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THE MIGRATION OF *HARMOLITA GRANDIS* FORM MINUTUM: AN IMPORTANT FACTOR IN ITS CONTROL¹

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During the spring of 1919, *Harmolita grandis* was found to be present in unusual numbers throughout the eastern portion of the great wheat belt. It was evident that should no control measures be used, the infestation might develop into a very serious one within a few years.

Because of the fact that the spring form of this species cannot migrate long distances (it being for the most part wingless) rotation of crops has been a long approved recommendation for the control of this important wheat pest. A search of the literature on this subject failed to reveal any definite data concerning the migratory powers of the spring form of this species. In as much as this has a direct bearing upon the kind of rotation that will effectively control this species, and since the writers have obtained definite data along this line, they deemed it worthy of publication.

It is a well known fact that the spring form of *H. grandis*, although wingless, can migrate short distances by its pedal efforts. It is also generally known that this insect hibernates for the most part in the stubble of the previous year's crop. This means that in case wheat is sown adjacent to the stubble of the previous year's wheat crop, the edge of this field will become infested by the spring form, which comes off the stubble. The second generation individuals which are winged and strong flyers, can then emerge from this infested strip and infest the entire field and even adjacent fields. It is the intention of the writers to show by definite data the distance the spring form of this species can migrate and

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thus determine the distance that wheat can be sown from stubble of the previous year's crop, without danger of infestation.

The following is the method by which these data were obtained. Wheat fields were selected adjacent to stubble, and samples taken at ten yard intervals from the edge of the field next to the stubble up to 100 yards toward the center. In every case, fields were selected which were in a crop other than wheat the previous year, in order to eliminate possible infestation caused by adults coming from the stubble on improperly plowed soil. Each sample consisted of three linear feet of drill row, each foot taken at an interval of five yards in the same row. These samples were brought to the laboratory and carefully examined, the percentage of culms infested by this species being recorded. In this way the distance the adults migrated from the stubble was definitely determined, it being established by the area of infestation. In all cases the infestation was heaviest adjacent to the stubble and decreased in a regular manner with increasing distance from the stubble.

Samples which were taken from eight fields were carefully examined and infestation percentages recorded. In all 280 linear feet of drill row representing 12,276 culms were handled, each culm being carefully examined to detect the presence of this species. The tabulated data from these examinations are found in the following table:

TABLE I

Fields	Distance from stubble	Linear ft. drill row counted	No. culms examined	No. culms infested with <i>H. grandis</i>	Per cent infestation
8	Next to stubble	26	1,093	133	12.1
8	10 yds.	26	1,204	58	4.8
8	20 yds.	26	1,103	27	2.4
8	30 yds.	26	1,139	18	1.6
8	40 yds.	26	1,156	7	0.6
8	50 yds.	26	1,171	4	0.4
8	60 yds.	26	1,088	1	0.09
8	70 yds.	26	1,038	1	0.10
8	80 yds.	26	1,158	1	0.08
8	90 yds.	24	1,025	1	0.10
8	100 yds.	24	1,101	0	0.0
			12,276		

NOTE: Samples from field 8 consisted of five linear feet of drill row except at 90 and 100 yards out which consisted of three linear feet.

From the above table and curve it can be seen that the greater part of the infestation occurred within ten yards of the standing stubble, and beyond 30 yards the infestation became practically negligible. The amount of infestation varied markedly in the eight fields, ranging from 20.1 per cent to 6.2 per cent at the stubble, but in every case it decreased in practically the same ratio as the distance from the stubble increased. These data show that under ordinary conditions very few of the wingless

Fig. 21. Curve constructed from the data found in Table I, showing the exact location of the percentages of infestation at various distances from the standing stubble.

adults of this species will migrate farther than 30 yards from the stubble which marked their emerging place.

Several fields which were in wheat the previous year were examined and only a trace of the spring generation of this species was found, and this only where the stubble of the previous year's crop had been improperly plowed. In one field which was in wheat the previous year, a count was taken 100 yards from the edge and showed no infestation; 150 yards showed an infestation of 0.94 per cent and 200 yards, none. From this it can be seen that by far the greater part of the infestation from this generation occurs in those fields which are adjacent to standing stubble of the previous year's wheat crop and within 30 yards of the edge.

Plate 17, 3 of the accompanying figures is an illustration of a plant infested by the spring form of this species. The four tillers on the right are infested. The leaves are broader than normal, darker green, and the center shoot is absent. They appear very much as if they were infested by Hessian fly. The four tillers on the left are normal healthy ones. The isolation of the infestation by the wingless spring generation was very apparent in some of the fields. At the edge adjacent to the stubble the wheat was very thin and dwarfed, which is characteristic of a heavy infestation from this species. Plate 17, 1 and 2 show this condition very well. Both were taken on the same day in the same field only 50 yards apart. Both were focused at the same distance. The first generation infestation was 19 per cent and the second generation infestation 85 per cent at the spot where the first picture was taken. At the location of the second picture there was none of the first generation found but a second generation infestation of about 50 per cent.

An examination of the volunteer wheat in the several stubble fields was made and in every case it was very highly infested with spring generation. Where volunteer wheat is abundant in the stubble fields which are harboring the over-wintering pupæ, it simply acts as a breeding place whereby the wingless first generation can oviposit, thus allowing the strong flying second generation to complete its task of infesting all the wheat in the vicinity.

Having found that practically all of the first brood was located along the edge (outer 30 yards) of wheat fields adjacent to standing stubble, and in volunteer wheat in the stubble, next it was decided to determine to what extent the winged second generation which came from these infested places could infest the wheat in the surrounding vicinity.

Counts were made in the same eight fields for second generation infestation but this time, instead of using ten yard intervals from the stubble, 50 yards were used and only four counts made, namely, next to stubble, at 50, 100 and 150 yards. The counts were made similar to those described above, three linear feet of drill row being taken at three

different places in the same row. Only the culms which had "shot" and were jointed were counted, as it is in these that the adults of the second generation oviposit.

The following table shows the location of the second generation infestation, the percentages being an average of the eight fields:

TABLE II. SECOND GENERATION INFESTATIONS ON THE SAME EIGHT FIELDS THAT THE FIRST GENERATION COUNTS WERE MADE

No. of fields	Linear ft. drill row	Distance from stubble	Tillers counted	Tillers infested	Per cent infestation
8	24	Next to stubble	448	227	50.7
8	24	50 yds.	423	100	23.6
8	24	100 yds.	413	53	12.8
8	24	150 yds.	409	26	6.4

On examining the data obtained from these counts it can be seen that although the heaviest infestation remained in those parts of the fields nearest the standing stubble, comparatively high infestations were found even at 150 yards, which is approximately the middle of most of the fields used in the counts. On the other hand the infestation caused by the first generation stopped at about 30 yards. This shows that the strong flying adults of the second generation will infest an entire field even though they come from a narrow infested strip or a small plot of volunteer wheat in or near standing stubble.

Since it has been shown that the second generation can infest an entire field next to standing stubble, the question now arises, are these second generation individuals able to infest wheat fields which are isolated from standing stubble areas. It has already been stated that practically none of the first generation could be found in last year's wheat which had been properly plowed. It was decided to make second generation counts in fields which were not adjacent to standing stubble. Also to determine the efficiency of plowing under the stubble of the previous year's crop, two types of these fields were taken; those in wheat last year, the stubble having been plowed under, and those in a crop other than wheat the previous year. Since all other conditions in these two classes of fields were practically identical, any marked variation in the percentages of infestation could be undoubtedly due to the fact that it came from the plowed-under stubble in the form of early wingless generation, and hence, on to the second generation infestation.

The counts were made in the following manner: Three linear feet of drill row were taken at five-yard intervals in the same row, these samples being taken at four places in each field, at the edge, 50 yards, 100 yards and 150 yards from the edge. The samples were taken to the laboratory and each culm carefully dissected and infestations recorded.

The following curves show in a graphic way how the winged second generation greatly increases its area of infestation over the area infested by the first generation. The curves represent the infestation of eight fields by both generations and are platted with equal value.

Fig. 22. Curves based on Table II.

Data were taken from seven fields which were in wheat last year but not next to standing stubble. The results are found in the table following:

TABLE III. SECOND GENERATION COUNTS ON SEVEN FIELDS IN WHEAT LAST YEAR BUT NOT NEXT TO STANDING STUBBLE

No. of fields	Linear feet	Distance from edge	Tillers counted	Tillers infested	Per cent infestation
7	21	At edge	318	45	14.1
7	21	50 yds.	365	34	9.6
7	21	100 yds.	367	57	15.5
7	21	150 yds.	374	25	6.7
			Total 1,414	161	Average 11.6%

The above table shows that the infestation, although markedly lighter than in fields adjacent to standing stubble, was fairly uniform throughout the fields.

Similar data were taken from eight fields which were in a crop other than wheat last year and at the same time not next to standing wheat stubble. The results from these eight fields are found in the following table:

TABLE IV. SECOND GENERATION COUNTS ON EIGHT FIELDS NOT IN WHEAT LAST YEAR AND NOT NEXT TO STANDING STUBBLE

No. of fields	Linear ft. drill row	Distance from stubble	Tillers counted	Tillers infested	Per cent infestation
8	24	At edge	458	64	13.9
8	24	50 yds.	465	50	10.7
8	24	100 yds.	498	34	6.8
8	24	150 yds.	498	47	9.6
			Total 1,919	195	Average 9.9%

Again the infestation was fairly uniform throughout the field. Although these fields were not in wheat last year nor next to standing stubble, the infestation from this species was practically the same (very slightly less) as fields on plowed wheat stubble. This is shown in the accompanying graph.

The fact that there was no great difference in the infestation in fields which were and were not in wheat the previous year, that is in fields not adjacent to stubble, tends to show that the plowing under of stubble is fairly efficient in the control of this species. If the first generation adults were able to emerge from plowed under stubble, surely there would be a much greater infestation in those fields which were in wheat last year.

Since we find the ordinary infestation in fields isolated from standing stubble which were not in wheat last year, the question arises "where is the source of infestation in these isolated fields?" This can be answered in only one way. The second generation must come from the first and since practically all of the first generation is found near the edge of the

Fig 23. Graph based on Table III.

wheat fields adjacent to stubble or in volunteer wheat in or near stubble, the source of infestation of these isolated fields must originate from these places. These data prove that the winged second generation are strong flyers and emerge from wheat in or very near standing stubble, scatter themselves broadcast, and infest all wheat fairly uniformly over the whole general neighborhood.

Because of the general distribution of the second generation it is certainly not practical to attempt to apply control measures here. The point of attack is certainly in the first generation, the infestation of which is always very limited in area.

It has already been stated that the plowing under of stubble is effective in preventing further infestation from this species. This is one more reason added to the list why wheat stubble should not be left standing after harvest any longer than possible. In some cases, however, farmers find it impossible to plow under the stubble. In this event, wheat should not be sown adjacent to this infested stubble as shown by the facts already set forth. In the data compiled in Table I, it is seen that practically none of the first generation will migrate more than 30 yards to oviposit. This is the key to the whole situation. By planting wheat not closer than 30 yards to standing stubble, one is fairly safe from infestation. Where the stubble can be thrown under without plowing up a hay crop, it should be, but where the hay crop is to be left with the stubble, the following year's wheat should not be sown within 30 yards of it. If it should be, it will act merely as a breeding place for the first generation and the resulting winged second generation will then infest the whole field and nearby fields as well, as is clearly shown by the data embodied in this paper.

It is also essential to keep down all volunteer wheat in or near stubble. This is most apt to spring up around old shock bottoms. This volunteer wheat will act as a breeding place exactly as will wheat sown next to stubble.

SUMMARY

In summarizing the data set forth in this paper, the writers wish to emphasize the following points: Should *H. grandis* increase at its present rate, a great deal of damage will result in the wheat growing region of the United States. The pest hibernates in the stubble and the wingless first generation will infest adjacent wheat or volunteer wheat in or near standing stubble, as it affords a breeding place whereby the first generation can survive, thus exposing the entire neighborhood to infestation from the strong flying second generation. Should the wingless first generation be deprived of its natural breeding places, namely the edge of wheat fields adjacent to standing stubble and volunteer wheat in or near stubble, the result will undoubtedly be a great decrease in the amount of infestation during the succeeding seasons.