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THERMAL DEFOLIATION

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Abstract

Cotton producers increasingly are under pressure to reduce chemical use, control stickiness, avoid weather damage and make a profit in the face of the lowest cotton prices in history. Organic producers are called upon to produce a high quality fiber without using any chemicals at all. The thermal defoliation research reported here is an attempt to provide producers with additional tools to meet these objectives. Thermal defoliation gives organic producers a way to terminate their crop. Other producers may appreciate being able to eliminate insects that cause stickiness, to defoliate during bad weather and to harvest shortly after treatment. Thermal defoliation was shown to work in three states (and over three years in New Mexico) in Pima, Acala and upland cotton varieties. While defoliation (leaf drop) is not as great as that attained with chemical treatment, desiccation (leaf withering) is usually more pronounced, and almost instantaneous. Two weeks after heat treating at 300 F for 8 seconds (burning 13 gallons of propane per acre) plants were 60% defoliated and 80% desiccated.

Introduction

The concept of using thermal defoliation to control late season insects was introduced in a Beltwide presentation last year (Funk et al., 2002a). Preliminary laboratory studies are reported elsewhere (Funk et. al., 2002b). Thermal defoliation investigations were continued in the 2002 season at four locations; Lubbock, TX, Las Cruces, NM, Five Points, CA and Shafter, CA. Initially conceived as an option for organic producers, thermal defoliation also shows potential to reduce stickiness and facilitate immediate harvesting.

Materials and Methods (2002)

Five Points, CA and Shafter, CA (Field Demonstrations)

The insect mortality demonstration at Shafter Research and Extension Center near Shafter, CA was limited to the outer two rows of two fields with fairly low silverleaf whitefly populations. Nymph populations were assessed on ten randomly selected leaves per row before thermal treatment and one and two days afterwards. Poisson distributions were assumed due to low silverleaf whitefly nymph counts (typically less than five per leaf).

The defoliation demonstration at West Side Research and Extension Center near Five Points involved the guard rows of twenty cotton plots that were part of a strip tillage study. Five levels of thermal treatment and two residence times were replicated four times on third year cotton. Plant height varied in response to sub-soiling treatments. Subjective visual assessment of desiccation and defoliation percent was performed 2, 7 and 14 days after treatment. Plant response to thermal treatment at West Side was used to set the treatment levels for the New Mexico study.

Lubbock, TX (Stripper Harvested) Study

One thermal treatment was contrasted with three control treatments. One of the controls was a tank mix of DEF™ and Prep™ each applied at a rate of 1 pint per acre. The second control treatment was Cyclone™ at 32 oz per acre. The third control was no treatment at all. Unfortunately, persistent rains delayed harvest for nearly two months.

Las Cruces, NM (Primary) Study

Two varieties, Delta Pine 565 and Acala 1517-99, were randomly assigned to 18 four row plots with three skip rows between each plot. A central composite experimental design with five levels of thermal treatment (from 229 F to 371 F) and five levels of residence time (from 4.7 to 12.6 seconds) was used to find the optimal combination of time and temperature. Two control treatments were run at the same time; a standard tank mix of chemical defoliant (1 quart/ac Finish and 7 oz/ac Gin Star) was applied to one plot of each variety, and three half plots of each variety received no treatment at all (green picked).

Results and Discussion

Five Points, CA and Shafter, CA (Field Demonstrations)

Demonstration treatments at the Shafter Research and Extension Center showed silverleaf whitefly mortality could be realized with thermal defoliation. Nymph populations were reduced significantly one and two days after treatment, to 0.875 and 0.575 from an initial level of 1.55 per leaf before treatment. There was no significant row or field interaction effects out of 40 leaf samples. Although leaves having nymphs remained attached to the plant, the fact that the leaves were desiccated meant that surviving nymphs that were counted may not have had an opportunity to complete their development. However, baseline silverleaf whitefly populations were not large enough to make conclusive inferences from the data.

Plant response to thermal treatment at the West Side Research and Extension Center helped inform the experiment design for the New Mexico study. Desiccation at seven and fourteen days was strongly influenced by the dwell time. On both dates desiccation was near zero for a treatment time of three seconds regardless of temperature. As treatment time approached 12 seconds desiccation approached from 70 to 80 percent at from 113 to 177 C (235 to 350 F) treatment temperature. Defoliation was complicated by an interaction effect. For the high temperature of 177 C (350 F), treatment time was not important to defoliation response, and actually decreased slightly at seven days after treatment. At the low temperature of 113 C (235 F) defoliation increased with increasing dwell time. Twelve seconds treatment at the low temperature resulted in the highest defoliation (approaching 75% after fourteen days).

Lubbock, TX (Stripper Harvested) Study

One thermal treatment, two different chemical treatments and a control (no) treatment all replicated three times produced the defoliation response summarized in Table 1. There was a significant (0.05 level) difference between each treatment. Bad weather prevented a timely harvest in this case, but the possibility of harvesting the thermally treated cotton within two days existed because desiccation was complete in that short time. Eighteen days after treatment the thermal plots had more leaves on the plants, but fewer green leaves compared to the control and chemical treatments. More leaves were stuck to the plant with thermal defoliation, but those leaves were completely desiccated and could be removed at the gin without green staining.

Las Cruces, NM (Primary) Study

Desiccation as used here means withered brown leaves no longer able to photosynthesize. Defoliation is defined for this test as leaf drop. Harvest is possible where only desiccation exists, but some leaf trash may be present in the seed cotton. A thermally treated field resembles one that has seen a hard frost; there is no insect activity, the shriveled leaves cling to the stalk, and regrowth, if any, is confined to the very bottom of the plant. Comparing this treatment to a chemically treated plot is difficult, because the chemical treatment usually is not evident for several days; leaves remain green and succulent until they fall to the ground. Successful chemical defoliation still requires a ten day wait before harvest can begin.

Yields varied between the two varieties, with Delta Pine 565 averaging 2.5 bale/ac and Acala 1517-99 returning 1.9 bale/ac. However, variety did **not** play a significant role in desiccation nor defoliation results. Treatment temperature, resident time, soil type, and row position (outside v. inside row) were the only significant variables in desiccation response at seven, fourteen and twenty-one days. Those four variables and three interactions were the only significant variables in defoliation response at seven, fourteen and twenty-one days. Table 2 summarizes these field responses. Eight seconds at 300 degrees requires about 13 gallons propane per acre, and results in 60% defoliation and 80% desiccation after two weeks. Note that cotton treated above 150 C (300 F) is desiccated enough that it could be harvested within two days (Figure 3).

Inferences concerning insect mortality were difficult to draw due to low initial population numbers. After two weeks, increasing temperatures correlated positively with increasing mortality. Two weeks following treatment the mean thermal treatment level saw nearly 50% insect mortality and the higher temperatures approached 90% mortality. For chemical defoliation insect mortality was only 30% (Table 3).

Ginning Test Results

Differences attributed to defoliation method (including observed levels of significance) are presented in Table 4. Seed cotton trash content was higher for thermally defoliated cotton by about 6 or 7 pounds (3 kg) per bale. Moisture content before ginning was lower. The gin was able to remove the trash found in thermally defoliated seed cotton. Classing office measurements that were statistically different favored thermal defoliation; leaf grade was lower and color grade was higher. These are averages of two varieties, significant differences due to variety showed up throughout the analysis.

Conclusions

Being able to treat late season sucking insect pests and get immediate results could give producers an important tool for preventing sticky cotton if insect populations suddenly increase. Being able to defoliate on a windy day and being able to pick within two days of defoliation regardless of accumulated heat units could be an important tool for timely harvest when bad weather is threatening. The fuel cost associated with thermal defoliation (about 12 gallons of propane per acre for heat) is similar to the cost of defoliant chemicals. The difference will be application costs, since aerial application of heat is infeasible. Application costs will be higher for thermal defoliation, so, absent important environmental or economic advantages (such as avoiding losses from weather or insect sugars) thermal defoliation will remain of interest primarily to organic producers.

Disclaimer

"Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture."

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References

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Table 1. Texas field results 18 DAT showing response to 9 seconds at 295 degrees and three control treatments.

18 Days After Treatment	% Defoliation	% Desiccation	% Green Leaf
Thermal	38	62	0
Prep+Def	77	9	12
Cyclone	57	27	17
No treatment	43	5	52

Table 2. New Mexico field results showing average response for each treatment combination and control.

Time	Temperature	Fuel	% Desiccation			% Defoliation		
(sec)	(F)	(gal/ac)	7 dat	14 dat	21 dat	7 dat	14 dat	21 dat
8.8	245	10	34	32	50	22	40	54
6	261	6.4	51	50	39	41	57	66
10.3	260	12.1	71	64	73	35	54	70
4.7	299	6.8	15	15	16	25	38	49
8.5	308	12.9	84	79	79	44	62	72
12.6	305	20.4	100	100	100	28	52	61
6	361	11.2	80	76	71	39	59	75
10.9	344	19.2	88	89	87	36	52	68
8.3	371	16.3	100	100	98	45	63	71
Control	Chemical	--	1	22	51	48	78	83
	Untreated	--	2	2	17	7	33	40

Table 3. Aphid mortality in New Mexico plots.

Treatment	Insect Mortality		
Temperature (f)	Day 1 (%)	Day 7 (%)	Day 14 (%)
229	54	45	0
250	19	0	0
300	40	0	47
350	61	24	74
371	25	0	87
Chemical Defoliant	26	29	30

Table 4. Significant differences in classing office data due to treatment.

	Treatment			
Measurement	Thermal	Chemical	Green	OSL
Wagon Trash (Percent)	8.85	7.54	7.66	0.0167
Wagon Moisture (Percent)	11.1	12.2	14.2	0.0137
Leaf Grade	3.19	3.5	3.83	0.0003
Color Grade (old code)	95.1	94.3	91.5	0.0051
Reflectance	74.5	74.1	71.9	<0.0001
Yellowness	81.8	80.9	86.9	0.0002

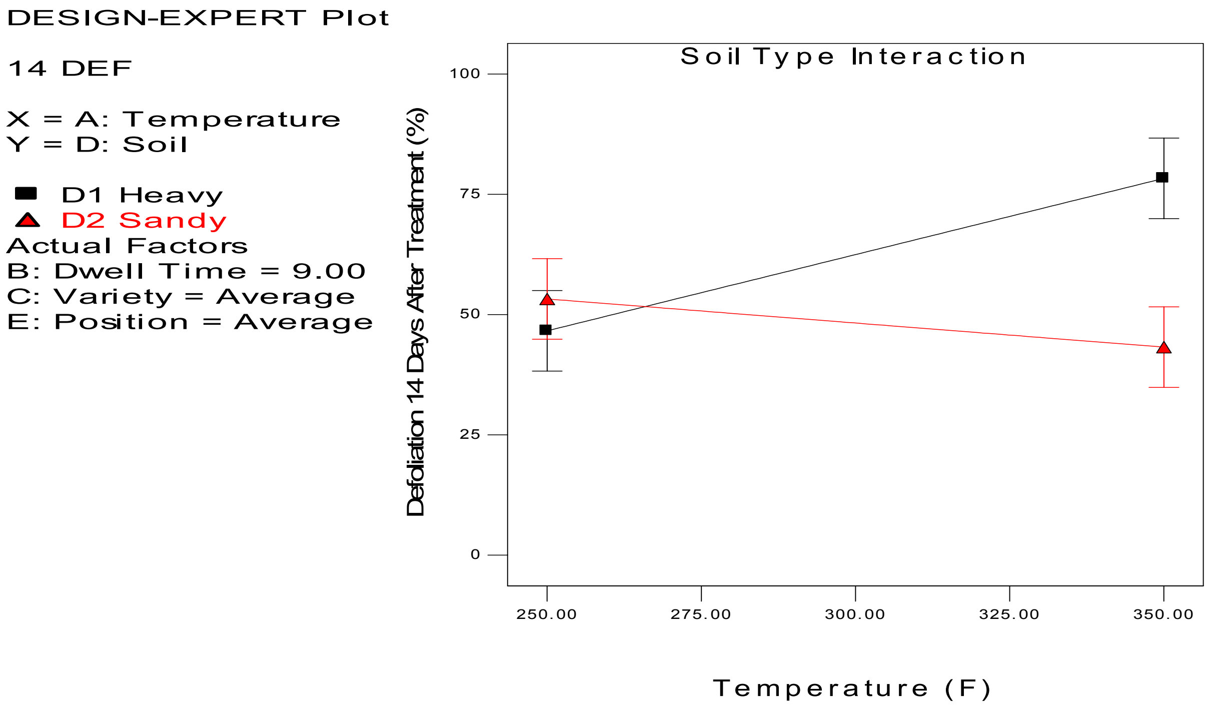

Figure 1. Percent defoliation 14 days after treatment as a function of temperature was influenced by soil type. Heavy soil, with plants still growing, responded positively, and sandy soil, with plants water stressed, showed less response.

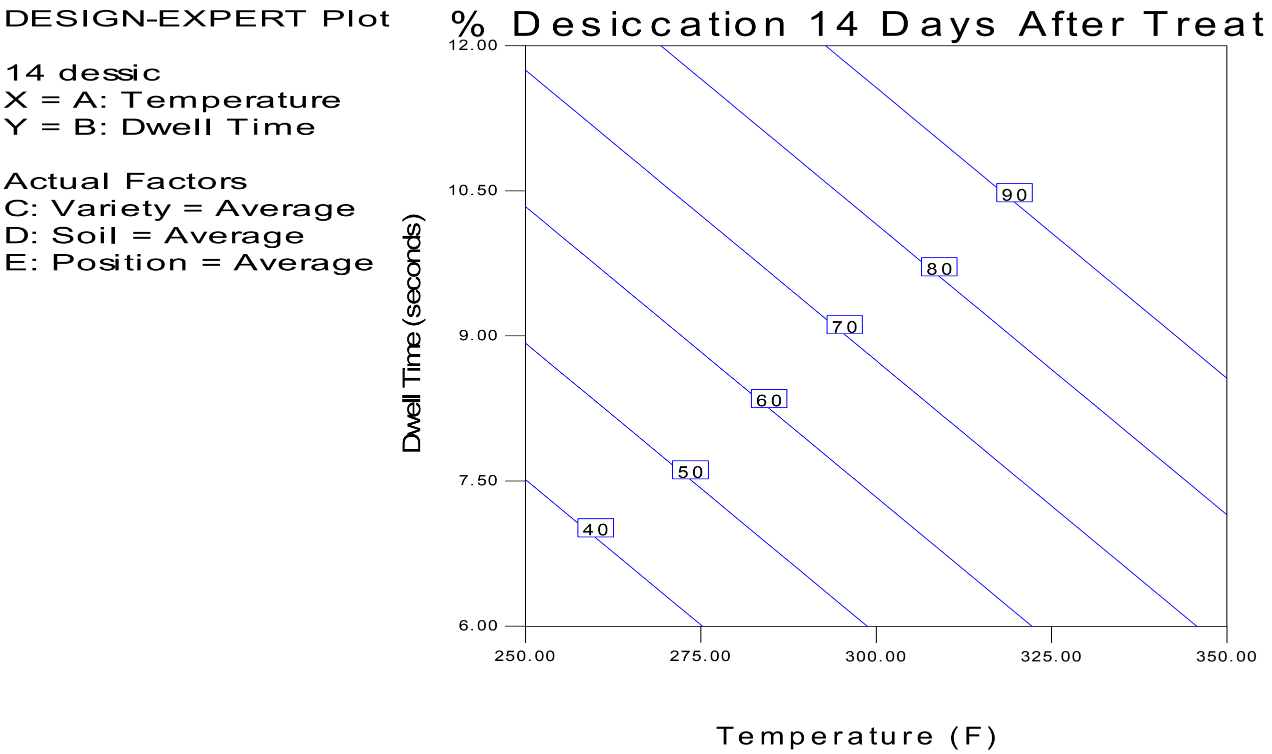

Figure 2. Percent desiccation (diagonals) 14 days after treatment as a function of temperature and dwell time.

Figure 3. Desiccation two days after thermal treatment.