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# Hydraulic Spray Applications of Insecticides for the Control of Slash Pine Cone and Seed Insects

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# Hydraulic Spray Applications of Insecticides for the Control of Slash Pine Cone and Seed Insects

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SUMMARY: Field spray tests were conducted from 1959 to 1961 in north Florida to evaluate the effectiveness of hydraulic spray applications of BHC, Guthion, and DDT for the control of coneworms, *Dioryctria* spp., and the slash pine seedworm, *Laspeyresia anaranjada*. Slash pines up to 40 feet in total height were protected from coneworm attack with BHC (4 lbs. gamma isomer/100 gal. water) or Guthion (1.5 lbs./100 gal. water). DDT (4 lbs./100 gal. water) did not give satisfactory protection from coneworms. Of the three tested, Guthion was the only insecticide which controlled the seedworm. A spray schedule is given for the control of coneworms and the seedworm on slash pine in north Florida.

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Within the past decade in the South, large programs for the reforestation of idle and cut-over forest lands and the increased popularity of direct seeding have resulted in an unprecedented need for large amounts of pine seed. The tremendous expansion in forest tree improvement through genetics research has increased the demands for genetically superior seed. As of June 1963, a total of 4,674 acres of improved natural pine seed-production stands had been established on Federal, State, and private lands in 11 southern states. An additional 3,360 acres of pine seed orchards have been planted to produce the high quality seed of the future. 1/ It is not unusual in slash pine seed production areas for insects to partially damage or completely destroy from 50 to 70 percent of a cone crop, or 30 to 50 percent of the seed crop. If such areas are to produce a continuous, dependable supply of superior seed, they must be protected from the ravages of insects which directly or indirectly destroy the seeds.

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1/ Seed production stand and seed orchard acreage data were obtained from U. S. Forest Service, Region 8, Division of State and Private Forestry, Atlanta, Georgia.

The results of field experiments on the chemical control of insects affecting slash pine, Pinus elliottii Engelm., seed production are presented. The studies were conducted on the Olustee Experimental Forest in northeast Florida from 1959 through 1961. The insecticides used were selected on the basis of their promising performance in laboratory screening tests (Merkel 1962) and exploratory field tests.

Because coneworms do the most damage, chemical control in these studies was directed primarily against three coneworms, Dioryctria abietella (D. & S.), D. amatella (Hulst), and D. clarioralis (Walker). In an attempt at simultaneous control, we included studies of the seedworm, Laspeyresia anaranjada Miller.

## MATERIALS AND METHODS

### Coneworms

The studies were conducted in an old field containing scattered, open-grown, naturally seeded slash pines. The trees averaged 15 years old, 40 feet tall, and 9.6 inches d.b.h.

All insecticides were applied with a Myers "Silver Cloud" hydraulic sprayer operated at a pump pressure of 600 p.s.i. Spray was delivered through a John Bean, adjustable, trigger-type spray gun fitted with a No. 14 disc nozzle-orifice. Insecticides were applied as whole-tree treatments in all tests. The spray was applied until it started to run off the needles and cones; this amounted to an average dosage of 8 gallons of spray per tree. All sprays were prepared from commercially available emulsifiable concentrates and no spreaders or stickers were added. 2/ Sprays were applied at dawn or sunset to minimize spray drift and contamination of unsprayed study trees.

The design of the 1959 and 1960 studies consisted of seven randomized complete blocks of four trees (treatments) per block. In 1961 a completely randomized design containing 31 trees was used because analysis of variance of cone infestation data from the previous 2 years showed that blocks did not contribute significantly to total variance.

Prior to the first spray application in each of the field tests, 20 sample branches bearing first- and second-year cones were selected randomly on each tree. After tagging and numbering each sample branch, we made a careful examination and count of sound cones and those infested by the Dioryctria coneworm. Cone infestation tallies were made at irregular intervals on the sprayed and unsprayed check trees throughout the summer to follow the trend of coneworm attacks.

In order to evaluate over-all effectiveness of different spray treatments, a final check of coneworm infestation was made when mature cones were collected in September. The effectiveness of the different insecticides and spray

2/ The author acknowledges the assistance of the Chemagro Corporation, Kansas City, Missouri, for supplying the Guthion used in these studies.

schedules for the control of coneworms was based on an analysis of variance of the cumulative percent cones infested during the period from just prior to the first spray application to the time of cone harvest in mid-September.

Data on percent first- and second-year cones infested by coneworms were transformed to arcsin $\sqrt{\text{percent}}$ for analysis of variance. Duncan's multiple-range test (Duncan 1955) was used to detect significant differences between treatment means.

Seedworms

The effect of treatments on seedworm (Laspeyresia) control was based on the percent mature cones infested with mature larvae overwintering in the cone axes.

Data on percent second-year cones infested by the seedworm were transformed to arcsin $\sqrt{\text{percent}}$ for analysis of variance. As in the case of coneworm tests, Duncan's multiple-range test (Duncan 1955) was used to detect significant differences between treatment means.

## STUDY RESULTS

### Dioryctria spp.--Coneworms

Detailed information on the life histories and habits of the three coneworm species present in the study area was not available when this series of tests was started in 1959. However, we did know that all of the coneworm species produced at least two complete generations a year. We also knew that all species did not depend solely on cones for their principal source of food. During the winter and early spring, coneworms are found boring in the vegetative and reproductive buds of both slash and longleaf pines, Pinus palustris Mill., and a little later in the flowers themselves. From late February through April, coneworms are more common in shoots and first-year cones. In late April, when second-year cones are starting to grow rapidly, coneworm attacks increase and usually continue until late August, when cones are nearly mature.

Our data also show that the relative abundance of any given coneworm species not only varies throughout the year on a given pine species, but there are also great differences in the relative abundance of coneworms between pine species. Thus, the fluctuation in populations of the various coneworm species presents a challenging problem in the placement and timing of insecticide applications.

The effectiveness of different spray schedules and insecticides on coneworm control are summarized in table 1. It was not possible to determine the effectiveness of each spray application within a given schedule because cone infestation was not evaluated specifically before and after each spray.

The initial experiment in 1959 (table 1) was designed to evaluate the effectiveness of a spray schedule A, consisting of arbitrary dates of spray application, i.e., every other month. The arbitrary or systematic spray schedule A was to be compared with spray schedule B, in which dates of application were timed with periods when incidence of coneworms were known or suspected of being high in first- or second-year cones. The differences in spray dates between schedules A and B had little effect on the degree of coneworm control. (Although spray schedule C consisted of two biologically-timed sprays designed to control the seedworm, L. anaranjada, results are included because of the good coneworm control that was obtained.)

Table 1.--Effectiveness of different hydraulic spray schedules in controlling coneworms and seedworms on slash pine cones, Olustee, Florida, 1959 to 1961

| Insecticide and Year | Concentration by weight of active toxicant | Sprays applied | Control of Dioryctria spp. | | Control of L. anaranjada |
|---|---|---|---|---|---|
| | | | First-year cones | Second-year cones | Second-year cones |
| | Percent | Schedules and dates | - - Percent - - | | Percent |
| 1959 | | | | | |
| BHC | 0.5 | A, 2/24; 4/25; 6/26; 8/24 | 100** | 85** | 0 |
| BHC | 0.5 | B, 2/24; 4/7; 5/29; 6/26 | 92** | 82** | 0 |
| BHC | 0.5 | C, 5/4; 5/19 | 92** | 79** | 0 |
| 1960 | | | | | |
| BHC | 0.5 | D, 2/20; 4/22; 6/15; 8/16 | 100** | 96** | 0 |
| BHC | 0.5 | E, 3/30; 6/1; 7/30 | 100** | 88** | 0 |
| BHC | 0.5 | F, 4/11; 4/22; 5/6; 5/13; 6/1 | 73** | 92** | 0 |
| 1961 | | | | | |
| BHC | 0.5 | G, 4/28; 5/29 | 94* | 99** | -- |
| Guthion | 0.2 | H, 4/24; 5/4; 5/16 | -- | 89** | 99** |
| Guthion | 0.2 | I, 4/24; 5/4; 5/29 | 100* | 95** | 98** |
| DDT | 0.5 | J, 4/24; 5/4; 5/16 | 57 | 20 | 13 |

* Treatments better than the check at the 5-percent level.
** Treatments better than the check at the 1-percent level.

In 1960 the arbitrary spray schedule D was repeated as in 1959. The biologically-timed schedule E was reduced to three sprays in 1960 because of the good performance of only two sprays (schedule C) in 1959. (The frequent spray applications in schedule F in 1960 are discussed under seedworm control.) The results of the 1960 test showed that three spray applications gave as good coneworm control as four applications.

The 1961 tests were designed to evaluate the effectiveness of only two BHC sprays (spray schedule G) applied when coneworm attacks on first- and second-year cones normally increase rapidly. Spray schedule G gave protection of second-year cones comparable to that obtained the previous 2 years.

Spray schedules H, I, and J were designed to evaluate the control of Guthion and DDT against both coneworms and seedworms with a rather close interval of time between three spray applications. Both Guthion spray schedules gave good control of coneworms on maturing cones; but effectiveness of protection of first-year cones was evaluated only in schedule I.

DDT gave moderate control of coneworms on first-year cones, and very poor control on second-year cones. Similar results were obtained with DDT in earlier exploratory field tests. We have not determined the reason for the differential effect of DDT in protecting first- and second-year cones.

Laspeyresia spp.--Seedworms

Two species of seedworm, Laspeyresia anaranjada Miller, and L. ingens Heinrich, infest second-year slash pine cones in northeast Florida. The slash pine cones in the study area contained virtually a pure population of L. anaranjada; however, this fact was not established definitely until after completion of rearings from 1959-crop cones in late May 1960.

L. anaranjada infests second-year cones only and has only one generation per year. The complete life cycle from egg to adult runs from May of one year to May of the following year in north Florida. The insect hibernates as a mature larva in the cone axis during the winter.

The eggs are laid on the surface of cone scales during the first 3 weeks of May and they hatch within a few days after being laid. The newly hatched seedworms wander over the cone surface for several hours before boring in. Once the larvae enter the cones, they are safe from contact with any residual or contact insecticide. Therefore, the effectiveness of chemical control of this seedworm depends on the moths and larvae contacting, or being contacted by, insecticides between the time of egg laying and larval entry into the cones.

Timing of insecticide applications is a more critical factor for control of seedworms than for the control of coneworms. However, more applications are needed to control coneworms because they develop multiple generations annually.

It should be noted that spray schedules C, F, H, I, and J for coneworm control in table 1 were also evaluated for their effectiveness in controlling seedworms. The two BHC sprays for seedworm control in 1959 (schedule C) were applied at the beginning and peak of the oviposition and egg hatch period of L. anaranjada but they failed to give control of the seedworm. The number of BHC applications was increased to five in 1960 (schedule F), with the idea of controlling both L. anaranjada and another seedworm, L. ingens, sometimes encountered in slash pine cones. Moth rearings from 1959-crop cones in late May 1960 revealed that a pure population of L. anaranjada was present. Thus, the April and June spray applications, which had been added to control L. ingens, were not necessary. These extra applications of BHC in 1960 failed to have any effect on L. anaranjada. Good control of L. anaranjada with Guthion in exploratory tests led to the use of this insecticide in the 1961 experiment (schedules H and I). Both these Guthion spray schedules gave excellent seedworm control, 99 and 98 percent, respectively. DDT was included in the 1961 study (schedule J) because of its general effectiveness against many species of olethreutid moths, but gave only 13 percent control of the seedworm on second-year cones and was considered a failure.

## DISCUSSION AND RECOMMENDATIONS

One of the most interesting results of these studies was the low incidence of infestation by *Dioryctria* spp. in study trees during the last $3\frac{1}{2}$ months (June through mid-September) of cone development, even though no sprays were applied after June 1 in some of the spray schedules. This low rate of infestation was observed for 3 consecutive years, even though the three *Dioryctria* species in north Florida have multiple generations annually. On unsprayed trees, by contrast, new attacks, especially on second-year cones, continued through August. Some possible reasons for spray effectiveness are: (1) insecticide deposits may have had a long residual life; (2) early sprays may have reduced the *Dioryctria* population so drastically that population buildup within trees was negligible from June through mid-September; (3) migration of moths from unsprayed to sprayed trees may have been very low during the late summer; and (4) early-season control of *Dioryctria* may have reduced the attraction this insect or the infested host material had for moth populations on unsprayed trees.

The following insecticide formulations are recommended for the control of *Dioryctria* spp. on slash pine cones:

BHC (gamma isomer)--4 pounds of active toxicant per 100 gallons of water.

Guthion--1.5 pounds of active toxicant per 100 gallons of water.

Hydraulic sprays of either of the above formulations should be applied once during the following periods: March 15-31; May 1-15; June 1-15; and July 10-20. If the reduction of control costs is a primary consideration, the July spray application can be omitted with negligible loss in cone protection. There is little difference between the cost of BHC and Guthion when used according to the above recommendations.

Even though precise timing does not appear to be a critical factor in the control of *Dioryctria* spp. on slash pine, it is apparent that two or three spray applications during the period from March 1 through June 1 are necessary to prevent coneworm population buildup and cone attack from June through August. It should be reemphasized that the above spray recommendations are an attempt to control three species of *Dioryctria*. As more knowledge of the habits of each coneworm species is obtained, more precise spray timing may be found advisable; and it may be possible to reduce the total number of spray applications.

To control the slash pine seedworm, *L. anaranjada*, the Guthion formulation of 1.5 pounds of active toxicant per 100 gallons of water should be substituted for BHC during the early May application in the coneworm spray schedule above. The optimum time for a single application of Guthion for the control of the seedworm in northeast Florida is between May 5 and 15. Since the oviposition and egg-hatch of this moth near the northern limits of the range of slash pine probably occurs from 1 to 2 weeks later than in north Florida, spray applications should be correspondingly later.

Every safety precaution should be taken in the mixing and application of BHC and Guthion. The manufacturer's label on the handling and use of these insecticides should be read carefully. Proper respiratory devices, as described by Fulton *et al.* (1962), should be worn when working with these insecticides.

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