# SYSTEMIC TREATMENT WITH ACEPHATE FOR GYPSY MOTH MANAGEMENT: POPULATION SUPPRESSION AND WOUND RESPONSE[1]

by R.C. Reardon and R.E. Webb[2]

**Abstract.** Oaks were treated with acephate containing ACECAPs or Mauget Inject-A-Cide 0 units 1984 and/or 1985. In 1985, both twice-treated (treated in 1984 and 1985) and once-treated (treated only in 1985) oaks had significantly fewer gypsy moth egg masses per tree than did control trees, and twice-treated oaks had fewer than those treated only in 1984. Implantation/injection did more damage to white oak than to red oak group trees.

**Résumé**. Des chênes ont été traités avec de l'acéphate contenant des ACECAPs ou des unités de Inject-A-Cide O Mauget en 1984 et/ou 1985. En 1985, les deux groupes de chênes, ceux traités à deux reprises (traités en 1984 et 1985) et ceux traités à une reprise (traités en 1985 seulement), avaient significativement moins de masses d'oeufs de spongieuse par arbre que les arbres contrôles et les chênes traités à deux reprises en avaient encore moins que ceux traités seulement en 1984. L'implantation /injection était plus dommageable aux arbres du groupe des chênes blancs qu'à ceux du groupe des chênes rouges.

ACECAPS[R], a form of Medicap Systemic Implantation Cartridge (Creative Sales Inc., Fremont, NE 68025) that contain powdered technical acephate, an organophosphate insecticide, are used to protect foliage and reduce larval populations of western spruce budworm, *Choristoneura occidentalis* (4, 5, 6, 8); gypsy moth, *Lymantria dispar* (2, 13); and other foliage feeding insects (14). Residue analysis of oak, *Quercus rubra* and *Q. alba,* foliage sampled from trees treated with ACECAPS found that residue levels for both acephate and its more toxic metabolite, methamidophos, peaked 12 days after budburst, as did observed larval mortality in a parallel bioassay of the foliage (13).

Inject-A-Cide 0 units, a form of Mauget Injection Units (J.J. Mauget Co., Burbank, CA 91504) containing liquid acephate have proven effective in reducing larval populations of western spruce budworm and spruce coneworm, *Dioryctria reniculelloides,* (7) and gypsy moth (13).

The response of trees to wounding and wound closure has been studied for Medicaps (3, 14, 12), for fungicide injections (10), and for Maugets (11). Generally, the extent of the wound response depends on such factors as tree vigor, application procedures, and the pesticide used. The two wounding responses monitored in this study were discolored wood (9) and radial shakes (i.e. vertical split) (1). ACECAPS are registered by the U.S. Environmental Protection Agency for control of the gypsy moth. Inject-A-Cide 0 units are not currently registered for this use. This paper reports the results of studies with ACECAPS and Inject-A-Cide 0 units applied to oaks to determine if yearly applications are necessary for protecting foliage and reducing populations of gypsy moth and to evaluate tree wounding response.

## Methods and Materials

Population reduction and wound response studies were conducted in the Buchanan State Forest in southern Pennsylvania, and additional wound response data were taken from oaks as part of a previously published efficacy study conducted in Elk Neck State Forest in Cecil County, Maryland (13). At the Buchanan site in 1984, 46 oaks were randomly selected and treated as follows: 28 received ACECAP implants, 10 received Inject-A-Cide 0 units, and 8 were left as untreated controls. Fourteen of the 28 trees treated in 1984 with ACECAP implants, and 5 of the 10 trees that in 1984 had received Inject-A-Cide 0 units were randomly selected within a treatment area and retreated with their respective treatments in 1985. An additional 10 oaks were selected in 1985 and five each were randomly assigned to treatment with ACECAP implants or with Inject-A-Cide 0 units. All treatments were ap-

1. This paper does not recommend the pesticide uses reported, nor does it imply that they have been registered by the appropriate governmental agencies.
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plied when red oak leaf expansion reached 30% (i.e. 5-to-8 cm in length). At the Elk Neck site, 5 white oaks and 5 red oaks that received ACECAP implants in 1983 were retreated with ACECAP implants in 1984. An additional 15 white oaks and 15 red oaks received ACECAP implants in 1984.

The liquid formulation of acephate, as 35% Orthene (Chevron Chemical Company, Ortho Agricultural Chemicals Division, San Francisco, CA 94105), was injected into the xylem tissue using Mauget injection units. The procedure consisted of drilling a hole in the xylem, just beyond the cambium layer, and inserting a 10 cm long plastic feeder tube to which a pressurized plastic unit (3 × 4.5 cm) containing insecticide was attached (5). One unit containing 1.8 g AI (active ingredient) of acephate (Inject-A-Cide 0) was inserted per 15 cm of circumference. The Mauget injectors were removed after 5 days.

The powdered formulation of acephate, as 97% Orthene, was introduced directly into the xylem in Medicap plastic cartridges (1 × 3 cm) with 1.0 g AI of acephate implanted per 10 cm of trunk circumference so that the implant sites spiraled up and around the lower trunk beginning 15 cm above the ground. Each cartridge was inserted into a drilled hole and tapped so that the outer end of the cartridge was flush with the cambium layer. The treatments were made on April 24, 1984, and April 26, 1985 at the Elk Neck and Buchanan sites, respectively. The gypsy moth larvae were in the first instar and were feeding on the tree foliage. The implantation and injection sites for trees treated the second year were approximately 3 cm above and between those made for the previous year.

For all treatments, densities of gypsy moth egg masses were estimated using visual counts from treated and control trees one month prior to treatment and five months after treatment, with a sample of egg masses collected to determine the percentage of old and new. Defoliation was estimated when approximately 95% of the larvae had pupated, and was assessed by examining each tree and visually estimating the amount of foliage consumed. Each sample tree was placed into one of three defoliation classes: 1, 20% or less; 2, 21-50%; 3, 51% or more.

Observations concerning the response of trees to wounding were made 2 and 3 years after the implantation or injection using the oaks at the Buchanan and Elk Neck sites. Tree wounding response was determined by measuring the length of radial shakes in the bark originating from the site of each implant or injection using three classes: 1, less than 10 cm; 2, 10 cm - 1 m; 3, greater than 1 m. Also, the extent of callus development over the implant or injection wound as well as in some cases associated shakes in the phloem were determined as closed or open. Of those trees treated in 1985, four trees per treatment were cut and dissected, and the extent of discolored wood above and below the implantation/injection sites were recorded.

Egg mass data at the Buchanan site were split into three parts to facilitate statistical analysis and interpretation. The trees treated only in 1984 were compared together, those treated only in 1985 were compared together, and those treated in both years were compared together, all against the common controls. Data were converted using log transformation and analyzed (analysis of variance) using the General Linear Models Procedure for Split Plots (treatment as the main plot effect and year as the split plot effect), using a LSD ($P = 0.05$) procedure to separate the Least Squares Means (SAS Institute 1985). Data are reported as geometric means (antilog of the log means).

## Results

Egg mass data (pre-season 1984, post-season 1984, post-season 1985) for the Buchanan study are presented in Table 1. Egg mass numbers on the untreated control trees indicated that gypsy moth populations in the Buchanan area roughly doubled during the 1984 season, but fell to pre-1984 levels by the end of the 1985 season, although differences over time were not statistically different. For trees treated only in 1984, pre-season 1984 mean egg mass densities were not significant, but treatment effects were significant for post-season 1984 mean egg mass densities and nonsignificant for post-season 1985 mean egg mass densities. This is reflected by the geometric means presented in Table 1A. Mean egg mass numbers on the trees receiving the three treatment regimens (ACECAPs, Inject-

A-Cide 0 Units, untreated controls) were similar among the treatments at the beginning of the study. Means decreased from 26.2 to 12.9 on trees receiving the ACECAPs. Inject-A-Cide 0 tree means dropped from 28.5 to 11.0. Mean egg mass levels on untreated trees rose from 22.3 to 51.9. While mean egg mass counts continued to drop on treatment trees during the 1985 season, a sharper drop occurred on control trees that season, indicating that much of the reduction on treated trees in 1985 was due to seasonal effects rather than a carry over of the 1984 treatments.

**Table 1. Densities of gypsy moth egg masses (geometric mean of egg masses + 1) on oak trees treated in 1984, 1985, or in both years with ACECAPs or Inject-A-Cide 0 units, Buchanan State Forest, Pennsylvania.**

| *Treatment* | *N* | *Pre-1984* | *Post-1984* | *Post-1985* |
|---|---|---|---|---|
| | | *Gypsy moth egg masses per tree* | | |
| **1A (Treated in 1984)**[1] | | | | |
| ACECAP | 14 | 26.2abc | 12.9bcd | 7.6d |
| Mauget | 5 | 28.5ab | 11.0bcd | 10.2cd |
| Control | 8 | 22.3abc | 51.9a | 25.1abc |
| **1B (Treated in 1984 and in 1985)**[1] | | | | |
| ACECAP | 14 | 36.1ab | 15.7bcd | 5.7d |
| Mauget | 5 | 16.8abcd | 8.2cd | 1.6e |
| Control | 8 | 22.3abc | 51.9a | 25.1abc |
| **1C (Treated in 1985)**[1] | | | | |
| ACECAP | 6 | | 65.2ab | 10.2c |
| Mauget | 5 | | 92.3a | 12.2c |
| Control | 8 | | 51.9ab | 25.1bc |

[1]Means with the same letter in the same column or in the same row are not significant (P = .05, comparison-wise error rate; LSD test).

For tree treated in both 1984 and 1985, preseason 1984 mean egg mass densities were nonsignificant but treatment effects were significant for post-season 1984 mean egg mass densities and for post-season 1985 mean egg mass densities. Egg mass densities fell on both the ACECAP-treated trees and Inject-A-Cide 0-treated trees (Table 1B). This decline continued during the 1985 season.

For trees treated only in 1985, mean egg mass densities fell dramatically during the 1985 season for those treated with ACECAPs or with Inject-A-Cide 0 units (Table 1C). However, the general decline seen on control trees obscured the treatment effects so that both post-1984 and post-1985 treatment effects for mean egg mass densities were nonsignificant for these trees.

Egg mass reductions indicate that introduction of acephate using either ACECAPs or Inject-A-Cide 0 units resulted in fewer egg masses during the year of application. Numbers were increased due to conditions favorable for gypsy moth during the 1984 season and decreased due to less favorable conditions in 1985. Specifically, there was an equal and significant decline in egg mass numbers on trees treated in 1984 with either

**Table 2. Gypsy moth defolation as percent of oaks treated in 1984, 1985, or in both years with ACECAPS or Inject-A-Cide 0 units, Buchanan State Forest, Pennsylvania.**

| *Treatment* | *N* | *1* | *2* | *3* | *1* | *2* | *3* |
|---|---|---|---|---|---|---|---|
| | | *Percent of trees in defoliation class*[1/] | | | | | |
| | | | *Post-1984* | | | *Post-1985* | |
| **1A (Treated in 1984)** | | | | | | | |
| ACECAP | 14 | 35 | 65 | 0 | 100 | 0 | 0 |
| Mauget | 5 | 40 | 60 | 0 | 100 | 0 | 0 |
| Control | 8 | 12 | 76 | 12 | 87 | 13 | 0 |
| **1B (Treated in 1984 and 1985)** | | | | | | | |
| ACECAP | 14 | 50 | 50 | 0 | 100 | 0 | 0 |
| Mauget | 5 | 60 | 40 | 0 | 100 | 0 | 0 |
| Control | 8 | 12 | 76 | 12 | 87 | 13 | 0 |
| **1C (Treated in 1985)** | | | | | | | |
| ACECAP | 6 | | | | 100 | 0 | 0 |
| Mauget | 5 | | | | 100 | 0 | 0 |
| Control | 8 | | | | 87 | 13 | 0 |

[1/]Class 1 trees had 0-20% defoliation, Class 2 trees had 21-50% defoliation, Class 3 trees had 51-100% defoliation.

ACECAPs or with Inject-A-Cide 0 units, compared with a significant rise in egg mass numbers on control trees. The continued decline recorded in 1985 for trees treated only in 1984 (both materials) was consistent with the overall decline in egg mass numbers seen on control trees during the 1985 season. The steeper decline seen on trees treated again in 1985, or only in 1985, was due to a combination of treatment effects and seasonal effects observed on control trees. The use of acephate in Medicaps gave equivalent results to its use in Mauget injection units.

There was less defoliation on treated trees than controls in 1984 at the Buchanan study site (Table 2). Defoliation of the control trees decreased in 1985 indicating a decline in gypsy moth populations. Post-season 1985 treatment effects were not significant for defoliation.

There were no differences in extent of wounding response among treatments (Table 3). Large shakes (class 3) were only recorded for trees treated with Inject-A-Cide 0 Units. White oaks produced larger shakes and fewer closed wounds than red oaks. Even though most of the white oaks with class 3 shakes were located in one area, we were unable to identify an associated causal factor (e.g., frost pocket). For oaks cut and dissected, discolored wood was associated with every implantation and injection site. White oak had larger discolored areas than red oak group. There was a large variation in the extent of discolored wood, radial shakes, and callus formation within a species. Three years following treatment, approximately 95% of wounds had callus formation and the trees did not appear (external observation) stressed.

## Discussion

Post-1985 population densities of gypsy moth on oaks treated in 1984, regardless of whether

**Table 3. Extent of wounding response on oaks treated once or treated twice with ACECAPS and Inject-A-Cide 0 Units, Buchanan State Forest, Pennsylvania and Elk Neck State Forest, Maryland.**

| *Treatment* | *no.* | *Tree species* | *Total no. implant/inject sites* | *Wound response (Percent of implant/inject) sites* Classes* 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | closed | open | closed | open | closed | open |
| **Elk Neck State Forest** | | | | | | | | | |
| Treated ACECAPs 1983 | 5 | *Q. rubra* | 51 | 78 | 10 | 4 | 8 | 0 | 0 |
| | 5 | *Q. alba* | 67 | 10 | 9 | 51 | 30 | 0 | 0 |
| Twice-treated ACECAPs (1983 and 1984) | 5 | *Q. rubra* | 51 | 82 | 12 | 2 | 4 | 0 | 0 |
| | 5 | *Q. alba* | 67 | 25 | 15 | 39 | 21 | 0 | 0 |
| Treated ACECAPs 1984 | 15 | *Q. rubra* | 214 | 80 | 6 | 6 | 7 | 0 | 0 |
| | 15 | *Q. alba* | 185 | 32 | 9 | 23 | 36 | 0 | 0 |
| **Buchanan State Forest** | | | | | | | | | |
| Treated ACECAPs (1984 or 1985) | 13 | *Q. alba* | 156 | 32 | 19 | 49 | 0 | 0 | 0 |
| | 7 | *Q. rubra* | 70 | 100 | 0 | 0 | 0 | 0 | 0 |
| Twice-treated ACECAPs (1984 and 1985) | 10 | *Q. alba* | 114 | 18 | 31 | 9 | 42 | 0 | 0 |
| | 4 | *Q. rubra* | 38 | 76 | 0 | 24 | 0 | 0 | 0 |
| Treated Inject-A-Cide 0 (1984 or 1985) | 10 | *Q. alba* | 106 | 10 | 10 | 50 | 0 | 30 | 0 |
| Twice-treated Inject-A-Cide 0 (1984 and 1985) | 2 | *Q. rubra* | 22 | 50 | 0 | 50 | 0 | 0 | 0 |
| | 3 | *Q. alba* | 29 | 0 | 0 | 34 | 0 | 66 | 0 |

*Classes of shakes 1 = less than 10 cm, 2 = 10 cm-1m and 3 = more than 1M they were treated again in 1985, were lower than those on control trees. These lower densities were probably attributed to initial population reduction in 1984, lack of significant tree to tree movement, and extensive over-wintering mortality of gypsy moth egg masses in many areas of southern Pennsylvania as evidenced by an overall decline in gypsy moth populations as indicated by the control tree data. Although residue levels of acephate and methamidophos persist in fir needles for longer than one year (4), it is unlikely that $LC_{50}$ levels would be found in foliage for a second year in a deciduous species such as oak.

A tree responds to wounds in two ways: first, by walling in injured areas (compartmentalization); then, by wound closure (production, differentiation, and maturation of callus). Even though the extent of wounding varies greatly, implantation or injection holes should be small, shallow, clean-edged, and as few as possible. Two consecutive yearly applications of ACECAPs or Mauget Inject-A-Cide 0 units further reduced the density of gypsy moth egg masses. Moreover, if neighboring untreated trees are heavily infested with gypsy moth egg masses, a second consecutive application would be justified. However, the response of white oak to the implantation or injection process is more severe with regard to discolored xylem tissue than that for red oak or black oak. Also, with many white oaks, wounding produces the development of extreme radial shakes in the phloem tissue which can extend up to four m above the specific implantation/injection site.

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