STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
NATURAL HISTORY SURVEY
STEPHEN A. FORBES, *Chief*

Vol. XVII. BULLETIN Article XI.

The Hessian Fly and the Illinois Wheat Crop

BY

W. P. FLINT and W. H. LARRIMER

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URBANA, ILLINOIS
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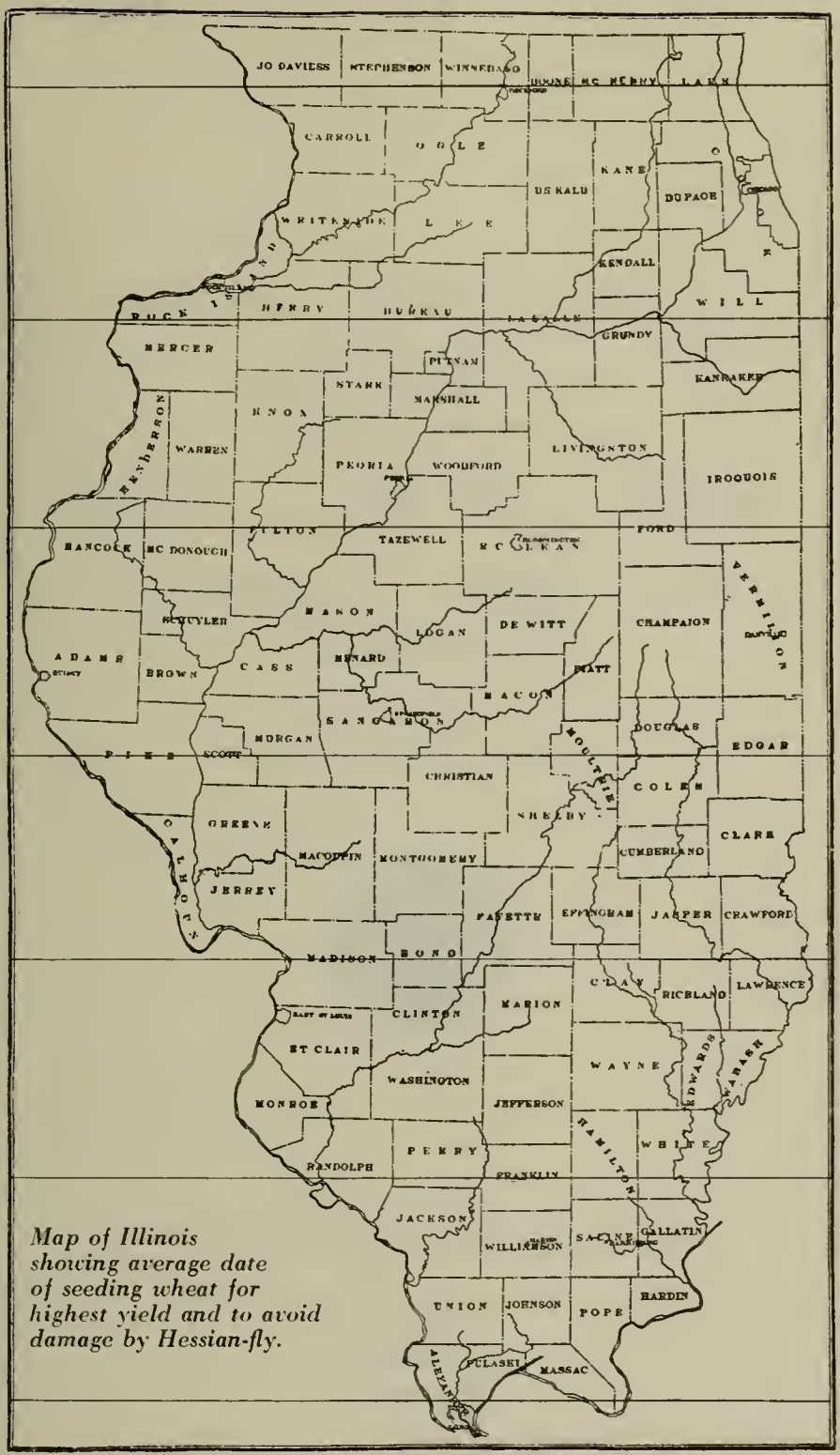

Map of Illinois showing average date of seeding wheat for highest yield and to avoid damage by Hessian-fly.

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THE HESSIAN FLY AND THE ILLINOIS WHEAT CROP

W. P. Flint[1] and W. H. Larrimer[2]

INTRODUCTION

The Hessian Fly, an insect that infests practically all of the large wheat-growing areas of the world, was first found in North America on Long Island in 1779 and was probably brought into this country in the straw used by the Hessian Troops sent here during the Revolutionary War. It was first recorded in Illinois in 1844, according to Webster[3], and it has been a factor in wheat production in this State ever since that time.

Of all the agricultural crops grown in Illinois, wheat is second in importance, being outranked only by corn. The annual value of the wheat crop to Illinois farmers is in the neighborhood of fifty million dollars. Of the 41,034,000 bushels produced in 1926, almost 95 per cent, or 38,934,000 bushels, was winter wheat[4]. Success in growing winter wheat in this State depends on many factors, including the weather, type and fertility of soil, variety of wheat grown, presence of plant diseases, and infestation by insects, particularly the Hessian Fly.

In years when this insect is very abundant, it may be the most important factor in the production of winter wheat, for it sometimes destroys a fourth or even a half of the entire crop of the State. On individual farms it may, and often does, destroy from fifty to one hundred per cent of all the wheat plants in a field.

The Hessian Fly feeds on rye and barley, besides wheat, and it has been found on some wild grasses, though not in sufficient numbers to affect the surrounding wheat. It does *not* feed on oats.

For many years, experiments have been carried on by entomologists and others in an effort to devise practicable methods of protecting the wheat crop against the ravages of this pest. In order to fight the fly successfully, we had to learn just how it lives through the year, and just where it is to be found during each season. A vast amount of detailed information on these questions has been accumulated as a basis for practical recommendations, but a brief outline of the main facts in the life history of the insect will serve our present purpose and show why certain methods are here recommended.

[1] Chief Entomologist, Illinois State Natural History Survey.
[2] Senior Entomologist in charge of cereal and forage insect investigations, United States Department of Agriculture, Bureau of Entomology.
[3] Webster, F. M. The Hessian Fly. *Ohio Agr. Exp. Sta. Bull.* 108. (1899.)
[4] Surratt, A. J. Illinois Crop and Live Stock Statistics. *Dept. of Agr. Circ.* 360. (1927.)

LIFE HISTORY

The Hessian Fly passes the winter in the puparium, or "flaxseed" stage, resting as a larva, or maggot, within a brown flaxseed-like case, which is usually to be found behind the lower leaf sheath of early-sown or volunteer wheat, and sometimes in the old stubble. In the latitude of central Illinois the spring brood emerges about the middle of April; that is, the maggots within the flaxseed cases change to the pupal stage and shortly thereafter burst open these cases and emerge as small sooty-black flies, a little smaller than the common house mosquito. The adult flies do not feed, so far as is known. The females, whose abdomens are packed full of orange-red eggs, mate with the males shortly after emerging and then proceed to deposit their eggs on the leaves of the wheat.

The eggs, which are so small that they can hardly be seen without the aid of a magnifying glass, are almost always deposited in the little grooves on the upper side of the wheat leaf. Hatching takes place from three to twelve days later, depending on the temperature and moisture.

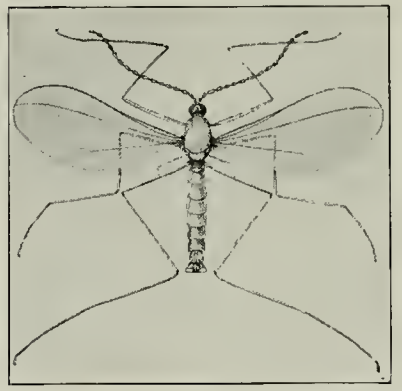

Fig. 1. Adult Hessian Fly, male.
(U. S. D. A. Bureau of Entomology.)

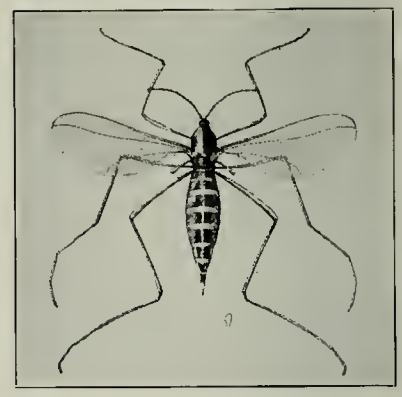

Fig. 2. Adult Hessian Fly, female.
(U. S. D. A. Bureau of Entomology.)

The little orange-red maggots which hatch from the eggs work their way downward until they reach a point where the leaf-sheath is joined to the main stem of the wheat plant. Their descent may be assisted by a drop of dew or rain. Having reached this point, they become permanently established and feed by sucking out the sap. A shoot that is attacked by several of them is weakened and finally killed. Under favorable weather conditions, the maggots grow very rapidly and become full-grown in about two weeks; and by this time they have attained a length of about an eighth of an inch and have become nearly white.

Shortly after the maggot is full-grown, its outer skin loosens, becomes detached from the inner skin, and then turns brown, forming a protective case, which is known as the puparium or "flaxseed," and from which the adult fly will emerge in due time.

Fig. 3. Hessian Fly life history chart. *(U. S. D. A. Bureau of Entomology.)*

In central Illinois the spring brood of maggots, which usually hatch in April, may reach the flaxseed stage by the first week in May; and sometimes, if conditions are favorable, adults may come out from some of these flaxseeds during the early part of May and lay eggs which produce a second spring brood of maggots. These maggots usually become established rather high up on the wheat plants and cause serious breaking over of the wheat when the heads begin to fill.

The Hessian Fly has been associated with wheat so long that it passes from stage to stage in its life history according to the development of the wheat plant. As the wheat ripens and the straw hardens and dries, the maggots change into the flaxseed stage, in which they remain, inactive, in the stubble or in the cut straw in the stack. If there is little rainfall during the summer, so that conditions are unfavorable for the growth of volunteer wheat, the flies remain in the flaxseed stage until the time of heavier rainfall in early autumn; but if the summer's rainfall is sufficient to bring about a growth of volunteer wheat, the flies emerge and lay their eggs on the wheat at about the time the volunteer plants become two-bladed; and the maggots hatching from these eggs become full-grown and ready to produce another brood of flies by early fall.

In most years, fortunately, the flies remain in the wheat stubble until the early fall rains have produced good conditions for the growth of volunteer wheat, or have brought up early-sown wheat in the fields. They usually begin coming out about the middle or latter part of August in central Illinois (somewhat earlier in northern Illinois and later in southern Illinois) and continue to emerge for about six weeks. These adult flies cannot survive the winter, and in central Illinois practically all of them die by the first week in October. If they find no growing wheat or other host plants on which to lay their eggs, they leave no progeny; but if they do find growing wheat, a fall brood of maggots will be produced, which will become full-grown and reach the flaxseed stage before cold weather sets in, and will thus be able to withstand the lowest winter temperatures that are likely to occur in any part of Illinois.

From these statements, it will be seen that normally there is at least one spring brood and one fall brood of the Hessian Fly. Under more favorable conditions there may be two spring broods and two fall broods, and under the most favorable conditions, two spring broods, one summer brood, and two fall broods, or five broods in the course of a single year. Some live puparia of the first spring brood always carry over to the fall, and usually even through the winter to the second season, thus providing for perpetuation of the species under adverse conditions.

The development of this insect is very largely dependent on temperature and moisture, or rather a combination of the two, as high temperatures will not bring through a brood of flies unless combined with an abundance of moisture. Some idea of the great differences in the length of time required for the completion of the life cycle under different sets of weather conditions may be gained from the fact that McColloch[5] in Kansas carried a brood through one complete generation in a period of

[5] McColloch, James W. Variations in the Length of the Flaxseed Stage of the Hessian Fly. *J. Ec. Ent.* 12: 252-255. (1919.)

twenty days, while under other conditions it required four years for an individual to complete the same cycle.

Under normal weather conditions in Illinois, the relatively fly-free date is September 18 for the northernmost tier of counties and progressively later as one goes southward, as shown on the map in Figure 4.

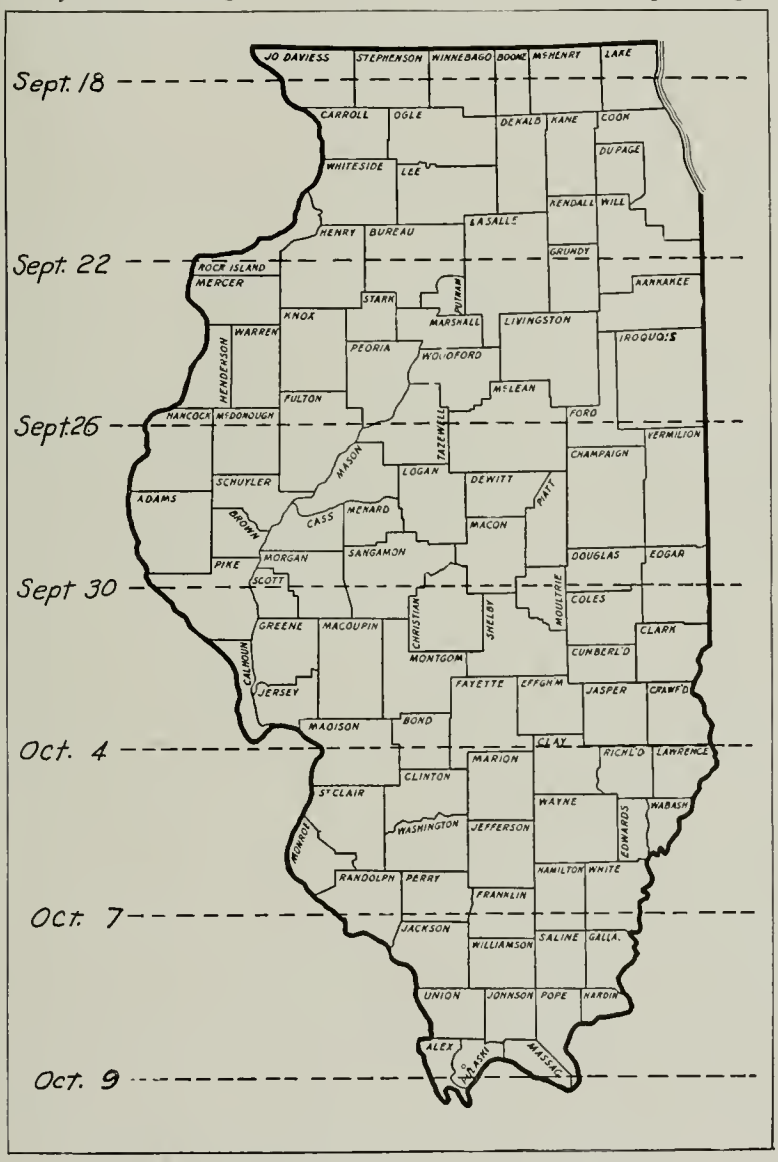

Fig. 4. Map of Illinois showing normal relatively fly-free dates for wheat seeding.

CONTROL MEASURES

It is advisable for wheat growers to protect their crop against the Hessian Fly in every way possible. The methods that have proved to be the best may be summarized as follows:

First: *Sow wheat late enough,* so that it will come up and make a growth at a time when there are no adults of the Hessian Fly to deposit their eggs upon it, *but early enough to withstand the winter.*

Second: Keep down all volunteer wheat, in so far as possible.

Third: Have the seed bed in good condition and the land in a high state of fertility, so that the wheat plants will start a vigorous growth. This is especially important in years of moderate to light infestation, when the first shoots to come up may become infested and die, but the later ones may still make a good crop.

Fourth: Plow under during the summer the stubble from the last crop, if such plowing does not interfere with good agronomic practice. This is an important, though often neglected, means of fighting the fly.

Fifth: Grow strong-stemmed varieties of wheat which do not easily break over.

Of these methods, the proper date of seeding is the most important. It has long been recognized, throughout the wheat-growing areas of North America, that wheat sown early in years when the Hessian Fly is abundant will be killed, and that wheat sown moderately late will often entirely escape infestation. On the other hand, there is a danger that very late seeding will cause a reduction in yield through winter killing.

DATE-OF-SEEDING EXPERIMENTS

In order to determine as exactly as possible what effect the date of seeding has on the degree of infestation by the Hessian Fly and on the yield of wheat, the entomologists of the Natural History Survey have been conducting a series of experiments since 1917 in fields in six different parts of the State, namely, in Winnebago (Boone, two years), LaSalle (Bureau, three years), Hancock, Macoupin, Jackson, and Champaign counties. During this time the federal Bureau of Entomology, cooperating with the Natural History Survey and the Illinois Agricultural Experiment Station, has also made similar experiments in Marion, Pulaski, and Randolph counties.

The general plan of these experiments was to sow a series of plots of wheat, each at least a half-acre in extent, making the first seeding at least two weeks before the date which was considered the average relatively fly-free date for that particular locality, and making the next seeding approximately five days later, and so on, until six or more seedings had been made. This plan gave a range of seedings extending over a period of one month or more, including approximately two weeks before and after the normal fly-free date.

In all fields north of Macoupin County, the variety of wheat grown was Turkey Red, most frequently the strain Turkey 10-110 developed by the University of Illinois. Fultz and Fulcaster were the varieties generally grown in the southern fields.

With the exceptions of the plots on the University Farm at Urbana and the field in charge of the Bureau of Entomology at Centralia, the seedings were made by farmers in parts of their wheat fields. Some of the experiments have been transferred from one farm to another in the same locality.

During the first half of November in each year, the percentage of fly infestation in each plot was taken by the entomologists, using the sampling method described in a previous paper[6]. The yield of wheat from each plot was measured at the regular time of harvest.

RESULTS

The following tables give the yield in bushels per acre and the percentage of fly infestation for each field and each date of seeding in each year throughout the period of the experiments, and the accompanying graphs are made from the averages for the entire period.

Several facts show up very clearly in these results. In the first place, it is evident that there is a very definite relationship between yield and infestation. By consulting the tables it will be seen that, without any exception, wheat heavily infested by the Hessian Fly has made lower yields than wheat grown during the same year and in the same field but seeded later so as to avoid the fly. Furthermore, as shown in the graphs, the average yield has always increased as the infestation decreased. Good yields were obtained from some early seedings during certain years, but never when the fly was abundant. In general, the degree of infestation has been of great importance in early seedings but of no consequence in late seedings. From the results of this work, and also from many other observations made in fields throughout the State, it is evident that the yield is not noticeably affected when less than ten per cent of the plants in a field are infested.

WINNEBAGO AND BOONE COUNTIES

In the extreme northern part of the State, the experimental plots have been located on farms in the vicinity of Rockford, for four years in Winnebago County and for two years just across the boundary line in Boone County. The work was begun in 1917 and continued to 1926 except for interruptions in 1918, 1921, and 1923. The dates of seeding ranged from September 2 to October 6. The painstaking work of Mr. E. R. Derivent, who has been our cooperator for several years, has contributed to the success of the experiment.

[6] Flint, W. P., Turner, C. F., and Davis, J. J. Methods in Entomological Field Experimentation. *J. Ec. Ent.* 12:178-183. (1919.)

Table I shows the yields from all the plots, arranged according to the date of seeding, for each of the six years; it also shows what per cent of the wheat plants in each plot were infested by the Hessian Fly. The normal relatively fly-free date for this locality is September 18. The average yield from all plots seeded before this date has been 24.8 bushels per acre. From all plots seeded after this date, the average yield has been 28.1 bushels per acre.

Judging from these results, anyone growing wheat in the northern tier of counties in the State will obtain the best yields if he sows during the period of September 17—30. It seems, also, that the degree of fly infestation drops very sharply in seedings made after September 16 and, in fact, can be considered of no consequence in its effect on yields from such seedings. The direct relationship of fly infestation and wheat yield appears very clearly in the graphs of Figure 5, which are made from averages for the six years.

TABLE I

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS
(BUSHELS PER ACRE)

WINNEBAGO AND BOONE COUNTIES
1917—1926

Date of seeding ☞	Sept. 2—6	Sept. 7—11	Sept. 12—16	Sept. 17—21	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6
Infestation November, 1917	8	7	4	2	0	0	....
1918 Yield	33.8	27.2	34.3	37.2	36.3	33.8	....
Infestation November, 1919	41	48	23	11	7	....	....
1920 Yield	17.3	18.5	19.3	20.1	19.3	....	....
Infestation November, 1920	21	1	1	2	....	0	0
1921 Yield	14.5	20.4	23.4	21.7	....	25.0	23.8
Infestation November, 1922	....	....	60	....	15	0	0
1923 Yield	....	....	15.3	....	13.7	16.1	16.1
Infestation November, 1924	12	0	2	....	0	0	0
1925 Yield	27.2	23.6	40.1	....	34.3	39.6	33.2
Infestation November, 1925	5	....	....	2	0	0	....
Yield 1926	32.8	....	....	35.9	38.9	32.4	....
Average Infestation	17	14	18	4	6	0	0
Average Yield	25.0	22.4	26.5	28.7	28.5	29.4	24.4

Normal fly-free date is September 18.

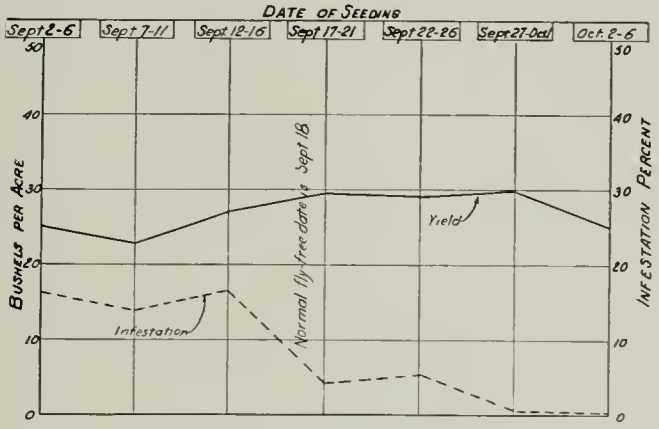

Fig. 5. Graphs showing average yield and average infestation for experimental plots in Winnebago and Boone counties.

LaSalle and Bureau Counties

The experiment which was started in Bureau County in 1917 has been continued in LaSalle County since 1920. The work has been done on three different farms. Mr. L. C. Rinker, of Grand Ridge, who has cooperated with the Natural History Survey for several years in this work, has been very careful in his handling of the fields. Most of the seedings were made between September 7 and October 6.

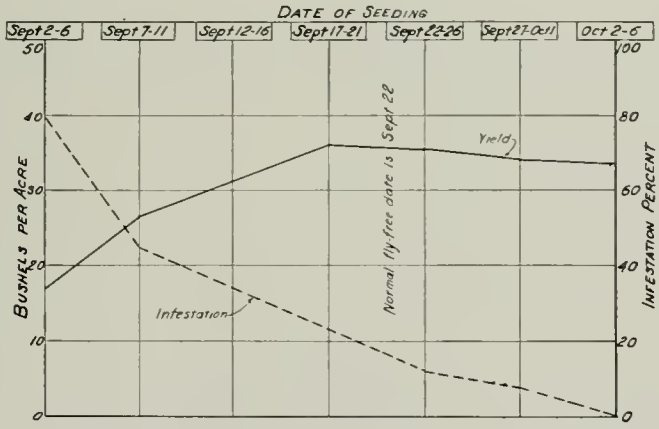

Fig. 6. Graphs showing average yield and average infestation for experimental plots in LaSalle and Bureau counties.

As shown in Table II, wheat sown in the period of September 17—26 gave the highest average yield. Infestation by the Hessian Fly was fairly heavy in most years up to September 22, which is the normal relatively fly-free date for this locality. This date, in general, coincides with the date of highest yields. In years when the Hessian Fly has been very abundant, the early seedings have made poor yields. Figure 6 shows graphically how the average yield rises as the average infestation falls in plots sown during the first three weeks in September; it also shows a slight reduction in yield from plots sown in October, due to winter killing.

TABLE II

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS
(BUSHELS PER ACRE)

LASALLE AND BUREAU COUNTIES
1917—1926

Date of seeding	Sept. 2—6	Sept. 7—11	Sept. 12—16	Sept. 17—21	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6
Infestation November, 1917	....	47	27	0	....	0	0
1918 Yield	....	27.8	31.9	35.6	....	32.2	27.8
Infestation November, 1918	....	15	12	4	0	0	0
1919 Yield	....	34.8	36.3	43.3	47.7	41.9	41.8
Infestation November, 1919	79	58	51	45	14	18	....
1920 Yield	20.9	20.9	29.0	24.2	33.1	27.4	....
Infestation November, 1920	....	50	28	44	43	43	11
1921 Yield	....	27.8	29.8	32.3	33.1	26.6	27.4
Infestation November, 1921	74	50	37	....	0	3	....
1922 Yield	12.1	16.1	20.1	....	20.1	20.1	....
Infestation November, 1922	....	83	90	79	25	7	0
1923 Yield	....	16.9	25.0	29.8	25.8	35.4	29.0
Infestation November, 1923	....	53	29	0	0	0	0
1924 Yield	....	19.8	27.0	40.3	39.5	36.7	29.4
Infestation November, 1924	....	33	33	23	16	6	2
1925 Yield	....	41.5	42.8	47.1	47.1	43.5	45.0
Infestation November, 1925	....	19	20	0	0	0	0
1926 Yield	....	32.8	33.9	34.4	37.3	42.0	35.0
Average Infestation	17	45	36	24	12	8	2
Average Yield	16.5	26.5	30.6	36.0	35.4	34.0	33.6

Normal fly-free date is September 22.

HANCOCK COUNTY

The experiment in Hancock County was carried on for the entire period from 1917 to 1926 on the farm of Mr. Kent Campbell near La-Harpe. Mr. Campbell has taken a great deal of personal interest in this work, and it is due to his care that we have such a complete set of records as are shown in Table III. His farm is kept in a very good state of fertility, and the average yield from his plots for the entire period is higher than that from any others in the State. The yields in the plots, moreover, correspond very well with the yields generally obtained in his fields.

TABLE III

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS (BUSHELS PER ACRE)

HANCOCK COUNTY
1917—1926

Date of seeding →	Sept. 7—11	Sept. 12—16	Sept. 17—21	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6	Oct. 7—11	Oct. 12—16
Infestation November, 1917.....	42	....	3	0	0	....	0	....
1919 Yield.....	33.8	....	42.8	50.0	49.7	....	40.3	....
Infestation November, 1918.....	45	13	2	0	0	0	....	....
1919 Yield.....	34.2	37.3	35.3	35.5	36.3	40.3	....	....
Infestation November, 1919.....	84	91	....	33	0	0	....	....
1920 Yield.....	20.8	23.4	....	31.0	35.4	34.6	....	....
Infestation November, 1920.....	90	81	58	49	36	2	....	....
1921 Yield.....	21.8	29.0	26.6	25.0	27.4	29.9	....	....
Infestation November, 1921.....	....	....	9	2	0	0	....	....
1922 Yield.....	....	....	18.1	20.9	23.4	24.2	....	....
Infestation November, 1922.....	....	22	21	7	....	4	2	2
1923 Yield.....	....	39.5	44.3	48.4	....	44.3	45.1	50.8
Infestation November, 1923.....	....	26	10	6	2	0	....	0
1924 Yield.....	....	39.9	33.4	33.8	44.4	35.8	....	27.0
Infestation November, 1924.....	64	55	....	48	19	4	0	....
1925 Yield.....	17.7	21.0	....	20.1	23.0	26.6	28.2	....
Infestation November, 1925.....	....	....	20	1	0	....	0	....
1926 Yield.....	....	....	35.2	45.8	38.9	....	26.6	....
Average Infestation	65	48	18	16	7	1	0	1
Average Yield.....	25.7	31.7	33.7	34.5	34.8	33.7	35.0	38.9

Normal fly-free date is September 26.

Here, as at other points, the early seedings have been severely damaged by the Hessian Fly during several seasons, so that the yields were greatly reduced. Though differences in yields are only partly due to the influence of the fly and partly to other seasonal factors, a comparison of the records for several years will show how large a part is played by the fly in early seedings. Plots seeded during the period of September 12—16, for example, produced more than 39 bushels per acre in 1923 and 1924, when the infestation was very light; but those seeded during the same period in 1919 and 1924, when the infestation was very heavy, produced only 23.4 and 21.0 bushels per acre, respectively.

For this locality, the highest average yield has been obtained from plots seeded between September 22 and October 7, although a few plots seeded later than October 12 have given very good yields. Here again, as shown by the averages, the normal relatively fly-free date, September 26, corresponds very closely with the date of highest yield. See Figure 7.

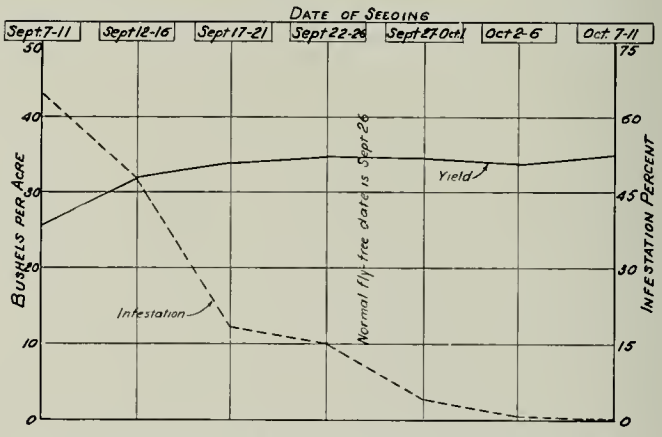

Fig. 7. Graphs showing average yield and average infestation for experimental plots in Hancock County.

CHAMPAIGN COUNTY

The date-of-seeding experiments on the University Farm in Champaign County were not started until the fall of 1919, but a very extended series has been carried out. Some very early and very late seedings, beginning with August 28 and ending with October 31, have been made since 1923. The results are shown in Table IV and Figure 8.

While all the early seedings have made a good growth and the plants have borne large tops in the fall, the yields from them have not been as high as those from the later seedings. The highest average yields were obtained from plots seeded between September 27 and October 12, that is, within two weeks after the normal relatively fly-free date for this locality.

In some seasons, however, October 12 is too late to prevent severe winter killing, and for this reason the best yield generally may be expected from seedings made between September 27 and October 6.

The figures for the first two years are especially significant. In 1920, the lowest yields were obtained from the early-sown plots, which all became heavily infested by the fly, and progressively higher yields were obtained from the late-sown plots as the infestation decreased. In 1921, on the contrary, the relatively high infestation in wheat sown between September 22 and October 1 was not of serious consequence because the infestation occurred late, and the feeding of the maggots that were in the wheat in the fall was curtailed by cold weather, and they all died during the winter.

TABLE IV

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS
(BUSHELS PER ACRE)

CHAMPAIGN COUNTY
1919—1927

Date of seeding →	Aug. 28—Sept. 1	Sept. 12—16	Sept. 17—21	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6	Oct. 7—11	Oct. 12—16	Oct. 17—21	Oct. 27—31	After Oct. 31
Infestation November, 1919	....	100	100	75	0	0	....	....	....	....	....
1920 Yield.....	....	23.3	28.5	40.3	43.1	37.9	....	....	....	....	....
Infestation November, 1920	....	100	100	100	95	38	0	0	....	....	....
1921 Yield.....	....	33.9	32.3	33.1	37.1	40.3	39.1	34.7	....	....	....
Infestation November, 1921	....	16	5	0	0	0	0	....	0	....	....
1922 Yield.....	....	25.0	30.6	28.2	33.8	32.2	36.3	....	40.3	....	....
Infestation November, 1922	....	1	0	0	....	0	....	0	0	0	....
1923 Yield.....	....	36.3	45.9	45.9	....	39.5	....	37.9	39.5	31.4	....
Infestation November, 1923	13	2	5	0	....	0	....	0	0	....	0
1924 Yield.....	32.1	34.3	33.2	36.0	....	40.8	....	38.9	31.4	....	32.7
Infestation November, 1924	74	42	17	6	4	6	0	....	0	0	....
1925 Yield.....	15.9	20.2	21.2	17.4	34.1	41.1	38.6	....	31.4	21.6	....
Infestation November, 1925	93	....	43	0	0	0	0	....	0	....	0
1926 Yield.....	12.1	....	20.4	35.3	34.0	32.7	33.1	....	27.3	....	24.6
Infestation November, 1926	29	17	6	....	....	....	9	....	6	8	0
1927 Yield.....	35.8	39.4	38.5	....	....	....	35.6	....	32.4	33.0	28.5
Average Infestation	52	40	35	26	20	6	2	0	1	2	0
Average Yield..	24.0	30.3	31.3	33.7	36.4	37.8	36.6	37.2	33.7	28.7	28.6

Normal fly-free date is September 28.

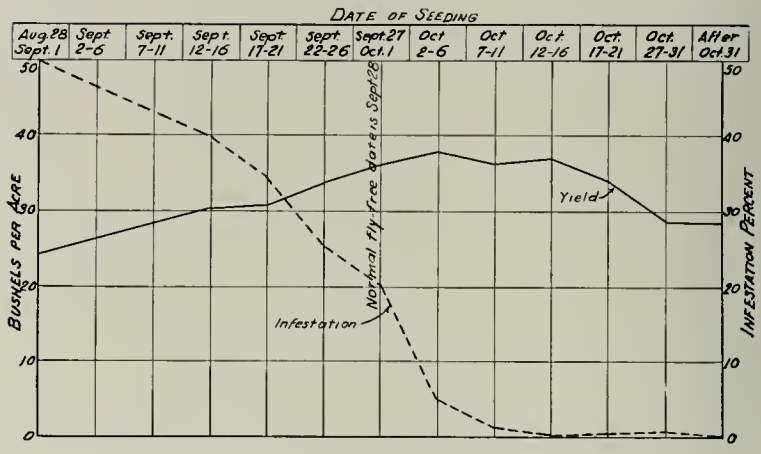

Fig. 8. Graphs showing average yield and average infestationfor experimental plots in Champaign County.

MACOUPIN COUNTY

The experiment in Macoupin County has been conducted for the entire period on the farm of Mr. Vernon Vaniman two miles south of Virden. Mr. Vaniman and his tenant, Mr. Theo. Anspaugh, have helped in every way in carrying on this experiment. Seedings were made as early as the middle of September and as late as the fourth week in October. The records for the eight years, as shown in Table V, are very good and may be relied upon as typical of conditions in that locality.

The figures on average infestation over the whole period indicate that the Hessian Fly normally is most abundant there in wheat sown from

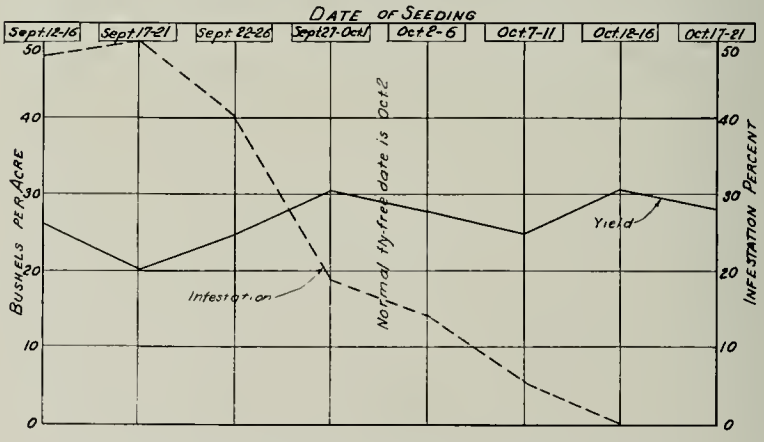

Fig. 9. Graphs showing average yield and average infestation for experimental plots in Macoupin County.

September 17 to 21, and progressively less abundant in wheat sown later. In certain years, however, notably in 1919, 1920, 1921, and 1925, plots seeded during September 22—26 became heavily infested and, on the whole, made very low yields. In every year except the first, when the flies were scarce throughout the season, the highest yields were obtained from plots seeded within a few days of the relatively fly-free date, October 2.

Figure 9 shows graphically this close relationship between fly infestation and yield. The graph for infestation reaches its highest point at the same time as the graph for yield reaches its lowest point. Then, as the former falls, the latter rises, and after October 1, when infestation becomes negligible, the yield is comparatively high. It is evident, therefore, that the best yields in this section can be expected, on the average, from wheat sown between October 1 and October 16.

TABLE V

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS (BUSHELS PER ACRE)

MACOUPIN COUNTY
1917—1926

Date of seeding	Sept. 12—16	Sept. 17—21	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6	Oct. 7—11	Oct. 12—16	Oct. 17—21
Infestation November, 1917.....	10	....	3	0	....	0	0	....
1918 Yield.....	46.8	....	43.6	41.9	....	37.1	37.1	....
Infestation November, 1918.....	....	28	16	0	0	0	....	0
1919 Yield.....	....	14.9	17.3	17.4	20.9	19.4	....	17.2
Infestation November, 1919.....	100	100	81	13	....	0	0	....
1920 Yield.....	10.5	12.1	23.4	30.6	....	29.8	33.1	....
Infestation November, 1920.....	....	94	88	85	73	44	0	....
1921 Yield.....	....	13.7	11.3	13.7	17.8	17.8	16.1	....
Infestation November, 1921.....	....	70	50	....	9	5	....	0
1922 Yield.....	....	11.3	12.9	....	22.7	17.7	....	19.3
Infestation November, 1922.....	....	2	1	....	1	1	....	0
1923 Yield.....	....	23.3	25.8	....	35.4	29.0	....	29.8
Infestation November, 1924.....	33	17	20	19	0	0	....	....
1925 Yield.....	21.7	21.6	23.0	24.4	29.4	26.0	....	....
Infestation November, 1925.....	....	68	55	0	0	....	0	0
1926 Yield.....	....	43.6	37.4	52.6	43.7	....	34.8	47.7
Average Infestation.	48	54	39	19	14	7	0	0
Average Yield.....	26.3	20.1	24.3	30.1	28.3	25.3	30.3	29.0

Normal fly-free date is October 2.

MARION COUNTY

The plots for date-of-seeding experiments in Marion County were located during the entire period on the farm of Mr. Ben Michael, west of Centralia. Mr. Michael's friendly cooperation has been enjoyed and is highly appreciated. During most of the period covered by these experiments, the Bureau of Entomology has had a man stationed there to devote his entire time to the Hessian Fly work, making observations not only on the degree of infestation in relation to yield, but also on the weather conditions which brought out the fly, the rate of parasitism, and the possible resistance of different varieties of wheat to the attack of the fly. In addition to the usual series, a number of very early seedings were made, beginning on August 28.

TABLE VI

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS
(BUSHELS PER ACRE)

MARION COUNTY
1919—1927

Date of seeding ☞	Aug. 28—Sept. 1	Sept. 12—16	Sept. 17—21	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6		Oct. 7—11	Oct. 12—16	Oct. 17—21
Infestation November, 1919	....	96	....	96	89	56		13	0	0
1920 Yield	....	9.9	....	14.9	11.2	14.9		10.6	9.8	10.9
Infestation November, 1920	....	....	77	85	85	54		6	0	0
1921 Yield	....	....	18.0	15.7	12.0	14.8		17.7	21.8	28.3
Infestation November, 1921	78	56	....	75	....	17		7	0	0
1922 Yield	33.0	37.5	....	36.4	....	35.0		30.1	29.0	29.8
Infestation November, 1922	64	63	....	42	85	74		77	72	15
1923 Yield	10.0	14.5	....	14.5	16.5	14.0		16.0	21.0	22.8
Infestation November, 1923	67	96	95	66	....	1		0	0	....
1924 Yield	1.5	2.0	2.5	6.5	....	26.8		21.0	25.5	....
Infestation November, 1924	....	15	....	22	24	15		0	0	0
1925 Yield	....	22.5	....	29.5	29.0	35.0		34.0	32.0	34.0
Infestation November, 1925	56	59	94	49	....	0		0	0	0
1926 Yield	8.0	10.0	8.5	20.5	....	28.0		26.0	23.5	26.0
Infestation November, 1926	....	....	....	....	....	....		0	0	....
1927 Yield	....	....	....	....	....	....		23.0	14.0	....
Average Infestation	66	64	89	62	71	31		13	9	3
Average Yield	13.1	16.1	9.7	19.7	17.2	24.1		22.3	22.1	25.3

Normal fly-free date is October 5.

The results as shown in Table VI and Figure 10 again indicate how directly the Hessian Fly affects the yield of wheat. It certainly is not merely an accident that the yield graph reaches high points whenever the infestation graph reaches low points, and *vice-versa,* throughout the experiment. The connection is unmistakable.

The normal relatively fly-free date for this locality is October 5. Judging from the data on the experimental plots, one can generally expect the best yields of wheat in this section from seedings made between October 4 and October 20.

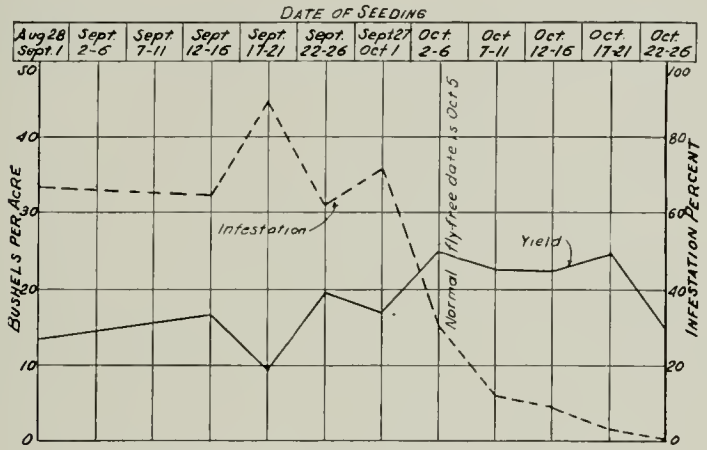

Fig. 10. Graphs showing average yield and average infestation for experimental plots in Marion County.

RANDOLPH COUNTY

The experimental work in Randolph County was done in the vicinity of Sparta. It was started on the farm of Mr. H. B. McIntire and has been continued, since 1920, on the farm of Mr. W. M. Beattie, whose reliability and interest have aided greatly in carrying on the work. The dates of seeding range from September 22 to October 21.

As will be seen by an analysis of Table VII, or by a glance at Figure 11, the yields have been about the same, on the average, for all dates of seeding. Leaving out of account the exceptionally high yield in 1921 from the earliest seeding, the data show that plots sown about October 7, which is the normal relatively fly-free date for this locality, have given the best average yield. The infestation percentages indicate that the fly usually is not abundant enough there to cause any considerable damage to wheat sown after October 4. In unusual years, however, such as 1919, seedings made during the first week in October may become heavily infested and may give low yields.

TABLE VII

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS (BUSHELS PER ACRE)

RANDOLPH COUNTY
1919—1927

Date of seeding ☞	Sept. 22-26	Sept. 27—Oct. 1	Oct. 2—6	Oct. 7—11	Oct. 12—16	Oct. 17—21
Infestation November, 1919	100	100	99	....	13	2
1920 Yield	7.3	5.5	12.1	....	22.0	16.5
Infestation November, 1920	26	8	13	0	....	0
1921 Yield	42.5	33.8	30.5	31.5	....	35.0
Infestation November, 1921	35	39	18	4	....	0
1922 Yield	32.5	30.5	33.0	24.0	....	23.0
Infestation November, 1922	9	16	23	19	....	4
1923 Yield	12.5	16.0	16.5	20.5	....	17.5
Infestation November, 1923	....	8	0	0	0	0
1924 Yield	....	16.5	16.5	14.0	20.5	16.0
Infestation November, 1924	....	29	1	0	0	0
1925 Yield	....	32.0	33.5	31.5	27.5	28.5
Infestation November, 1925	....	20	0	....	0	0
1926 Yield	....	17.5	20.0	....	19.5	22.0
Infestation November, 1926	....	7	0	0	0	0
1927 Yield	....	21.0	21.5	21.0	19.5	14.0
Average Infestation	43	28	19	4	3	1
Average Yield	23.7	21.6	23.0	23.8	21.8	21.6

Normal fly-free date is October 7.

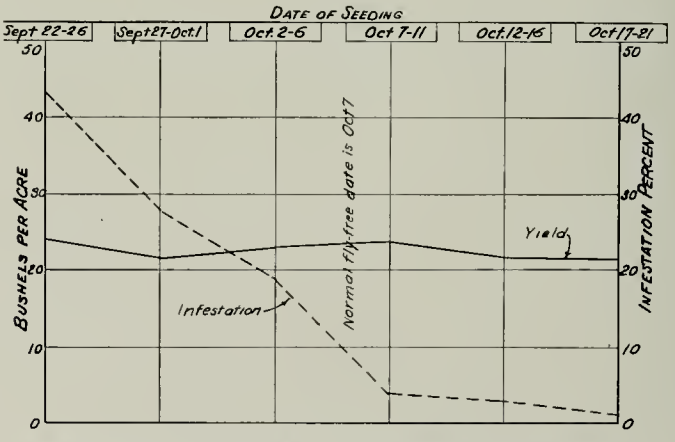

Fig. 11. Graphs showing average yield and average infestation for experimental plots in Randolph County.

JACKSON COUNTY

The work in Jackson County has been done on several different farms in different years, under conditions that are hardly comparable. It has been interfered with by flooding of the plots, by winds, and by several other factors which have tended to confuse the results. In 1918, for example, when the plots were on rich bottomland that had been heavily treated with fertilizer, flooding interfered with cutting, so that the data had to be discarded. The results shown in Table VIII and Figure 12, therefore, cannot be considered as truly representative of this section of the State. The difference in the yields obtained from plots sown before the relatively fly-free date (October 7) and from those sown after this date, has been less than in any other county where the experiments were made. On the average, nevertheless, the best yields have been obtained from seedings made between October 2 and

TABLE VIII

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS
(BUSHELS PER ACRE)

JACKSON COUNTY
1918—1926

Date of seeding ☛	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6		Oct. 7—11	Oct. 12—16	Oct. 17—21	Oct. 22—26
Infestation November, 1918..	2	1	0		0	0	0	....
1919 Yield.....	19.2	22.2	20.2		20.2	21.2	9.1	....
Infestation November, 1920..	20	29	16		0	0	0	....
1921 Yield.....	6.5	12.1	10.5		9.7	8.1	6.5	....
Infestation November, 1921..	....	65	33		0	....	0	0
1922 Yield.....	....	12.1	16.4		14.9	....	18.5	18.5
Infestation November, 1922..	....	52	72		....	26	3	0
1923 Yield.....	....	3.6	4.6		....	6.4	4.8	11.2
Infestation November, 1923..	....	0	0		0	0	....	0
1924 Yield.....	....	13.0	16.5		16.5	20.6	....	24.6
Infestation November, 1924..	10	7	0		0	0	0	....
1925 Yield.....	24.1	29.7	30.7		35.0	27.7	24.5	....
Infestation November, 1925..	....	....	0		0	....	0	....
1926 Yield.....	....	....	32.4		29.6	....	26.9	....
Average Infestation	11	26	17		0	5	0	0
Average Yield....	16.6	15.5	18.8		21.0	16.8	15.1	18.1

Normal fly-free date is October 7.

October 12, though the yields from other seedings have not been much lower. More information on plots under more uniform conditions is needed in this locality before any definite conclusions can be drawn.

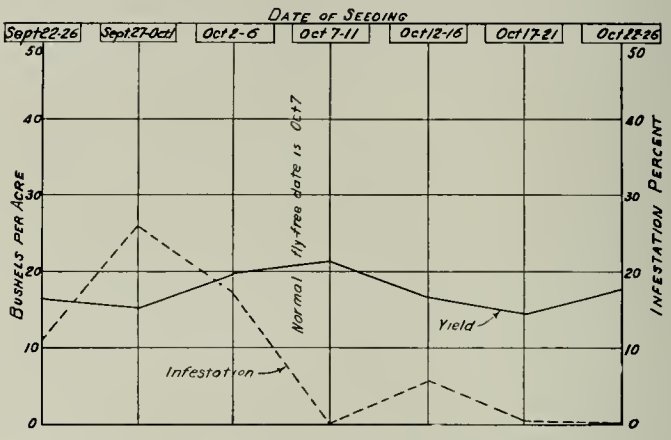

Fig. 12. Graphs showing average yield and average infestation for experimental plots in Jackson County.

PULASKI COUNTY

The date-of-seeding experiment in Pulaski County was made in cooperation with several different farmers in the vicinity of Grand Chain. Since 1922, the experiment has been located on the farm of Mr. A. J. Schoenborn, whose interest in the work has been a great help.

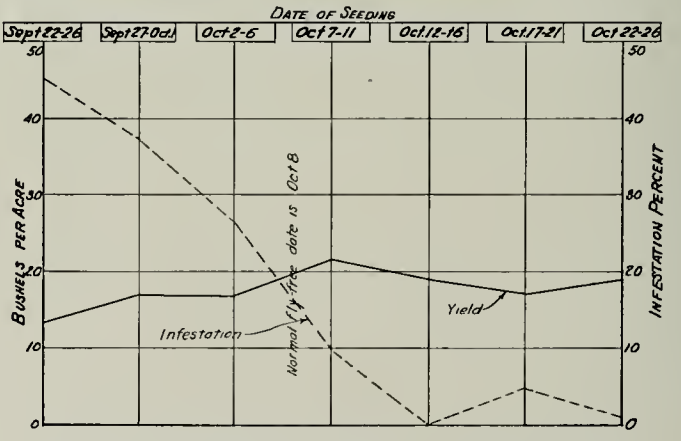

Fig. 13. Graphs showing average yield and average infestation for experimental plots in Pulaski County.

The experimental plots have had very good attention, and the results shown in Table IX can be considered as representing average conditions in this locality. Most of the seedings were made between September 27 and October 26.

In general, the best yields have been obtained from plots sown between October 5 and October 26. It will be noticed in Figure 13 that the yield graph reaches its highest point in the period of October 7—11, when the infestation graph falls to the 10 per cent mark. From this we may conclude that wheat sown within a few days after the normal fly-free date, October 8, will usually escape serious infestation. In the fall of 1922, however, when the fly was unusually late in making its appearance in this locality, wheat sown during the second week of October became heavily infested and made a low yield.

TABLE IX

PER CENT INFESTATION BY THE HESSIAN FLY AND WHEAT YIELDS
(BUSHELS PER ACRE)

PULASKI COUNTY
1919—1927

Date of seeding →	Sept. 22—26	Sept. 27—Oct. 1	Oct. 2—6	Oct. 7—11	Oct. 12—16	Oct. 17—21	Oct. 22—26
Infestation November, 1919..	100	92	92	....	....	....	0
1920 Yield.....	6.5	16.0	10.0	....	....	....	15.5
Infestation November, 1920..	10	0	0	6	0	0	0
1921 Yield.....	14.0	7.5	9.0	15.5	12.0	13.5	14.0
Infestation November, 1921..	....	19	12	0	0	0	0
1922 Yield.....	....	20.0	18.5	28.5	25.5	26.0	24.5
Infestation November, 1922..	25	38	39	68	....	28	7
1923 Yield.....	18.5	23.5	17.5	16.5	....	19.5	16.5
Infestation November, 1923..	....	....	36	0	0	....	0
1924 Yield.....	....	....	17.5	25.0	32.5	....	26.0
Infestation November, 1924..	....	....	15	0	0	0	....
1925 Yield.....	....	....	11.0	13.0	11.5	7.5	....
Infestation November, 1925..	....	....	0	0	....	0	....
1926 Yield.....	....	....	36.0	35.5	....	28.8	....
Infestation November, 1926..	....	....	11	4	0	0	....
1927 Yield.....	....	....	17.5	15.0	11.0	9.0	....
Average Infestation	45	37	26	10	0	5	1
Average Yield....	13.0	16.8	17.1	21.3	18.5	17.4	19.3

Normal fly-free date is October 8.

SUMMARY

Table X shows the average yields of wheat obtained from all seedings made before, and from all those made after, the normal relatively fly-free date for each of the localities named. In every locality, with the exception of Randolph and Jackson counties (see pp. 379-382), there has been an appreciable increase in the yield from the later seedings as compared with the earlier seedings. In most cases the increase in yield is sufficient to pay an added return equal to, or greater than, the taxes on the land. This increase does not involve any additional labor or any expenditure for fertilizer or any other outlay.

From Table X, which also gives the average per cent infestation by the Hessian Fly in these two groups of seedings, it will be seen that the wheat sown after the relatively fly-free date has not been sufficiently infested at any point in the State to cause a marked decline in yield. In all the fields except the one in Marion County (Table VI), seedings made on the normal fly-free date have been relatively free from infestation throughout the entire period of the experiments. In a few sections of the State it seems safe to make seedings a little earlier than this date in years when the Hessian Fly is known to be comparatively scarce in those particular localities.

Early seeding does not produce high yields of wheat on the average. The same is true of very late seeding.

In years when the Hessian Fly is abundant, it is almost sure to cause a very marked decrease in yield from wheat sown early. The

TABLE X

AVERAGE YIELDS OF WHEAT (BUSHELS PER ACRE) AND PERCENTAGES OF PLANTS INFESTED BY HESSIAN FLY IN PLOTS SOWN BEFORE AND AFTER THE NORMAL RELATIVELY FLY-FREE DATE

INCLUDING ALL YEARS COVERED BY EXPERIMENTS

Location of plots	Number of years	AVERAGE YIELD from wheat sown BEFORE	AFTER	AVERAGE INFESTATION in wheat sown BEFORE	AFTER
Winnebago County[1]	6	24.8	28 1	17	2
LaSalle County[2]	9	29 8	34.4	39	8
Hancock County	9	32.0	35.0	33	3
Champaign County	8	30.6	34.8	44	5
Macoupin County	8	24.8	27.7	40	6
Marion County	8	17.8	23.0	60	8
Randolph County	8	22.5	22.3	28	2
Jackson County	7	17.0	17.2	19	1
Pulaski County	8	16.2	19.2	33	4
AVERAGES (weighted by years)		25.1	27.4	36	4

[1] Boone County, two years.
[2] Bureau County, three years.

results obtained from the experimental plots in such years are summarized in Table XI, showing that the difference between the yields from wheat sown before the fly-free date and after this date has averaged more than five bushels per acre.

TABLE XI

AVERAGE YIELDS OF WHEAT (BUSHELS PER ACRE) AND PERCENTAGES OF PLANTS INFESTED BY HESSIAN FLY IN PLOTS SOWN BEFORE AND AFTER THE NORMAL RELATIVELY FLY-FREE DATE

EXCLUDING YEARS OF SLIGHT INFESTATION

Location of plots	Number of years	AVERAGE YIELD from wheat sown BEFORE	AFTER	AVERAGE INFESTATION in wheat sown BEFORE	AFTER
Winnebago County[1]	2	17.6	16.9	43	6
LaSalle County[2]	7	28.1	32.2	46	10
Hancock County	3	24.0	29.3	65	11
Champaign County	4	25.7	34.4	65	11
Macoupin County	4	22.8	27.3	67	12
Marion County	6	16.2	21.8	66	11
Randolph County	3	18.3	20.6	49	7
Jackson County	2	9.2	12.4	55	5
Pulaski County	2	15 3	17.0	64	26
AVERAGES (weighted by years)		21.2	25.6	58	11

[1] Boone County, one year.
[2] Bureau County, two years.

In view of the very definite relationship between infestation and yield, the Hessian Fly cannot be disregarded as a factor in wheat production in Illinois, but must be considered every year. The entomologists of the State Natural History Survey and the Federal Bureau of Entomology cooperatively make a special Hessian Fly survey of Illinois each season during August, and the results of this survey, giving the relative abundance of the fly in all of the principal wheat-growing sections of the State, can be obtained by writing to the chief entomologist of the Natural History Survey at Urbana or through the Farm Bureau in each county. With this information at hand, growers should use their own judgment in regard to the time of seeding.

ACKNOWLEDGMENT

This work was made possible through the assistance of a number of entomologists connected with the field station of the Bureau of Entomology at Lafayette, Indiana, and the entomologists of the Natural History Survey. Thanks are also due to the department of agronomy of the Illinois Agricultural Experiment Station for threshing all wheat samples from the experimental plots.