WHITE GRUBS AND THEIR CONTROL IN FOREST TREE NURSERIES [1]

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Because white grubs have caused severe-losses in forest tree nurseries in numerous; areas of the United States, it is believed worthwhile to make available results of attempts to control them in Wisconsin.

The damage caused by grubs is of three main types (a) killing of 1-0 stock by cutting the primary root, (b) killing of 2-0 or older stock by stripping the bark or cutting the roots, (e) slowing of growth by feeding at the root terminals. Such damage is caused not only by the true white grubs belonging to the genus Phyllophaga but also by a number of related forms. Usually the actual injury occurs some time before symptoms begin to appear as discolored foliage or wilting. Fresh damage in 1-0 stock, however, can be easily recognized by the seedlings being pulled down.

There are over 130 species of Phyllophaga alone recorded from the United States. The length of life cycle depends upon the species and on the environmental conditions encountered, being shorter in the warmer climates. This is true both for Phyllophaga and its relatives.

For a typical three-year cycle the life history of a June beetle in central Wisconsin is briefly as follows:

1st year -- In May the adults emerge from soil, fly, feed, and mate. The eggs are laid in late May or in June. The young grub hatches about the first week in July. Very little damage is caused by the first stage larva; in fact, the feeding habits of this stage are not known with certainty. Late in the summer the grub moults to the second stage. With the coming of cold weather it migrates some distance below the surface and overwinters.

2nd year -- In the spring the grub migrates to near the surface where it feeds voraciously and increases rapidly in size. About the middle of the summer it, moults and becomes a third instar grub, which continues to feed heavily until cold weather appears when it moves doom to pass the winter.

3rd year -- The overwintered third stage larva may migrate to near the surface and feed heavily for a time and then go damn to pupate, or it apparently may remain quite inactive until June, at which time it pupates.

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After about two weeks: the adult emerges from the pupa. The young adult remains quiescent in the soil from about July until the following spring when it emerges.

The major damage is caused primarily by the second or early third instar grubs. When the cycle is three years, the damage appears in the season after flight of the beetles; but when the cycle is one or two years, injury occurs during the year in which the eggs are laid. When the cycle is four or more years, damage my start during the second year and be continued for two or more years. This means that in order to predict accurately when damage will occur it is necessary to study the species present and find out when the adults are on the wing in a particular locality. Light traps are commonly used for this purpose.

The results of studies of the food plants of the adults and of tests for control of the beetles and eggs, reported in 1950 [1] showed that the logical approach to control of the insects was through. killing the grubs by means of soil insecticides. Consequently, for the past four years insecticides have been tested in soil cages against the grubs. Many of the newer organic insecticides have remained effective in the soil longer than was anticipated. As the tests are still underway, it is not known yet just how long some of them will persist and remain effective.

In view of the demonstrated persistence of the materials in the soil, it became necessary to test for possible injury to the plants which might be caused by a lengthy exposure to the insecticide. The fact that lead arsenate, long a standard for grub control, is very injurious to seedlings and drastically reduces the stand is well known. Of the more promising insecticides tested, it was found that benzene hexa chloride (BHC) at one pound of the gamma isomer per acre caused death or malformation of many of the young seedlings. The cotyledons and primary needles died from the tip toward the base and this was accompanied by a twisting of the stem. When the roots were examined, it was discovered that a short, clubbed root had developed instead of a norm l type. Secondary roots may arise from above the club and in turn be clubbed. Associated with the clubbing is a great increase in the number of chromosomes and certain other cell abnormalities. In contrast, no abnormal effects have resulted from the use of chlordane, aldrin, or dieldrin.

The percentages of control obtained during the four years with the 16 insecticides tested are given in Table l. When a treatment was judged to be ineffective the cages involved were completely cleaned out and fresh soil introduced so that other tests could be made. At present, 206 cages (mostly 2'x2'x2' underground, with a like portion above ground) are in use. The tests are of two types: (a) tests of initial toxicity, in which first stage larvae are introduced into cages previously treated with insecticide and in which a sod was established, and (b) residual

1 Shenefelt, R. D. and Simkover, Ii. G. 1950. White Grubs in Wisconsin Forest Tree Nurseries. Jour. Forestry 48(9): 429-434.

establishment; in which adult beetles are introduced into the-cages, allowed to lay their eggs and the ability insecticide to prevent establishment of the grubs is determined.

In tests against first stage grubs, the cages were examined about two weeks after the grubs were introduced and, in certain instances, the living grubs put back and the cage examined a month later. In the residual establishment tests examinations were mails about two weeks after hatching was nearly completed and again after a four-week interval. It is believed that the first examination of the residual-establishment cages indicates the relative speed which the young grubs are killed. Tests made in salve tins with newly hatched grubs and older grubs, showed that the grubs are most easily killed by insecticides just after hatching.

The data obtained from the cage tests show that when insecticide is mixed into the soil it is more effective and persistent than when applied from above as an emulsion or solution and washed in with water.

From the information gathered, it is evident that treatment should be preventive rather than curative. It does not seem feasible to wait until damage starts to appear and then treat successfully. There is no way of predicting where the beetles will lay their eggs in a nursery -- and damage may occur during the same year, before the trees are lifted. This means that the insecticide should be in the ground by the time the eggs hatch.

At the present time chlordane is being used in the state forest tree nurseries of Wisconsin to prevent grub damage. As they become free of trees, areas are treated with a 10 per cent chlordane dust. The dust is applied with a power row crop duster, using 100 pounds per acre. To get on the proper amount of dust it is necessary to set the power duster at a definite speed (we use the full speed of the motor) and at a definite hopper opening. The rate per acre is then determined by the speed with which the duster is drawn over the area. By using 10 pounds of dust and knowing the width of the dusted swath, one can soon determine the necessary speed. Immediately after a section is dusted, the material is worked into the ground to a depth of about 8 inches by means of a rototiller or disc. The dust should be applied at a time when there is little wind.

Areas which cannot be dusted because of the presence of trees receive an application of chlordane emulsion which is applied through the overhead sprinkling system. A fifty-five gallon drum is connected to the intake pipe by means of pipes containing a valve. Suction created by the pump will draw the material into the system. The drum is nearly filled with water, and the amount of emulsion concentrate necessary to give a dosage of five pounds per acre over the area to be sprinkled is added. Then the pump is started, and the rate of withdrawal from the barrel is regulated so that, the emulsion concentrate is diluted to at least one part in 2,000 parts of water. No corrosion of the pump or system have been observed from this procedure. After the emulsion has been used, the *sprinkling* system is operated for three to four hours to drive the chlordane into the soil. A small power sprayer_: may be used to apply emulsions directly_ to a small area or may be used to pump the. material directly into the upright leading to a single horizontal pipe by connecting the hose directly to the upright and forcing in the insecticide while the sprinkling system is being operated.

The emulsion treatment is applied not later than ten days after the June beetle flight begins and is regarded as only a temporary application, i.e., as areas become free of trees they are dusted. It is not used on 2-2 stock which usually withstands considerable root pruning without evident damage to the trees.

Material for the chlordane dust treatment costs about $15.00 per acre (delivered) while the cost of sufficient 40 per cent emulsion concentrate to treat an acre is about $6.15.

As a result of application of chlordane as described above, there was practically no damage in the Wisconsin state forest tree nurseries during 1950 in spite of a very heavy flight of June beetles and anticipated damage. One private forest tree nursery within two miles of one of the protected nurseries, however, suffered extensive losses.

At the present time we do not know how long the treatment will give protection. Nor do we know whether or not it will be as effective in other soil types as it is in Wisconsin. Since the effect of soil insecticides varies with soil type and plant variety, it is suggested that those planning to control white grubs used dusts or emulsions on small plots, which should then be seeded in order to test for possible plant injury. However, chlordane has not been found to injure 20 species of conifers tested in Plainfield sand.

Ground containing a large grub population may be freed from grubs by using a soil fumigant where it is believed that the returns during the first season would justify the expense of material and application (about $70.00 per acre).

The writers would be glad to receive specimens of adult June beetles or grubs from other parts of the country and answer inquiries of nurserymen with a white grub problem.

Table 1. Percent white grub control obtained with soil insecticides in field cages. Griffith State Nursery, Wisconsin Rapids, Wisconsin, 1947-1950.

Insecticide	Rate of application lbs./A.	Mode of applic.	Initial Tests against First Instar: 1st reading	Initial Tests against First Instar: 2nd reading	Residual-establishment tests: First year 1st read.	First year 2nd read.	Second year 1st read.	Second year 2nd read.	Third year 1st read.	Third year 2nd read.	Fourth year 1st read.	Fourth year 2nd read.
Lead arsenate	500	mixed in	75.0[1]				-8.8	85.4	85.2	88.8	39.5	28.0
	1000	"	42.3				96.1	97.5	75.8	76.0		
Chlordane	0.5	"			63.1	78.8						
	1	"			66.3	76.9						
	2.5	"	100[1]				100		100		92.8	93.5
	10	"	100				100		97.2	100		
	10	emul.	86.5				100		85.2	100		
Aldrin	1	mixed in			98.8	100						
	10	"			100		99.9	100				
	10	emul.	100				99.1	100				
Dieldrin	1	mixed in			94.8	98.2						
	10	"			99.7	100	99.0	100				
	10	emul.	83.3	100			97.4	100				
BHC	0.25 gamma	mixed in	100[2]									
	0.5 gamma	"	100[2]									
	1 gamma	"	100[1]				100		98.3	98.8	73.3	98.2
	1 gamma	emul.	53.8				100		96.9	100		
DDT	5	mixed in					46.2	43.8				
	10	"	-50.0[1]				73.1	79.2				
	10	emul.	-21.2									
	25	mixed in	-62.5[1]				-23.1	41.7				
TDE	10	emul.	- 9.6				-77.0	-91.5				
CS 645	10	mixed in			95.2	97.5	78.6	76.0				
	10	emul.	27.8	100			70.3	84.3				
Toxaphene	10	"	-17.3				23.5	74.5				
	20	mixed in			96.1	98.2	89.1	92.6				
	20	emul.	83.3	90.9			57.4	93.3				
Parathion	2.5	mixed in	90.4				89.6	95.0	61.3	22.5		
	2.5	w.p.sprinkled on soil					73.8	90.7				
	108.2	1/1000 sol. sprinkled on soil					100		85.4	85.2		
DPP[3]	50.4	1/2000 sprinkled on soil					99.6	100				
AC 4049	5	mixed in	- 3.33	30.0								
	10	"	30.0	90.0								
Sulphur	500	"			7.7	50.0						
Phenothiozene	10	"	86.5				-35.7	87.1				
Mercurous bichlor.	8.85	1/1000 sol. sprinkled	15.4[4]				-25.2[4]	-22.9[4]				
NMRI-448	10	emul.	3.8[4]									

1/ Based on a single control cage.

2/ 10 first instar larvae used per cage.

3/ diethyl paranitrophenol phosphate.

4/ Only 2 cages treated.