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HESSIAN FLY EXPERIMENTS.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KY.

Bulletin No. 103.

HESSIAN FLY EXPERIMENTS.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

It is now possible to complete the report on experiments made during 1901-1902 with reference to Hessian fly injury in its relation to the time of planting wheat. Statements concerning the benefit resulting from early planting have hitherto been based very largely or entirely on the results of the general practice of farmers. Wheat growers themselves sometimes contradict the assertion that late planting is a means of avoiding injury, basing their opinion on isolated cases of good crops having been obtained from very early-sown seed. Such crops are undoubtedly sometimes obtained, but if we knew all the circumstances an explanation could, in many of the cases, be given entirely consistent with the common opinion that late planting is the better practice. The following record continues and completes the partial report published in Bulletin 96.

Eight plots of Hungarian wheat were planted in the fall of 1901, one week apart, on the following dates: September 26, October 3, 10, 17, 24, 31, November 7, 14. The plots occupied one twenty-second of an acre of ground each. The land was in barley in the spring of 1901, and was already infested with Hessian fly. While a primary object of the experiments was to ascertain the time at which wheat might be planted so as to escape the fly, it was hoped that they might also throw some light on the question as to how late wheat may be planted and yet escape injury from freezing—a question that is so in-

timately bound up with the former that it must be considered in any effort to get facts that will serve as a basis for recommendations as to practice.

Effect of the Winter on the Plantings.

Wheat planted in Kentucky in the fall of 1901 did not give as good a crop as usual. Some farmers attributed this to late planting and bad winter weather—especially to a heavy sleet storm that occurred in January—while others think the fly took it, notwithstanding the lateness with which most of it was planted. But if the winter was the chief cause of the general failure, our later plantings should have suffered most, whereas they suffered no more, as far as was visible, than the others. Furthermore, the late plantings were not injured at all in the fall by the fly. From observations made on these plots and others on the Experiment Farm, as well as on wheat growing on farms in the vicinity, it is plain that the general failure was largely the result of bad weather at the time of planting. The month of October was very dry, the rainfall being well below the average for the month. Only two fully cloudy days were recorded by the local weather station for the month. The variety plantings on the Farm have always done well whenever wheat is good in this part of the State, but in 1901 came the nearest failing they have ever done. The seed lay for a long time in the ground, owing to drought; then came a beating rain, leaving a crust on the surface, through which the plants that developed emerged with difficulty and but tardily. Such as pushed through grew very well afterward and were not harmed perceptibly by winter weather. In this case, again, the fly had nothing to do with the failure in the fall and winter, for the seed was planted after most of the adult flies had disappeared. Considering, therefore, facts of all sorts that came under my observation, it was concluded that failure to secure a good crop in the spring of 1902 was due more to conditions at the time of planting than either to the winter weather or to injury by fly.

Relative Condition of the Plantings.

During the fall there was a wide difference between the wheat

of our different plantings, due in part to the work of the fly and partly to the conditions of weather and soil at the time of, and immediately following, the planting of the seed.

Of course, in general, the early-sown wheat grew ahead of the rest, but earliness of planting was proved not to be the only factor in furthering the growth of the young plants.

Even though the soil might be very dry, the wheat came up promptly and did well afterward if rain followed the planting. But if no rain followed, the seed lay in the soil longer without germinating; and, if the drought was long-continued, the stand of plants was likely to be poor. Similarly, if the soil was very wet when the seed was sown, the stand was less perfect than if the planting was done when the soil was in better condition. The result was that some of the plots sown rather late were better than others sown earlier, in cases where neither were affected by the fly.

After the three last plantings (on October 31 and November 7 and 14) the weather was not suitable for growth. On October 31 the average temperature was 62° F., but sank to 85° on the following day. On the 7th of November the mean temperature was 46°, and on the 14th it was 38°. The average for the month was 40.2° F. The wheat in these three later plots was not visible as late as the 20th of November, but subsequently the tips of some of the plants could be discerned along the drilled rows. In the spring, to my surprise, these two latest plots showed a very good stand of plants, though they remained somewhat behind the others, and were harvested eleven days after the three earliest. The planting of October 31 never did show a good stand of plants.

As showing the condition of the plantings in the spring, the following is taken from notes made May 12, 1902:

Planting of September 26—Average height about 12 inches; stand not as good as in the next.

Planting of October 3—Average height 18 inches; better than the preceding; tallest of all the plantings.

Planting of October 10—Average height 16 inches; good, though not quite as tall as the planting of October 3.

Planting of October 17—Average height 12 inches; not

quite as tall as planting of October 10, but good; one row wanting, owing to failure of the drill.

Planting of October 24—Average height 12 inches; good, but not quite equal to the planting of October 17.

Planting of October 31—Average height 10 inches; plants scattering and small; the poorest stand of all.

Planting of November 7—Average height 10 inches; stand good, considering lateness.

Planting of November 14—Average height 9 inches; quite uniform; a rather better stand than in preceding planting.

The differences in the heights of the plantings continued well toward harvest time, as the notes following, made May 31, show:

September 26—Scattering; headed out, but uneven in height; 25 inches high.

October 3—Fully headed out; even; 36 inches high.

October 10—Headed out; even; 36 inches high.

October 17—Headed out; even; 32 inches high.

October 24—Mostly headed out; uneven; 26 inches high.

October 31—Scattering; uneven; some heads; 18 inches high.

November 7—Heading out; even; 24 inches high.

November 14—Heading out; even; 26 inches high.

When some of the plantings were nearly ready to harvest the following notes were made (June 10). Contrary to my expectation they show not only that the late plantings were slower than the others in ripening, but that the earliest of all (that of September 26) was later than October plantings. This is to be attributed to the fact that in the September planting some stalks were killed outright by the fly, and others pushed up to take their places, thus making the growth uneven and in general later than in plots where less injury of this sort was done:

September 26—Thin and not ripening.

October 3—Very good; heads becoming yellow.

October 10—Perhaps the best; maturing.

October 17—About like planting of October 3.

October 24—Not as good as preceding.

October 31—Thin and not good.

November 7—Fair; not ripening.

November 14—One of the best; not ripening.

Yield and Quality of Grain.

While the yield was not large for any of the plots, the relative yields are perhaps as significant as they would have been if they had been greater. The three earliest plots (of September 26, October 3 and October 10) were harvested June 26. The two next (October 17 and October 24) were cut July 2. The three latest (October 31, November 7 and November 14) were cut July 7. All of the wheat was threshed July 10.

Planting of September 26—16 pounds.

Planting of October 3—40 pounds.

Planting of October 10—28 pounds.

Planting of October 17—30 pounds.

Planting of October 24—20 pounds.

Planting of October 31—8 pounds.

Planting of November 7—24 pounds.

Planting of November 14—28 pounds.

The best yield was thus at the rate of but 14 bushels per acre, while the worst was at the rate of somewhat less than 3 bushels per acre. But it must be noted that the latest planting was one of the best in the matter of yield, while the earliest planting was one of the two worst.

It seems to me that, so far as mere weight of yield is concerned, the late plantings have done about as well as the others.

When the quality of the wheat from the different plots is considered, it appears that the plantings of October 3, 10, 17 and 24 stand first, while the planting of October 31 proves decidedly the poorest. The plot producing the most wheat also produced the best, though the differences between wheats from the plantings of October 3, 10 and 17 were so slight as to be scarcely worthy of consideration. Wheat from each plot was submitted to Mr. W. W. Patterson, of the Lexington Roller Mills, for rating, and his judgment is given below. My own

rating is given beside it, and was made without knowledge of Mr. Patterson's conclusions. Being based in part on data to which he did not have access, the closeness of the two is quite surprising. The weight of 10 cubic centimeters of each wheat is also given, and will be observed to verify in a general way the ratings.

| Date planted. | Mr. Patterson's rating. | Author's rating. | Weight of 10 cc. |
|---------------|-------------------------|------------------|------------------|
| September 26 | 3rd | 4th | 7.4 grams |
| October 3 | 1st | 1st | 7.6 " |
| October 10 | 4th | 3rd | 7.5 " |
| October 17 | 2d | 2d | 7.6 " |
| October 24 | 5th | 5th | 7.3 " |
| October 31 | 8th | 8th | 6.8 " |
| November 7 | 7th | 7th | 7.5 " |
| November 14 | 6th | 6th | 7.3 " |

That the grain from the planting of October 3 was best there could be no question. The seeds were larger, plumper, and with no defective ones. In all the other lots some shriveled seeds could be found, and were especially numerous in the wheat planted October 31, the lightest—bulk for bulk, as well as absolutely—of all. Wheat from the two latest plantings did not prove as good when closely scrutinized and weighed as was expected. It was not quite as plump as that of most of the early plantings, and did not seem as well matured. It was cut a little early, I think, and on this account, while the evidence points to the inference that very late planting will result in inferior grain, I am disposed to suspend judgment on this point until more evidence is secured. A single test is not sufficient basis for a conclusion.

Injury by Fly in the Fall.

When it was reported in Bulletin 96 of this Station that on November 6, 1901, the planting of September 26 showed 33 per cent. of its plants infested with fly; that the planting of October 3 showed 1 per cent. infested, and that none of the other plantings were infested at all, it was supposed, as then suggested, that later examinations would prove that other plots

than the two named were infested also. This seemed probable because Hessian fly eggs were found November 1 on wheat planted October 17, and as this wheat was not up on October 26, some adult fly must have been abroad after the latter date. But it seems now that the eggs laid late in the season did not hatch, and consequently the percentages of injury remained practically unchanged in the plots after the date of my first examination (November 6). A thorough examination was made March 10, 1902, while the wheat was still in a dormant hibernating condition. At this time 30 per cent. of the plants from the September 26 planting was infested with flaxseeds; 9-10 of 1 per cent. of the planting of October 3 was infested, one of the specimens found being still a larva. Neither larvæ nor flaxseeds were found in any of the later plantings.

Plots of wheat were planted again on the same ground in the fall of 1902, beginning on the 15th of September. The season has been more open than in 1901, the first touch of winter coming on the 25th and 26th of November, yet the results of examinations of the different plantings of wheat confirm, in a general way, those made in the winter of 1901-1902. The first two plots were examined on November 21 and the remainder on November 28, 1902.

Planting of September 15—37 per cent. infested.

Planting of September 22—38 per cent. infested.

Planting of September 29—12 per cent. infested.

Planting of October 6—2 per cent. infested.

Planting of October 13—None infested.

Planting of October 20—None infested.

Planting of October 27—None infested.

Injury by Fly in the Spring.

What is the influence of fall-infested wheat on non-infested plantings beside it during the spring? How far does the fly spread in a season from such infested wheat? These questions were suggested by the examinations made during the fall and winter, and have a practical interest for every grower of wheat. It should be stated that the plantings formed one continuous

block, the consecutive plots being separated by a strip scarcely wider than that separating the drilled rows, with the earliest planting at one end of the block and the latest at the other. An examination made May 12, 1902, showed that the condition of the wheat with reference to Hessian fly injury had changed after the emergence of the winter brood, and that the insects had spread from the planting of September 26 to the other plantings, the extent of the injury in them being in proportion to their nearness to the early planting. The flaxseeds found at this time were still white in the majority of cases, and represented a spring brood.

Planting of September 26—40 per cent. infested.

Planting of October 3—37 per cent. infested.

Planting of October 10—23 per cent. infested.

Planting of October 17—24 per cent. infested.

Planting of October 24—22 per cent. infested.

Planting of October 31—14 per cent. infested.

Planting of November 7—17 per cent. infested.

Planting of November 14—10 per cent. infested.

The injury, it will be observed, does not diminish regularly; but this could hardly be expected. Subsequently, on June 15, wheat from the plots was examined by an assistant, and while the percentages found were smaller than those obtained by me early in the season, they show the relative injury to be about the same. The flaxseeds found at this time appear to represent a second spring brood—the one that continues the fly during the summer.

Planting of September 26—32 per cent. infested.

Planting of October 3—25.7 per cent. infested.

Planting of October 10—15 per cent. infested.

Planting of October 17—12.8 per cent. infested.

Planting of October 24—1.6 per cent. infested.

Planting of October 31—5 per cent. infested.

Planting of November 7—4 per cent. infested.

Planting of November 14—6.6 per cent. infested.

The inference that may be drawn from these facts is that wheat that has escaped the fall injury will be injured in the spring proportionately to its nearness to fall-infested wheat.

Yet it would be unsafe to assert that an isolated field of late planted wheat will never be severely injured. Though small and fragile, the adult Hessian fly shows a surprising activity, and, aided by winds, is no doubt at times disseminated long distances from the fields in which it emerges. As an example it may be mentioned that a small isolated planting on the Experiment Farm became infested in the spring to the extent of 20 per cent. The infested wheat nearest to this planting must have been a quarter of a mile away, but it is possible that the adults that visited it came from flaxseeds in straw at a barn near by.

Dusting and Spraying for Hessian Fly.

It is sometimes claimed that applications of lime, Paris green and other materials have a beneficial effect in deterring the fly from placing its eggs on wheat. The use of lime dusted on the plants has been especially recommended. On September 22, 1902, in addition to an untreated plot, two additional plots were sown. Subsequently one-half of one of the plots was dusted with air-slaked lime, another was sprayed with lime and Paris green in water, a third with Bordeaux mixture, and a fourth with coal-oil emulsion. Each half plot contained 1.44 acre.

Dusting with Lime.—The first application was made October 4, when two pounds of lime were used. On October 13 two pounds more were sown over the plants. The third and last application was made October 20, when two pounds were used.

Twenty-five per cent, of the wheat was found to be infested with fly when it was examined November 28.

Lime and Paris Green.—The spray used consisted of one pound of Paris green, two pounds of lime and 140 gallons of water. One and a half gallons of this mixture were used on each of the dates October 4, 13 and 20.

Thirty-one per cent. was infested on November 21.

Bordeaux Mixture.—The mixture used consisted of six and a half pounds of bluestone, three and a half of lime, and 32

gallons of water. One and a half gallons were applied on each of the following dates: October 4, 13 and 20.

Nineteen per cent. was infested on November 28.

Coal-oil Emulsion.—The emulsion consisted of one-half pound of whale-oil soap in one gallon of water, churned with two gallons of coal-oil. One part of this was used with nine of water. Applications were made on the same dates as in the other treatments, one and a half gallons of the diluted emulsion being used each time.

Nine per cent. was infested November 21.

The untreated wheat planted on September 22 was infested, as will be remembered, to the extent of 38 per cent. All of the treated lots may thus be supposed to have been benefited. But in the case of the plots treated respectively with lime by dusting, and with lime and Paris green in a spray, the reduction in the per cent. of injury is so slight as to indicate that the treatment is of no practical value. The reduction from spraying with Bordeaux mixture is much more decided, and indicates that this material could profitably be used on wheat. Its chief value is, of course, as a fungicide, and it was only used on the wheat with the idea that if lime alone was beneficial, this mixture should prove still better. It remains to be seen to what extent it acts as a check on the red rust. Of all the materials used, coal-oil alone approximates a complete remedy. The reduction of the injury to 9 per cent. is most gratifying, and is quite surprising, considering the difficulty of reaching all parts of the plants with a spray. It is probable that it checks the injury in part by destroying the eggs.

Deep Plowing to Destroy the Hessian Fly.

It seems likely that an insect as small and fragile as the Hessian fly may be destroyed by burying it so deep in the soil that the adult cannot make its way out. Badly infested wheat must sometimes be plowed up to make a place for something else. May it not be possible to destroy the fly at the same time by very deep plowing? If good is to be accomplished, stubble

might be so treated in some cases. Just to see what the indications were, I had one of my assistants gather in August, 1902, a number of flaxseeds and place them at different depths in soil in the Vivarium. The fly was so badly parasitized at the time that only a few living flaxseeds could be secured. Five lots of fifteen flaxseeds each were buried, one at a depth of two inches, another at three, a third at four, a fourth at five, and the last at six inches. From the result recorded below it would appear that plowing to a depth of six inches would greatly reduce the numbers of emerging flies.

| DEPTH | August | | | | | | | | Sept. | Emerged |
|---------|--------|----|----|----|----|----|----|----|-------|----------------------------------|
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | | |
| 2 inch. | 1 | | | | | 1 | | 1 | 2 | 33 % |
| 3 inch. | 2 | 2 | | 2 | | | | 1 | | 46 ² / ₃ % |
| 4 inch. | | | | 1 | | | | | | 6 ² / ₃ % |
| 5 inch. | | | | | | | | | | None |
| 6 inch. | | | | | | | | | | None |

The Fly in the Vivarium.

The only difference between the fly indoors and out that attracted special attention was in rate of development. Broods kept indoors were always somewhat ahead of those in the field, the time depending on the condition of the weather out of doors.

Number of Broods Developed During the Season.

The brood that developed to the flaxseed stage in the fall emerged in the field as adults from about April 21 to April 24. This is to be styled the winter brood.

The adults laid eggs at once for the first spring brood, which developed very rapidly, and was observed to be adult from May 21 to May 24. These adults in turn laid eggs for the second spring brood, and were observed partly in the grub and partly in the flaxseed stage on June 3 and 4, and remained in the flaxseed stage when the wheat was cut. Provided no broods developed during the summer on volunteer plants, this gives but three broods for the year. I am disposed to consider

this the full number for this region, though from a pressure of other duties it has not been possible to give the subject the continuous attention during the summer that could be desired.

Hessian Fly in Barley.

The experimental wheat plots were planted in 1901 on land that had been the previous spring in infested barley. In the spring of 1902 barley was planted next the plots of wheat, and it was found that when the adult flies emerged they spread from the wheat to the barley. From my observation thus far I should say the fly attacked this grain as freely as it does wheat.

The Fly in Rye.

But the fly does not attack rye freely. It happened that some rye had been used in our drill previous to planting the first wheat plot in the fall of 1901, and a small quantity in the seed-trough was overlooked when sowing the wheat. The rye came up pretty evenly scattered among the wheat, and in the spring of 1902 was pulled up and examined for flaxseeds. Not a single one was found, although the wheat in the midst of which the rye grew was badly infested. Rye in the regular plantings on the Farm has also been examined from time to time, and in no case has fly been found on this cereal. It is my present opinion, therefore, that one need not fear the attacks of the fly on this grain.

The Joint-Worm in the Experimental Wheat.

In looking over the large numbers of wheat plants necessary to get percentages of Hessian fly injury during the spring, the larvæ, pupæ and adults of a joint-worm were frequently encountered within the swollen bases of the stems. They were not observed at all during the fall. The first larvæ observed were found May 3. The stems infested by this insect could always be distinguished from those occupied by the fly by the swollen condition of the stem itself, the worm occupying the interior of the swollen portion, instead of being crowded in

behind the sheaths of the blades. Infested stems were invariably destroyed by the attack. On May 12, 1902, the insect was found chiefly in the pupa stage, with occasional larvæ and some adults that had not yet escaped. All but one of the experimental plots were infested, but unevenly so, as will appear from the following record made at the time:

Planting of September 26—20 per cent. infested.

Planting of October 3—5 per cent. infested.

Planting of October 10—10 per cent. infested.

Planting of October 17—17 per cent. infested.

Planting of October 24—21 per cent. infested.

Planting of October 31—8 per cent. infested.

Planting of November 7—None infested.

Planting of November 14—2 per cent. infested.

The adults were found to be common on the blades May 17, when many examples were collected by sweeping. They were still to be taken from the blades on May 21. I consider the insect found here to be the *Isosoma grande*, first described by C. V. Riley, and subsequently noticed by Professor S. A. Forbes in his third annual report (1885, p. 34) as State Entomologist of Illinois. In color my material agrees with the descriptions of these authors, but my specimens, preserved dry and in fluid, are smaller, in no case reaching a length of four millimeters, averaging about 3.7mm. With one exception all of the many specimens collected are winged. The single wingless example measures but 2 millimeters in length, and appears to pertain to the species long known under the name *Isosoma tritici*.

Summary.

The observations and experiments thus far made in the field and in the Vivarium point to the following conclusions, though they are not considered final results:

1. To escape severe fall injury from the fly wheat should not be planted in this part of Kentucky before the 6th of October. The 8th or 10th of this month will probably prove safer dates during very mild falls.

2. Wheat that, from late planting, has escaped fall injury

entirely may, the following spring, be badly damaged if it stands near infested wheat.

3. Very deep plowing will destroy many of the flies in infested stubble.

4. Spraying with dilute coal-oil emulsion reduces injury from the fly.

5. Spraying with Bordeaux mixture reduces injury, but not as decidedly as the emulsion.

6. Lime and Paris green in water, and dry lime alone, are of no practical benefit.

7. Barley is as susceptible to attack as wheat.

8. Rye is but little, if at all, injured by Hessian fly.

9. Three annual broods of the fly develop in Eastern Kentucky.