Western Gulf Forest Pest Management Cooperative

Report on
Research Accomplishments in 2003

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2003 WGFPMC Members:

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Texas Forest Service
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Table of Contents

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Executive Summary

The Western Gulf Forest Pest Management Cooperative (WGFPMC) made significant strides in 2003. A brief summary of WGFPMC activities is given below. Two primary research projects (systemic injection studies and tip moth impact/hazard/control) were continued from 2002. Eight smaller studies were initiated and/or completed. Separate detailed reports for each study are attached. The purpose of this report is to provide executive committee members with an update on research findings and a basis for evaluating the merits of the attached 2004 Project Proposals.

Membership in the WGFPMC changed for the better in 2003. We welcomed Forest Investment Associates as our newest member. Fortunately, we did not lose any members.

Seasonal technicians Jamie Burns, Joanne Murphy, Valena Bryan, Brian Pope and Billy Whitworth were hired to provide assistance with field and lab studies. We appreciate the assistance Allen Smith, Southern Pine Beetle Prevention Specialist, provided with cone evaluations and GPS/GIS work.

Service to members continues to be an important part of the WGFPMC. To this end, three issues of the *PEST* newsletter were prepared and distributed. Also, 7 presentations, 12 meeting requests, and 86 phone/e-mail requests were addressed relating to the following topics: leaf-cutting ants/Volcano®, pine tip moth, reproduction weevils, bark beetles (southern pine beetle, *Ips* and black turpentine beetle), cone and seed insects (coneworms and seed bugs), spider mites, phylloxeran (aphids) and cutworms.

Given that Volcano® leafcutter ant bait is expected to be phased out in 5 - 8 years, trials were conducted in 2001 to evaluate the effectiveness of another citrus pulp bait containing the active ingredient fipronil (Blitz®, produced by Aventis). As a result of these trials, a registration package was submitted to the Environmental Protection Agency (EPA) to register this formulation in the U.S. under the new product name "BES 100." The new formulation awaits final EPA approval. In the mean time, a small study was initiated in 2003 to evaluate the effectiveness a product similar to the old Amdro® leaf-cutting ant bait called Grant's Kills Ants™ Total Ant Killer Bait.

Rainfall was near normal (46+ inches in Lufkin) for the third straight year in the Western Gulf region. The annual drought period was early in 2003, with little rain falling from March through May, particularly in southeast Texas. The 2002 outbreak of forest tent caterpillar in river bottoms of southeast Texas and Louisiana declined to generally low levels in 2003. However, populations of red oak borer in central and northern Arkansas are still very abundant. On the positive side, pine tip moth populations continued to occur at relatively low levels in 2003 compared to previous years and no infestations of the southern pine beetle (SPB) were reported in Texas, Louisiana, Arkansas or Oklahoma in 2003. However, 50 – 60 SPB infestations were reported to have developed on state and national forests in Mississippi.

Progress continues on the evaluation and development of systemic insecticides and injection systems. For the fifth year in a row, trees injected a single time in 1999 with emamectin benzoate alone or combined with thiamethoxam had significantly reduced levels of coneworm damage. A second manuscript tentatively entitled "Systemic insecticide injections for control of cone and seed insects in loblolly pine seed orchards – 5 year results" is in preparation. A second study, initiated in 2001, was continued to determine the duration of different application rates for emamectin benzoate and thiamethoxam. The higher rate treatments continued to provide good protection against coneworm. A third study was established in April 2003 to evaluate the Denim® formulation of emamectin benzoate and two formulations of fipronil using three different injection systems. Drought conditions in April and May appeared to have reduced the movement of these chemicals. Pest control for the first year was good, but was lower compared to the same period during the Duration and Rate studies.

The tip moth project, established in 2001 to evaluate the true impact of pine tip moth on the growth of loblolly pine and identify site characteristics that influence the occurrence and severity of pine tip moth infestations, was further expanded in 2003. Thirty-two impact plots on 19 sites are now established in the Western Gulf Region. Results again indicate that multiple applications of Mimic® significantly reduced infestation levels of pine tip moth compared to untreated trees during each of five moth generations. Tip moth populations were somewhat higher one first-year sites compared to 2002. This resulted in a significant impact on the growth of unprotected trees. In contrast, Mimic® provided only moderate protection on second-year sites, resulting in no significant gains in tree growth. An additional 20 hazard-rating plots were established in 2003, bringing the total to 61. The development of a hazard-rating model is on going. Mr. Andy Burrow, Temple-Inland, will take over the development of the model. Systemic insecticide trials revealed that fipronil continued to reduce tip moth damage for two growing seasons (10 moth generations). Additional fipronil trials conducted in 2003 to evaluate application techniques and rates showed that root soaks and dips and plant hole treatments at high rates were highly effective in reducing tip moth damage. Operational planting trials on four sites showed that plantation areas containing fipronil-treated seedlings had less tip moth damage and improved tree growth compared to untreated areas. The WGFPMC had assisted in two tip moth studies 2002; one to validate spray timing dates for sites in Texas, Louisiana and Arkansas and the other to evaluate the use of pheromone trap catches to predict subsequent tip moth damage. Both studies have resulted in publications (see attached).

The "Forestry Pesticides" web page (http://tfsfrd.tamu.edu/pest/ASP/pesticide_intro.htm) was unveiled on the TFS web site in October 2002. Nearly all known forestry-related pesticides (insecticides, herbicides and fungicides) were cross-referenced with pest and site uses, resulting in over 500,000 pest cases. We are continuing to update the database on regular basis.

2003 Leaf-cutting Ant Trials

Highlights:

- A registration package was submitted to EPA in 2002 to register the Blitz® formulation in the U. S. under the new product name "BES 100." EPA has yet to approve the registration.

- A 'new' ant bait, Grant's Kills Ants® Total Ant Killer Bait, was registered in TX and LA in late 2003. A small trial was initiated in December to evaluate its efficacy against the Texas leaf-cutting ant.

Justification: The Amdro® leaf-cutting ant bait was marketed by American Cyanimid in the late 1980's to mid 1990's. The bait contained the active ingredient hydramethylnon and an oil on a corn grit carrier. The bait was taken off the market around 1997, due to low sales as a result of dissatisfaction with the bait's performance. Grant Laboratories, CA, has recently acquired the rights to the 'old' Amdro leaf-cutting ant bait. They are now marketing this same bait under the name 'Grant's Kills Ants® Total Ant Killer Bait'. This bait was approved for registration in TX in November 2003.

Objective: Reevaluate the efficacy of the hydramethylnon/corn grit bait formulation (Grant's Kills Ants® Total Ant Killer Bait) in reducing activity in Texas leaf-cutting ant colonies.

Study Sites: Active colonies (13) were located in east Texas on lands owned by Texas Forest Service, Temple-Inland and private landowners.

Insecticide:

Hydramethylnon – slow-acting poison on a corn grit carrier.

Grant's Kills Ants® Total Ant Killer Bait - concentration (0.88% a.i.); corn grit and soybean oil; packing (tight); color (yellow); size (< 1mm to 4 mm).

Research Approach:

Application rates were based on the label recommendation of ¾ lb per colony. A cyclone spreader was used to evenly spread measured amounts of hydramethylnon bait over the central nest area (CNA).

Bait - Loose bait spread evenly over entire CNA at ¾ lb per colony in December 2003 and February 2004.

Check - untreated colonies

Application Dates:

Early Winter 2003: Treatments applied in December.

Late Winter 2004: Treatments applied in February.

Data Collection: The number of active entrance/exit mounds was counted prior to treatment and periodically following treatment at 2, 8, and 16 weeks. Two or more untreated colonies were included as checks and monitored in winter treatments to account for possible seasonal changes in ant activity. For each colony, the percent of initial activity was/will be calculated as the current number of active mounds at each post-treatment check (X 100) divided by the initial number of active mounds.

Results (so far):

Efficacy Trial: - Colonies treated in December 2003 were not rechecked until 8 weeks post-treatment (Table 1). The activity of all colonies, treated and untreated, in early February 2004 was essential unchanged compared to pretreatment levels.

Table 1. Efficacy of hydramethylnon (Grant's Killer Ant® Total Ant Killer Bait) applied by spreader to control the Texas leaf-cutting ant (*Atta texana*) in east Texas (Winter 2003-2004).

Treatment	Period Colonies Treated	No. of Colonies Treated	Mean Nest Area (ft^2)	Mean # Mounds @ Trt.	Mean % initial activity [a] (% inactive colonies): 2 wk	8 wk	16 wk
Grants Total Ant Killer Bait spread 3/4 lb over CNA	15-Dec	3	494	95		74.7 **a** (0)	
	20 - 26 Feb	5	333	87			
Check (no treatment)	15-Dec	2	525	102		80.3 a (0)	
	2/20 - 2/26	3	264	90			
Total		13					

CNA = Central Nest Area

[a] Means followed by the same letter within each column are not significantly different at the 5% level (Fisher's Protected LSD).

Summary: If the Grant's bait was effective against leaf-cutting ants, we should have observed little or no activity 8 weeks after treatment. However, all treated colonies were very active after 8 weeks.

Evaluations conducted by the WGFPMC in 1996 on Amdro® leaf-cutting ant bait revealed that two factors were likely responsible for the poor bait performance.

1) Storage length/temperature. Baits stored for longer than 3 months after opening and/or stored at high temperatures (>90°F) have a tendency to go stale or turn rancid. Rancid bait is unattractive to the ants.
2) Bait particle size. The bait was originally developed for fire ants – a much smaller ant compared to leaf-cutting ants. Most leaf-cutting ant foragers will pick up particles greater than 2 mm in diameter. However, more than 50% of the Amdro® bait particles are less than 2 mm in diameter; such small particles are likely to be 'lost' to the ants when spread over the central nest area.

It seems unlikely that storage length and/or high temperatures are to blame for the recent bait failure as the bait was reported to be 'fresh'. More likely, the bait particle size is generally too small to be attractive to leaf-cutting ants.

The future availability of Volcano® is limited due to the persistence of sulfluramid in the environment (e.g., chemicals related to sulfluramid have been found in the blood of factory workers). EPA and Griffin L.L.C. reached an agreement in 2001 to halt production of technical sulfluramid. Griffin will be permitted to produce and sell Volcano® until their supply of technical sulfluramid has been utilized. In 2001, Griffin estimates that Volcano® should be available for the next 7 - 10 years before phase out in 2008 - 2011. Another provision of the EPA/Griffin agreement was that the use language would be changed from "Pine Forest Sites" to "Pine Reforestation Sites - within and immediately surrounding the site." This new use language restricts application to ant colonies in harvested areas being replanted in pine and includes areas directly adjacent to these sites.

In early 2002, Bayer CropScience (previously Aventis) submitted a registration package to the Environmental Protection Agency (EPA) to register the Blitz® formulation in the U.S. under the new product name "BES 100." The site uses are to be expanded to include all pertinent sites except pastures and within citrus orchards. The sale and use of the BES-100 bait is to be restricted to licensed applicators. After nearly two years, EPA has yet to approve the registration of BES-100. In early February 2004, I was informed by Mr. Adrian Krygsman, (Bayer registration manager for BES-100) that the original EPA product manager overseeing the registration process for BES-100 had been replaced. Mr. Krygsman expects to see some renewed activity by EPA toward BES-100. The WGFPMC submitted a letter of support for the BES-100 registration to Mr. Richard Gebken, EPA, in mid-February of 2004. We hope to hear something from EPA in the next month or two.

1999-2003 Systemic Insecticide Duration Study - Magnolia Springs, TX

Highlights:

- Single and double Systemic Tree Injection Tube (STIT) injections of treatments containing emamectin benzoate continued to reduce coneworm damage by 63 - 74% in 2003 – 5 years after initial injection.
- STIT injection treatments containing emamectin benzoate or thiamethoxam did not significantly reduce seed bug damage or improve filled seed yield in 2003 – 42 months post treatment. Control of seed bugs will require yearly injections.

Objectives: 1) Continue evaluations on the residual activity of emamectin benzoate and emamectin benzoate/thiamethoxam mixture, applied by the STIT injector in 1999 and 2000 for control of coneworms and seed bugs in loblolly pine seed orchards.

Study Site: 20 acre "082" orchard (drought-hardy loblolly pine) removed from production in 1995 -- Texas Forest Service Magnolia Springs Seed Orchard, Jasper Co., TX.

Insecticides:

Emamectin benzoate (Arise SL®) -- avermectin derivative

Thiamethoxam (Novartis 293) -- experimental insecticide formulation with similar activity compared to imidacloprid.

Design: Randomized complete block with clones as blocks. 10 treatments X 10 clones reduced in 2003 to 5 treatments X 10 clones (= 50 ramets).

Application Methods:

STIT Injection – In 1999 and 2000, a 6mm (3/8 in) diameter hole, 11 cm (4.5 in) deep was drilled parallel to the ground; number of holes was equal to the volume of insecticide solution to be applied divided by 50 ml (the capacity of each injector); holes were placed at a height of 1 m. -- the prefilled STIT injector (Helson et al. 2001) was hammered into the drill hole, and pressurized to 50 psi. Most treatment solutions drained within 15 minutes. The volume of insecticide solution applied was based on the diameter of each treatment tree as follows:

Tree	Treatments	
Diameter	1 and 2	3 and 4
<15 cm	20 ml	40 ml combined
16 - 20 cm	20 - 40 ml	40 - 80 ml
21 - 25 cm	40 - 60 ml	80 - 120 ml
26 - 30 cm	60 - 80 ml	120 - 160 ml
>30 cm	+20 ml/5 cm dia. increment	+40 ml/5 cm dia. increment

Treatments:

1) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999) (N = 10)
2) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999 & April 2000) (N = 10)
3) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999) (N = 10)
4) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999 & April 2000) (N = 10)
5) Check (untreated) (N = 10)

Data Collection:

***Dioryctria* Attacks** -- All cones in study trees that could be reached by bucket truck were picked in early October; cones were categorized as small dead, large dead, green infested, with other insect or disease damage, or healthy.

Seed Bug Damage -- 10 healthy cones were picked "at random" from all healthy cones collected from each ramet; seed lots were radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Conelet and Cone Survival: Data was not collected in 2003.

Results: The orchard block containing the treatment trees had not been sprayed since 1995, suggesting that pressure from coneworms and seed bugs would be moderate to high. This was confirmed for coneworms by over 27% damage on check cones in 2003, relatively close to the high damage levels (34% and 32%) observed in 2001 and 2002, respectively (Table 2). Lower numbers of seed bugs were observed in the trees in 2003. This was confirmed by the 23% damage by seed bugs to seed from check trees (Table 3), compared to 31% in 2002. Seedworm damage to seed from check trees was considered insignificant (1% or less in 2003), so the data were not included in the analysis.

Treatment Effect on Coneworm Damage: In 1999 and 2000, treatments containing emamectin benzoate (alone or combined with thiamethoxam) significantly reduced early and late coneworm damage compared to the check (Table 2). Overall reductions for both emamectin benzoate alone and emamectin benzoate plus thiamethoxam treatments were >96% compared to the check. Overall reductions declined somewhat in 2001 (range 84% to 91%) and further in 2002 (range 45 to 58%) (Fig. 1). However, the treatment effects improved in 2003; reduction in coneworm damage ranged from 63% to 74%. The addition of thiamethoxam did not improve or reduce the performance of emamectin benzoate against coneworm. Results for two-injection treatments containing emamectin benzoate did not differ significantly from single-injection treatments. Therefore, a single injection of emamectin benzoate is sufficient to protect trees against coneworm for five full years. Only the double dose of emamectin benzoate plus thiamethoxam saw significantly higher proportions of healthy cones compared to the check, but this treatment did not differ from the other injection treatments. Overall, the five-year average for coneworm damage reduction ranges from 74% to 80% (Fig. 1).

Treatment Effect on Seed Bug Damage: In 2003, seed bug damage levels (23%) were lower in check cones compared to levels in 1999 (53%), 2000 (24%), 2001 (33%) and 2002 (32%) (Table 3, Fig. 2). In contrast to the previous four years, damage levels early in the growing season were generally similar to those later in the year. This, along with the lower overall damage levels, indicates that shieldbacked pine seed bug populations had fallen off to levels near those of leaffooted pine seed bug. None of the treatments significantly reduced early and late seed bug damage or increased the number of full seeds per cone compared to the check. This indicates that yearly treatments of thiamethoxam are necessary to maintain adequate protection against seed bugs.

Treatment Effect on Overall Insect Damage: An estimate of the combined losses due to coneworms and seed bugs was calculated. In this study, it is conservatively estimated that coneworms and seed bugs in combination reduced the potential seed crops of check trees in 2003 by 43%; compared to 41% in 1999, 29% in 2000 and 51% in both 2001 and 2002 (Table 4, Fig. 3). One treatment continues to stand out with regard to its ability to reduce overall insect damage: emamectin benzoate + thiamethoxam. Two injections of this treatment in 2000 continued to reduce overall insect damage by 39% in 2003.

Summary: Over the past five years, emamectin benzoate has exhibited excellent protection against coneworms, but has not been as effective against seed bugs. The data suggest that a single injection of emamectin benzoate can protect trees against coneworm for 60 months or longer. A second injection is not necessary during the second growing season to improve efficacy. The Arise SL® formulation of emamectin benzoate is reported to be highly effective (providing 3+ years of protection) in Japan against the pinewood nematode, *Bursaphelenchus xylophilus*, and its cerambycid vector, *Monochamus alternatus* (Dr. David Cox, Syngenta, personal communication). The maximum duration of this chemical's residual activity against cone and seed insects has yet to be determined.

In contrast, thiamethoxam provided good protection against seed bugs during the year of injection, but generally showed little or inconsistent effects against coneworms. Thiamethoxam did provided some extended protection (18 mo.), but not as extensive as was found for emamectin benzoate against coneworms. Protection improved significantly with a second injection of thiamethoxam. An additional study was initiated in 2001 to determine optimal application rates of emamectin benzoate and thiamethoxam.

Individual tree injections in seed orchards offer several advantages. Control efforts can be allocated to clones on the basis of inherent susceptibility to insect attacks, genetic worth, and high potential for seed production, as suggested by DeBarr (1971). With these criteria, only 10 – 25% of the ramets in an orchard might need to be protected with insecticides. In turn, the pesticide load (amount of pesticide per acre) produced by conventional application techniques could be substantially reduced. Potential environmental concerns from insecticides in runoff water could be virtually eliminated because insecticides would be contained in the tree. Specific situations where systemic injections may be particularly useful include protecting seeds on trees with control pollinated crosses, protecting selected ramets of genetically-valued clones in early-generation orchards after emphasis shifts to newer orchards, and providing insect control in orchards located in environmentally sensitive sites where conventional air and ground sprays may be hazardous.

Syngenta Crop Protection recently registered emamectin benzoate (Proclaim®, Denim®) and thiamethoxam (Actera®) with EPA in the United States. However, the small seed orchard market and the flammability of the product carrier has discouraged Syngenta from pursuing registration of the Arise® (emamectin benzoate) formulation in this country. A preliminary trial conducted in 2002 indicated that the Denim® formulation can be injected into loblolly pine using the STIT injector. However, the rate of injection of Denim® was slower (50 ml in 15 minutes) compared to the Arise® formulation (50 ml in 4 minutes). An injection study was initiated in 2003 to test the efficacy of the Denim® formulation for control of cone and seed insects.

An attempt is being made to expand the forestry market of emamectin benzoate through trials with other tree and pest species. For example, emamectin benzoate injected into several species of hardwood was nearly as effective as imidacloprid in causing mortality to larvae of the Asian longhorned beetle (Therese Poland, USFS, personal communication). In another trial, emamectin benzoate was injected into two white pine trees near Blackburg, VA in early August 2002. Twigs, taken from these injected trees two weeks later, were presented to male and female pales weevils, *Hylobius pales*, in petri dishes. Feeding activity was considerably reduced compared to untreated twigs and 100% mortality of both weevil sexes occurred within two weeks after exposure to treated twigs (Jeff Fidgeon, Virginia Tech, unpublished data). Emamectin benzoate also was found in field trials to be highly effective against forest tent caterpillar in Kentucky (Dr. Dave Cox, Syngenta, personal communication). A list of potential markets for emamectin benzoate has been submitted to Syngenta (see Supplement B)

The STIT injector, developed by Dr. Blair Helson (Helson et al. 200), has been successfully used to inject 50 ml of insecticide into loblolly pine. However, the system has several limitations. The STIT injector is not manufactured (at this time), so considerable effort is required to make and maintain functional injectors. The effort and time required to load and clean each injector is considerable. Two manufactured injection systems are currently available – the Arborjet™ and Sidewinder™ systems. Characteristics of the three systems (STIT, Arborjet™ and Sidewinder™) were compared while conducting the Denim® trial (see Supplement A).

References:

DeBarr, G.L. 1971. The value of insect control in seed orchards: some economic and biological considerations. p. 178-185 *in* Proc., 11th Southern Forest Tree Improv. Conf., Atlanta, GA.

Helson, B.V., D.B. Lyons, K.V. Wanner, and T.A. Scarr. 2001. Control of conifer defoliators with neem-based systemic bioinsecticides using a novel injection device. Can. Entomol. 133: 729-744.

Table 2. Mean percentages (± SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with systemic injections of emamectin benzoate (EB) or emamectin benzoate + thiamethoxam (EB + Thia.), Magnolia Springs Seed Orchard, Jasper Co., TX, 1999 - 2003.

				Mean Coneworm Damage (%)				
Year	Treatment	Application Technique, Treatment Date(s)	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
1999	EB	STIT - Apr., '99	20	1.0 ± 0.3 **a**†	0.3 ± 0.1 **a**	1.3 ± 0.4 **a**	41.3 ± 4.4 **a**	57.4 ± 4.5 **b**
	EB + Thia.	STIT - Apr., '99	20	3.3 ± 0.6 **b**	0.9 ± 0.2 **a**	4.2 ± 0.8 **b**	42.5 ± 3.2 **a**	53.3 ± 3.2 **b**
	Check		10	12.0 ± 1.7 **d**	9.4 ± 2.8 **c**	21.4 ± 3.8 **d**	41.1 ± 2.7 **a**	37.6 ± 3.8 **a**
2000	EB	STIT - Apr., '99	10	0.1 ± 0.1 **a**	0.5 ± 0.3 **a**	0.6 ± 0.3 **a**	47.0 ± 7.7 **a**	52.4 ± 7.8 **a**
	EB	STIT - Apr., '99 & '00	10	0.4 + 0.3 **a**	0.1 ± 0.1 **a**	0.5 ± 0.3 **a**	60.1 ± 5.9 **a**	39.4 ± 5.9 **a**
	EB + Thia.	STIT - Apr., '99	10	0.2 ± 0.1 **a**	0.5 ± 0.4 **a**	0.7 ± 0.5 **a**	51.6 ± 6.1 **a**	47.8 ± 6.2 **a**
	EB + Thia.	STIT - Apr., '99 & '00	10	0.5 ± 0.3 **a**	0.4 ± 0.2 **a**	0.8 ± 0.3 **a**	55.1 ± 7.2 **a**	44.6 ± 7.3 **a**
	Check		10	4.0 ± 0.9 **b**	17.1 ± 4.2 **b**	21.1 ± 4.3 **b**	51.3 ± 3.6 **a**	27.6 ± 5.0 **a**
2001	EB	STIT - Apr., '99	6	3.3 ± 1.0 **a**	1.8 ± 0.9 **a**	5.0 ± 1.3 **a**	27.1 ± 8.4 **a**	67.8 ± 9.4 **b**
	EB	STIT - Apr., '99 & '00	6	4.3 ± 1.0 **a**	1.1 ± 0.4 **a**	5.4 ± 1.1 **a**	30.7 ± 8.2 **a**	63.9 ± 9.0 **b**
	EB + Thia.	STIT - Apr., '99	6	3.1 ± 1.3 **a**	1.3 ± 0.4 **a**	4.4 ± 1.4 **a**	28.8 ± 7.6 **a**	66.7 ± 8.6 **b**
	EB + Thia.	STIT - Apr., '99 & '00	5	2.8 ± 2.0 **a**	0.3 ± 0.2 **a**	3.1 ± 2.1 **a**	28.3 ± 5.2 **a**	71.4 ± 5.4 **b**
	Check		6	14.9 ± 2.2 **b**	19.2 ± 3.6 **b**	34.2 ± 3.3 **b**	17.3 ± 3.6 **a**	48.5 ± 5.1 **a**
2002	EB	STIT - Apr., '99	10	6.8 ± 1.6 **a**	8.6 ± 1.2 **ab**	15.4 ± 2.5 **a**	10.7 ± 4.3 **a**	74.0 ± 6.2 **ab**
	EB	STIT - Apr., '99 & '00	10	7.4 ± 2.5 **a**	7.1 ± 1.8 **a**	14.5 ± 3.6 **a**	7.8 ± 3.4 **a**	77.7 ± 5.9 **b**
	EB + Thia.	STIT - Apr., '99	9	6.3 ± 1.1 **a**	11.3 ± 2.1 **ab**	17.6 ± 2.6 **a**	12.9 ± 4.9 **a**	69.5 ± 7.1 **ab**
	EB + Thia.	STIT - Apr., '99 & '00	9	5.3 ± 0.7 **a**	8.1 ± 1.4 **ab**	13.5 ± 1.6 **a**	12.5 ± 3.2 **a**	74.0 ± 3.9 **ab**
	Check		10	20.0 ± 3.6 **b**	12.2 ± 1.9 **b**	32.2 ± 4.4 **b**	8.6 ± 2.7 **a**	59.2 ± 4.0 **a**
2003	EB	STIT - Apr., '99	10	5.2 ± 0.9 **a**	1.8 ± 0.6 **a**	7.0 ± 1.0 **a**	13.7 ± 4.6 **a**	79.3 ± 4.9 **ab**
	EB	STIT - Apr., '99 & '00	10	7.0 ± 2.7 **a**	1.5 ± 0.5 **a**	8.5 ± 2.7 **a**	14.0 ± 3.7 **a**	77.4 ± 5.2 **ab**
	EB + Thia.	STIT - Apr., '99	9	6.0 ± 3.0 **a**	4.1 ± 1.6 **a**	10.1 ± 3.0 **a**	14.1 ± 5.3 **a**	75.8 ± 7.6 **ab**
	EB + Thia.	STIT - Apr., '99 & '00	10	6.1 ± 2.2 **a**	1.5 ± 0.7 **a**	7.5 ± 2.7 **a**	11.8 ± 3.5 **a**	80.6 ± 5.4 **b**
	Check		10	16.3 ± 2.2 **b**	10.9 ± 3.4 **b**	27.2 ± 3.6 **b**	7.9 ± 1.9 **a**	64.9 ± 4.5 **a**

* Mortality or wounds caused by drought, pitch canker, squirrel, midge, or mechanical damage.

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 3. Seed bug damage, seed extracted, and seed quality (Mean ± SE) from second-year cones of loblolly pine protected with systemic injections of emamectin benzoate (EB) or emamectin benzoate + thiamethoxam (EB + Thia.), Magnolia Springs Seed Orchard, Jasper Co., TX, 1999 - 2003.

Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Seed Bug Damage (%): Early (2nd Yr Abort)	Mean Seed Bug Damage (%): Late	Mean Seed Bug Damage (%): Total	Mean No. Seeds per Cone	Mean No. Filled Seed per Cone	Mean No. Empty Seed per Cone
1999	EB	STIT - Apr., '99	20	0.7 ± 0.2 **b***	34.4 ± 3.7 **c**	35.1 ± 3.8 **c**	66.4 ± 7.0 **a**	32.1 ± 6.5 **ab**	13.3 ± 2.4 **a**
	EB + Thia.	STIT - Apr., '99	20	0.4 ± 0.1 **ab**	24.6 ± 3.9 **b**	25.0 ± 3.9 **b**	83.1 ± 6.9 **a**	48.4 ± 6.2 **c**	16.1 ± 1.8 **a**
	Check		10	1.7 ± 0.3 **c**	51.3 ± 5.3 **d**	53.0 ± 5.5 **d**	60.2 ± 6.9 **a**	18.6 ± 5.8 **a**	10.5 ± 1.6 **a**
2000	EB	STIT - Apr., '99	10	0.5 ± 0.3 **a**	15.6 ± 2.8 **b**	16.1 ± 3.0 **b**	81.3 ± 11.5 **a**	59.1 ± 9.6 **ab**	7.6 ± 1.1 **a**
	EB	STIT - Apr., '99 & '00	10	0.6 ± 0.2 **ab**	14.4 ± 2.0 **b**	15.1 ± 2.1 **b**	89.0 ± 9.1 **a**	62.6 ± 7.5 **abc**	10.2 ± 1.6 **a**
	EB + Thia.	STIT - Apr., '99	10	0.4 ± 0.1 **a**	17.2 ± 2.8 **bc**	17.6 ± 2.9 **bc**	97.6 ± 7.2 **a**	66.1 ± 6.0 **bcd**	12.2 ± 2.3 **a**
	EB + Thia.	STIT - Apr., '99 & '00	10	0.7 ± 0.3 **ab**	6.9 ± 1.4 **a**	7.6 ± 1.5 **a**	103.8 ± 6.9 **a**	86.8 ± 7.4 **d**	8.7 ± 1.1 **a**
	Check		10	1.3 ± 0.5 **b**	23.0 ± 3.2 **c**	24.3 ± 3.5 **c**	75.8 ± 10.3 **a**	48.3 ± 6.9 **a**	8.8 ± 2.3 **a**
2001	EB	STIT - Apr., '99	6	0.7 ± 0.3 **a**	39.1 ± 8.3 **a**	39.8 ± 8.2 **a**	76.1 ± 17.5 **a**	44.0 ± 15.8 **a**	5.9 ± 2.0 **a**
	EB	STIT - Apr., '99 & '00	6	1.0 ± 0.4 **a**	36.2 ± 2.3 **a**	37.2 ± 2.6 **a**	94.7 ± 13.9 **a**	50.2 ± 8.6 **a**	8.7 ± 1.7 **a**
	EB + Thia.	STIT - Apr., '99	6	0.3 ± 0.1 **a**	32.9 ± 2.5 **a**	33.2 ± 2.7 **a**	87.2 ± 13.2 **a**	50.1 ± 8.3 **a**	7.4 ± 3.1 **a**
	EB + Thia.	STIT - Apr., '99 & '00	5	0.7 ± 0.2 **a**	20.1 ± 2.9 **a**	20.8 ± 2.9 **a**	103.0 ± 11.4 **a**	75.2 ± 10.4 **a**	6.1 ± 1.4 **a**
	Check		6	0.5 ± 0.2 **a**	32.5 ± 5.1 **a**	33.0 ± 5.0 **a**	84.5 ± 9.6 **a**	51.5 ± 8.4 **a**	5.3 ± 1.7 **a**
2002	EB	STIT - Apr., '99	10	6.2 ± 4.3 **b**	28.3 ± 3.7 **a**	34.4 ± 5.0 **a**	65.3 ± 9.2 **a**	42.4 ± 9.1 **a**	3.0 ± 0.6 **a**
	EB	STIT - Apr., '99 & '00	10	2.3 ± 1.1 **ab**	28.6 ± 6.5 **a**	30.9 ± 6.3 **a**	82.1 ± 8.8 **a**	57.1 ± 8.3 **a**	3.0 ± 0.4 **a**
	EB + Thia.	STIT - Apr., '99	9	1.6 ± 0.8 **ab**	34.0 ± 7.0 **a**	35.6 ± 7.6 **a**	76.9 ± 9.1 **a**	49.4 ± 9.3 **a**	4.2 ± 0.7 **a**
	EB + Thia.	STIT - Apr., '99 & '00	9	0.6 ± 0.1 **a**	25.2 ± 2.6 **a**	25.8 ± 2.7 **a**	84.9 ± 3.8 **a**	59.1 ± 4.4 **a**	3.3 ± 0.5 **a**
	Check		10	0.5 ± 0.1 **a**	31.2 ± 1.7 **a**	31.6 ± 1.7 **a**	83.4 ± 6.2 **a**	53.1 ± 4.8 **a**	3.0 ± 0.5 **a**
2003	EB	STIT - Apr., '99	10	11.7 ± 5.2 **a**	12.7 ± 1.8 **a**	24.4 ± 4.6 **a**	112.8 ± 11.5 **a**	80.1 ± 10.3 **a**	3.9 ± 0.8 **a**
	EB	STIT - Apr., '99 & '00	10	8.5 ± 1.8 **a**	16.9 ± 2.3 **a**	25.4 ± 2.7 **a**	113.9 ± 7.0 **a**	79.6 ± 6.8 **a**	4.2 ± 0.8 **a**
	EB + Thia.	STIT - Apr., '99	9	5.6 ± 1.2 **a**	18.9 ± 2.7 **a**	24.6 ± 3.0 **a**	106.3 ± 6.1 **a**	73.3 ± 5.1 **a**	5.6 ± 1.5 **a**
	EB + Thia.	STIT - Apr., '99 & '00	10	9.1 ± 1.2 **a**	13.5 ± 1.8 **a**	22.6 ± 1.8 **a**	114.2 ± 7.3 **a**	82.0 ± 5.1 **a**	4.6 ± 0.5 **a**
	Check		10	8.7 ± 2.0 **a**	14.2 ± 2.0 **a**	22.9 ± 2.6 **a**	118.9 ± 8.8 **a**	86.9 ± 7.5 **a**	3.8 ± 0.8 **a**

* Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 4. Mean % (± SE) cone and seed losses from insects (coneworms and seed bugs) and reductions in damage from second-year cones of loblolly pine protected with systemic injections of emamectin benzoate (EB) or emamectin benzoate + thiamethoxam (EB + Thia.), Magnolia Springs Seed Orchard, Jasper Co., TX, 1999 - 2003.

	Application	1999			2000			2001			2002			2003		
Treatment	Technique, Treatment Date(s)	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)
EB	STIT - Apr., '99	20	20.1 ± 2.4 **a***	51.0												
EB	STIT - Apr., '99	10			10	9.2 ± 2.4 **ab**	67.5	6	32.7 ± 7.0 **b**	36.3	10	39.8 ± 4.3 **ab**	21.7	10	26.9 ± 4.3 **a**	36.5
EB	STIT - Apr., '99 & '00	10			10	6.0 ± 1.2 **a**	79.0	6	29.4 ± 2.8 **b**	42.7	10	39.1 ± 5.6 **ab**	23.0	10	27.6 ± 3.3 **a**	34.8
EB + Thia.	STIT - Apr., '99	20	17.4 ± 2.2 **a**	57.7												
EB + Thia.	STIT - Apr., '99	10			10	8.0 ± 0.8 **ab**	71.9	6	27.4 ± 3.3 **ab**	46.6	9	38.9 ± 3.8 **ab**	23.4	9	28.3 ± 3.0 **a**	33.2
EB + Thia.	STIT - Apr., '99 & '00	10			10	4.1 ± 0.7 **a**	85.7	5	17.7 ± 2.8 **a**	65.5	9	32.7 ± 2.1 **a**	35.6	10	25.7 ± 2.8 **a**	39.2
Check		10	41.1 ± 3.6 **b**		10	28.4 ± 3.0 **e**		6	51.3 ± 3.4 **c**		10	50.8 ± 3.8 **b**		10	42.3 ± 3.2 **b**	

* Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

Figure 1. Percent of loblolly pine cones damaged by coneworm (*Dioryctria* spp.) following one (1999) or two (1999, 2000) injections of systemic insecticides during the Duration Study, Magnolia Springs Seed Orchard, Jasper Co., TX.

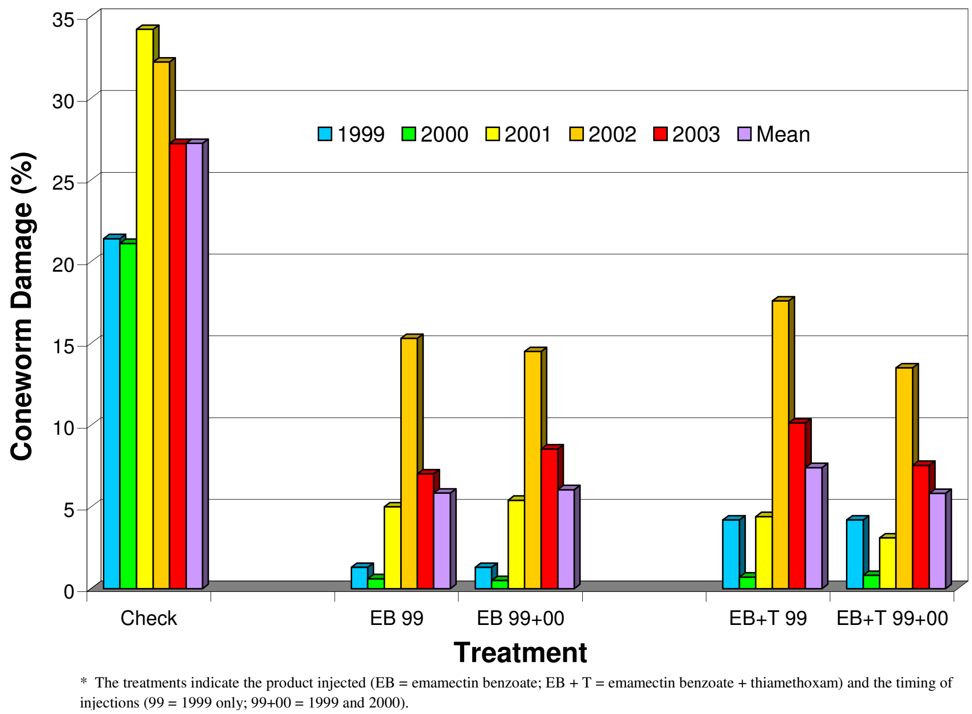


Figure 2. Percent of loblolly pine seeds damaged by seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) following one (1999) or two (1999, 2000) injections of systemic insecticides during the Duration Study, Magnolia Springs Seed Orchard, Jasper Co., TX.

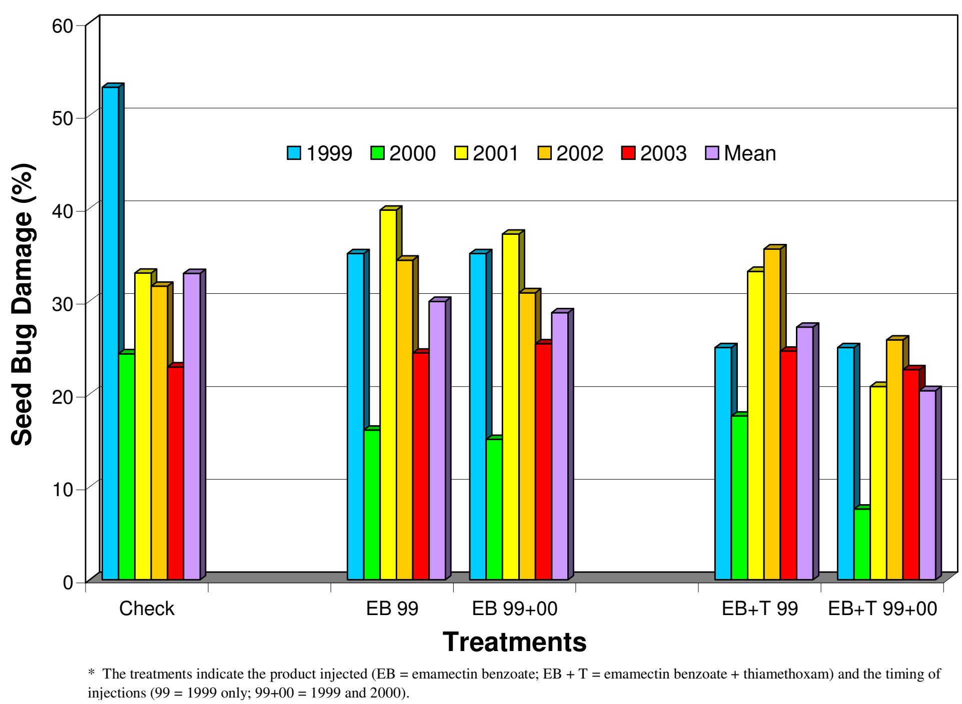
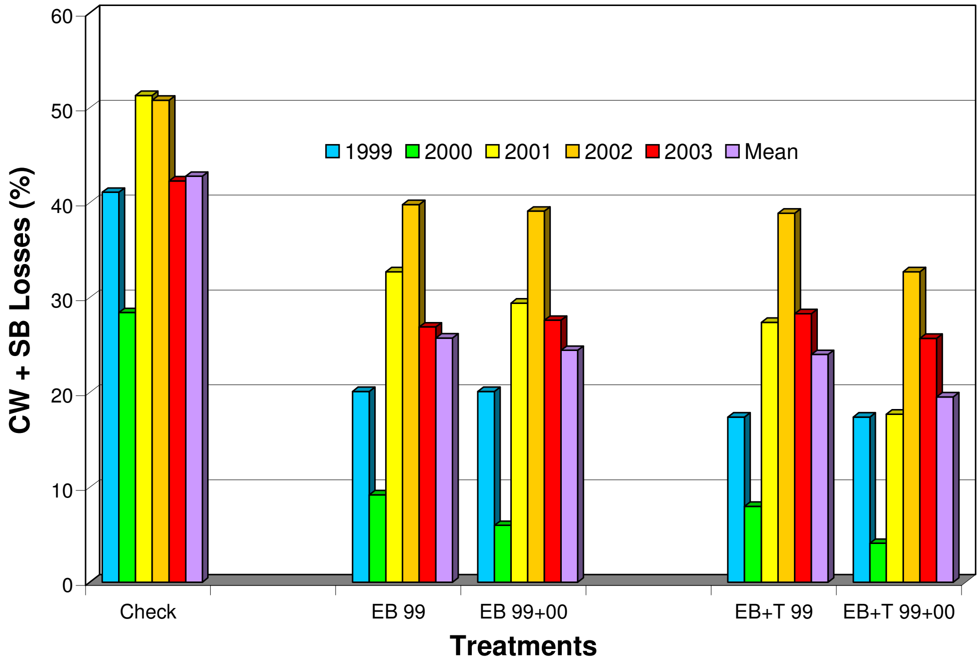


Figure 3. Percent combined losses from coneworm (*Dioryctria* spp.) and seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) following one (1999) or two (1999, 2000) injections of systemic insecticides during the Duration Study, Magnolia Springs Seed Orchard, Jasper Co., TX.



* The treatments indicate the product injected (EB = emamectin benzoate; EB + T = emamectin benzoate + thiamethoxam) and the timing of injections (99 = 1999 only; 99+00 = 1999 and 2000).

2001-2003 Systemic Insecticide Injection Rate Study - Magnolia Springs, TX

Highlights:

- Single injections of emamectin benzoate alone or in combination with thiamethoxam at high (20 ml) rates reduced coneworm damage by 79%, but not seed bug damage in 2003.
- Overall insect damage (coneworm + seed bug) was reduced to the greatest extent (49% and 50%) by emamectin benzoate plus thiamethoxam injected at rates of 20 ml and 10ml, respectively.

Objectives: 1) Evaluate the efficacy of systemic injections of emamectin benzoate and thiamethoxam, alone or combined, in reducing seed crop losses in loblolly pine seed orchards; 2) evaluate the combination treatment, emamectin benzoate plus thiamethoxam, applied at three rates using a pressurized injection system; and 3) determine the duration of treatment efficacy.

Study Site: 20 acre orchard block containing 11 year-old drought-hardy loblolly pine -- Texas Forest Service Magnolia Springs Seed Orchard, Jasper Co., TX.

Insecticides:

Emamectin benzoate (Arise SL®) -- avermectin derivative

Thiamethoxam (Novartis 293) -- experimental insecticide with similar activity compared to imidacloprid.

Design: Randomized complete block with clones as blocks. 6 treatments X 10 clones = 60 ramets used for study.

Application Methods:

STIT Injection – In April 2001, a 6mm (3/8 in) diameter hole, 11 cm (4.5 in) deep was drilled parallel to the ground at each injection site; number of holes was equal to the volume of insecticide solution to be applied divided by 50 ml (the capacity of each injector); holes were placed at a height of 1 m. The prefilled STIT injector (Helson et al. 2001) was hammered into the drill hole and pressurized to 50 psi. Most treatment solutions drained within 15 minutes. The volume of insecticide solution applied was based on the diameter of each treatment tree as follows:

Tree	Treatments		
Diameter	1, 4 & 5	2	3
11 - 15 cm	20 ml	10 ml	3 ml
16 - 20 cm	20 - 40 ml	10 - 20 ml	3 - 6 ml
21 - 25 cm	40 - 60 ml	20 - 30 ml	6 - 9 ml
26 - 30 cm	60 - 80 ml	30 - 40 ml	9 - 12 ml
>30 cm	+20 ml/5 cm dia. increment	+10 ml/5 cm dia. increment	+3 ml/5 cm dia. increment

Treatments:

1) 20 ml rate each for 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam (25WG) by STIT injector (N = 10)
2) 10 ml rate each for 4% emamectin benzoate (Arise SL®) 5% thiamethoxam (25WG) by STIT injector (N = 10)
3) 3 ml rate each for 4% emamectin benzoate (Arise SL®) 5% thiamethoxam (25WG) by STIT injector (N = 10)
4) 20 ml rate for 4% emamectin benzoate (Arise SL®) alone by STIT injector (N = 10)
5) 20 ml rate for 5% thiamethoxam (25WG) alone by STIT injector (N = 10)

** 6) ~~Asana® XL (foliar standard)~~ ** Not evaluated in 2003 **

7) Check (untreated) (N = 10)

Data Collection:

***Dioryctria* Attacks** -- All cones in study trees that could be reached by bucket truck were picked in early October; cones were categorized as small dead, large dead, green infested, with other insect or disease damage, or healthy.

Seed Bug Damage -- 10 healthy cones were picked "at random" from all healthy cones collected from each ramet; seeds were extracted and radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Conelet and Cone Survival: Data was not collected in 2003.

Results: The orchard block containing the treatment trees has not been sprayed since establishment - suggesting that pressure from coneworms and seed bugs would be moderate to high. This was confirmed for coneworms by over 32% damage on check cones in 2003 (Table 5). Lower numbers of both leaf-footed and shieldbacked pine seed bugs were observed in the trees in 2003. This was reflected by the 19% damage to seed from check trees (Table 6). Seedworm damage to seed from check trees was considered insignificant (1% or less in 2003), so the data were not included in the analysis.

Treatment Effect on Coneworm Damage: All injection treatments continued to significantly reduced early and late coneworm damage compared to the check (Table 5, Fig. 4). Overall, the high rate treatments of emamectin benzoate alone and combined with thiamethoxam provided the greatest reduction in total coneworm damage (both 79%) compared to the check. The moderate rate of emamectin benzoate plus thiamethoxam (10 ml) was only slightly less effective; reducing damage by 77%. Thiamethoxam alone continued to show significant activity; reducing coneworm damage by 42% compared to the check. All injection treatments had significantly higher proportions of healthy cones compared to the check. A good relationship again was found in 2003 between rates of emamectin benzoate and thiamethoxam applied and incidence of coneworm damage ($r^2 = 0.696$) (Fig. 5).

Treatment Effect on Seed Bug Damage: In 2003, seed bug damage levels (19%) were relatively low in check cones compared to 2001 and 2002 levels (33% both years) (Table 6, Fig. 6). As in past years, higher levels of damage occurred late in the growing season compared to earlier in the year, indicating that the shieldbacked pine seed bug had a much greater impact on seed production at this orchard than did the leaffooted pine seed bug. None of the injection treatments significantly reduced total seed bug damage, nor did these treatments increase the number of full seeds per cone compared to the check. There was no relationship found in 2003 between rates of emamectin benzoate and thiamethoxam applied and incidence of seed bug damage ($r^2 = 0.000$) (Fig. 7).

Treatment Effect on Overall Insect Damage: An estimate of the combined losses due to coneworms and seed bugs was calculated. In this study, it is conservatively estimated that in 2003 coneworms and seed bugs in combination reduced the potential seed crops of check trees by 43%; down from 51% in 2002 and 60% in 2001 (Table 7, Fig. 8). As in 2001 and 2002, three treatments were most effective in reducing overall insect damage: 20 ml of emamectin benzoate alone and the two higher rates (10 ml and 20 ml) of emamectin benzoate plus thiamethoxam. Injections of these treatments in 2003 reduced overall insect damage by 43%, 49% and 50%, respectively. A fair relationship continues to be found between rates of emamectin benzoate and thiamethoxam applied and overall insect losses ($r^2 = 0.413$) (Fig. 9)

Summary: This study again demonstrates that emamectin benzoate, alone or in combination with thiamethoxam, is highly effective against coneworms; protecting cones for at least 3 years. Regression curves indicate that the 20ml rate of emamectin benzoate is necessary to maintain the highest levels of reduction of coneworm and seed bug damage and provides the greatest gain in cone survival and filled seed per cone. Although, thiamethoxam alone does show activity against coneworms and seed bugs, the duration of activity is not as great as that of emamectin benzoate. Also, the addition of thiamethoxam generally does not appear to improve the performance of emamectin benzoate. Therefore, a search should begin for an alternative chemical that has a greater effect on seed bug when injected alone or combined with emamectin benzoate.

Although, all injection treatments showed a marked reduction in efficacy in 2002 compared to results observed in 2001, all emamectin benzoate treatments showed improvements in protection against coneworms in 2003. This is similar to results observed in the Duration study in 2003. It is apparent that once trees are injected, they have the ability to reallocate emamectin benzoate into new growing shoot and cone tissue each spring and summer. The amount of chemical that is moved into these new tissues may be dependent on moisture conditions at the time of tissue growth.

Reference:

Helson, B.V., D.B. Lyons, K.V. Wanner, and T.A. Scarr. 2001. Control of conifer defoliators with neem-based systemic bioinsecticides using a novel injection device. Can. Ent. 133: 729-744.

Table 5. Mean percentages (± SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with systemic injection of emamectin benzoate (EB), thiamethoxam (Thia.), emamectin benzoate + thiamethoxam (EB + Thia.) or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2001 - 2003.

				Mean Coneworm Damage (%)				
Year	Treatment	Application Technique, Treatment Date(s)	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
2001	EB (20)	STIT - Apr., '01	10	1.5 ± 0.5 **a**†	1.0 ± 0.4 **a**	2.5 ± 0.7 **ab**	19.6 ± 7.0 **a**	77.9 ± 6.9 **bc**
	EB + Thia. (20)	STIT - Apr., '01	10	1.0 ± 0.3 **a**	1.5 ± 1.0 **a**	2.5 ± 1.2 **b**	14.3 ± 5.6 **a**	83.2 ± 6.7 **c**
	EB + Thia. (10)	STIT - Apr., '01	10	1.2 ± 0.4 **a**	1.5 ± 0.4 **ab**	2.7 ± 0.7 **ab**	17.4 ± 4.4 **a**	79.9 ± 4.5 **bc**
	EB + Thia. (3)	STIT - Apr., '01	10	2.6 ± 0.6 **a**	2.6 ± 0.7 **ab**	5.2 ± 1.3 **ab**	18.5 ± 5.1 **a**	76.3 ± 4.8 **bc**
	Thia. (20)	STIT - Apr., '01	10	2.7 ± 1.0 **a**	3.1 ± 1.2 **bc**	5.8 ± 2.0 **b**	15.5 ± 6.2 **a**	78.7 ± 6.2 **bc**
	Asana XL	Hydraulic Foliar 5X in '01	10	7.8 ± 1.5 **b**	12.0 ± 2.5 **c**	19.8 ± 3.2 **c**	11.8 ± 2.0 **a**	68.4 ± 5.0 **b**
	Check		10	16.3 ± 2.4 **c**	29.5 ± 1.9 **d**	45.8 ± 3.4 **d**	9.9 ± 1.3 **a**	44.3 ± 3.2 **a**
2002	EB (20)	STIT - Apr., '01	10	3.9 ± 1.5 **a**	6.0 ± 3.1 **a**	9.8 ± 4.6 **a**	3.2 ± 0.7 **a**	87.0 ± 4.3 **b**
	EB + Thia. (20)	STIT - Apr., '01	10	5.3 + 2.7 **a**	4.2 ± 1.2 **a**	9.6 ± 2.8 **a**	6.6 ± 1.9 **a**	83.9 ± 4.2 **b**
	EB + Thia. (10)	STIT - Apr., '01	10	7.4 ± 4.0 **a**	5.2 ± 1.4 **a**	12.6 ± 5.2 **a**	7.2 ± 2.3 **a**	80.2 ± 7.0 **b**
	EB + Thia. (3)	STIT - Apr., '01	10	8.9 ± 3.0 **b**	8.8 ± 2.7 **b**	17.7 ± 5.6 **b**	7.5 ± 2.0 **a**	74.8 ± 7.1 **ab**
	Thia. (20)	STIT - Apr., '01	10	5.5 ± 1.0 **b**	9.2 ± 3.7 **b**	14.7 ± 3.9 **b**	7.3 ± 2.2 **a**	78.0 ± 5.9 **b**
	Asana XL	Hydraulic Foliar 5X in '01	9	6.5 ± 2.2 **b**	8.5 ± 2.4 **b**	15.0 ± 4.2 **b**	3.7 ± 1.2 **a**	81.2 ± 4.8 **b**
	Check		10	21.6 ± 4.1 **b**	11.9 ± 1.0 **b**	33.5 ± 4.1 **b**	6.1 ± 1.7 **a**	60.4 ± 4.7 **a**
2003	EB (20)	STIT - Apr., '01	9	4.0 ± 0.8 **ab**	2.9 ± 1.6 **a**	6.9 ± 1.9 **a**	11.6 ± 2.4 **a**	81.5 ± 3.9 **b**
	EB + Thia. (20)	STIT - Apr., '01	10	3.4 + 0.7 **a**	3.3 ± 1.5 **a**	6.7 ± 1.8 **a**	12.2 ± 3.1 **a**	81.1 ± 4.1 **b**
	EB + Thia. (10)	STIT - Apr., '01	10	6.0 ± 1.3 **abc**	1.3 ± 0.5 **a**	7.4 ± 1.5 **a**	10.7 ± 3.5 **a**	81.9 ± 4.6 **b**
	EB + Thia. (3)	STIT - Apr., '01	10	8.0 ± 1.3 **bcd**	3.4 ± 1.1 **ab**	11.4 ± 1.8 **ab**	12.0 ± 4.3 **a**	76.6 ± 3.9 **b**
	Thia. (20)	STIT - Apr., '01	9	11.1 ± 2.2 **cd**	7.9 ± 2.3 **b**	19.0 ± 2.7 **b**	9.8 ± 2.5 **a**	71.2 ± 3.9 **b**
	Check		10	19.3 ± 3.5 **d**	13.2 ± 2.5 **c**	32.5 ± 3.6 **c**	11.4 ± 3.9 **a**	56.1 ± 4.2 **a**

* Mortality or wounds caused by drought, pitch canker, squirrel, midge, or mechanical damage.

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 6. Seed bug damage, seed extracted, and seed quality (Mean ± SE) from second-year cones of loblolly pine protected with systemic injection of emamectin benzoate (EB), thiamethoxam (Thia.), emamectin benzoate + thiamethoxam (EB + Thia.) or foliar treatments of Asana XL®, Magnolia Springs Seed Orchard, Jasper Co., TX, 2001 - 2002.

Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Seed Bug Damage (%): Early (2nd Yr Abort)	Mean Seed Bug Damage (%): Late	Mean Seed Bug Damage (%): Total	Mean No. Seeds per Cone	Mean No. Filled Seed per Cone	Mean No. Empty Seed per Cone
2001	EB (20)	STIT - Apr., '01	10	0.7 ± 0.2 **a***	19.8 ± 4.2 **cd**	20.5 ± 4.3 **cd**	120.1 ± 6.0 **a**	80.7 ± 7.3 **cd**	13.9 ± 1.6 **a**
	EB + Thia. (20)	STIT - Apr., '01	10	0.6 ± 0.1 **a**	15.8 ± 3.4 **bc**	16.4 ± 3.4 **bc**	122.2 ± 7.6 **a**	88.5 ± 7.8 **cd**	12.6 ± 2.0 **a**
	EB + Thia. (10)	STIT - Apr., '01	10	0.6 ± 0.1 **a**	14.3 ± 3.3 **ab**	14.9 ± 3.4 **ab**	118.7 ± 6.4 **a**	86.1 ± 8.9 **cd**	15.3 ± 3.1 **a**
	EB + Thia. (3)	STIT - Apr., '01	10	1.4 ± 0.4 **a**	25.1 ± 4.3 **d**	26.5 ± 4.5 **d**	109.1 ± 7.8 **a**	64.6 ± 7.3 **ab**	15.2 ± 2.0 **a**
	Thia. (20)	STIT - Apr., '01	10	0.8 ± 0.2 **a**	19.6 ± 4.1 **cd**	20.4 ± 4.1 **cd**	115.5 ± 7.9 **a**	79.0 ± 9.5 **bc**	13.5 ± 2.0 **a**
	Asana XL	Hydraulic Foliar 5X in '01	10	0.6 ± 0.3 **a**	9.9 ± 3.2 **a**	10.5 ± 3.3 **a**	118.8 ± 7.5 **a**	94.3 ± 8.2 **d**	11.2 ± 1.5 **a**
	Check		10	0.8 ± 0.2 **a**	31.7 ± 2.9 **e**	32.5 ± 2.9 **e**	105.7 ± 6.4 **a**	56.9 ± 4.3 **a**	13.5 ± 2.3 **a**
2002	EB (20)	STIT - Apr., '01	10	1.0 ± 0.3 **a**	29.0 ± 5.5 **ab**	29.9 ± 5.4 **ab**	73.3 ± 9.3 **a**	48.0 ± 10.3 **a**	6.1 ± 1.5 **a**
	EB + Thia. (20)	STIT - Apr., '01	10	1.5 ± 0.4 **a**	25.7 ± 5.9 **ab**	27.2 ± 6.2 **ab**	85.5 ± 8.1 **ab**	60.1 ± 9.3 **ab**	5.0 ± 1.1 **a**
	EB + Thia. (10)	STIT - Apr., '01	10	2.1 ± 0.8 **a**	28.5 ± 6.6 **ab**	30.6 ± 7.2 **ab**	78.2 ± 11.7 **a**	56.3 ± 11.7 **a**	3.5 ± 0.6 **a**
	EB + Thia. (3)	STIT - Apr., '01	10	1.3 ± 0.3 **a**	27.5 ± 5.0 **ab**	28.8 ± 5.1 **ab**	77.2 ± 10.4 **a**	52.3 ± 10.0 **a**	4.6 ± 0.7 **a**
	Thia. (20)	STIT - Apr., '01	10	1.4 ± 0.3 **a**	28.8 ± 6.4 **ab**	30.2 ± 6.6 **ab**	84.4 ± 9.6 **ab**	58.9 ± 9.9 **ab**	4.2 ± 1.0 **a**
	Asana XL	Hydraulic Foliar 5X in '02	9	1.2 ± 0.4 **a**	16.1 ± 4.0 **a**	17.3 ± 4.3 **a**	115.1 ± 7.7 **b**	92.8 ± 10.7 **b**	4.2 ± 0.7 **a**
	Check		10	1.6 ± 0.3 **a**	32.2 ± 4.4 **b**	33.9 ± 4.5 **b**	73.4 ± 9.7 **a**	45.1 ± 9.1 **a**	5.0 ± 1.2 **a**
2003	EB (20)	STIT - Apr., '01	9	5.8 ± 2.2 **a**	15.3 ± 2.8 **a**	21.1 ± 4.1 **a**	116.7 ± 9.1 **a**	88.3 ± 10.5 **a**	4.1 ± 0.8 **a**
	EB + Thia. (20)	STIT - Apr., '01	10	3.0 ± 0.5 **a**	16.6 ± 2.7 **a**	19.5 ± 2.9 **a**	111.3 ± 10.3 **a**	84.0 ± 9.6 **a**	4.3 ± 1.0 **a**
	EB + Thia. (10)	STIT - Apr., '01	10	4.1 ± 1.6 **a**	13.8 ± 2.1 **a**	17.9 ± 2.8 **a**	131.3 ± 5.2 **a**	103.2 ± 6.9 **a**	3.7 ± 0.6 **a**
	EB + Thia. (3)	STIT - Apr., '01	10	3.6 ± 0.7 **a**	15.8 ± 3.0 **a**	19.4 ± 3.3 **a**	120.7 ± 7.8 **a**	92.7 ± 7.3 **a**	3.9 ± 0.7 **a**
	Thia. (20)	STIT - Apr., '01	9	4.7 ± 1.5 **a**	14.7 ± 3.3 **a**	19.4 ± 3.5 **a**	125.4 ± 5.7 **a**	96.9 ± 8.1 **a**	4.2 ± 0.8 **a**
	Check		10	4.3 ± 0.9 **a**	14.9 ± 3.1 **a**	19.2 ± 3.6 **a**	119.6 ± 7.1 **a**	92.8 ± 8.4 **a**	4.0 ± 0.5 **a**

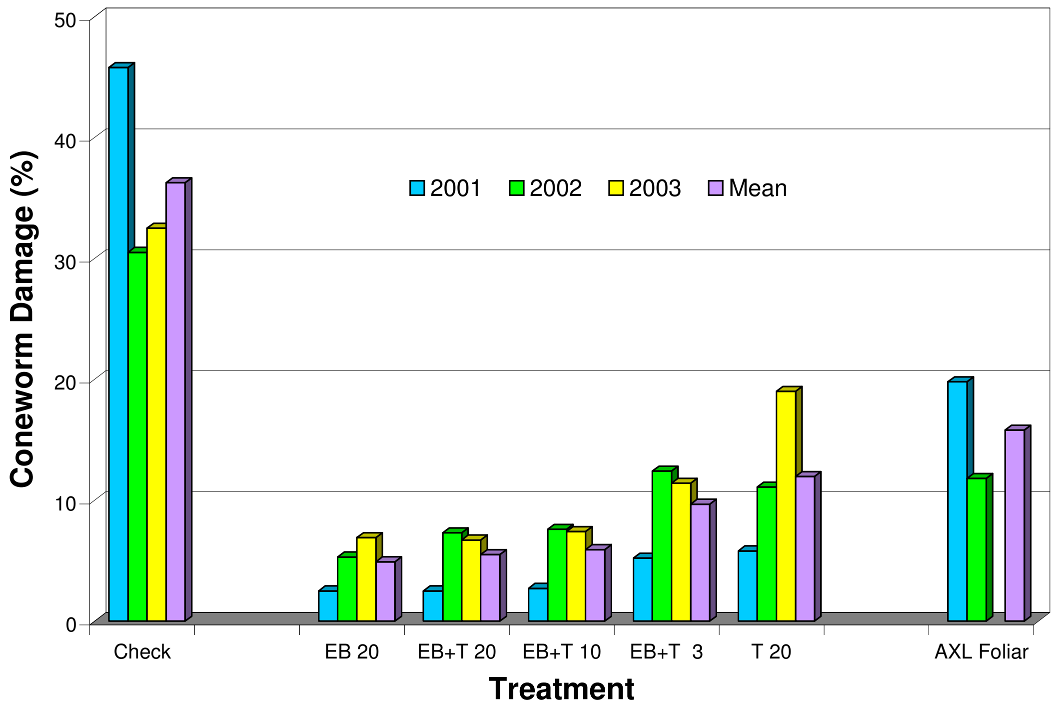
* Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 7. Mean % (± SE) cone and seed losses from insects (coneworms and seed bugs) and reductions in damage from second-year cones of loblolly pine protected with systemic injection of emamectin benzoate (EB), thiamethoxam (Thia.), emamectin benzoate + thiamethoxam (EB + Thia.), or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2001 - 2003.

		2001			2002			2003		
Treatment	Application Technique, Treatment Date(s)	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)
EB 20 ml	STIT - Apr., '01	10	16.7 ± 2.3 **ab***	72.2	10	34.7 ± 6.1 **a**	34.8	9	24.4 ± 3.4 **ab**	43.4
EB + Thia. 20 ml	STIT - Apr., '01	10	16.0 ± 3.0 **ab**	73.4	10	30.7 ± 5.4 **a**	42.3	10	21.9 ± 2.7 **a**	49.3
EB + Thia. 10 ml	STIT - Apr., '01	10	14.6 ± 2.6 **a**	75.7	10	33.8 ± 5.9 **a**	36.5	10	21.6 ± 2.3 **a**	49.9
EB + Thia. 3 ml	STIT - Apr., '01	10	25.5 ± 3.8 **c**	57.6	10	38.2 ± 5.4 **ab**	28.2	10	26.0 ± 4.1 **ab**	39.8
Thia. 20 ml	STIT - Apr., '01	10	22.0 ± 3.8 **bc**	63.4	10	36.0 ± 4.7 **a**	32.3	9	33.2 ± 3.1 **b**	23.0
Asana XL	Hydraulic Foliar 5X in '01	10	27.1 ± 3.4 **c**	54.9	9	28.0 ± 6.2 **a**	47.4			
Check		10	60.1 ± 2.9 **d**		10	53.2 ± 4.7 **b**		10	43.1 ± 4.3 **c**	

* Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

Figure 4. Percent of loblolly pine cones damaged by coneworm (*Dioryctria* spp.) following injections of systemic insecticides during the Rate Study, Magnolia Springs Seed Orchard, Jasper Co., Texas.



* The treatments indicate the product injected (EB = emamectin benzoate; T = thiamethoxam) and rate (3 = 3 ml, 10 = 10 ml & 20 = 20 ml).

Figure 5. Relationship between coneworm (*Dioryctria* spp.) damage and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Jasper Co., TX, 2001 - 2003.

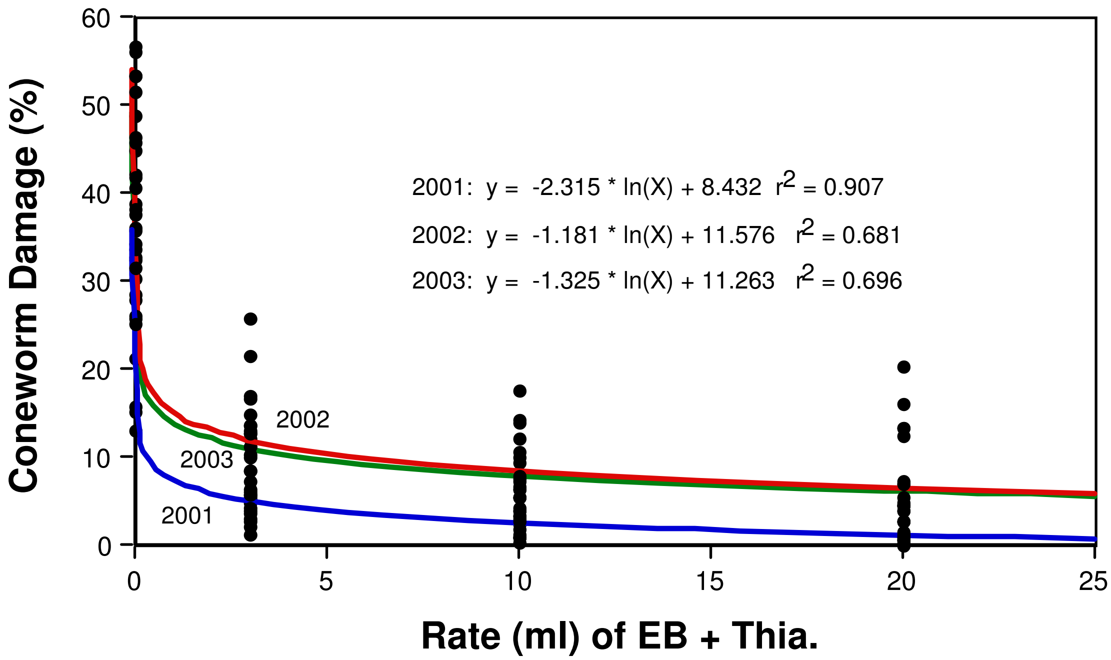
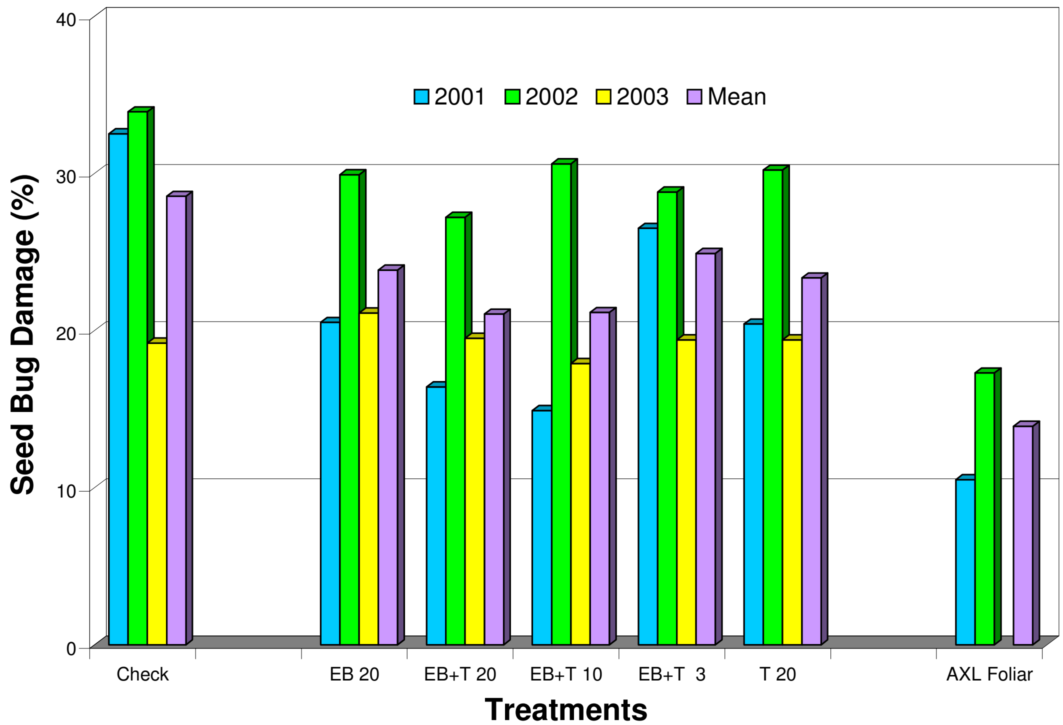


Figure 6. Percent of loblolly pine cones damaged by seed bug (*Tetyra* sp. and *Leptoglossus* sp.) following injections of systemic insecticides during the Rate Study, Magnolia Springs Seed Orchard, Jasper Co., Texas.



* The treatments indicate the product injected (EB = emamectin benzoate; T = thiamethoxam) and rate (3 = 3 ml, 10 = 10 ml & 20 = 20 ml).

Figure 7. Relationship between seed bug (*Tetyra* sp. and *Leptoglossus* sp.) damage and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Jasper Co., TX, 2001 - 2003.

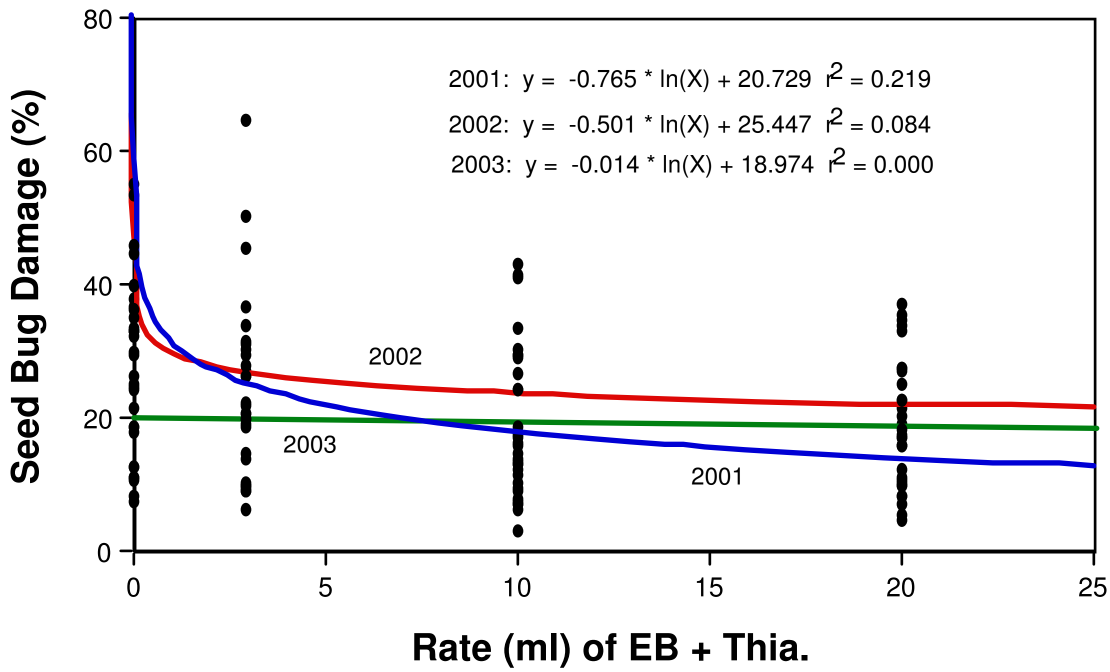
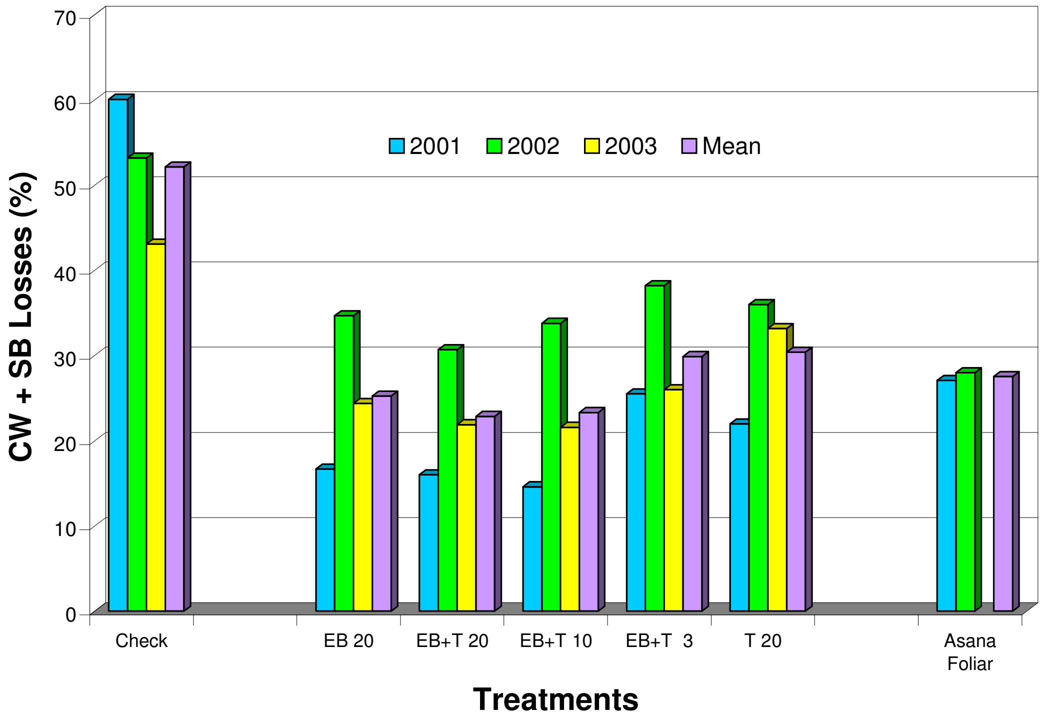
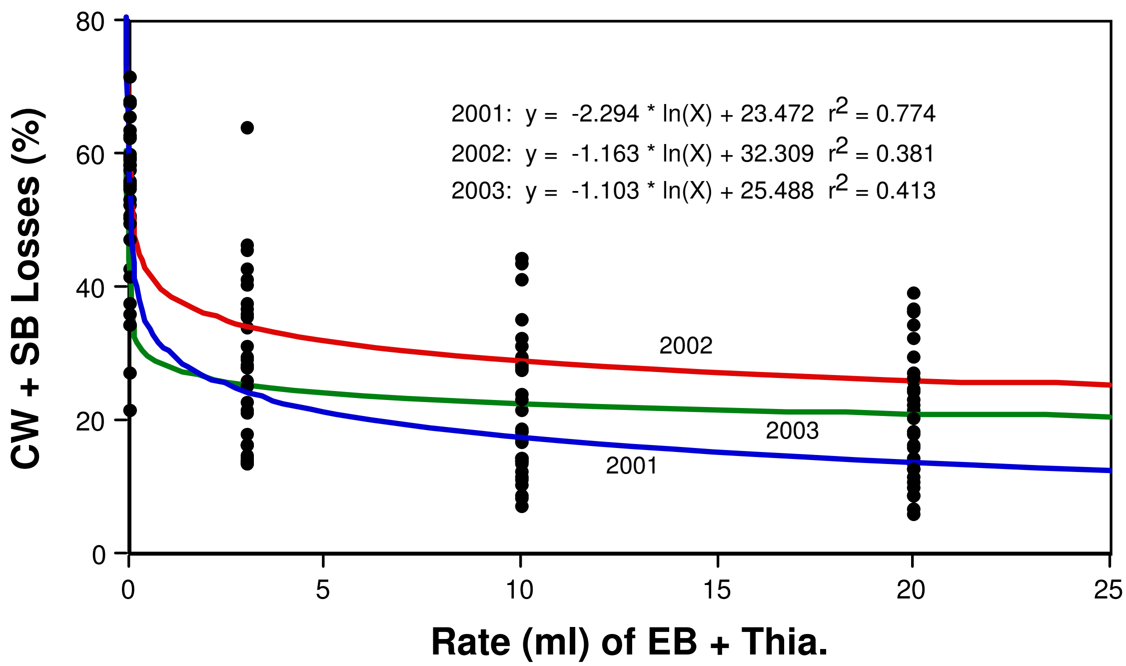


Figure 8. Percent combined losses from coneworm (*Dioryctria* spp.) and seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) following injections of systemic insecticides during the Rate Study Magnolia Springs Seed Orchard, Jasper Co., TX.



* The treatments indicate the product injected (EB = emamectin benzoate; T = thiamethoxam) and rate (3 = 3 ml, 10 = 10 ml & 20 = 20 ml).

Figure 9. Relationship between overall insect damage (coneworm + seed bug) and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Jasper Co., TX, 2001– 2003.



2003 Systemic Insecticide Injection Denim® and Fipronil Study – Magnolia Springs, TX

Highlights:

- Denim® (16 ml, all injection methods) improved conelet survival by 48% and cone survival by 23%. However, fipronil (10 ml, Termidor® & EC) only improved conelet survival by 26%.
- Single injections of Denim® (16 and 8 ml rates) reduced coneworm damage by 62% and 64%, respectively, and seed bug damage by 25% and 30%, respectively.
- Overall insect damage (coneworm + seed bug) was reduced to the greatest extent (47% and 43%) by Denim® injected at rates of 8 ml and 16 ml, respectively.

Objectives: 1) Evaluate the efficacy of systemic injections of Denim® (emamectin benzoate) in reducing seed crop losses in loblolly pine seed orchards; 2) evaluate the treatments applied using the STIT, Arborjet™, and Sidewinder™ pressurized injection systems; 3) determine the duration of treatment efficacy; and 4) secondarily, evaluate the potential of fipronil for reducing cone and seed insect damage.

Study Site: 20 acre orchard block containing 11 year-old drought-hardy loblolly pine -- Texas Forest Service Magnolia Springs Seed Orchard, Jasper Co., TX.

Insecticides:

Emamectin benzoate (Denim®) -- avermectin derivative

Fipronil (Termidor® and experimental EC formulations) -- a pheny pyrazole insecticide that has shown systemic activity against other Lepidoptera (tip moth)

Design: Randomized complete block with clones as blocks. 8 treatments X 6-8 clones = 62 ramets used for study.

Application Methods:

In late March 2003, study trees were selected and measured for DBH to determine volume of insecticide to be injected.

STIT – In early April, four holes, 6mm (3/8 in) diameter and 8 cm (3 in) deep, were drilled about 1 m high at cardinal points on the tree bole. The pre-determined volume of insecticide was divided among four injectors. The prefilled injector was hammered into the drill hole and pressurized to 70 psi. Most treatment solutions drained within 30 minutes.

Arborjet™: Throughout April, at least four holes, 3/8 in diameter and 8 cm (3 in) deep, were drilled about 1 m high at cardinal points on the tree bole. Arborplugs were installed in each hole. The Arborjet™ system was used to inject a predetermined amount of product into each hole. Due to drought conditions, usually one or more plugs failed (leaked) on each treatment tree. Either additional injection points were installed on a treatment tree until the full amount was injected into each tree or injections were delayed until early in the morning on later dates.

Sidewinder™: Throughout April, at least four holes, 9mm (7/16 in) diameter and 8 cm (3 in) deep, were drilled about 1 m high at cardinal points on the tree bole. The Sidewinder™ drill was installed in the hole and a predetermined amount of product was pumped into the tree. Due to drought conditions, injections often failed (leaks). Either new injection points were installed until the full amount was injected into each tree or injections were delayed until early in the morning on later dates.

Treatments:

1) 16 ml of 1.92% emamectin benzoate (Denim®) per inch tree diameter at breast height (DBH) by STIT injector (N = 8)
2) 8 ml of 2% emamectin benzoate (Denim®) per inch tree DBH by STIT injector (N = 8)
3) 16 ml of 2% emamectin benzoate (Denim®) per inch tree DBH by Arborjet™ injector (N = 8)
4) 16 ml of 2% emamectin benzoate (Denim®) per inch tree DBH by Sidewinder™ injector (N = 8)
5) 10 ml of 4% fipronil (experimental EC) per inch tree DBH by Arborjet™ or Sidewinder™ injectors (N = 8)
6) 4 ml of 4% fipronil (Termidor®) per inch tree DBH by Arborjet™ or Sidewinder™ injectors (N = 6)
7) Asana® XL (foliar standard) applied by hydraulic sprayer to foliage 5 times per year at 9.6 oz/100 gal at 5-week intervals beginning in April. (N = 8)
8) Check (untreated) (N = 8)

Data Collection:

Conelet and Cone Survival – Six to ten branches were tagged per sample tree (minimum of 50 conelets and 50 cones) in April; conelets and cones were reevaluated for damage and survival in late September.

***Dioryctria* Attacks** -- All cones in study trees that could be reached by bucket truck were picked in early October; cones were categorized as small dead, large dead, green infested, with other insect or disease damage, or healthy.

Seed Bug Damage -- 10 healthy cones were picked "at random" from all healthy cones collected from each ramet; seeds were extracted and radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Results: The study trees averaged 30.4 cm in diameter. The effectiveness of each injection system (STIT, Arborjet™ & Sidewinder™) in applying Denim® and fipronil treatments is described in detail in the Comparison Report (Supplement A). Briefly, the STIT was used effectively to treat study trees over a two-day period in early April. Injection times averaged 33 and 22 minutes for the 16 ml and 8 ml rates, respectively. No more than four injection points were needed to apply the product. Unfortunately, due to drought condition, the products were difficult to inject using both the Arborjet™ and Sidewinder™ systems, so multiple visits (early in the morning) were required to treat all the study trees. Nearly half the Denim® and fipronil trees were not injected until late April. Although the injections times (31 min Arborjet™ and 24 min Sidewinder™) were comparable to the STIT, these methods averaged twice as many injection points or more per tree (10 points Arborjet™; 8 points Sidewinder™).

The orchard block containing the treatment trees has not been sprayed since establishment - suggesting that pressure from coneworms and seed bugs would be moderate to high. This was confirmed for coneworms by 31% damage on check cones in 2003 (Table 9). Relatively low numbers of both leaf-footed and shieldbacked pine seed bugs were observed in the trees in 2003. This was reflected by the 21% damage to seed from check trees (Table 10). Seedworm damage to seed from check trees was considered insignificant (1% or less in 2003), so the data were not included in the analysis.

Treatment Effect on Conelet and Cone Survival: Cones and conelets on tagged branches were examined in April and October. All injection and foliar treatments significantly improved survival of conelets, but only the Denim® treatments improved survival of cones compared to check trees (Table 8, Figs. 10 & 11). None of the Denim® treatments differed significantly from each other in conelet or cone survival. Overall, Denim® applied by the Arborjet™ system, provided the best protection of conelets and cones, significantly improving survival by 52% and 29%, respectively, over that of the check (Table 8).

Treatment Effect on Coneworm Damage: All injection treatments significantly reduced early and late coneworm damage compared to the check (Table 9, Fig. 12). Although damage was reduced, the amount of early season damage was fairly high (>7%) for all treatments. Overall, the Denim® treatment (16 ml) applied by the STIT injector provided the greatest reduction in total coneworm damage (73%) compared to the check (Fig. 12). The other Denim® treatments (8 ml STIT, 16 ml Sidewinder™ and 16 ml Arborjet™) were a little less effective; reducing damage by 64%, 59% and 55%, respectively. Two of three high rate Denim® treatments (STIT & Sidewinder™) had significantly higher proportions of healthy cones compared to the check.

Treatment Effect on Seed Bug Damage: In 2003, seed bug damage levels (21%) were lower in check cones compared to previous years (Table 10, see also Table 6 in Rate Study). The higher level of damage late in the growing season compared to earlier in the year again indicates that the shieldbacked pine seed bug had a much greater impact on seed production at this orchard than did the leaffooted pine seed bug. None of the treatments, including Asana XL, significantly reduced total seed bug damage (Fig. 13), nor did these treatments increase the number of full seeds per cone compared to the check.

Treatment Effect on Overall Insect Damage: An estimate of the combined losses due to two primary insect pest groups, coneworms and seed bugs, was calculated as in the Duration and Rate studies by adding the proportion of coneworm-damaged cones to the proportion of all seed in healthy cones damaged by seed-bug. In this study, it is conservatively estimated that in 2003 coneworms and seed bugs in combination reduced the potential seed crops of check trees by 41% (Table 11). The Denim® treatments (8 ml and 16 ml) were most effective in reducing overall insect damage, 47% and 43%, respectively (Fig. 14).

Summary: This is the third study to demonstrate that emamectin benzoate is effective in protecting 1st-and 2nd-year loblolly cones against coneworms. However, the 1st-year effects of Denim® were not as great as those observed for Arise® in previous studies (Duration and Rate). Mostly likely the drought conditions that were prevalent at the time of injection and later (April through May) were responsible for reduced movement of emamectin benzoate in the trees. This is supported by the relatively high damage levels to small 2nd-year cones early in the season and low damage levels to large 2nd-year cones late in the season.

Denim® is a more viscous formulation (27 centipose) compared to the Arise® (5 centipose). High viscosity, combined with drought conditions, caused injection times to increase substantially (20-40 minutes per tree for Denim® versus 5-10 minutes per tree for Arise®). If injection of seed orchard trees is ever to become cost effective, it is essential that injection times be reduced to 10-15 minutes per tree. Arborjet™ is in the process of obtaining technical emamectin benzoate from Syngenta for the purpose of developing a low viscosity formulation for injection use (Joe Doccola, Arborjet™, personal communication).

Six years of work by the WGFPMC have proven that emamectin benzoate is highly effective in protecting cone crops. Unfortunately, because seed orchard use constitutes a very small market (only ~2,000 acres in the South), Syngenta has been reluctant to support an injection use registration. An effort is been made to encourage other researchers to test this active ingredient on other insect targets. Preliminary evidence indicate that injected emamectin benzoate is also very effective against forest tent caterpillar (Kentucky) and reproduction weevils (Virginia) and has moderate effects on Asian longhorned beetle. In light of this, a list of potential markets (pest targets) was prepared and submitted to Dave Cox, Syngenta (see Supplement B). Arborjet™ is very interested in emamectin benzoate and is in negotiations with Syngenta to possibly obtain a sub-label for this active ingredient. They are particularly interested in determining if emamectin benzoate has activity against other beetles include the emerald ash borer and southern pine bark beetles, particularly the southern pine beetle. A proposal to test single-tree injections of emamectin benzoate and other actives for protection against southern pine beetle and/or *Ips* engravers is included in the proposal section.

Fipronil has shown good to excellent activity against pine tip moth in the Seedling Treatment, Technique and Rate, and Operational Planting Studies (2002 –2003). It was hoped that injected fipronil also would reduce coneworm damage in seed orchards. Although, neither formulation of fipronil (Termidor® and EC) performed well in reducing overall coneworm damage, a similar trend of high early and low late season damage was observed for fipronil compared to Denim®. This suggests that fipronil may require better conditions and perhaps more time than emamectin benzoate to be translocated to the target sites (cones) in the canopy. Further evaluations of effects of fipronil on coneworms and seed bugs damage on trees injected in 2003 is warranted for 2004.

Table 8. Mean percentages (± SE) of surviving conelets and cones on branches of loblolly pine protected with systemic injection of Denim® (emamectin benzoate) or fipronil or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003.

Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Survival (%) Conelets	Mean Survival (%) Cones
2003	Denim® 16 ml	STIT - Apr., '03	8	89.1 ± 4.0 **cd**†	82.8 ± 4.9 **cd**
	Denim® 16 ml	Arborjet (AJ) - Apr., '03	8	96.0 ± 0.9 **d**	89.1 ± 4.2 **d**
	Denim® 16 ml	Sidewinder (SW) - Apr., '03	8	94.2 ± 3.1 **d**	81.9 ± 5.4 **bcd**
	Denim® 8 ml	STIT - Apr., '03	8	88.1 ± 5.1 **cd**	85.8 ± 1.5 **cd**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	84.9 ± 3.6 **bc**	65.3 ± 5.0 **a**
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	71.7 ± 7.2 **ab**	63.6 ± 11.2 **a**
	Asana® XL	Hydraulic Foliar 5X in '03	8	82.0 ± 3.3 **bc**	72.0 ± 4.9 **abc**
	Check		8	63.0 ± 3.8 **a**	68.9 ± 4.7 **ab**
2003 *	Denim® 16 ml	STIT, AJ & SW - Apr., '03	24	93.1 ± 1.7 **d**	84.6 ± 2.8 **cd**
	Denim® 8 ml	STIT - Apr., '03	8	88.1 ± 5.1 **cd**	85.8 ± 1.5 **bc**
	Fipronil 10 ml	AJ & SW - Apr., '03	14	79.2 ± 4.0 **b**	64.6 ± 5.3 **a**
	Asana® XL	Hydraulic Foliar 5X in '03	8	82.0 ± 3.3 **bc**	72.0 ± 4.9 **ab**
	Check		8	63.0 ± 3.8 **a**	68.9 ± 4.7 **a**

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

* Comparison after three Denim® 16 ml and two fipronil treatments were combined.

Table 9. Mean percentages (± SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with systemic injections of Denim® (emamectin benzoate) or fipronil or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003.

Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Coneworm Damage (%) Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
2003	Denim® 16 ml	STIT - Apr., '03	8	8.1 ± 2.2 **a**†	0.5 ± 0.2 **a**	8.6 ± 2.2 **a**	5.1 ± 1.2 **a**	86.3 ± 2.8 **b**
	Denim® 16 ml	Arborjet (AJ) - Apr., '03	8	10.4 ± 4.3 **a**	3.5 ± 2.6 **ab**	13.9 ± 4.7 **a**	17.0 ± 4.8 **b**	69.1 ± 4.9 **ab**
	Denim® 16 ml	Sidewinder (SW) - Apr., '03	8	10.3 ± 5.4 **a**	2.4 ± 2.0 **a**	12.7 ± 5.6 **a**	10.2 ± 2.5 **ab**	77.1 ± 7.4 **b**
	Denim® 8 ml	STIT - Apr., '03	8	7.2 ± 1.9 **a**	3.9 ± 3.4 **ab**	11.0 ± 3.9 **a**	15.1 ± 4.2 **b**	73.9 ± 6.8 **ab**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	16.5 ± 3.5 **ab**	3.0 ± 0.9 **ab**	19.5 ± 4.2 **ab**	14.0 ± 3.0 **b**	66.5 ± 6.8 **a**
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	26.3 ± 11.2 **b**	6.3 ± 1.8 **bc**	32.7 ± 12.2 **b**	8.9 ± 2.2 **ab**	58.5 ± 11.9 **a**
	Asana® XL	Hydraulic Foliar 5X in '03	8	16.6 ± 4.1 **b**	8.8 ± 2.4 **c**	25.4 ± 5.3 **b**	11.1 ± 1.9 **b**	63.5 ± 6.0 **a**
	Check		8	19.4 ± 4.9 **b**	11.2 ± 2.0 **c**	30.6 ± 4.6 **b**	13.6 ± 2.8 **b**	55.8 ± 6.4 **a**
2003 **	Denim® 16 ml	STIT, AJ & SW - Apr., '03	24	9.6 ± 2.3 **a**	2.1 ± 1.1 **a**	11.7 ± 2.5 **a**	10.8 ± 2.0 **a**	77.5 ± 3.3 **b**
	Denim® 8 ml	STIT - Apr., '03	8	7.2 ± 1.9 **a**	3.9 ± 3.4 **ab**	11.0 ± 3.9 **a**	15.1 ± 4.2 **a**	73.9 ± 6.8 **ab**
	Fipronil 10 ml	AJ & SW - Apr., '03	14	20.7 ± 5.1 **b**	4.5 ± 1.1 **bc**	25.1 ± 5.8 **b**	11.8 ± 2.0 **a**	63.0 ± 6.2 **a**
	Asana® XL	Hydraulic Foliar 5X in '03	8	16.6 ± 4.1 **b**	8.8 ± 2.4 **cd**	25.4 ± 5.3 **b**	11.1 ± 1.9 **a**	63.5 ± 6.0 **ab**
	Check		8	19.4 ± 4.9 **b**	11.2 ± 2.0 **d**	30.6 ± 4.6 **b**	13.6 ± 2.8 **a**	55.8 ± 6.4 **a**

* Mortality or wounds caused by drought, pitch canker, squirrel, midge, or mechanical damage.

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

** Comparison after three Denim® 16 ml and two fipronil treatments were combined.

Table 10. Seed bug damage, seed extracted, and seed quality (Mean ± SE) from second-year cones of loblolly pine protected with systemic injections of emamectin benzoate (Denim®) or fipronil or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003.

Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Seed Bug Damage (%) Early (2nd Yr Abort)	Late	Total	Mean No. Seeds per Cone	Mean No. Filled Seed per Cone	Mean No. Empty Seed per Cone
2003	Denim® 16 ml	STIT - Apr., '03	8	1.1 ± 0.2 **ab**†	16.9 ± 3.9 **a**	18.0 ± 3.8 **a**	122.1 ± 10.4 **a**	93.3 ± 10.1 **a**	4.7 ± 0.7 **b**
	Denim® 16 ml	Arborjet (AJ) - Apr., '03	8	1.1 ± 0.3 **ab**	12.1 ± 3.1 **a**	13.2 ± 3.0 **a**	108.8 ± 5.7 **a**	89.1 ± 6.5 **a**	3.9 ± 0.5 **ab**
	Denim® 16 ml	Sidewinder (SW) - Apr., '03	8	0.7 ± 0.2 **a**	15.8 ± 3.9 **a**	16.5 ± 3.9 **a**	109.0 ± 5.7 **a**	85.9 ± 7.7 **a**	4.1 ± 0.8 **ab**
	Denim® 8 ml	STIT - Apr., '03	8	0.7 ± 0.3 **a**	14.2 ± 2.9 **a**	14.9 ± 3.0 **a**	107.5 ± 10.5 **a**	86.3 ± 10.0 **a**	4.4 ± 1.2 **ab**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	4.9 ± 1.5 **c**	15.5 ± 2.9 **a**	20.3 ± 3.7 **a**	100.8 ± 6.4 **a**	77.2 ± 7.5 **a**	3.1 ± 0.6 **ab**
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	9.2 ± 4.9 **c**	12.5 ± 2.6 **a**	21.7 ± 5.1 **a**	99.3 ± 15.8 **a**	75.9 ± 14.8 **a**	2.4 ± 0.5 **a**
	Asana® XL	Hydraulic Foliar 5X in '03	8	0.9 ± 0.3 **a**	14.3 ± 3.9 **a**	15.2 ± 3.9 **a**	109.5 ± 10.9 **a**	91.4 ± 12.3 **a**	3.0 ± 0.6 **ab**
	Check		8	4.3 ± 1.4 **bc**	16.9 ± 4.4 **a**	21.2 ± 4.0 **a**	99.6 ± 9.6 **a**	76.4 ± 9.8 **a**	3.3 ± 0.6 **ab**
2003 **	Denim® 16 ml	STIT, AJ & SW - Apr., '03	24	1.0 ± 0.1 **a**	14.9 ± 2.1 **a**	15.9 ± 2.0 **a**	113.3 ± 4.3 **a**	89.5 ± 7.3 **a**	4.2 ± 0.4 **b**
	Denim® 8 ml	STIT - Apr., '03	8	0.7 ± 0.3 **a**	14.2 ± 2.9 **a**	14.9 ± 3.0 **a**	107.5 ± 10.5 **a**	86.3 ± 10.0 **a**	4.4 ± 1.2 **ab**
	Fipronil 10 ml	AJ & SW - Apr., '03	14	6.7 ± 2.2 **b**	14.2 ± 2.0 **a**	20.9 ± 2.9 **a**	100.1 ± 7.4 **a**	76.7 ± 7.3 **a**	2.8 ± 0.4 **a**
	Asana® XL	Hydraulic Foliar 5X in '03	8	0.9 ± 0.3 **a**	14.3 ± 3.9 **a**	15.2 ± 3.9 **a**	109.5 ± 10.9 **a**	91.4 ± 12.3 **a**	3.0 ± 0.6 **ab**
	Check		8	4.3 ± 1.4 **b**	16.9 ± 4.4 **a**	21.2 ± 4.0 **a**	99.6 ± 9.6 **a**	76.4 ± 9.8 **a**	3.3 ± 0.6 **ab**

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.
** Comparison after three Denim® 16 ml and two fipronil treatments were combined.

Table 11. Mean % (± SE) cone and seed losses from insects (coneworms and seed bugs) and reductions in damage from second-year cones of loblolly pine protected with systemic injection of Denim® (emamectin benzoate), or fipronil, or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003.

				2003	
Year	Treatment	Application Technique & Rate & Treatment Date	N	Mean Combined Losses (%)	Mean Reduction (%)
2003	Denim® 16 ml	STIT - Apr., '03	8	23.7 ± 4.7 **a**†	42.5
	Denim® 16 ml	Arborjet (AJ) - Apr., '03	8	22.6 ± 5.8 **a**	45.0
	Denim® 16 ml	Sidewinder (SW) - Apr., '03	8	23.9 ± 6.2 **a**	41.8
	Denim® 8 ml	STIT - Apr., '03	8	21.8 ± 4.1 **a**	47.0
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	31.5 ± 5.2 **ab**	23.5
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	44.0 ± 10.9 **b**	-7.1
	Asana® XL	Hydraulic Foliar 5X in '03	8	34.4 ± 6.1 **ab**	16.5
	Check		8	41.1 ± 4.3 **b**	
2003 **	Denim® 16 ml	STIT, AJ & SW - Apr., '03	24	23.4 ± 3.1 **a**	43.1
	Denim® 8 ml	STIT - Apr., '03	8	21.8 ± 4.1 **a**	47.0
	Fipronil 10 ml	AJ & SW - Apr., '03	14	36.9 ± 5.5 **b**	10.4
	Asana® XL	Hydraulic Foliar 5X in '03	8	34.4 ± 6.1 **ab**	16.5
	Check		8	41.1 ± 4.3 **b**	

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

** Comparison after three Denim® 16 ml and two fipronil treatments were combined.

Figure 10. Percent survival and gain in survival of loblolly pine conelets protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX - 2003.

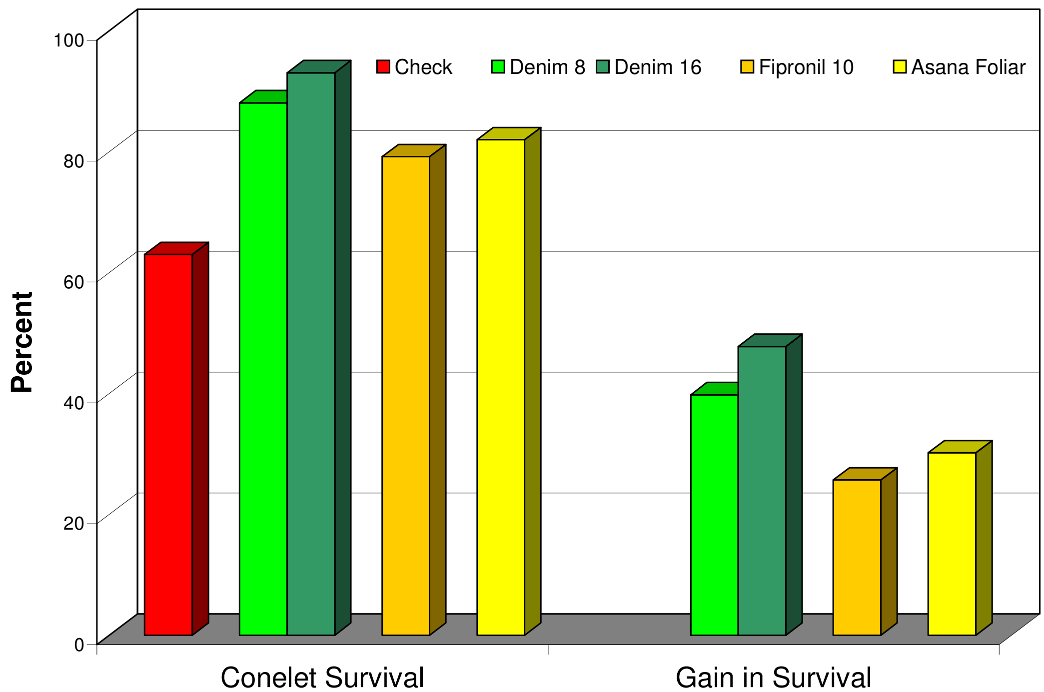


Figure 11. Percent survival and gain in survival of loblolly pine cones protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX - 2003.

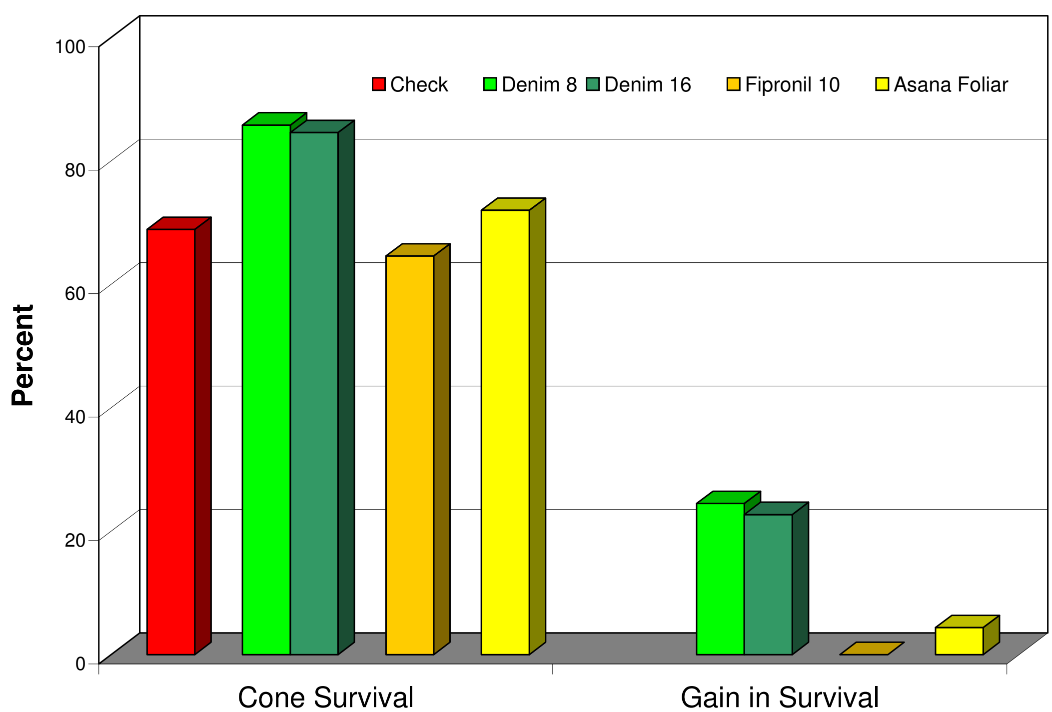


Figure 12. Percent coneworms (*Dyrictria* spp.) damage and reduction in damage on second-year loblolly pine cones protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX - 2003.

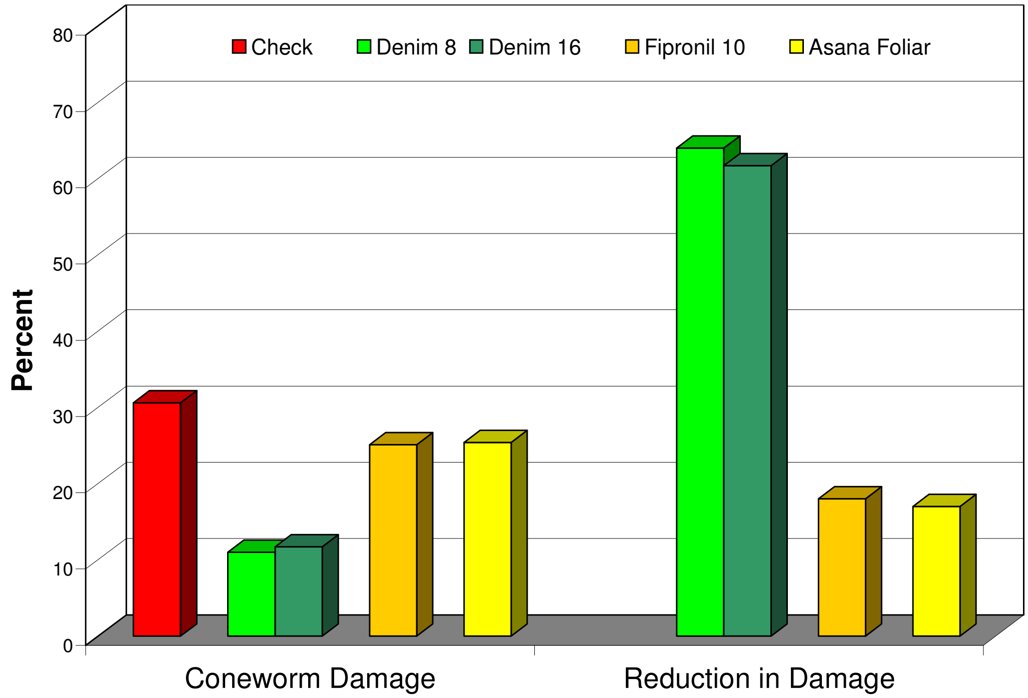


Figure 13. Percent seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) damage and reduction in damage on loblolly pine seed protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX - 2003.

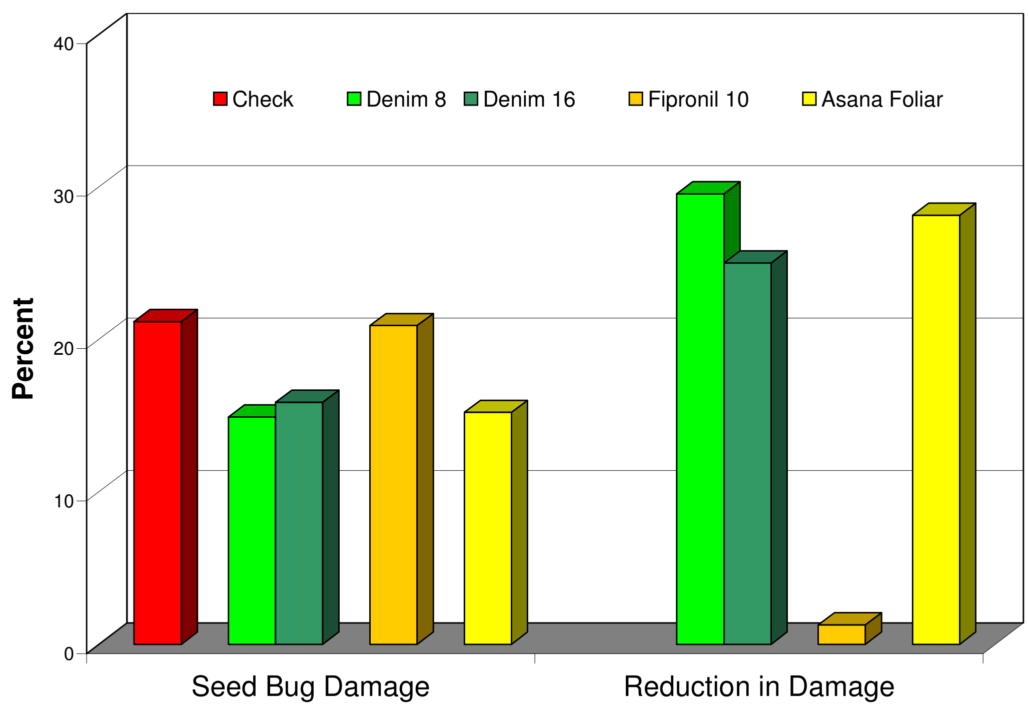
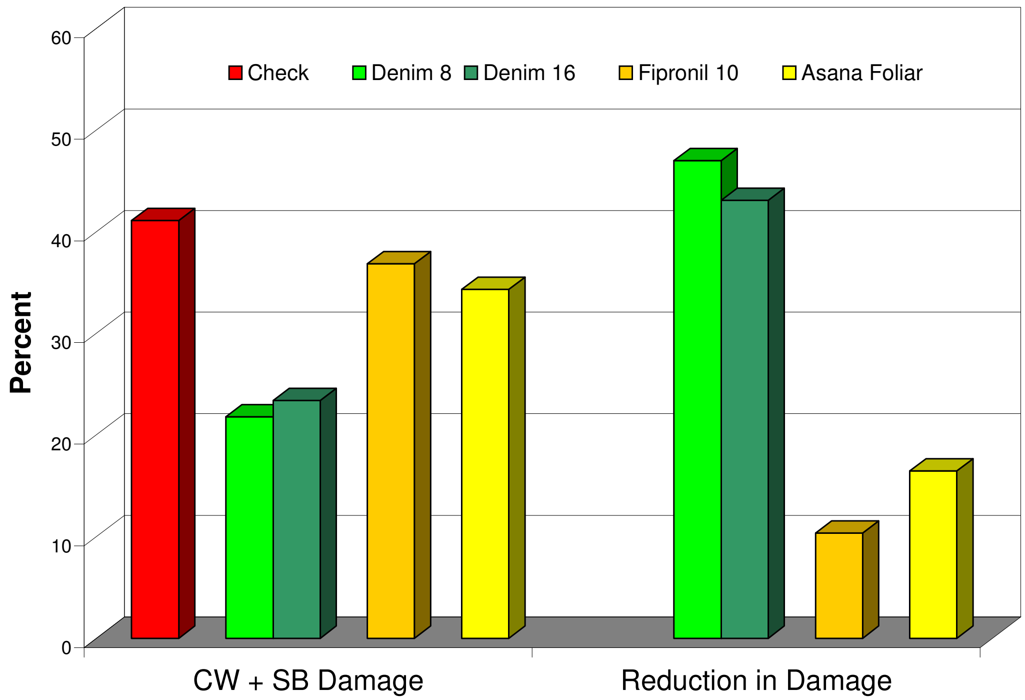


Figure 14. Percent combined losses from coneworms (*Dyrictria* spp.) and seed bug (*Tetyra* sp. and *Leptoglossus* sp.) damage and reduction in damage on loblolly pine cones and seed protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX - 2003.



SUPPLEMENT A
A Comparison of Three Tree Injection Systems

Objective: The objective of this study was to evaluate the effectiveness of three different tree injection systems for injection of Denim® (emamectin benzoate) into loblolly pine for control of various cone and seed insects.

Justification: Cone and seed insects may severely reduce potential seed yields in southern pine seed orchards that produce genetically improved seed for regeneration programs. Two of the most important insect pest groups are the coneworms (*Dioryctria* spp.) that attack flowers, cones and stems of pines and the seed bugs (*Leptoglossus corculus* (Say) and *Tetyra bipunctata* (Herrich-Schaffer)), that suck the contents from developing seeds in conelets and cones (Ebel et al. 1980). Without a comprehensive insect-control program, these insect groups commonly destroy 50% of the potential seed crop; 90% losses are not uncommon (Fatzinger et al. 1980).

The Western Gulf Forest Pest Management Cooperative's (WGFPMC) Systemic Insecticide Duration and Rate Studies have demonstrated that trunk injection of emamectin benzoate (Arise®), alone or in combination with thiamethoxam, is effective for protecting cones against coneworms and seed bugs (Grosman et al. 2002, see also 2001 and 2002 WGFPMC Systemic Injection Reports). These treatments provided >50% reduction in coneworm damage for four consecutive years (1999 –2002). Regression curves indicate that 10 ml of the emamectin benzoate and thiamethoxam per inch diameter at breast height (DBH) is necessary to maintain highest levels of reduction of coneworm and seed bug damage and provides the greatest gain in cone survival and filled seed per cone. Unfortunately, the Arise® formulation from Japan will not be registered for use in the United States due to the flammability of the carrier (Dave Cox, Syngenta Crop Protection, personal communication).

Syngenta recently (1999) registered emamectin benzoate (Denim®) with EPA in the United States for use against lepidopteran pests on cole crops. This formulation has not been tested for its efficacy against cone and seed insects in pine seed orchards.

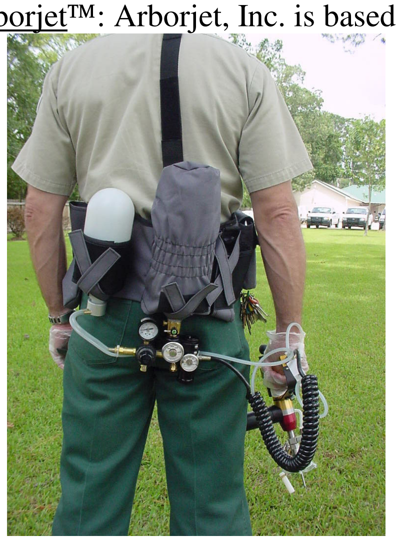
The injection or implant of systemic insecticides into drill holes on individual pine trees has been evaluated as an alternative to foliar applications, but with limited success. In loblolly and slash pines, the drilled holes necessary for insecticide application quickly fill with oleoresin released by the tree in response to the wounding (Don Grosman, personal observation). To bypass or overcome the resin response of pines, a pressurized systemic tree injection tube (STIT) was developed by Dr. Blair Helson, Canadian Forest Service (Helson et al. 2001). Trials conducted on loblolly pine showed that 50 ml of the Arise® formulation can be completely injected or pushed into a tree using the STIT injector in as little as 4 minutes (Don Grosman, unpublished data). A more recent test showed that 50 ml of undiluted Denim® can be injected using the STIT injector in 15 minutes.

The STIT injector has been successfully used to injecting high volumes of insecticide into loblolly pine. However, the system can have several limitations. The STIT injector is not manufactured, so considerable effort is required to make and maintain functional injectors. The effort and time required to load and clean each injector is considerable. Two manufactured injection systems are/will be available in 2003 – the Viper System by Arborjet™ and the Sidewinder™ Backpack System. With the possible registration of a systemic insecticide for protection of cones in pine seed orchards, seed orchard managers will be interested to know which system is easiest to use, safest to use, and most economical. The goal of this study was to compare several characteristics of three injection systems under operational conditions.

System Descriptions:

Systemic Tree Injection Tube (STIT): Dr. Blair Helson, Canadian Forest Service, provides a full description of the system (Helson et al. 2001). Basically, the system unit is composed of three main parts – a maple syrup spile, an 18” piece of 7/8” OD X 5/8” ID vinyl tubing, and a tire valve. These pieces are connected using adhesive and hose clamps. The cost is approximately $2.20 to produce each unit (not including labor). Each unit has a product capacity of 75 ml, but a maximum volume of 50 ml is recommended. To fill each unit, the tip of the spile is first plugged with a rubber cork. The valve stem is then removed from the tire valve. A 50 ml syringe (w/ 2 mm wide tip) is used to fill the unit through the tire valve opening. Lastly, the valve stem is reinstalled. When ready to inject, the applicator drills at least four holes (1 cm diameter and 7 cm deep) drilled horizontally (using a cordless or gasoline-powered drill) into each treatment tree about 30 cm above the ground. The final number of holes is based on the volume of insecticide determined for each tree divided by 50 ml (the capacity of the injector). After drilling the holes, the applicator should invert each injector unit so that the spile is on top. The rubber cork is removed and the spile tip is hammered into each drill hole until snug. The injector unit is rotated so that the tire valve is now above the spile. The spile is hammered again until it is firmly imbedded in the hole. The injector unit is pressurized to approximately 60 – 80 psi (= 4200 - 5600 gscm) using a bicycle pump or compressed air tank. After each injector has drained, the injector unit is depressurized, the stile is removed and the drill hole is plugged with a cork to reduce the chance of fungal invasion.

Arborjet™: Arborjet, Inc. is based in Winchester, MA. The system invented by Peter Wild, CEO, has just come out on the market in 2003 and uses the VIPER method (Volume Injection Pressure Enhanced Reservoir). The Arborjet™ compressed air system has several components, including the Arborjet™ injection device (‘gun’) with Viper needle and sheath and tree pressure gauge, regulators and tubing, 2 liter medicament bottle, compressed air/nitrogen tank (88 cu. in.), shoulder strap utility belt and holster, and Arborplug™. The gun has a shot- and dose-sizer designed to meter the amount of product applied (from 0 – 3 ml). At this time, the entire system can be purchased for $4,500 (the price is expected to come down sometime in the future). A detailed description of the VIPER methodology for injection of trees is provided on the Internet at



http://www.arborjet.com/docs/Arborjet_VIPER_Methodology.pdf. Briefly, the VIPER method consists of three basic steps: drill, plug and inject. The injection site is drilled using a 7/32 to 3/8" drill bit to a depth of ¾ to 5/8" "(the length of the Arborplug is ¾", the depth of setting the port is defined by the formula 5/8" + bark thickness) depending on tree type. The number of injection sites is largely dependent of the miscibility of the product formulation, but usually ranges from DBH/2 to DBH/3. Into each drill hole, an Arborplug™ is set to a specific depth with a setter tool and hammer. Once the plug is set, the device needle is inserted and the specified dosage is administered. Once the injection is complete, the needle is removed, but the internal septa in the plug keeps the applied dose in the tree. The injection plugs are left in the tree and eventually will be over grown. **Note:** Arborjet™ will soon offer two new systems; one is a manual system (special promotional offer for $749, normally $2,100) and the other a battery-operated system (available in the spring 2003).

Sidewinder™: This system has been developed over the past 14 years by Geoff Eldridge, Sidewinder Injector Systems, of Noosaville, Australia. The Sidewinder™ backpack system features a heavy duty 12-volt drill coupled to a hollow rotary injector nozzle assembly incorporating detachable drill bit and holder and a pressure gauge to allow control of injection pressure. The drill/injector is attached to a light-weight fiberglass shell (with military style harness) which houses a chemical injection pump, sealed 12-volt battery that powers the drill, and 1 – 5 liter chemical reservoir container. At this time, the entire system can be purchased for $1,170. A description of the Sidewinder™ injection methodology is provided on the Internet at http://www.treeinjectors.com/html/operation.html. Briefly, the Sidewinder™ method consists of three basic steps: drill, inject and plug. A drill bit holder (with a standard 6 mm drill bit) is engaged over nozzle. A hole is drilled square on to the tree surface to a depth of 1 – 2 inches. The drill bit holder is disengaged and the injection nozzle is screwed into tree's active xylem, leaving a few millimeters of thread exposed. The pump handle is raised and then depressed to force chemical product into the tree. Each stroke of the handle will inject 5 ml of fluid. When sufficient product has been injected, the pressure is allowed to drop to zero, the drill is reversed and the nozzle is unscrewed. The tip and drive lug of plastic sealing plug is placed in the slot in the end of injection nozzle and the plug is screwed into the injection hole. Eventually, the tree will overgrow the plug.

Research Approach:

The comparison trial was conducted at the Texas Forest Service Magnolia Springs Seed Orchard in a block containing 10-year old drought-hardy loblolly pine. This orchard section has not been treated with insecticides since it was established. In spring 2003, 3 ramets from each of 8 to 10 loblolly clones were selected. The treatments included:

1) 1.9 % emamectin benzoate (Denim®) by STIT injector at 16 ml per inch diameter at breast height (DBH)
2) 1.9 % emamectin benzoate (Denim®) by Arborjet™ injector at 16 ml per inch diameter at breast height (DBH)
3) 1.9 % emamectin benzoate (Denim®) by Sidewinder™ injector at 16 ml per inch diameter at breast height (DBH)

As part of a study to evaluate the efficacy of the Denim® formulation of emamectin benzoate, the injection treatments were applied using the STIT, Arborjet™ or Sidewinder™ injection system to selected ramets in April 2003. Because conditions were extremely dry in April, a second trial was conducted in early June just after a heavy rain. For both trials, six centimeter deep holes (1 cm dia. for STIT and Arborjet™; 6 mm dia. for Sidewinder™) were drilled into each treatment tree approximately 30 cm above the ground. Each tree had at least four injection points (at cardinal directions).

Results:

The initial comparison trial was started at 12 noon on April 3rd. However, because no rain had fallen for 9 days (since March 25), injections using the Arborjet™ and Sidewinder™ were very slow and/or resulted in several failures (significant leaks and/or ruptures). A second effort starting at 12 noon on April 9 showed similar results compared to April 3. It was suggested by Joe Doccola (Arborjet™, personal communication) that during hot and/or dry periods, the stomata in the foliage of pine and other trees tend to be open in the early morning. Injections during the period when stomata are open may result in better uptake of chemical products. Subsequent injections on April 15, 22 and 28 from 7:00 AM to about 10:00 AM generally resulted in faster injection rates and fewer failures. Overall, injection times and rates for the STIT and Arborjet™ injectors were similar (Table 13). However, the STIT injectors almost never leaked; whereas, there were leaks (minor and major) around one or more Arborplug™ of every injected tree. Also, on occasion, if the Arborplug was not set well, the injection resulted in the separation of the phloem from the xylem and sometimes caused the bark to split and loss of the chemical.

The average injection rate for the Sidewinder™ (9.8 ml/minute) was about 50% faster compared to the other two injectors, but like the Arborjet™, there were frequent leaks and/or ruptures around the injection nozzle. For both the Arborjet™ and Sidewinder™, if leaks began, they were essentially impossible to stop and usually got worse. Often, if a heavy leak began, it was better to stop injecting and try a new injection point. As a result, eight or more injection points (on average) were needed for the Arborjet™ and Sidewinder™ while the STIT never needed more than four injection sites (Table 12).

Because of the difficulties experienced with the Arborjet™ and Sidewinder™ during the dry period in April, a second comparison trial was conducted after a heavy rain in mid-June, 2003. Overall, the injection times decreased and injection rates increased for all three injection systems. However, the STIT showed the greatest improvement during the wet period; injection time decreased by 60%

Table 12. Comparison of injection times and rates of three injection systems for loblolly pine during dry and wet conditions at Magnolia Springs Seed Orchard, Kirbyville TX - 2003.

Injection Method	Injection Period	Moisture & Temperature Conditions	No. of Trees Injected	Mean DBH	Mean Injection Volume	Mean No. of Injection Points	Mean Injection Time	Mean Injection Rate (ml/min.)
STIT	April 9 - 15	Dry, 71°F	10	11.7	195	4.0	32.7	6.6
Arborjet	April 3 - 28	Dry, 72°F	8	11.1	178	9.9	30.6	6.3
Sidewinder	April 15 - 28	Dry, 74°F	8	12.7	205	7.9	24.3	9.8
STIT	June 13	Wet, 80°F	10	10.4	166	-----	13.1	12.7
Arborjet	June 13	Wet, 80°F	7	10.1	161	-----	22.4	7.3
Sidewinder	June 13	Wet, 80°F	10	10.6	169	-----	17.8	10.1

and injection rate increased by 92% (Table 12). Again, the STIT injector almost never leaked, whereas the Arborjet™ and Sidewinder™ still leaked on occasion, but not nearly to the extent observed during the dry period. Also, the rupturing observed with the Sidewinder™ during the dry period became much less frequent during the wet period.

Table 13 shows a comparison of the three tested injection systems relative to ten criteria (manufacturing, company experience and location, cost of system, chemical product loading, power and pressure supplies, system installation, product injection, potential for chemical exposure, system cleaning, and restrictions related to soil moisture conditions). Each criterion had a value of 6 points. These points were divided among the three injection systems with the "best" system receiving the majority of the points for a given criterion.

The Sidewinder™ system had the highest number of points (25) based on the fact it is manufactured (usually an assurance of good quality) and has been proven in the field for the past 14 years. Also it is easy to load product, has convenient and cheap power supplies, is easy to install on a tree, has a consistent injection rate (10 ml/minute) under dry and wet conditions, and is easy to clean. Some important limitations include a moderate risk of exposure to chemicals being loaded or injected and problems with injections during dry periods (ruptures are common under dry conditions).

The Arborjet™ system was second with 20 points. Some attractive features include the fact that it is also a manufactured system with very good and local support, it is easy to load chemical product, and there is little potential for exposure to chemical. Some limitations may include the fact that this is a new system that is still being proven in the field, the cost is high ($4,500), the injection rate was lowest (6 ml/minute) among the systems, and plug failures (leaks) were fairly common, particularly during dry periods.

The STIT system received the fewest points (15), but it does have some attractive features which include being very cheap to make, having the highest injection rate (13 ml/minute) under wet conditions, can treat a number of trees at the same time, and generally is not restricted by soil moisture conditions. This system does have some limitations. Considerable time and effort is involved in the making, loading and cleaning of the injection units. Since this is not a manufactured system, there is no product support and the quality of the product is dependent on person(s) assembling the injector units.

Conclusions:

All three injection system were found to be operationally effective in the injection of Denim® (emamectin benzoate) into loblolly pine. However, the seed orchard manager needs to consider several factors (cost, convenience, injection rate, safety, etc.) before selecting a system to use. The development of new and/or improved injection systems is anticipated in the near future with the realization that protection of trees and crops with systemic chemicals is an economically viable option. Already, Arborjet™ is about to release two new less expensive systems – manual and battery-operated. Also, up to four Sidewinder™ systems can be connected to a compressed air injector pump on a single tractor or any other suitable mobile power source (not tested) to improve treatment efficiency. Lastly, Dr. Blair Helson reported that he is currently in negotiations with a company to manufacture his STIT concept (personal communication).

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Table 2. Comparison of Three Injection Systems for Possible Use in Pine Seed Orchards.

	Systemic Tree Injection Tube (STIT)	Pts	Arborjet	Pts	Sidewinder	Pts
1) System manufactured?	No	0	Yes	3	Yes	3
Pros			System premade (product quality expected to be good); product support available		System premade (product quality expected to be good); product support available	
Cons	Must make injection units by hand (product quality questionable); no support		System still being developed			
2) Company experience and location	NA	0	Arborjet	3	Sidewinder	3
Pros	--------		U.S.-based (easy to contact); response quick		Established (developed and used during past 14 years)	
Cons	--------		New (developed in last 3 years)		Australia-based (not easy to contact); response slower	
3) Cost	$2.20 / injection unit (does not include labor costs)	4	$4,500 for Arborjet's hydraulic high production system (**Note:** a manual Arborjet system is now available for $2,100, but not tested)	1	$1,170 for Sidewinder's manual backpack system (**Note**: system can be modified to allow use of multiple injectors w/ inbuilt air compressor; increasing cost to $3,770)	1
Pros	Low cost					
Cons			Moderate to high initial cost		Moderate to high initial cost	
4) Loading injectors with chemical product	Product must be hand-loaded into each injector unit; requires installing rubber cork in stile opening, removing tire valve, loading with predetermined amount of product, and reinstalling tire valve [total time per 1 liter (20 injectors) = ~20 minutes].	1	Injector belt can holds 2-liter product reservoir tank [total time to load 1 liter = ~2 minutes].	2.5	Backpack can hold 1-, 2- or 5-liter product reservoir bottles [total time to load 1 liter = ~1 minute].	2.5
Pros	Know exactly how much product is going into each injection point.		Easy to load; has shot- and Dose-sizer to meter amount of product applied.		Very easy to load; potential to treat over 100 trees with a single load (5 liters). Pump set to deliver 5 ml per handle stroke.	
Cons	Labor intensive, time consuming					

Table 2 cont. Comparison of Three Injection Systems for Possible Use in Pine Seed Orchards.

	Systemic Tree Injection Tube (STIT)	Pts	Arborjet	Pts	Sidewinder	Pts
5) 'Power Supplies'	Cordless drill w/ batteries & compressed air/CO_2 tanks (to create pressure)	1	Cordless drill w/ batteries & compressed air/nitrogen tanks (to create pressure). **Note:** Manual system available, but not tested.	2.5	2 - 12 volt batteries (to power drill) carried in backpack & arm strength (to create pressure) **Note:** Compressed air system available, but not tested.	2.5
Pros	Batteries - can be charged anywhere. Air Tanks - Can use large or small compressed air tanks which can be filled by electricity or at dive shops; little pressure needed, so air supply can last a week or more before refill is required.		Batteries - can be charged anywhere. Air Tanks - air supply/pressure can last 2 -3 full days before refill is required; air tank carried on belt.		Batteries - can be charged anywhere and last several days. Arm strength - cheap power; amount of pressure is easily regulated.	
Cons	Batteries - charge drains quickly. Large Air Tanks - more difficult to move around orchard.		Batteries - charge drains quickly. Air Tanks - Must used small air/nitrogen tank; only can fill at dive shops; must take off belt to adjust pressure to system (somewhat inconvenient).		Arm fatigue may set in	
6) Installation of unit on tree	Drill 3/8" dia. & 3 inch deep hole horizontally into tree trunk at 3 ft above ground. Invert injector unit, remove rubber plug from stile opening, tap stile into drill hole until snug, rotate injector 180 degrees, hammer stile until firmly imbedded into hole. [total time per injector = ~30 seconds to 1 minute]	1.5	Drill 3/8" dia. & 3 inch deep hole horizontally into tree trunk at 3 ft above ground. Insert plug at drill hole opening, hammer plug into hole until firmly imbedded. Insert needle of viper 'gun' through plug. [total time per injection point = ~30 seconds to 1 minute]	1.5	Drill 7/32" dia. & 2 inch deep hole horizontally into tree trunk at 3 ft above ground. Drill in threaded injector nozzle into hole. [total time per injection point = ~10 - 15 seconds]	3
Pros	Fairly quick and easy to install; depth of installation not critical		Fairly quick and easy to install		Very quick and easy to install; drill is part of the injection system; wound site (drill hole) is small	
Cons	Drill not part of injection system; wound site (drill hole) fairly large		Drill not part of system; wound site (drill hole) fairly large; care must be taken to drill hole and install plug horizontally otherwise chemical product may leak around plug; can be difficult to determine optimal depth to install plug		Can be difficult to determine optimal depth to drill in injector nozzle; care must be taken to drill hole and install injector nozzle horizontally otherwise chemical product may leak around nozzle.	

Table 2 cont. Comparison of Three Injection Systems for Possible Use in Pine Seed Orchards.

	Systemic Tree Injection Tube (STIT)	Pts	Arborjet	Pts	Sidewinder	Pts
7) Injection of Product	Pressurize injector unit to 70 - 80 psi. Wait until product has drained from injector into tree. Depressurize and twist off injector. Insert cork plug into injection hole. [total time per injector = ~10 - 30 minutes]	3	Depress trigger to fire product into injection chamber. Hold injector in place and continue firing injector until predetermined volume has been forced into tree. Remove needle. [total time per injection point = ~2 - 6 minutes]	1	Depress pump handle to push product into tree. Reverse drill and remove injector nozzle. Install threaded plug. [total time per injection point = ~1 - 6 minutes]	2
Pros	Once injector is pressurized, can go and install other injectors on same tree or other trees; leaks around stile are very rare. Injection rate low to high (avg. ~7 (dry) - 13 (wet) ml/min.; range: 4 - 18 ml/min.)		Injection rate can be moderate (avg. ~6 - 7 ml/min.; range: 4 - 10 ml/min.)		Injection rate moderate (avg. ~10 ml/min. (dry & wet); range: 5 - 15 ml/min)	
Cons			Can only inject at one site at a time; too much pressure on pine (> 300 psi) can result in separation of bark from wood or leaks or ruptures around plug. Injection rate can be low (avg. 6 - 7 ml/min.; range: 4 - 10 ml/min.)		Can only inject at one site at a time; too much pressure on pine (> 300 psi) can result in separation of bark from wood or leaks or ruptures around nozzle.	
8) Potential for exposure to chemical product	Moderate	1.5	Little	3	Moderate	1.5
Pros	Chemical can be loaded into units in lab under controlled conditions		One step process to transfer chemical to reservoir. Exposure during injection process unlikely.		One step process to transfer chemical to reservoir.	
Cons	Loading is two step process for each injection unit: draw product into a 50 ml syringe and then transfer to injector unit. Exposure also possible when removing rubber plug prior to installing injector unit on tree.		Potential for exposure 1) when initially priming injection system.		Potential for exposure: 1) when initially priming injection system; 2) when removing injector nozzle from tree (if pressure still present, chemical can quirt out hole; 3) in between injections, must hold drill/injector nozzle up, otherwise chemical will drain out nozzle.	

Table 2 cont. Comparison of Three Injection Systems for Possible Use in Pine Seed Orchards.

	Systemic Tree Injection Tube (STIT)	**Pts**	**Arborjet**	**Pts**	**Sidewinder**	**Pts**
9) Cleaning injectors	Each injector unit needs to be cleaned after each use; requires removing tire valve, flushing with water or other solvent and reinstalling tire valve (total time for 20 units = 20 minutes).	1	Injector system can be cleaned at end of day with water or other solvent [total time = ~10 minutes]. More extensive cleaning required periodically.	2	Injector system can be cleaned at end of day with water or other solvent [total time = ~10 minutes].	3
Pros	Cleaning is easy		CD or video available to show and/or explain process to clean system.		Cleaning is easy	
Cons	Labor intensive, time consuming		Injector system complex so more extensive cleaning can be time comsuming			
10) Soil moisture conditions restrictions?	No	3	Yes	1.5	Yes	1.5
Pros	High moisture conditions (after heavy rain) preferred, but not necessary.					
Cons			High moisture conditions (after heavy rain) almost essential to inject throughout day. Under dry conditions, only can get moderate uptake when stomates of plant are open, i.e., early morning.		High moisture conditions (after heavy rain) almost essential to inject throughout day. Under dry conditions, only can get moderate uptake when stomates of plant are open, i.e., early morning.	
Total Points	**Systemic Tree Injection Tube (STIT)**	**16.0**	**Arborjet**	**21.0**	**Sidewinder**	**23.0**

SUPPLEMENT B
Potential Forestry Market Areas for Emamectin Benzoate (EB)

Nematodes

Pine wood nematode – This nematode causes extensive mortality of exotic pines (Scotch) planted in the mid-west (Kansas). Applications of EB (Arise) in Japan have provided 4+ years of protection against pine wood nematode. EB could be used to protect exotic pines in the U.S.

Lepidoptera

Denim® (1.92% EB) is registered with EPA for use on cole crops for control of several lepidopteran pests.

Coneworm (*Dioryctria* spp.) – This insect group causes extensive cone mortality in conifer seed orchards in the southeastern and western U.S. In east Texas, coneworm caused 25 – 35% cone mortality from 1999 – 2002. There are about 2,000 acres of seed orchards in the southeastern states. The majority of the trees are loblolly pine. Recent trials (1999 – 2003) showed that EB, applied by STIT injector at about 10 ml/inch DBH, can reduce coneworm damage by >90% for 3 years and by and average of 80% over 5 years (D. Grosman, unpublished data). EB may also be used to protect cone crops on Ponderosa pine, Douglas fir, and other conifer species in the western U.S.

Given the results indicated above for coneworms, it seems likely that EB would show similar activity against other lepidopteran pest of trees including tip moth, gypsy moth, clear wing borers, forest tent caterpillar, etc.

Forest Tent Caterpillar (*Malocosoma disstria*) – This is a native insect that has periodic outbreaks on oak and other hardwoods. Mortality of foals in Kentucky recently was linked to local outbreaks of forest tent caterpillar. Injections of EB in 2003 were found to be highly effective in reducing defoliation by this insect (Dave Cox, Syngenta, personal communication).

Gypsy Moth (*Lymantria dispar*) – An exotic species introduced in Massachusetts in the 1800's has spread west to the Great Lakes and south to North Carolina. Defoliation of trees (oaks, maple) for 3 or more years can result in mortality. Given the proven effects on forest tent caterpillar, residential trees would likely be protected from gypsy moth with injections of EB. Trials are needed to confirm this hypothesis.

Pine Tip Moth (*Rhyacionia* spp.) - Tip moth is a significant pests in Christmas tree plantations. In addition to causing reduced growth, tip moth larvae cause cosmetic damage that reduce the aesthetic appearance of trees. Trees to be harvested and sold as Christmas trees could be injected in the spring prior to harvest.

Clearwing borers (*Parathrene dollii* and *P. tricinicta*) and the cottonwood twig borer (Gypsonoma haimbachiana) – These borers cause serious losses in cottonwood plantations.

There are a number of other lepidopteran defoliators and borers that periodically become pests in the South and may be affected by EB. They include the linden looper (*Erannis tiliaria*), eastern oak looper

(*Phigalia titea*), eastern tent caterpillar (*Malscosoma americanum*), elm spanworm (*Ennomos subsignarius*), fall cankerworm (*Alsophila pometaria*), spring cankerworm (*Paleacrita vernata*), fall webworm (*Hyphantria cunea*), oakworms (*Anisota senatoria*, *A. virginiensis*, and *A. stigma*), variable oakleaf caterpillar (*Heterocampa manteo*), poplar tentmaker (*Clostera inclusa*), walnut caterpillar (*Datana integerrima*), yellownecked caterpillar (*Datana ministra*), whitemarked tussock moth (*Hemerocampa leucostigma*), carpenterworm (*Prionoxystus robiniae*), and bagworm (*Thyridopteryx ephemeraeformis*).

Coleoptera

Asian Longhorned Beetle (ALB) – Exotic beetle introduced near New York City, Chicago, and most recently in Jersey City. Preliminary trials conducted by Dr. Therese Poland (USFS) involved gravimetric injection of EB using the Shot Wan dispensers. The results indicated significant larval mortality, but not adult mortality (personal communication). EB efficacy did not differ from imidacloprid, which showed slightly better protection. Dr. Poland is unsure of the actual volume of EB introduced into the trees. Additional injections using a pressurized injector (STIT, Arborjet™ or Sidewinder™) would insure that the full volume is injected and may provide improved results.

Emerald Ash Borer (EAB) – This exotic insect was recently discovered attacking ash in Michigan. It may be possible to inject trees to protect them for 3-4 years. Trials are needed to determine if EB has activity against EAB.

Red Oak Borer (ROB) - This insect has recently killed thousands of red oak trees in northern Arkansas and southern Missouri. It may be possible to inject residential trees and protect them for 3-4 years. Trials are needed to determine if EB has activity against ROB.

Pales Weevil (*Hylobius pales*) – Pales weevils are known to vector the pathogen that causes procerum root disease on white pine. The weevil breeds in the stumps of trees harvested as Christmas trees. In August 2002, white pine in Virginia were injected (Arborjet™ system) with EB at 4 ml/inch DBH. Four weeks later, branch segments from these trees were presented to 20 individual weevils in separate petri dishes. All weevils died within 6 days while all check weevils survived (Jeff Fidgeon, Virginia Tech, unpublished data). Weevil populations and occurrence of procerum root disease may be reduced if trees in Christmas trees plantations were injected with EB 2-3 months prior to harvest.

Southern pine Beetle (*Dendroctonus frontalis*) – This insect kills millions of pine trees each year in the southern U.S. SPB outbreaks frequently move into urban areas. Given the duration of EB in loblolly pine (shown for coneworm) and the apparent activity against weevils, it may be possible to inject residential trees at the beginning of an area outbreak and protect them against SPB for the duration of the outbreak (3-4 years). Trials are needed to determine if EB has activity against SPB.

If effective against SPB, individual trees could be protected against several other *Dendroctonus* bark beetle species including black turpentine beetle (*D. terebrans*), red turpentine beetle (*D. valens*), mountain pine beetle (*D. ponderosae*), western pine beetle (*D. brevicomis*) and spruce beetle (*D. rufipennis*); numerous *Ips* engraver beetles (*Ips* spp.); and cone beetles (*Conophthorus* spp.).

2001 - 2003 Tip Moth Impact Study – Western Gulf Region

Highlights:

- Nantucket pine tip moth damage levels on first-year check trees were moderate (12%) in 2003 compared to the high (22%) in 2001 and low (7%) in 2002. Damage levels on second-year check trees in 2003 were lower (15%) than in 2002 (22%).
- Periodic applications of Mimic® to first-year pine seedlings in 2003 reduced tip moth infestation levels by 90% compared to untreated trees. The treatment was less effective on second-year trees, reducing damage by 75%.
- Third-year trees, previously treated with Mimic®, maintained growth gains in height (10%), diameter (17%) and volume (38%) even without additional treatments in 2003. Mimic® treatments also reduced incidence of forking by nearly 31% compared to check trees.
- There was no significant gain in growth (height, diameter or volume) as a result of Mimic® treatments on two-year old seedlings.
- The exclusion of tip moth on treated trees in first-year sites in 2003 improved mean height by 13%, diameter growth by 14%, and volume index by 25% compared to check trees.

Objectives: 1) Determine the impact of Nantucket pine tip moth infestation on height and diameter growth and form of loblolly pine in the Western Gulf Region and 2) identify a treatment threshold for pine tip moth infestation.

Study Sites: Most WGFPMC members had established 2 to 3 impact study sites by 2003. In most plantation sites, two areas were selected and divided into 2 plots each, with each plot containing 126 trees (9 rows X 14 trees). Tip moth populations were monitored on TFS sites in East Texas.

Population Monitoring: Tip moth populations were monitored in the Lufkin area by placing 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at each of 7 sites. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early December 2002, and monitored until end of 2003. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticide:
Mimic® 2F (tebufenozide) - molting stimulant specific to Lepidoptera.

Design: 19 sites X 1-2 plots X 2 treatments X 50 trees = 3400 monitored trees.

Treatments:
1) Mimic® 2F applied once per generation at 0.08 oz / gal.
2) Check

Application Methods: Treatments were randomly assigned to each plot pair at the establishment of each site. Pesticides were applied by backpack sprayer or spray bottle to all 126 trees within the designated Mimic® plot (treatment area) on first- and second-year sites. Application dates were based on Fettig's optimal spray period predictions for locations near each study site (Fettig et al. 2003), generally every 7-8 weeks starting in late February and ending in late August.

Tip Moth Damage Survey: Tip moth infestation levels were determined in each plot by surveying the internal 50 trees within each plot during the pupal stage of each tip moth generation for the first two years after establishment. Each tree was ranked on the extent of tip moth damage including: 1) tree identified as infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated, and 3) separately, the terminal was identified as infested or not. Trees also were surveyed a final time in November. At this time, data also were collected on tree height and diameter at 6 inches above the ground. Tree height, diameter at breast height (DBH) and form data were collected on third-year sites. Tree form was evaluated based on number of forks occurring on each tree: 0 = no forks, 1 = one fork, 2 = two to four forks and 3 = five or more forks. A fork is defined by the presence of a lateral branch that is more than half the diameter of the main stem at its base.

Results: Figure 15 shows the mean number of pine tip moths captured in traps per day at several one- to three-year-old sites surrounding Lufkin, TX from 1999- 2003. For the fifth year in row, trap catches in the Lufkin, TX area indicate four full generations with at least a partial fifth generation developing late in the summer. The optimal spray periods in east Texas (near Lufkin) for the first four generations are predicted to be March 22-26, May 21-25, July 10-14, and Aug 19-23 (Fettig et al. 2003). Based on previous years' trap data (Fig. 15), a fifth spray period was calculated to be September 29 to October 3. In contrast, optimal spray periods for southern Arkansas sites (near Crossett) are April 6-10, June 5-9, July 30-August 3, and Sept. 13-17.

Figure 16 shows the distribution of the 32 first-, second- and third-year impact study sites in the Western Gulf Region.

<u>Group 1 - Third-year sites (15)</u>:
Nearly ¾ of the third-year Mimic®-treated plots still showed significantly greater tree height and volume growth compared to the neighboring untreated trees (Figs. 17 & 18). After three years, the height, diameter, and volume of Mimic®-treated trees have been improved by 10%, 17%, and 38%, respectively, compared to check trees (Table 16). Individually, only 2 of 14 sites showed significant differences in forking levels between the two treatment plots (Fig. 19). Overall, Mimic® treatments significantly lowered the proportion of trees with forks by nearly 31% compared to check trees.

<u>Group 2 - Second-year sites (7)</u>: Overall, tip moth infestation levels on untreated second-year trees was generally lower (15% shoots and 31% terminals) in 2003 compared to 2002 (22% shoots and 31% terminals) (Table 14 & 15). Unfortunately, protection of second-year trees during the second generation was relatively poor with Mimic®, only reducing shoot and terminal damage by 42% and 26%, respectively. This, combined with only moderate reductions during the second (68%) and third (59%) generations of the first year, may explain why only one of the seven sites showed significant gains in height (two for volume) after two years of Mimic® sprays (Figs. 20 & 21, Table 16). Overall, after two years, the height of Mimic®-treated trees was only improved by 1% compared to check trees (Table 16). The overall diameter and volume were 1 and 2% greater for check trees than for Mimic®-treated trees.

<u>Group 3 - First-year sites (10)</u>: Overall, tip moth infestation levels on untreated first-year seedlings were moderate (12% of shoots and 20% of terminals) in 2003 compared to the high (22% of shoots

and 34% of terminals) in 2001 and low (7% of shoots and 15% of terminals) in 2002 (Table 14 & 15). Mimic® protection was not great (50%) during the first generation, but it was excellent (94% on average) for the remaining generations. Mimic®-treated trees on five of 10 sites showed significant gains in height and volume compared to untreated check trees (Figs. 22 & 23). Overall, Mimic®-treated seedlings saw gains in height, diameter and volume of 13%, 14% and 25%, respectively, compared to check trees (Table 16).

Figures 24, 25 & 26 show the cumulative effects of Mimic® treatments on height, diameter and volume growth, respectively, for all sites from 2001 and 2003. It is apparent from the data collected so far that the differences in height, diameter and volume between treated and untreated trees became greater with each year even after Mimic® treatments were discontinued.

Summary: Overall, tip moth populations and damage levels had gradually declined over the past three or more years, but appear to have stabilized somewhat in 2003. Multiple applications of Mimic® significantly reduced tip moth infestation levels on both Group 2 and Group 3 sites in 2003. Whereas, Mimic® treatments did significantly improve tree growth on first-year sites in 2001 and 2003 and second-year sites in 2002, they did not improve tree growth on first-year sites in 2002 or second-year sites in 2003. One reason may be that tip moth populations were too low (below some threshold) to impact the growth of untreated trees on first and second-year sites in 2002 and 2003, respectively. In contrast, tip moth populations were apparently high enough on second-year sites to significantly impact growth of unprotected trees. It is conservatively estimated that yearly mean tip moth damage levels (percent shoots infested) need to exceed 10% before there is a significant impact on tree growth in a given year.

Fettig (et al. 2000) concluded that tip moth damage occurring during the first generation has the greatest impact on growth. This may be true on second-year sites when first generation damage is fairly high. However, very little damage has occurred recently in the Western Gulf region on first year sites during the first generation: 1) because the moth is just beginning to colonize the area and populations are very low, and 2) the first flush of growth after transplant is much shorter than future flushes. During the first year, the effects of second and third tip moth generations appear to be most crucial. This conclusion is supported by the fact that Group 2 trees in 2002 had good protection (85% reduction) from Mimic® during the first generation, while only moderate protection (68% and 59% reduction) was obtained during the second and third generations, respectively. The result was that the treatments over the course of the year had no impact on tree growth. In contrast, Group 3 trees had relatively poor protection (49% reduction) during the first generation, but excellent protection during the second and third generation (90% reduction for both generations). The result was significant growth gains with Mimic® treatments. Regression analysis is on going to determine the damage threshold for impact on tree growth. Also, analysis will attempt to determine the relationship between time and extent of tip moth protection and tree growth.

Given the disparity in tip moth population levels over the past three years, it is suggested that additional impact sites be established in 2004. Also, it is important to continue treatments on second-year sites and monitor tip moth damage and impact on third-year sites in 2004.

References:

Fettig, C.J., K.W. McCravy and C.W. Berisford. 2000. Effects of Nantucket pine tip moth insecticide spray schedules on loblolly pine seedlings. So. J. Appl. For. 24(2):106 – 111.

Fettig, C.J., J.T. Nowak, D.M. Grosman and C.W. Berisford. 2003. Nantucket pine tip moth phenology and timing of insecticide spray applications in the Western Gulf region. USDA Forest Service So. Res. Stat. Res. Pap. SRS-32. 13p.

Figure 15. Mean number of pine tip moth adults captured per trap per day near Lufkin, TX (1999 – 2003).

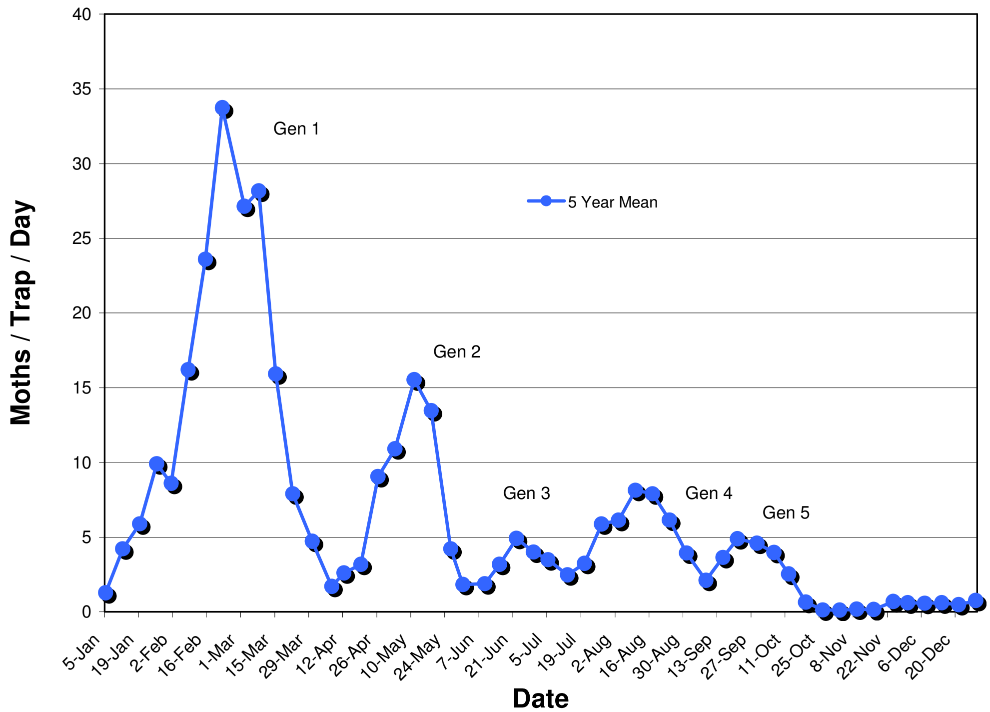


Figure 16. Distribution of 32 one-, two- and three-year old impact sites in the Western Gulf Region – 2003.

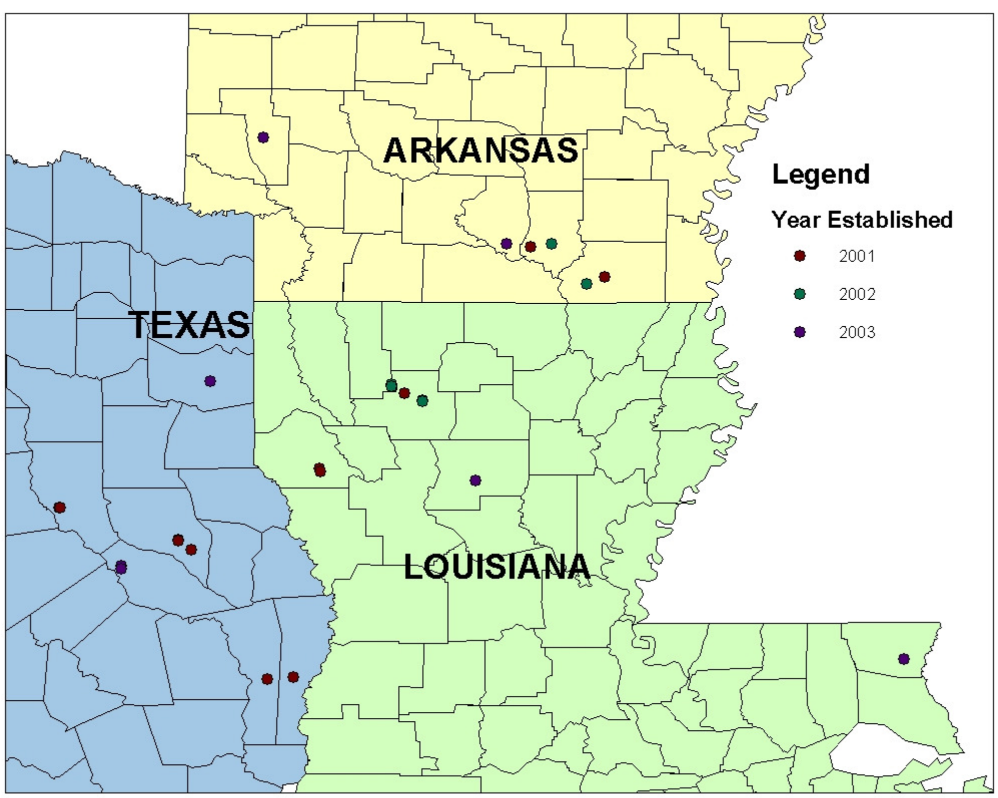


Table 14. Mean percent (± SE) of loblolly pine shoots (in top whorl) infested by Nantucket pine tip moth on one- and two-year old loblolly pine trees following treatment with Mimic® after the each of 5 generations; Arkansas, Louisiana and Texas sites - 2001 - 2003.

Age	N Plots	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Average	% Reduction
2001								
Year 1 (planted 2001)								
Mimic	16	0.29 ± 0.11	1.58 ± 0.35	3.12 ± 0.42	2.23 ± 0.44	1.46 ± 0.38	1.74	**92**
Check	16	4.60 ± 0.59	23.00 ± 1.21	21.88 ± 1.18	34.29 ± 1.50	28.01 ± 1.42	22.36	
% Reduction		**94**	**93**	**86**	**93**	**95**		
2002								
Year 1 (planted 2002)								
Mimic	7	0.55 ± 0.25	2.59 ± 0.57	1.81 ± 0.46	1.73 ± 0.47	0.94 ± 0.30	1.52	**80**
Check	7	3.60 ± 0.74	8.00 ± 1.19	4.37 ± 0.73	10.90 ± 1.23	10.52 ± 1.19	7.48	
% Reduction		**85**	**68**	**59**	**84**	**91**		
Year 2 (planted 2001)								
Mimic	16	1.77 ± 0.31	1.85 ± 0.29	3.47 ± 0.40	6.19 ± 0.57	5.61 ± 0.61	3.78	**83**
Check	16	12.12 ± 0.77	16.78 ± 0.93	11.48 ± 0.76	32.21 ± 1.20	37.05 ± 1.33	21.93	
% Reduction		**85**	**89**	**70**	**81**	**85**		
2003								
Year 1 (planted 2003)								
Mimic	10	1.98 ± 0.57	1.87 ± 0.47	1.48 ± 0.43	0.39 ± 0.23	0.34 ± 0.17	1.21	**90**
Check	10	3.86 ± 0.79	17.81 ± 1.49	15.54 ± 1.41	13.58 ± 1.20	10.23 ± 0.98	12.21	
% Reduction		**49**	**90**	**90**	**97**	**97**		
Year 2 (planted 2002)								
Mimic	7	0.12 ± 0.12	5.15 ± 0.79	3.61 ± 0.88	3.73 ± 0.93	6.34 ± 0.93	3.79	**75**
Check	7	7.50 ± 1.25	8.92 ± 1.11	14.92 ± 1.47	24.35 ± 2.20	21.63 ± 1.58	15.46	
% Reduction		**98**	**42**	**76**	**85**	**71**		

Table 15. Mean percent (± SE) of loblolly pine terminals infested by Nantucket pine tip moth on one- and two-year old loblolly pine trees following treatment with Mimic® after the each of 5 generations; Arkansas, Louisiana and Texas sites - 2001 & 2002.

Age	N Plots	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Average	% Reduction
2001								
Year 1 (planted 2001)								
Mimic	16	0.52 ± 0.26	3.05 ± 0.64	6.17 ± 0.91	4.85 ± 0.82	2.11 ± 0.56	3.34	**90**
Check	16	7.42 ± 0.95	38.89 ± 1.84	33.72 ± 1.79	47.35 ± 1.92	42.40 ± 1.98	33.96	
% Reduction		**93**	**92**	**82**	**90**	**95**		
2002								
Year 1 (planted 2002)								
Mimic	7	1.26 ± 0.63	3.85 ± 1.14	3.91 ± 1.16	4.32 ± 1.22	2.90 ± 1.01	3.25	**78**
Check	7	7.48 ± 1.54	10.89 ± 1.95	9.80 ± 1.87	20.31 ± 2.52	24.90 ± 2.72	14.68	
% Reduction		**83**	**65**	**60**	**79**	**88**		
Year 2 (planted 2001)								
Mimic	16	2.95 ± 0.59	3.93 ± 0.70	5.89 ± 0.85	9.08 ± 1.01	9.12 ± 1.01	6.19	**80**
Check	16	19.10 ± 1.39	26.73 ± 1.60	20.40 ± 1.47	43.09 ± 1.75	46.08 ± 1.76	31.08	
% Reduction		**85**	**85**	**71**	**79**	**80**		
2003								
Year 1 (planted 2003)								
Mimic	10	2.70 ± 0.77	2.40 ± 0.71	2.20 ± 0.69	0.41 ± 0.29	1.01 ± 0.45	1.74	**91**
Check	10	5.19 ± 1.10	26.59 ± 2.13	19.86 ± 1.90	19.08 ± 1.80	30.72 ± 2.90	20.29	
% Reduction		**48**	**91**	**89**	**98**	**97**		
Year 2 (planted 2002)								
Mimic	7	0.36 ± 0.36	9.15 ± 1.59	6.91 ± 1.62	5.69 ± 1.48	27.67 ± 4.08	9.96	**68**
Check	7	14.45 ± 2.20	12.34 ± 1.85	25.51 ± 2.78	27.13 ± 2.83	74.28 ± 5.23	30.74	
% Reduction		**97**	**26**	**73**	**79**	**63**		

Table 16. Mean (± SE) tree height, diameter and volume and percent growth gain of one-, two- and three-year old loblolly pine following treatment with Mimic®; Arkansas, Louisiana and Texas sites - 2001 - 2003.

Age	N Plots	Height (cm)	% Gain	Diameter (cm)	% Gain	Volume (cm^3)	% Gain
2001							
Year 1 (planted 2001)							
Mimic	16	62.2 ± 1.1	**27.8**	1.30 ± 0.03	**12.1**	200.6 ± 14.3	**45.6**
			$P < 0.0001$		$P < 0.0001$		$P < 0.0001$
Check	16	48.7 ± 0.9		1.16 ± 0.04		137.7 ± 9.7	
2002							
Year 1 (planted 2002)							
Mimic	7	58.0 ± 1.3	**-1.9**	1.27 ± 0.03	**-1.6**	131.4 ± 8.9	**-12.2**
			$P > 0.05$		$P > 0.05$		$P > 0.05$
Check	7	59.2 ± 1.4		1.29 ± 0.04		149.7 ± 13.0	
Year 2 (planted 2001)							
Mimic	15	157.0 ± 2.4	**10.7**	3.27 ± 0.06	**12.0**	2824.1 ± 146.7	**37.5**
			$P < 0.0001$		$P < 0.0001$		$P < 0.0001$
Check	15	141.9 ± 2.1		2.92 ± 0.05		2053.5 ± 115.4	
2003							
Year 1 (planted 2003)							
Mimic	10	63.1 ± 1.2	**13.4**	1.09 ± 0.03	**13.7**	141.4 ± 10.0	**25.3**
			$P < 0.0001$		$P < 0.001$		$P = 0.05$
Check	10	55.6 ± 1.2		0.96 ± 0.03		112.9 ± 10.8	
Year 2 (planted 2002)							
Mimic	7	148.8 ± 2.7	**1.0**	3.53 ± 0.09	**-1.3**	2343.2 ± 127.6	**-2.1**
			$P > 0.05$		$P > 0.05$		$P > 0.05$
Check	7	147.3 ± 3.0		3.57 ± 0.08		2393.0 ± 125.7	
Year 3 (planted 2001)							
Mimic	15	298.7 ± 3.6	**9.8**	3.84 ± 0.06	**17.4**	6465.3 ± 264.5	**38.1**
			$P < 0.0001$		$P < 0.0001$		$P < 0.0001$
Check	15	272.2 ± 3.4		3.27 ± 0.06		4680.0 ± 224.8	

Figure 17. Mean height (cm) of three-year old loblolly pine treated with Mimic® (first two years) compared to untreated trees on 15 Western Gulf sites.

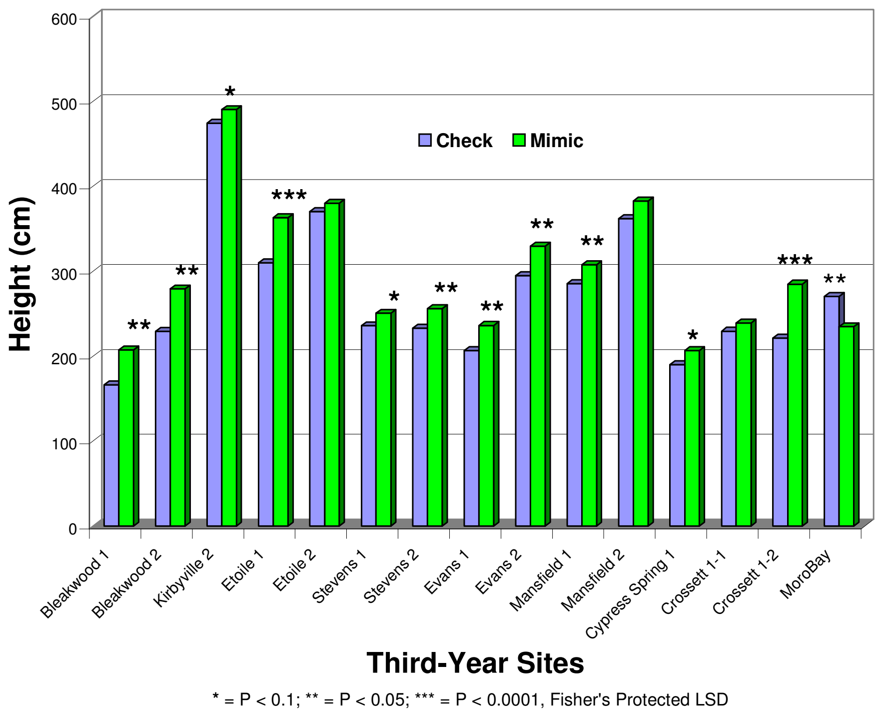


Figure 18. Mean volume (cm^3) of three-year old loblolly pine treated with Mimic® (first two years) compared to untreated trees on 15 Western Gulf sites.

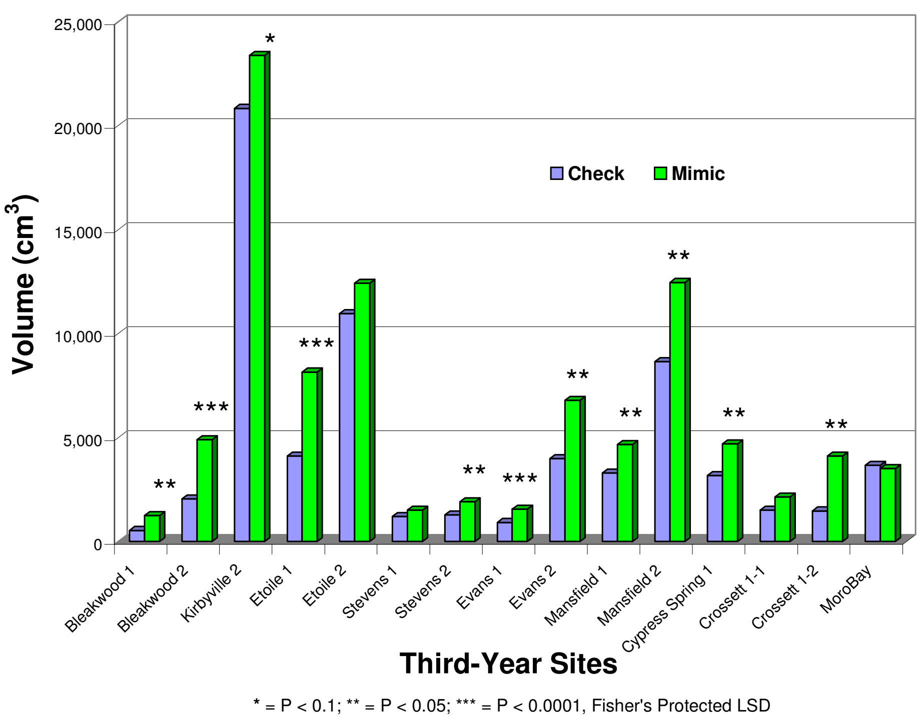


Figure 19. Proportion of three-year old Mimic®-treated and untreated loblolly pine with forks on each 14 Western Gulf sites.

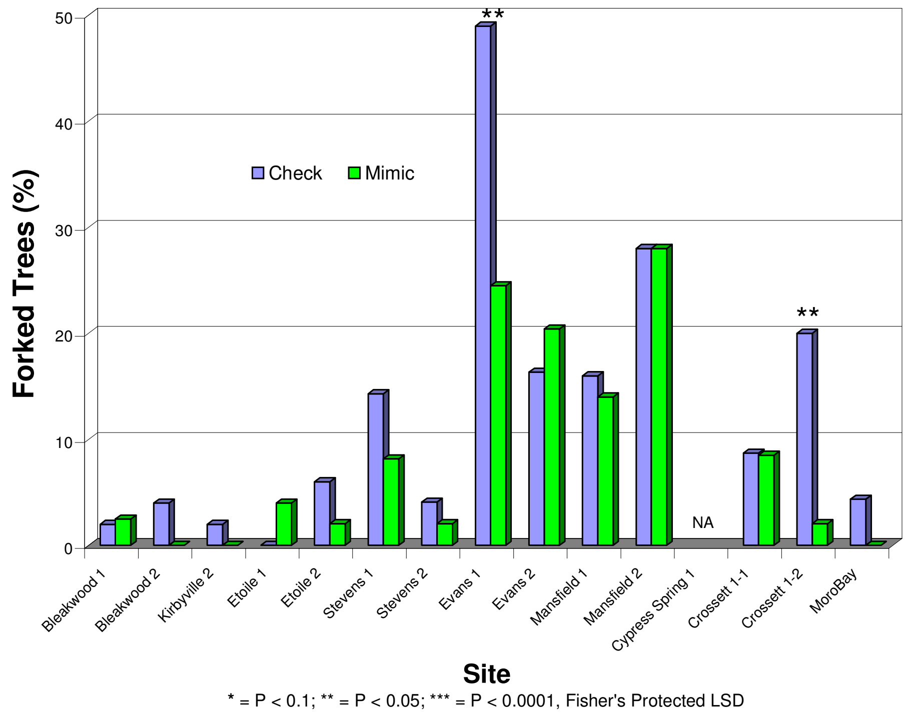


Figure 20. Mean height (cm) of two-year old loblolly pine treated with Mimic® (each year) compared to untreated trees on seven Western Gulf sites.

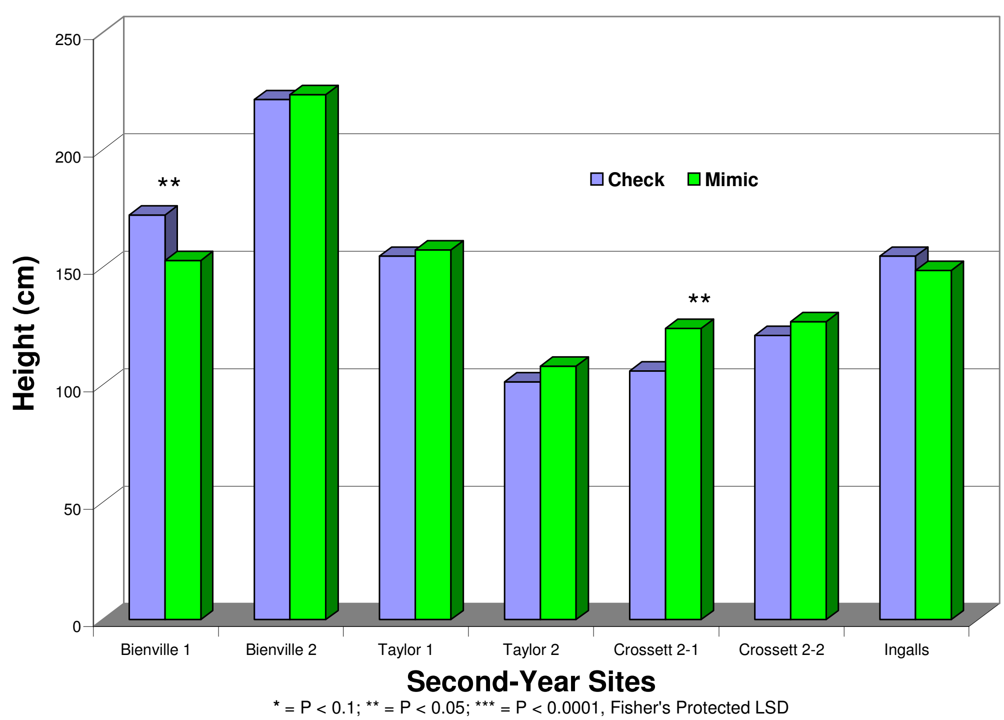


Figure 21. Mean volume (cm^3) of two-year old loblolly pine treated with Mimic® (each year) compared to untreated trees on seven Western Gulf sites.

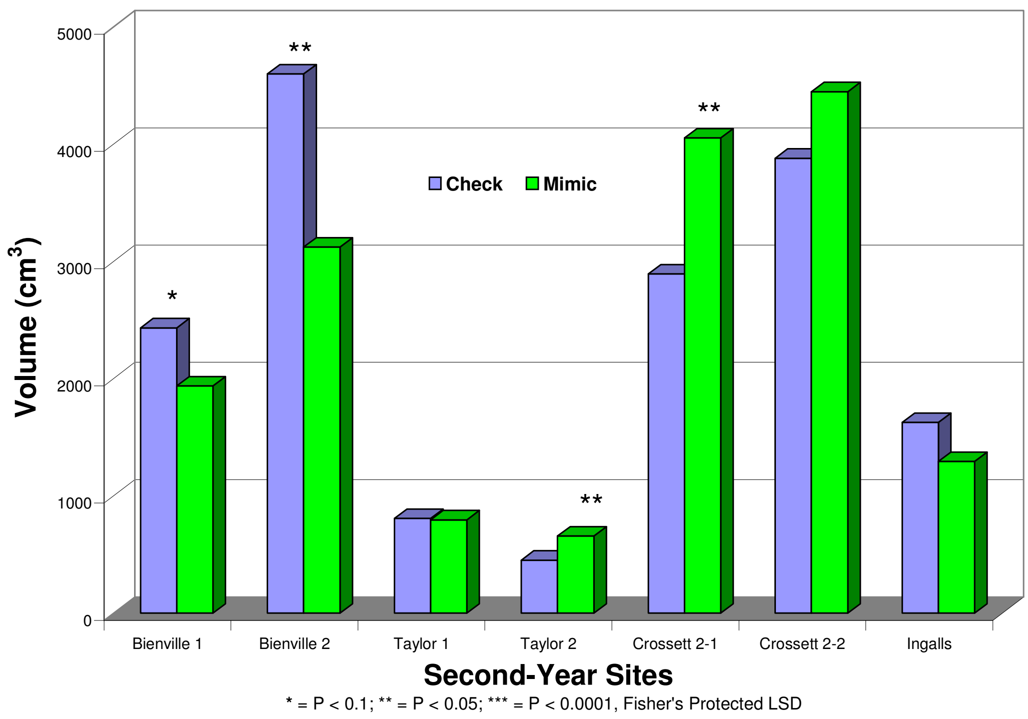


Figure 22. Mean height (cm) of one-year old loblolly pine treated with Mimic® compared to untreated trees on 10 Western Gulf sites.

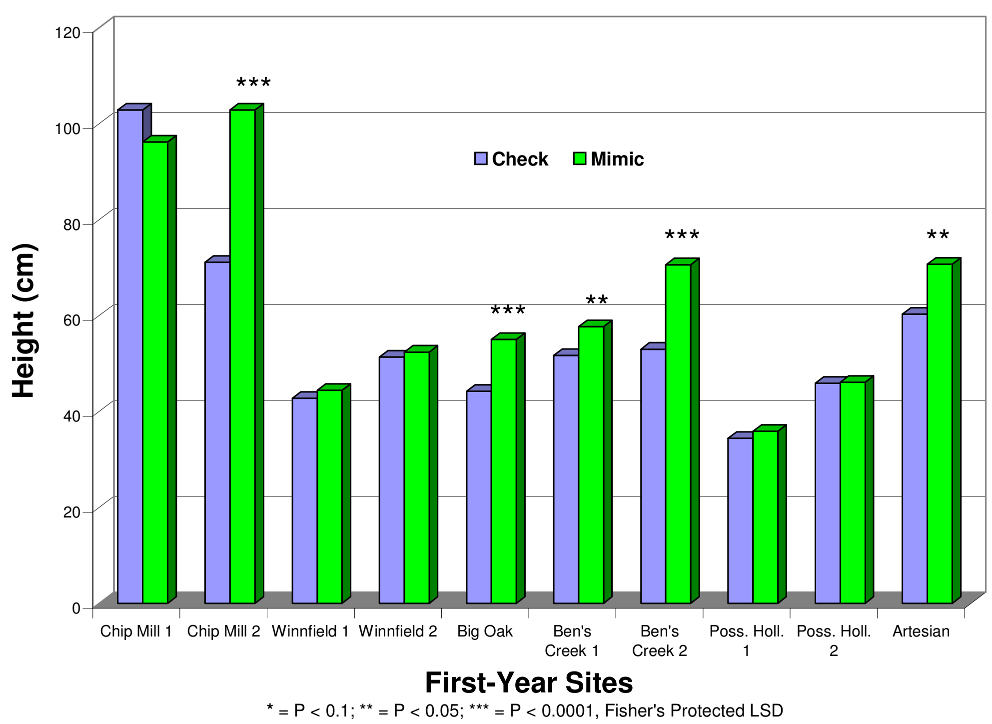


Figure 23. Mean volume (cm^3) of one-year old loblolly pine treated with Mimic® compared to untreated trees on 10 Western Gulf sites.

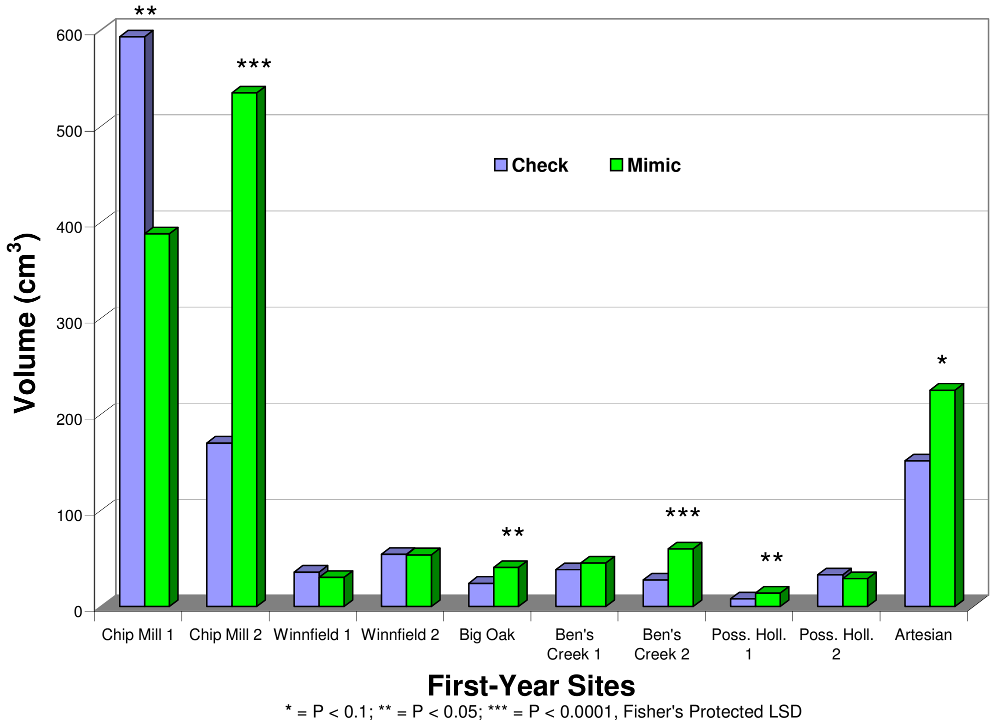


Figure 24. Mean height (cm) of one- to three year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 –2003.

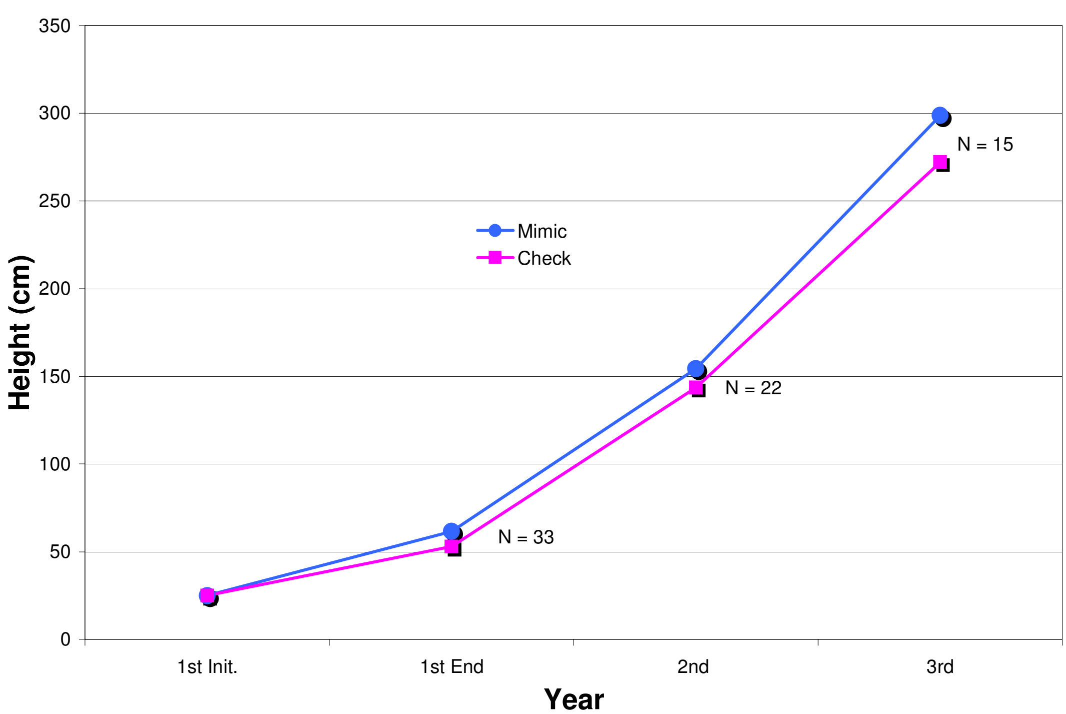


Figure 25. Mean diameter (cm) of one- to three-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2003.

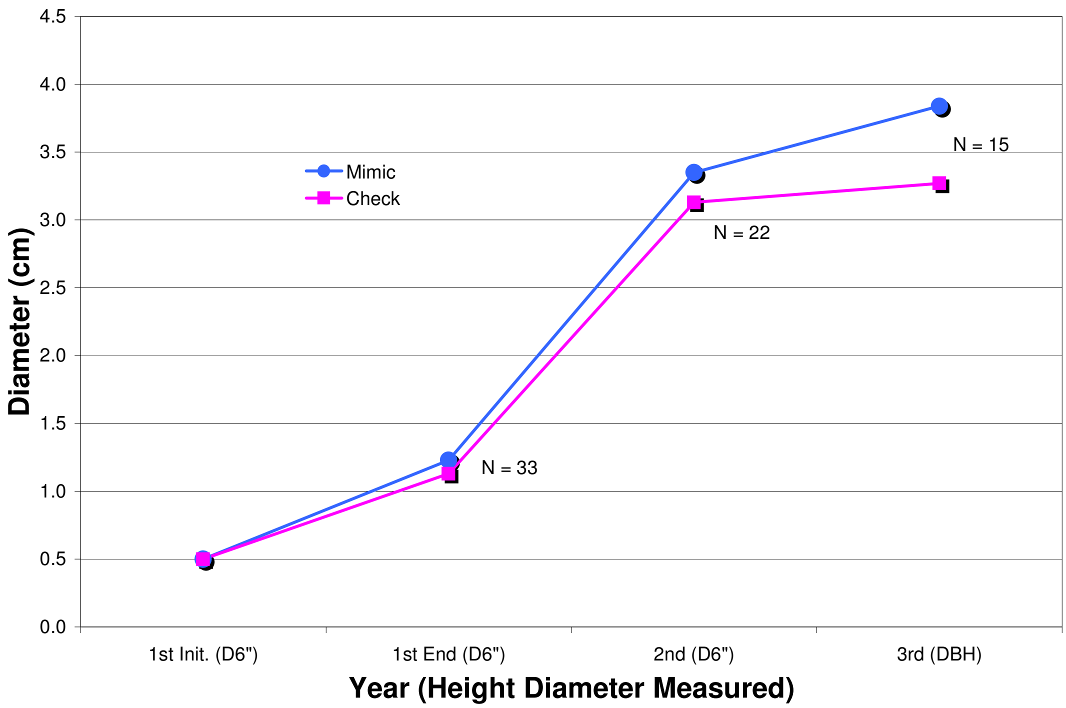
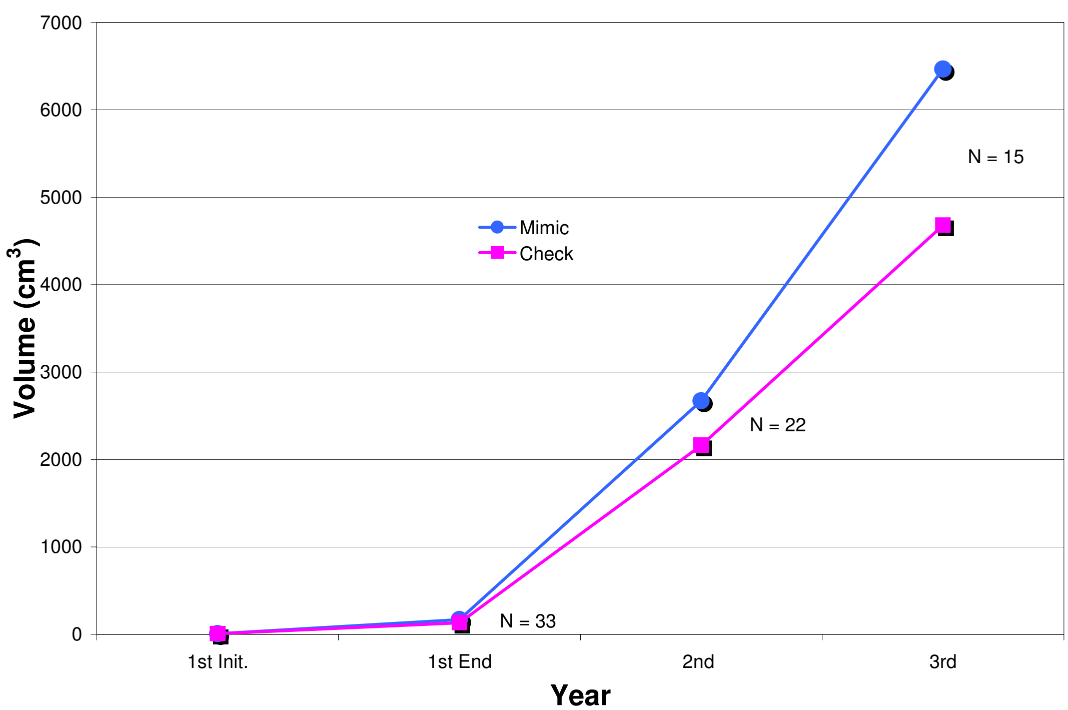


Figure 26. Mean volume (cm^3) of one- to three-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2003.



2001 - 2003 Tip Moth Hazard Rating Study – Western Gulf Region

Highlights:

- Site characteristic data were collected from 45 plots (21-1st year and 24-2nd year) in the Western Gulf Region in 2003.

Objective: Identify abiotic factors that influence the occurrence and severity of Nantucket pine tip moth infestations.

Cooperators: Western Gulf Forest Pest Management Coop. members
Dr. C. Wayne Berisford, University of Georgia
X Dr. Roy Hedden, Clemson University
Mr. Andy Burrow, Temple-Inland Forest Products

Study Sites: WGFPMC members selected from 2 to 7 new first-year plantations in 2003. Several were the same as those used in the Impact Study. When associated with the Impact Study, the untreated Impact plot was also used to collect tip moth and site characteristic data for the Hazard Rating Study. In this situation, a plot area within each plantation was selected - each plot containing 126 trees (9 rows X 14 trees). The internal 50 trees were evaluated for tip moth damage. For plantations with Hazard Rating plots alone, a plot area representative of the plantation was selected and contained 50 trees (5 rows X 10 trees).

Site Characteristic Data: Site characteristic data collected from 45 Western Gulf plots (21-1st year and 24-2nd year) in 2003 included:

Soil - Texture and drainage
Soil description/profile: depth of 'A' and to 'B' horizons; color and texture of 'B' Horizon
Depth to hard-pan or plow-pan
Depth to gleying
Soil sample (standard analysis plus minor elements and pH)

Tree - Age (1-2)
Percent tip moth infestation of terminal and top whorl shoots – 1st, 2nd, 3rd, and last generation
Height and diameter at 6 inch above ground

Site - Previous stand history
Site index (base 25 years)
Silvicultural prescription (for entire monitoring period)
Slope, aspect, and position (ridge, side-slope, bottom, flat)
Competing vegetation: 5 random samples within each plot to determine proportion of bare ground, grasses, forbes and non arborescent woody stems after 2nd and last tip moth generation.
Rainfall (on sight or from nearest weather station)
Estimate of the acreage of susceptible loblolly stands in the 2-5 year age class (< 15 ft tall) adjacent to or within 1/2 mile of study stand boundary

Tip Moth Damage Survey: Tip moth infestation levels were determined in each plot by surveying the internal 50 trees during the pupal stage of the first, second and last tip moth generation. Each tree was ranked on the extent of tip moth damage including: 1) tree identified as infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated, and 3) separately, the terminal was identified as infested or not. On 2^{nd} year sites, the 50 sample trees were measured after the last generation for height and diameter at 6 inches and assessed for the occurrence of fusiform rust galls. Incidence of fusiform rust was measured by counting the number of fusiform galls on the main stem and on branches within 12 inches of the main stem of each tree.

Results: Sixteen hazard-rating plots (most in conjunction with the impact sites) were established in 2001. A seventeenth plot was added when Potlatch joined the WGFPMC. These hazard-rating plots were phased out after 2002. Twenty-four and 21 more plots were established in 2002 and 2003, respectively. All 2001 data from the 17 plots had been forwarded to Dr. Roy Hedden by November, 2002. Dr. Hedden had agreed prior to the establishment of the Hazard Rating Project to develop a regression model to identify the most important abiotic factors influencing tip moth occurrence and severity. However, communication with Dr. Hedden never was well established and essentially stopped for several months when he refused to answer phone calls or emails from Drs. Don Grosman and Scott Cameron, IP. In April 2003, we received word that Dr. Hedden had some personal problems that he needed to address and would get back to us in June 2003. After June, Don and Scott made numerous attempts to contact Dr. Hedden. They have received no response. Unfortunately, after nearly three years and 61 plots, we have no hazard-rating model to show for our efforts. In light of these events, a search was begun for someone with biometric expertise to help develop a predictive model. It so happens that we have a biometrician in our neighborhood. Mr. Andy Burrow, Temple Inland, has enthusiastically volunteered to help us develop the model. With a Masters in Biometrics and minor in statistics, Mr. Burrows has the expertise the WGFPMC needs to get the job done. The data (3 years worth) is being consolidated and will be sent to Mr. Burrows by the end of March 2004. It is anticipated that a basic hazard rating model will be developed by the fall of 2004.

Figure 27 shows the distribution of all 61 hazard-rating sites established in the Western Gulf Region from 2001 to 2003. Tables 17 and 18 summarize the levels of tip moth infestation (shoots and terminals, respectively) that have occurred on first- and second-year sites through this period. Mean tip moth infestations levels (shoots and terminals) were higher on first-year seedlings in 2003 compared to 2002. In contrast, infestation levels were lower on second-year sites in 2003 compared to 2002. Given the variability of tip moth population levels from year to year and within and between regions, it is important that hazard-rating sites continue to be established on diverse sites for the duration of the five-year study period. The mean height, diameter and volume of two-year old trees on 17 Western Gulf sites in 2002 and 24 sites in 2003 are shown in Table 19. The mean heights and diameters of the two groups were very similar.

Figure 27. Distribution of 61 hazard-rating plots established 2001 -2003 in the Western Gulf region.

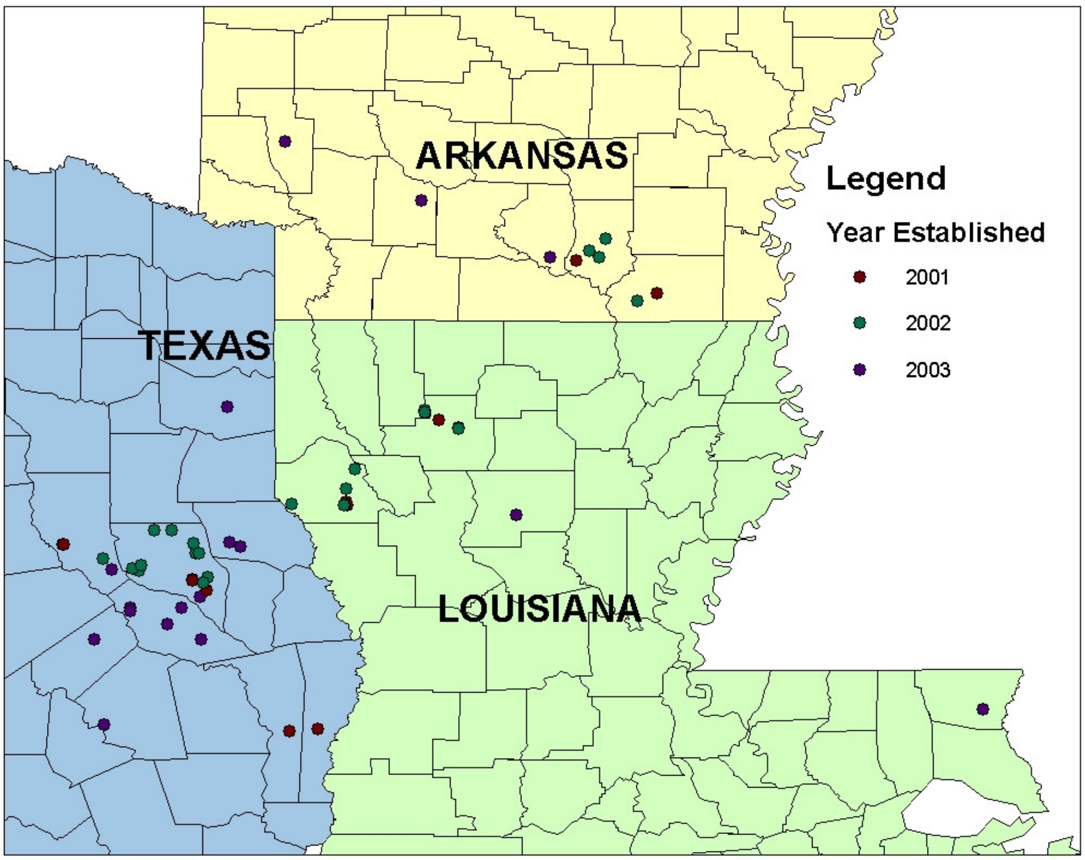


Table 17. Mean percent (± SE) of loblolly pine shoots (in top whorl) infested by pine tip moth on unprotected one- and two-year old loblolly pine after each of 5 generations, Western Gulf Region, 2001 - 2003.

Age	N Plots	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Average
Year 1							
planted 2001	16	4.59 ± 0.59	22.78 ± 1.18	21.88 ± 1.18	34.29 ± 1.49	28.01 ± 1.42	22.31
planted 2002	24	3.45 ± 0.40	5.09 ± 0.48	3.98 ± 0.39	11.12 ± 0.64	12.78 ± 0.68	7.28
planted 2003	21	4.34 ± 0.52	14.95 ± 0.93	13.27 ± 1.01	16.56 ± 1.01	16.47 ± 0.87	13.12
Year 2							
planted 2001	17	11.64 ± 0.73	15.90 ± 0.88	10.79 ± 0.72	30.81 ± 1.15	35.12 ± 1.29	20.85
planted 2002	24	7.07 ± 0.50	8.09 ± 0.54	10.16 ± 0.57	15.73 ± 0.78	20.72 ± 0.82	12.35

Table 18. Mean percent (± SE) of loblolly pine terminals infested by pine tip moth on unprotected one- and two-year old loblolly pine after each of 5 generations, Western Gulf Region, 2001 - 2003.

Age	N Plots	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Average
Year 1							
planted 2001	16	7.40 ± 0.90	38.90 ± 1.80	33.70 ± 1.80	47.30 ± 1.90	42.40 ± 2.00	33.94
planted 2002	24	5.20 ± 0.70	8.70 ± 0.90	8.60 ± 0.90	20.10 ± 1.20	24.10 ± 1.30	13.34
planted 2003	21	7.20 ± 0.84	22.45 ± 1.33	19.77 ± 1.52	26.80 ± 1.65	26.13 ± 1.37	20.47
Year 2							
planted 2001	17	19.10 ± 1.40	25.70 ± 1.50	19.30 ± 1.40	43.10 ± 1.70	46.10 ± 1.80	30.66
planted 2002	24	14.50 ± 1.07	14.49 ± 1.04	20.24 ± 1.22	24.51 ± 1.31	30.47 ± 1.34	20.84

Table 19. Mean (± SE) height, diameter and volume growth of unprotected two-year old loblolly pine on 41 Western Gulf hazard rating plots - 2002 & 2003.

Age	N Plots	Height (cm)	Diameter (cm)	Volume (cm^3)
planted 2001	17	149.83 ± 2.28	3.11 ± 0.06	2539.3 ± 131.7
planted 2002	24	151.09 ± 1.62	3.06 ± 0.04	1957.0 ± 59.0

Seedling Systemic Treatment Study: 2002 - 2003

Highlights:

- Fipronil, applied at lower rates, continued to show the highest level of activity of all root soak treatments, reducing tip moth damage by 27% during the second year (by 58% overall for 2 years) compared to untreated check trees.
- Increasing the treatment rate two-fold did not significantly improve protection provided by any of the chemical treatments for the second year in a row.
- Fipronil- and imidacloprid-treated seedlings continued to have the greatest improvement in height, diameter and volume parameters compared to check trees for the second year in a row.

Objectives: The objectives of this research are to: 1) evaluate the efficacy of several systemic insecticides (emamectin benzoate, imidacloprid, thiamethoxam, fipronil, and azadirachtin) in reducing tip moth damage on loblolly pine seedlings; and 2) determine the duration of treatment efficacy.

Study Sites: Two second-year plantations were selected in the Fairchild State Forest (Cherokee Co.) in east Texas. Two plots, containing 350 trees (5 rows X 70 trees), were established in each plantation. A third plot, containing 500 trees (5 rows X 100 trees), was established near one of the other plots. Second-year plantations were used in the study because tip moth populations are usually well established at this age and would ensure that significant tip moth pressure is placed on treated seedlings.

Population Monitoring: Tip moth populations were monitored by placing 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at each site. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February 2002 and monitored through December 2003. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Proclaim® (emamectin benzoate) - an avermectin derivative with activity against Lepidoptera.
Termidor® (fipronil) – a pheny pyrazole with some systemic activity against Lepidoptera.
Imidacloprid – highly systemic neonictinoid with activity against Lepidoptera.
Actera® (thiamethoxam) – a related neonicotinoid with high systemic activity.
Neemix® (azadirachtin) – natural plant-derived compound with some systemic activity.
Mimic® (tebufenozide) – molting stimulant with specific activity against Lepidoptera.

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. Plots 1 & 2: 2 sites X 7 treatments X 50 trees = 700 monitored trees. Plot 3: 1 site X 10 treatments X 50 trees = 500 monitored trees.

Treatments:

Plot 1 & 2: Chemical Effect:

1) Emamectin benzoate (Proclaim®) solution (0.12%) root soak
2) Fipronil (Termidor® SC) solution (0.157%) root soak
3) Imidacloprid (technical) solution (0.53%) root soak
4) Thiamethoxam (25 WP) solution (0.17%) root soak
** ~~5) Azadiractin (Neemix 4.5) solution (0.145%) root soak~~
6) Tebufenozide (Mimic®) foliar application (5X) prior to each generation at 0.8 oz/gal
7) Check (untreated)

Plot 3: Rate Effect

1) Emamectin benzoate (Proclaim®) solution (0.12%) root soak
2) Emamectin benzoate (Proclaim®) solution (0.24%) root soak
3) Fipronil (Termidor® SC) solution (0.146%) root soak
6) Fipronil (Termidor® SC) solution (0.287%) root soak
7) Imidacloprid (technical) solution (0.53%) root soak
8) Imidacloprid (technical) solution (1.064 %) root soak
7) Thiamethoxam (25 WP) solution (0.17%) root soak
9) Thiamethoxam (25 WP) solution (0.34%) root soak
** ~~10) Azadiractin (Neemix 4.5) solution (0.145%) root soak~~
** ~~11) Azadiractin (Neemix 4.5) solution (0.290%) root soak~~
10) Check (untreated) in Plot 1 used in comparisons

** Azadirachtin treatment evaluations were discontinued after 2002 due to poor survival.

Treatment Methods: A single family (Advanced Generation) of bare root loblolly pine seedlings was used from the Texas Forest Service Indian Mounds Nursery at Alto, TX. Bare root seedlings (150) were lifted after receiving at least 400 chilling hours (hours where temperature is below 40^{o}F). The seedlings were culled of small caliper (< 3 mm dia.) seedlings. When ready, the seedlings' roots were soaked in insecticide solution or water for 2 hours. After immersion, the seedlings were bagged and placed in cold storage until the following day. Fifty seedlings from each treatment were planted (6 X 10 ft spacing) on Plot 1 & 2. Plot 3 was planted on 3 X 10 foot spacing. Mimic® (0.8 oz/gal) was applied by backpack sprayer before each tip moth generation until the foliage was moist. Application dates were based optimal spray periods predicted by Fettig (et al. 2003) for Jacksonville, TX (approximately 17 miles NNW of the Fairchild State Forest site)

Treatment Evaluation: Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Each tree was measured for diameter and height and evaluated for form (occurrence of forks) in the fall (November) following planting.

Results:

<u>Plots 1 & 2 – Chemical Effect</u>: The patterns of tip moth damage levels in response to treatment was essentially the same for Plots 1 & 2 for both 2002 and 2003. Therefore, the data from the two plots were pooled.

In 2002, all root soak treatments had shown significantly lower tip moth damage levels after the first two tip moth generations compared to check trees (Table 20, Figure 28). However, only fipronil and Mimic® continued to reduce damage levels through the fifth generation. The fipronil treatment (90% reduction) was comparable to the standard, Mimic® foliar treatment (92%). The fipronil, imidacloprid and thiamethoxam treatments each resulted in significant (or nearly significant) gains in tree height, diameter and volume growth compared to check trees (Table 21).

In 2003, damage levels on check trees averaged nearly 50% lower than 2002 levels (Table 20, Fig. 28). Activity of all root soak treatments also declined compared to the previous year. However, fipronil consistently had the lowest level of tip moth damage of all root soak treatments. Tip moth damage on fipronil-treated trees was significantly lower than the check during the 4^{th} and 5^{th} generations. Overall, fipronil reduced damage by 27% in 2003 and by 58% over the past 2 years. The fipronil, imidacloprid and Mimic® treatments each resulted in significant gains in tree diameter and volume growth compared to check trees (Table 21). However, only Mimic®-treated trees continued to be significantly taller in height than check trees. The fipronil and Mimic® treatments both resulted in significantly lower levels of forking compared to the other root soak treatments and check.

<u>Plots 3 – Rate Effect</u>: Check trees were not included in Plot 3 upon establishment because of space and seedling limitations. However, because Plot 3 was situated within 15 m of Plot 1, it was initially assumed that the check trees in Plot 1 could be used in comparisons of treatments in Plot 3. However, it became apparent in 2003 that differences in topography, moisture conditions and soils between the two plots had resulted in marked differences in tip moth damage levels and tree growth. Subsequently, only indirect comparisons are made between check trees in plot 1 and treatment trees in Plot 3.

In 2002, all chemical treatments had much lower tip moth damage levels after all five tip moth generations compared to check trees in a neighboring plot (Plot 1) (Table 22, Figure 29). Increasing the treatment rate two fold did not improve the performance of any of the bare root treatments. The fipronil treatments (single and double rate) provided the greatest reduction in damage, 85% and 91%, respectively, compared to the neighboring check. Emamectin benzoate, imidacloprid and thiamethoxam were nearly equal in their effectiveness, reducing tip moth damage by 50 to 65%. The fipronil and imidacloprid treatments had the greatest impact on tree growth. Both treatments resulted in gains in tree height (23 to 42%), diameter (27 to 49%) and volume growth (91 to 178%) compared to neighboring check trees (Table 23).

In 2003, damage levels after the 1^{st} generation were too low to make a valid comparison among treatments. All chemical treatments showed much lower tip moth damage levels after the last four tip moth generations compared to check trees in a neighboring plot (Plot 1) (Table 22, Figure 29). Higher treatment rates (2X) did not improve the performance of any of the bare root treatments. The fipronil treatments (single and double rate) again provided the greatest reduction in damage, 89% and 88%, respectively, compared to the other chemical treatments and the neighboring check. Emamectin benzoate, imidacloprid and thiamethoxam were nearly equal in their effectiveness; reducing tip moth damage by 67 to 78%. The fipronil and imidacloprid treatments again had the greatest impact on tree growth. Both treatments resulted in gains in tree height (30 to 38%), diameter (33 to 41%) and volume growth (126 to 160%) compared to neighboring check trees

(Table 23). Fipronil and thiamethoxam were the only treatments at low and high levels that had significantly lower levels of forking compared to the neighboring check trees.

Summary: Seedlings soaked in fipronil, imidacloprid and thiamethoxam all appeared to show moderate to high resistance against tip moth for the first two generations in year 1, but only those treated with fipronil consistently retained their resistance through the fifth tip moth generation. Fipronil continued to show activity through the second year; significantly reducing damage during the 4th and 5th generations. Doubling the root soak dose rate did not improve the performance of fipronil or any other chemical. The nearly complete exclusion of tip moth damage by both Mimic® and fipronil during the two year period resulted in a marked reduction in forking compared to check trees. Given these results, further monitoring of the treatment plots are warranted through 2004.

References:

Fettig, C.J., J.T. Nowak, D.M. Grosman and C.W. Berisford. 2003. Nantucket pine tip moth phenology and timing of insecticide spray applications in the Western Gulf region. USDA Forest Service So. Res. Stat. Res. Pap. SRS-32. 13pp.

Figure 28. Effects of chemical root soaks on shoot infestation levels of Nantucket pine tip moth on one- and two-year old loblolly pine: 2002 – 2003.

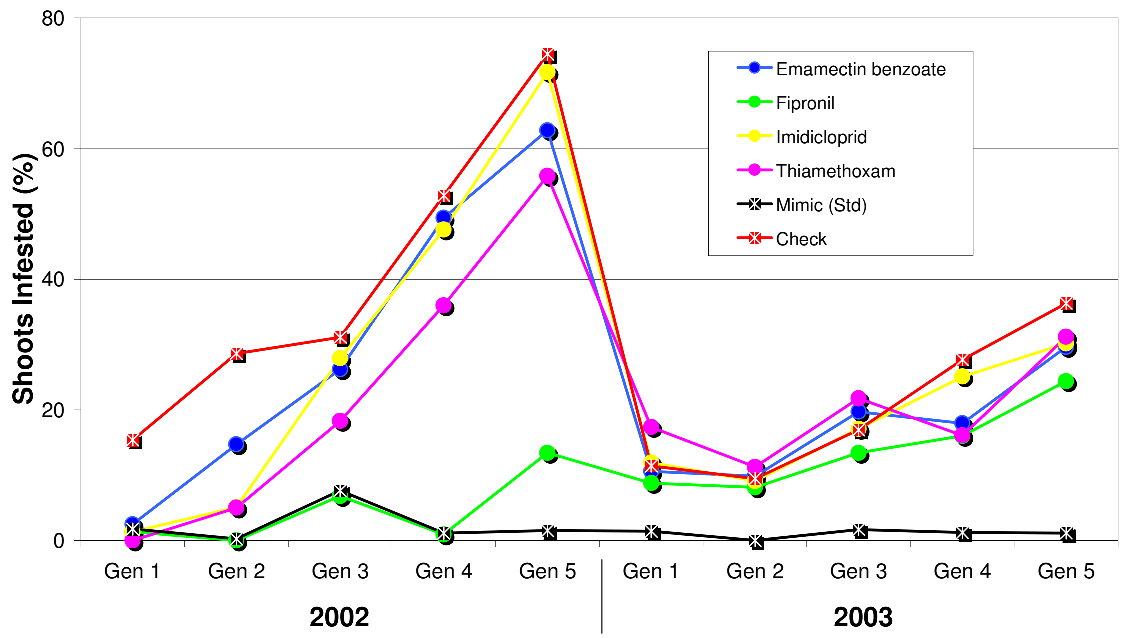


Figure 29. Effects of chemical rate of root soaks on shoot infestation levels of Nantucket pine tip moth on one- and two-year old loblolly pine: 2002 – 2003.

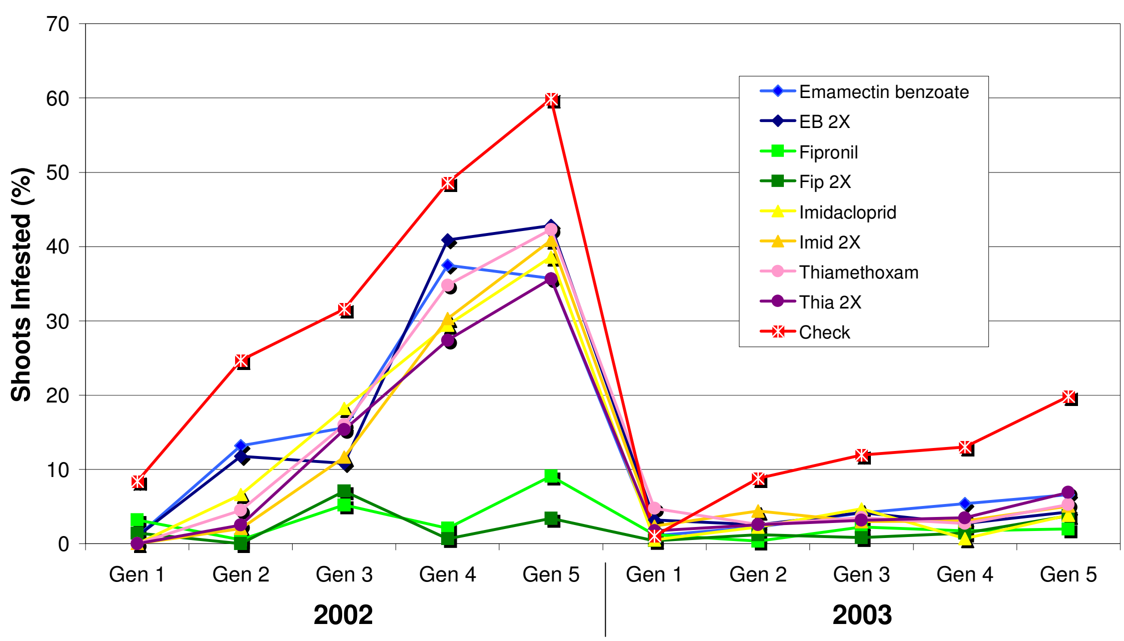


Table 20. Effect of systemic chemical treatments on pine tip moth infestation of loblolly pine shoots (top whorl) after each generation during two growing seasons on **Plots 1 & 2**, Evans Tract, Fairchild State Forest, Cherokee Co., TX, 2002 - 2003.

		CY 2002										Mean %	Mean Pct.
		Mean Percent Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)										Infested Yr.	Red. (All 5
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5		1	Gen)
EB (0.12% ai)	100	2.5 **a** *	(84)	14.7 **c**	(49)	26.2 **c**	(16)	49.4 **c**	(6)	62.8 **c**	(16)	31.1	**34**
FIP (0.146% ai)	100	1.3 **a**	(92)	0.0 **a**	(100)	6.8 **a**	(78)	0.9 **a**	(98)	13.4 **b**	(82)	4.5	**90**
IMID (0.532% ai)	100	1.3 **a**	(92)	5.1 **b**	(82)	27.9 **c**	(10)	47.6 **c**	(10)	71.7 **d**	(4)	30.7	**40**
THIA (0.17% ai)	100	0.0 **a**	(100)	5.0 **ab**	(83)	18.3 **b**	(41)	36.0 **b**	(32)	55.8 **c**	(25)	23.0	**56**
Mimic® (foliar)	100	1.8 **a**	(89)	0.3 **ab**	(97)	7.6 **a**	(76)	1.1 **a**	(98)	1.5 **a**	(98)	2.5	**92**
Check	100	15.4 **b**		28.6 **d**		31.1 **c**		52.8 **c**		74.5 **d**		40.5	

		CY 2003										Mean %	Mean Pct.	Mean Pct.
		Mean Percent Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)										Infested Yr.	Red. (All 5	Red. (2 Yr
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5		1	Gen)	Avg)
EB (0.12% ai)	100	10.6 **b** *	(7)	9.8 **b**	(-4)	19.7 **c**	(-16)	18.0 **b**	(35)	29.6 **bc**	(18)	17.5	**8**	**21**
FIP (0.146% ai)	100	8.8 **b**	(23)	8.1 **b**	(14)	13.4 **b**	(21)	16.0 **b**	(42)	24.4 **b**	(33)	14.1	**27**	**58**
IMID (0.532% ai)	100	11.9 **bc**	(-4)	9.1 **b**	(4)	17.1 **bc**	(-1)	25.1 **c**	(9)	30.2 **bc**	(17)	18.7	**5**	**22**
THIA (0.17% ai)	100	17.4 **c**	(-52)	11.3 **b**	(-19)	21.8 **c**	(-28)	16.1 **b**	(42)	31.2 **bc**	(14)	19.5	**-9**	**24**
Mimic® (foliar)	100	1.4 **a**	(88)	0.0 **a**	(100)	1.7 **a**	(90)	1.2 **a**	(96)	1.1 **a**	(97)	1.1	**94**	**93**
Check	100	11.4 **bc**		9.5 **b**		17.0 **bc**		27.7 **c**		36.3 **c**		20.4		

§ EB = emamectin benzoate, FIP = fipronil, IMID = imidacloprid, THIA = Thiamethoxam.

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 21. Effect of systemic chemical treatments on loblolly pine growth and form after each of 5 pine tip moth generations in 2002 and 2003 on **Plots 1 & 2**, Evans Tract, Fairchild State Forest, Cherokee Co., TX - 2002.

Treatment §	N	Mean Tree Measurements (Pct. Gain Compared to Check)												% Trees with Forks in 2003
		Height (cm)				Diameter (cm)				Volume (cm^3)				
		2002		2003		2002		2003		2002		2003		
EB (0.12% ai)	100	47.1 **a** *	(-9)	145.1 **a**	(-3)	0.69 **a**	(-8)	2.61 **a**	(-4)	27.3 **a**	(-27)	1083.3 **a**	(-17)	16.8 **b**
FIP (0.146% ai)	100	56.3 **cd**	(9)	157.3 **b**	(5)	0.82 **ab**	(9)	3.00 **c**	(10)	47.6 **b**	(27)	1678.2 **c**	(28)	1.0 **a**
IMID (0.532% ai)	100	55.2 **bc**	(7)	156.7 **b**	(4)	0.85 **bc**	(12)	3.07 **cd**	(12)	47.6 **bc**	(27)	1687.7 **c**	(29)	16.3 **b**
THIA (0.17% ai)	100	55.1 **bc**	(7)	157.6 **b**	(5)	0.84 **bc**	(11)	2.95 **bc**	(8)	47.4 **b**	(26)	1551.6 **bc**	(18)	19.2 **b**
Mimic® (foliar)	100	59.9 **d**	(16)	173.6 **c**	(15)	0.91 **c**	(20)	3.25 **d**	(19)	60.6 **c**	(61)	2189.9 **d**	(67)	4.0 **a**
Check	100	51.7 **b**		150.3 **ab**		0.75 **a**		2.73 **ab**		37.5 **ab**		1312.4 **ab**		18.4 **b**

§ EB = emamectin benzoate, FIP = fipronil, IMID = imidacloprid, THIA = Thiamethoxam.
* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 22. Effect of systemic chemical treatments on pine tip moth infestation of loblolly pine shoots (top whorl) after each generation of two growing seasons on **Plot 3**, Evans Tract, Fairchild State Forest, Cherokee Co., TX, 2002 - 2003.

		CY 2002					Mean %	Mean Pct.
		Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)					Infested Yr.	Red. (All
Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	1	5 Gen)
EB	50	1.0 **ab** * (88)	13.4 **d** (46)	15.6 **bc** (51)	37.5 **cd** (23)	35.7 **b** (40)	20.6	**50**
EB - 2X	50	1.0 **ab** (88)	12.4 **cd** (50)	10.8 **abc** (66)	40.9 **d** (16)	42.9 **b** (28)	21.6	**50**
FIP	50	3.2 **b** (62)	0.5 **a** (98)	5.2 **a** (84)	2.1 **a** (96)	9.1 **a** (85)	4.0	**85**
FIP - 2X	50	1.4 **ab** (83)	0.0 **a** (100)	7.1 **ab** (78)	0.7 **a** (99)	3.4 **a** (94)	2.5	**91**
IMID	50	0.0 **a** (100)	6.6 **bc** (73)	18.2 **c** (42)	29.4 **bc** (40)	38.6 **b** (36)	18.6	**58**
IMID - 2X	50	0.0 **a** (100)	2.0 **ab** (92)	11.6 **abc** (63)	30.3 **bc** (38)	40.8 **b** (32)	16.9	**65**
THIA	50	0.0 **a** (100)	4.5 **ab** (82)	16.0 **c** (49)	34.8 **bcd** (29)	42.3 **b** (29)	19.5	**58**
THIA - 2X	50	0.0 **a** (100)	2.5 **ab** (90)	15.4 **bc** (51)	27.4 **b** (44)	35.7 **b** (40)	16.2	**65**
Check (plot 1)	50	8.4	24.7	31.6	48.6	59.9	34.6	

		CY 2003					Mean %	Mean Pct.	Mean Pct.
		Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)					Infested Yr.	Red. (Last	Red. (2 Yr
Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	2	4 Gen)	Avg)
EB	50	1.1 **a** * (-5)	2.2 **ab** (75)	4.1 **ab** (65)	5.4 **b** (59)	6.6 **b** (67)	3.9	**67**	**57**
EB - 2X	50	3.2 **ab** (-214)	2.5 **ab** (71)	4.2 **ab** (65)	2.7 **ab** (79)	4.3 **ab** (78)	3.4	**73**	**60**
FIP	50	1.2 **ab** (-17)	0.3 **a** (96)	2.2 **ab** (81)	1.7 **a** (87)	2.0 **a** (90)	1.5	**89**	**87**
FIP - 2X	50	0.4 **a** (60)	1.2 **a** (87)	0.8 **a** (93)	1.4 **a** (89)	3.8 **ab** (81)	1.5	**88**	**90**
IMID	50	0.5 **a** (51)	2.2 **ab** (75)	4.7 **b** (61)	0.7 **a** (95)	3.8 **ab** (81)	2.4	**78**	**67**
IMID - 2X	50	2.3 **ab** (-130)	4.4 **b** (50)	3.0 **ab** (75)	3.1 **ab** (77)	5.1 **ab** (74)	3.6	**69**	**67**
THIA	50	4.8 **b** (-367)	2.6 **ab** (71)	3.5 **ab** (71)	2.7 **ab** (79)	5.3 **ab** (73)	3.8	**74**	**65**
THIA - 2X	50	1.7 **ab** (-70)	2.6 **ab** (71)	3.2 **ab** (74)	3.5 **ab** (73)	6.9 **b** (65)	3.6	**71**	**68**
Check (plot 1)	50	1.0	8.8	11.9	13.0	19.8	10.9		

§ EB = emamectin benzoate, FIP = fipronil, IMID = imidacloprid, THIA = Thiamethoxam.
* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 23. Effect of systemic chemical treatments on loblolly pine growth and survival after each of 5 generations on **Plots 3**, Evans Tract, Fairchild State Forest, Cherokee Co., TX - 2002.

Treatment §	N	Mean Tree Measurements (Pct. Gain Compared to Check): Height (cm) 2002	Height (cm) 2003	Diameter (cm) 2002	Diameter (cm) 2003	Volume (cm^3) 2002	Volume (cm^3) 2003	% Trees with Forks in 2003
EB	50	62.3 **ab** * (14)	187.5 **a** (20)	0.99 **ab** (18)	3.18 **ab** (22)	67.4 **a** (39)	2098.6 **a** (75)	34.7 **c**
EB - 2X	50	66.3 **abc** (21)	195.9 **ab** (26)	1.01 **ab** (21)	3.24 **abc** (25)	75.2 **a** (55)	2205.1 **a** (84)	14.3 **ab**
FIP	50	77.9 **d** (42)	215.7 **c** (38)	1.25 **e** (49)	3.67 **d** (41)	134.8 **c** (178)	3121.3 **b** (160)	6.3 **a**
FIP - 2X	50	71.2 **cd** (30)	202.6 **bc** (30)	1.15 **cde** (38)	3.50 **cd** (35)	111.3 **bc** (130)	2708.9 **b** (126)	16.0 **ab**
IMID	50	67.3 **bc** (23)	202.1 **bc** (30)	1.07 **bcd** (27)	3.47 **bcd** (33)	92.5 **ab** (91)	2712.9 **b** (126)	28.6 **bc**
IMID - 2X	50	74.4 **d** (36)	206.6 **bc** (33)	1.15 **de** (38)	3.56 **d** (37)	110.5 **bc** (128)	2779.5 **b** (132)	10.2 **a**
THIA	50	66.3 **abc** (21)	203.3 **bc** (30)	1.04 **bc** (24)	3.39 **abcd** (30)	90.0 **ab** (86)	2616.4 **ab** (118)	18.4 **ab**
THIA - 2X	50	59.8 **a** (9)	186.3 **a** (20)	0.92 **a** (19)	3.09 **a** (19)	69.7 **a** (44)	2130.6 **a** (78)	4.2 **a**
Check (plot 1)	50	54.8	155.8	0.84	2.60	48.4	1198.0	36.7

§ EB = emamectin benzoate, FIP = fipronil, IMID = imidacloprid, THIA = Thiamethoxam.

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Fipronil Technique and Rate Study - 2003

Highlights:

- Pine seedlings treated with fipronil (Termidor®) using plant hole, root dip with Terrasorb™, root soak (0.3%) and single in-furrow techniques, reduced tip moth damage by 86%, 79%, 67% and 23%, respectively, compared to untreated check trees.
- Seedlings treated by root soak (0.3% Regent®) and root dip (0.3% Termidor® + Terrasorb™) consistently had the greatest improvement in height, diameter and volume parameters compared to check trees.
- Seedlings soaked with Regent® consistently had less tip moth damage than seedlings soaked with Termidor at the same rate (0.3%). There were no significant differences in height and diameter growth between these treatments, but volume index was significantly greater for Regent®-treated trees.
- Increasing rate from 0.0003% to 0.3% significantly improved protection provided by fipronil (Termidor®) root soaks. The effect of chemical rate on tree growth was inconsistent.
- Seedlings treated with the highest fipronil concentration (6.5% in plant holes) experienced significantly lower seedling survival compared to check trees. In contrast, seedlings treated with moderate fipronil rates had significantly higher survival.
- Disulfoton and imidacloprid plus fertilizer spikes reduced tip moth damage for 2 and 3 generations, respectively. Both treatments resulted in marked improvements in all tree growth parameters compared to check trees.

Objectives: 1) Determine the efficacy of fipronil in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this product applied at different rates to nursery beds, lifted bare root seedlings, and plant holes; 3) determine the effect of fipronil formulation on seedling protection; 4) determine the duration of chemical activity, and 5) secondarily, evaluate the effects of different insecticide/fertilizer spikes on tip moth damage and tree growth.

Study Sites: Three second-year plantations were selected near Wells, Woden and Huntington in Angelina Co. in east Texas. Second-year plantations were used in the study because tip moth populations are usually well established at this age and would ensure that significant tip moth pressure was placed on treated seedlings. One plot, containing 9 treatments and 450 trees (5 rows X 90 trees), was established in each of two plantations (Wells and Woden). The Huntington site had 11 treatments (550 trees).

Population Monitoring: Tip moth populations were monitored by placing 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at each site. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February 2003 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Termidor® and Regent® (fipronil) – a phenyl pyrazole with some systemic activity against Lepidoptera.

Imidacloprid – highly systemic neonictinoid with activity against Lepidoptera.

Disufoton – systemic organophosphate with activity against Lepidoptera.

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. Plots 1 & 2: 2 sites X 9 treatments X 50 trees = 450 monitored trees. Plot 3: 1 site X 11 treatments X 50 trees = 550 monitored trees.

Treatments:

1) In furrow treatment of nursery bed with fipronil (0.0246% Termidor® SC) solution applied in October only.
2) In furrow treatment of nursery bed with fipronil (0.0123% Termidor® SC) solution applied once in October and again in December.
3) Root soak of bare root seedling in fipronil (0.003% Termidor® SC) solution
4) Root soak of bare root seedling in fipronil (0.03% Termidor® SC) solution
5) Root soak of bare root seedling in fipronil (0.3% Termidor® SC) solution.
6) Root soak of bare root seedling in fipronil (0.3% Regent® SC) solution.
7) Root dip of bare root seedling in fipronil (0.3% Termidor® SC) and TerraSorb® solution.
8) Plant hole treatment (liquid) – 30 ml of fipronil (6.5% Termidor® SC) solution per plant hole.
9) Bare root seedling - Check (lift and plant)

* 10) Plant spikes – 3 imidacloprid (50 mg ai each) + fertilizer (16N:8P:12K) spikes per tree
* 11) Plant spikes – 3 disulfoton (50 mg ai each) + fertilizer (16N:8P:12K) spikes per tree

* Treatments only evaluated at Huntington, TX site.

Treatment Methods: A single family (Advanced Generation) of bare root loblolly pine seedlings was used from the Texas Forest Service Indian Mounds Nursery at Alto, TX. Lateral root pruning equipment was used to apply Treatment 1 and 2 (described above) to a nursery bed section in October and December 2002. For all treatments, seedlings were lifted in January in a manner to cause the least breakage of roots, culled of small and large caliper seedlings, bagged and stored briefly in cold storage. When ready, the cold-stored seedlings to be used for Treatment 3 - 7 were warmed at room temperature (~70^{o}F) for 3 hours. For each of Treatments 3 - 6, 150 seedlings were soaked in 9.5 liters (2.5 gal) of insecticide solution for 2 hours. For Treatment 7, the same number of seedlings were dipped in the fipronil/TerraSorb® solution. After treatment, all seedlings were dipped in TerraSorb® solution, rebagged and placed in cold storage until the following day. Fifty seedlings from each treatment were planted (1.8 X 3 m (= 6 X 10 ft) spacing) on each of the three plantation sites.

Note: Three study plots (one in VA and two in GA) were also established by Dr. Scott Cameron, International Paper Co, and two plots (both in NC) by Mr. Wilson Edwards, Weyerhaeuser Co. on the East Coast. The data from these sites will be consolidated with the TX data and a final report will be sent to members in the summer of 2004.

Treatment Evaluation: Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Each tree was measured for diameter (at 6”) and height in the fall (November) following planting.

Results: In general, similar patterns of treatment performance were found on all three sites. As a result, data from the three sites were pooled for analysis.

Survival: Treatment concentration affected seedling survival. Seedlings treated with fipronil (6.5%) in the plant hole generally did not show phytotoxic symptoms, but were apparently negatively affected by the treatment. These seedlings had significantly lower survival compared to the check (Table 24). In contrast, seedlings treated in the nursery bed or by root dip and root soaks (at rates $\geq$ 0.03%) had significantly greater survival than check trees. Neither insecticide/fertilizer spike treatment had an affect on survival compared to check trees (Table 28).

Tip Moth Infestation: All treatments showed relatively similar tip moth infestation levels (2 – 5% of shoots and 4 – 11% for terminals) after the 1st generation (Tables 25 and 26). Only the double in-furrow, 0.3% Regent® root soak, and 6.5% plant hole treatments had significantly lower damage levels compared to the check. Most chemical treatments (except double in-furrow and 0.003% root soak) showed a marked reduction in tip moth damage during the 2nd and/or 3rd generations compared to the 1st. This indicates that fipronil moved slowly in the seedlings and may require 5+ months before chemical concentrations reach effective levels in pine shoots. However, with the exception of the plant hole treatment, all treatments showed reductions in efficacy after five generations. Overall, pine seedlings treated with fipronil (Termidor®) using plant hole, root dip with Terrasorb™, root soak (0.3%) and single in-furrow techniques, reduced tip moth damage by 86%, 79%, 67% and 23%, respectively, compared to untreated check trees. Seedlings soaked with Regent® consistently had less tip moth damage than seedlings soaked with Termidor at the same rate (0.3%). However, the differences between these two treatments were not statistically significant. Excellent relationships were found between fipronil (Termidor®) concentration and tip moth damage to shoots during generations 2 – 5 (r^2 ranged from 0.844 to 1.000) (Fig. 30).

At the Huntington plot, fertilizer spikes containing disulfoton or imidacloprid were effective in significantly reducing tip moth damage for 2 and 3 generations, respectively (Fig. 31). By the fifth generation, neither treatment damage level differed from the check.

Tree Growth: Seedlings treated by root soak (0.3% Regent®) and root dip (0.3% Termidor® + Terrasorb™) consistently had the greatest improvement in height, diameter and volume index compared to check trees (Table 27). There was no difference in tree growth between seedlings soaked with 0.3% Regent® and those soaked in Termidor® at the same rate. The effect of fipronil rate on growth was inconsistent.

Disulfoton and imidacloprid plus fertilizer spikes treatments both resulted in marked improvements in all growth parameters compared to check trees (Table 28).

Summary: Fipronil continues to show considerable potential as a seedling treatment for protection against pine tip moth. The results presented above indicate that further monitoring of the treatment plots are warranted through 2004.

Treatment of seedlings in-furrow while they are still in the nursery bed would be most economical and have the least potential for worker exposure to the chemical. The single in-furrow application in October resulted in some reduction (18%) in tip moth damage through the year. Because it appears that fipronil requires several months to move through the plant to the upper shoots, better protection may be obtained with this treatment technique if higher rates (4X) were applied or if seedlings in nursery beds were treated earlier in the year (perhaps June or July).

Seedlings soaked in fipronil (Termidor®) at concentrations ranging from 0.0003% to 0.3%, showed a clearly defined rate response for the second through the fifth generations. Unfortunately, the highest rate (0.3%) did not hold up as long as it did in 2002 (see 2X rate in the Seedling Treatment Study). It is possible that 2003 seedlings were more water-saturated just prior to treatment compared to 2002 seedlings, so the 2003 plants were not able take up as much fipronil at treatment. Lifting seedlings for treatment when the soil is moderately dry and treating early in the morning when the stomates are open may improve chemical uptake by seedlings. Based on the regression curves (Fig. 30), treatment effects may be improved by increasing the concentration of fipronil up to 3%. Currently, there is an EPA restriction of 0.13 lbs active ingredient per acre per year that can be applied directly to the soil. However, Harry Quicke, BASF, has indicated there is no restriction on rate when treating lifted seedlings prior to transplant (personal communication).

Regent®-treated seedlings consistently had less tip moth damage and better volume growth compared to seedlings treated with Termidor® at the same rate. Regent® should be used in all future trials because this formulation already has an in-furrow use on its label, it has a much larger market than Termidor® and it provides better protection against tip moth.

Somewhat surprisingly, the root dip treatment provided very good protection of seedlings through most of the growing season. However, based on the 2003 results, an increase in fipronil concentration in the Terrasorb™ mixture could extend protection well into the second year. Seedlings treated with a mixture of fipronil and Terrasorb™ had the greatest height and diameter of all treatments. As there are several types of root coatings available (Terrasorb™, Driwater™, clay slurry), it would be of interest to determine if the performance of fipronil in a root dip treatment could be improved at all with the use of Driwater™ or clay slurry.

The concentration used in the plant hole treatment was exceptionally high (6.5%). It was hoped that a single application could be made per rotation of the stand (~25 years X 0.13 lb ai / ac / yr). Harry Quicke's, BASF, opinion now is that EPA would not approve such a high rate applied directly to the soil. Regardless, the high concentration proved to be somewhat toxic to the young seedlings, reducing survival by 15%. However, the growth of remaining trees apparently was not affected by the higher concentrations. Combining lower rate plant hole treatments with in-furrow and/or root soak or dips treatments may provide long duration protection against tip moth.

Table 24. Effect of fipronil application technique and rate on survival of loblolly pine after each of 5 generations on three sites in east Texas - 2003.

Treatment §	N	Mean Percent Seedling Survival					Mean %
		Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Gain
T Fip Furrow 1	150	100	99	99	98 *	98 *	**9**
T Fip Furrow 1+1	150	99	98	97	96	96 *	**7**
T Fip + TerraSorb Dip	150	100	100	99	99 *	99 *	**10**
T Fip Soak 0.003%	150	100	99	97	94	92	**2**
T Fip Soak 0.03%	150	99	99	97	94	94	**4**
T Fip Soak 0.3%	150	99	99	98	97 *	97 *	**8**
R Fip Soak 0.3%	150	100	99	99	98 *	98 *	**9**
T Fip Plant Hole 6.5%	150	93 *	82 *	78 *	76 *	76 *	**-15**
Check	300	99	98	97	92	90	

§ T = Termidor, R = Regent.
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 25. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on three sites in east Texas - 2003.

Treatment §	N	Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check) Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Mean % Infested	Mean % Red.
T Fip Furrow 1	150	4.5 **(15)**	8.2 **(11)**	10.2 **(33)** *	25.8 **(10)**	26.2 **(23)** *	15.0	**18**
T Fip Furrow 1+1	150	1.7 **(69)** *	10.3 **(-12)**	15.4 **(-2)**	26.8 **(7)**	33.3 **(2)**	17.5	**13**
T Fip + TerraSorb Dip	150	2.3 **(57)** *	2.0 **(79)** *	1.2 **(92)** *	5.0 **(83)** *	6.2 **(82)** *	3.3	**79**
T Fip Soak 0.003%	150	2.5 **(54)** *	6.2 **(33)** *	11.9 **(21)**	25.5 **(11)**	36.3 **(-7)**	16.5	**23**
T Fip Soak 0.03%	150	3.3 **(39)**	5.6 **(39)** *	8.5 **(43)** *	21.0 **(27)**	28.2 **(17)**	13.3	**33**
T Fip Soak 0.3%	150	2.2 **(60)** *	1.5 **(84)** *	2.6 **(82)** *	9.2 **(68)** *	19.8 **(42)** *	7.1	**67**
R Fip Soak 0.3%	150	1.9 **(64)** *	0.3 **(97)** *	1.4 **(90)** *	8.3 **(71)** *	12.8 **(62)** *	5.0	**77**
T Fip Plant Hole 6.5%	150	2.9 **(46)**	0.9 **(90)** *	0.2 **(99)** *	0.4 **(98)** *	0.2 **(97)** *	0.9	**86**
Check	300	5.4	9.2	15.1	28.7	34.1	18.5	

§ T = Termidor, R = Regent.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

[shaded] = treatment reduced damage by >75% compared to check.

Table 26. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine terminals after each of 5 generations on three sites in east Texas - 2003.

Treatment §	N	Mean Percent Terminals Infested by Tip Moth (Pct. Reduction Compared to Check) Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Mean % Infested	Mean % Red.
T Fip Furrow 1	150	11.3 **(-5)**	22.2 **(5)**	22.3 **(31)** *	37.4 **(21)** *	40.8 **(14)**	26.8	**13**
T Fip Furrow 1+1	150	4.7 **(56)** *	23.8 **(-3)**	37.7 **(-16)**	48.3 **(-2)**	45.1 **(5)**	31.9	**8**
T Fip + TerraSorb Dip	150	6.0 **(44)**	4.7 **(80)** *	3.4 **(90)** *	6.8 **(86)** *	12.2 **(74)** *	6.6	**75**
T Fip Soak 0.003%	150	6.0 **(44)**	16.2 **(30)** *	26.2 **(19)**	44.7 **(5)**	54.0 **(-14)**	29.4	**17**
T Fip Soak 0.03%	150	8.8 **(18)**	10.1 **(56)** *	16.4 **(49)** *	38.3 **(19)** *	43.3 **(9)**	23.4	**30**
T Fip Soak 0.3%	150	6.0 **(44)**	3.4 **(85)** *	6.1 **(81)** *	18.5 **(61)** *	27.4 **(42)** *	12.3	**63**
R Fip Soak 0.3%	150	4.0 **(63)** *	1.4 **(94)** *	2.7 **(92)** *	12.9 **(73)** *	17.0 **(64)** *	7.6	**77**
T Fip Plant Hole 6.5%	150	4.3 **(60)** *	2.4 **(90)** *	0.9 **(97)** *	1.8 **(96)** *	0.9 **(98)** *	2.1	**88**
Check	300	10.7	23.2	32.4	47.1	47.4	32.2	

§ T = Termidor, R = Regent.
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
[shaded] = treatment reduced damage by >75% compared to check.

Table 27. Effect of fipronil treatments on first-year loblolly pine growth and survival on three sites in east Texas - 2003.

		Mean Tree Measurements (Pct. Gain Compared to Check)		
Treatment §	N	Height (cm)	Diameter (cm)	Volume (cm^3)
T Fip Furrow 1	150	54.8 **bc** * (8)	1.26 **bc** (15)	117.6 **bc** (39)
T Fip Furrow 1+1	150	50.8 **a** (0)	1.15 **a** (5)	88.8 **ab** (5)
T Fip + TerraSorb Dip	150	60.5 **d** (19)	1.29 **c** (18)	129.1 **c** (52)
T Fip Soak 0.003%	150	52.0 **ab** (2)	1.16 **ab** (6)	86.5 **a** (2)
T Fip Soak 0.03%	150	54.2 **abc** (7)	1.12 **ab** (2)	93.9 **ab** (11)
T Fip Soak 0.3%	150	51.8 **ab** (2)	1.13 **ab** (3)	83.9 **a** (-1)
R Fip Soak 0.3%	150	57.9 **cd** (14)	1.26 **bc** (15)	140.0 **c** (65)
T Fip Plant Hole 6.5%	150	54.5 **abc** (7)	1.08 **a** (-1)	110.7 **abc** (31)
Check	300	50.8 **a**	1.09 **a**	84.8 **a**

§ T = Termidor, R = Regent
* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 28. Effect of insecticide + fertilizer spikes on first-year loblolly pine growth and survival, Huntington, TX - 2003.

		Mean Tree Measurements (Pct. Gain Compared to Check)			
Treatment §	N	Height (cm)	Diameter (cm)	Volume (cm^3)	% Survival
Imidacloprid + Fertilizer	50	58.5 **b** (19)	1.21 **b** (14)	101.4 **b** (40)	98 **a**
Disulfton + Fertilizer	50	54.5 **b** (10)	1.22 **b** (15)	97.4 **b** (34)	94 **a**
Check	100	49.3 **a**	1.06 **a**	72.6 **a**	92 **a**

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Figure 30. Relationship between tip moth damage to shoots after generations 2 - 5 and rate of fipronil applied by root soaks to loblolly pine seedlings at three sites in east Texas, 2003.

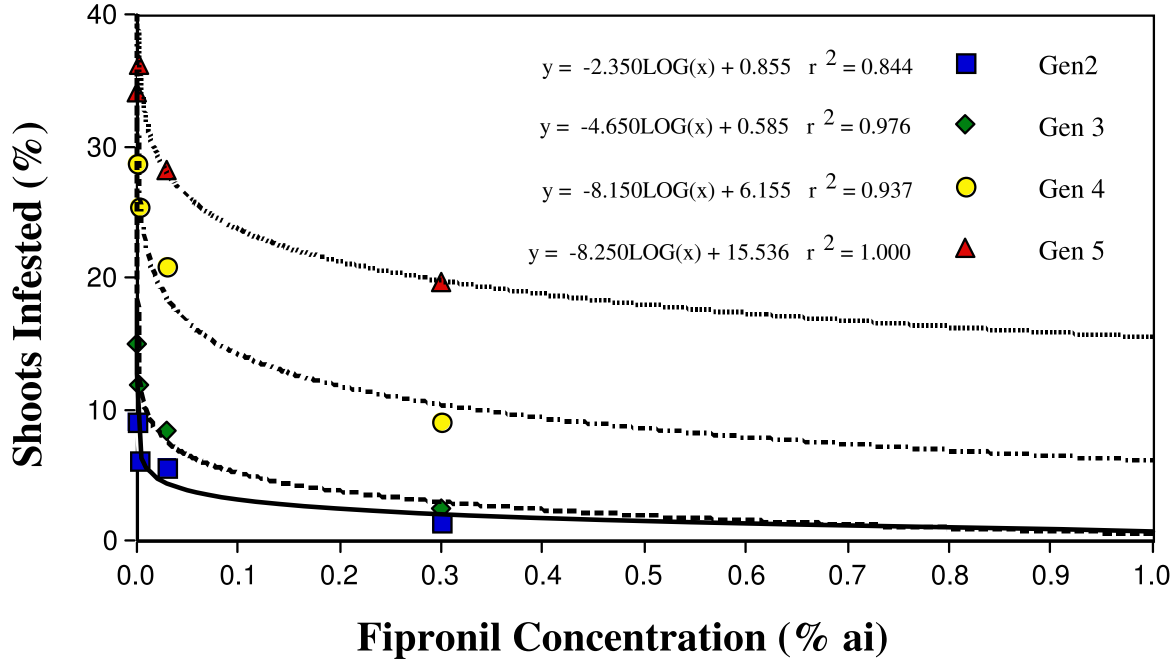
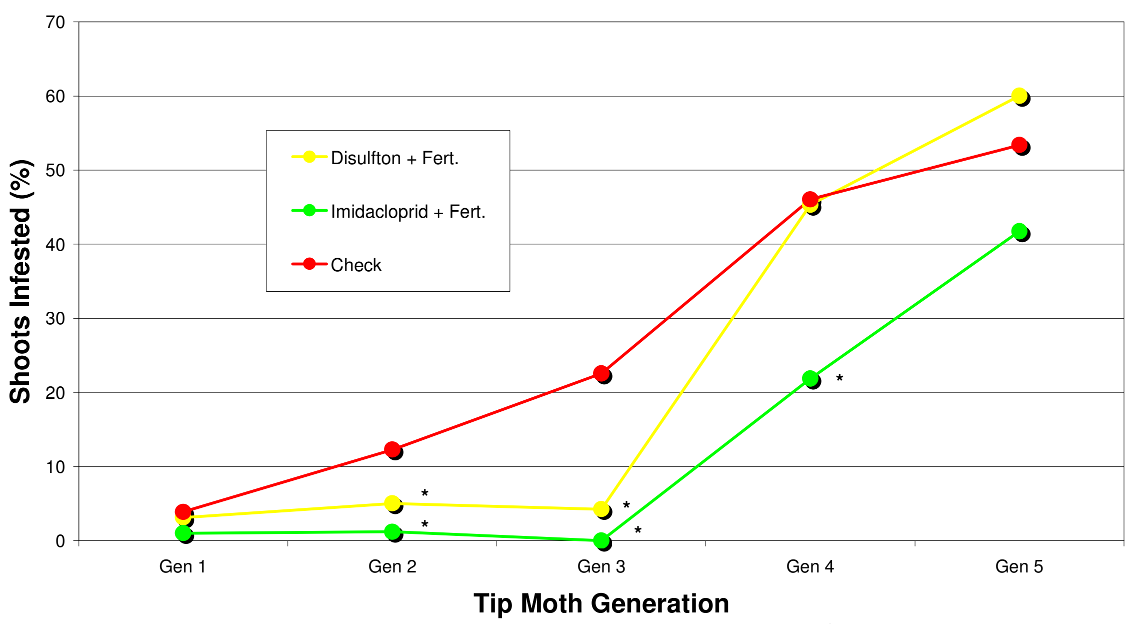


Figure 31. Effect of imidacloprid or disulfoton plus fertilizer spikes on tip moth damage to shoots for 5 generations, Huntington, TX, 2003.



Fipronil Operational Planting Study for Control of Pine Tip Moth

Highlights:
- Fipronil-treated seedlings in both treatment areas consistently had lower tip moth damage levels (shoot and terminal) compared to check areas throughout the growing season. Overall, fipronil reduced damage by 83% - 87%.
- Treated seedlings also had significantly less damage caused by regeneration weevils and reduced infestation by aphids.
- Overall, height, diameter and volume index were improved by fipronil in both treated areas.

Objectives:
The objectives of this research were to 1) determine the efficacy of fipronil in reducing pine tip moth infestation levels in loblolly pine plantations and 2) determine the duration of chemical activity.

Study Sites: Four first-year plantations were selected, three in east Texas [near Linden (Anthony), Camden (IP) and Zavalla (Temple)] and one in north Louisiana [Deer Rd near Sailes (Weyerhaeuser)]. The plantations ranged in size from 19 – 38 acres.

Population Monitoring: Tip moth populations were monitored by placing 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at each site. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February, 2003 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:
Termidor® (fipronil) – a pheny pyrazole insecticide with some systemic activity against Lepidoptera.

Design: Four plantations were divided in half. Half of the plantation was planted with treated seedlings and the other half with untreated seedlings. Ten 10-tree plots were evenly spaced throughout each half. Also in each half, a 100-tree plot was established with the reverse treatment.

Treatments:
1) Root soak of bare root seedlings for 2 hours in 0.3% fipronil (Termidor® SC) solution.
2) Bare root seedling - Check (lift and plant)

Treatment Methods: A single family (Advanced Generation) of bare root loblolly pine seedlings was used from the Texas Forest Service Indian Mounds Nursery at Alto, TX. The seedlings (~20,000) were lifted in January in a manner to cause the least breakage of roots, culled of small and large caliper seedlings, bagged and stored briefly in cold storage. When ready, half the cold-stored seedlings were warmed at room temperature (~70°F) for 3 hours. These seedlings were soaked in two 190-liter (50 gal) tanks of fipronil (0.3% ai) solution for 2 hours. All seedlings (treated and untreated) were dipped in TerraSorb™ solution, rebagged and placed in cold storage until the following day. Seedlings were hand-planted on three sites (Camden, Linden and Deer Rd) and machine-planted on the fourth (Zavalla). The spacing was variable and dependent on the preference of participating members.

Each of the four plantations was divided in half. One half was planted with fipronil-treated seedlings. The other half was planted with untreated seedlings at the same spacing. A small 100-tree plot was established in each half tract as a contrast to the treatment of the other half tract. The plot in the treated half contained untreated seedlings, while the plot in untreated half contained treated seedlings. Ten 10-tree plots were evenly spaced within each of the half tract (20 – 10 tree plots / whole tract) to evaluate tip moth damage levels in this area. The plantations were treated with herbicide after planting if necessary to minimize herbaceous and/or woody competition.

Treatment Evaluation: Tip moth damage was evaluated in each 100- and 10-tree plots after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., weevils, coneworms, aphids, sawfly, etc. Each tree was measured for diameter (at 6") and height in the fall (November) following planting.

Results: In general, similar patterns of treatment performance against tip moth were found on all four sites. As a result, data from the four sites were pooled for analysis.

Tip Moth Infestation Levels: Tip moth populations were fairly low on all four first-year plantation sites; damage levels never exceed 25% of the shoots infested on any of the sites. All treatments showed relatively similar tip moth infestation levels (2 – 3% of shoots and 2 – 5% for terminals) after the 1st generation (Fig. 32, Tables 28 and 29). The two fipronil treatment areas showed reduced tip moth damage during the 2nd and/or 3rd generations compared to the 1st. This again (like the Technique and Rate Study) indicates that fipronil moves slowly in the seedlings and may require 5+ months before chemical concentrations reach effective levels in pine shoots (during the 3rd generation). However, both fipronil treatment areas showed some reductions in efficacy after five generations. Overall, tip moth damage on pine seedlings treated with fipronil (Termidor®) was reduced by 83% compared to untreated check trees.

Aphid Infestation and Weevil Damage: In addition to tip moth damage, pine seedlings also were evaluated for the occurrence of other insects or their damage. Aphid infestation and regeneration weevil-caused damage were most prevalent in 2003.

The pattern of aphid occurrence on each site was similar so the data were pooled for analysis. Plantation areas containing fipronil-treated seedlings had significantly lower aphid populations in May (after the first tip moth generation) compared to check areas (Figure 33). Although area-wide aphid populations had declined by July, fipronil-treated areas still had lower infestation levels compared to check areas.

The patterns of weevil-caused damage were variable on each site and at each visit in May and July so data are presented separately for each site and month. Regeneration weevil-caused damage was found on all sites in May, but was considerably more prevalent on the Linden and Deer Road sites

(Fig. 34). All sites saw the highest level of damage in the Check 100 plots established within the fipronil-treated plantation half. In July, only the Deer Road site continued to experience additional damage due to weevils (Fig. 35). The weevil-caused damage was twice as high in the 10 X 10 check plots compared to the other treatments.

Tree Growth and Survival: Table 31 shows the overall effects of fipronil treatment on height, diameter and volume growth. However, because there were significant interactions between site and treatment for each growth parameter, the treatment means also are presented for each site and parameter (Figs 36 – 38). A large part of the site and treatment variability is most likely due to differences in soil nutrients and moisture across each plantation. Overall, seedlings treated with fipronil were significantly taller than check trees, with gains ranging from 5 – 16% (Table 31). In contrast, only fipronil-treated seedlings planted within the check area (Fipronil 100) had significantly greater diameters and volumes. Gains for these parameters were 19% and 47%, respectively. There were no differences in tree survival among the treatment areas.

Summary: Fipronil was highly effective in reducing potential tip moth damage on all four study sites for the 2nd through 5th generations. There did not appear to be much effect on the first generation. This delayed effect is similar to that observed in the Technique and Rate Study. Again, it apparently takes fipronil 5+ months to reach high enough concentrations in the shoots to affect tip moth infestation levels. Treating seedlings in the nursery bed in mid-summer prior to lifting would provide enough time for the chemical to build up in the shoots in time for the first tip moth generation. If the seedlings were also treated after lifting (soak or dip) or at planting (plant hole), then higher concentrations would become available later in the growing season when damage levels are usually highest.

It is interesting to note that, in the Fipronil 100 plot, damage levels began to climb after the 3rd generation (Fig. 30), indicating that 1) tip moth pressure had built up in the check plantation to the point that larval attacks overcame the fipronil protection, and 2) under high tip moth pressure, the 0.3% fipronil root soak treatment can only protect individual seedlings for about one year. However, in the fipronil-treated plantation (Fipronil 10X10), there was no marked increase in damage levels during the 4th and 5th generations. This indicates that planting large areas with fipronil-treated seedlings deters tip moth from colonizing new plantations and subsequent populations are kept low within the treated area. The duration of the area-wide effects have yet to be determined.

Figure 32. Mean effect of fipronil treatment on four operational planting sites in east Texas (3) and Louisiana (1) – 2003.

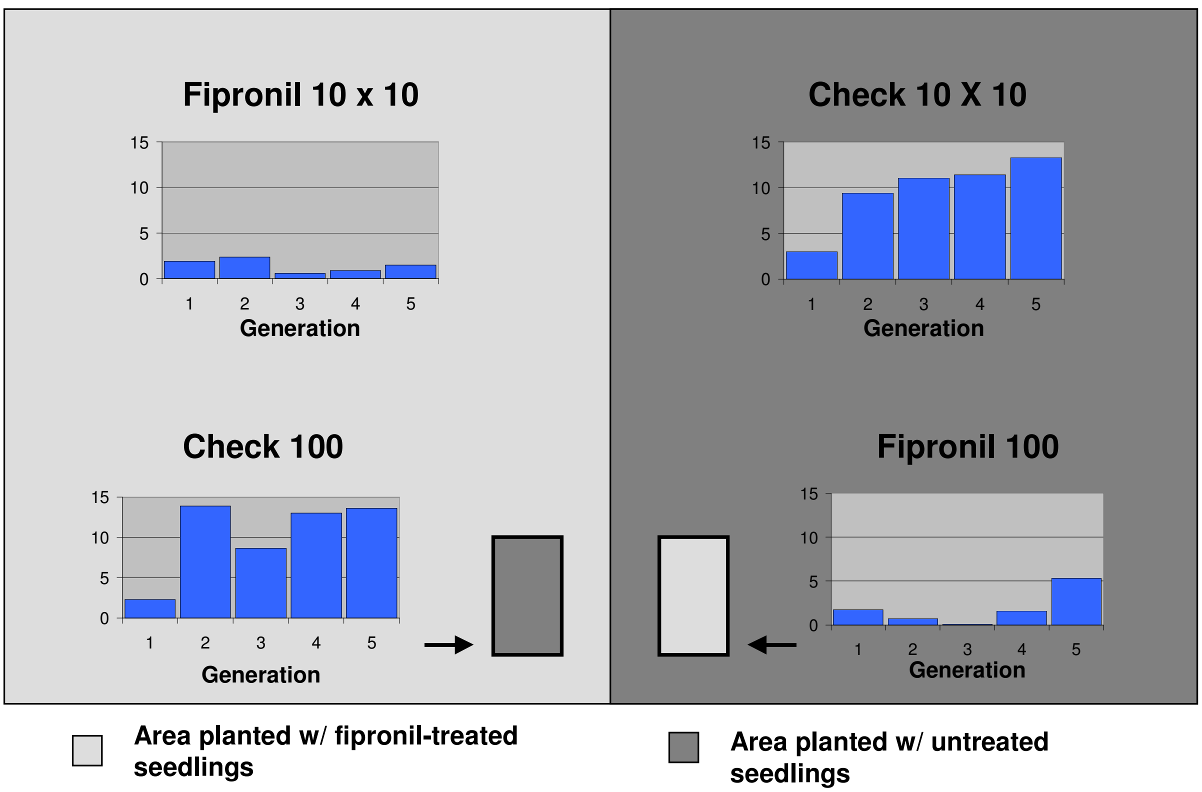


Table 29. Effect of operational planting of fipronil-treated seedlings on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on four sites in east Texas or Louisiana - 2003.

		Mean Percent Top Whorl Shoots Infested by Tip Moth					5 Gen	Pct
Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Mean %	Red.
Fipronil 100	400	1.7 **a** *	0.7 **a**	0.1 **a**	1.4 **a**	5.3 **b**	**1.8**	**83.0**
Fipronil 10 X 10	400	1.9 **a**	2.4 **a**	0.8 **a**	0.9 **a**	1.5 **a**	**1.5**	**84.6**
Check 100	400	2.3 **a**	13.9 **c**	10.8 **b**	13.3 **b**	13.6 **c**	**10.8**	
Check 10 X 10	400	3.0 **a**	9.4 **b**	11.8 **b**	11.5 **b**	13.3 **c**	**9.8**	

* Means followed by a different letter are significantly different at the 5% level based on Fisher's Protected LSD.

Table 30. Effect of operational planting of fipronil-treated seedlings on pine tip moth infestation of loblolly pine terminals after each of 5 generations on four sites in east Texas or Louisiana - 2003.

		Mean Percent Terminals Infested by Tip Moth					5 Gen	Pct
Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Mean %	Red.
Fipronil 100	400	1.8 **a** *	1.3 **a**	0.3 **a**	2.9 **a**	8.8 **b**	**3.0**	**83.0**
Fipronil 10 X 10	400	2.6 **a**	3.3 **a**	1.5 **a**	0.9 **a**	2.4 **a**	**2.1**	**87.3**
Check 100	400	4.3 **a**	23.8 **c**	18.8 **b**	21.9 **b**	20.2 **c**	**17.8**	
Check 10 X 10	400	4.7 **a**	16.4 **b**	22.1 **b**	18.0 **b**	22.7 **c**	**16.8**	

* Means followed by a different letter are significantly different at the 5% level based on Fisher's Protected LSD.

Table 31. Effect of operational planting of fipronil-treated seedlings on loblolly pine growth and survival after first season on four sites in east Texas or Louisiana - 2003.

		Mean End of Season Tree Measurements (Pct. Gain Compared to Similar Check)			
Treatment	N	Height (cm)	Diameter (cm)	Volume (cm^3)	% Survival
Fipronil 100	328	52.3 **c** * (16)	0.94 **b** (16)	64.7 **c** (46)	81.0 **a**
Fipronil 10 X 10	339	49.1 **b** (5)	0.86 **a** (1)	57.5 **bc** (13)	84.8 **a**
Check 100	352	45.1 **a**	0.81 **a**	44.4 **a**	83.8 **a**
Check 10 X 10	335	46.7 **a**	0.85 **a**	50.7 **ab**	83.5 **a**

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Figure 33. Effect of fipronil treatments on aphid infestation in May and July on four plantation sites (3 in TX and 1 in LA) – 2003.

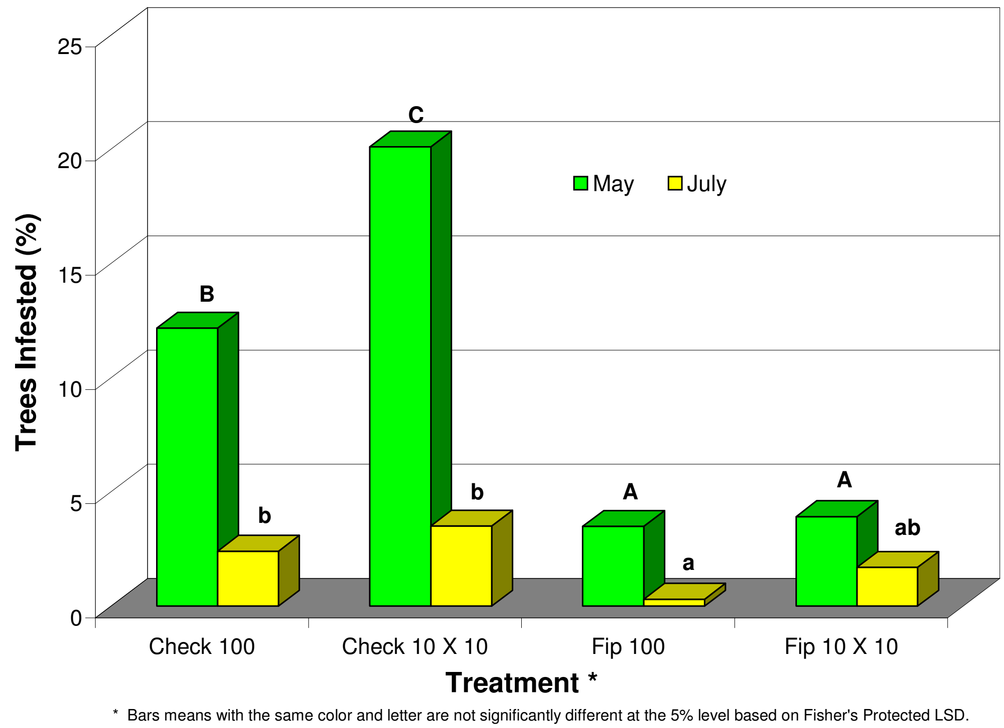


Figure 34. Effect of fipronil treatments on occurrence of regeneration weevil-caused damage in May on each of four plantation sites – 2003.

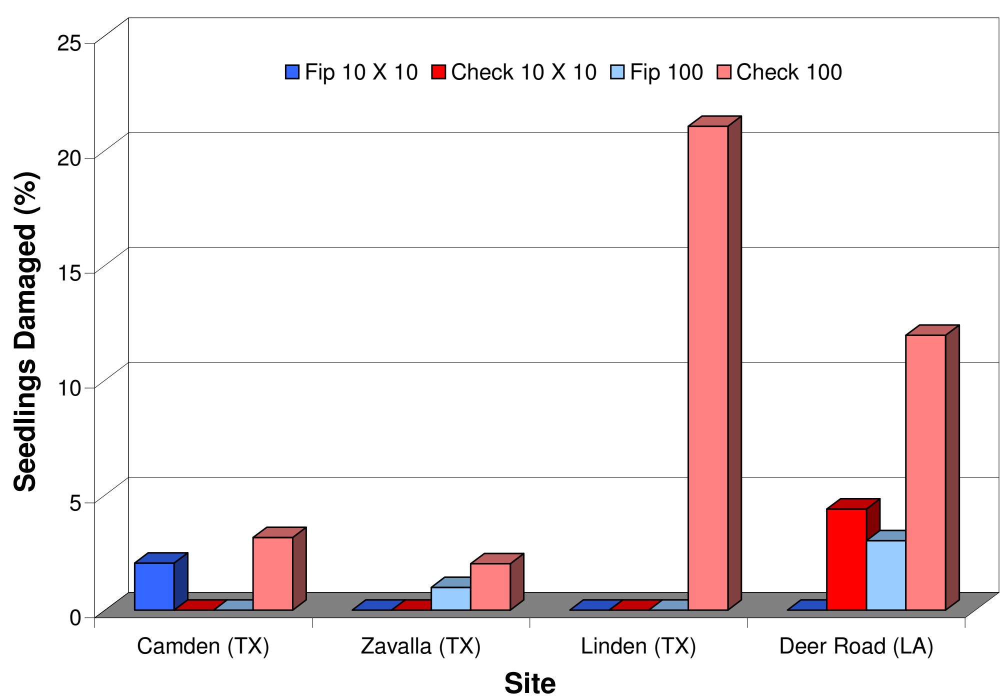


Figure 35. Effect of fipronil treatments on occurrence of regeneration weevil damage in July on each of four plantation sites – 2003.

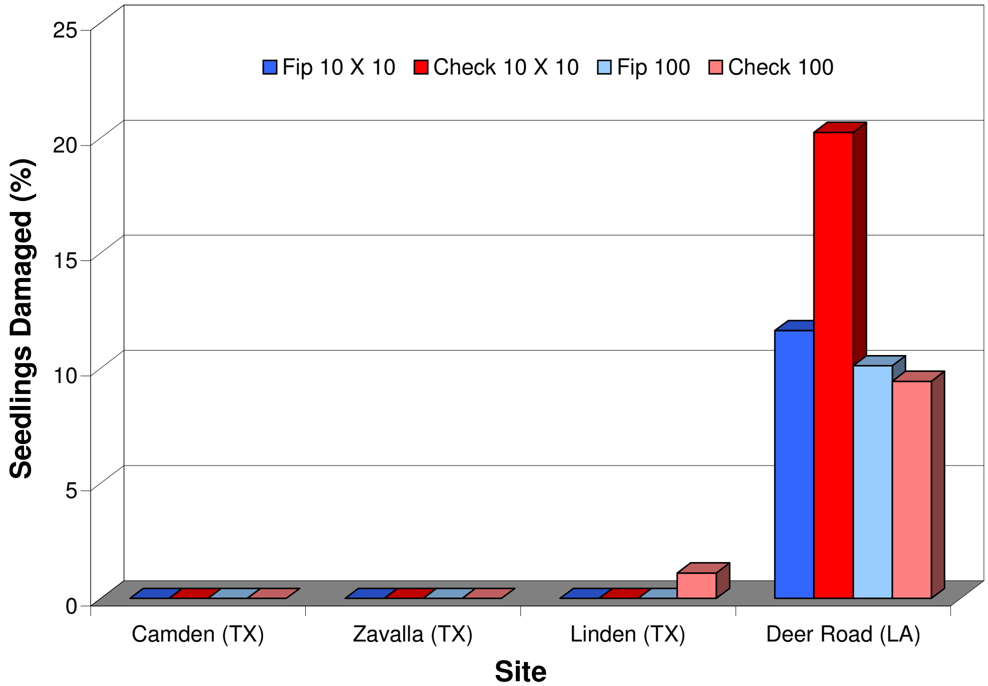


Figure 36. Mean height of fipronil-treated and untreated first-year loblolly pine on four sites - 2003.

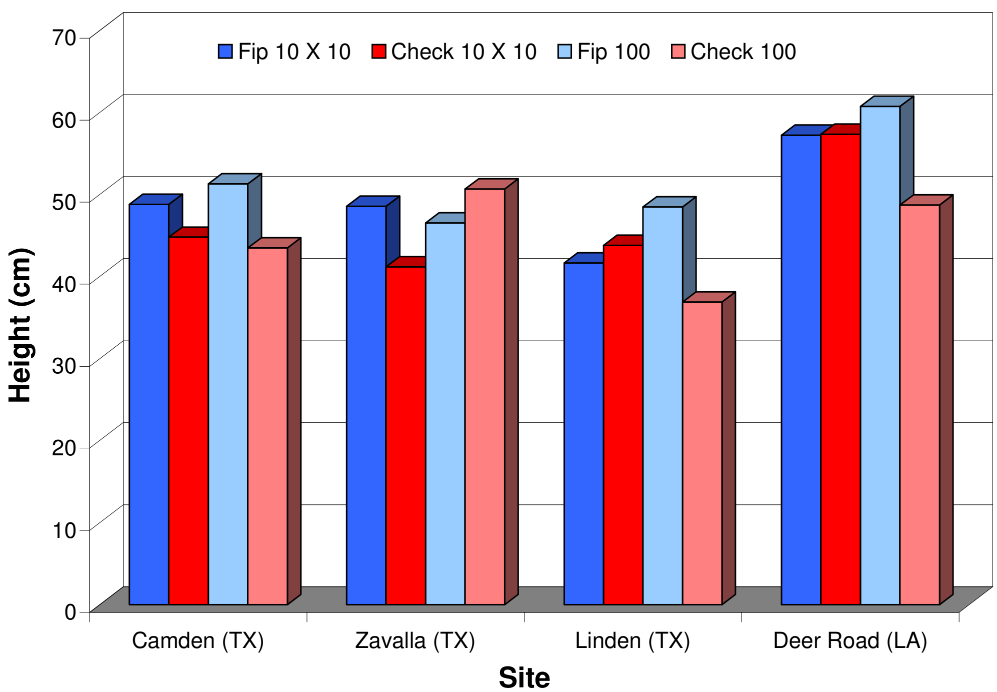


Figure 37. Mean diameter of fipronil-treated and untreated first-year loblolly pine on four sites - 2003.

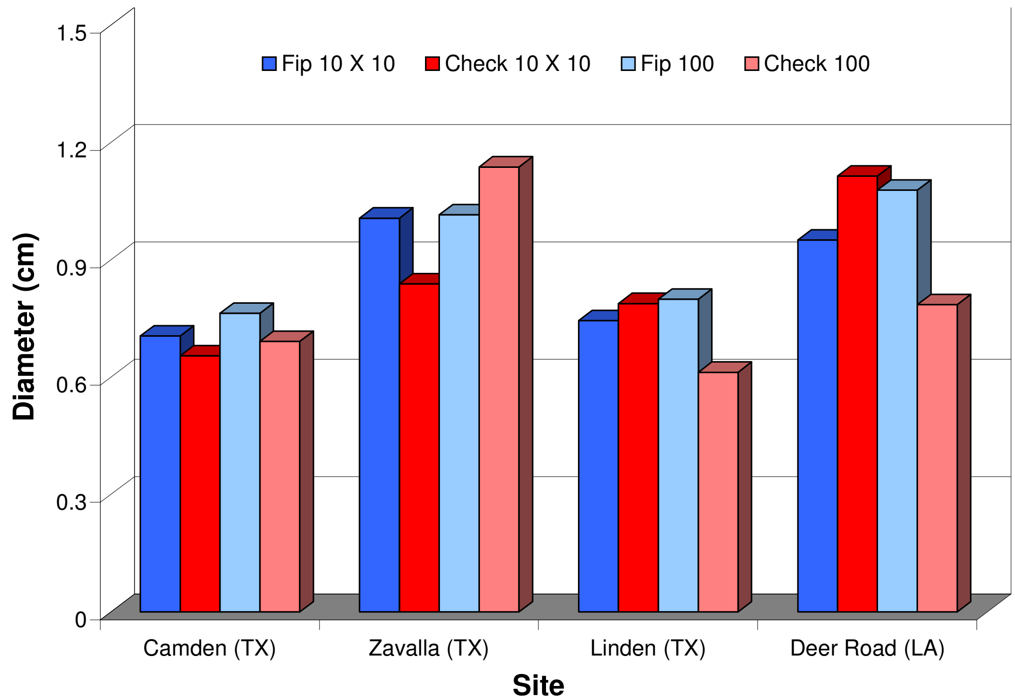
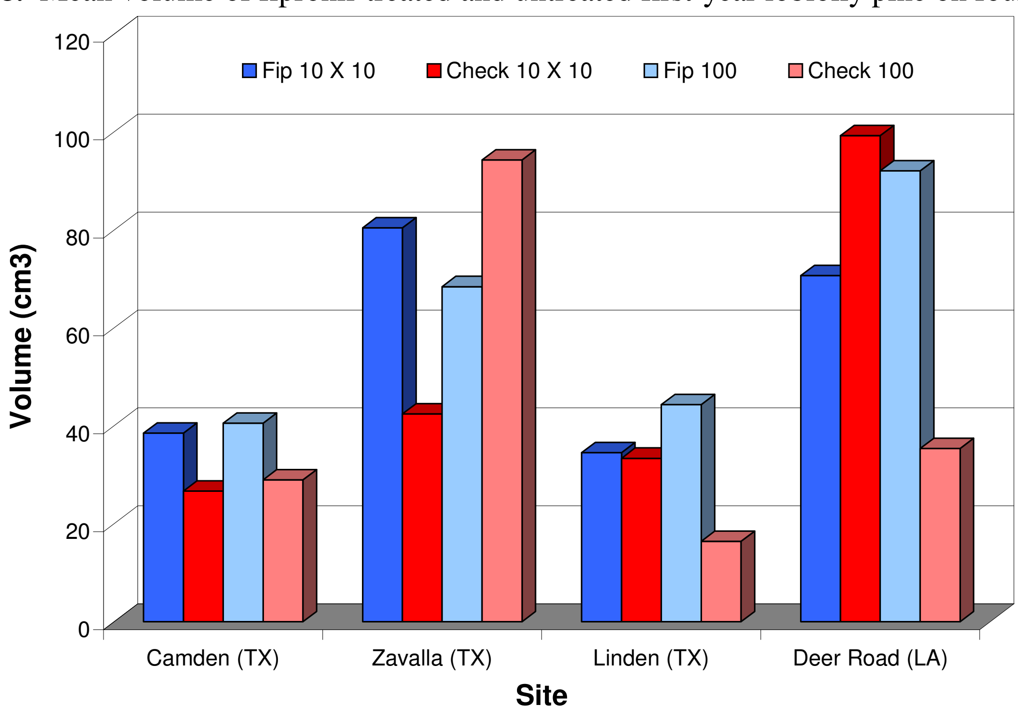


Figure 38. Mean volume of fipronil-treated and untreated first-year loblolly pine on four sites - 2003.



2003 Expenditures vs. Budget

Expenditures to operate the WGFPMC for CY 2003 totaled $141,174 (Table 32). This was $4,560 less than the projected $145,734 budget (Table 33 and 34). Sources of funding to cover expenses were derived from membership dues (40%), the FSPIAP federal grants for systemic injection and tip moth control and industry grants for leaf-cutting ant trials (16%), and the Texas Forest Service (44%). Of this total, 86% was devoted to professional salaries, fringe benefits, and seasonal wages, and the remainder (16%) to equipment, operating expenses, and indirect costs. Due to the federal and corporate grants ($31,761), we currently have a surplus of $5,438 in the WGFPMC account and $10,087 in the federal grant accounts (total = $15,525 at the end of CY 2003). The gain of one new member (Forest Investment Associates) should keep membership funding stable through CY2004. As a result, membership dues will remain at $8,000 per full member and $2,500 for associate members in CY 2004.

Emergency Funds (rediscovered WGFPMC funds from FY2000 and 2001) now totaling $27,576 are currently being held in a separate account awaiting a decision on how to spend them.

Table 32. WGFPMC Expenditures by Source of Funding - CY 2003

	Source				% of
	WGFPMC	TFS	Fed./Ind. Grants *	Total	Total
A. Salaries and Wages					
Principal Investigator (Grosman) (100%)	$ 16,170 (30%)	$ 37,731 (70%)	$ 0	$ 53,901	
Staff Forester (75%)	11,435 (32%)	15,521 (43%)	0	26,956	
SPB Specialist (11%)	3,834 (11%)	0	0	3,834	
4 Seasonal Technician (4 mos. ea.)	7,802		10,122	17,924	
Total Saleries and Wages	$ 39,241	$ 53,252	$ 10,122	$ 102,615	
B. Fringe Benefits / TFS Matching	$ 5,480	$ 7,436	$ 3,513	$ 16,429	
	44,721	60,688	13,635	119,044	86%
C. Operating Expenses					
Supplies	$ 3,327	$ 0	$ 2,208	$ 5,535	
Vehicle Use and Maintainance	2,091	0	1,780	3,871	
Travel	1,618	0	293	1,911	
Telecommunications (15% of FPM)	447	0	0	447	
Utilities (15% of FPM)	0	1,165	0	1,165	
Other Services (rentals, publications, postage, etc.)	4,939	0	717	5,656	
Total Operating Expenses	$ 12,422	$ 1,165	$ 4,998	$ 18,585	14%
Indirect Costs (10.5%)			3,545	3,545	
Grand Total	$ 57,143	$ 61,853	$ 22,178	$ 141,174	
% of Total	40%	44%	16%	100%	100%

* Grant funds remaining from 2002; grant awarded to TFS from the Forest Service Pesticide Impact Assessment Program to evaluate systemic insecticide treatment of seedlings for control of pine tip moth (Jan 1 - Dec 31, 2003); and grant donations from Griffin L.L.C. and Dow AgroScience for evaluation of leafcutting ant baits.

	WGFPMC	TFS	Fed./Ind. Grants
Funding Available as of January 1, 2003	$ 62,581	$ 65,141	$ 31,761

Table 33. WGFPMC Approved Budget by Source of Funding - CY 2003

	Source			% of
	WGFPMC	TFS and Others*	Total	Total
A. Salaries and Wages				
Principal Investigator (Grosman) (100%)	$ 15,865 (30%)	$ 37,021 (70%)	$ 52,886	
Staff Forester (Upton) (75%)	12,558 (35%)	14,352 (43%)	26,910	
Research Specialist (Smith) (10%)	3,200 (10%)	0	3,200	
3 Seasonal Technician (4 mo. ea)		17,280	17,280	
Total Salaries and Wages	$ 31,623	$ 68,653	$ 100,276	
B. Fringe Benefits (30% of Salaries)	$ 9,487	$ 15,412	$ 24,899	
	41,110	84,065	125,175	86%
C. Operating Expenses				
Supplies	$ 4,000	$ 1,000	$ 5,000	
Vehicle Use and Maintainance	3,724	1,000	4,724	
Travel	4,250	750	5,000	
Telecommunications (15% of FPM)	335	0	335	
Utilities (15% of FPM)	0	1,300	1,300	
Other Services (rentals, publications, postage, etc.)	3,200	1,000	4,200	
Total Operating Expenses	$ 15,509	$ 5,050	$ 20,559	14%
Grand Total	$ 56,619 **	$ 89,115	$ 145,734	
% of Total	39%	61%	100%	100%

* includes any new members or federal grants.

** member dues at $8,000/yr for six members; $2,500/yr for one member, $4,119 CY02 surplus,and $2,000 for WGTIP seed analysis.

Table 34. WGFPMC Approved Budget by Source of Project - CY 2003

	Activity				
	Administration	Tip Moth Studies		Systemic	
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	Total
A. Salaries and Wages					
Entomologist III (100%)	$ 21,155 (40%)	$ 10,577 (20%)	$ 10,577 (20%)	$ 10,577 (20%)	$ 52,886
Staff Forester (75%)	0	8,970 (25%)	8,970 (25%)	8,970 (25%)	26,910
Research Specialis (10%)	0	1,600 (5%)	0	1,600 (0%)	3,200
3 Seasonal Technicians (4 mos. ea.)	0	5,876 (34%)	5,702 (33%)	5,702 (33%)	17,280
B. Fringe Benefits (30% of Salaries)	$ 6,347	$ 6,344	$ 5,864	$ 6,344	$ 24,899
C. Operating Expenses					
Travel and Vehicle Use	$ 4,750	$ 2,340	$ 1,740	$ 894	$ 9,724
Supplies & Postage	2,700	1,600	1,200	1,200	6,700
Other Operating Expenses	1,335	930	930	940	4,135
Grand Total	$ 36,287	$ 38,237	$ 34,983	$ 36,227	$ 145,734