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Insects Destructive to Grain and Grain Products Stored in Bins and Granaries.

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A large amount of wheat, estimated at 30,000,000 bushels, is still stored in bins and granaries and with the opening of spring the infesting insects, which were unusually abundant last fall, will again become very active and will work so vigorously that the farmer must kill them, dispose of his grain, or allow them seriously to damage it. The infesting insects, if left unchecked, can easily cause a loss equal to from five to fifteen per cent of the total value of the grain.

Of the several species of beetles and their larvae attacking stored grains, not more than five or six are commonly found in the farmers' bins, of which the two species of grain weevils (snout beetles or little "bill-bugs"), the grain molitor, the cadelle, and the saw-toothed grain beetle are the most damaging. To these may be added three species of moths, the Angoumois grain moth, which is the most serious attacking corn, and the two meal moths, which are the serious ones in meal, bran, or any other ground grain products. All of these species are of small size, none of the beetles exceeding five-eighths of an inch in length, and most of them being less than one-fourth of an inch long. They are reddish, brown, or black in color. The moths are tiny "millers," and with the exception of the Angoumois grain moth, the work of their larvae in bins, granaries and mills may be distinguished from that of the beetles by the presence of web or silk in the grain, bran, meal or flour. Only two of these insects are true weevils, although

the farmer and the miller usually apply the term "weevil" to most of them.

Measures to be employed in the control of this class of insects are both insecticidal and preventive.

INSECTICIDAL METHODS OF CONTROL.

Fortunately, it matters little what species may be causing the trouble, for all succumb to the same treatment. The simplest, most effective, and least expensive remedy for all insects infesting the farmers' grain and grain products stored in tight bins is careful fumigation with carbon bisulphide.

While carbon bisulphide fumigation is effective and is strongly recommended for all insect infestations in the farmers' bins, it is not an effective fumigation in flour mills, and since there is such an element of danger from fire in its use in these mills and in large grain elevators, it is not recommended for this purpose. It is prohibited by mill and grain-elevator insurance companies, and the use of it voids the policies.

The Amount of Carbon Bisulphide to be Used. The amount of liquid to be used depends on the temperature, on the size and shape of the building, on its tightness, and on the nature of the attack. Since temperature is a very important factor in the success of fumigation, it should always be given careful consideration. Our fumigation experiments, conducted in practically an air-tight chamber with the larvae, the pupæ, and the adults of the confused flour beetle (*Tribolium confusum*) and the adults of the rice weevil (*Calandra oryzae*), show that while at a temperature of 90° F. one pound of carbon bisulphide is sufficient for every 500 cubic feet of space, at a temperature of 80° F. one pound of the liquid is required for 400 cubic feet of space, and at a temperature of 70° F. one pound of the liquid is required for every 300 cubic feet of space. At a temperature below 60° F. the amount of carbon bisulphide required and the results obtained are so unsatisfactory that it is impracticable to attempt fumigation. If the building is reasonably tight and the temperature is above 70° F., five pounds of carbon bisulphide is sufficient for every 1,000 cubic feet of space, or one pound for every 25 bushels of grain. In case the building or bins are not sufficiently tight to allow thorough fumigation, the amount of the liquid should be doubled or even tripled.

Preparation. The building and bins must be as nearly air-tight as possible in order that the vapor may remain in all parts of the space in full strength and for the required time. The vapor must enter all cracks and crevices by diffusion. Doors

should be wedged tight. If they are loose, either paper should be pasted over them, or cotton batting should be inserted in the openings with a case knife. A similar treatment should be given all holes and cracks in the wall and floor. The batting should be packed tightly. The door and one or two windows should be so arranged that they can be opened from the outside when fumigation is completed. Care should be taken to have everything ready and in place, so that after the distribution of the liquid has begun it will be unnecessary to stop to adjust anything. Everything should be done to avoid unnecessary delays and to facilitate the rapid evaporation of the liquid.

Placing the Liquid. Since the vapor is heavier than air and settles to the lower parts, the liquid should be placed in shallow pans at the top of the bins or buildings. It should be well distributed, not more than a pound in a place, and even less than this amount where it is practical to have it distributed in small quantities. If larger amounts are used in one place, it should be placed in pans having considerable evaporating surface. In large bins, to hasten and to equalize the operation, it is well to put a quantity of the liquid in the center of the grain by thrusting into it a gas pipe, loosely plugged at one end, down which the carbon bisulphide may be poured, the plug being then loosened with a rod. The plug should be attached to the rod in order that it may be withdrawn. The liquid may be applied or sprinkled directly upon the grain. Unless used in excessive quantities the liquid will not injure the edible or germinative qualities of the grains or seeds.

If a building of more than one floor is to be fumigated the operator should begin on the first floor and work upward, and after placing the liquid in the upper story, leave the building through a window that he can close after him. If it is impossible to get out from the upper story, the carbon bisulphide should first be distributed there, and the operator should work downward as rapidly as possible to avoid the settling vapor.

Length of Exposure. The bins or building should be allowed to fumigate 36 hours. If the grain is not to be used for germinating purposes, it is well to subject it to the fumigation for 48 hours. The best plan usually is to apply the liquid on a Saturday afternoon and leave the building closed until the following Monday.

Ventilation. Doors and windows should be opened wide and the building or bins aired thoroughly one or two hours before

being entered. Slight traces of the odor will linger in corners and other places where the air does not circulate freely, but these will gradually disappear.

Precaution. The vapor of this liquid is highly inflammable and explosive. No fire or light of any sort should be allowed about the building while the fumigation is in progress. The application should always be made in daylight, for artificial light of any kind is dangerous. Electric lights must not be used, since when turning them on or off there is always danger of producing a spark. It is not safe to have heat of any kind in the building while the fumigation is in progress.

PREVENTIVE METHODS OF CONTROL.

In order that infestation in the stack may be avoided, the grain should be threshed as soon after harvesting as practicable. The writer has found on several occasions that where the grain was left in the stack until early fall it was seriously infested with the Angoumois grain moth and the grain weevil. Fresh grain should not be exposed to attack by storage in bins or granaries containing infested grain. Before storing, the old grain should be removed and the floors, walls, and ceilings of the bins thoroughly cleaned. If the granary has been badly infested, it should be fumigated before the new grain is stored. Since cleanliness is very important in the prevention of injury by these insects, all dust, dirt, rubbish, refuse grain, flour, and meal, which serve only as breeding-places, should be removed. If the grain is infested by the grain or meal moth, frequent agitation or handling of the grain will destroy many of them, because they are unable to free themselves from a mass of it and perish in the attempt. A liberal use of air-slaked lime is recommended for dusting in corners and along the edges of bins. This lime should be dusted in the bins as soon as they are empty, but removed before storing the grain. Granaries, as far as possible, should be constructed so as to be easily kept clean, and in such a manner as not to allow materials to collect and afford lurking places for insects. Granaries should also be constructed so as to avoid dampness. This dampness induces a condition in the grain termed "heating," and thus favors a rapid increase in insect life. It is also a fact that when insects are abundant in grain, they cause, in some unexplained manner, a rise in temperature. If corn is showing infestation in the open crib, it should be shelled at once, and, after it is stored in tight bins or in the granary, should be fumigated with carbon bisulphide.