little of the disease in the irrigated sections of Egypt, hardly any in Kashmir, and on the high plateau of Ethiopia it was entirely absent.

As reported by some of the workers previously cited, losses due to stripe disease may, at times, amount to more than 50 per cent. Although losses as severe as this are not common, losses of from 10 to 25 per cent are of frequent occurrence and emphasize the importance of preventing the disease by means of effective seed treatments or the development of immune or highly resistant varieties. Progress in this direction, of course, is aided considerably by a general knowledge of the facts concerning the life cycle of the causal organism and the conditions that favor or inhibit the development of the disease.

NATURE OF THE DISEASE

The fungus that causes the stripe disease of barley was first described by Rabenhorst, in 1857, as *Helminthosporium gramineum*.

³ PORTER, R. H. A PRELIMINARY REPORT OF SURVEYS FOR PLANT DISEASES IN EAST CHINA. U. S. Dept. Agr., Bur. Plant Indus. Plant Disease Rptr. Sup. 46:163-166. 1926. [Mimeographed.]

⁴ In correspondence.

The contributions of various early workers to the general knowledge of this disease and its causal organism are reviewed by Ravn (28), who did considerable research work in this field and definitely distinguished stripe disease from what is known in the United States as net blotch caused by *H. teres* Sacc. (*Pyrenophora teres*). The failure of some of the earlier writers to distinguish definitely between these two barley diseases is ably discussed by Ravn (28) and by Drechsler (4). The latter writer also gives an excellent description of the symptoms of both diseases and of the causal organisms.

Ravn's (28) view, that the life cycle of the stripe-disease fungus is analogous to that of some of the cereal smuts, has been generally accepted until a relatively recent time. The conidia from sporulating lesions on the leaves of diseased plants, according to Ravn, are carried to the heads of healthy plants, where they either infect the embryo or become lodged between the glume and the pericarp of the seed. In the latter case they germinate there and form a mycelial web, which, in a latent condition, carries over the fungus until the seed germinates. At this time the mycelium revives, infects the embryo and eventually the shoots, and keeps pace with the growing points of the infected culms. The leaves and leaf sheaths, according to Ravn, become infected by means of the fungus growing out from the culm. The spores from the lesions on the leaves, of course, are carried to the healthy heads of that crop, and thus the life cycle is completed.

Smith (35) maintains that the coleoptile is the first organ to become infected, that infection proceeds from the inner side of the coleoptile to the first leaf and thus successively from each leaf to the next emerging leaf and from the leaves to the pith of the stems, and that invasion of the growing point results in speedy death of the culm. Furthermore, according to Smith, the mycelium that invades the head of the diseased culm comes from the sheathing base of the uppermost leaf and not from the stem. This is evident, he states, from the fact that—

the diseased areas on the chaffs of the newly emerged ear are precisely those upper and dorsal parts which were in contact with the diseased parts of the enveloping sheath, not the embryonic ends which are tucked in toward the rachis.

He bases his conclusions on a histological study of microtome sections as well as on observations on growing plants. The somewhat earlier results obtained by Vogt (38) agree in the main with those of Smith. Johnson (14) also suggested that in view of the fact that germinating seed can be successfully inoculated without removing the hulls, infection may take place through the coleoptile.

In experiments with Wisconsin Pedigree No. 5 barley, which was infected with loose and covered smuts as well as with stripe disease, it was occasionally observed that rather vigorous but stripe-diseased plants produced heads entirely affected with either loose or covered smuts. This could be interpreted to favor Smith's view, if it may be assumed that the stripe-disease fungus would not harmoniously share the growing point of a culm with either of these smut fungi.

In regard to various other phases of stripe disease, the results obtained or the views expressed by investigators frequently differ. A brief review of some of these follows.

TIME AND MANNER OF INOCULATION

Investigators in general agree that the heads, and therefore the kernels, of healthy plants receive their inoculum in the form of conidia borne primarily by the wind from leaves of diseased plants. Some of the earlier workers believed that flower infection occurred after the manner of loose smut of wheat. At present, however, the generally accepted view is that the conidia lodge near the awn end of the glume, where, under favorable conditions, they germinate, giving rise to a mycelial growth between the glume and the pericarp. This mycelium, in a latent state, is generally conceded to be the main factor in carrying the disease over from one crop to another. Investigators are not entirely agreed, however, as to the time during which head inoculation takes place. Genau (6), for example, states that inoculation of barley flowers with conidial suspension was most successful the day after they opened. He thinks the time for effective inoculation is limited to the blossoming period. Winkelman (40), however, using a different method, secured infection by inoculating the kernels at different periods after flowering time. He believes that even if the spores adhere to the outside of the glume, they may germinate there under favorable moisture conditions, the fungus may penetrate the glume, and the mycelium may spread between the glume and pericarp. Inasmuch as infection of the plants can be brought about by applying mycelium or spores to the outside of the seeds at the time of sowing, it seems reasonable to suppose that inoculation of the kernels of healthy plants in the field may occur for a considerable period. It probably is contingent, to some extent, on suitable conditions of atmospheric moisture and temperature.

LOCATION OF THE FUNGUS IN THE SEED

As may be gathered from the previous paragraph, the consensus of opinion is that the chief agent in carrying the fungus in the seed is the dormant mycelium between the glume and the pericarp. The fact that the disease can be controlled easily by seed treatments other than the hot-water treatment seems to dispose of the probability of mycelium in the embryo, although Ravn (28) contends that the embryo may harbor the fungus. The work of Winkelman (40), Johnson (14), and others suggests that conidia borne on the outside of the kernel may, under favorable conditions, carry over the disease; (although Smith (35) considers the possibility of infection from this source very slight, as does also Fuchs (5)). Kiessling (15) and Van Poeteren (26) claim that they found perithecia of the perfect stage of the fungus on the glumes of barley, and Vogt (38) states that the black sclerotia on the stubble of diseased plants in the fall develop into perithecia of *Pleospora gramineum*. Genau (6) claims that he used ascospores successfully in inoculating plants. However, it does not seem to be generally believed that ascospores play an important rôle as inoculum for stripe disease.

The mycelium that develops beneath the glume evidently penetrates the pericarp to some extent, as is evidenced by the fact that removing the glumes from seeds causes little or no reduction in the percentage of infected plants. From the two seed lots, Fuchs (5) obtained, respectively, 32.4 and 4.5 per cent of stripe-diseased plants from seed with the hulls removed and 32.3 and 4.5 per cent from

normal seed. In a similar experiment, the data for which are shown in Table 1, the writers obtained an average of 17.1 per cent of infection from normal seed, 15 per cent from hulled seed, and 17.1 per cent when the removed hulls were sown with the hulled seed.

TABLE 1.—*Stripe disease in Wisconsin Pedigree No. 5 barley grown in the field from three lots of seed: (1) Hulls not removed; (2) hulls removed; (3) hulls removed but sown with the seed; Arlington Experiment Farm, Rosslyn, Va., 1929-30*

Replication No.	Results from seeds with—								
	Hulls not removed; total plants			Hulls removed; total plants			Removed hulls sown with seed; total plants		
	Grown		Infected	Grown		Infected	Grown		Infected
	Number	Number	Per cent	Number	Number	Per cent	Number	Number	Per cent
1.....	32	19	23.2	46	3	6.5	55	8	14.5
2.....	34	12	14.3	54	10	18.5	53	13	24.5
3.....	78	13	16.6	57	12	21.1	49	7	14.3
4.....	90	13	14.4	55	7	12.5	71	11	15.5
Total.....	334	57	17.1	213	32	15.0	228	39	17.1

Vogt (38) states that the hyphae of the resting mycelium traverse the cells of the inner epidermis of the glume and the outer cell layer of the pericarp. Mycelium was not detected in the interior of the endosperm or in any part of the embryo. He further states that microscopic evidence proves that the mycelium in the pericarp is primarily, if not exclusively, the agent that transmits the disease.

LONGEVITY OF CONIDIA AND SEED-BORNE MYCELIUM

There is some diversity of opinion regarding the length of time during which the conidia of *Helminthosporium gramineum* remain viable. Genau (6) obtained no germination after three and one-half months. Winkelman (40) secured germination of conidia eight months old. Ravn (28) states that spores eight months old germinated sparingly. Fuchs (5) obtained excellent germination for 9 months; after which the viability declined rapidly, so that after 17 months only 5 per cent of the spores germinated. Isenbeck (18) secured 90 per cent germination after 12 months and 20 per cent after 34 months, the spore material being held at a temperature below 5° C. Spores taken from dried barley leaves kept in the laboratory at the Arlington Experiment Farm, Rosslyn, Va. (near Washington, D. C.), failed to show any signs of germination after four months. Doubtless the longevity of the conidia depends upon conditions of temperature and humidity during the period of storage. Since there appears to be some evidence that conidia on the outside of the kernel may perpetuate the disease under certain conditions, it follows that the length of the period during which and the conditions under which they remain viable may be of some importance in this respect.

Here again may be pointed out the greater importance of the seed-borne dormant mycelium in the perpetuation of the disease. Ravn (28) found abundant stripe disease in 1898 in plants grown from seed harvested in 1896. Genau (6) states that he found the mycelium

in grain viable after two years, and Smith (35) reports similar results. In 1927 the writers found over 7 per cent of stripe disease in barley grown from seed raised in 1922, indicating that a 5-year period failed to kill the seed-borne mycelium.

VIABILITY OF SEED FROM DISEASED PLANTS

Conflicting statements have been made by different investigators about the extent to which stripe-diseased plants may produce viable seeds and whether such seeds necessarily give rise to infected plants. Most of the investigators, in describing stripe-diseased plants, state that the heads may form kernels but that these usually are sterile. Ravn (28) found that of 200 kernels from infected plants only 2 germinated. Drechsler (4) states that the ovaries in the heads of diseased plants rarely develop anything beyond abortive seeds and that viable seeds are not generally produced. Novák (23), on the contrary, states that 300 seeds taken from infected plants and sown in the greenhouse produced healthy plants. However, it does not necessarily follow that none of these kernels carried the fungus. Novák does not state at what temperature the greenhouse was maintained, and it is easily possible that a relatively high temperature (25° C., for example) during the period of germination may have enabled the seedlings to escape infection, as frequently is the case.

In July, 1927, stripe-diseased plants of Minsturdi and Wisconsin Pedigree No. 6 barley were collected at Madison, Wis., and stored in the laboratory at the Arlington Experiment Farm. On January 14, 1929, a number of heads of each variety were selected, the kernels were carefully threshed out by hand, and the better-developed ones were sown in a greenhouse kept at a temperature of 15° C. Of 50 kernels of the Minsturdi barley sown, only 5 germinated, and the plants that developed were free from stripe disease. Of 100 kernels of Wisconsin Pedigree No. 6, 17 germinated, and only 4 plants showed stripe-disease infection.

Two years later, on February 5, 1931, 50 heads were selected at random from this same lot of diseased plants of Wisconsin Pedigree No. 6 barley collected in 1927. The heads were carefully hand threshed, and 615 seeds were obtained, most of which apparently were abortive. Nevertheless, all of them were placed in a germinator kept at a temperature of 25° C., along with 100 normal kernels of this same variety grown in 1925 and then 6 years old. Of the normal kernels 54 per cent germinated. None of the kernels from the 50 diseased heads showed any indication of viability, although two years before some of the kernels from this lot of material had germinated. Evidently storage for 37 months under conditions obtaining in the laboratory cupboard was sufficient to destroy what viability any of these seeds may once have had.

SECONDARY INFECTION

Secondary infection by spores of *Helminthosporium gramineum* on leaves of barley probably is not common in nature. Ravn (28), using mycelium, obtained infection in 39 per cent of his trials. The writers made parallel inoculations on young barley leaves in the greenhouse with spores of *H. gramineum* and *H. teres*. Freshly collected spores of both species were applied to barley leaves, after which

the plants were placed in a moist chamber for 48 hours. After 12 days all the leaves inoculated with spores of *H. teres* were abundantly infected and showed the characteristic netting which is the outward manifestation of net blotch. The leaves inoculated with spores of *H. gramineum*, however, showed only slight indications of local infection, and these were not characteristic of stripe disease. In view of these results it seems highly improbable that any appreciable amount of secondary infection by *H. gramineum* occurs in the field even under the most favorable natural conditions.

EFFECT OF ENVIRONMENTAL CONDITIONS

SOIL FERTILITY

Ravn (28) states that he observed no effect of manure on the incidence of stripe disease, although he cites Rostrup's results in which the latter had observed 13 per cent of stripe disease where nitrogen fertilizers had been used and only 5 to 7 per cent where none had been applied. Plant (25) found that neither manure nor fertilizers had any effect on the amount of stripe disease in the crop. Rippel and Ludwig (31), on the other hand, report that stripe disease is inhibited by increased soil fertility and that the disease develops most abundantly in the more poorly fertilized soil. Smith (35) also states that any condition favorable for the plant, such as abundant soil fertility, tends to make it grow away from the disease. The writers are, to some extent, inclined to agree with this latter view. While no experiments were made along this line, it often has been observed that in rows where the plants, on the whole, were more or less stunted and lacking in vigor, owing to poor fertility, the percentage of stripe-diseased plants invariably was greater than where vegetative growth was more vigorous because of more fertile soil.

Some observations have been made also on the relation between soil type and stripe disease. Riehm (30) refers to an instance in which seed sown in marshy soil produced a healthy crop; in another case, seed sown in light soil produced a stripe-diseased crop. This would be in agreement with the theory that high fertility tends to inhibit stripe-disease development, it being assumed that the marshy soil is the more fertile. Kiessling (15), on the contrary, makes the statement that the disease was favored by damp black soil.

SOIL TEMPERATURE AND MOISTURE

Most investigators who have studied the physiology of stripe-disease infection mention the fact that when naturally inoculated seed is sown the development of the disease is favored by the prevalence of a relatively low soil temperature during the period immediately after the seed is sown and before the seedlings emerge. Most of them draw their conclusions from field observations, while a few rely upon data secured from experiments in which soil temperature was a controlled factor. All are not in exact agreement regarding the optimum soil temperature for stripe-disease development, but it is placed below 20° C. and usually above 10°. These differences of opinion may be accounted for by concurrent differences in soil moisture, which also seem to be a factor influencing infection, or by the fact that the investigators may have been dealing with different physiologic forms.

Johnson (14) distinguished between two physiologic forms of *Helminthosporium gramineum* by means of differences in temperature requirements when these different strains were grown in pure culture. Isenbeck (13) suggests the existence of three physiologic forms, based on their differences when grown in pure culture and also on differences in results obtained in inoculation experiments.

Numerous field observations prior to 1922 had convinced the writers of the importance of soil temperature as a factor in the development of stripe disease. In the fall of 1922, experiments were begun to determine, within rather wide limits, the cardinal temperatures for the development of stripe disease in plants grown from naturally inoculated seed. A study of the relation of soil moisture to the development of stripe disease was included.

In most of these experiments the plants were grown to the second-leaf or third-leaf stage in metal cans suspended in tanks containing water, the temperature of which was automatically controlled. The equipment used has been described previously (16).

The first experiment was somewhat preliminary in nature and was intended primarily to try out the equipment. Seed of Wisconsin Pedigree No. 6 barley (crop of 1922) was sown in soil at each of six temperatures. The results were not very striking, as there was little difference in the amount of infection secured at 10°, 15°, and 20° C. (Table 2, series 1.) The small number of plants grown and the fact that they were allowed to mature in the cans, thus preventing normal development, make these results, on the whole, rather unimportant.

TABLE 2.—Effect of soil temperature on development of stripe disease in Wisconsin Pedigree No. 6 barley grown from naturally inoculated seed in controlled soil-temperature tanks in the greenhouse, Arlington Experiment Farm, Rosslyn, Va.

Series	Temperature of soil ° C.	Days before emergence Number	Seeds sown Number	Plants grown Number	Plants infected	
					Number	Per cent
1	10	60	60	57	5	8.8
	15	60	60	47	4	8.5
	20	45	45	39	3	7.7
	24	80	80	49	1	2.0
	28	60	60	53	0	0
	32	60	60	51	0	0
2	10	360	360	340	25	7.4
	15	360	360	350	15	4.3
	20	360	360	337	9	2.7
	24	360	360	336	1	.3
	28	360	360	336	0	0
	32	360	360	292	0	0
3	10	25	160	129	21	16.3
	15	25	160	135	37	27.4
	20	25	160	137	28	20.4
	24	16	480	400	52	13.0
	28	7	480	409	66	16.1
	32	5	490	400	24	6.0
	36	4	480	350	5	1.4
	40	3	480	320	0	0

¹ Transplanted to bench in first, second, and third leaf stages, respectively.

In the second series the same temperatures were employed, and the seed used was from the same lot of barley grown in 1922. Three hundred and sixty seeds were sown in soil maintained at each of six temperatures. When the plants reached the third-leaf stage they were transplanted to the greenhouse bench, where they were grown until the stripe-diseased plants had developed sufficiently to be counted.

The results shown in Table 2, series 2, indicate that in this case 10° C. was the temperature most conducive to stripe-disease development. The upper limiting temperature seemed to be somewhat above 24°, since at this temperature one stripe-diseased plant developed.

Inasmuch as the highest percentage of infection occurred at the lowest temperature, it was decided to try the effect of a still lower soil temperature. Accordingly, in the third series (Table 2) the temperatures ranged from 6° to 28° C. The plants grown at 6° were equally divided into three lots and were transplanted from the tanks when in the first-leaf, second-leaf, and third-leaf stages, respectively. All the other plants were transferred to the greenhouse bench when the third-leaf stage had been reached, the average temperature of the greenhouse being about 25°. Again the greatest amount of infection occurred at the lowest temperature, although in this series slightly more stripe disease developed at 15° than at 10°. The differences in infection in the three lots grown at 6° and transferred to the warm greenhouse bench at different stages were not statistically significant, showing that the influence of soil temperature on the development of stripe disease does not extend beyond the time of emergence.

To secure additional data on this phase, the two following series of experiments were conducted: In series 1 the two temperatures 28° and 12° C. were used. Naturally inoculated seed of Wisconsin Pedigree No. 6 barley was sown in soil maintained at these temperatures. When the plants emerged, two-thirds of them at each temperature were transferred to the other temperature, that is, approximately two-thirds of those that had grown to emergence at 12° were transferred to the tanks maintained at 28°, while a like number that had grown to emergence at 28° were transferred to a 12° soil-temperature environment. The remainder of the plants were kept at the respective temperatures at which they had been grown to emergence. When in the fourth-leaf stage, the plants were transferred to the greenhouse bench, where they were grown until final data were taken. The data shown in Table 3 indicate that the change in soil temperature after the plants had emerged had no effect upon the percentage of stripe-diseased plants.

TABLE 3.—*Effect on the development of stripe disease of growing barley at a high soil temperature until after the time of emergence and then at a low soil temperature and vice versa*

Series	Soil temperature		Plants grown	Plants infected	
	Before emergence	After emergence			
	° C.	° C.	Number	Number	Per cent
1.....	28	12	1,280	14	1.1
	28	28	806	1	.18
	12	28	1,322	218	16.5
	12	12	657	110	16.7
2.....	28	12	634	12	1.89
	28	28	595	6	1.00
	12	28	666	87	13.06
	12	12	647	86	13.14

The fact that in series 1 a slightly greater percentage of stripe disease occurred in the lot transferred from 28° to 12° C. (1.1 per

cent) than occurred in the lot grown continuously at relatively high temperatures (0.15 per cent) may have been due to the fact that some plants emerged after the transfer had been made. The same may be said about the results obtained in series 2 (Table 3), in which 25° was used as the higher temperature. The same procedure used in series 1 was followed in series 2 except that approximately one-half instead of two-thirds of the plants were transferred at the time of emergence. It will be noted that in the lot transferred from 25° to 12°, 12 plants, or 1.89 per cent, were diseased, while in the lot remaining at 25° only 6 plants, or 1 per cent, were infected. Undoubtedly this again was due to plants whose emergence was delayed until after the cans had been transferred. On the other hand, in both series there was nearly the same relative amount of infection in the plants that had been transferred at the time of emergence from 12° to the higher temperatures as occurred in the plants that had been kept at 12° after the time of emergence.

In order to determine to what extent, if any, the soil-moisture content previous to the time of emergence influences the development of stripe disease in plants grown from naturally inoculated seed, experiments were conducted under controlled conditions with soil moisture as the varied factor. In the first experiment, which was of a preliminary nature, 600 seeds of naturally inoculated Wisconsin Pedigree No. 6 barley were sown in the greenhouse bench in soil the moisture content of which had been adjusted to 44 per cent of saturation. A like number of seeds were sown in soil that was heavily watered after sowing and that received a daily watering, so that its moisture content probably remained near 90 per cent of saturation. Both sections of the greenhouse bench were covered with a heavy canvas to lessen evaporation and to maintain a more or less uniform soil temperature, ranging from 13° to 18°, with a mean temperature of about 15° C. These conditions were maintained until the plants emerged. The stripe-disease data taken later and shown in Table 4 seem to indicate that the excessive soil moisture inhibited to some extent the development of stripe disease, as in the wetter soil 16 per cent and in the drier soil 25 per cent of the plants became stripe diseased.

TABLE 4.—Effect of soil moisture during period of emergence on development of stripe disease in Wisconsin Pedigree No. 6 barley grown in the greenhouse from naturally inoculated seed, Arlington Experiment Farm, Rosslyn, Va.

Soil		Plants grown	Plants infected	
Temperature	Moisture ¹			
° C.	Per cent	Number	Number	Per cent
13-18	90-95	520	83	16
13-18	44	563	148	25

¹ Expressed as percentage of saturation.

A similar experiment was then tried with a number of different seed lots, as shown in Table 5. The drier soil was adjusted to 40 per cent of its water-holding capacity, while, as in the previous experiment, the wetter soil was kept near saturation. One hundred seeds of

each lot were used at each moisture. The temperature of the greenhouse was kept as near 15° C. as possible. The same procedure was followed as before, and similar results were obtained. The experiment was repeated (series 2), and again the results indicated that excessive soil moisture before emergence tends to inhibit stripe-disease development.

TABLE 5.—Effect of extremes of soil moisture on development of stripe disease in different lots of barley grown from naturally inoculated seed in 5-inch flats in the greenhouse, 100 seeds of each lot being used at each soil moisture, in each series, Arlington Experiment Farm, Rosslyn, Va.

Lot No.	Seed			Stripe-diseased plants at soil moisture of percentage shown ¹			
	Variety	From crop of—	Grown in—	Series 1		Series 2	
				40 per cent	90 per cent	40 per cent	90 per cent
1	Wisconsin Pedigree No. 6	1922	Wisconsin	7	5.9	(?)	(?)
2	do	1923	do	20	10.7	14.0	9.1
3	do	1924	do	30	14.3	35.5	16.0
4	Unnamed	1924	Illinois	0	0	19.5	3.8
5	do	1925	Minnesota	11	8.3	27.8	15.4
6	Odessa	1925	do	4	5.7	15.7	2.6
	Average			12	7.5	22.7	9.4

¹ Expressed as percentage of saturation.

² Destroyed by mice.

Experiments were then carried out involving concurrent variations in both soil temperature and soil moisture. The soil temperatures selected were within the range generally found to be conducive to stripe-disease development, namely, 10° to 15° C. The data from four consecutive experiments are shown in Table 6. In series 1, 2, and 3, two temperatures, 10° and 15°, and two soil moistures were used. In series 4 a uniform soil temperature of 12° was employed, and the soil was adjusted to four different degrees of moisture. The seed used in series 1, 2, and 3 was from the same lot of naturally inoculated Wisconsin Pedigree No. 6 barley. A different lot of this seed was used in series 4.

TABLE 6.—Effect of soil moisture on development of stripe disease in Wisconsin Pedigree No. 6 barley grown from naturally inoculated seed under conditions of controlled soil moisture and soil temperature in the greenhouse, Arlington Experiment Farm, Rosslyn, Va.

Series	Soil		Days to emerge	Plants grown	Plants infected	
	Temperature	Moisture ¹			Number	Per cent
	° C.	Per cent				
1	10	15	18	50	11	10.6
	15	15	14	52	11	21.2
	10	72	16	44	3	5.8
	15	72	9	52	2	3.8
2	10	35	10	272	33	12.1
	15	35	7	262	31	11.8
	10	62	10	272	24	8.8
	15	62	7	282	24	8.5
3	10	27	12	150	20	10.8
	15	27	10	100	30	15.8
	10	53	12	173	7	4.0
	15	53	10	168	5	3.0
4	12	50	10	270	51	18.9
	12	65	10	390	56	14.4
	12	75	10	380	48	12.6
	12	85	10	200	24	12.0

¹ Expressed as percentage of saturation.

In series 1, one lot of soil was adjusted to 15 and the other to 72 per cent of its water-holding capacity. It will be noted in Table 6 that this difference in soil moisture seemed to cause a considerable difference in the percentage of stripe disease that developed. Similar results were secured in series 2 and 3, in which the same temperatures but two less widely separated degrees of soil moisture were used. In all three series the differences in infection percentages, due apparently to the difference in temperature between 10° and 15° C., were less pronounced than those due to the differences in soil moisture.

In the fourth series a single soil temperature of 12° C. was maintained, but four different soil moistures were employed. It had been planned to use a very low, an extremely high, and two intermediate percentages of soil moisture, but through a miscalculation the lowest and highest adjustments turned out to be 50 and 85 per cent of saturation, respectively. As will be observed in Table 6, the four less extreme differences in soil moisture in series 4 resulted in smaller differences in the development of stripe disease than occurred in the other three series. However, the results from all four series seem to indicate that the development of stripe disease is favored by relatively low soil moistures.

In the next two experiments it was planned to use three temperatures and four soil moistures. This was done in the first series, the results of which are shown in Table 7. In the second series, however, the lowest moisture adjustment proved unsatisfactory and had to be omitted. The data from the remainder of this series also are presented in Table 7. The average percentages of stripe-diseased plants at soil temperatures of 10°, 15°, and 20° C., irrespective of soil moisture differences were: In series 1, 13.7, 11.3, and 7.8, respectively; and in series 2, 22.6, 15.8, and 6.3, respectively. In a general way, these data indicate that the soil with the lowest temperature and with the lowest soil moisture usually was the most favorable for stripe-disease development. There were, however, several marked exceptions to this, both as to temperature and moisture. In series 1, for example, in soil 35 per cent saturated, more stripe disease developed at 20° than at 10°. There is also an unexplainable increase in infection at 10° in the 50 per cent moisture (19.3 per cent) as compared with the 35 per cent moisture (10.5 per cent). A similar but smaller increase occurred at 15°. In series 2 in the soil approximately 95 per cent saturated there seems to be an unduly high percentage of stripe at 10° compared with the infection at 15°. This may have been due to some uncontrolled factor.

In order to compare the above greenhouse results with field data, a date-of-sowing experiment was carried out with seed of Wisconsin Pedigree No. 6 barley. Sowings were made at approximately weekly intervals from September 25 to December 4. Data on soil moisture, soil temperature, and rainfall are recorded in Table 8 together with data on the stripe-disease infection taken the following May.

TABLE 7.—Combined effects of soil temperature and soil moisture on development of stripe disease in Wisconsin Pedigree No. 6 barley grown in the greenhouse from naturally inoculated seed, Arlington Experiment Farm, Rosslyn, Va.

Series	Soil		Plants grown	Plants infected		
	Moisture ¹	Temperature				
	Per cent	° C.	Number	Number	Per cent	Average per cent
1	27	10	218	40	18.5	13.2
		25	205	25	12.2	
		20	194	17	8.8	
	35	10	229	24	10.5	11.9
		15	226	29	12.8	
		20	227	28	12.3	
	50	10	228	44	19.3	14.5
		15	225	37	16.4	
		20	233	18	7.7	
	95	10	188	12	6.5	4.3
		15	183	7	3.8	
		20	163	4	2.5	
2	35	10	213	51	23.9	18.8
		15	243	56	23.0	
		20	241	30	12.4	
	60	10	226	56	24.8	14.8
		15	205	30	14.6	
		20	219	11	5.0	
	95	10	188	36	19.1	10.1
		15	164	16	9.8	
		20	188	3	1.6	

¹ Expressed as percentage of saturation.

TABLE 8.—Field data on effect of date of sowing and resultant soil temperature and moisture on development of stripe disease in Wisconsin Pedigree No. 6 barley grown from naturally inoculated seed, Arlington Experiment Farm, Rosslyn, Va.

Plot No.	Date sown	Days to emerge	Soil moisture ¹	Rain-fall ²	Soil temperature ³		Plants grown	Plants infected	
					Range	Mean ⁴			
			Per cent	Inches	° C.	° C.	Number	Number	Per cent
1	Sept. 25	5	71	0	17-20	23	802	10	1.2
2	Oct. 1	7	34	0	13-21	17	1,313	106	8.1
3	Oct. 8	9	8	4 T	11-22	17	1,682	236	14.2
4	Oct. 15	11	16	1.22	9-21	16	987	140	14.5
5	Oct. 22	12	48	.87	8-20	11	781	115	14.7
6	Oct. 29	15	44	.45	2-20	9	822	167	18.1
7	Nov. 5	17	63	1.60	2-15	9	348	34	9.8
8	Nov. 14	20	55	1.01	2-15	7	521	41	7.9
9	Nov. 22	26	51	2.36	2-15	8	186	8	4.3
10	Dec. 4		66		2-14	3	125	5	4.0

¹ Percentage of saturation at time of sowing.

² From sowing to emergence.

³ Mean of the daily mean temperatures.

⁴ T=trace.

The first sowing, made in relatively wet soil (71 per cent saturated) and followed by a rather high average soil temperature (23° C.), resulted in only 1.2 per cent of infection. The second sowing, made in drier soil (34 per cent saturated) and followed by a lower average soil temperature (17°), resulted in 8 per cent of infection. The third sowing, made in very dry soil (only 8 per cent saturated), but followed by the same average soil temperature (17°), showed 14.2 per cent of infection. In the fourth sowing a slight drop in the average soil temperature (16°) was offset by a slight increase in soil moisture (16 per cent of saturation) and the percentage of infection was about the same (14.5). The fifth sowing was made in much wetter soil (48 per cent saturated), but was followed by a considerably lower

average soil temperature (11°). Again these two changes seemed to offset each other as reflected by no appreciable change in the percentage of infection (14.7). The sixth sowing, made in soil not much changed in moisture content (44 per cent saturation), but followed by a 2-degree drop in the average soil temperature (9°), resulted in a crop with 18.1 per cent of stripe disease. The results from subsequent sowings are hardly comparable with the above results, on account of the reduced stands caused by winterkilling. However, in each case the soil was very wet, the rainfall rather heavy, and the soil temperature very low. The plants from the last sowing did not emerge until the following spring. That more infection was not found in the last four plots may possibly be due to the greater readiness with which the infected plants may have succumbed to winterkilling. At any rate, it seems evident that infection can take place at the lowest temperature at which barley will germinate and grow. These results also, on the whole, indicate that both high temperatures (above 20°) and a relatively high moisture content of the soil have an inhibiting effect upon stripe-disease development. Of these two factors, temperature seems to be the more important.

The apparent inhibition of stripe-disease development in plants grown from naturally inoculated seed in nearly saturated soil is possibly due to lack of sufficient oxygen for the rapid growth of the fungus, the oxygen requirements of which may be relatively high, and also, perhaps, to the rapid absorption of water by the seed, which gives the young plant an early start and enables it to grow away from the fungus. On the other hand, the frequently observed increase in the percentage of stripe disease in plants grown to emergence in relatively dry soil may be due to the slow absorption by the seed of sufficient water to bring about rapid germination. This delay in the emergence of the coleoptile from the seed naturally would give the reviving fungus mycelium a better chance to infect it as it grows out between the pericarp and the glume.

From the foregoing remarks it might be expected that soaking naturally inoculated seed previous to sowing it would reduce the amount of stripe disease. Such, however, did not prove to be the case when tried experimentally. Seed of Wisconsin Pedigree No. 5 barley was divided into three lots. The first was sown without treatment of any kind. The second lot was soaked in water and sown immediately. The third lot also was soaked in water, but the seed was dried thoroughly for one hour before being sown. The experiment was further varied by soaking the seed for different lengths of time—1, 2, and 3 hours. No consistent differences were observed in the relative number of diseased plants from the different lots of seed. Soaking the seed in water before sowing evidently does not affect stripe-disease development in the same way as sowing the seed in very wet soil.

CONTROL OF STRIPE DISEASE BY SEED TREATMENT

The writers have reviewed briefly the literature up to 1926 on the control of stripe disease (18, 19). Much interesting work has been done since that time, especially with dust fungicides. No attempt will be made to give here a complete review of the rather voluminous literature, but a few references will be cited to show the general trend in seed-treatment practices for the control of stripe disease.

In 1926, Molz (21) reported that stripe disease could be successfully combated with Höchst, Tutan, Abavit B, and Agfa. While dust disinfectants are advantageous in that they can be applied considerably in advance of seeding time, he warns against storing treated seed in a damp atmosphere, as injury to the embryo is likely to result, especially after treatment with some of the dust disinfectants now on the market.

In 1927, Lindfors (20) stated that stripe disease could be satisfactorily controlled with Abavit B and Tutan Dusts. Uspulun Dust, he stated, was unreliable and Tillantin Dust useless.

Straib (37) reported in 1927 excellent stripe-disease control with Höchst and in addition a nearly 10 per cent increase in yield.

Sinning (33, 34) in 1927 and 1929 secured excellent results with Höchst, but Abavit B proved unsatisfactory.

In 1927, Howitt and Stone (12) controlled stripe disease in Success hooded barley with Uspulun and Semesan solutions at 45° C. and with Du Pont Dust No. 12. Semesan Dust, Uspulun Dust, Bayer Dust, copper carbonate, and Vitrioline, while relatively ineffective in control, reduced the amount of stripe disease to some extent and increased the yield of grain.

Rodenhisser (32), in three years' experiments, secured control with cold and hot (45° C.) solutions of Uspulun, Germisan, and Semesan. However, the results with Germisan were not entirely consistent. He also reported complete control without seed injury with the Du Pont Dusts K-1-A and K-1-B⁵ and almost complete control with Du Pont No. 12, S. F. A. No. 225, and Wa Wa Dust. Unlike many other investigators, including the writers, he did not find Höchst extremely effective.

Porter, Yu, and Chen (27), in 1929, found liquid treatments more effective than dust treatments on hull-less barley in China.

Reddy and Burnett (29), in two years' extensive experiments with numerous varieties of barley, reported in 1930 that they found Ceresan and a number of dust fungicides, made in their laboratory, very effective in stripe-disease control, as well as conducive to increase in yield.

A large number of European workers could be cited, but many of them used dust fungicides relatively unknown or at least unavailable in this country. Most of them report effective control of stripe disease with solutions of Uspulun and Germisan. Some of the fungicidal dusts frequently used with different degrees of success were Agfa, Abavit B, Tutan, Urania, S. F. A. Nos. 225 and 225-V, Höchst, and Tillantin. Conflicting results reported by various workers may be attributed to the use of different varieties of barley, different methods of applying the fungicides, variations in environmental conditions during germination, and a possible variation from year to year in the chemical composition of the compounds used.

The work on the control of stripe disease conducted by the writers from 1922 to 1925 and part of the work of 1926 has been previously reported (18, 19). These experiments were continued up to and during 1930. While certain fungicides were being found ineffective and discarded, others appeared on the market or were submitted by commercial concerns for experimental trial before being offered for

⁵In experiments with Minstardl barley treated with K-1-A and K-1-B, the writers found in 1927 that these dusts were extremely injurious to the seed. These dusts were the experimental forerunners of Ceresan.

sale. Most of these compounds have now passed the experimental stage and either have been discarded as ineffective or impractical or, having stood the test of experimental investigation, are now being offered on the market as standard commercial fungicides. It seems timely, therefore, to give an account of the results of the seed-treatment experiments carried on from 1926 to 1930, inclusive.

EXPERIMENTS IN 1926

In 1926 seven liquid seed treatments were used in experiments on Wisconsin Pedigree No. 6 spring barley to determine their effect on germination, stripe-disease control, and yield. Uspulun, Semesan, and Bayer Compound were used in 0.5 per cent solutions; Germisan, Corona 620, and Tillantin C were used in 0.25 per cent solutions; and formaldehyde solution was used in the usual 1:320 strength, that is, 1 part of 37 per cent formaldehyde in 320 parts of water, which is a 0.12 per cent solution of formaldehyde gas in water. In each case the seed was placed in loose cheesecloth sacks and immersed for an hour in the different solutions, which were contained in earthenware jars. The seed was then drained and immediately dried, except the lot treated with formaldehyde. This was washed in water before being dried, in order to prevent injury to the seed for it was not possible to sow the seed at once. This washing, it is thought, may have decreased slightly the efficacy of the formaldehyde treatment. The seed was treated at the Arlington Experiment Farm and shipped to Madison, Wis., where it was sown on the West Hill farm of the Wisconsin Agricultural Experiment Station.

To determine the effect of the different seed treatments on germination and stripe-disease control, seed was sown in rod rows at the rate of 250 seeds per row. There were eight replications for each treatment and for each control. Germination counts were made five days after the seedlings had emerged. Stripe-disease data, taken after the plants had headed, are shown in Table 9, along with the germination data. It will be observed that Germisan, as in previous experiments (18), was superior to all the other treatments in that it completely eliminated stripe disease. While the other treatments reduced the occurrence of stripe disease to less than 0.5 per cent, the low percentage of stripe disease in the controls renders these results rather insignificant. None of the seed treatments, it seemed, greatly affected germination.

TABLE 9.—Effect of liquid seed treatments on germination, stripe-disease control, and yield in Wisconsin Pedigree No. 6 barley sown at Madison, Wis., 1926

No.	Seed treatment			Germination	Stripe-diseased plants		Yield per acre	Increase over control		Odds
	Name	Concentration	Time		Number	Per cent		Bushels	Per cent	
		Per cent	Hours	Per cent	Number	Per cent	Bushels	Bushels	Per cent	
1	Control (untreated)			78.3	112	5.0	43.2			
2	Uspulun	0.5	1	78.0	4	.16	54.9	11.7	27.1	40:1
3	Semesan	.5	1	75.4	2	.07	50.4	7.2	16.7	18:1
4	Control (untreated)			73.4	4	.15	43.2			
5	Bayer Compound	.5	1	72.7	0	0	52.2	9.0	20.8	16:1
6	Germisan	.25	1	71.6	115	5.00	50.4	2.4	5.0	4:1
7	Control (untreated)			68.2	1	.04	48.0			
8	Corona 620	.25	1	71.6	115	5.00	48.0			
9	Tillantin C	.25	1	72.8	2	.08	49.6	1.6	3.3	3:1
10	Control (untreated)			67.2	8	.33	51.8	4.8	10.2	46:1
11	Formaldehyde	.12	1	67.2	8	.33	47.0			
12	Control (untreated)			67.2	8	.33	49.6	2.6	5.5	4:1

To secure data on the effect of these seed treatments on yield, a parallel series of sowings was made in 1/80-acre plots. Sufficient seed had been treated for 12 replications, but an unforeseen shortage of land made it necessary to limit the experiment to four replications for each treatment and for each control, thus, unfortunately, making the yield data less significant. Each plot was harvested and threshed separately and the grain carefully weighed. The summarized results, expressed in bushels per acre, are shown in Table 9.

Uspulun, Semesan, Bayer Compound, and Tillantin C increased the yields in all four replications as compared with the yields from the corresponding control plots. Germisan, Corona 620, and formaldehyde showed increased yields in only two out of the four replications. However, only in the case of Uspulun and Tillantin C were these increases even slightly significant. The average yield from all the plots sown to treated seed exceeded the average yield from the control plots by 13 per cent. With only 5 per cent of stripe disease in the control plots at heading time, it seems reasonable to suppose that part of this difference in yield was brought about by the control of other diseases in addition to the control of stripe disease to a greater extent than is indicated by the count of stripe-diseased plants at heading time.

Experiments with dust fungicides for the control of stripe disease also were carried out during the 1926 season, but as the results of these investigations have already been published (19), they are not included here.

EXPERIMENTS IN 1927

In the fall of 1926 a number of dust fungicides were used in experiments for the control of covered smut in Tennessee Winter barley. Treated and untreated seed was sown in three parallel series of plots in which the soil had been limed, left untreated, or acidified with ammonium sulphate. The procedure in these experiments has been described in a previous publication (17) and need not be repeated here. The amount of stripe disease that appeared in the plots the following spring is shown in Table 10, with the data on the control of this disease.

The relative alkalinity or acidity of the soil seemed to have no marked effect either on the development of stripe disease or on its control by any of the fungicides used. When an average of only 3.8 per cent of stripe disease occurred in the controls, Abavit B, Semesan Jr., and Wa Wa Dust completely prevented its occurrence; with one exception, all the other dusts reduced its occurrence to less than 0.2 per cent.

Seed of Tennessee Winter barley treated with a number of experimental dust disinfectants also was sown in paired row rows in October, 1926, and the data taken the following May are shown in Table 11. With an average of 3.8 per cent of stripe disease in the controls, only two of the dust fungicides used prevented stripe disease without injuring the seed. The liquid fungicides gave satisfactory control, as usual.

TABLE 10.—*Stripe-diseased plants in Tennessee Winter barley grown from seed, untreated or treated with different dust disinfectants, and sown in row rows replicated sixteen times for each disinfectant on each of three plots, one limed, one untreated, and one acidified, Arlington Experiment Farm, Rosslyn, Va., October 16, 1926*

[Data taken in May, 1927]

No.	Seed treatment Name	Stripe-diseased plants on—			Total infected plants	
		Limed soil	Untreated soil	Acidified soil		
		Number	Number	Number	Number	Per cent
	Control (untreated).....	123	120	98	341	3.5
1	Abavit B.....	0	0	0	0	0
2	S. F. A. No. 225.....	1	5	4	10	.10
3	S. F. A. No. 225-V.....	1	0	0	1	.01
4	S. I. 220.....	20	11	21	52	.54
5	Semesan.....	1	1	3	5	.05
6	Semesan Jr.....	0	0	0	0	0
	Control (untreated).....	124	121	154	399	4.16
7	Du Pont No. 12.....	0	0	2	2	.02
8	Du Pont No. 45.....	0	1	1	2	.02
9	Boyer Dust.....	6	3	3	12	.13
10	Boyer Dust II.....	1	4	6	11	.11
11	Wa Wa Dust.....	0	0	0	0	0
12	Mercury C.....	1	1	1	3	.03
	Total from untreated seed.....	247	241	252	740	-----
	Total from treated seed.....	11	15	20	46	-----
	Ratio, untreated to treated.....	22:1	16:1	13:1	16:1	-----

* No. 4 not included.

TABLE 11.—*Control of stripe disease in Tennessee Winter barley by a number of experimental dust fungicides, and also by four liquid fungicides, Arlington Experiment Farm, Rosslyn, Va., 1926-27*

No.	Seed treatment Name	Stripe-diseased plants	
		Number	Per cent
	Control (untreated).....	72	4.0
1	Cuprobol.....	66	3.7
2	Vitrioline.....	5	.28
3	Karasch A.....	7	.4
4	Resorcin.....	41	2.3
5	Resorcin one-half, copper carbonate one-half.....	45	2.6
6	Resorcin one-third, copper carbonate two-thirds.....	54	3.0
	Control (untreated).....	76	4.2
7	Resorcin one-third, dextrin two-thirds.....	40	2.3
8	Mercurous chloride one-half, copper carbonate one-half.....	20	1.2
9	Mercuric chloride one-half, copper carbonate one-half.....	0	0
10	Du Pont No. 50.....	1	.06
11	Du Pont No. 67.....	45	2.7
12	Du Pont No. 68.....	25	1.4
	Control (untreated).....	73	4.0
13	Du Pont No. 35.....	0	0
14	Du Pont No. 42.....	0	0
15	Du Pont No. 53.....	3	.15
16	Du Pont No. 57.....	6	.30
17	Du Pont No. 64.....	0	0
18	Mercuric oxide one-half, copper carbonate one-half.....	5	.30
	Control (untreated).....	63	3.30
19	Mercuric sulphate one-half, copper carbonate one-half.....	12	.70
20	Uspulun (0.5 per cent, 1 hour).....	1	.06
21	Semesan (0.5 per cent, 1 hour).....	0	0
22	Germisan (0.25 per cent, 1 hour).....	0	0
23	Formaldehyde (0.12 per cent, 1 hour).....	0	0
	Control (untreated).....	64	3.0

* Seed injury and reduced stand.

In the spring of 1927, further field experiments on the relation of soil reaction and soil moisture to the occurrence and control of stripe disease were carried out on the Arlington Experiment Farm in a manner similar to that previously described for covered smut in barley (17). Three plots, each 18 by 132 feet, were treated as follows: Plot 1 was given a dressing of air-slaked lime at the rate of 4,000 pounds per acre, plot 2 was left untreated, and to plot 3 ammonium sulphate was added at the rate of 400 pounds per acre. The lime was applied the day before sowing and thoroughly disked into the soil. The ammonium sulphate was applied shortly before the land was leveled preparatory to sowing. Composite soil samples, taken immediately before sowing, showed the following reactions: Plot 1, pH 8.4; plot 2, pH 6; plot 3, pH 5.2.* The soil contained 50 per cent of its water-holding capacity at the time of sowing the seed on March 17. Rain was excluded from half of each plot until April 2, when the seedlings emerged. During this time the other half of each plot was artificially watered with the equivalent of a soil-saturating rain. In addition to this artificial watering, the rainfall during this period was 0.75 inch.

The infection data taken later in the season are shown in Table 12. No significant differences in stripe-disease development or control in the three plots were evident. Therefore, it follows that in the type of soil used, Keyport silt loam, stripe-disease development, or its control by the fungicides used was not affected by a difference in soil reaction over the range from pH 5.2 to pH 8.4 or by a range in soil moisture from 50 per cent saturation to the degree of saturation obtained by the method described. These results do not parallel very closely those shown in series 4, Table 6.

TABLE 12.—*Stripe-diseased plants in Wisconsin Pedigree No. 6 barley grown from naturally inoculated seed, untreated or dusted with different seed disinfectants, and sown in rod rows replicated sixteen times for each disinfectant on each of three plots, one limed, one untreated, and one acidified, half of each plot being kept dry until after emergence and the other half heavily watered, Arlington Experiment Farm, Rosslyn, Va., 1927*

Seed treatment		Stripe-diseased plants in—									
		Wet soil					Dry soil				
No.	Name	Limed	Un- treated	Acid- ified	Total	Per cent	Limed	Un- treated	Acid- ified	Total	Per cent
1	Control (untreated).....	230	241	205	676	12.2	208	229	209	706	12.8
2	Abavit B.....	8	4	4	14	.2	2	3	4	9	.1
3	Tutan.....	8	5	2	15	.2	16	8	2	26	.3
4	S. F. A. No. 225-V.....	0	1	0	1	T	0	0	0	0	0
5	Sernesan.....	0	0	1	1	T	0	1	0	1	T
6	Da Font No. 12.....	0	0	0	0	0	0	0	0	0	0
7	Bayer Dust.....	1	2	1	4	T	8	3	4	13	.2
	Wa Wa Dust.....	0	0	0	0	0	0	0	0	0	0
	Infected plants from treat- ed seed.....	15	12	8	35	-----	24	15	10	49	-----
	Ratio, untreated to treated.	15:1	20:1	25:1	10:1	-----	11:1	15:1	21:1	14:1	-----

* T=trace.

* These determinations were made by E. F. Snyder, associate chemist, Bureau of Chemistry and Soils whose assistance is gratefully acknowledged.

With an average of 12.5 per cent of stripe disease in the controls, Wa Wa Dust and Du Pont No. 12 eliminated the disease completely, while the rest of the treatments reduced its occurrence to less than 0.5 per cent.

In addition to the seven fungicidal dusts used in the above experiment, in 1927 six other dusts and one liquid fungicide were employed in additional seed-treatment experiments for the control of stripe disease in spring barley.

Five of the thirteen dust fungicides used came from Germany and are not commercially available in this country, namely: Abavit B, Tutan, S. I. No. 220, S. F. A. No. 225-V, and Höchst. Höchst also is known as Trockenbeize Tillantin. The following four dusts were supplied by the E. I. du Pont de Nemours & Co.: Semesan, Semesan Jr., and Du Pont Dust Nos. 12 and 45. The Bayer Co. furnished Bayer Dust and Bayer Dust II. Wa Wa Dust came from the Chicago Process Co., and Mercury C from the Roessler & Hasslacher Chemical Co. The liquid fungicide used was Germisan, made by Saccharin-Fabrik Aktiengesellschaft, Magdeburg, Germany, and not commercially available in this country. In previous experiments this fungicide had controlled stripe disease almost perfectly.

The following eight lots of barley were used: Minsturdi barley, crop of 1925, received from J. J. Christensen, St. Paul, Minn.; unnamed variety, crop of 1925, received from L. W. Melander, St. Paul, Minn.; five lots of Wisconsin Pedigree No. 6 barley, crops of 1922, 1923, 1924, 1925, and 1926, received from J. G. Dickson, Madison, Wis.; and Manchuria barley, crop of 1926, received from A. N. Hume, Brookings, S. Dak.

The dust fungicides were applied to the seed at the rate of 4 ounces per bushel, after which the seed was continuously shaken for about 30 minutes in a closed container, as described and illustrated in a previous paper (17). The seed was then shaken in a fine sieve so that all the excess dust was removed. By means of this "excess method" every seed was coated as thoroughly as it would be in the most efficient dusting machine.

The Germisan was applied by immersing the seed in a 0.25 per cent solution at room temperature for one hour, after which it was allowed to dry.

The seed was sown at the rate of 250 seeds per row in rod rows replicated four times for each treatment and each seed lot in each of two parallel series: Series 1 was sown on the Arlington Experiment Farm on March 10, series 2 was sown on the East Hill farm of the Wisconsin Agricultural Experiment Station on April 27. A third series was sown at Madison, Wis., on May 1, at the rate of 10 grams of seed per rod row, using only five of the seed lots and devoting only two rod rows to each treatment of each seed lot.

Emergence data on series 1, taken April 1 to 6, 1927, are presented in Table 13. Owing to unfavorable soil conditions in part of the field, two of the seed lots emerged so irregularly that emergence data on these are not included. It will be observed that Tutan and Wa Wa Dust caused marked reductions in the percentages of germination, while none of the other treatments seemed to have any appreciable effect.

Stripe-disease data on series 1 were taken on May 28. The number of stripe-diseased plants from each lot of seed is given in Table 14, together with the average percentages of infection in the whole series.

Stripe disease was eliminated by Tutan, S. F. A. No. 225-V, Wa Wa Dust, Höchst, and by the water solution of Germisan. With the exception of S. I. No. 220, which was relatively ineffective, all the other dusts reduced the occurrence of stripe disease to a mere trace, while an average of 10.8 per cent appeared in the controls. This general average was lowered by the relatively light infection in the Manchuria barley and in the Wisconsin Pedigree No. 6 barley grown from 1926 seed.

TABLE 13.—*Emergence data on barley grown from six lots of seed, untreated or treated with different fungicides, and sown at the rate of 250 seeds per rod row replicated four times for each treatment and each seed lot, Arlington Experiment Farm, Rosslyn, Va., March 10, 1927*

[Data taken March 29 to April 6]

Seed treatment		Percentage of emergence from 1,000 seeds of—					Average emergence	Increase or decrease in emergence as compared with average of controls	
		Min-sturdi, crop of 1925	Un-named variety, crop of 1925	Wisconsin Pedigree No. 6, crop of—					Man-churia, crop of 1926
				1924	1925	1926			
No.	Name								
	Control (untreated)	84.0	65.5	84.3	85.4	90.3	88.1	Per cent	
1	Abavit B.....	79.3	59.1	90.3	85.2	88.2	83.0	Per cent	
2	Tutan.....	63.9	58.3	73.2	81.3	68.2	71.6	---	
3	S. F. A. No. 225-V.....	84.5	82.0	88.2	87.7	89.8	83.5	-1.8	
4	S. I. No. 220.....	76.7	67.5	86.9	87.2	89.9	84.4	-14.1	
5	Semesan.....	86.0	84.1	92.0	87.8	90.8	92.4	-6	
6	Semesan Jr.....	84.2	67.1	90.5	84.9	93.4	89.8	-1.1	
7	Du Pont No. 12.....	70.0	83.6	86.4	81.6	88.6	84.9	+2.3	
8	Control.....	84.0	82.9	88.0	86.2	90.1	89.8	+1.8	
9	Du Pont No. 45.....	57.1	51.4	82.7	83.2	85.2	81.4	-4.3	
10	Bayer Dust.....	89.7	67.9	88.8	85.9	90.4	90.1	-9.7	
11	Bayer Dust II.....	82.3	85.1	90.4	85.6	89.9	88.9	+8	
12	Wa Wa Dust.....	45.9	32.0	74.3	80.5	64.5	58.7	+7.5	
13	Mercury C.....	86.0	87.8	91.9	86.3	90.5	89.0	-23.9	
14	Höchst.....	78.3	61.3	86.8	85.1	83.3	82.8	+2.0	
	Germisan (0.25 per cent, 1 hour).....	88.0	71.7	85.9	85.9	91.7	84.4	-3.6	
								+1.2	

Series 2 was sown at Madison, Wis., April 27, and the seedlings emerged May 9. Emergence data taken eight days later are shown in Table 15. In contrast with similar data secured in series 1 (Table 13), none of the treatments showed any appreciable effect upon the percentages of germination, with the possible exception of Wa Wa Dust, which, as compared with the controls, reduced the average percentage of germination 7 per cent.

Stripe-disease data were taken in July. The number of stripe-diseased plants from each lot of treated and untreated seed are shown in Table 16, together with the average percentages of stripe disease for each treatment. When an average of only 8.4 per cent of infection occurred in the controls, the treatments were not so effective as were those in series 1, when stripe disease in the controls averaged 10.8 per cent. The soil-moisture content between the dates of sowing and emergence in series 2 varied from 30 to 60 per cent of saturation, while in series 1 it was consistently over 50 per cent during the corresponding period. Undoubtedly the relatively lower moisture content of the soil in series 2, especially during the first few days after sowing, was responsible for the slightly decreased efficiency of the dust fungicides in this series.

TABLE 14.—*Stripe-diseased barley plants grown from different varieties or lots of seed, untreated or treated with different seed disinfectants, and sown in rod rows replicated four times for each treatment and seed lot, Arlington Experiment Farm, Rosslyn, Va., 1927*

Seed treatment		Stripe-diseased plants from 1,000 seeds of—							Total plants infected	
		Min-sturd, crop of 1925	Un-named variety, crop of 1925	Wisconsin Pedigree No. 6, crop of—						
No.	Name			1922	1923	1924	1925	1926		
	Control (untreated).....	105	80	58	107	122	92	13	4	Number
1	Abavit B.....	0	1	0	1	1	0	0	0	587
2	Tutan.....	0	0	0	0	0	0	0	0	10.83
3	S. F. A. No. 225-V.....	0	0	0	0	0	0	0	0	3
4	S. I. No. 220.....	22	22	40	25	74	43	5	7	0.06
5	Semesan.....	0	0	0	0	3	0	0	1	0
6	Semesan Jr.....	0	1	2	0	1	2	3	0	0
7	Du Pont No. 12.....	0	0	0	0	1	0	0	1	4.42
	Control (untreated).....	95	102	88	75	92	82	11	7	0.07
8	Du Pont No. 45.....	1	4	0	0	2	1	0	0	1.10
9	Bayer Dust.....	3	3	0	0	3	0	0	0	0.02
10	Bayer Dust II.....	2	2	2	1	15	0	0	0	1
11	Wa Wa Dust.....	0	0	0	0	0	0	0	0	10.80
12	Mercury C.....	2	0	0	0	3	0	0	0	5
13	Höchst.....	0	0	0	0	0	0	0	0	0.16
14	Germisan (0.25 per cent, 1 hour).....	0	0	0	0	0	0	0	0	0
	Total in controls.....	200	188	146	182	214	174	24	11	1,130
	Total from treated seed ¹	8	11	4	2	29	3	3	1	61
	Ratio, untreated to treated ¹	25:1	17:1	37:1	91:1	7:1	58:1	8:1	11:1	19:1

¹ No. 4 not included.TABLE 15.—*Emergence data on barley grown from eight lots of seed, untreated or treated with different seed disinfectants, and sown at the rate of 250 seeds per rod row replicated four times for each treatment and seed lot, at Madison, Wis., April 27, 1927*

Seed treatment		Percentage of emergence from 1,000 seeds of—							Average emergence	Increase or decrease in emergence as compared with average of controls	
		Min-sturd, crop of 1925	Un-named variety, crop of 1925	Wisconsin Pedigree No. 6, crop of—							Mac-churia, crop of 1926
No.	Name			1922	1923	1924	1925	1926			
	Control (untreated).....	74	71	68	68	63	74	72	77	P. d. 71	P. d.
1	Abavit B.....	67	63	67	71	66	72	68	72	68	-2
2	Tutan.....	63	65	60	72	65	79	65	75	69	-1
3	S. F. A. No. 225-V.....	72	60	73	69	69	74	73	74	71	+1
4	S. I. No. 220.....	62	69	73	67	69	79	67	75	70	0
5	Semesan.....	60	72	74	74	76	76	75	75	74	+4
6	Semesan Jr.....	71	69	70	73	70	73	74	79	72	+2
7	Du Pont No. 12.....	63	63	65	63	70	71	71	73	67	-3
	Control (untreated).....	68	65	69	60	64	77	72	72	68	-2
8	Du Pont No. 45.....	70	65	65	64	66	70	71	70	68	+2
9	Bayer Dust.....	73	73	71	68	70	70	74	72	72	+2
10	Bayer Dust II.....	74	72	72	67	69	76	75	74	72	+2
11	Wa Wa Dust.....	65	62	68	59	62	70	67	61	63	-7
12	Mercury C.....	77	72	77	72	75	74	73	71	74	+4
13	Höchst.....	72	67	-----	-----	73	73	71	71	71	+1
14	Germisan (0.25 per cent, 1 hour).....	75	68	-----	-----	73	76	74	73	73	+3

TABLE 16.—*Stripe-diseased barley plants grown from different varieties or lots of seed, untreated or treated with different seed disinfectants, and sown in rod rows replicated four times for each treatment and seed lot, Madison, Wis., 1927*

Seed treatment		Stripe-diseased plants from 1,000 seeds of—								Total stripe-diseased plants	
		Min-sturdl, crop of 1925	Un-named variety, crop of 1925	Wisconsin Pedigree No. 6, crop of—					Man-churia, crop of 1926		
				1922	1923	1924	1925	1926			
No.	Name										
	Control (untreated).....	96	74	36	41	102	47	11	10	Number	Per cent
1	Abavit B.....	0	0	0	0	1	0	1	0	417	8.80
2	Tutan.....	1	7	7	1	4	4	1	0	2	.04
3	S. F. A. No. 225-V.....	0	4	0	0	1	0	0	0	25	.50
4	S. I. No. 220.....	15	9	53	20	77	33	6	0	7	.14
5	Semesan.....	3	2	1	1	3	2	0	0	216	4.15
6	Semesan Jr.....	2	2	3	0	7	0	0	0	12	.23
7	Du Pont No. 12.....	0	0	0	0	1	0	0	0	14	.27
	Control (untreated).....	105	62	40	38	96	56	7	5	1	.02
8	Du Pont No. 45.....	0	1	1	1	9	0	0	0	409	8.10
9	Bayer Dust.....	1	4	2	0	9	0	2	0	12	.23
10	Bayer Dust II.....	3	3	5	1	11	0	0	1	18	.35
11	Wa Wa Dust.....	0	0	0	0	0	0	0	0	24	.45
12	Mercury C.....	2	1	0	1	5	1	0	0	0	0
13	Höchst.....	0	0	0	0	0	0	0	0	10	.20
14	Germisan (0.25 per cent, 1 hour).....	0	1	0	0	0	0	0	0	0	0
	Total in controls.....	201	136	78	79	198	103	18	15	826	-----
	Total from treated seed ¹	12	27	19	5	51	7	4	1	126	-----
	Ratio, untreated to treated ¹	17:1	5:1	4:1	17:1	4:1	15:1	5:1	15:1	7:1	-----

¹ No. 4 not included.

Wa Wa Dust and Höchst were the only fungicides that prevented the disease completely, although Abavit B, Du Pont No. 12, and Germisan gave very nearly perfect control. All the remaining dusts reduced the amount of infection to 0.5 per cent or less, with the exception of S. I. No. 220, which, as in series 1, was relatively ineffective.

TABLE 17.—*Occurrence of stripe disease in spring barley grown from five lots of seed, untreated or treated with different fungicides, and sown in paired rod rows at the rate of 10 grams per row, Madison, Wis., May 1, 1927*

Seed treatment		Infected plants from seed of—					Total plants infected	
		Min-sturdl, crop of 1925	Un-named variety, crop of 1925	Wisconsin Pedigree No. 6, crop of—				
				1924	1925	1926		
No.	Name							
	Control (untreated).....	81	45	77	32	8	Number	Per cent
1	Abavit B.....	0	0	2	0	0	243	10.56
2	Tutan.....	4	0	0	1	0	2	.09
3	S. F. A. No. 225-V.....	1	0	1	0	0	5	.22
4	S. I. No. 220.....	16	15	55	21	6	2	.10
5	Semesan.....	0	1	3	0	1	113	4.87
6	Semesan Jr.....	1	2	8	0	0	6	.25
7	Du Pont No. 12.....	0	0	1	0	0	11	.48
	Control (untreated).....	70	38	100	24	10	1	.04
8	Du Pont No. 45.....	1	0	9	1	0	242	10.52
9	Bayer Dust.....	2	0	6	2	0	11	.47
10	Bayer Dust II.....	1	1	5	0	0	10	.41
11	Wa Wa Dust.....	0	0	0	0	0	7	.30
12	Mercury C.....	1	0	2	0	0	0	0
13	Höchst.....	0	0	0	0	0	3	.13
14	Germisan (0.25 per cent, 1 hour).....	0	0	0	0	0	0	0

In the series sown May 1, the results were very similar to those described above. (Table 17.) Wa Wa Dust, Höchst, and Germisan solution gave complete control, while all the other fungicides reduced the percentage of infection to less than 0.5 per cent, with the exception of S. I. No. 220, which was relatively ineffective, as before.

In Tables 14 and 16 it will be observed that in Wisconsin Pedigree No. 6 barley the 1923 seed lot in each case produced the highest ratio between the total number of diseased plants from untreated and treated seed. This seems to indicate that, under the same conditions, the treatments, as a whole, were relatively more effective in stripe-disease control in this seed lot than in the seed from the 1924 crop, which in each case shows the lowest ratio between numbers of diseased plants from untreated and treated seed. In this respect the 1925 seed lot occupies a position next to that of the 1923 seed lot in both series, while the relative positions of the 1922 and 1926 seed lots with respect to one another are reversed in the two series.

These data, although not highly significant, suggest the possibility that naturally inoculated seed of a given variety of barley from one crop year may respond to seed treatment more readily than seed of this same variety grown in another crop year. This difference in response to seed treatment may be dependent on certain environmental conditions which obtain during the period in which stripe-disease inoculation takes place and which may cause the infective material to be more deep-seated in the seed in some years than it is in others. On the other hand, it seems evident from these data that the age of the seed does not materially affect the seed-borne stripe-disease organism so far as its susceptibility to control by seed treatment is concerned. If this were the case, it would be reasonable to expect that the seed treatments would have been most effective in the control of stripe disease in the 1922 seed lot and least effective in the 1926 seed lot. However, such was not the case.

In order to determine what effect, if any, the fungicides had on the stand in series 2, it was planned to make a total plant count. This, however, proved to be impracticable on account of the hard, dry soil. Therefore, total culm counts were made, and the results are shown in Table 18. It will be observed that, on the whole, the treatments caused little increase or decrease in the average number of culms per thousand seeds sown, as compared with the number of culms from an equal number of untreated seeds. Only in the case of Semesan was the increase barely significant, according to the odds computed by Student's method. Likewise, Wa Wa Dust was the only treatment that appeared to cause a significant decrease in the relative numbers of culms. As a whole, the treatments seemed to cause an average increase of only 0.72 per cent in the total number of culms, as compared with the controls. However, since over 8 per cent of the culms in the control rows were stripe diseased and an average of not over 0.5 per cent of infection occurred in any of the rows from treated seed, some benefits from seed treatment are apparent.

TABLE 18.—Number of culms of barley grown from eight lots of seed, untreated or treated with different seed disinfectants, and sown at the rate of 250 seeds per row in paired rod rows replicated twice for each treatment and seed lot, Madison, Wis., 1927

Seed treatment		Total culms from 1,000 seeds of--								Summary			
No.	Name	Miscanthus, crop of 1925	Unnamed variety, crop of 1925	Wisconsin Pedigree No. 3, crop of--					Miscanthus, crop of 1926	Average number culms from 1,000 seeds	Increase or decrease, as compared with control		
				1922	1923	1924	1925	1926			Culms	Per cent	Odds
	Control (untreated)	1,012	1,195	1,208	1,022	983	1,053	1,042	1,217	1,062			
1	Abavit B	932	1,066	1,220	1,028	1,080	1,056	974	1,179	1,007	-30	-2.7	8:1
2	Tutan	974	1,191	1,228	1,199	1,125	1,073	953	1,187	1,116	+19	1.7	3:1
3	S. F. A. No. 225-V	972	1,170	1,351	1,328	1,242	1,110	1,024	1,171	1,171	+74	6.7	12:1
4	Semesan	1,016	1,203	1,268	1,295	1,258	1,113	1,094	1,216	1,183	+68	7.8	48:1
5	Semesan Jr.	1,052	1,147	1,223	1,155	1,208	1,044	1,072	1,200	1,138	+41	3.7	14:1
6	Du Pont No. 12	1,034	1,004	1,092	995	1,148	1,054	1,070	1,165	1,078	-19	-1.7	4:1
7	S. I. No. 220												
	Control (untreated)	1,079	1,180	1,089	1,075	1,118	1,123	1,025	1,143	1,102			
8	Du Pont No. 45	970	1,124	1,106	1,058	1,139	1,082	932	1,137	1,009	-28	-2.6	8:1
9	Bayer Dust	1,048	1,129	1,095	1,144	1,213	1,070	1,027	1,158	1,111	+14	1.3	2:1
10	Bayer Dust II	1,091	1,157	1,086	1,123	1,212	1,054	1,056	1,157	1,113	+16	1.5	3:1
11	Wa Wa Dust	810	962	998	1,005	1,124	1,036	912	997	992	-105	-9.6	51:1
12	Mercury C	1,046	1,236	1,090	1,266	1,238	1,127	970	1,210	1,148	+51	4.5	9:1
13	Höchst	966	1,036			1,342	1,082	932		1,072	-25	-2.3	1:1
14	Germisan (0.25 per cent, 1 hour)	1,080	990			1,305	1,145	1,008		1,107	+10	.9	2:1

EXPERIMENTS IN 1928

During the spring of 1928, data again were taken on the occurrence of stripe disease in Tennessee Winter barley grown from seed that had been treated with different fungicides and sown the preceding fall on the Arlington Experiment Farm. The seed had been sown in rod rows replicated twenty times for each treatment in each of two parallel series. Series 1 had been sown September 21, 1927, in soil the moisture content of which amounted to only 13 per cent of saturation and which received no rainfall until after the plants had emerged. Series 2 had been sown October 7, 1927, in soil the moisture content of which was 65 per cent of saturation and which received an inch of rainfall three days after the seed had been sown. The mean soil temperatures during the periods of emergence in series 1 and 2 were 18° and 16° C., respectively. Tests in the field and in the greenhouse failed to show that any of the treatments had any appreciable effect on the percentages of germination, as shown in Table 19.

The stripe-disease data, taken in May, 1928, also are shown in Table 19. The infection in the controls in series 2 was much more severe than in series 1, probably because of the lower soil temperatures that prevailed after series 2 was sown. However, in spite of the more favorable conditions for stripe-disease development in series 2, stripe-disease control by all the dusts was better in this series than in the dry soil of series 1. The outstanding fungicide in both series was Höchst. Abavit B, Mercury C, Wa Wa Dust, and several others were fairly effective. However, a number of these contain a mercury content too high to make them practicable as seed-treatment compounds for barley, in view of the fact that cheaper and equally effective fungicides are now on the market.

TABLE 19.—*Emergence of, and stripe-disease control in, Tennessee Winter barley grown from treated and untreated seed sown on Arlington Experiment Farm, Rosslyn, Va., in rod rows replicated 20 times for each treatment and control in each of two series: Series 1 sown September 21, 1927, in soil 13 per cent saturated; series 2 sown October 7, 1927, in soil 65 per cent saturated*

Seed treatment		Emergence		Stripe-diseased plants			
No.	Name	Field	Greenhouse	Series 1		Series 2	
		Per cent	Per cent	Number	Per cent	Number	Per cent
	Control (untreated).....	75	76	199	5.75	403	13.71
1	Abavit B.....	75	86	15	.43	0	0
2	S. F. A. No. 225.....	80	83	27	.77	5	.15
3	S. F. A. No. 225-V.....	74	92	29	.82	8	.18
4	Höchst.....	76	91	2	.05	0	0
5	Tutan.....	80	92	110	2.93	90	2.76
6	Vitrioline.....	79	86	193	5.37	106	6.34
7	Mercury C.....	78	85	25	.68	2	.06
	Control (untreated).....	81	80	210	5.74	428	14.46
8	Wa Wa Dust.....	79	86	10	.27	4	.13
9	Semesan.....	80	87	17	.45	5	.16
10	Semesan Jr.....	80	87	13	.34	5	.16
11	Du Pont No. 35.....	81	87	26	.71	6	.18
12	Du Pont No. 45.....	78	89	23	.62	2	.06
13	Du Pont No. 53.....	82	88	62	1.67	36	1.13
14	Du Pont No. 64.....	80	88	27	.75	2	.06

In the spring of 1928 further experiments on the control of stripe disease in spring barley were conducted with fungicides that had proved effective in previous tests, as well as with a few additional experimental dust fungicides recently submitted by commercial concerns. Most of the latter were used in a preliminary experiment, along with other dusts of questionable merit, but three were used in the more frequently replicated trials.

The seed used was Wisconsin Pedigree No. 6 barley from the 1925 and 1926 crops grown on the Rock County farm, near Janesville, Wis. The dusts were applied at the rate of 3 ounces per bushel and thoroughly mixed with the seed in a mechanical contrivance, as previously described (17). Two parallel series were sown, as before, the first at Arlington Experiment Farm and the second at Madison, Wis. Because of unfavorable weather and soil conditions, the plants in the first series failed to develop beyond the seedling stage, and no data of value were obtained from them.

At Madison, Wis., the seed was sown April 26 on the East Hill farm of the Wisconsin Agricultural Experiment Station. In the first experiment, in which dusts of unknown or questionable merit were tested, only seed from the 1926 crop was used, and 4 rod rows were devoted to each treatment. In the second experiment 24 rod rows were used for each treatment on each seed lot. Germination tests were made in the greenhouse.

The infection data taken on the first experiment at Madison, Wis., are shown in Table 20. Only two of the experimental dusts used showed any especial effectiveness in stripe-disease control; namely, Bayer 189 and Abavit Special. Different dilutions of formaldehyde, paraformaldehyde, or iodine with talc or kaolin proved ineffective, notwithstanding certain claims that had been made to the contrary.

TABLE 20.—*Stripe-diseased plants in Wisconsin Pedigree No. 6 barley grown from seed, untreated or treated with various experimental dust disinfectants, and sown in rod rows replicated four times for each treatment, Madison, Wis., April 26, 1928*

Seed treatment				Seed treatment			
No.	Name	Stripe-diseased plants		No.	Name	Stripe-diseased plants	
		Num-ber	Per-cent			Num-ber	Per-cent
	Control (untreated).....	83	10.4	16	Iodine, 3 per cent.....	70	8.8
1	Bayer HT-3.....	69	8.6	17	Iodine, 2 per cent.....	72	9.0
2	Agia 331.....	8	1.0	18	Metaphen.....	32	4.0
3	Bayer No. 192.....	20	2.5	19	Du Pont No. 68.....	37	4.6
4	Bayer No. 194.....	60	6.3	20	Abavit Special.....	1	.1
5	Bayer No. 196.....	16	2.0	21	Sulphur + potassium perman- ganate.....	32	10.3
6	Bayer No. 200.....	65	6.9		Control (untreated).....	80	10.0
7	Bayer No. 189.....	1	.1	22	Formaldehyde, dry, 6 per cent on talc.....	75	9.4
8	Control (untreated).....	77	9.6	23	Formaldehyde, dry, 5 per cent on talc.....	73	9.1
9	U. T. 348.....	21	2.6	24	Formaldehyde, dry, 4 per cent on talc.....	68	8.3
10	U. T. 488.....	45	5.6	25	Bayer Dust.....	13	1.6
11	Paraformaldehyde, 20 per cent.....	36	3.8	26	Copper oxychloride.....	57	7.1
12	Paraformaldehyde, 15 per cent.....	49	6.1	27	Vitrioline.....	28	3.5
13	Paraformaldehyde, 10 per cent.....	67	8.4	28	Tutan.....	8	1.0
14	Paraformaldehyde, 5 per cent.....	76	9.5				
15	Iodine, 5 per cent.....	53	6.6				
	Control (untreated).....	73	9.1				
	Iodine, 4 per cent.....	69	8.6				

Infection data on the second experiment are presented in Table 21, together with the germination data secured in the greenhouse. None of the treatments, it will be observed, seemed to have any pronounced effect on germination.

TABLE 21.—*Emergence of, and stripe-diseased plants in, Wisconsin Pedigree No. 6 barley grown from 1925 and 1926 seed, untreated or treated with different seed disinfectants, and sown in paired rod rows replicated twelve times for each seed lot and each treatment at Madison, Wis., April 26, 1928*

Seed-treatment		Emergence	Total stripe-diseased plants from—			
No.	Name		1925 seed		1926 seed	
		Per cent	Number	Per cent	Number	Per cent
	Control (untreated).....	88	259	5.40	795	13.40
1	Abavit B.....	90	6	.13	46	.87
2	S. F. A. No. 225-V.....	89	13	.27	67	1.27
3	Höchst.....	89	0	0	0	0
4	Samesan.....	86	21	.44	71	1.34
5	Samesan Jr.....	89	30	.63	72	1.36
6	Du Pont K-1-C.....	92	0	0	0	0
	Control (untreated).....	95	240	6.00	653	12.37
7	Du Pont K-1-D.....	90	1	.02	0	0
8	Wa Wa Dust.....	95	2	.04	5	.09
9	Mercury C.....	87	3	.06	29	.55
10	Bayer 171-A.....	88	45	.94	161	3.05
11	Paraformaldehyde.....	85	115	2.40	553	10.50
12	Germisan (0.25 per cent, 1 hour).....	83	0	0	1	.02

In the controls from 1925 and 1926 seed, the number of stripe-diseased plants averaged 5.2 per cent and 12.9 per cent, respectively. Höchst again was outstanding in its complete control of stripe disease in all replications, as also was the Du Pont Dust K-1-C. The essential ingredient of the latter dust consisted of 1.5 per cent of ethyl mercuric chloride. K-1-D contained only 1 per cent of this chemical, and, as will be observed in Table 23, it was on the border line of complete effectiveness. A product similar to K-1-C, but containing 2 per cent of ethyl mercuric chloride, is now on the market under the

trade name of Ceresan. Next in the order of effectiveness came Germisan (0.25 per cent solution), Wa Wa Dust, Mercury C, and Abavit B. The remaining dusts were relatively ineffective, as none of them reduced the infection in the plants from 1926 seed to less than 1 per cent.

In order to determine whether the more efficient treatments caused any consistent increases in the yield of grain, the different replications were harvested and each 2-row replication was threshed separately in a plot thresher. The average yields per replication are presented in Table 22, together with the average increase in yield caused by each treatment. With 5.2 per cent of stripe disease in the controls from 1925 seed, and less than 0.2 per cent of infection in any of the rows from treated seed, the different treatments seemed to cause an increase in yield of from 0.2 per cent in the case of K-1-D to 16.1 per cent in the case of Abavit B. Only in the case of Abavit B and Germisan, however, were the increases in yield significant on the basis of the odds calculated according to Student's method.

TABLE 22.—Percentage of stripe-diseased plants in and yield from Wisconsin Pedigree No. 6 barley grown from two lots of naturally inoculated seed, untreated or treated with various seed disinfectants, and sown at Madison, Wis., April 26, 1928, in paired row rows replicated twelve times for each treatment and each seed lot

1925 SEED						
No.	Seed treatment	Stripe-diseased plants	Average replication yield	Increase in yield as compared with control		
	Name			Grams	Per cent	Odds
	Control (untreated).....	Per cent 5.20	Grams 514			
1	Abavit B.....	.13	713	99	16.1	638:1
3	Höchst.....	0	672	58	9.4	8:1
6	Du Pont K-1-C.....	0	662	48	7.8	18:1
7	Du Pont K-1-D.....	.02	615	1	.2	1:1
8	Wa Wa Dust.....	.04	631	17	2.8	2:1
9	Mercury C.....	.06	655	41	6.7	12:1
12	Germisan.....	0	689	75	12.2	68:1
1926 SEED						
	Control (untreated).....	12.9	551			
1	Abavit B.....	.87	647	98	17.4	93:1
3	Höchst.....	0	644	93	16.9	100:1
6	Du Pont K-1-C.....	0	652	101	18.3	21:1
7	Du Pont K-1-D.....	0	740	189	34.3	207:1
8	Wa Wa Dust.....	.06	641	90	16.3	1,221:1
9	Mercury C.....	.55	633	82	14.9	15:1
12	Germisan.....	.02	685	134	24.3	188:1

In the control rows from the 1926 seed the stripe disease averaged 12.9 per cent, while the average infection for the treated seed was 0.22 per cent. Five of the seven treatments compared caused significant increases in yield of from 16.3 per cent to 34.3 per cent, the average increase for all treatments being 20.3 per cent.

EXPERIMENTS IN 1929

Experiments begun in the fall of 1928 and designed to test the efficiency of certain fungicides in the control of smuts in Tennessee Winter and Wisconsin Winter barleys yielded some data on the control of stripe disease in these varieties the following spring. Seven

dust fungicides had been used together with a 1:320 solution of 37 per cent formaldehyde for comparison. The dusts had been applied to the seed at the rate of 3 ounces per bushel. The formaldehyde treatment had been applied as follows: The seed was soaked in water for 15 minutes and then was allowed to lie covered for four hours. After a 20-minute immersion in the 1:320 formaldehyde solution it was again covered for three hours and then dried with a fan. The seed was sown October 18, 1928, in soil that was only 19 per cent saturated. This lack of ample soil moisture seems to be reflected in the relatively poor control of stripe disease by some of the dusts, as shown by the data which were taken in May, 1929, presented in Table 23.

TABLE 23.—*Stripe-diseased plants in Tennessee Winter and Wisconsin Winter barley grown from seed, untreated or treated with different fungicides, and sown in row rows replicated eight times for each treatment and control in each variety, Arlington Experiment Farm, Rosslyn, Va., October 18, 1928*

Seed treatment		Stripe-diseased plants			
No.	Name	Tennessee Winter		Wisconsin Winter	
		Number	Per cent	Number	Per cent
	Control (untreated).....	101	5.10	21	1.05
1	Ceresan.....	1	.05	1	.05
2	Bayer P. M. A.....	6	.30	0	0
3	Höchst.....	15	.75	1	.05
4	Abavit B.....	27	1.35	7	.35
5	Formaldehyde.....	9	.45	3	.15

Experiments on the control of stripe disease in two varieties of spring barley in 1929 were restricted to seven dust fungicides and one liquid fungicide. Seed of Wisconsin Pedigree No. 5 was used in an experiment of rather limited scope designed primarily to test several dust fungicides as to their efficiency in loose-smut control. However, more stripe disease than loose smut developed; therefore, data were taken on the control of this disease, as shown in Table 24. Ceresan, Bayer P. M. A., and Höchst gave perfect control, and Mercury C was very good, but Abavit B, which had been consistently effective in previous experiments, gave only about 50 per cent control in series 1, although in the more limited replications of series 2 it permitted only one stripe-diseased plant. The Abavit B used in series 1 came from a container that had been partly open since the preceding October, while that used in series 2 came from a sealed container. This may account for the different results obtained in the two series. Corona 80-B and Smuttox proved relatively worthless as fungicides for stripe-disease control. Germisan, the liquid fungicide, proved effective, as usual.

Naturally inoculated seed of Wisconsin Pedigree No. 6 barley was used in 1929 in rather extensive field experiments carried out at a number of experiment stations in addition to the Arlington Experiment Farm. The seed was treated at the Arlington farm February 27, 1929, 3 ounces per bushel being used in the case of each of the dust fungicides. The Germisan treatment, as usual, consisted of a 1-hour soak at room temperature in a 0.25 per cent water solution of Germisan, after which the seed was thoroughly dried.

TABLE 24.—*Stripe-diseased plants in Wisconsin Pedigree No. 5 barley grown from seed, untreated or treated with different fungicides, and sown at Arlington Experiment Farm, Rosslyn, Va., in two series*

[Series 1, sown March 13 in quadruplicated rod rows in soil 46 to 50 per cent saturated and with an average temperature of 11.5° C. during the period of emergence; series 2, sown April 8 in paired rod rows in soil 75 per cent saturated, with a rainfall of 1.2 inches and an average soil temperature of 16.1° during the period of emergence]

Seed treatment		Stripe-diseased plants			
No.	Name	Series 1		Series 2	
		Number	Per cent	Number	Per cent
	Control (untreated).....	152	22.3	31	6.8
1	Ceresan.....	0	0	0	0
2	Bayer P. M. A.....	0	0	0	0
3	Höchst.....	0	0	0	0
4	Abavit B.....	68	10.1	1	.2
	Control (untreated).....	138	21.8	21	4.4
5	Mercury C.....	5	.6	2	.4
6	Corona 80-B.....	127	14.8	24	4.4
7	Smuttox.....	172	19.7	13	2.4
8	Germisan.....	0	0	0	0

The untreated and treated seed was packeted and sent to the different stations for sowing. The following are the stations and the workers whose cooperation made this work possible:

Arlington Experiment Farm, Rosslyn, Va.
 Manhattan, Kans.; C. O. Johnston.
 North Platte, Nebr.; G. F. Sprague.
 Madison, Wis.; J. G. Dickson.
 Brookings, S. Dak.; K. H. Klages.
 St. Paul, Minn.; C. S. Holton.
 Fargo, N. Dak.; W. E. Brentzel.
 Dickinson, N. Dak.; R. W. Smith.

TABLE 25.—*Stripe-diseased plants in Wisconsin Pedigree No. 6 barley, grown from seed untreated or treated with different fungicides and sown in rod rows replicated four times for each treatment and control at each of eight stations¹ in 1929, and data on the length of, and environmental conditions during, the period of emergence*

Seed treatment		Percentage of stripe-diseased plants at station No.— ¹								Total infected plants	
No.	Name	1	2	3	4	5	6	7	8	Number	Per cent
	Control (untreated).....	7.7	1.4	12.7	8.1	10.7	4.5	3.0	4.1	522	6.5
1	Ceresan.....	0	0	0	0	0	0	0	0	0	0
2	Bayer P. M. A.....	0	0	0	0	0	0	0	0	0	0
3	Höchst.....	0	0	0	0	0	0	0	0	0	0
4	Abavit B.....	0	0	.8	.1	.2	0	0	0	11	.14
	Control (untreated).....	5.4	1.4	18.0	6.8	8.5	4.2	2.8	3.2	462	5.6
5	Mercury C.....	0	0	.7	.1	.2	1	0	0	11	.14
6	Corona 80-B.....	4.7	1.4	14.0	5.6	5.4	3.0	4.3	2.5	416	5.0
7	Smuttox.....	6.1	2.0	13.4	5.3	4.5	3.7	5.0	2.9	447	5.4
8	Germisan (0.25 per cent, 1 hour).....	0	0	0	0	0	0	0	0	0	0
Items		Other data for stations numbered as above									
Time to emerge.....days		11	16	23	13	13	13	17	13		
Soil moisture: ²											
At sowing.....		15	11	20	15	(³)	24	12	20		
At emergence.....		29	(³)	25	13	(³)	24	(³)	18		
Mean soil temperature.....° C.		12	12	10	9	*7	9	4	3		
Rainfall.....inches		.44	.72	3.30	.74	.85	.41	1.40	.09		

¹ Stations at: 1, Rosslyn, Va.; 2, Manhattan, Kans.; 3, North Platte, Nebr.; 4, Madison, Wis.; 5, Brookings, S. Dak.; 6, St. Paul, Minn.; 7, Fargo, N. Dak.; 8, Dickinson, N. Dak.

² Expressed as percentage of saturation.

³ Moist; no soil test made.

* Air temperature.

At each station the seed was sown in rod rows replicated four times for each treatment and control. The stripe-disease data taken later in the season are summarized in Table 25, together with data relating to environmental conditions during the period of emergence at each station. A study of the latter data fails to show any consistent correlation between any set of environmental conditions recorded there and the development or the control of stripe disease.

As in a number of previous experiments, Ceresan, Höchst, Bayer P. M. A., and Germisan controlled stripe disease completely, while Abavit B and Mercury C reduced its occurrence to a small trace. Corona 80-B and Smuttox failed entirely to qualify as fungicides for stripe-disease control. In several cases more stripe disease occurred where these compounds were used than was found in the corresponding controls.

EXPERIMENTS IN 1930

During the winter of 1929-30, different commercial concerns sent a number of new fungicidal dusts to be tested for their value in the control of various cereal diseases. These were, accordingly, included in experiments for the control of stripe disease, together with several other fungicidal dusts that had been used in previous experiments.

Five lots of spring barley were used in the experiments: Lot A, Wisconsin Pedigree No. 5, and lot B, Wisconsin Pedigree No. 6, both grown in 1928 at the Wisconsin Agricultural Experiment Station; lot C, Minnesota Velvet, grown in 1929 on the farm of N. Y. Keenan, Oregon, Wis.; and lots D and E, unknown varieties grown in 1929 near Waukesha, Wis.

The different dust fungicides were applied to the seed March 8, 1930, at the rate of 3 ounces per bushel, while the Germisan treatment was carried out as in previous experiments. To determine the effect of the treatments on germination, seed of each of the first three lots of barley, lots A, B, and C, treated with each of the fungicides was sown in the greenhouse bench. The data on germination, taken 10 days later, are given in Table 26. It will be noted that none of the treatments seemed to exert any injurious effect upon germination.

TABLE 26.—Germination percentages of lots A, B, and C of spring barleys grown from untreated and treated seed sown March 19, 1930, in the greenhouse, Arlington Experiment Farm, Rosslyn, Va.

Seed treatment		Percentage of germination			Average
No.	Name	Lot A	Lot B	Lot C	
	Control (untreated).....	78	93	95	<i>Per cent</i> 88.9
1	Ceresan.....	82	92	98	91.0
2	Dubay No. 655.....	78	95	97	90.0
3	Dubay No. 665.....	87	96	97	93.3
4	Abavit B.....	83	96	96	91.6
	Control (untreated).....	83	91	96	90.0
5	Höchst.....	81	96	99	92.0
6	Wa Wa Dust.....	83	84	95	87.3
7	Corona Oat Dust.....	86	83	90	88.3
8	Sterocide.....	79	90	96	88.3
	Control (untreated).....	85	83	92	86.6
9	Sanoseed Grain Dust.....	75	88	98	87.0
10	Acce Dust No. 7.....	86	90	98	91.3
11	Wienert's Compound.....	85	94	88	89.0
12	Germisan.....	86	92	99	92.3

Untreated and treated seed of all five lots of barley, lots A, B, C, D, and E, was sown on the Arlington Experiment Farm in paired rod rows in four parallel series. Each series was sown on a different date and on a different part of the farm, in order to secure different environmental conditions. The salient facts regarding the dates of sowing, the length of the periods from sowing to emergence, and the environmental conditions during these periods are shown in Table 27. Unfortunately, sudden inclement weather interrupted the work of sowing series 1 so that it was not possible to include seed of lots D and E in this series.

TABLE 27.—*Environmental data on experiments for the control of stripe disease in five lots of spring barley sown on Arlington Experiment Farm, Rosslyn, Va., 1930*

Series No.	Date sown	Days to emerge	Average soil temperature ¹	Moisture content ² of soil		Rainfall ³
				At sowing	At emergence	
			^a C.			Inches
1	Mar. 11	19	5	67	56	1.01
2	Mar. 17	18	6	68	56	.65
3	Mar. 18	17	6.5	70	50	.65
4	Mar. 20	16	7.5	40	39	.96

¹ From sowing to emergence.

² Expressed as percentage of water-holding capacity.

Untreated and treated seed of lots A, B, and C was sown also at Madison, Wis., April 25, and the seedlings emerged May 3. A second sowing of seed of lot A was made at Madison, Wis., April 30, and the seedlings emerged May 6. In each case only two rod rows were sown for each treatment and each seed lot.

The stripe-disease data taken at the Arlington Experiment Farm and at Madison, Wis., are presented in Tables 28 and 29, respectively. At the former place, stripe disease was completely eliminated in all replications only by Dubay No. 665 and Corona Oat Dust.⁷ However, it was reduced to a general average of less than 0.1 per cent by Ceresan, Dubay No. 655, Höchst, and Germisan, the total number of stripe-diseased plants in all four series being 2, 1, 2, and 3, respectively, as compared with an average of slightly over 900 stripe-diseased plants in corresponding control rows. Abavit B, Wa Wa Dust, and Wienert's Compound, while fairly effective on the whole, were not consistently effective, for in certain replications they permitted the occurrence of more than 1 per cent of stripe-diseased plants. Sterocide, Sanoseed Grain Dust, and Acco Dust No. 7 yielded, on the whole, very unsatisfactory results.

⁷ It should be stated that in 1930 this dust contained ethyl mercuric chloride, to which doubtless may be attributed its effectiveness in this case. At present this compound does not contain this ingredient and is not recommended for stripe-disease control.

TABLE 28.—Percentage of stripe-diseased plants in five lots of barley grown from untreated or treated seed sown in paired rod rows in four series, March 11, 17, 18, and 20, 1930, respectively, Arlington Experiment Farm, Rosslyn, Va.

Seed treatment		Percentage of stripe-diseased plants in—														
		Lot A					Lot B					Lot C				
		Series No.				Aver- age	Series No.				Aver- age	Series No.				Aver- age
No.	Name	1	2	3	4		1	2	3	4		1	2	3	4	
	First control (untreated).....	17.2	21.0	15.6	34.8	22.8	4.3	8.6	6.4	4.0	5.7	10.7	13.2	4.7	6.5	8.9
1	Ceresan.....	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0
2	Dubay No. 655.....	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0
3	Dubay No. 665.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Abavit B.....	1.0	4	0	0	4	0	2	0	0	0	1	1.8	0	0	5
	Second control (untreated).....	16.1	22.0	13.9	33.0	21.2	5.0	7.4	6.9	2.4	5.6	10.9	11.4	8.8	7.0	9.6
5	Höchst.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Wa Wa Dust.....	1.4	3.6	2.0	2	1.8	0	2	2	0	1	3.7	1.8	0	0	1.4
7	Corona Oat Dust.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Sterocide.....	16.4	18.4	9.2	15.1	14.2	4.0	6	9	6	1.0	7.4	0	0	0	1.9
	Third control (untreated).....	19.3	20.3	18.5	25.7	20.9	6.0	7.3	6.0	3.8	5.9	10.8	13.0	5.4	9.5	9.9
9	Sanoseed Grain Dust.....	16.3	9.6	11.3	5.3	10.4	5	8	9	2	7	1.8	2.6	8	2	1.2
10	Acco Dust No. 7.....	20.0	21.6	17.6	22.7	20.3	4.8	8.3	3.5	6.7	5.0	5.8	6.1	2.6	6	4.0
11	Wienert's Compound.....	2.3	6	4	0	8	0	0	0	0	0	6	0	0	0	1
12	Germisan (0.25 per cent, 1 hour).....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Seed treatment		Percentage of stripe-diseased plants in—Continued										Total stripe-diseased plants
		Lot D ¹					Lot E ²					
		Series No.				Average	Series No.				Average	
No.	Name	1	2	3	4		1	2	3	4		
	First control (untreated).....		15.4	1.4	10.5	10.3		6.8	1.7	1.6	3.3	No. 900 10.4
1	Ceresan.....		0	0	0	0		0	0	0	0	2 T
2	Dubay No. 655.....		0	0	0	0		0	0	0	0	1 T
3	Dubay No. 665.....		0	0	0	0		0	0	0	0	0
4	Abavit B.....		0	0	0	0		0	0	0	0	19 2
	Second control (untreated).....		10.5	3.3	14.2	10.1		6.6	3.0	1.6	3.9	012 10.27
5	Höchst.....		0	0	0	0		0	2	0	1	2 T
6	Wa Wa Dust.....		0	0	0	0		4	0	0	1	70 8
7	Corona Oat Dust.....		0	0	0	0		0	0	0	0	0
8	Sterocide.....		4.6	7	1.3	2.5		3.1	8	0	1.3	371 4.34
	Third control (untreated).....		12.3	4.3	10.4	9.4		6.3	2.6	2.6	3.9	894 10.2
9	Sanoseed Grain Dust.....		8	2.3	4	1.0		9	8	0	5	249 2.8
10	Acco Dust No. 7.....		6.4	1.1	5.6	4.7		3.3	1.7	1.2	2.0	664 7.6
11	Wienert's Compound.....		0	0	0	0		0	0	0	0	17 2
12	Germisan (0.25 per cent, 1 hour).....		2	0	4	2		0	0	0	0	3 T

¹ T=trace, or less than 0.1 per cent.² Unknown varieties from Waukesha, Wis.

In general, the results obtained at Madison, Wis., were similar to those obtained at the Arlington farm, except that instead of only two, five dusts, namely, Ceresan, Dubay No. 655, Dubay No. 665, Höchst, and Corona Oat Dust, as well as the Germisan liquid treatment, completely eliminated stripe disease. Wa Wa Dust and Wienert's Compound were slightly more effective at Madison, Wis., than at the Arlington farm, while Sterocide, Sanoseed Grain Dust, and Acco Dust No. 7, as before, were entirely unsatisfactory from the standpoint of stripe-disease control. The results from Abavit B were identical⁷ at both places.

TABLE 29.—Percentage of stripe-diseased plants in three lots of barley grown from untreated or treated seed sown in paired rod rows at Madison, Wis., April, 1930

Seed treatment		Stripe-diseased plants in—				Total stripe-diseased plants	
		Wisconsin Pedigree No. 5		Wisconsin Pedigree No. 6	Minnesota Velvet		
No.	Name	Series 1	Series 2				
		Per cent	Per cent	Per cent	Per cent	Number	Per cent
	First control (untreated).....	12.0	13.8	2.1	0.9	113	7.2
1	Ceresan.....	0	0	0	0	0	0
2	Dubay No. 655.....	0	0	0	0	0	0
3	Dubay No. 686.....	0	0	0	0	0	0
4	Abavit B.....	2	3	0	2	3	2
	Second control (untreated).....	13.6	8.0	4.6	2.3	144	7.0
5	Höchst.....	0	0	0	0	0	0
6	Wa Wa Dust.....	0	6	0	0	2	1
7	Corona Oat Dust.....	0	0	0	0	0	0
8	Sterocide.....	9.7	9.3	1.8	2	89	4.6
	Third control (untreated).....	13.7	10.7	4.6	2.5	150	7.6
9	Sanoseed Grain Dust.....	4.5	6.9	2	5	57	2.7
10	Acco Dust No. 7.....	13.8	11.0	2.6	3.2	135	7.2
11	Wienert's Compound.....	4	1.0	6	0	8	4
12	Germisan (0.25 per cent, 1 hour).....	0	0	0	0	0	0

DISCUSSION

In the five years from 1926 to 1930, inclusive, more than 75 fungicidal dusts were used in experiments on the control of stripe disease. Only one of these, namely, Abavit B, was included in experiments covering this entire period. Three of the dusts were tested over a period of four years, six were tried for three years, eight for two years, and the remainder were used in only one year's experiments. A number of previously untried experimental dusts received from different companies or individuals, as well as some made up in the laboratory, were limited to tests in preliminary greenhouse experiments, in which their injurious effects upon seed germination or their other objectionable features furnished sufficient reasons for promptly discarding them. No mention is made of these dusts in the foregoing pages.

Eight dusts were received from Germany and one from France. None of these has ever been on the market in the United States.

More than 50 dusts were submitted by different individuals or commercial concerns in the United States. Most of these were experimental dusts and never reached the stage of commercial manufacture. Many were discarded as ineffective after one or two trials. The formulae of some, however, with slight modifications have been more recently used in the manufacture of very effective fungicides.

Of the 21 or more dusts made up from materials in the laboratory, none proved very promising. A few were effective in stripe-disease control, but seriously injured germination and stand.

A representative number of the dusts that were tested are listed in Table 30, which shows the number of seasons each dust was tested, the total number of rod rows devoted to each during this period, the number of stripe-diseased plants found in these rows and also in an equal number of rows from untreated seed, and finally, the degree of control obtained by using each dust.

TABLE 30.—*Relative efficiency of a number of fungicidal dusts in the control of stripe disease in barley in experiments covering from one to five years, the liquid fungicide Germisan being included for comparison*

No.	Treatment Name	Seasons tested	Rod-row replications	Infected plants from—		Average control
				Untreated seed	Treated seed	
		Number	Number	Number	Number	Per cent
	Germisan (liquid).....	5	208	3,747	5	99.9
1	Abavit B.....	5	342	7,146	230	96.7
2	Höchst.....	4	236	4,762	20	99.9
3	Wa Wa Dust.....	4	296	3,466	94	98.6
4	Mercury C.....	4	242	4,663	111	97.9
5	Ceresan.....	3	114	2,575	4	99.8
6	S. F. A. No. 225-V.....	3	243	4,536	145	96.8
7	Germisan.....	3	252	5,281	184	96.5
8	Bayer Dust.....	3	192	3,781	148	96.1
9	Germisan Jr.....	3	304	3,899	180	95.4
10	S. F. A. No. 225.....	3	108	1,652	120	92.7
11	Du Pont No. 35.....	2	24	501	6	98.8
12	Du Pont No. 45.....	2	32	1,829	44	97.6
13	Du Pont No. 64.....	2	24	711	29	95.9
14	Tutan.....	2	168	3,340	279	91.7
15	Du Pont No. 53.....	2	24	711	101	85.8
16	Vitrioline.....	2	8	152	33	78.3
17	S. I. No. 220.....	2	140	2,297	680	70.4
18	Du Pont No. 68.....	2	8	149	62	58.4
19	Corona Oat Dust ¹	1	42	1,062	0	100.0
20	Dubay No. 685.....	1	42	900	0	100.0
21	Dubay No. 656.....	1	42	900	1	99.9
22	Bayer F. M. A.....	1	46	857	6	99.3
23	Abavit No. 1394.....	1	4	80	1	98.8
24	Bayer No. 18.....	1	4	77	1	98.7
25	Wienert's Dust.....	1	42	1,062	25	97.7
26	Bayer Dust II.....	1	122	1,588	64	96.0
27	Du Pont No. 57.....	1	4	73	5	93.2
28	Agfa No. 351.....	1	4	83	8	90.4
29	Karaseh A.....	1	4	72	7	90.3
30	Bayer No. 171-A.....	1	24	653	161	75.3
31	Sanosed Grain Dust.....	1	42	1,062	306	71.2
32	Sterocida.....	1	46	1,070	460	57.0
33	Copper oxychloride.....	1	4	80	57	28.8
34	Iodin, 5 per cent.....	1	4	73	53	27.4
35	Paraformaldehyde, 25 per cent.....	1	48	593	868	25.2
36	Aceto Dust No. 7.....	1	42	1,062	799	24.8
37	Corona 80-B.....	1	38	675	567	16.0
38	Cuprohol.....	1	4	72	66	8.3
39	Smutttox.....	1	38	675	532	6.3
40	Formaldehyde dust, 6 per cent.....	1	4	80	75	6.3

¹ Contained 0.75 per cent of ethyl mercuric chloride. The Corona Oat Dust now on the market does not contain ethyl mercuric chloride.

The figure for control was obtained as follows:

$$\left(1 - \frac{\text{diseased plants from treated seed}}{\text{diseased plants from untreated seed}}\right) \times 100$$

the result, of course, being expressed in terms of percentage. The significance of this figure is, of course, largely governed by the number of replications, as well as by the number of seasons covered by the tests. Similar data are given for the liquid treatment, Germisan, which was used for comparison in many of the experiments.

Taking into consideration the number of seasons in which they were tested and the number of replications used, as well as the percentage control, shown in Table 34, the two most effective dust fungicides were Ceresan and Höchst. Abavit B, the most extensively tested dust fungicide, was somewhat lacking in consistent effectiveness, as were also Mercury C, Wa Wa Dust, and a number of others. Among those tested for two seasons, Du Pont No. 35 was most efficient, and its formula is now used in the manufacture of a seed-corn disinfectant.

Corona Out Dust,⁸ Dubay No. 655, and Dubay No. 665 were the most effective dust fungicides among those used in only one season's tests. The two latter are slight modifications of Ceresan. Bayer P. M. A. was effective in stripe-disease control, but was somewhat injurious to germination. Abavit 1394 and Bayer 189 were promising in a very limited number of replications.

SUMMARY

Stripe disease is practically coextensive with barley culture. The losses caused by it emphasize the desirability of its prevention by seed treatment or by growing resistant varieties.

Stripe disease is caused by *Helminthosporium gramineum* Rabh. and should not be confused with net blotch caused by *H. teres* nor spot blotch caused by *H. sativum*.

Kernels of healthy heads become inoculated by spores blown from near-by diseased plants. These spores become lodged between the glume and the pericarp of the seed, where they germinate and give rise to mycelium, which lies dormant there until the seed germinates. This mycelium then revives and infects the emerging coleoptile, which in turn carries the infection to the next leaf. Successively emerging leaves are infected in turn, and finally the head, which commonly does not emerge completely and seldom produces viable seeds.

Natural inoculation of kernels in the field by wind-borne spores may occur for a considerable period after flowering.

Under some conditions, spores on the outside of the seed may produce infection in the seedling, but it is generally conceded that dormant mycelium is the principal means of the fungus living over from one crop to another.

Removing the glumes from naturally inoculated kernels before sowing had no effect on the percentage of stripe-diseased plants.

Conidia may remain viable from 3½ to 34 months, according to different investigators. Longevity is undoubtedly contingent on conditions of temperature and moisture during storage of the spore material.

Dormant mycelium in the seed remains viable for at least five years.

Viable seeds from diseased plants are not the rule; yet they are not uncommon.

Increased soil fertility or any other condition favoring vigorous plant growth apparently decreases the percentage of diseased plants from naturally inoculated seed.

Growing temperatures of 15° C., or below, during the period of emergence favor the development of the disease in plants from naturally inoculated seed. Temperatures above 20° C. during that period tend to inhibit the development of the disease. Likewise, relatively dry soil (less than 40 per cent saturated) during germination is more conducive to stripe-disease development than extremely wet soil (approximately 90 per cent saturated).

During the 5-year period 1926-1930, more than 75 fungicidal dusts were tested in stripe-disease control experiments. The effectiveness of the dust fungicides used was found to be independent of soil reaction

⁸ This lot contained 0.75 per cent of ethyl mercuric chloride.

and of soil moisture except when the latter was less than 25 per cent of saturation, in which case the effectiveness of the fungicides was reduced. In experiments in which yield data were obtained, the average percentage increase in yield from seed treated with certain fungicides over that from untreated seed invariably was greater than the percentage of stripe-diseased plants from untreated seed observed at the time of heading. This additional increase in yield probably was due to the control of other unobserved diseases, as well as to the control of stripe disease to a greater extent than was indicated by the percentage of stripe disease found in the plants from untreated seed at the time the data were taken.

Although the ordinary wet formaldehyde treatment controls stripe disease satisfactorily, formaldehyde dusts were found ineffective for this purpose.

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