Western Gulf Forest Pest Management Cooperative

Report on
Research Accomplishments in 2001

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2001 WGFPMC Members:

International Paper Company
Louisiana Pacific Corporation
Plum Creek Timber Company, Inc.
Temple-Inland Forest Products Corporation
Texas Forest Service
U.S.D.A. Forest Service - Forest Health Protection R8
Willamette Industries, Inc.
Dow AgroSciences

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Executive Summary

2001 was another productive year for the Western Gulf Forest Pest Management Cooperative (WGFPMC). A brief summary of WGFPMC activities is given below. Two research projects (leaf-cutting ants and systemic injection studies) were continued from 2000. A third project, tip moth impact/hazard-rating/control, was initiated. Separate detailed reports for each project 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 2002 Project Proposals.

Membership in the WGFPMC generally remained unchanged through 2001 except for name changes. The Timber Company merged with Plum Creek Timber Company and Rhom & Haas merged with Dow AgroSciences.

Frank McCook, our research specialist, has taken a position with the new Texas Forest Inventory and Assessment and Health Monitoring Program. We appreciate his assistant these past 4 years and wish him the best in his new position. Seasonal technicians, Javier Vara, Jamie Burns and Mathew Phillips, were hired to provide assistance with field studies and continue development of the pesticide web site.

Service to members continues to be an important part of the WGFPMC. To this end, four issues of the PEST newsletter were prepared and distributed. Also, 11 presentations, 18 meeting requests, and 26 phone requests were addressed relating to the following topics: leaf-cutting ants/Volcano®, pine tip moth, reproduction weevils, bark beetles (*Ips* and black turpentine), cone and seed insects (coneworm and seed bug), sawflies, mealybugs, rabbits, and tree mortality of unknown cause.

Since the establishment of the WGFPMC in 1996, considerable effort has been devoted to finding and registering an alternative to methyl bromide for the control of the Texas leaf-cutting ant. Through our cooperative efforts, the WGFPMC was instrumental in obtaining a 24C (Special Local Need) registration in Texas for Volcano®, a sulfluramid bait, in 1999 and in Louisiana in 2000. We are proud to say that all industry reports indicate the Volcano® has been nearly 100% effective in halting leaf-cutting ant activity with a single application. Unfortunately, the Environmental Protection Agency (EPA) is concerned about the persistence of sulfluramide chemicals in the environment. As a result of this concern, Griffin L.L.C. and EPA have reached an agreement to halt production of technical sulfluramid and to phase out Volcano® once the stock of technical product is exhausted (estimated at 7 – 10 years). In light of these events, we are now searching for an alternative to Volcano®. Trials were conducted during the winter of 2000/2001 and summer of 2001 to evaluate the effectiveness of another citrus pulp bait containing the active ingredient fipronil (Blitz®, produced by Aventis).

Rainfall returned to normal (46+ inches) in the Western Gulf region after nearly five years (1996 – 2000) with severe drought conditions. However, as usually is the case, we received little rainfall from July through October. The effects of the 1999 and 2000 droughts were still being felt early in 2001 with the death of numerous large oaks and pines as well as an indirect effect on the population development of several insect species. Outbreaks of cankerworm and katydids were reported in central Texas and of loblolly pine sawfly in southern Arkansas and northern Louisiana. Pine tip moth populations also reached high levels in the late summer when drought conditions prevailed in August. On the positive side, no infestations of the southern pine beetle were reported in Texas, Louisiana, Arkansas or Oklahoma in 2001

In 1999 and 2000, it was hypothesized that severe drought conditions caused significant second year cone mortality (40%+) at the TFS Magnolia Spring Seed Orchard in Texas. This hypothesis was supported in 2001 when little second year cone mortality occurred under more normal rainfall conditions. Considerable progress has been made in the evaluation and development of systemic insecticides and injection systems. For the third year in a row, trees injected a single time in 1999 with emamectin benzoate and thiamethoxam had significantly reduced levels of both coneworm and seed bug damage. Additional data indicate that a single injection of emamectin benzoate into Florida loblolly pines also significantly reduced damage from coneworms. A second study was initiated to determine the optimal application rates for emamectin benzoate and thiamethoxam. A manuscript entitled "Systemic insecticide injections for control of cone and seed insects in loblolly pine seed orchards – 2 year results" was submitted and accepted for publication in the Southern Journal of Applied Forestry. It is scheduled to appear in print in August, 2002.

A new project was 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. Data analysis is on going. However some results indicate that multiple applications of Mimic® significantly reduced infestation levels of pine tip moth compared to untreated trees during each of five moth generations. Additional data indicate that systemic insecticides have some potential in reducing tip moth damage.

Finally, work is progressing on the development a web-based list of forestry-related pesticides that would be cross-referenced with pest and site uses. We hope to complete the project in 2002.

2001 Leaf-cutting Ant Trials

Highlights:

- In preference trials, Blitz® was significantly more attractive to Texas leaf-cutting ants (TLCA) than Volcano® during both the winter and summer.
- In retrieval trials conducted during the summer 2001, TLCA retrieved all bait (Blitz®) within 2.5-3 hours after application. The bait was not attractive to birds.
- Blitz® and Volcano® baits, tested during the winter of 2000/2001 and summer 2001, were essentially equal (90-100%) in their effectiveness in halting TLCA activity 8 weeks after treatment. However, Blitz reduced ant activity at a faster rate.

Objectives: 1) Determine TLCA preference to Blitz® and Volcano® baits; 2) evaluate the efficacy of the Blitz® fipronil bait in reducing activity in Texas leaf-cutting ant colonies; 3) determine the effect of season on treatment efficacy; 4) determine time required for TLCA to retrieve bait applied to the central nest area (CAN); and 5) determine if birds are attracted to Blitz®.

Study Sites: 200 active colonies were located in east Texas on lands owned by International Paper, Louisiana Pacific, and Temple-Inland and private landowners.

Insecticides:

Sulfluramid -- slow-acting poison on a citrus pulp carrier.

Volcano® - concentration (0.5% a.i.); citrus pulp (?); packing (loose); color (light tan); size (variable 2 - 25 mm).

Fipronil – slow-acting poison on a citrus pulp carrier.

Blitz® - concentration (0.03% a.i.); citrus pulp (orange); packing (tight); color (dark brown); size (uniform 4 mm).

Research Approach:

<u>Preference Trial:</u> Given the differences in physical and chemical characteristics between the Volcano® and new Blitz® baits, field trials were conducted during the summer of 2001 to determine if TLCA have preference for a particular bait formulation. Treatments included: 1) Blitz 0.03% ai, 2) Volcano® 0.5% ai, and 5) check (blank citrus pulp). Five grams of each bait formulation were weighed and placed in each of 10 petri dishes (10 replications per treatment). Subsequently, in the field, one dish of each formulation was randomly placed along a leaf-cutting ant foraging trail. For each replicate, the dishes were monitored for three hours or until all bait from one dish had been removed by the ants. At that time, all dishes were recovered and the remaining contents of each dish were weighed. The data were analyzed to determine the percent of bait removed for each formulation.

<u>Retrieval Trial:</u> A trial was conducted in east Texas during the summer 2001. Two active leaf-cutting colonies 100m of each other were selected. Blitz® (0.03% ai) was applied at 10 g/m^2 by cyclone spreader to the central nest area of a colony just before the ants become active (~ 9 AM).

Once the colonies were treated, two 15-cm diameter areas were marked and the number of bait particles present within each area were counted. Five petri dish tops containing 4 bait particles (~10 g/m^2, summer) also were evenly distributed within the central nest area. The dishes, marked area, and CNA were monitored at 30-minute intervals and the number or percentage of bait particles remaining was recorded. Each colony was monitored until no bait could be found in the dishes or CNA. In addition, observations were made to determine if animals (birds), other than leaf-cutting ants, were feeding on the applied bait.

Efficacy Trials: Application rates were based on the area (length X width) of the central nest.

Sulfluramid

Volcano®- 1) 4 g/m^2 applied during the winter trials only.
2) 10 g/m^2 applied during the summer trials only.

Fipronil

Blitz®- 1) 10 g/m^2 applied to CNA during the winter and summer trials.

Check - untreated colonies

A cyclone spreader was used in 2001 to evenly spread measured amounts of sulfluramid or fipronil bait over the CNA.

Application Dates:

Winter 2000/2001: Treatments applied in January and February.
Summer 2001: Treatments applied in July and August.

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

Results:

Preference Trial: TLCA showed a significant preference for Blitz® over Volcano® during the summer months in 2001 (Table 1). The greater attraction to the Blitz® bait is a product of the ant's greater attraction to orange citrus pulp (used in Blitz®) compared to other citrus pulps (grapefruit, lemon, lime, etc.) used in the Volcano® bait. Note: Additional observations made during the efficacy trials indicate that TLCA will readily retrieve the Volcano® bait when there is no choice.

Retrieval Trial: Two colonies were treated in Jasper County, TX on October 18, 2001. Table 2 shows the size, number of active mounds, and amount of bait applied within each central nest area and the amount of bait remaining at each 30-minute interval.

Generally, the ants became active (excavating soil or searching for plant material) around 9 AM (PDT) and were most active (large number of ants observed) between 10 AM and 12 PM. The vast majority (80-90%) of the bait in dishes, flagged area, and central nest area was retrieved by the ants during this 1.5-2 hour period (10:00 AM – 12 PM).

No birds were observed retrieving or feeding on any of the bait formulations during these trials.

Efficacy Trial (Winter 2000-2001): - Both Blitz® and Volcano® were 100% effective in completely halting ant activity within 8 weeks of treatment (Table 3). However, the proportion of colonies inactive and the level of remaining ant activity at 2 weeks post-treatment indicates that the Blitz® bait generally reduced/halted ant activity more rapidly than did Volcano®. This appears to be due to a lesser degree of attraction to the Volcano® citrus pulp compared to the Blitz® citrus pulp (see preference trial above).

Efficacy Trial (Summer 2001): After 16 weeks, only the Blitz standard treatment was 100% effective in completely halting TLCA activity during the summer (Table 3). The Volcano® treatment had one failure. The failure appeared to have resulted from two factors: 1) limited ant attraction to the Volcano® citrus pulp and 2) reduced ant activity (foraging) under the drought conditions that occurred during the treatment period (July – August).

Summary: Overall, citrus pulp baits (containing sulfluramid or fipronil) continue to be a highly effective alternative to methyl bromide for control of TLCA. Evaluations of Blitz® indicate that it is as effective as Volcano® Leafcutter Ant Bait at the recommended rates of 10 g/m^2. However, Blitz® reduces ant activity at a faster rate compared to Volcano®. Field observations and results from preference trials indicate that Blitz® is more attractive to TLCA than Volcano®. TLCA appear to prefer baits of citrus pulp produced from oranges (i.e., Blitz®) over bait produced from other citrus fruits such as grapefruit, lemon, etc. (i.e., Volcano®).

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. recently reached an agreement to halt production of technical sulfluramid. Griffin will be permitted to produce and sell Volcano® until their supply of technical sulfluramid has been utilized. Griffin estimates that Volcano® should be available for the next 7 – 10 years before phase out. Another provision of the EPA/Griffin agreement was that the use language would be changed from “Pine Forest Sites” to “Pine Reforestation Sites.” This new use language restricts application to ant colonies in harvested areas being replanted in pine and includes areas directly adjacent to these sites.

Recently, EPA granted a Section 3 registration to Aventis (formerly Rhone Polenc and AgroEvo) for outdoor use of fipronil against fire ants. Aventis is currently considering the potential for registration of Blitz® in the United States.

Table 1. Attractiveness of fipronil (Blitz®) and sulfluramid (Volcano®) baits to the Texas leaf-cutting ant (*Atta texana*) - September and October 2001.

Treatment	N	Mean Percent Citrus Pulp Bait Removed from dishes ± SE
Fipronil (Blitz®)	10	79.1 ± 7.8 b
Sulfluramid (Volcano®)	10	35.0 ± 5.3 a
Blank citrus pulp	10	63.5 ± 10.4 b

[a] Means followed by the same letter are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Table 2. Bait retrieval of Blitz® by the Texas leaf-cutting ant, *Atta texana* , from two colonies in Jasper Co., TX - October, 2001.

	Activity					
	Colony 1			Colony 2		
Time	Dish [a]	Flagged Area [b]	Central Nest [c]	Dish	Flagged Area	Central Nest
	LP-20, 468 sq ft, 187 AM [d], treated w/ 21 oz Blitz (10g/m2) at 900 hours (9:00 AM)			LP-21, 598 sq ft, 209 AM, treated w/ 26 oz Blitz (10g/m^2) at 1910 hours (9:10 PM)		
0 h	5w4	6 & 13	100%	5w4	8 & 9	100%
0.5 h	5w4	6 & 13	100%	5w4	8 & 9	100%
1 h	1w3, 4w4	4 & 13	95%	2w0, 1w3 2w4	8 & 9	95%
1.5 h	2w0, 1w3, 2w4	4 & 11	80%	3w0, 1w1 1w4	6 & 2	80%
2 h	3w0, 1w1, 1w4	3 & 4	60%	4w0, 1w1	2 & 0	60%
2.5 h	4w0, 1w4,	0 & 0	20%	4w0, 1w1	0 & 0	30%
3 h	5w0	0 & 0	0%	5w0	0 & 0	5%
3.5 h				5w0	0 & 0	0%

[a] Five petri dishes, each containing four pieces of bait, were evenly distributed within the central nest area; number indicates # of dishes with number of bait pieces at each hourly interval.

[b] The number of bait particles in two flagged areas, 6" radius, were counted at each interval.

[c] Estimate of the percent of bait remaining in the central nest area at each interval.

[d] Active Mounds

Table 3. Efficacy of fipronil (Blitz®) and sulfluramid (Volcano®) applied by spreader to control the Texas leaf-cutting ant (*Atta texana*) in east Texas (Winter 2000-2001 and Summer 2001).

Treatment	No. of Colonies Treated	Mean Nest Area (m^2)	Mean # Mounds @ Trt.	Mean % initial activity [a] (% inactive colonies):					
				2 wk		8 wk		16 wk	
Winter 2000/2001									
Fipronil (Blitz®) @ 10g/m^2	12	31	90	3.7 a	(50)	0.0 a	(100)	0.0 a	(100)
Sulfluramid (Volcano®) @ 4g/m^2	12	45	130	14.9 b	(0)	0.0 a	(100)	0.0 a	(100)
Check (no treatment)	10	40	91	88.9 c	(0)	92.8 b	(10)	64.4 b	(0)
Summer 2001									
Fipronil (Blitz®) @ 10g/m^2	10	56	221	0.5 a	(70)	0.0 a	(100)	0.0 a	(100)
Sulfluramid (Volcano®) @ 10g/m^2	10	53	181	9.9 b	(10)	0.2 a	(90)	6.7 a	(90)
Check (no treatment)	10	36	169	82.3 c	(0)	100.0 b	(0)	87.4 b	(0)

[a] Means followed by the same letter within each season and column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

1999-2001 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 84 - 91% in 2001 – 3 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 2001 – 18 months post treatment. Control of seed bug using thiamethoxam 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 coneworm 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 with similar activity compared to imidacloprid.

Design: Randomized complete block with clones as blocks. 10 treatments X 10 clones reduced to 5 treatments X 6 most susceptible clones (= 30 ramets) used for study in 2001.

Application Methods:

STIT Injection – In 1999 and 2000, a 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 injector 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	5 and 6
<15 cm	20 ml	40 ml combined	30 ml combined
16 - 20 cm	20 - 40 ml	40 - 80 ml	30 - 60 ml
21 - 25 cm	40 - 60 ml	80 - 120 ml	60 - 90 ml
26 - 30 cm	60 - 80 ml	120 - 160 ml	90 -120 ml
>30 cm	+20 ml/5 cm dia. increment	+40 ml/5 cm dia. increment	+30 ml/5 cm dia. increment

Treatments:

1) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999) (N = 6)
2) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999 & April 2000) (N = 6)
3) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999) (N = 6)
4) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999 & April 2000) (N = 6)
5) Check(N = 6)

Data Collection:

***Dioryctria* Attacks** -- All cones 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.

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 34% damage on check cones in 2001, the highest damage level in four years (Table 4). Moderate numbers of seed bugs were observed in the trees in 2001. This was confirmed by the 33% damage by seed bugs to seed from check trees (Table 5), compared to 53% in 1999 and 24% in 2000. Seedworm damage to seed from check trees was considered insignificant (1% or less in 2001), 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 4). Overall reductions for both emamectin benzoate alone and emamectin benzoate plus thiamethoxam treatments were >96% compared to the check. In 2001, the treatments continued to reduce coneworm damage. Overall reductions ranged from 84% to 91%. 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 at least three full years. All treatments containing emamectin benzoate saw significantly higher proportions of healthy cones compared to the check.

Treatment Effect on Seed Bug Damage: In 2001, seed bug damage levels (33%) were moderate in check cones compared to 1999 levels (54%) and 2000 levels (24%) (Table 5). 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 significantly reduced early and late seed bug damage or increased the number of full seeds per cone compared to the check. This indicates that the yearly treatments of thiamethoxam are necessary to maintain adequate protection against seed bugs. Although not statistically significant at $P < 0.05$, the second injection of thiamethoxam did reduce late season damage by 37% and increased full seed yield by 46%.

Treatment Effect on Overall Insect Damage: An estimate of the combined losses due to two primary insect pest groups, coneworms and seed bugs, can be calculated by adding the proportion of coneworm-damaged cones to the proportion of all seed in "apparently" healthy cones damaged by seed-bug. (**Note:** this does not take into account the portion of sound seed that might be retrieved from some of the less damaged "other" cones.) In this study, it is conservatively estimated that coneworms and seed bugs in combination reduced the potential seed crops of check trees by 51%; compared to 41% in 1999 and 29% in 2000 (Table 6). Two treatments stand out with regard to their ability to reduce overall insect damage: emamectin benzoate alone and emamectin benzoate + thiamethoxam. Two injections of these treatments in 2000 continued to reduce overall insect damage by 43% and 66%, respectively, in 2001.

Summary: Over the past three years, emamectin benzoate has exhibited the best overall protection against coneworms, but was less effective against seed bugs. The data suggest that a single injection of emamectin benzoate can protect trees against coneworm for 30 months or longer. A second injection is not necessary during the second growing season. The Arise SL® formulation of emamectin benzoate is reported to be highly effective (providing 4+ years of protection) in Japan against the pinewood nematode, *Bursaphelenchus xylophilus*, and its cerambycid vector, *Monochamus alternatus* (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 following injection, but generally showed little or inconsistent effects against coneworms. Thiamethoxam does 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 has so far discouraged Syngenta from pursuing registration of the Arise® (emamectin benzoate) formulation in this country. An attempt is being made to expand the forestry market through trials with other tree species.

Table 4. 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), emamectin benzoate + thiamethoxam (EB + Thia.), imidacloprid (Imid.) or foliar treatments of imidacloprid or Asana XL®, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 1999 - 2001.

				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**
	Imid.	STIT - Apr., '99	20	6.3 ± 0.8 **c**	5.4 ± 1.3 **b**	11.8 ± 1.8 **c**	38.6 ± 2.7 **a**	49.6 ± 3.8 **b**
	Imid.	Hydraulic Foliar 5X in '99	10	9.8 ± 1.3 **d**	8.1 ± 1.7 **c**	17.9 ± 2.8 **d**	33.9 ± 3.9 **a**	48.1 ± 4.7 **ab**
	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**
	Imid.	STIT - Apr., '99	10	3.4 ± 1.1 **b**	17.7 ± 4.2 **b**	21.1 ± 5.0 **b**	44.8 ± 6.4 **a**	34.1 ± 6.9 **a**
	Imid.	STIT - Apr., '99 & '00	10	4.3 ± 1.3 **b**	12.1 ± 4.4 **b**	16.4 ± 4.3 **b**	44.2 ± 4.9 **a**	39.3 ± 6.0 **a**
	Asana XL	Hydraulic Foliar 5X in '00	10	5.0 ± 1.1 **b**	7.4 ± 2.2 **b**	12.4 ± 2.9 **b**	43.5 ± 5.5 **a**	44.1 ± 7.0 **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**

* 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 5. 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), emamectin benzoate + thiamethoxam (EB + Thia.), imidacloprid (Imid.) or foliar treatments of imidacloprid or Asana XL®, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 1999 - 2001.

				Mean Seed Bug Damage (%)			Mean No.	Mean No.	Mean No.
Year	Treatment	Application Technique, Treatment Date(s)	N	Early (2nd Yr Abort)	Late	Total	Seeds per Cone	Filled Seed per Cone	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**
	Imid.	STIT - Apr., '99	20	0.4 ± 0.2 **a**	9.2 ± 1.2 **a**	9.6 ± 1.3 **a**	78.7 ± 6.5 **a**	60.5 ± 5.8 **c**	10.6 ± 1.2 **a**
	Imid.	Hydraulic Foliar 5X in '99	10	0.9 ± 0.3 **b**	28.1 ± 2.2 **bc**	29.0 ± 2.2 **bc**	68.1 ± 7.0 **a**	35.3 ± 4.5 **bc**	12.0 ± 2.2 **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**
	Imid.	STIT - Apr., '99	10	0.5 ± 0.2 **a**	14.4 ± 3.1 **b**	14.9 ± 3.2 **b**	96.5 ± 9.9 **a**	68.9 ± 9.2 **bcd**	12.3 ± 2.1 **a**
	Imid.	STIT - Apr., '99 & '00	10	0.2 ± 0.1 **a**	5.5 ± 1.5 **a**	6.1 ± 1.5 **a**	105.6 ± 10.3 **a**	86.1 ± 8.5 **cd**	11.1 ± 1.9 **a**
	Asana XL	Hydraulic Foliar 5X in '00	10	0.3 ± 0.2 **a**	5.2 ± 0.8 **a**	5.5 ± 0.8 **a**	93.3 ± 5.5 **a**	75.1 ± 5.1 **bcd**	10.4 ± 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**

* 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. 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), emamectin benzoate + thiamethoxam (EB + Thia.), imidacloprid (Imid.) or foliar treatments of imidacloprid or Asana XL, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 1999 - 2000.

		1999			2000			2001		
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	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
EB	STIT - Apr., '99 & '00	10			10	6.0 ± 1.2 **a**	79.0	6	29.4 ± 2.8 **b**	42.7
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
EB + Thia.	STIT - Apr., '99 & '00	10			10	4.1 ± 0.7 **a**	85.7	5	17.7 ± 2.8 **a**	65.5
Imid.	STIT - Apr., '99	20	15.9 ± 1.7 **a**	61.2						
Imid.	STIT - Apr., '99	10			10	25.6 ± 4.8 **de**	9.7			
Imid.	STIT - Apr., '99 & '00	10			10	18.9 ± 4.2 **cd**	33.4			
Imid.	Hydraulic Foliar 5X in '99	10	31.6 ± 2.7 **b**	23.1						
Asana XL	Hydraulic Foliar 5X in '00	10			10	14.8 ± 2.7 **bc**	47.7			
Check		10	41.1 ± 3.6 **b**		10	28.4 ± 3.0 **e**		6	51.3 ± 3.4 **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.

2001 Systemic Insecticide Injection Rate Study - Magnolia Springs, TX

Highlights:

- Emamectin benzoate plus thiamethoxam (20 ml) injected in April 2001 improved conelet survival by 30% and cone survival by 62%.
- Single injections of emamectin benzoate alone or in combination with thiamethoxam at high (20 ml) and moderate (10 ml) rates reduced coneworm damage by 94 - 95% and seed bug damage by 37 – 54% in 2001.
- Overall insect damage (coneworm + seed bug) was reduced to the greatest extent (73% and 76%) 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 10 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. 7 treatments X 10 clones = 70 ramets used for study.

Application Methods:

STIT Injection – In April 2001, a 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 injector 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 injector
2) 10 ml rate each for 4% emamectin benzoate (Arise SL®) 5% thiamethoxam (25WG) by injector
3) 3 ml rate each for 4% emamectin benzoate (Arise SL®) 5% thiamethoxam (25WG) by injector
4) 20 ml rate for 4% emamectin benzoate (Arise SL®) alone by injector
5) 20 ml rate for 5% thiamethoxam (25WG) alone by injector
6) Asana XL (standard) applied by hydraulic sprayer to foliage 5 times per year at 9.6 oz/100 gal at 5-week intervals beginning in April.
7) Check

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 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 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 46% damage on check cones in 2001; (Table 7). Moderate numbers of seed bugs, particularly leaf-footed pine seed bug, were observed in the trees in 2001. This was reflected by the 33% damage to seed from check trees (Table 8). Seedworm damage to seed from check trees was considered insignificant (1% or less in 2001), so the data were not included in the analysis.

Treatment Effect on Conelet and Cone Survival: Cones on tagged branches were examined in April and October. All injection and foliar treatments significantly improved survival of conelets and cones compared to check trees. Overall, the higher rates of emamectin benzoate plus thiamethoxam combination treatments (10 ml and 20 ml) provided the best protection of conelets, significantly improving survival by 28% and 30%, respectively, over that of the check (Table 9). Similarly, cone survival was most improved by the higher rates of emamectin benzoate plus thiamethoxam; 58% by the 10-ml rate and 62% by the 20-ml rate. Logarithmic curves show significant relationships between rates of emamectin benzoate and thiamethoxam applied and both conelet survival ($r^2 = 0.954$; $P < 0.0001$) and cone survival (R2 = 0.996; $P < 0.0001$) (Figs. 1 & 2).

Treatment Effect on Coneworm Damage: Treatments containing emamectin benzoate, alone or combined with thiamethoxam at higher rates ($\geq$ 10 ml), significantly reduced early and late coneworm damage compared to the check (Table 7). Overall reductions for both emamectin benzoate alone and emamectin benzoate plus thiamethoxam treatments were >94% compared to the check. The emamectin benzoate plus thiamethoxam (3 ml) and thiamethoxam alone were only slightly less effective; reducing damage by 89% and 87%, respectively. All injection treatments had significantly higher proportions of healthy cones compared to the check. A highly significant relationship was found between rates of emamectin benzoate and thiamethoxam applied and incidence of coneworm damage (r^2 = 1.000; $P < 0.0001$) (Fig. 3).

Treatment Effect on Seed Bug Damage: In 2001, seed bug damage levels (33%) were moderate in check cones, falling between 1999 levels (54%) and 2000 levels (24%) (Table 8). 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. All injection treatments significantly reduced total seed bug damage. However, the higher rates (10 and 20 ml) of emamectin benzoate and thiamethoxam provided the greatest reductions in damage, 54% and 50% respectively, compared to the checks. These treatments also increased the number of full seeds per cone by 56% and 51% respectively compared to the check. A significant relationship was found between rates of emamectin benzoate and thiamethoxam applied and incidence of seed bug damage (r^2 = 0.779; $P < 0.0001$) (Fig. 4)

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 by adding the proportion of coneworm-damaged cones to the proportion of all seed in healthy cones damaged by seed-bug. (**Note:** this does not take into account the portion of sound seed that might be retrieved from some of the less damaged "other" cones.) In this study, it is conservatively estimated that coneworms and seed bugs in combination reduced the potential seed crops of check trees by 60% (Table 10). Three treatments stand out with regard to their ability to reduce overall insect damage: 20 ml of emamectin benzoate alone and the two higher rates (10 ml and 20 ml) of emamectin benzoate + thiamethoxam. Injections of these treatments in 2001 reduced overall insect damage by 72%, 76% and 73%, respectively. A significant relationship was found between rates of emamectin benzoate and thiamethoxam applied and overall insect losses (r^2 = 0.777; $P < 0.0001$) (Fig. 5)

Summary: This study again demonstrates that emamectin benzoate, alone or in combination with thiamethoxam, is highly effective at protecting cones against coneworms. Surprising, thiamethoxam alone was nearly as effective as emamectin benzoate at reducing coneworm damage during the first season after injection. Regression curves indicate that roughly 10ml of the emamectin benzoate and thiamethoxam is necessary to provide optimal reduction of coneworm and seed bug damage and the greatest gain in conelet and cone survival and filled seed per cone. No significant increase in efficacy was achieved by increasing dosages from 10 to 20 ml.

Table 7. Mean percentages (± SE) of surviving conelets and cones on branches of loblolly pine protected with systemic injection of emamectin benzoate alone, emamectin benzoate + thiamethoxam, thiamethoxam alone or foliar treatments of Asana XL®, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2001.

Year	Treatment (Rate in ml)	Application Technique, Treatment Date(s)	N	Mean Survival (%) Conelets	Mean Survival (%) Cones
2001	Emamectin benzoate (20)	STIT - Apr., '01	10	78.5 + 9.0 **bc†**	87.8 + 4.4 **c**
	EB + Thia. (20)	STIT - Apr., '01	10	91.3 + 3.6 **d**	94.4 + 2.3 **c**
	EB + Thia. (10)	STIT - Apr., '01	10	89.4 + 4.8 **cd**	92.3 + 3.0 **c**
	EB + Thia. (3)	STIT - Apr., '01	10	79.7 + 5.9 **ab**	89.4 + 3.8 **c**
	Thiamethoxam (20)	STIT - Apr., '01	10	85.9 + 4.8 **bcd**	88.6 + 4.0 **c**
	Asana XL	Hydraulic Foliar 5X in '01	10	91.4 + 2.5 **d**	78.4 + 4.3 **b**
	Check		10	70.0 + 4.3 **a**	58.4 + 6.9 **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 8. 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 alone (EB), emamectin benzoate + thiamethoxam (EB + Thia.), thiamethoxam alone (Thia.) or foliar treatments of Asana XL®, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2001.

				Mean Coneworm Damage (%)				
Year	Treatment (Rate in ml)	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 **a**	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**

* Mortality or wounds caused by 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 9. Seed bug damage, seed extracted, and seed quality (Mean ± SE) from second-year cones of loblolly pine protected with systemic injection of emamectin benzoate alone (EB), emamectin benzoate + thiamethoxam (EB + Thia.), thiamethoxam alone (Thia.) or foliar treatments of Asana XL®, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2001.

				Mean Seed Bug Damage (%)			Mean No.	Mean No.	Mean No.
Year	Treatment	Application Technique, Treatment Date(s)	N	Early (2nd Yr Abort)	Late	Total	Seeds per Cone	Filled Seed per Cone	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**

* 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 10. 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, Magnolia Springs, Jasper Co., TX, 2001.

Treatment	Application Technique & Rate & Treatment Date	N	Mean Combined Losses (%)	Mean Reduction (%)
EB	STIT - 20 ml - Apr., '01	10	16.7 ± 2.3 **ab***	72.2
EB + Thia.	STIT - 20 ml - Apr., '01	10	16.0 ± 3.0 **ab**	73.4
EB + Thia.	STIT - 10 ml - Apr., '01	10	14.6 ± 2.6 **a**	75.7
EB + Thia.	STIT - 3 ml - Apr., '01	10	25.5 ± 3.8 **c**	57.6
Thia	STIT - 20 ml - Apr., '01	10	22.0 ± 3.8 **bc**	63.4
Asana XL	Hydraulic Foliar 5X in '00	10	27.1 ± 3.4 **c**	54.9
Check		10	60.1 ± 2.9 **d**	

* 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.

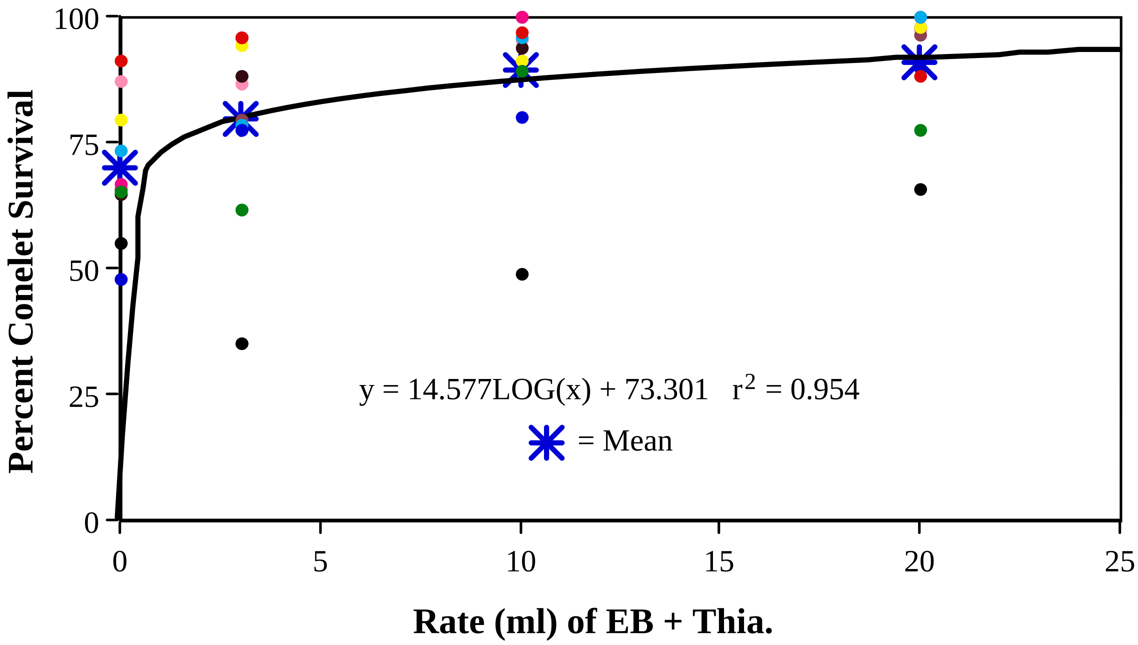


Figure 1. Relationship between loblolly pine conelet survival and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX – 2001.

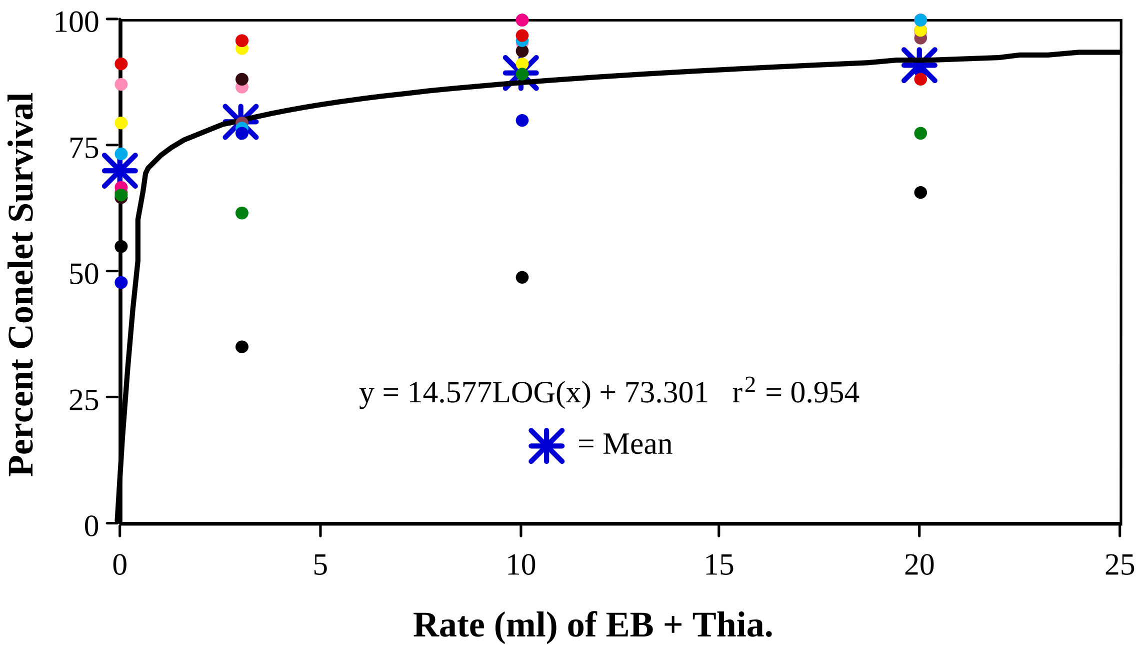


Figure 2. Relationship between loblolly pine cone survival and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX – 2001.

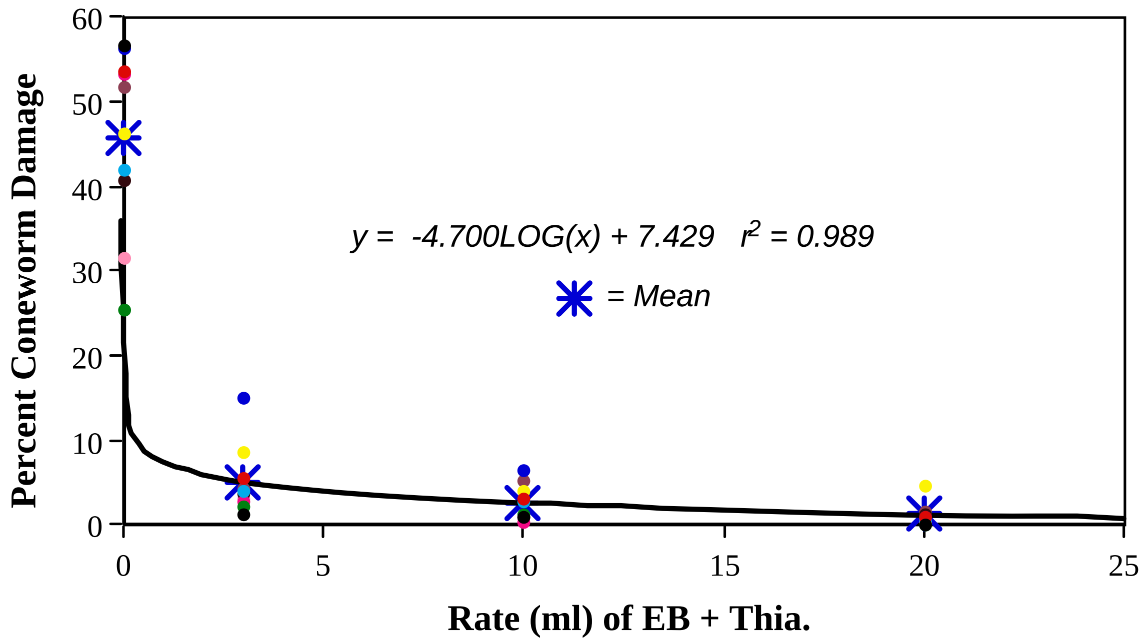


Figure 3. Relationship between coneworm (*Dioryctria* spp.) damage and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX – 2001.

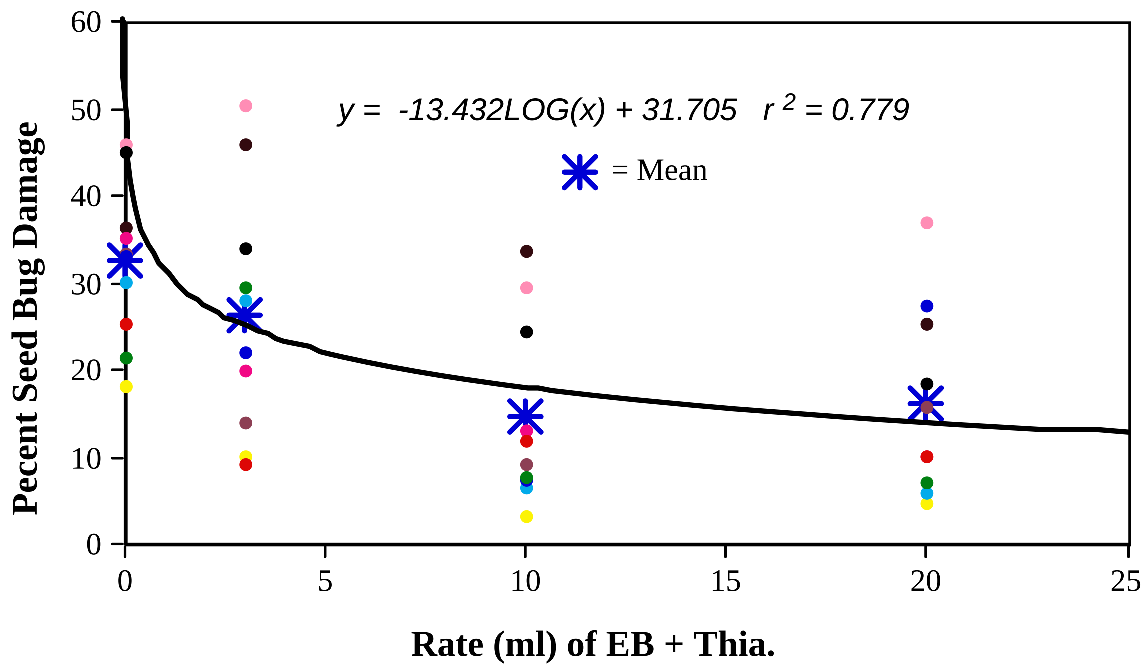


Figure 4. Relationship between seed bug (*Tetyra* sp. and *Leptoglossus* sp.) damage and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX – 2001.

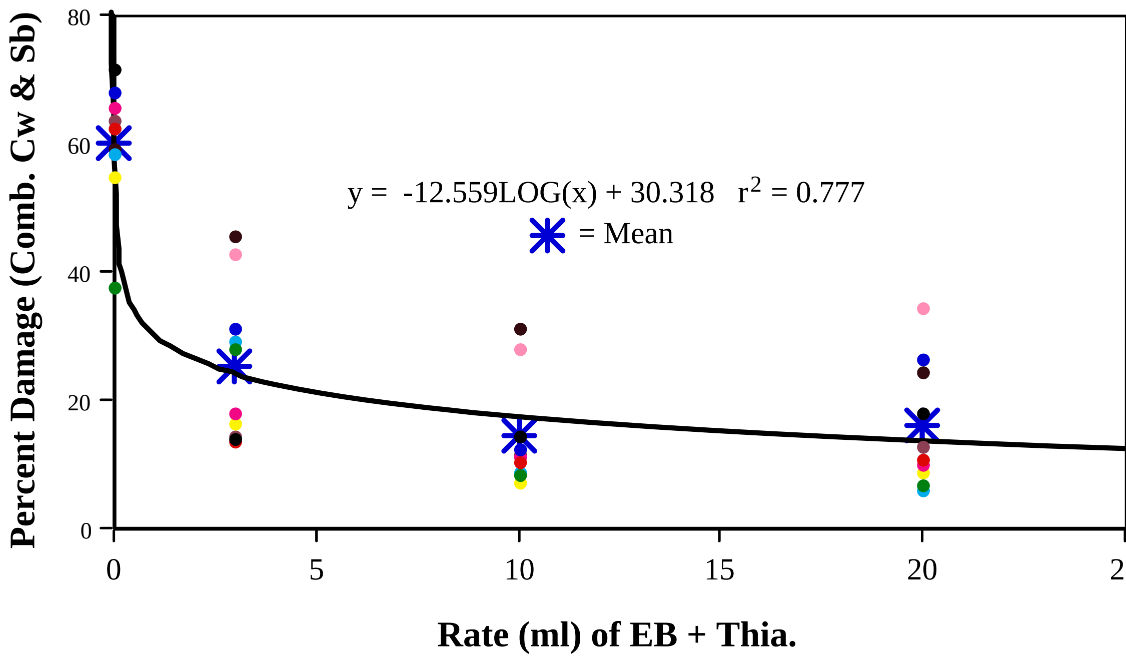


Figure 5. Relationship between overall insect damage (coneworm + seed bug) and rate of emamectin benzoate + thiamethoxam injected into loblolly pine trees, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX – 2001.

2001 Systemic Insecticide Study – Marianna, FL & Chico, CA

Highlights:

- λ Single STIT injections of emamectin benzoate into loblolly pine at the Bellamy SO in Florida reduced coneworm damage by 87% in 2001 – comparable to results in Texas.
- λ STIT injections of emamectin benzoate did not significantly improve conelet and cone survival compared to check trees.

Objectives: 1) Evaluation of emamectin benzoate, thiamethoxam, and/or emamectin benzoate/thiamethoxam mixture, applied by the STIT injector for control of coneworm and seed bugs in loblolly pine, ponderosa pine or Douglas-fir seed orchards.

Cooperators: Dr. R. Scott Cameron and Mr. Tim Slichter, International Paper Company
Dr. Nancy Rappaport, Mr. Henry Switzer and Ms. Carline Rudolph, U.S. Forest Service

Study Sites: International Paper's Bellamy seed orchard (containing loblolly pine) at Marianna, FL and USFS Genetic Resource and Conservation Center seed orchard (GRCCSO) (containing 21 year-old ponderosa pine and 15 year-old Douglas-fir) at Chico, CA

Insecticides:

Emamectin benzoate (Arise SL®) -- avermectin derivative
Thiamethoxam (Novartis 293) -- experimental insecticide with similar activity compared to imidacloprid.

Design: At GRCCSO, randomized complete block with clones as blocks. 2 treatments X 12 clones (= 24 ramets) for each tree species (ponderosa pine and Douglas-fir). At Bellamy SO, randomized complete block with clones as blocks (loblolly pine). 2 treatments X 4 clones X 3 ramets/clone (= 24 ramets).

Application Methods:

STIT Injection – At both sites, a 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 injector 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 Diameter	Treatment Rate
<15 cm	20 ml
16 - 20 cm	20 - 40 ml
21 - 25 cm	40 - 60 ml
26 - 30 cm	60 - 80 ml
>30 cm	+20 ml/5 cm dia. increment

Treatments:

1) 4% emamectin benzoate (Arise SL®) by STIT injector (applied Feb. 2001 at GRCCSO, Chico, CA and Mar. 2001 at Bellamy SO, Marion, FL)
2) 5% thiamethoxam by STIT injector (applied Feb. 2001 at GRCCSO, Chico, CA)
5) Check (both sites and treatments)

Data Collection:

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

***Dioryctria* Attacks** -- All cones 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 “apparently” healthy cones collected from each ramet; seeds were extracted and seed lots were radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Results:

Bellamy Seed Orchard**:** The orchard block containing the treatment trees had been sprayed in 2000 - suggesting that pressure from coneworms and seed bugs would be low. This was confirmed for coneworms when only 6% damage was found on check cones in 2001 (Table 11).

Treatment Effect on Conelet and Cone Survival: Cones on tagged branches were examined in April and October. The injection of emamectin benzoate did not significantly improve survival of conelets and cones compared to check trees (Table 12).

Treatment Effect on Coneworm Damage: Treatment of trees with emamectin benzoate significantly reduced early and late coneworm damage compared to the check (Table 11). Overall reduction for emamectin benzoate was 87% compared to the check. The injection treatment also had a significantly higher proportion of healthy cones compared to the check.

Treatment Effect on Seed Bug Damage: Seed analysis to determine the effect of emamectin benzoate on seed bug damage levels is on going. The results of these analyses also will be used to determine treatment effect on overall insect damage, i.e., combined losses due to coneworms and seed bugs.

GRCCSO: The cones were collected in October, but due to a disabling illness (Ms. Rudolph) the cones have yet to be evaluated and the seed has not been extracted. The results of this study will be presented in next year’s report.

Summary: The Florida trial so far indicates that the efficacy of STIT injections of emamectin benzoate is not geographically restricted. I am currently working with Dave Cox, Syngenta, towards the registration of this product in the United States.

Table 11. Mean percentages (± SE) of surviving conelets and cones on branches of loblolly pine protected with systemic injection of emamectin benzoate alone, Bellamy Seed Orchard, Marianna, Jackson Co., FL, 2001.

Year	Treatment (Rate in ml)	Application Technique, Treatment Date(s)	N	Mean Survival (%)	
				Conelets	Cones
2001	Emamectin benzoate (20)	STIT - Apr., '01	12	77.0 ± 9.6 **a†**	96.7 ± 2.0 **a**
	Check		12	66.7 ± 6.7 **a**	95.5 ± 2.1 **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 12. 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 alone (EB), Bellamy Seed Orchard, Marianna, Jackson Co., FL, 2001.

Year	Treatment (Rate in ml)	Application Technique, Treatment Date(s)	N	Mean Coneworm Damage (%): Early (small dead)	Mean Coneworm Damage (%): Late (large dead and infested)	Mean Coneworm Damage (%): Total	Mean Other Damage (%) *	Mean Healthy (%)
2001	EB (20)	STIT - Apr., '01	12	0.1 ± 0.0 **a†**	0.7 ± 0.2 **a**	0.8 ± 0.2 **a**	4.3 ± 1.5 **a**	94.9 ± 1.7 **b**
	Check		12	1.5 ± 0.4 **b**	4.8 ± 0.7 **b**	6.3 ± 1.0 **b**	3.1 ± 0.4 **a**	90.6 ± 1.2 **a**

* Mortality or wounds caused by 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.

Asana® Rate Study for Cone and Seed Insect Control in Southern Pine Seed Orchards - A Regional Cooperative Study Plan

Highlights:

- λ Data has been collected on conelet and cone survival and coneworm infestation levels. Seed analysis and other data analysis are on going.

Objective: Evaluate the efficacy of different rates of esfenvalerate, Asana®, for coneworm and seed bug control in loblolly and slash pine seed orchards across the South. The current labeled rate and two lower rates were compared to a check having no insecticide application.

Cooperators, Site & Tree Species:

Florida Department of Forestry, Baker Seed Orchard; slash pine
International Paper, Springhill Seed Orchard, loblolly pine
International Paper, Pensacola (Jay) Seed Orchard, loblolly pine
Mississippi Forestry Commission, Craig Seed Orchard, loblolly pine
Temple Inland, Forest Lake Seed Orchard, loblolly pine
Weyerhaeuser, Lyons Seed Orchard, loblolly pine

Treatments:

1) Asana® applied at a rate of 0.19 pounds active ingredient/acre (ai/ac) at each of five monthly treatments.
2) Asana® applied at a rate of 0.10 pounds ai/ac at each of five monthly treatments.
3) Asana® applied at a rate of 0.03 pounds ai/ac at each of five monthly treatments.
4) Check (unprotected trees).

Application Methods

The timing of the applications was identical for all treatments. For loblolly pine seed orchards, the first application was within 7 days of peak pollen flight (April). The first application in slash pine seed orchards was made about April 1. In orchards of either species, the initial application was followed by four subsequent applications made at monthly intervals (May, June, July, and August).

Fixed wing or rotary wing aircraft were used. The aircraft were set up to deliver an effective swath width of 60-ft and calibrated to deliver 5 gallons of solution per acre. The aircraft made two passes over each row or aisle to deliver a total spray volume of 10 gallons of solution per acre. This assumes a 30-ft. row spacing in the orchard. The aircraft released the insecticide 10-20 ft. above the tops of the trees.

Field Layout

In each orchard, four treatment plots were laid out in the test area. Each plot was at least 5 rows wide and comprised at least 5 acres. There were 4 rows of buffer trees between treatments.

A complete block design was used. The experimental unit consisted of one treatment plot. Each orchard served as a replicate. Two sample ramets were selected from each of six clones in each plot for a total of 48 sample trees each orchard. These same six clones were sampled in each plot within an orchard, but clones differed among orchards. Treatments were randomly assigned to plots within each orchard.

Data Collection:

Conelet and Cone Survival – Four 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 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 seed lots were radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Secondary Pests. Test trees were visually inspected for the occurrence of homopteran insect populations (i.e., scales and mealybugs) about once a month. If it was determined that secondary pests were present, the relative population levels of the insects was determined by a scoring system (Cameron, 1989): 0 = none, 1 = few insects on scattered branches, 2 = many branches with few insects, or few branches with moderate to large numbers of insects, and 3 = many branches with many insects.

Results:

Data analysis of survival and cone count data is currently being conducted by Drs. Tom Byram and Dudley Huber. Seed lots are currently being radiographed by the WGFPMC. The complete results will be presented in next year's report.

2001 Tip Moth Impact Study – Western Gulf Region

Highlights:

- λ Tip moth monitoring with pheromone traps indicated the occurrence of 5 generations at 7 of 8 impact sites in 2001.
- λ Periodic applications of Mimic® to first-year pine seedlings reduced tip moth infestation levels by 92% compared to untreated trees.
- λ The exclusion of tip moth on Mimic®-treated trees improved mean height by 25%, diameter growth by 23%, and volume index by 87% 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, 2) identify abiotic factors that influence the occurrence and severity of tip moth infestations and 3) identify a treatment threshold for pine tip moth infestation.

Study Sites: Each Coop member selected 1 to 3 first-year plantations. Two areas within each plantation were selected and divided into 2 plots each - each plot containing 126 trees (9 rows X 14 trees). Given that tip moth populations are generally higher in older (2 - 4 year old) plantations, tip moth populations also were monitored in one 3-year old plantation near most study sites.

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, 2001, and monitored until the beginning of November. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticide:

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

Design: 8 sites X 2 plots X 2 treatments X 50 trees = 1600 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 each site in 2001. Pesticides were applied by backpack sprayer or spray bottle to all 126 trees within the designated Mimic® plot (treatment area) until the foliage was moist. Application dates were based on trap catches and degree day calculations, 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. 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 were collected on tree height, diameter, and percent tree mortality.

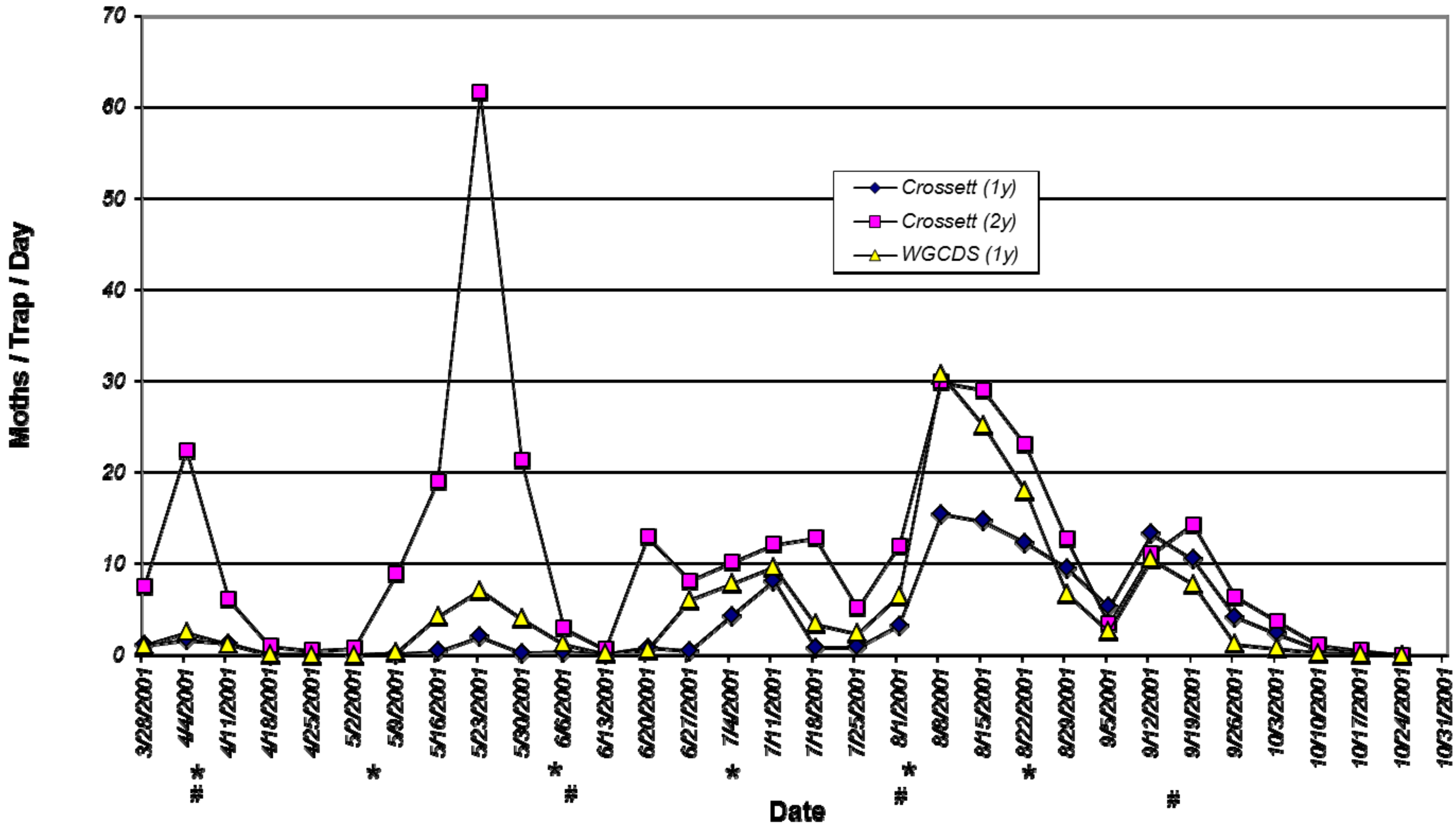
Results: Figures 6 to 10 show the distribution of pine tip moths captured in traps at eight study sites in 2001. Based on the latitude of the sites, we had expected four generations of tip moth at all but the most southern sites (Bleakwood and Kirbyville, TX). However, trap catches at all but one site (Cypress Springs, LA) indicated a fifth generation had developed late in the summer.

Based on trap catch numbers and degree day calculations, the optimal spray dates for the first four generations were determined to be about March 24, May 28, July 12, and August 22 (Figs. 6 - 10).

Tip moth infestation levels were relatively low on check trees during the first generation but increased dramatically after mid-June when drought conditions prevailed (Table 13). The Mimic® treatments provided excellent control during all tip moth generations (Fig. 11) - reducing infestation levels by an average of 92% (Table 13). Nearly all Mimic®-treated plots showed markedly greater tree height and diameter growth compared to the neighboring untreated trees. Overall, the exclusion of tip moth on treated trees improved tree height, diameter and volume index by 25%, 23% and 87%, respectively, compared to untreated trees (Table 14). The only site not showing this trend was at Cypress Springs, LA. High mortality on this site may have confounded the effects of the Mimic® treatment (Table 14).

Summary: Multiple applications of Mimic® significantly reduced tip moth damage during the first year after planting. Although tip moth populations were not exceptionally high during the spring, the near total exclusion of tip moth during this period allowed tree growth to reach its potential. It is important to continue treatments into 2002 to determine the impact of tip moth when populations are well established in the 2nd year.

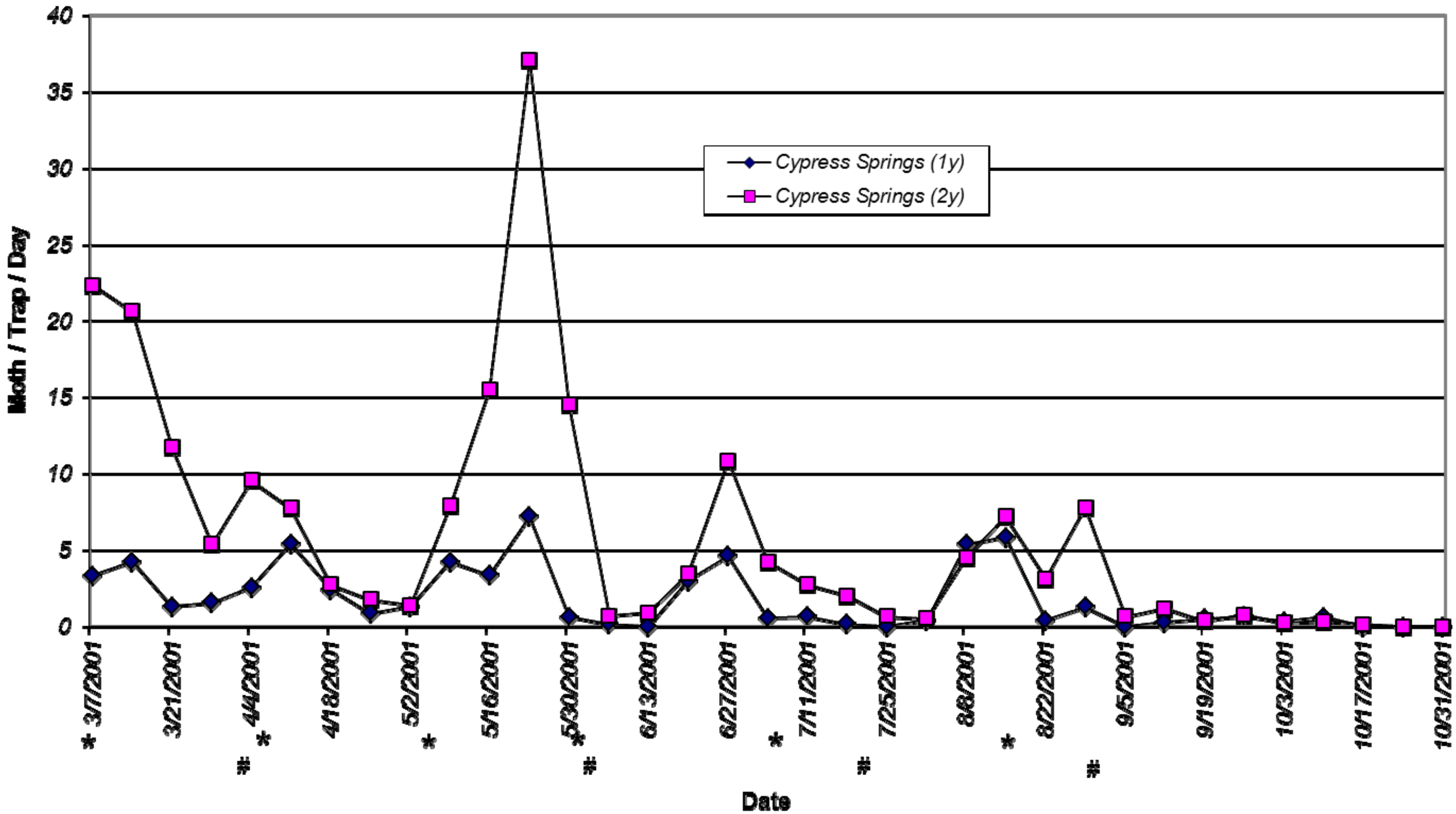
Figure 6. *Tip Moth Catch in or near Crossett, AR site - 2001*



* Sprayed Mimic: April 5, May 4, Jun 4, Jul 3, Aug 2, Aug 22

Fettig Predictions: Apr 8, Jun 7, Aug 1, Sep 15

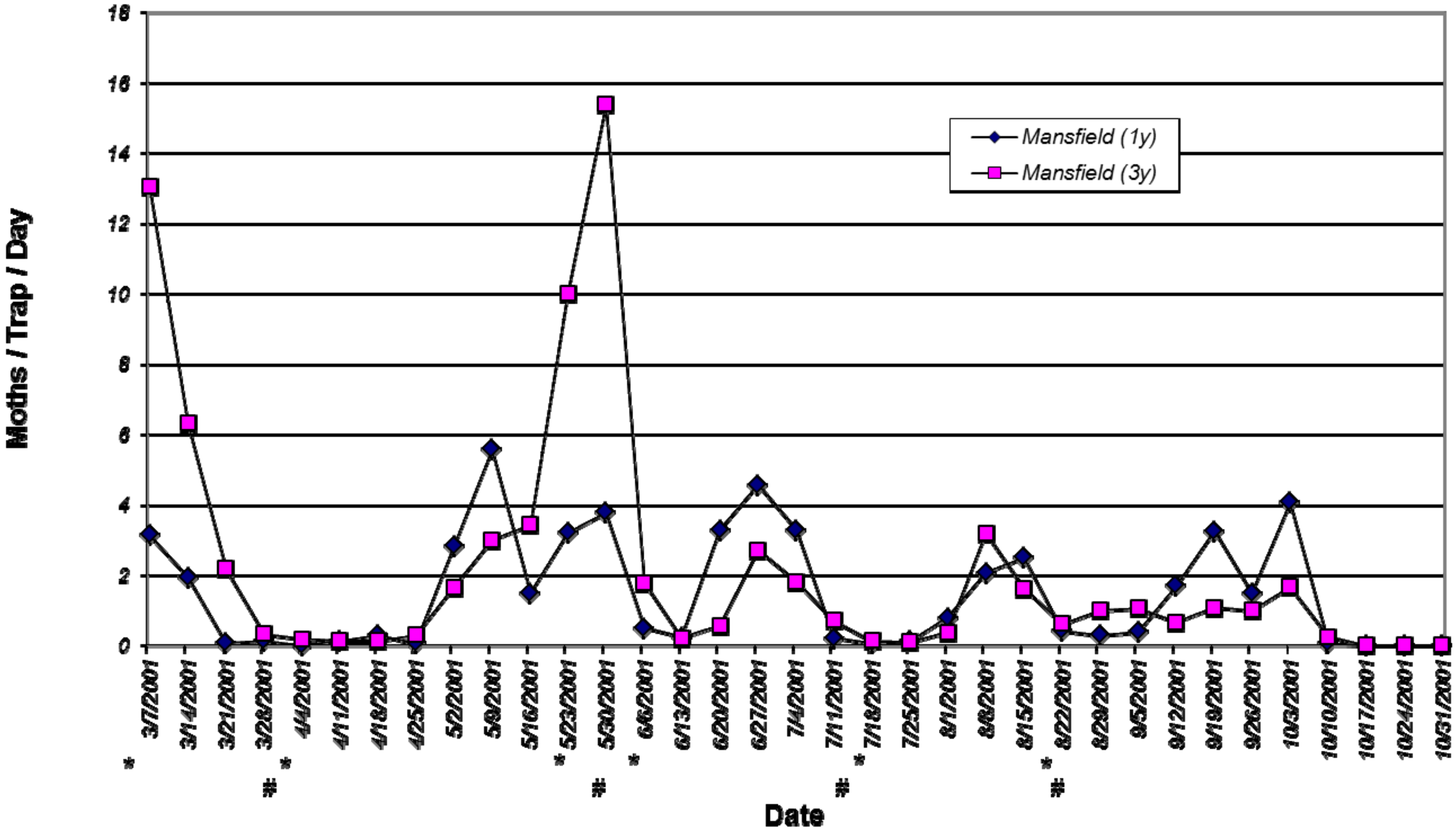
Figure 7. *Pine tip moth catch in or near Cypress Spring, LA site - 2001*



** Sprayed Mimic: Mar. 5, Apr. 5, May 3, May 31, Jul 5, Aug 15*

 # Fettig Predictions: Apr 3, Jun 2, July 22, Aug 31

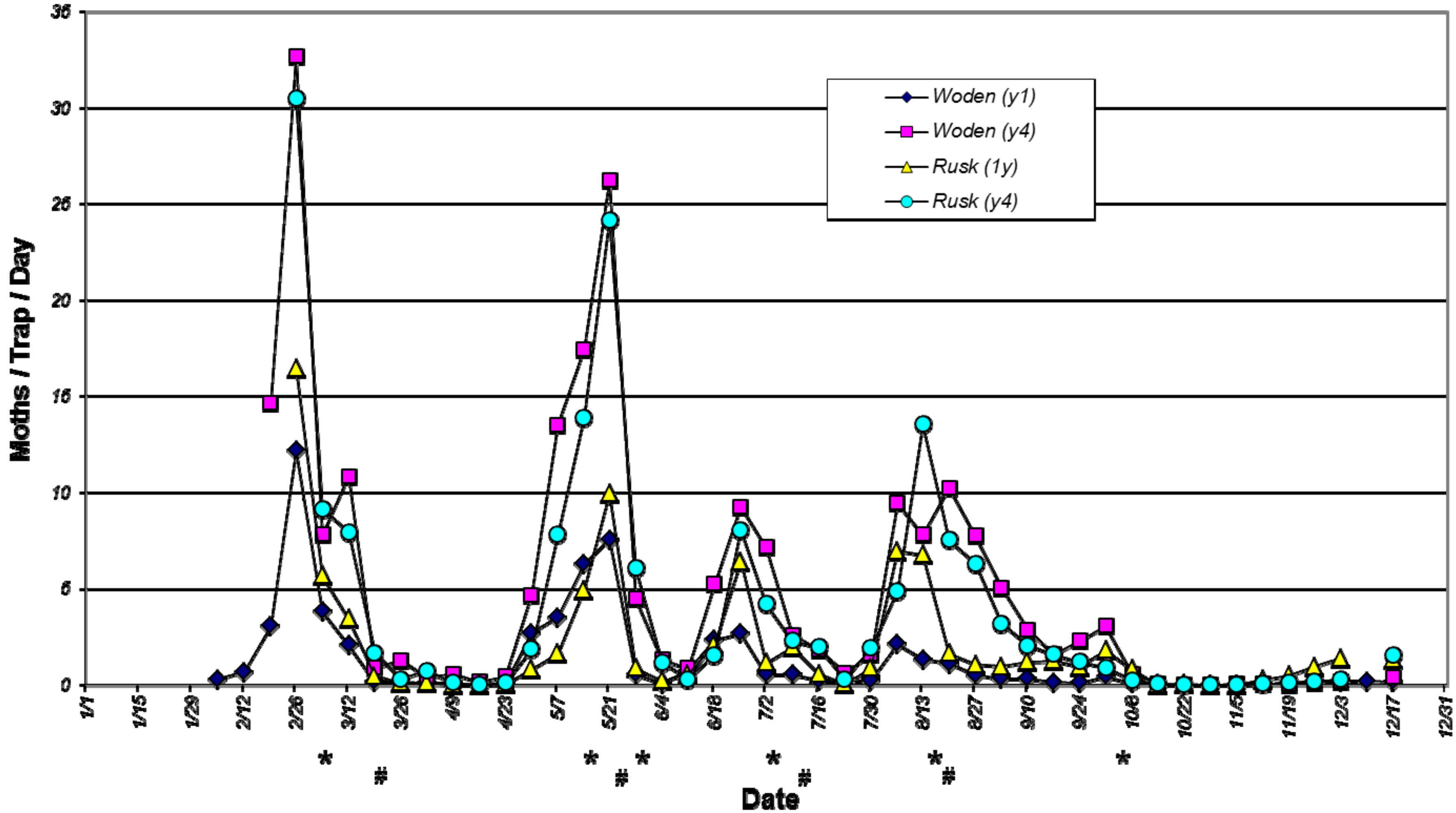
Figure 8. *Tip Moth Catch in or near Mansfield, LA site - 2001*



** Sprayed Mimic: March 6, April 2, May 21, June 4, & July 16, Aug 20*

 # Fettig Predictions for Natchitoches, LA (closest to Mansfield): Mar 29, May 28 July 12, Aug 21

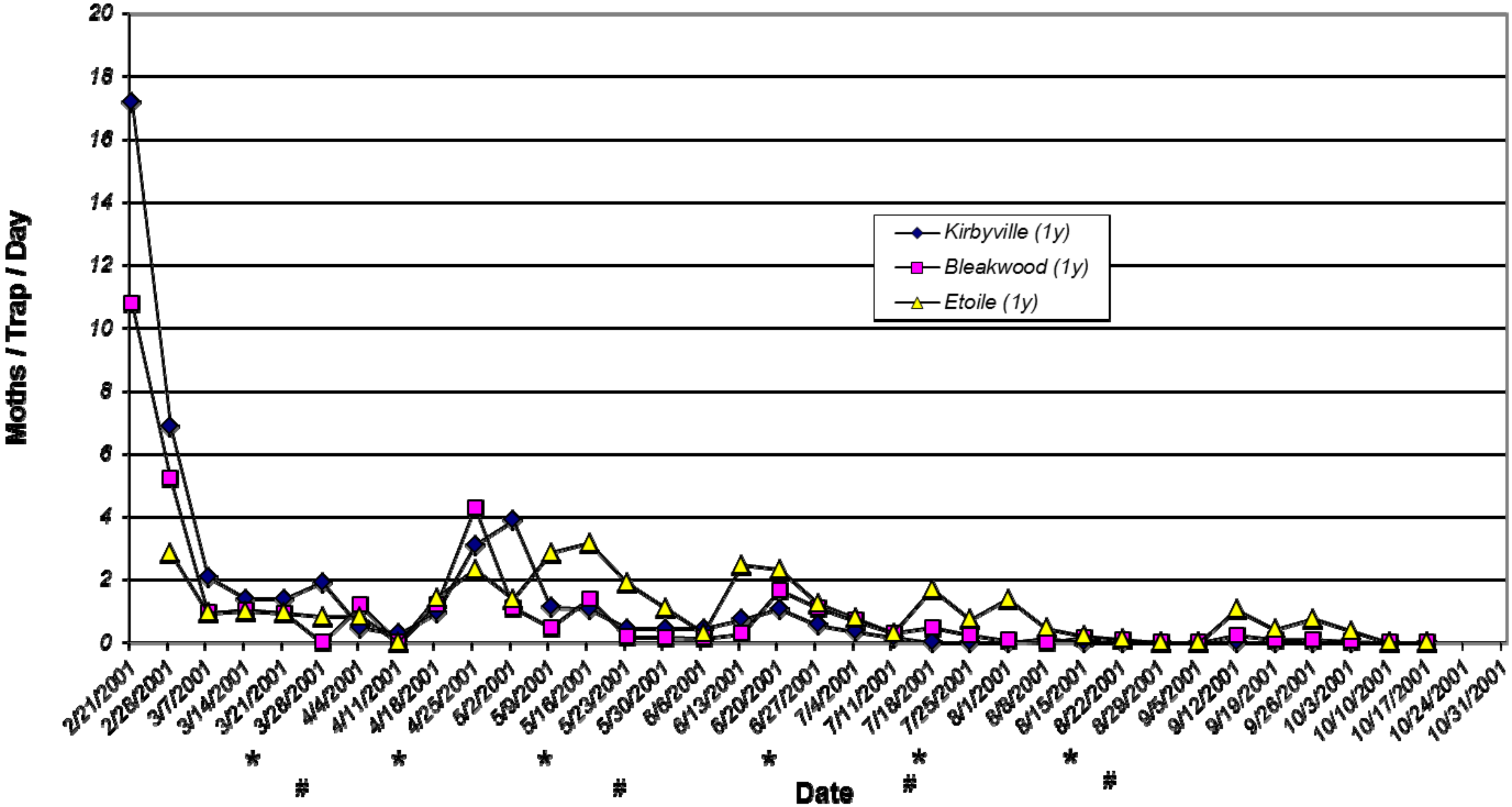
Figure 9. *Tip moth catch in or near Woden and Rusk, TX sites - 2001*



* Sprayed Mimic: March 6, May 11, May 30, July 6, Aug 16, Oct 6

\# Fettig Predictions: March 24, May 23 July 12, Aug 21

Figure 10. *Tip moth catch at Kirbyville, Bleakwood and Etoile, TX sites - 2001*



** = Temple spray dates: 3/15, 4/10, 5/8, 6/18, 7/17, 8/13,*

 # Fettig Predictions: Etoile - Mar 24, May 23 July 12, Aug 21
Kirbyville & Bleakwood - Mar 24, May 23, July 17, Aug 26

Table 13. Mean percent of loblolly pine shoots (in top whorl) infested by pine tip moth following treatment with Mimic® after the each of 5 generations - 2001.

	Generation 1				Generation 2				Generation 3				Generation 4				Generation 5			
	Mimic		Check		Mimic		Check		Mimic		Check		Mimic		Check		Mimic		Check	
Site	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2
Crossett, AR	0.00	0.50	4.50	0.00	5.38	6.81	39.56	24.91	9.77	5.55	35.80	30.09	2.17	1.04	80.46	78.99	0.71	0.51	29.97	32.75
Cypress Springs, LA	0.00	0.00	1.02	0.61	0.00	0.00	46.67	32.38	6.25	0.00	23.06	26.56	0.00	6.67	44.35	42.51	12.50	9.65	21.73	33.04
Mansfield, LA	0.00	0.00	2.27	4.76	0.88	0.00	24.34	20.05	2.03	4.28	28.46	12.81	2.44	15.75	62.63	58.81				
Rusk, TX	0.00	1.70	3.51	1.04	3.13	1.77	14.09	25.92	1.67	4.20	29.48	37.16	0.69	3.88	41.92	61.15	0.42	5.25	56.66	73.73
Woden, TX	1.09	0.00	0.41	7.04	0.00	1.06	40.84	20.46	0.00	0.96	46.09	19.56	0.53	0.98	37.47	15.52	0.00	0.00	12.26	5.79
Etoile, TX	0.00	0.00	2.09	5.50	1.50	0.50	11.58	17.36	5.00	3.88	24.79	26.94	3.13	1.33	27.50	19.14	0.00	0.00	21.62	18.97
Bleakwood, TX	0.67	0.00	6.23	1.07	1.80	0.82	13.78	12.55	1.07	4.07	10.64	6.84	0.50	0.40	0.97	5.07	0.00	0.00	17.57	10.94
Kirbyville, TX	0.00	0.50	16.54	15.63	0.40	0.00	25.68	7.50	0.40	0.00	1.63	0.00	0.00	0.00	0.33	4.30	0.00	0.00	6.66	9.86
Mean *	0.22	0.34	4.57	4.46	1.64	1.37	27.07	20.14	3.27	2.87	24.99	20.00	1.18	3.76	36.95	35.69	1.95	2.20	23.78	26.44
	0.28 a		4.51 b		1.50 a		23.60 b		3.07 a		22.49 b		2.47 a		36.32 b		2.07 a		25.11 b	
% Reduction	93.8				93.6				86.3				93.2				91.7			

* Means within a row (for each generation) with the same letter are not significantly different at the 5% level based on Fisher's Protected LSD

Figure 11. Mean level of tip moth infestation on first year loblolly pine seedlings in Mimic-treated and untreated plots at 8 Western Gulf sites - 2001.

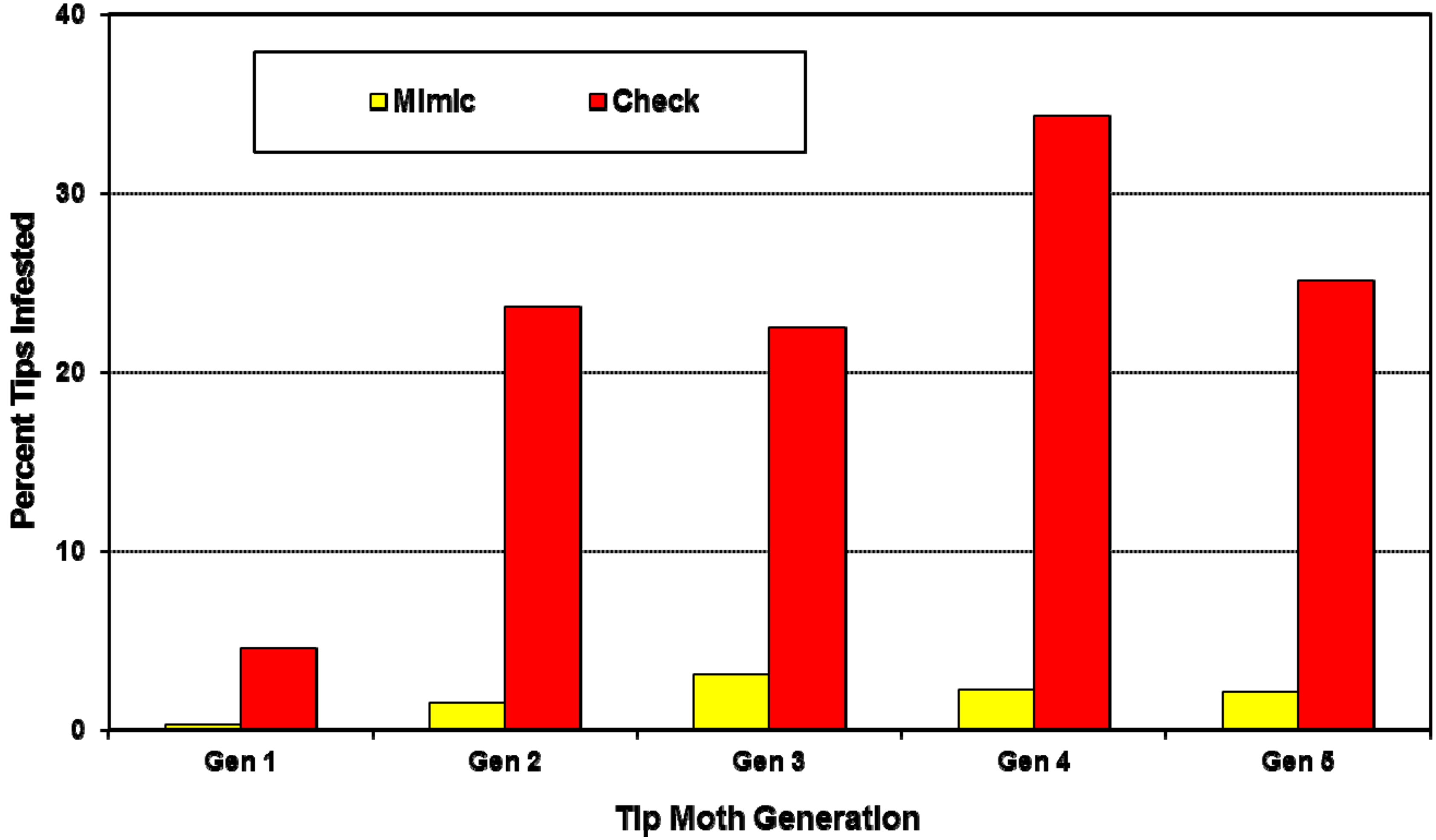


Table 14. Mean height, diameter, volume index and survival of Mimic®-treated and check seedlings after the 5th tip moth generation - 2001.

	Height (cm) after Generation 5				*Diameter (cm) after Generation 5*				*Volume Index ($H*D^2$) after Generation 5*				*Survival (%) after Generation 5*			
	Mimic		*Check*		*Mimic*		*Check*		*Mimic*		*Check*		*Mimic*		*Check*	
Site	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*	*Plot 1*	*Plot 2*
Crossett, AR	*58.37*	*63.51*	*47.44*	*47.24*	*1.22*	*1.20*	*1.01*	*1.07*	*103.51*	*103.45*	*61.42*	*68.54*	*94.0*	*98.0*	*96.0*	*100.0*
Cypress Springs, LA	*20.23*	*17.43*	*17.24*	*18.15*	*0.38*	*0.25*	*0.33*	*0.37*	*3.78*	*1.70*	*2.91*	*3.62*	*40.8*	*40.4*	*57.1*	*67.3*
Mansfield, LA	*58.36*	*76.92*	*42.76*	*61.63*	*1.44*	*2.08*	*1.27*	*1.60*	*145.46*	*412.32*	*85.10*	*211.12*	*100.0*	*100.0*	*100.0*	*100.0*
Rusk, TX	*32.97*	*55.52*	*29.30*	*41.09*	*0.59*	*1.04*	*0.49*	*0.77*	*16.14*	*70.20*	*10.12*	*30.09*	*69.4*	*93.9*	*55.1*	*89.8*
Woden, TX	*40.38*	*37.63*	*34.57*	*35.58*	*0.60*	*0.50*	*0.51*	*0.52*	*18.08*	*11.20*	*11.45*	*11.60*	*95.9*	*65.3*	*85.7*	*81.6*
Etoile, TX	*77.47*	*81.85*	*66.86*	*56.27*	*1.96*	*2.46*	*1.71*	*1.54*	*343.10*	*539.62*	*228.63*	*152.45*	*100.0*	*100.0*	*94.0*	*100.0*
Bleakwood, TX	*65.28*	*51.29*	*45.96*	*42.29*	*1.52*	*1.19*	*1.14*	*1.02*	*186.00*	*97.56*	*72.93*	*56.06*	*98.0*	*95.8*	*64.1*	*64.0*
Kirbyville, TX	*110.23*	*80.70*	*86.68*	*70.92*	*3.03*	*2.24*	*2.39*	*1.96*	*1098.65*	*548.15*	*602.51*	*366.44*	*100.0*	*100.0*	*96.0*	*90.0*
*Mean **	*57.91*	*58.11*	*46.35*	*46.65*	*1.34*	*1.37*	*1.11*	*1.11*	*239.34*	*223.03*	*134.38*	*112.49*	*87.26*	*86.68*	*81.00*	*86.59*
	58.01 a		*46.50 b*		*1.36 a*		*1.11 b*		*231.18 a*		*123.44 b*		*86.97 a*		*83.79 b*	
% Gain	*-24.8*				*-22.5*				*-87.3*				*-3.8*			

2001 Tip Moth Hazard Rating Study – Southern U. S.

Highlights:

- Site characteristic data were collected from 17 plots across the South in 2001.

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, Pine Tip Moth Consortium
Dr. Roy Hedden, Clemson University

Study Sites: Coop members selected from 1 to 12 first-year plantations (those selected in the Western Gulf Region were the same as those used in the impact study). A plot area within each plantation was selected - each plot containing 126 trees (9 rows X 14 trees). The untreated plot was used to collect site characteristic data. Tip moth populations also were monitored in one 3-year old plantation near most study sites.

Site Characteristic Data: Site characteristic data collected from 17 plots (8 in Western Gulf Region, 9 on east coast) in 2001 included:

.

Soil - Texture and drainage
Percent organic matter
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 – 1^{st}, 2^{nd}, and last generation
Height and diameter at 6 inch height

Site - Previous stand history
Productivity index (average height of 20 protected trees in impact plot)
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.
Rainfall (on sight or from nearest weather station)
Estimate of the acreage of susceptible loblolly stands in the 2-5 year age class (< 20 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 each 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. Trees also were surveyed a final time in November. At that time, data also were collected on tree height, diameter, and percent tree mortality.

Results: Nearly all data has been collected from each of the 17 plots established in 2001. Once the data set is complete, it will be given to Dr. Roy Hedden. He will develop a regression model to identify the most important abiotic factors influencing tip moth occurrence and severity. The result will be presented in next year's report.

Treatment of Loblolly Pine Seedlings with Emamectin Benzoate or Messenger® for Control of Pine Tip Moth

Highlights:

- λ Emamectin benzoate, applied as a root soak, reduced tip moth damage by 88% and 44% for generation 1 and 2, respectively, but was ineffective thereafter. Application of emamectin benzoate into the plant hole appeared to be ineffective.
- λ Messenger® also reduced tip moth damage for the first two generations, but was ineffective thereafter.

Objectives: 1) Evaluate the efficacy of emamectin benzoate and Messenger® in reducing growth losses on first year loblolly pine seedlings; 2) evaluate these products using several application techniques; and 3) determine the duration of treatment efficacy.

Study Sites: Three first-year plantations were selected in east Texas. Each plot containing 350 trees (5 rows X 70 trees). Given that tip moth populations are generally higher in older (2 - 4 year old) plantations, tip moth populations also were monitored in two 3-year old plantations in Angelina Co.

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, 2001 and monitored until the beginning of November. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Proclaim® (emamectin benzoate) - an avermectin derivative with activity against Lepidoptera

Messenger® (harpin protein) - enhances a plant's own growth systems and natural defenses

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. 3 sites X 7 treatments X 50 trees = 1050 monitored trees.

Treatments:

1) Proclaim®(0.08% ai) - root soak of bare root seedlings for 2 hours prior to planting
2) Messenger® - root soak of bare root seedlings in solution for 15 seconds prior to planting
3) Water - root soak of bare root seedlings for 2 hours prior to planting
4) Proclaim® (0.08% ai) - soil drench of containerized seedlings with 30 ml prior to planting
5) Water - soil drench of containerized seedlings with 30 ml prior to planting
6) Proclaim® - Granular (1.5 g) in plant hole with bare root seedling
7) Check - Bare root seedling (lift and plant)

Treatment Methods: Loblolly pine, bare root seedlings from the Texas Forest Service nursery at Alto, TX and containerized seedlings form International Forestry, were used in this study. For bare root seedlings, 150 seedlings were lifted for each treatment. 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 (emamectin benzoate) or 15 seconds (Messenger®). After immersion, the seedlings were bagged and placed in cold storage until the following day. For containerized seedlings, root plugs were dipped into insecticide solution or water and planted immediately. Fifty seedlings from each treatment were planted (6 X 10 ft spacing) on each of 3 sites.

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. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Each tree was measured for diameter and height in the fall (November) following planting.

Results: All chemical treatments showed significantly lower tip moth damage levels after the first tip moth generation compared to check trees (Table 15). However, reduced damage continued into the 2nd generation only for the emamectin benzoate bare root soak, containerized seedling treatments (EB and water drench) and Messenger® dip treatments. The containerized seedling treatments even showed significantly reduced tip moth damage levels after the 4th and 5th generations, but it is believed that this is a result of the seedling's significantly smaller size and poorer health, i.e., lower survival rate (Table 16). None of the treatments significantly improved tree height or diameter growth compared to check trees.

Summary: Seedlings soaked in emamectin benzoate or exposed to the harpin protein (Messenger®) appeared to show moderate resistance against tip moth for the first two generations, but became susceptible thereafter. Application of emamectin benzoate into the plant hole appeared to be ineffective. Given these results further trials are warranted to test the potential of different systemic insecticides for protection of seedlings against pine tip moth.

Table 15. Mean percent of loblolly pine shoots (in top whorl) infested by pine tip moth after the each of 5 generations - 2001.

	Generation 1				Generation 2				Generation 3				Generation 4				Generation 5			
Treatment †	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*
EB BR Soak	0.66	0.00	2.84	1.13 ***	21.58	0.90	33.90	18.03 ***	56.39	1.84	20.73	26.34	53.91	35.31	47.22	45.43	40.14	40.35	45.87	42.01
EB BR Plant Hole	8.00	0.00	1.67	3.22 ***	39.14	2.80	43.49	27.75	50.66	5.54	18.67	24.41	56.22	21.26	42.35	39.30	39.77	31.40	44.75	38.42
H2O BR Soak	7.17	0.00	1.04	2.78 ***	25.57	5.20	51.75	27.22	48.52	6.33	16.56	23.07	44.13	19.65	54.24	38.91	56.35	30.35	62.57	49.28
EB Cont. Drench	0.00	0.00	0.00	0.00 ***	10.87	0.78	34.41	14.65 ***	40.73	2.38	20.92	21.66	42.64	8.96	32.33	28.33 ***	28.18	21.88	33.12	27.73 ***
H2O Cont. Drench	1.11	0.00	0.83	0.63 ***	11.30	1.09	33.82	13.83 ***	32.52	0.00	20.72	16.88 *	40.05	11.85	42.84	29.84 **	35.92	20.46	53.28	35.13 *
Messenger BR	11.00	0.00	1.73	4.24 **	33.77	5.60	34.90	24.36 *	53.23	5.27	19.76	25.65	57.53	32.48	59.72	49.91	47.17	37.43	47.49	44.03
Check BR	18.63	2.00	8.50	9.72	36.86	8.07	52.89	32.18	59.38	3.57	18.25	26.06	55.56	28.90	51.25	44.79	51.41	42.47	51.63	48.36

*Treatment significantly different compared to check: * = P < 0.05; ** = P <0.001; *** = P < 0.0001 (Fisher's Protected LSD)*

† EB = emamectin benzoate; BR = bare root; Cont. = containerized

Table 16. Mean height, diameter, volume index and survival of first year loblolly pine seedlings after the 5th tip moth generation - 2001.

	Height (cm) after Generation 5				*Diameter (cm) after Generation 5*				*Volume Index ($H*D^2$) after Generation 5*				*Survival (%) after Generation 5*			
Treatment	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*	*Evans*	*Beulah*	*L-P*	*Mean*
EB BR Soak	44.96	59.19	59.50	54.41	0.73	1.08	1.26	1.01	29.44	80.98	112.03	73.07	96.0	96.0	86.0	92.7
EB BR Plant Hole	45.05	61.30	55.30	54.22	0.80	1.20	1.27	1.10	33.90	97.88	117.10	84.09	88.0	100.0	92.0	93.3
H2O BR Soak	40.64	53.27	54.28	49.71	0.68	1.02	1.26	0.99	24.42	65.77	113.33	69.09	80.0	96.0	88.0	88.0 *
EB Cont. Drench	30.71	36.71	40.63	35.93 ***	0.43	0.62	0.80	0.62 ***	6.70	17.16	34.52	19.25 ***	84.0	80.0	80.0	81.3 **
H2O Cont. Drench	33.39	36.57	33.71	34.71 ***	0.51	0.57	0.65	0.57 ***	12.27	14.97	20.48	15.76 ***	72.0	88.0	66.0	75.3 ***
Messenger BR	45.87	60.70	58.94	55.17	0.78	1.09	1.37	1.08	37.50	86.68	132.88	85.69	92.0	94.0	94.0	93.3
Check BR	37.16	61.94	57.31	52.59	0.59	1.18	1.33	1.05	18.72	99.16	122.59	81.71	90.0	100.0	96.0	95.3

*Treatment significantly different compared to check: * = P < 0.05; ** = P <0.001; *** = P < 0.0001 (Fisher's Protected LSD)*

† EB = emamectin benzoate; BR = bare root; Cont. = containerized