Western Gulf Forest Pest Management Cooperative

Report on
Research Accomplishments in 2000

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2000 WGFPMC Members:

Champion International Corporation
International Paper Company
Louisiana Pacific Corporation
Temple-Inland Forest Products Corporation
The Timber Company, Inc.
Texas Forest Service
U.S.D.A. Forest Service - Forest Health Protection R8
Willamette Industries, Inc.
Rohm and Haas, Inc.

January, 2001

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2000 was another productive year for the Western Gulf Forest Pest Management Cooperative (WGFPMC). A brief summary of WGFPMC activities is given below. Four research projects (leaf-cutting ants, systemic injection, pest survey, and tip moth spray studies) were continued from 1999. 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 2001 Project Proposals.

The beginning of 2000 brought several changes in membership. We welcome the addition of two full members, The Timber Company, Inc. and Willamette Industries, Inc., and an associate member, Rohm and Haas, Inc. One member, Champion International, was lost with their merger with International Paper Company.

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, 12 presentations, 6 meeting requests, and 29 phone requests were made relating to the following topics: Volcano®, pine tip moth, reproduction weevils, pest survey information, drought, *Ips* engraver beetles, and snails.

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 October, 1999. However, the bait did not become available through Red River Specialties until January, 2000. By this time most industries had already arranged contracts to have their leaf-cutting ant colonies treated with methyl bromide. By September, 2000 we also obtained a 24C registration in Louisiana. Full scale treatment of leaf-cutting ant colonies began in the fall of 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. The only failure that was reported occurred when the bait was applied just prior to rain.

Unfortunately, the future availability of Volcano® is now in question. Recent reports from the Environmental Protection Agency (EPA) indicate concern about the persistence of sulfluramide chemicals in the environment. As a result of this concern, Griffin L.L.C./Dupont are reported to be selling off the rights to the sulfluramid chemical. In light of these events, we are now searching for an alternative to Volcano®.

For the fourth time in five years (1996 – 2000), severe drought conditions prevailed in the Western Gulf region. No significant rainfall was recorded from July through October and there were many days when high temperatures exceeded 100^{o} F. The severe summer weather appeared to have a direct effect on the survival of young trees in plantations and cones in seed orchards as well as an indirect effect on the population development of several insect species.
The Pest survey was expanded again to include new one-year old sites as well as several additional older plantations managed by our new member, Willamette Industries. As can be expected, tree mortality due to drought was highest on one-year old sites. Overall, Texas sites

averaged 38% drought-induced mortality. However, those Texas sites with no herbaceous weed control averaged nearly 95%. Incidence of drought-induced mortality in older trees (2 – 3 years old) was also fairly common. As in past years (1998 & 1999), pine tip moth was the most abundant biotic factor affecting young loblolly pine. During the “wet” spring months of 2000, tip moth levels were generally lower than during the previous spring and damage was restricted to the lower crown. However, with the onset of severe drought conditions in July, pine tip moth populations increased dramatically and the larvae caused considerable damage in the upper crown on nearly all sites evaluated. Older trees (5+ years old), stressed by severe drought conditions, often were attacked by *Ips* engraver beetles throughout the Western Gulf region in 2000. Large patches of beetle-infested trees, sometimes 100 trees or more, were common in several areas, particularly in counties making up the western fringe of the loblolly pine range (e.g., Anderson, Houston, Walker and Montgomery counties in Texas).

Each WGFPMC member will soon receive copies of the individual pest surveys for each study site provided by the member for the project. An agreement was made with Potlatch Corp. in 1999 that allowed us to conduct pest surveys on several of their ALPS research sites in southern Arkansas. As per our agreement a copy of the Pest Survey summary report only will be sent to Nick Chappell, Potlatch, along with summaries of their southern Arkansas sites.

Severe drought conditions also appear to have caused significant second year cone mortality (40%+) at the TFS Magnolia Spring Seed Orchard in Texas. Similar mortality was observed after the drought of 1999. Despite cone losses due to drought, considerable progress has been made in the evaluation and development of systemic insecticides and injection systems. For the second year in a row, trees injected with emamectin benzoate and thiamethoxam had significantly reduced levels of both coneworm and seed bug damage. Additional data suggests that a single injection of emamectin benzoate can protect trees from coneworms for at least three years.

Spray trails were continued into 2000 from 1999 to evaluate the efficacy of several foliar insecticides to protect trees against pine tip moth. This study also was used as a preliminary trial to assess the impact of tip moth on pine growth. Although two products, Mimic® and Pounce®, both significantly reduced tip moth damage compared to checks, only Mimic® (multiple applications at the labeled rate) significantly improved tree growth and reduced the incidence of forking.

Finally, work has commenced 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 2001.

2000 Leaf-cutting Ant Studies

Highlights:

- λ In preference trials, Volcano® was significantly less attractive to Texas leaf-cutting ant (TLCA) than the Griffin standard (GX-483) during the summer, but equally attractive during the winter.
- λ In retrieval trials conducted during the summer 2000, TLCA retrieved all bait (Volcano®, Griffin standard, or Mirex-S®) within 3-4 hours after application. The bait was not attractive to birds.
- λ Volcano®, tested during the winter of 1999/2000, was 100% effective in halting TLCA activity at the label-recommended rate of 4 g/m^2 and 80% effective at 10 g/m^2 during the summer.
- λ Volcano® Leafcutter Ant Bait received a 24C (Special Local Need) registration in Louisiana.

Objectives: 1) Continue evaluating Volcano® to determine efficacy for reducing activity in Texas leaf-cutting ant colonies, 2) determine the effect of season on treatment efficacy, and 3) compare TLCA preference to different bait formulations; 4) determine time required for TLCA to retrieve bait applied to central nest area; and 5) determine if birds are attracted to Volcano®.

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

Insecticides:

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

Griffin standard - concentration (0.3% a.i.); citrus pulp (orange); packing (tight); color (dark brown); size (uniform 4 mm).

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

Mirex-S® - concentration (0.3% a.i.); citrus pulp (orange?); packing (tight); color (dark brown); size (uniform 4 mm).

Acephate -- fast-acting poison on a citrus pulp carrier.

Griffin citrus pulp placebo treated at concentration (9% and 4.5% a.i.); citrus pulp (orange); packing (tight); color (dark brown); size (uniform 4 mm).

Research Approach:

Preference Trial: Given the differences in physical and chemical characteristics between the Griffin standard and new Volcano® baits, field trials were conducted during the summer of 2000 to determine if TLCA have preference for a particular bait formulation. Treatments included: 1) Griffin standard 0.3% ai, 2) Griffin 0.5% ai, 3) Volcano® 0.5% ai, 4) Mexican 0.5% (same citrus pulp as in Volcano® but pressed by Griffin), 5) Griffin check (blank citrus pulp) and 6) Mexican 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.

Retrieval Trial: A trial was conducted in east Texas during the summer 2000. Three active leaf-cutting colonies were selected between 100 and 400m of each other. Treatments were randomly assigned to the selected ant nests. Volcano® (0.5% ai), Griffin GX-483 (standard, 0.3% ai), or Mirex-S® (0.3% ai) were applied at 10 g/m^2 by cyclone spreader to the central nest area of a colony just before the ants become active (~ 6 PM).

Once the colonies were treated, two 15 cm diameter areas were marked and the number of baited 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 central nest area were monitored at hourly intervals and the number or percentage of bait particles remaining were recorded. Each colony was monitored until no bait could be found in the dishes or central nest area. 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

Griffin GX-483-
1) 2 g/m^2 bait applied to CNA during the winter trials only.
2) 4 g/m^2 applied during the winter trials only.
3) 6 g/m^2 applied during the winter trials only.
4) 10 g/m^2 applied during the summer trials only.

Volcano®-
1) 2 g/m^2 applied to CNA during the winter trials only.
2) 4 g/m^2 applied during the winter trials only.
3) 6 g/m^2 applied during the winter trials only.
4) 10 g/m^2 applied during the summer trials only.

Mirex-S®-
1) 10 g/m^2 applied to CNA during the summer trials only.

Acephate -
1) 4 g/m^2 (9% ai) applied to CNA during the winter trials only.
2) 4 g/m^2 (4.5% ai) applied during the winter trials only.

Check - untreated colonies

Application Methods:

Spreader - A cyclone spreader was used in 2000 to evenly spread measured amounts of sulfluramid bait over the central nest area (CNA).

Application Dates:

Winter 1999-2000: Treatments applied between January and February.

Summer 2000: Treatments applied between 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 eleven 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 divided by the initial number of active mounds. Differences in mean percent of initial activity among treatments were tested for significance. Data were analyzed by GLM and the Fisher's protected LSD test using the StatView program.

Results:

<u>Preference Trial</u>: TLCA showed a significant preference for the Griffin standard over Volcano® during the summer months in both 1999 and 2000, but were equally attracted to both baits in the winter of 1999/2000 (Figure 1). The variability in preference appears to result from 1) increased number of choices in plant material available to the ants in the summer vs. winter and 2) the ants greater attraction to orange citrus pulp (used in the Griffin standard) compared to other citrus pulp (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.

<u>Retrieval Trial</u>: Three colonies each were treated in Jasper County, TX on August 16 and Rusk County, TX on August 31, 2000. Table 1 & 2 show the size, number of active mounds, and amount of bait applied within each central nest area and the amount of bait remaining at each hourly interval.

Generally, the ants became active (excavating soil or searching for plant material) around 8-9 PM on both dates and were most active (large number of ants observed) between 10 PM and 2 AM. The vast majority (80-90%) of the bait in dishes, flagged area, and central nest area was retrieved by the ants within a 3 – 4 hour period (9 PM – 1 AM). The ants appeared to be more attracted to the Griffin GX-483 and Mirex-S® baits than to the Volcano® formulation.

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

We intend to repeat this experiment at least twice more during the winter (after leaf fall) of 2000/01 to evaluate seasonal retrieval behavior of leaf-cutting ants. Also, observations will be made to determine if birds are more apt to feed on bait particles when applied in late morning or early afternoon.

<u>Efficacy Trial (winter 1999-2000)</u>: - As in the winters 1997/98 and 1998/99, all three Griffin (GX-483) sulfluramid rates (2 - 6 g/m^2) were 100% effective in completely halting TLCA activity after 16 weeks post-treatment during the winter of 1999/2000 (Table 3). However, only the highest Volcano® rate (6 g/m^2) was 100% effective; the other two rates each had one failure out of 10-11 replicates. Although most Volcano® treatments were ultimately effective, the rate at which ant activity was reduced at 2 and 8 weeks was markedly slower

for Volcano® than for the Griffin standard (Table 3). This appears to be due to a lesser degree of attraction to the Volcano® citrus pulp compared to the Griffin standard citrus pulp (see preference trial above). Neither of the acephate treatments was particularly effective in halting ant activity

Efficacy Trial (summer 2000): After 16 weeks, only the Griffin standard treatment was 100% effective in completely halting TLCA activity during the summer (Table 4). The other two treatments (Volcano® and Mirex-S®) had 2 and 4 failures, respectively. The failures (at least for the Volcano®) appeared to have resulted from two factors: 1) limited ant attraction to the Volcano® citrus pulp and 2) reduced ant activity (foraging) under the severe drought conditions that occurred during the treatment period (July – August).

Summary: Overall, citrus pulp baits containing sulfluramid continue to be a highly effective alternative to methyl bromide for control of TLCA. Evaluations of Volcano® Leafcutter Ant Bait indicate that it is only slightly less effective (10% - winter and 20% summer) compared to the Griffin standard bait at the recommended rates of 4g/m^2 in winter and 10 g/m^2 in summer. However, Volcano® may require 2 to 8 weeks longer to completely halt ant activity compared to the Griffin standard. Field observation and results from preference trials indicate that Volcano® is not as attractive to TLCA as the Griffin standard during the summer months. Attraction was not influenced by bait particle size or percent active ingredient. The principal factor limiting the attractiveness of ants to sulfluramid baits appears to be the type of citrus pulp used to produce the bait. TLCA appear to prefer citrus pulp produced from oranges over pulp from other citrus fruits (grapefruit, lemon, etc).

The future availability of Volcano® is being reconsidered at this time due to its persistence in the environment (e.g., chemicals related to sulfluramid have been found in the blood of factory works). It is unclear what Griffin plans to do, but one possibility is that Griffin will sell off the rights to sulfluramid. Given the difficulties faced by Griffin in obtaining a Section 3 registration for outdoor use of sulfluramid, it seems unlikely that any other company will take up the fight to get this product registered.

Recently, EPA granted a Section 3 registration to Aventis (formerly Rhone Polenc and AgroEvo) for outdoor use of fipronil against fire ants. Ken Kukorowski (Aventis) has indicated an interest in having the WGFPMC test their fipronil bait, Blitz® (0.03% ai on citrus pulp carrier), against the Texas leaf-cutting ant. A proposal is attached to evaluate Blitz® as an alternative to Volcano®. If trials go well, Aventis may be willing to pursue EPA registration.

Figure 1. Seasonal preference of the Texas leaf-cutting ant (*Atta texana*) to sulfluramid baits (Griffin's GX-483 and Volcano®) in 1999 and 2000.

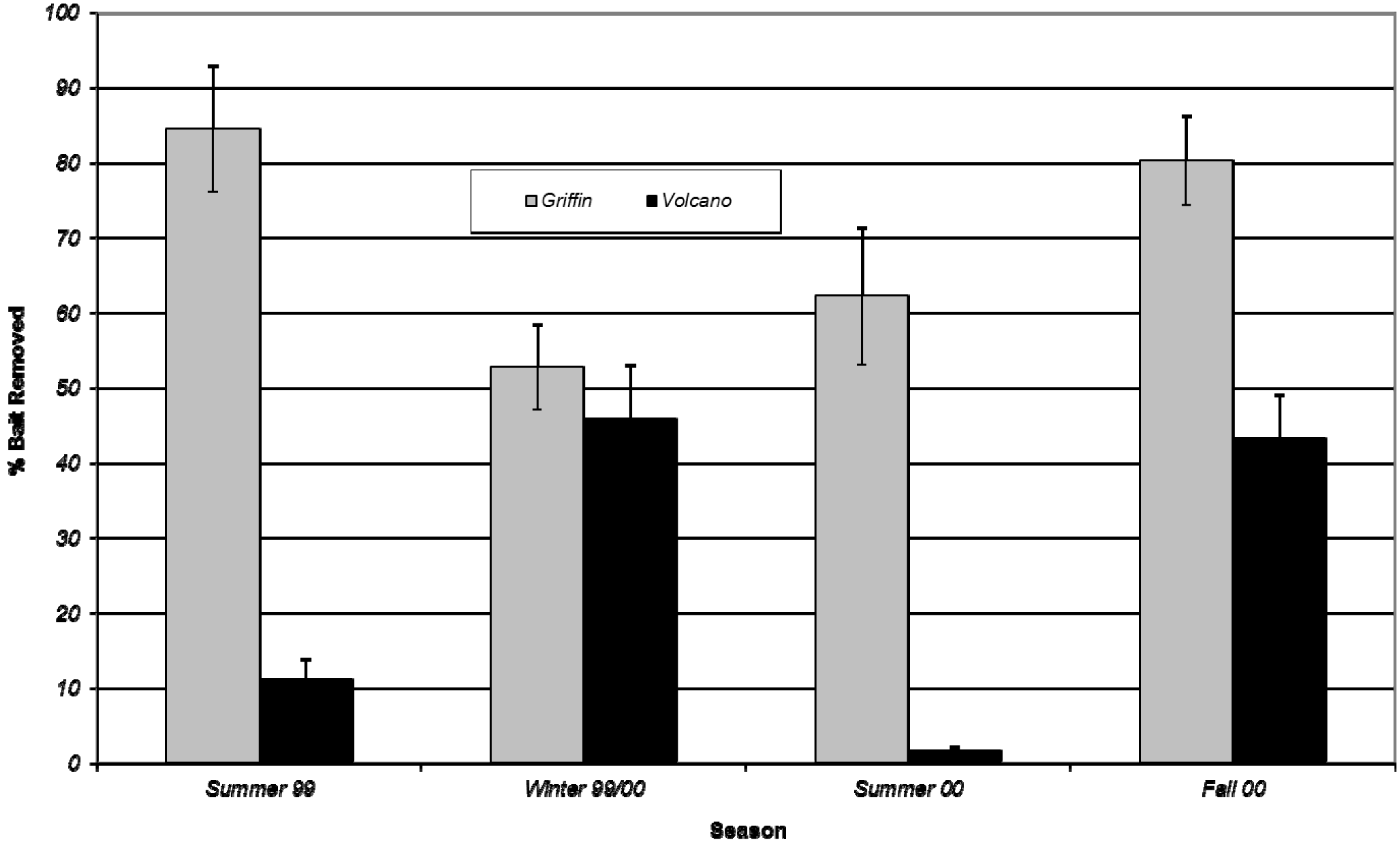


Table 1. Bait retrieval by the Texas leaf-cutting ant, *Atta texana*, from three colonies in Jasper Co., TX - August 16, 2000.

	Activity								
	Colony 1 - Volcano			Colony 2 - Griffin			Colony 3 - Mirex S		
Time	Dish [a]	Flagged Area [b]	Central Nest [c]	Dish	Flagged Area	Central Nest	Dish	Flagged Area	Central Nest
	C 405-15, 204 sq ft, 63 AM [d], treated w/ 9 oz Volcano (10g/m^2) at 1840 hours (6:40 PM [e])			C 405-14, 462 sq ft, 106 AM, treated w/ 20 oz GX-483 (10g/m^2) at 1910 hours (7:10 PM)			C 405-13, 551 sq ft, 153 AM, treated w/ 24 oz Mirex-S (10g/m^2) at 1940 hours (7:40 PM)		
0 h	5w4	4 & 13	100%	5w4	8 & 9	100%	5w4	13 & 10	100%
1 h	5w4	4 & 13	100%	5w4	8 & 4	90%	5w4	13 & 10	90%
2 h	1w3, 4w4	4 & 13	90%	2w0, 1w3 2w4	0 & 0	70%	1w0, 4w4	0 & 6	60%
3 h	1w0, 1w2, 3w4	4 & 11	70%	3w0, 1w1 1w4	0 & 0	50%	3w0, 2w4	0 & 0	30%
4 h	1w0, 2w1, 2w4	0 & 0	50%	4w0, 1w4	0 & 0	30%	3w0,2w4	0 & 0	5%
5 h	2w0, 1w1, 1w3, 1w4	0 & 0	20%	5w0	0 & 0	0%	3w0, 2w2	0 & 0	2%
6 h	3w0, 2w3	0 & 0	5%				4w0, 1w1	0 & 0	1%
7 h	3w0, 2w3	0 & 0	4%				5w0	0 & 0	0%
8 h	4w0, 1w3	0 & 0	3%						
9 h	4w0, 1w3	0 & 0	2%						
10 h	4w0, 1w3	0 & 0	1%						
11 h	4w0, 1w3	0 & 0	0%						
12 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] Rough estimate of the percent of bait remaining in the central nest area at each interval.
[d] Active Mounds
[e] Daylight Savings Time

Table 2. Bait retrieval by the Texas leaf-cutting ant, *Atta texana*, from three colonies in Rusk Co., TX - August 31, 2000.

	Activity								
	Colony 1 - Volcano			Colony 2 - Griffin			Colony 3 - Mirex S		
Time	Dish [a]	Flagged Area [b]	Central Nest [c]	Dish	Flagged Area	Central Nest	Dish	Flagged Area	Central Nest
	TK 51, 396 sq ft, 81 AM [d], treated w/ 17 oz Volcano (10g/m^2) at 1700 hours (5:00 PM [e])			TK 40, 627 sq ft, 118 AM, treated w/ 28 oz GX-483 (10g/m^2) at 1720 hours (5:20 PM)			TK 52, 696 sq ft, 128 AM, treated w/ 31 oz Mirex-S (10g/m^2) at 1750 hours (5:50 PM)		
0 h	5w4	6 & 10	100%	5w4	10 & 15	100%	5w4	14 & 21	100%
1 h	5w4	6 & 10	100%	5w4	10 & 15	100%	5w4	14 & 21	100%
2 h	5w4	6 & 10	100%	5w4	10 & 15	100%	5w4	14 & 21	100%
3 h	5w4	6 & 10	100%	2w0, 3w4	10 & 13	90%	5w4	14 & 21	100%
4 h	1w0, 4w4	5 & 8	100%	3w0, 1w3 1w4	5 & 9	60%	5w4	14 & 17	90%
5 h	1w0, 1w2, 3w4	0 & 0	80%	5w0	4 & 0	40%	2w3, 3w4	11 & 17	80%
6 h	1w0, 1w2, 3w4	0 & 0	60%	5w0	0 & 0	20%	1w1, 2w3, 2w4	4 & 6	60%
7 h	2w0, 2w1, 1w3	0 & 0	30%	5w0	0 & 0	1%	2w0, 1w1, 1w4	0 & 0	30%
8 h	2w0, 1w1, 1w2, 1w3	0 & 0	15%	5w0	0 & 0	0%	3w0, 1w1, 1w4	0 & 0	10%
9 h	3w0, 1w2 1w3	0 & 0	>1%	5w0	0 & 0	0%	3w0, 1w1, 1w3	0 & 0	1%
10 h	4w0, 1w1	0 & 0	>1%				4w0, 1w1	0 & 0	0%
11 h	5w0	0 & 0	0%				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] Rough estimate of the percent of bait remaining in the central nest area at each interval.
[d] Active Mounds
[e] Daylight Savings Time

Table 3. Efficacy of sulfuramid (GX-483 or Volcano®) and acephate baits (all on citrus pulp carrier) applied by spreader to control the Texas leaf-cutting ant (Atta texana) in east Texas (Winter 1999-2000).

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	
Sulfluramid (GX-483)									
to CNA @ 6g/m^2	2	44	115	2.6 **a**	(0)	0.0 **a**	(100)	0.0 **a**	(100)
to CNA @ 4g/m^2	10	53	144	15.9 **ab**	(0)	0.1 **a**	(90)	0.0 **a**	(100)
to CNA @ 2g/m^2	1	41	103	9.7 **ab**	(0)	0.0 **a**	(100)	0.0 **ab**	(100)
Sulfluramid (Volcano®)									
to CNA @ 6g/m^2	10	54	160	30.5 **ab**	(0)	4.1 **a**	(50)	0.0 **a**	(100)
to CNA @ 4g/m^2	10	57	155	38.1 **b**	(0)	10.6 **a**	(50)	0.7 **ab**	(90)
to CNA @ 2g/m^2	11	49	132	35.2 **b**	(0)	8.3 **a**	(64)	2.9 **ab**	(91)
Acephate									
to CNA @ 4g/m^2 (High)	4	30	84	16.1 **ab**	(0)	21.3 **a**	(0)	13.5 **ab**	(25)
to CNA @ 4g/m^2 (Low)	5	26	73	39.7 **b**	(0)	72.1 **b**	(0)	51.3 **bc**	(20)
Check (no treatment)	9	50	145	66.8 **c**	(0)	84.7 **b**	(0)	68.0 **c**	(11)
Total	62								

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).

Table 4. Efficacy of sulfuramid (GX-483, Volcano®, and Mirex-S®) applied by spreader to control the Texas leaf-cutting ant *(Atta texana)* in east Texas (Summer 2000).

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	
Sulfluramid (GX-483) to CNA @ 10g/m^2	11	48	112	2.1 **a**	(64)	1.1 **a**	(91)	0.0 **a**	(100)
Sulfluramid (Volcano®) to CNA @ 10g/m^2	11	49	124	6.5 **a**	(18)	9.5 **a**	(64)	1.7 **a**	(80)
Sulfluramid (Mirex S®) to CNA @ 10g/m^2	11	50	111	7.0 **a**	(18)	8.0 **a**	(55)	13.9 **a**	(64)
Check (no treatment)	11	48	111	110.7 **b**	(0)	161.2 **b**	(0)	137.2 **b**	(0)
Total	44								

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).

1999 - 2000 Systemic Injection Study - Magnolia Springs, TX

Highlights:

- λ Single Systemic Tree Injection Tube (STIT) injection of treatments containing emamectin benzoate (applied in 1999) reduced coneworm damage by 96 - 97% in 2000. A second injection of emamectin benzoate in April 2000 did not improve protection.
- λ STIT injection treatments containing imidacloprid or thiamethoxam reduced seed bug damage by 82% and 53%, respectively, in 1999 and by 69% and 75%, respectively, after a second injection in 2000. These same treatments improved full seed yield by 225% and 160%, respectively, in 1999 and by 78% and 80%, respectively, in 2000.
- λ Trees injected once in 1998 with emamectin benzoate using the Wedgle Tip™ injector and receiving no additional treatments generally exhibited the same level of coneworm damage reduction (61%) in 2000 as had been observed on 1998 cones (60%) and 1999 cones (59%).

Objectives: 1) Determine the effectiveness of high volume Systemic Tree Injection Tube (STIT) injections of emamectin benzoate, emamectin benzoate/thiamethoxam mixture, and imidacloprid for control of coneworm and seed bugs in loblolly pine seed orchards, 2) continue evaluations on the residual activity of emamectin benzoate, emamectin benzoate/thiamethoxam mixture, and imidacloprid applied by the STIT injector in 1999 and imidacloprid and emamectin benzoate applied by Wedgle Tip™ injections in 1998.

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:

Imidacloprid (Pointer®, Merit® 75WP, and Admire® 2F) -- chloronicotinyl with high systemic activity

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 4-10 clones = 88 ramets used for study.

Application Methods:

Wedgle Tip™ Injection – In 1998, plugs of bark were removed with a hole punch at 10 cm intervals around the trees circumference; height was dependent on bark thickness (thin bark trees injected at base); screwed in screw-type plug -- 1 ml of acephate (60% ai), emamectin benzoate (4% ai), thiamethoxam (5% ai), or Imidacloprid (5% ai) was injected; after 24 hours another 1 ml was injected for a total of 2 ml / injection point.

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 Diameter	Treatments 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)
2) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999 & April 2000)
3) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999)
4) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999 & April 2000)
5) 5% imidacloprid (Admire 2F) by STIT injector (applied April 1999)
6) 5% imidacloprid (Admire 2F) by STIT injector (applied April 1999 & April 2000)
7) Asana XL® applied to foliage 5 times 9.6 oz / 100 gal at 5 - 7 week intervals beginning in April
8) Check
9) 4% emamectin benzoate by Wedgle Tip™ (applied April 1998)
10) 5% imidacloprid (Pointer) by Wedgle Tip™ (applied April & July 1998)

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. All treatments were evaluated in 1999 and 2000.

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. All treatments were evaluated in 1999 and 2000.

Results: The STIT injector was successfully used to inject a high volume (50 ml) of insecticide solution into loblolly pines in a short period of time - often less than 4 minutes for emamectin benzoate and 10 to 15 minutes for imidacloprid and thiamethoxam. None of the treatments appeared to adversely affect the health of the injected trees in 1999 or 2000.

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 high trap catches (*Dioryctria amatella* numbers were at their highest level in over 15 years in 1999) in the area and over 21% damage on check cones in both 1999 and 2000 (Fig. 2, Table 6). High numbers of seed bugs were observed in the trees in 1999. This was confirmed by the 53% damage to seed from check trees (Table 7). Seed bug numbers appeared to decline in 2000 based on field observations and lower levels of damage (24%) to seed from check trees compared to 1999. Seedworm damage to seed from check trees was considered insignificant (1% or less in 1999 and 2000), so the data were not included in the analysis.

Treatment Effect on Coneworm Damage: In 1999, the two emamectin benzoate alone groups (Treatments 1 and 2) did not differ significantly in their levels of coneworm damage and so the data were pooled. Similarly, the two emamectin benzoate plus thiamethoxam groups (Treatments 3 and 4) were pooled, as were the two imidacloprid alone groups (Treatments 5 and 6). Damage levels on check trees were similar early in the growing season compared to late in the season. However, damage on emamectin benzoate-treated trees was generally three-fold higher early compared to later in the season. This suggests that complete translocation of the chemical into the tree canopy requires two or more months.

Treatments that included emamectin benzoate consistently provided the best overall protection against coneworm attack (Table 5). Overall, coneworm damage reductions for emamectin benzoate alone, emamectin benzoate + thiamethoxam, and imidacloprid, were 94%, 81%, and 64%, respectively, compared to the check (Fig. 3). The imidacloprid foliar treatment was ineffective against coneworm (Table 5). “Other” damage/mortality was exceptionally high, but consistent across all treatments (range: 35 – 46%). Although not quantified, most of the damage/mortality is believed to be drought induced. The percent of cones classified as healthy was significantly higher for the three injection treatments compared to the check.

Of the two treatments applied by Wedgle Tip™ injector in April 1998, only emamectin benzoate alone significantly reduced coneworm damage in 1999 (Table 8). Surprisingly, the level of coneworm damage reduction in 1999 (70%) improved compared to the level of damage reduction observed in 1998 (60%).

In 2000, only those treatments containing emamectin benzoate (alone or combined with thiamethoxam) 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 >96% compared to the check (Fig. 3). This indicates that the addition of thiamethoxam did not improve or reduce the performance of emamectin benzoate against coneworm. 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 two full years. As in 1999, severe drought conditions during the summer of 2000 appeared to have caused exceptionally high second-year cone abortion (classified as other damage). The level of other damage/mortality was more variable (range: 44 – 60%) across treatments in 2000 and appears to have had a confounding effect on the percent of healthy cones remaining (Table 5).

Of the two treatments applied by Wedgle Tip™ injector in April 1998, only emamectin benzoate alone significantly reduced coneworm damage in 2000 (Table 7). The level of coneworm damage reduction in 2000 (61%) was comparable to the level of damage reduction observed in 1998 (60%) and 1999 (59%).

Treatment Effect on Seed Bug Damage: In 1999, seed bug damage levels in check cones were exceptionally high (53%, Table 6); four times greater than observed in 1998 (13%). The two emamectin benzoate alone treatments (Groups 1 and 2) did not differ significantly in their levels of seed bug damage so the data were pooled. Similarly, the two emamectin benzoate plus thiamethoxam groups were pooled, as were the two imidacloprid groups. Levels of early-season damage (seed bug-aborted) were markedly lower compared to late-season (seed bug-damaged) damage. Seed bug-aborted seeds are caused by the leaffooted pine seed bugs feeding on developing seeds in cones during late May through June. In contrast, seed bug-damaged seeds, detectable on the radiographs, are caused by leaffooted and shieldbacked pine seed bugs feeding on maturing seeds in August and early September. This suggests that shieldbacked pine seed bugs caused the majority of the damage in 1999. All treatments provided significant protection against seed bug attack and most, with the exception of emamectin benzoate alone, improved the yield of full seeds (Table 6). Overall seed bug damage reductions for imidacloprid, emamectin benzoate + thiamethoxam, imidacloprid foliar, and emamectin benzoate alone were 82%, 53%, 45%, and 34%, respectively, compared to the check (Fig. 4). The same treatments improved full seed yield by 225%, 160%, 90% and 72%, respectively, compared to the check (Fig. 5).

Of the two treatments applied by Wedgle Tip™ injector in April 1998, only imidacloprid alone significantly reduced seed bug damage in 1999 (Table 7). The level of seed bug damage reduction in 1999 (52%) was 20% less than the level of damage reduction observed in 1998 (69%).

In 2000, seed bug damage levels (24%) in check cones were less than half of 1999 levels (Table 6). 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. Most treatments (injection and foliar) significantly reduced early and late seed bug damage and increased the number of full seeds per cone compared to the check. Single injections of most chemicals from 1999 continued to provide significant protection against seed bugs through the 2000 growing season. However, additional reductions in damage were obtained with a second injection of treatments containing thiamethoxam or imidacloprid. This indicates that the yearly treatments of thiamethoxam or imidacloprid are generally necessary to maintain adequate protection against seed bugs. Overall reductions for the Asana XL® foliar and two injection treatments of emamectin benzoate plus thiamethoxam, imidacloprid, and emamectin benzoate alone were 79%, 75%, 69%, and 38%, respectively, compared to the check (Fig. 4). The same treatments improved full seed yield by 51%, 80%, 78% and 30%, respectively, compared to the check (Fig. 5).

Neither of the two treatments applied by Wedgle Tip™ injector in April 1998 differed in the level of seed bug damage compared to the checks in 2000 (Table 7).

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 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 41% in 1999 and 29% in 2000 (Table 8). 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 reduced overall insect damage by 79% and 86%, respectively. It as unknown why a second injection of imidacloprid failed to provide the same level of protection as it did in 1999.

Summary: The STIT injector was successfully used to inject high volumes of insecticide solutions into loblolly pine. Over the past two 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 18 months or longer. A second injection is not necessary during the second growing season. However, it appears the effects of treatments on coneworms were slow to take effect in 1999. This suggests that it may be preferable to inject in the fall to obtain complete protection the following year. 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 actual extent of this chemical's residual activity against cone and seed insects has yet to be determined.

In contrast, imidacloprid and thiamethoxam provided good protection against seed bug in 1999, but generally showed little or inconsistent effects against coneworms. Imidacloprid and thiamethoxam also provided extended protection (18 mo.), but not as extensive as was found for emamectin benzoate against coneworms. Protection improved significantly with a second injection of either imidacloprid or thiamethoxam. Given the extended protection provided by emamectin benzoate (coneworms) and imidacloprid (seed bugs) in 2000, further evaluation of the residual effects of 1999 and 2000 treatments is warranted in 2001. Additional studies are planned to determine optimal application rates and timing.

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.

Figure 2. Total trap catch of four *Dioryctria* spp. from 1985 - 2000 at Magnolia Springs Seed Orchard, TX.

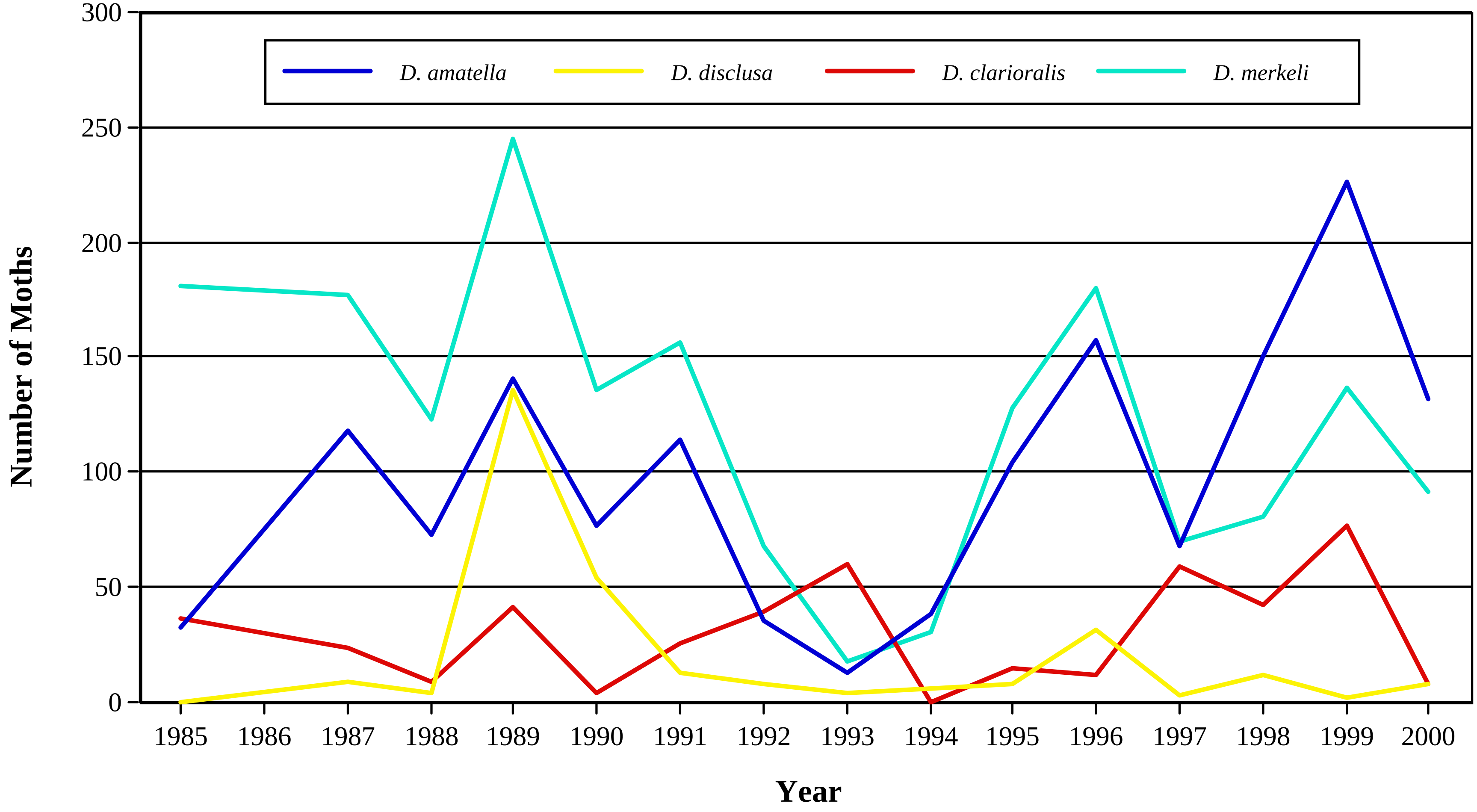
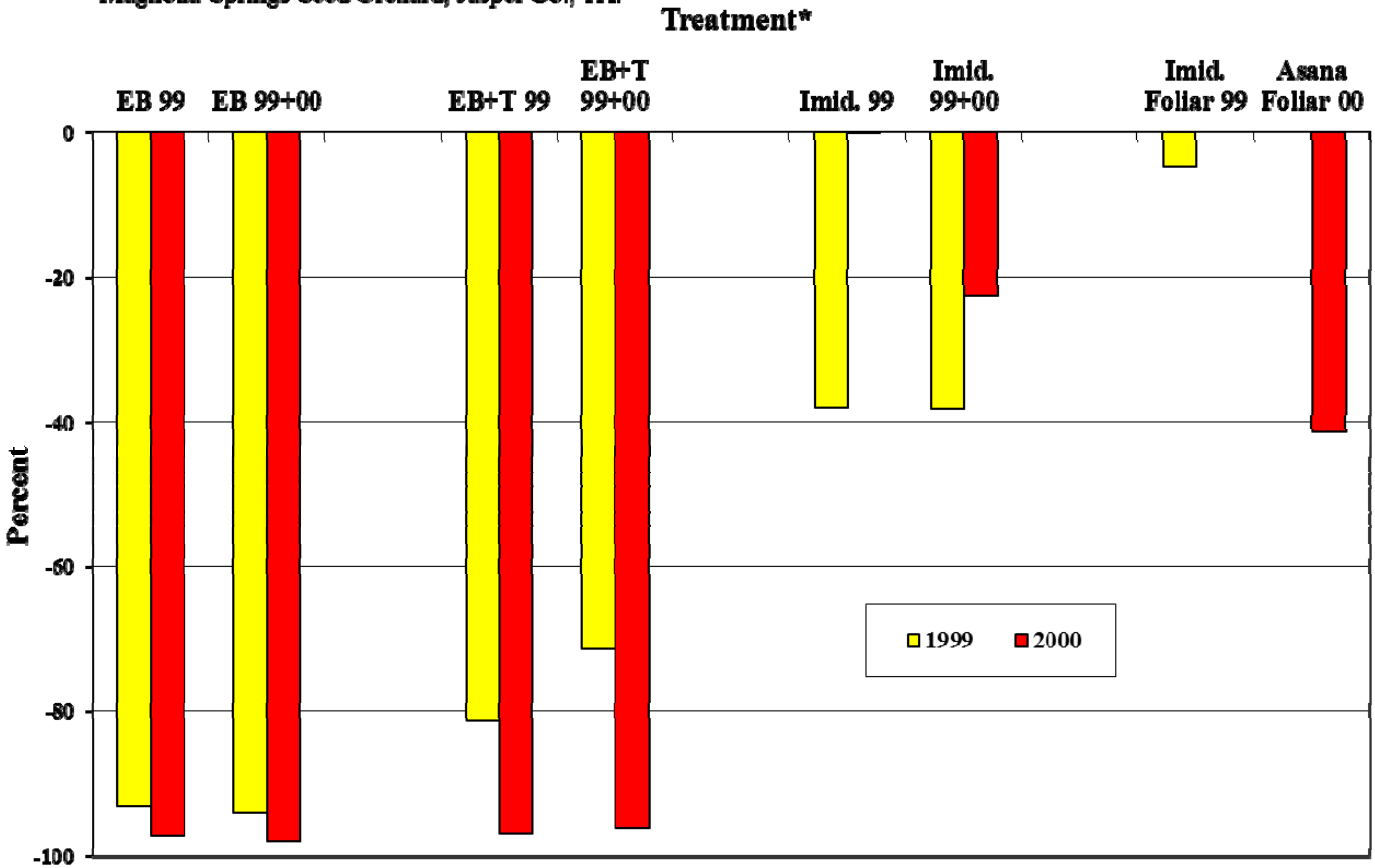
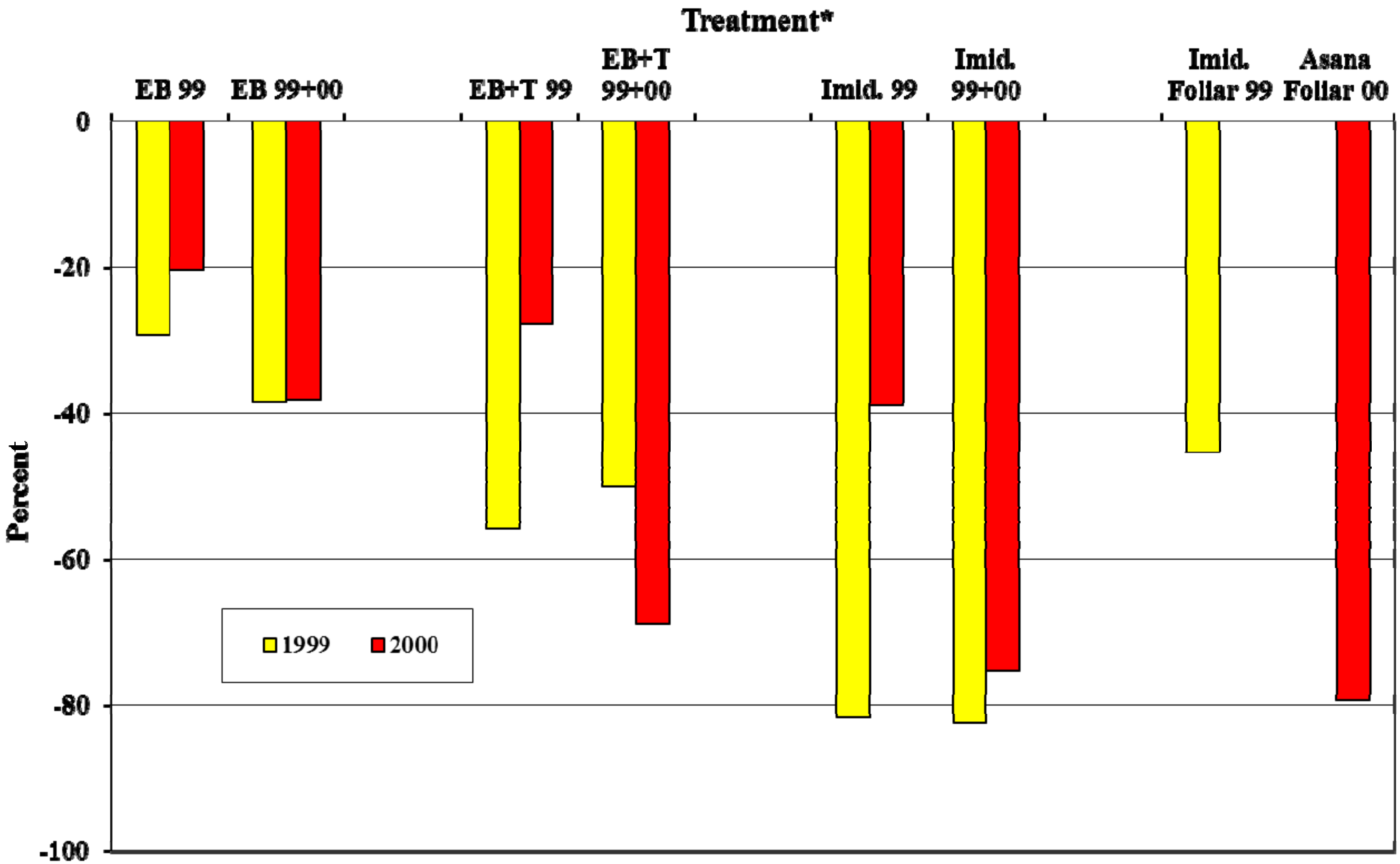


Figure 3. Percent reduction in coneworm (*Dioryctria* spp.) damage in 1999 and 2000 compared to check trees, Magnolia Springs Seed Orchard, Jasper Co., TX.



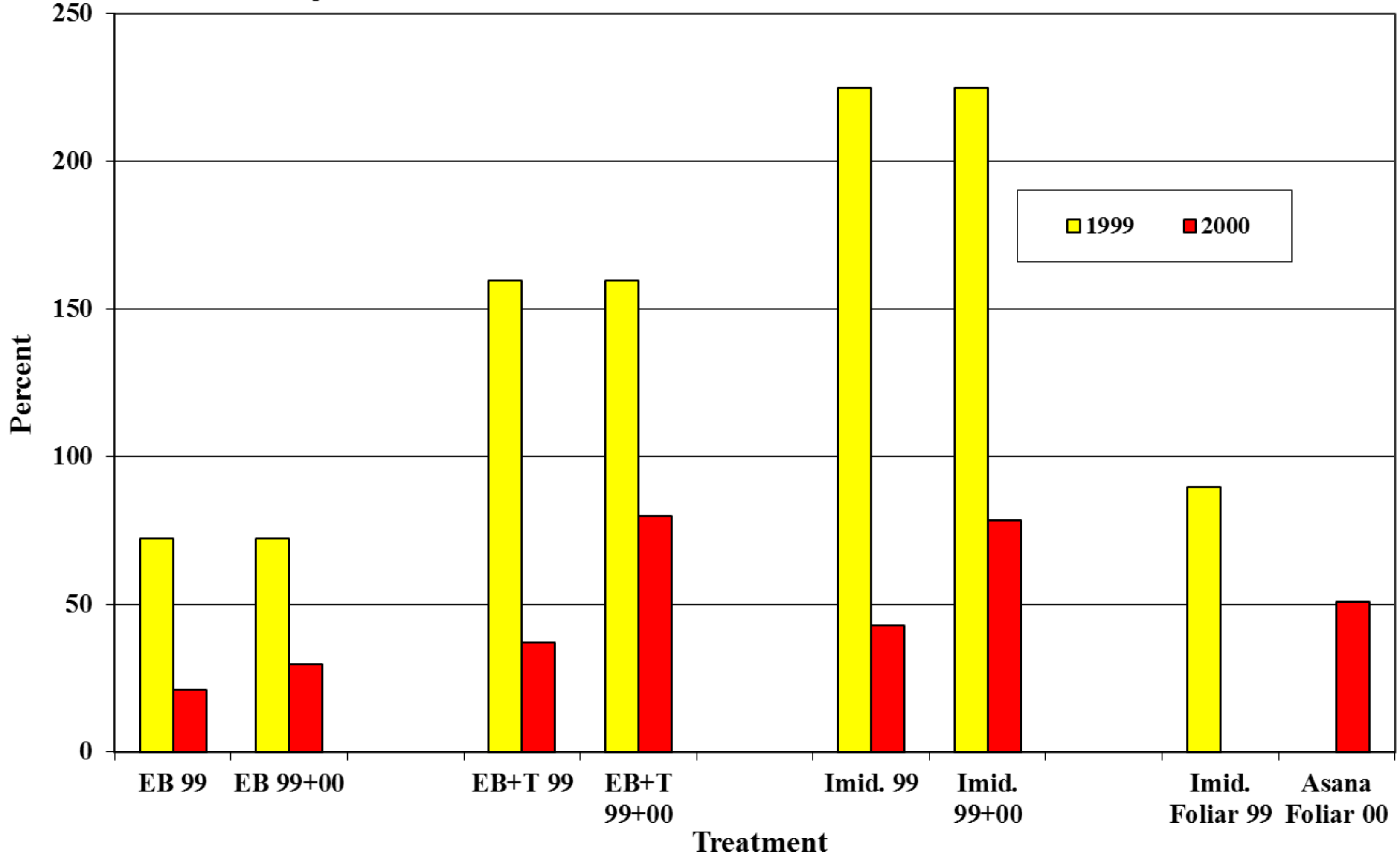
* The treatments indicate the product injected (EB = emamectin benzoate; EB – T = emamectin benzoate – thiamethoxam; Imid. = imidacloprid) and the timing of injections (99 = 1999 only; 99–00 = 1999 and 2000).

Figure 3. Percent reduction in damage by seed bugs (*Leptoglossus* spp.) in 1999 and 2000 compared to the check in 1999 and 2000, Magnolia Springs Seed Orchard, Jasper Co., TX.



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

Figure 5. Percent gain in full seed per cone in 1999 and 2000 compared to check trees, Magnolia Springs Seed Orchard, Jasper Co., TX.



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

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

			Mean % Coneworm Damage [a]				
Year	Treatment	Application Technique, Trt. Date(s), Group(s)	Early (small dead)	Late (large dead and infested)	Total	Mean % Other Damage [a b]	Mean % Healthy [a]
1999	EB	STIT - Apr, 99, Grp 1 & 2	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, Grp 1 & 2	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, Grp 1 & 2	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	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		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, Grp 1	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, Grp 2	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, Grp 1	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, Grp 2	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, Grp 1	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, Grp 2	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	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		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**

[a] Picked cones (surface damage)
[b] Mortality or wounds caused by drought, pitch canker, squirrel, midge, or mechanical.
* 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 PLSD.

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

			Mean % Seed Bug Damage			Mean No.	Mean No.	Mean No.
Year	Treatment	Application Technique Trt. Date(s), Group(s)	Early (2nd Yr Abort)	Late	Total	Seeds per Cone	Filled Seed per Cone	Empty Seed per Cone
1999	EB	STIT - Apr, 99, Grp 1 & 2	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, Grp 1 & 2	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, Grp 1 & 2	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	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		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, Grp 1	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, Grp 2	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, Grp 1	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, Grp 2	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, Grp 1	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, Grp 2	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	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		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**

* 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 PLSD.

Table 7. Residual effects of 1998 Wedgle Tip™ injections of emamectin benzoate and imidacloprid on cone and seed losses due to coneworm and seed bug on drought-hardy loblolly pine at Magnolia Springs Seed Orchard - 1999 and 2000.

	Treatment	Coneworm	Other	Healthy	Seed bug	Combined Insect Losses	Pct. Reduction
1999	Emamectin benzoate	8.1 **a***	24.0 **a**	67.9 **b**	43.6 **ab**	37.7 **a**	8.9 **-**
	Imidacloprid	23.3 **ab**	37.2 **a**	38.5 **a**	25.8 **a**	33.3 **a**	19.7 **-**
	Check	27.0 **b**	46.0 **a**	27.0 **a**	53.3 **b**	41.4 **a**	
2000	Emamectin benzoate	7.4 **a**	42.9 **a**	49.7 **b**	29.8 **a**	22.2 **a**	16.5 **-**
	Imidacloprid	16.8 **ab**	60.8 **a**	22.4 **a**	25.7 **a**	22.6 **a**	15.0 **-**
	Check	19.2 **b**	49.7 **a**	31.1 **ab**	23.7 **a**	26.6 **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 PLSD.

Table 8. Mean % ($\pm$ 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, Jasper Co., TX, 1999 - 2000.

		1999		2000	
Treatment	Appl. Tech., Trt. Date(s), Group(s)	Mean % Combined Losses	Mean % Reduction	Mean % Combined Losses	Mean % Reduction
EB	STIT - Apr, 99, Grp 1 & 2	20.1 $\pm$ 2.4 **a***	51.0		
EB	STIT - Apr, 99, Grp 1			9.2 $\pm$ 2.4 **ab**	67.5
EB	STIT - Apr, 99 & 00, Grp 2			6.0 $\pm$ 1.2 **a**	79.0
EB + Thia.	STIT - Apr, 99, Grp 1 & 2	17.4 $\pm$ 2.2 **a**	57.7		
EB + Thia.	STIT - Apr, 99, Grp 1			8.0 $\pm$ 0.8 **ab**	71.9
EB + Thia.	STIT - Apr, 99 & 00, Grp 2			4.1 $\pm$ 0.7 **a**	85.7
Imid.	STIT - Apr, 99, Grp 1 & 2	15.9 $\pm$ 1.7 **a**	61.2		
Imid.	STIT - Apr, 99, Grp 1			25.6 $\pm$ 4.8 **de**	9.7
Imid.	STIT - Apr, 99 & 00, Grp 2			18.9 $\pm$ 4.2 **cd**	33.4
Imid.	Hydraulic Foliar 5X in '99	31.6 $\pm$ 2.7 **b**	23.1		
Asana XL	Hydraulic Foliar 5X in '00			14.8 $\pm$ 2.7 **bc**	47.7
Check		41.1 $\pm$ 3.6 **b**		28.4 $\pm$ 3.0 **e**	

* 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 PLSD.

2000 Pest Survey – Arkansas, Louisiana and Texas

Highlights:

- λ Nantucket pine tip moth (*Rhyacionia frustrana*) was again the most common biotic factor damaging young loblolly pine plantations in Arkansas, Louisiana and Texas during both the spring and fall of 2000.
- λ Aphids and needle rust were the only biotic factors, other than tip moth, occurring at levels higher than 10% during the spring of 2000.
- λ In the spring, chlorosis was the most common abiotic factor with improper planting causing the most tree mortality. By contrast, in the fall, bent needle, chlorosis, and sinuosity were common abiotic factors and drought caused exceptional first year seedling mortality.

Objectives: 1) Continue evaluation of the occurrence and impact of primary and secondary insect and disease pests in pine plantations and, 2) determine the influence of different levels of stand management using site preparation, fertilization, weed control, and other practices on the occurrence and impact of insect and disease pests.

Study Sites: 202 sites/plots (including research sites, progeny tests, and plantations) containing 1, 2, 3, 4, 5, or 6 year old loblolly pine in eastern Texas, northern Louisiana, or southern Arkansas and managed by Champion, International Paper, Louisiana Pacific, Temple Inland, Texas Forest Service, The Timber Co., U.S. Forest Service, Willamette, and Potlatch were surveyed during the spring of 2000. 221 sites/plots were surveyed in the fall of 2000.

Survey Methods: The number of trees evaluated per plot or site was generally dependent on age/size (i.e., 50 trees per site/plot for 1 and 2 year olds, and 35 trees for 3, 4, 5, and 6 yr. olds).

Research Sites - Depending on the number of trees within a measurement plot, every third to fifth tree was evaluated. Every fifth evaluated tree was also measured for height.

Progeny Test Sites - Every tenth tree was evaluated along a rough transect made through each test site. Every third evaluated tree also was measured for height.

Plantation Sites - 5 to 7 random points were selected along access roads or trails within each plantation. At each point, a 1 chain transect was made perpendicular into the plantation from the road or trail. At the end of the transect, 5 of the nearest trees were evaluated and two were measured for height.

Each surveyed tree was evaluated for occurrence of any biotic or abiotic-caused damage or mortality. Each tree was ranked on the extent of any insect- or disease- or other-related damage:

A) Pine tip moth; Ranking: tree identified as infested or not. If infested, the proportion of tips infested on the top whorl and terminal was calculated. Separately, the terminal was identified as infested or not.

B) Deodar weevil; red-headed pine sawfly; black-headed pine sawfly; aphids; and scales; Ranking: 1 = 0% of tree infested; 2 = 1 - 40% infested; 3 = 41-80% infested; 4 = 81-100%; 5 = agent caused tree mortality.

C) Pine weevils; Ranking: 1 = no damage; 2 = 1 - 40% girdled; 3 = 41 - 80% girdled; 4 = 81 - 100% girdled; 5 = agent caused tree mortality.

D) Fusiform rust; Ranking: 1 = no galls; 2 = one branch gall; 3 = two or more branch galls; 4 = one or more stem galls; 5 = agent caused tree mortality.

E) Southern pine beetle; *Ips* engraver beetles; black turpentine beetle; and annosum root rot; Ranking: 1 = not attacked or infected; 2 = attacked or infected; 3 = agent caused tree mortality.

F) Others agents recorded as causing damage, including drought-caused tip dieback, mechanical (storm, bird, machine) damage , trunk resinosis, chlorosis, herbicide damage (roseting), vines, deer/rodent, bent needle, or sinuosity (aka. speed wobble).

G) Other factors recorded as possibly causing or contributing to mortality included drought, improper planting (J-root or planting to high), too wet, or unknown.

H) Form of seedling or tree; Ranking: 1 = no forks; 2 = one fork; 3 = two to four forks; 4 = five or more forks.

Survey Period: Most sites were surveyed between April 12 and May 30, 2000 and between September 12 and October 24, 2000.

Silvicultural Intensity Ranking: Each plot or site was ranked based on the intensity of site preparation, weed control, fertilization and other practices applied by mid-summer 1998.

Site Preparation:	0 - none
	1 - chop, burn, <u>or</u> shear
	2 - chemical, bed, rip (subsoil), <u>or</u> tillage (disking)
	3 - any two of chemical, bed, rip, or tillage
	4 - 3-N-1 (subsoil, fracturing, <u>and</u> tillage)
Herbicide:	0 - none
	1 - 1 application (herbaceous <u>or</u> woody)
	2 - 1 application each of herbaceous <u>and</u> woody
	3 - continuous herbaceous and woody (at least 1 appl./yr)
	4 - continuous herbaceous and woody <u>and/or</u> plastic mulch
Fertilization:	0 - none
	1 - 1 application of either DAP, KCl, Urea or micronutrients
	2 - 1 application of any two (DAP, KCl, Urea and/or micronutrients)
	3 - continuous fertilization (either DAP, KCL, or Urea) - 1 appl./yr
	4 - continuous fertilization (any two of DAP, KCL, Urea and/or micros) - multiple appl./yr
Other practices:	2 - irrigation
	1 - pest control as needed
	2 - thinning
	1 - pruning

Results: The distribution of sites surveyed during the spring and fall of 2000 by age group and relative silvicultural intensity is shown in Table 9. Most sites surveyed were 1 - 3 years old and had a low to high silvicultural intensity level.

During both the spring and fall of 2000, Nantucket pine tip moth, *Rhyacionia frustrana*, was consistently the most common biotic factor damaging loblolly pine in Arkansas, Louisiana and Texas (Table 10 & 11). All (100%) of 202 plots/sites visited in the spring and 221 plots/sites visited in the fall had some level of tip moth infestation. Three-year old plots in southern Arkansas and northern Louisiana were generally the hardest hit during the spring with 49% of all trees infested, 10% of all evaluated tips infested, and 16% of all terminals infested (Table 10). Two-year old trees were hardest hit in Texas plots. In the fall, tip moth infestation levels increased dramatically in most Arkansas and Texas plot/sites, but were generally highest in two- and three-year old stands: 78 – 100% of the trees, 34 – 65% of the tips, and 41 – 82% of the terminals (Table 11). Table 13 generally shows that infestation levels of tip moth were highest in two- and three-year old stands during both spring and fall periods.

Only one other biotic factor, aphids (*Cinara* spp.), was observed at levels that warrant mentioning. Aphids were most commonly found (10 - 16%) during the spring on two- to four-year old trees in Arkansas and Louisiana sites (Table 10). However, in most cases, individual trees exhibited less than 10% infestation levels. This accounts for the low level of sooty mold observed.

Coneworm (*Dioryctria* spp.), common on two-year old seedlings (30% in Arkansas) and older trees (23 - 34% in Texas) in spring of 1999, were rare during the spring of 2000 (Table 10).

Data analyses to evaluate the influence of different levels of stand management on the occurrence and impact of insect and disease pests in 2000 are on-going. However, in 1998 and 1999 the data indicated that infestation levels of Nantucket pine tip moth increased significantly with silvicultural intensity, but only in one- and two-year old plots/sites during the fall. Site preparation had the greatest influence during the first year and herbaceous weed control appeared to influence tip moth populations during the second year. In spring 1999, coneworm and aphid infestation levels also increased as silvicultural practices intensified. The impact of tip moth on tree growth and yield has not been determined in the Western Gulf region. However, tree form rank (incidence of branch forking) was significantly related to the percent of trees infested with pine tip moth in 1999. In fact, the relative percent of trees with at least one fork more than doubled (24% to 53%) as the level of tip moth infestation increased from 0 to 100%.

Summary: Based on data collected in 1998 - 2000, Nantucket pine tip moth appears to be the most important biotic factor affecting the health of young loblolly pine in eastern Texas and southern Arkansas. There is strong evidence to suggest that infestation levels of tip moth (as well as coneworm and aphids) increase with silvicultural intensity, and subsequently, the incidence of forking also increases. Although, the monitoring of insect and disease levels in the Western Gulf region should continue, the survey should be scaled back with efforts focused on sites that contain multiple silvicultural treatments (industry demonstration sites, TAMU Culture/Density sites, etc.). Greater research emphasis should be placed on determining the true impact of pine tip moth on the growth and yield of pine in the Western Gulf region and evaluating conditions that influence tip moth population development.

Table 9. Number of plots/sites surveyed in spring and fall, 2000 by age group and relative management intensity in Arkansas, Louisiana, and Texas.

	Relative Intensity Level [a]									
	Natural or Low		Moderate (Oper.)		High (Oper.)		Max. Potential		Total	
Age (yrs)	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
1	32	32	8	8	12	12	0	0	52	52
2	8	8	20	36	17	17	3	3	48	64
3	16	16	33	36	9	9	0	0	58	61
4	12	12	27	27	0	0	0	0	39	39
5+	4	4	1	1	0	0	0	0	5	5
Total	72	72	89	108	38	38	3	3	202	221

[a] Low = natural regeneration or low intensity site preparation only (0 - 2 pt).;

Moderate = low to moderate intensity site prep. + 1 herbaceous or woody control appl. and/or 1 fertlizer appl. (3 - 5 pts);

High = moderate to high intensity site prep. and more than 1 appl. of herbicide and/or 1 or more appl. of fertilizer and/or thinning and pruning (6 - 10 pts);

Maximum = high intensity site prep + continuous weed control + continuous fertilization + irrigation + pest control (11 - 15 pts).

Table 10. Occurrence and impact of biotic (insects and diseases) and abiotic (other) factors in 202 sites/plots in Arkansas, Louisiana and Texas in spring 2000.

	Age and State								
	Yr 1		Yr 2		Yr 3		Yr 4		Yr 5+
	Ar/La	**Tex.**	**Ar/La**	**Tex.**	**Ar/La**	**Tex.**	**Ar/La**	**Tex.**	**Tex.**
Sites/Plots Surveyed	4	48	36	28	11	24	24	15	5
Average Ranking of Silvi. Intensity [a]	2.50	4.50	3.78	5.59	4.09	3.13	3.43	2.40	1.00
Insects:									
Pine tip moth:									
trees infested	3.6%	13.3%	39.5%	40.5%	48.8%	30.6%	10.9%	25.1%	8.3%
tips infested	1.9%	4.8%	9.3%	11.0%	9.9%	4.8%	1.5%	1.4%	1.3%
terminals infested	1.9%	6.8%	16.1%	12.9%	16.4%	9.2%	4.8%	2.4%	1.7%
Aphid:		0.6%	11.7%	4.9%	10.2%	4.0%	16.7%	4.4%	
Pine coneworm:									
trees infested			0.1%	0.6%	4.2%	0.5%	0.3%	1.0%	0.6%
tips infested					0.7%				
terminals infested			0.1%		1.0%	0.1%			
Pitch midge:				1.0%	2.5%	3.3%	1.5%	0.6%	1.1%
Cerambycid:	0.6%			0.4%	1.1%	0.6%		1.7%	2.3%
Pine webworm:			0.2%			0.1%	0.1%		
Pitch twig moth:									
Pales Weevil:		0.8%			0.3%				
Mealy bug				0.2%		0.1%			
Scales:			0.1%						0.6%
Red-headed pine sawfly:									
Diseases:									
Fusiform rust:							0.1%		
Pitch canker:					0.2%	0.3%			
Needle Rust:			22.0%		57.3%		19.0%		
Needlecast:									
Sooty Mold:			1.7%	0.1%	11.2%	0.5%	0.1%		
Other:									
Yellow Needle Tip			15.4%		2.0%		0.3%		
Bent Needle									
Resin bud:			0.8%		0.4%	0.6%	1.0%		
Chlorotic:	9.6%	11.2%	6.3%	1.1%	5.8%	7.9%	1.1%	1.3%	
Trunk Resinosis:				0.1%		0.1%		0.6%	
Herbicide Damage:		2.2%	0.1%	1.2%		4.5%			
Avg Rank		0.6	0.1	0.2		0.4			
Mortality									
Drought:									
Needle/Tip Dieback:		0.8%		0.1%		0.2%		0.2%	
Mortality		1.1%	0.1%	1.9%		7.8%			
Deer/Rodent Damage:			5.8%	0.1%	0.3%	0.2%			
Mortality									
Mechanical		0.2%	0.1%	0.9%	3.2%	1.2%	0.8%	1.6%	2.3%
Vine:			0.1%	0.4%		0.7%	7.0%	9.0%	9.7%
Sinuosity					0.4%	0.2%	4.5%		
Improper plant:	13.5%	1.8%							
Too wet:	0.5%								
Unknown mortality:	2.0%	1.8%	0.1%					3.2%	
Overall Mortality:	16.0%	4.7%	0.2%	1.9%		7.8%		3.2%	
Form (1 or more forks):	9.7%	39.8%	62.8%	69.0%	72.4%	62.3%	61.9%	59.4%	2.0%
Avg Rank	1.10	1.60	1.70	2.10	1.90	1.90	1.90	1.80	1.30
Height (average ft)									

[a] Silvicultural Intensity Ranking: each site was ranked based on intensity of site prep, weed control, fertilization, other practices applied by April 2000.

Site Prep.	Weed Control	Fertilization	Other Practices
0 - None	0 - None	0 -None	1 - pest control
1 - chop, burn, or shear	1 - 1 appl. (herb or woody)	1 - 1 appl. of DAP, KCl, or urea	1 - pruning
2 - chemical, bed, rip, or tillage	2 - 1 appl ea. of herb & woody	2 - 1 appl. of any two forms	2 - irrigation
3 - any 2 of chem., bed, rip, or tillage	3 - 1 appll/yr of herb. & woody	3 - 1 appl/yr of any one form	2 - thinning
4 - 3-N-1 plow	4 - mult appl/yr of herb & woody	4 - mult appl/yr of two or more forms	

Overall 0-2 pts = low intensity; 3-5 pts = medium intensity; 6-10 pts = high intensity; 11+ pts = maximum intensity.

[b] Fusiform Rust Ranking: 1 = no galls; 2 = one branch gall; 3 = two or more branch galls; 4 = one or more stem galls

[c] Tree Form Ranking: 1 = no forks; 2 = one fork; 3 = two to four forks; 4 = five or more forks

Highlighted areas - indicate those factors present on 10% or more of the trees in at least one age class/geographic area.

Table 11. Occurrence and impact of biotic (insects and diseases) and abiotic (other) factors in 221 sites/plots in Arkansas, Lousiana and Texas in fall 2000.

	Age and State								
	Yr 1		**Yr 2**		**Yr 3**		**Yr 4**		**Yr 5+**
	Ar/La	**Tex.**	**Ar/La**	**Tex.**	**Ar/La**	**Tex.**	**Ar/La**	**Tex.**	**Tex.**
Sites/Plots Surveyed	4	48	36	28	19	24	24	15	5
Average Ranking of Silvi. Intensity [a]	2.50	5.25	3.92	5.79	2.37	3.13	3.43	2.40	1.00
Insects:									
Pine tip moth:									
trees infested	19.9%	61.7%	94.2%	78.4%	99.8%	83.9%	56.3%	63.2%	30.9%
tips infested	6.8%	19.9%	64.1%	34.5%	65.4%	33.8%	12.5%	20.9%	4.2%
terminals infested	14.2%	25.8%	77.4%	41.4%	81.9%	45.1%	22.6%	27.5%	6.3%
Aphid:									
Pine coneworm:									
trees infested			0.1%	0.2%	0.2%	0.2%	0.3%	0.7%	
tips infested									
terminals infested			0.1%				0.1%		
Pitch midge:			0.2%	3.3%	0.3%	2.7%	0.1%	2.0%	1.1%
Cerambycid:		0.1%		0.8%		0.3%			
Pine webworm:	6.2%		1.4%	0.1%	0.6%	0.7%	0.6%	0.2%	
Leafhopper				0.6%		0.3%		0.8%	
Pales Weevil:					0.2%				
Mealy bug				0.1%			0.3%		
Scales:				0.1%		0.1%			
Red-headed pine sawfly:				0.1%					
Diseases:									
Fusiform rust:							0.5%		
Pitch canker:							0.1%		
Needle Rust:									
Needlecast:									
Sooty Mold:				0.1%	0.5%			0.2%	
Other:									
Yellow Needle Tip									
Bent Needle		0.1%	0.1%	15.1%	5.0%	13.0%	59.5%	12.1%	24.6%
Resin bud:		0.1%	0.1%	0.9%		0.4%		1.3%	
Chlorotic:	11.2%	0.9%	19.1%	1.7%	16.9%	1.9%	2.1%	2.0%	0.6%
Trunk Resinosis:			2.3%	0.9%	1.7%	2.5%	6.3%	3.1%	
Herbicide Damage:	6.0%	3.4%	3.9%	0.1%	3.7%	2.3%		0.4%	
Avg Rank									
Mortality									
Drought:									
Needle/Tip Dieback:	4.4%	14.9%	1.8%	8.1%	3.3%	4.8%	0.2%	2.1%	
Mortality	5.7%	38.2%	5.1%	10.0%	6.3%	0.2%			
Deer/Rodent Damage:						0.1%		0.2%	
Mortality									
Mechanical		0.2%		0.2%		0.2%		0.4%	1.7%
Vine:		1.9%	0.1%	0.8%		0.4%	5.8%	3.6%	
Sinuosity		0.6%	1.4%	3.6%	16.4%	5.2%	38.1%	4.3%	4.6%
Improper plant:	41.8%								
Too wet:									
Unknown mortality:	1.0%	0.1%		0.9%		0.1%			
Overall Mortality:	50.7%	38.3%	4.8%	11.0%	6.3%	0.2%			
Form (1 or more forks):	19.3%	45.7%	56.4%	47.3%	67.9%	36.4%	30.9%	32.2%	12.6%
Avg Rank	1.20	1.60	1.70	1.60	1.90	1.40	1.30	1.40	1.10
Height (average ft)									

[a] Silvicultural Intensity Ranking: each site was ranked based on intensity of site prep, weed control, fertilization, other practices applied by April 2000.

Site Prep.	Weed Control	Fertilization	Other Practices
0 - None	0 - None	0 -None	1 - pest control
1 - chop, burn, or shear	1 - 1 appl. (herb or woody)	1 - 1 appl. of DAP, KCl, or urea	1 - pruning
2 - chemical, bed, rip, or tillage	2 - 1 appl ea. of herb & woody	2 - 1 appl. of any two forms	2 - irrigation
3 - any 2 of chem., bed, rip, or tillage	3 - 1 appll/yr of herb. & woody	3 - 1 appl/yr of any one form	2 - thinning
4 - 3-N-1 plow	4 - mult appl/yr of herb & woody	4 - mult appl/yr of two or more forms	

Overall 0-2 pts = low intensity; 3-5 pts = medium intensity; 6-10 pts = high intensity; 11+ pts = maximum intensity.

[b] Fusiform Rust Ranking: 1 = no galls; 2 = one branch gall; 3 = two or more branch galls; 4 = one or more stem galls

[c] Tree Form Ranking: 1 = no forks; 2 = one fork; 3 = two to four forks; 4 = five or more forks

Highlighted areas - indicate those factors present on 10% or more of the trees in at least one age class/geographic area.

Table 12. Tree, tip and terminal infestation levels by Nantucket pine tip moth in the Western Gulf region (Arkansas, Louisiana and Texas) - 1998 - 2000.

	Percent Trees Infested by Season / Year				
Tree	Fall			Spring	
Age	1998	1999	2000	1999	2000
1	53.5	59.2	55.7	26.4	8.5
2	76.3	80.7	82.3	52.1	35.1
3	57.8	73.4	90.9	32.3	35.3
4	81.6	59.3	61.0	14.3	20.6
5+	80.8	43.5	30.9	24.4	8.6

	Percent Shoots Infested by Season / Year				
Tree	Fall			Spring	
Age	1998	1999	2000	1999	2000
1	41.2	40.0	18.0	9.9	3.4
2	34.7	55.6	51.2	15.5	9.1
3	23.2	33.7	47.8	5.7	6.2
4	56.6	24.0	18.2	2.1	1.4
5+	64.1	16.1	4.2	1.2	1.3

	Percent Terminals Infested by Season / Year				
Tree	Fall			Spring	
Age	1998	1999	2000	1999	2000
1	46.7	45.3	24.1	17.2	5.1
2	49.7	62.5	61.7	23.3	13.2
3	32.4	38.8	61.4	9.5	11.1
4	69.2	25.9	25.9	2.9	3.2
5+	82.1	19.0	6.3	1.1	1.7

2000 Tip Moth Spray/Impact Study - East Texas

Highlights:

- λ Tip moth trap monitoring indicated the occurrence of 5 generations in Angelina Co, TX in 2000.
- λ Periodic applications of Mimic® and Pounce® (at label recommended rate) and Mimic® (half label rate) significantly reduced tip moth infestation levels.
- λ A single application of Pounce® or emamectin benzoate did not control tip moth levels past the second generation.

Objectives: 1) Determine efficacy of Pounce®, Mimic®, and emamectin benzoate in reducing infestation levels of Nantucket pine tip moth, 2) determine the effects of Nantucket pine tip moth on the growth and yield of loblolly pine in operationally-managed pine stands, and 3) continue monitoring tip moth populations occurring in Angelina Co., TX.

Study Sites: Three first-year plantations in Angelina Co., Texas (owned and managed by Temple Inland) were used for the spray trials and for monitoring tip moth populations in 1999. An area of each plantation was selected and divided into 4 plots, each 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 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 January, 2000 and monitored until the beginning of November. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Pounce® 3.2 EC (permethrin) - - broad spectrum pyrethroid insecticide
Mimic® 2F (tebufenozide) - - molting stimulant specific to lepidoptera
Proclaim® (emamectin benzoate)

Design: Randomized complete block design with sites as blocks. 7 treatments X 3 sites X 50 trees = 1050 monitored trees.

Treatments:

1) Pounce® 3.2 EC applied once (1st generation) at 0.08 oz / gal.
2) Pounce® 3.2 EC applied once per generation at 0.08 oz / gal.
3) Mimic® 2F applied once per generation at 0.08 oz / gal.
4) Mimic® 2F applied once per generation at 0.08 oz / gal.
5) Emamectin benzoate applied once (1st generation) at 0.6 oz / gal water
6) Emamectin benzoate applied once (1st generation) at 0.6 oz / gal water plus 2% oil
7) Check

Application Methods: Treatments were randomly assigned to a plot at each site in 2000. The same pesticides were applied to the same plots for the remainder of the study. Pesticides were applied by backpack sprayer to all 126 trees within the 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 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 also were collected on tree height, diameter, form (forking), and percent tree mortality.

Results: Figure 6 shows the distribution of pine tip moths captured in traps at three 3-year old study sites and two 4-year old sites in 2000. Based on the latitude of Angelina Co., we had expected four generations of tip moth in this area. However, trap catches at all sites indicated a fifth generation had developed late in the summer. A fifth generation in a normally four generation area is apparently not unusual when extreme drought conditions and high temperatures favor population and larval development.

Based on trap catch numbers and degree day calculations, the optimal spray dates for the first four generations were determined to be March 10, May 9, June 26, August 18 and September 22 (Fig. 6).

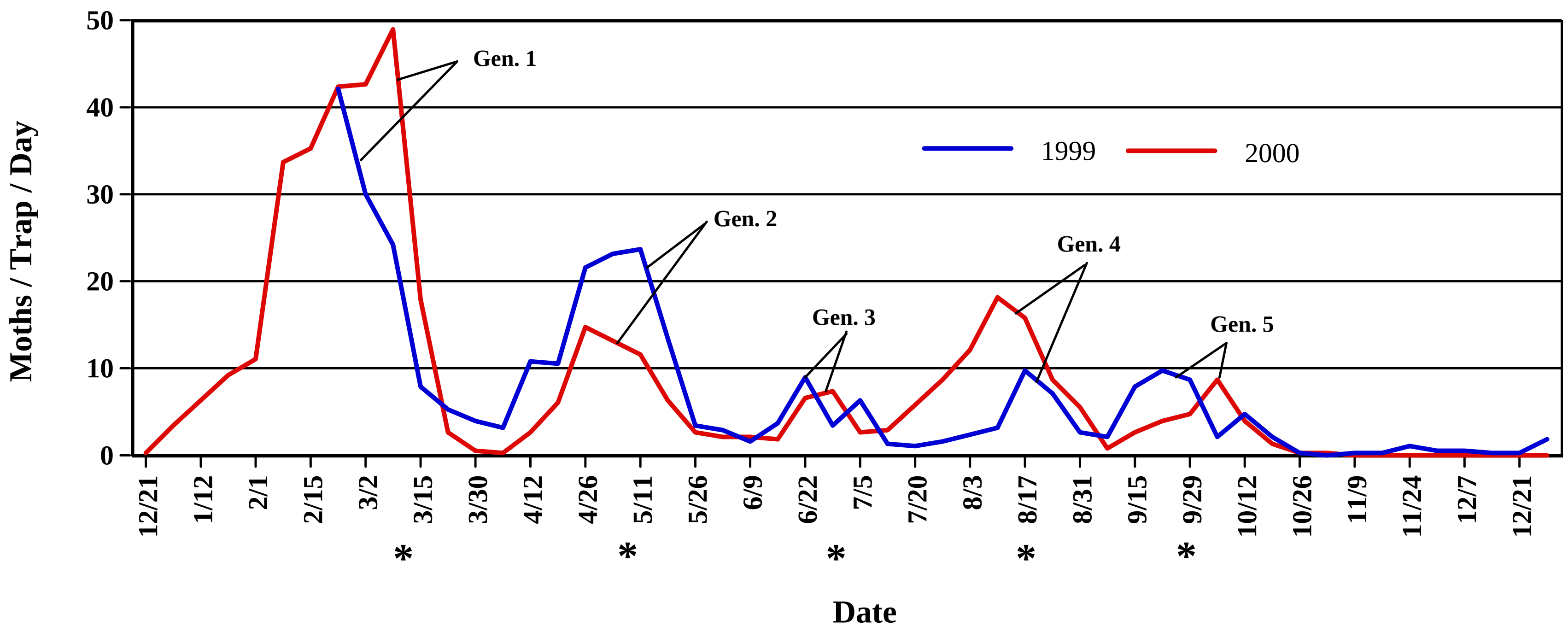
Tip moth infestation levels were relatively low on check trees during the first two generations but increased dramatically after mid-July when drought conditions became severe (Table 14). The single Pounce® treatment provided good control during the first tip moth generation, but did not protect the trees during later moth generations (Table 14). Multiple treatments of Mimic® (both full and half rates) and Pounce® (except for the second generation) significantly reduced tip moth infestation levels compared to the check. However, only trees receiving the Mimic® (full rate) treatment had significantly greater tree height and diameter and better form (fewer forks) compared to check trees (Table 15). It appears that variability in soil nutrients and/or moisture among the plots had a confounding effect on the insecticide treatments. Modification of the study design – random treatment of fewer trees in a smaller area – would likely eliminate the confounding effects of soil nutrients/moisture (Scott Cameron, personal communication).

Summary: Multiple applications of Mimic® (full and half rate) or Pounce® significantly reduced tip moth damage during most of the year. However, a single application of high concentration Pounce® solution was not sufficient to protect seedlings from tip moth throughout the first growing season.

The effort required to predict optimal spray dates in a given year by means of degree day calculations is a significant deterrence toward establishment of tip moth control programs in plantations. Extrapolation of optimal spray intervals for Texas from Mississippi data was generally successful in 1999, but cannot be considered reliable. Dr. Chris Fettig (University of Georgia) recently was awarded a Forest Health Protection Technology Development Program grant for his proposal entitled “Nantucket Pine Tip Moth Phenology and Timing of

Insecticide Applications in Arkansas, Louisiana, and Texas." Hopefully, his research efforts will provide improved methods for timing tip moth sprays in the Western Gulf region.

Figure 6. Nantucket pine tip moth catch in Angelina Co., TX in 1999 and 2000 and spray dates in 2000.



* = Degree day calculated spray dates on March 10, May 9, June 26, August 18 and September 22

Table 13. Incidence of pine tip moth damage on two-year old loblolly pine after each moth generation in Angelina Co., Texas - 2000

	Tip Moth Generation														
	1			2			3			4			5		
Treatment	% Trees Infested *	% Tips Infested	% Term Infested	% Trees Infested	% Tips Infested	% Term Infested	% Trees Infested	% Tips Infested	% Term Infested	% Trees Infested	% Tips Infested	% Term Infested	% Trees Infested	% Tips Infested	% Term Infested
Pounce (single appl.) (2.4 ml/gal)	0.0 **a**	0.0 **a**	0.0 **a**	43.8 **c**	8.9 **c**	12.9 **c**	66.5 **b**	12.6 **b**	25.1 **b**	78.2 **b**	20.2 **bc**	38.0 **c**	85.6 **b**	30.2 **b**	38.4 **b**
Pounce (applied ea. gen) (2.4 ml/gal)	2.3 **ab**	0.0 **a**	0.0 **a**	13.8 **ab**	1.6 **a**	5.0 **abc**	7.4 **a**	0.8 **a**	2.3 **a**	9.9 **a**	2.9 **a**	4.3 **ab**	35.4 **a**	1.6 **a**	1.8 **a**
Mimic (applied ea. gen) (2.4 ml/gal)	4.5 **bc**	0.0 **a**	0.0 **a**	5.8 **a**	0.6 **a**	2.1 **a**	5.0 **a**	0.4 **a**	1.4 **a**	4.7 **a**	0.6 **a**	2.0 **a**	13.0 **a**	2.9 **a**	3.1 **a**
Mimic (applied ea. gen) (1.2 ml/gal)	2.0 **abc**	0.1 **a**	0.0 **a**	9.3 **a**	0.6 **a**	1.3 **a**	6.0 **a**	1.2 **a**	2.0 **a**	10.7 **a**	1.9 **a**	4.0 **ab**	18.1 **a**	4.5 **a**	8.8 **a**
EB + water (single appl.) (17.7 ml/gal)	6.0 **c**	1.0 **a**	1.3 **a**	37.3 **c**	3.6 **abc**	5.0 **abc**	64.0 **b**	10.4 **b**	18.0 **b**	72.7 **b**	21.1 **bc**	27.3 **bc**	77.8 **b**	28.5 **b**	41.1 **b**
EB + oil (single appl.) (17.7 ml/gal)	3.3 **bc**	0.8 **a**	0.7 **a**	41.4 **c**	6.3 **bc**	11.6 **bc**	59.3 **b**	8.6 **b**	14.0 **b**	79.1 **b**	29.7 **c**	40.8 **c**	87.8 **b**	38.1 **b**	54.6 **b**
Check	31.9 **d**	7.1 **b**	5.9 **b**	29.5 **bc**	1.9 **ab**	3.9 **ab**	74.3 **b**	12.4 **b**	23.7 **b**	66.7 **b**	18.8 **b**	30.9 **c**	84.1 **b**	26.8 **b**	44.0 **b**

Spray Dates: Gen. 1 - March 16; Gen. 2 - May 9; Gen. 3 - June 26; Gen. 4 - Aug. 18; Gen. 5 - Sept. 22

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

Table 14. Tree height, ground line diameter and incidence of forking on two-year old loblolly pine after foliar applications of different insecticides in Angelina Co., Texas - 2000.

Treatment	Mean Height (cm)	Mean Diameter (cm)	Proportion w/ at least 1 fork
Pounce (single appl.) (2.4 ml/gal)	159.9 **bcd**	3.4 **cd**	29.5% **c**
Pounce (applied ea. gen) (2.4 ml/gal)	126.6 **a**	2.7 **a**	11.7% **ab**
Mimic (applied ea. gen) (2.4 ml/gal)	177.2 **f**	3.4 **d**	8.4% **a**
Mimic (applied ea. gen) (1.2 ml/gal)	162.9 **cde**	3.2 **bcd**	18.4% **b**
EB + water (single appl.) (17.7 ml/gal)	164.7 **cde**	3.2 **bcd**	20.5% **b**
EB + oil (single appl.) (17.7 ml/gal)	152.0 **b**	3.0 **b**	16.1% **b**
Check	159.3 **bc**	3.1 **bc**	17.8% **b**

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