Cotton Thermal Defoliation Economics

By Paul Funk, Carlos Armijo, Gerald Hawkes, and James D. Libbin

Abstract

Cotton harvest-aid chemical and application expenses are justified by increased quantity and value of harvested fiber and decreased harvest costs. Chemical use may be restricted in certain production situations. Harvest preparation costs and producer returns were compared for thermal defoliation in organic and chemical harvest aids in conventional Pima cotton using a crop cost and return estimator. A positive return to land and risk can be reached for organic Pima with yields greater than 600 pounds per acre and prices over $2.43 per pound. Thermal defoliation allows early harvest without the chemicals deemed necessary to produce a high-quality conventional crop.

Introduction

Mechanized cotton harvest is not practical in much of the U.S. without defoliation. Defoliation typically is accomplished with a mixture of several chemicals collectively called harvest aids. The primary ingredients in harvest aids cause leaves to desiccate and fall from the plant. Additional ingredients may be added to cause mature bolls to open, kill insects or weeds, and prevent leaf re-growth. Defoliation is cost effective for three reasons. Defoliation results in more open bolls and better harvest machine access to the lint in them so that more of the crop yield potential is recovered. Defoliation also results in cleaner fiber because it reduces leaf particle foreign matter content and because chlorophyll staining and weather related damage may be avoided. Higher classing office leaf and color grades (which contribute to higher lint value) are associated with cleaner fiber.

Since defoliation helps synchronize crop termination, once-over harvest is possible, minimizing harvest costs. And because defoliation makes it possible to harvest earlier in the season, extending both the number of days and the day length, it improves harvest machinery utilization, also lowering production costs. In addition, more rapid plant drying after dew or rain may allow for more hours in the field and better utilization of harvest machinery. Thus, harvest-aid chemical and application expenses are justified by increased quantity and value of harvested fiber, and decreased harvest costs.

Paul A. Funk is a Research Agricultural Engineer and Carlos B. Armijo is a Textile Technologist, both for the USDA – Agricultural Research Service, Southwestern Cotton Ginning Research Laboratory. Gerald M. Hawkes is an Associate Professor for Agricultural Economics and Ag Business and James D. Libbin is an Associate Dean and Director of Academic Programs for the College of Agricultural, Consumer, and Environmental Sciences, both at New Mexico State University.

Harvest aids are applied with spray rigs (ground) or crop dusters (air). Typically, the crop is ready for harvest ten to fourteen days after treatment. If weather or plant conditions are particularly unfavorable, a second application may be required. Occasionally, harvest aids are applied at the wrong time and yields are reduced. None of these factors are easy to measure, but all have negative yield and profit implications for conventionally produced cotton.

Recommendations for chemical combination, amount, and timing vary with locale, as well as field and plant conditions and current and predicted weather (Albers, Fishel & Mobley, 1994; Ball & Glover, 1999; Boman et al., 2008; Burmester, Monks & Patterson, 2009; Faircloth, Saunders & Wilson, 2009; Gwathmey & Craig, 2007; Hutmacher, et al., 2003; Jost, Brown & Culperrer, 2006; Luper et al., 2005; MSUcares, 2010; Silvertooth, 2001; Stewart & Miller, 2007; and Wright & Brecke, 2009).

Chemical defoliants are restricted in organic production, near dwellings or sensitive crops such as citrus, and during high winds. However, complete leaf desiccation and partial removal can be accomplished by briefly exposing the crop to heat. Thermal defoliation has been tested and determined effective on all species and varieties of cotton across the full range of climate zones and production practices in the U.S. It has been shown to adequately prepare the crop for harvest without reducing lint value or yield (Funk et al., 2006). Further benefits of thermal defoliation include late season insect pest control. Both aphid and whitefly populations were found to collapse after thermal treatment (Bundy, Funk & Steiner, 2006). With thermal defoliation, growers have the potential to harvest as soon as 24 hours after treatment (Showler, Funk & Armijo, 2006). Harvest timeliness can improve cotton returns (Segarra, Keeling & Abernathy, 1990).

The largest thermal defoliator presently in commercial use can treat less than two acres per hour, much less than current spray rigs (under ideal conditions, the largest self-propelled sprayers can treat up to 1,000 acres in one day). Aerial application likewise can treat vast areas in a short time, resulting in comparatively low application costs, ranging from $4.50 to $8.50 per acre, not including chemicals.

The objective of this paper is to compare harvest preparation costs and returns using thermal and conventional means, and to provide producers considering thermal defoliation a framework to analyze the economics of that management decision. Organic Pima cotton was treated with a commercial thermal defoliator in 2008, 2009, and 2011. While organic Pima production is the focus of this paper, thermal defoliation may be applied to other crops.

Materials and Methods

Apparatus

Research with experimental and prototype thermal defoliators (Funk et al., 2006) led to the specifications for the six-row commercial thermal defoliator which was used for data collection. Figure 1 shows the defoliator, identifying major components. This commercial defoliator was designed and built by Ag-Industrial Mfg., Inc. (Lodi, CA) for $365,000. The thermal defoliator treated six rows (15 feet) with each field pass, and it covered 225 square feet. It had four-wheel hydrostatic drive and independent rear steering. The wheels were on legs that hydraulically extended, adjusting the entire machine to achieve the proper treatment height and lifting it further to provide for increased ground clearance when maneuvering. A single 330 HP diesel engine connected to hydraulic pumps powered three fan/burner units and provided locomotion. Each burner was supplied with liquid propane fuel, vaporized in heating coils proximate to its flame. About two-thirds of the hot air forced through the cotton canopy was recirculated through the fan/burner units to conserve thermal energy. Figure 2 shows the commercial defoliator treating cotton. Ground speed averaged 1.3 mph in 2008 and 1.5 mph in 2009. Hot air was blown through plants for just under eight and just under seven seconds, respectively. Treatment air temperature ranged from 273 to 296° F, safely below the scorching point of cotton lint (and well below the combustion point of dry plant materials), but still hot enough to kill leaves and insects. Leaves changed to a light olive green color in a few hours (Figure 2) and became dry overnight, so that it was possible to harvest the following day. The crop response time presents an advantage to using the thermal defoliator over chemical applications, which can take up to two weeks to desiccate the cotton plant enough to harvest.

Instrumentation

The commercial thermal defoliator was equipped with the following instrumentation to record operating parameters:

- A data logger (dataTaker DT800; Computer Aided Solutions, Chesterland, OH)
- Temperature sensors (Type K thermocouples, Omega Engineering, Stamford, CT)

- Pressure sensors (Model 267 Differential Pressure Transducer, Setra, Boxborough, MA)
- A radar ground speed sensor (063-0171-939, Raven Industries, Sioux Falls, SD)
- GPS (Invicta 115, Raven Industries, Sioux Falls, SD)
- An ultrasonic crop height sensor (ToughSonic TS-21S, Senix Corp., Bristol, VT)
- A liquid propane fuel flow meter (IT400, Sponsler, Inc., Westminster, SC)

The electronics were placed in a weather tight enclosure near the operator's seat. The GPS antenna and propane fuel meter were mounted nearby.

Field Treatment

Data for this analysis came from operating the commercial thermal defoliator in the San Joaquin Valley of California. Organic Pima cotton was grown on 80 acres in 2008, 54 acres in 2009, and 165.5 acres in 2011 (Table 1). Conditions varied considerably during data collection. Treatment usually began once all dew had evaporated, early to mid-morning, continuing for one shift (ten hours). A second driver would operate the defoliator at night if harvest was being rushed to avoid fall rains. Ambient temperature (measured at the driver's location, influenced by the thermal plume emanating from the treatment tunnels) ranged from below 65° F at night to over 120° F in the afternoon, and averaged 83 to 87° F during the days of operation.

Field Measurements

GPS data collected in the field in 2008 was used to estimate defoliator speed and field efficiency, which was used to calculate treatment rate (unit area per unit time). With independent rear steering, getting the back of the machine on the same six rows as the front was difficult, especially in the dark. Consequently, the first few runs made by a driver unfamiliar with the defoliator, classified as training runs, were not included in the average. Once the operator became familiar with the commercial defoliator, turning and treatment times became more consistent. On subsequent days, the number of training runs tended to be fewer. Other data were omitted when the engine protection system switch (Frank W. Murphy Mfg., Tulsa, OK) shut down the engine, usually when it detected either a burner or engine overheat event. Because it took several minutes for the systems to cool down, reset, restart, and again reach operating conditions, rows where this occurred were also omitted from the analysis. Data from normal field runs were averaged over three days to obtain an estimate of defoliator speed accounting for both on-row treatment and end-of-row maneuvering. On-row treatment as a percentage of total time, or field efficiency, was 88 percent in 2008. For 2009 and 2011, farm records (labor hours, fuel purchased) were divided by the area treated to arrive at cost and consumption figures. Field efficiency was not available for these seasons. The overall accomplishment rate was 0.52, 0.54, and 0.65 hours per acre in 2008, 2009, and 2011 respectively. The 2011 organic Pima crop grew on several small fields. Apparently this required more end-of-row maneuvering, explaining the slower accomplishment rate. The commercial defoliator required only one operator. The wage burden for equipment operators in the San Joaquin Valley was $9.50 per hour, resulting in a labor cost of $4.95, $5.14, and $6.13 per acre in 2008, 2009 and 2011 (Table 1).

The defoliator used two fuels: propane to heat plant treatment air and diesel for fan power and locomotion. Propane consumption values published previously from multi-state thermal defoliation trials are presented in Table 2. This illustrates the variability of fuel use and its dependence on season, location, variety, cultural practices, and plant architecture. Some values are based on field trials in several states with a two-row prototype thermal defoliator similar in design to the commercial unit. Propane consumption ranged from 17 to 34 gallons per acre (Funk et al., 2005). These values were similar to propane consumption reported nearly four decades earlier, 14 to 17 gallons per acre, for a defoliator using a different design (Kent & Porterfield, 1967; Batchelder et al., 1971). Propane consumption recorded during field trials with the commercial defoliator (20 to 30 gallons per acre) are in the higher range because irrigated Pima plants tend to be taller and fuller than upland cultivars grown on dry land. More plant material requires more heating fuel. Propane consumption was 30, 19, and 22 gallons per acre for the reported seasons. This resulted in per acre propane costs that were $48.30, $30.27, and $59.21 per acre in 2008, 2009, and 2011.

Diesel fuel consumption was estimated to be approximately five gallons per hour or three gallons per acre based on daily refueling records for the commercial thermal defoliator. There was a big spread in off-road diesel prices, from $2.23 in 2009 to $3.33 in 2011. In 2008, 2009, and 2011 consumption was 3.1, 2.7, and 3.2 gallons per acre. Diesel costs were $9.55, $6.03, and $10.74 per acre, red dyed (no highway tax), bulk delivered.

Organic Model Inputs

The variable cost of treatment was more sensitive to the price of propane than to any other parameter. Fixed costs were most sensitive to the initial cost of the machine. Other key model inputs included interest rates, diesel prices, and labor rates. These values fluctuated with time and location. They can be adjusted to reflect current local values. The values used in the presented analysis, based on an average of the 2009 and 2011 defoliation seasons, are:

- Machinery interest rate: 7%
- Propane (bulk, delivered): $2.19/gallon
- Diesel (red, bulk, delivered): $2.83/gallon

Farm labor was lowered to the New Mexico level: $7.50/hour. The capital cost of the defoliator was raised to $450,000 to reflect current machinery costs, which have risen with the price of steel and other inputs. It was assumed that 100 acres of Pima would be produced each year, and the defoliator would be used for 15 years, leading to an hourly fixed cost (including depreciation, taxes, insurance, and interest) of $566 and an annual per acre fixed cost of $323. The only repair history available was for the 2011 season, so its value ($23.88 per acre) was used in the analysis.

Conventional Model Inputs

Table 3 lists harvest aid chemical combinations recommended for various regions and conditions. Additionally, the total cost for each harvest aid tank mix at the recommended application rate is provided, based on 2010 prices, by way of updating and expanding on earlier work (GAPAC; Boman). Chemical cost per acre ranged from $4.88 to $51.77, with an average of $19.38 and a standard deviation of $10.41. Custom application costs vary considerably as well, ranging from $4.50 to $8.50 per acre by air and potentially costing even more by ground rig, depending on many factors. Total chemical defoliation cost is typically $30 to $60 per acre. In the presented analysis, the cost of defoliation was assumed to be $38.00 per acre, based on conversations with conventional Pima producers in New Mexico.

Results and Discussion

The New Mexico State University (NMSU) crop cost and return estimator (Hawkes & Libbin, 2007; 2010) was used to assist with the economic analysis. Simulation results for producing conventional Pima cotton in southern New Mexico are shown in Table 4. The NMSU crop cost and return estimator is a whole-farm budget generator. It allocates all costs and all returns for the whole farm to the commodities produced based on actual (or projected) use of purchased and non-purchased inputs, labor and management resources, and machinery and land inventories. Our initial assumption was that Pima cotton would be produced on 100 acres of a 750-acre farm. As a basis for comparison, we found the break-even price for conventionally produced Pima cotton with a yield of 750 pounds per acre was $1.23 per pound.

Table 5 presents similar results for organically produced Pima cotton (with the same base farm size situation and acreage/yield/price assumptions for the other crops: alfalfa, sorghum, wheat, lettuce, onions, and chile). With yields of 685 pounds per acre the break-even price was $1.83 per pound for organic production, including thermal defoliation. Organically produced cotton secures a higher price, usually accompanied by a lower yield. The June 2010 Annual Organic Cotton Market Summary (USDA-AMS) indicated that organic cotton carried a 49 percent price premium over conventional cotton (multiplying $1.23 by 149% results in $1.83). Organic production's different cost structure accounts for a significant portion of the difference between the return to land and risk figures for the conventional and organic scenarios.

Return to land and risk measures profitability of the enterprise after all costs (cash and non-cash, purchased and non-purchased, fixed and variable) are accounted for and subtracted from comprehensive gross income, with the exceptions of any allocation for land purchase, rental, or investment return and with the exception of a return for the entrepreneur's aggregate risk. Some of the cost structure differences can be attributed to crop protection chemicals and fertilizer, and lower yields in organic production, but the largest cost difference is due to the use of a thermal defoliator in organic Pima cotton production.

Because the thermal defoliator is used only on cotton (as is the cotton picker), all of its fixed costs (depreciation, interest, repairs, property taxes, and insurance) are allocated to cotton. Other machinery is allocated across crops in proportion to hours used. This approach makes the number of acres produced a particularly sensitive variable. The per-acre fixed costs are approximately twice the amount if used on 50 acres as compared to 100 acres *unless* the life of the machine is measured in total hours rather than total years. We defined expected useful life of the cotton defoliator in years rather than hours. Our assumption is that future developments will make this model technologically obsolete well before it wears out. This assumption will likely not be true for subsequent generations of thermal defoliators. The definition of expected useful life in years encourages the machine's owners to find custom work for their investment on other farmers' fields. Fixed costs are then spread over the acres defoliated rather than the acres owned.

At projected 2011 seasonal average prices (we assumed the current market price of $1.23 per pound) and a yield of 750 pounds per acre (typical for New Mexico but likely low for Arizona and California), conventionally-produced Pima cotton achieves break even. A slight increase in price per pound or per acre yield makes conventional Pima cotton an attractive long-run component of a crop rotation. At a yield of 685 pounds per acre and $1.83 per pound (the 49% premium commanded by organic Pima), return to land and risk was break even for the crop produced using thermal defoliation as well.

Yields can vary quite a bit, and prices, too. Table 6 presents a sensitivity analysis of break-even prices for conventional and organic Pima cotton production using the thermal defoliator. For this analysis, break even is defined as the price necessary to just reach a positive return to land and risk. Table 6 shows break-even prices for several levels of acreage produced (defoliated) and for various conventional and organic Pima yields. Yields of 700 pounds per acre have been achieved in New Mexico under organic production. Yields of 850 have been achieved for conventional Pima. Price is determined by fiber quality as well as market forces. As of December, 2011 conventional Pima of "typical" quality was trading over $1.50 per pound.

The high price of a dedicated piece of equipment makes organic production costs and returns more sensitive to harvested area. However, with the price premium awarded for organic fiber, it would be possible realize a positive return using thermal defoliation. The key uncertainty is finding a buyer in what has been described as a limited niche market.

Conclusion

Cotton harvest-aid chemical costs and application expenses are justified by increased quantity and value of harvested fiber, and decreased harvest costs. Chemical use is restricted in certain production situations, and may be taxed or further curtailed in the future. Thermal defoliation is an effective alternative to conventional chemical harvest preparation, but it may cost twice as much per acre. Thermal defoliation (organic) and chemical harvest aids (conventional) Pima cotton were compared using a crop cost and return estimator. A positive return to land and risk can be obtained for organic Pima if yields are greater than 685 pounds per acre and prices are over $1.83 per pound; with conventional production, where yields may be above 750 pounds per acre, a positive return can be realized with prices above $1.23 per pound. Thermal defoliation allows early harvest without the chemicals deemed necessary to produce a high-quality conventional crop, but a price premium is necessary to make it viable. For Organic Pima, the price premium can be 50 percent or more, but the market is limited. Timely harvest by thermal defoliation resulted in higher yields, less weather damage, improved classing office grades, and a better price – about $3.00 per pound in 2011 – than the grower would have realized otherwise.

Disclaimer

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Table 1. Commercial defoliation data from three seasons in California

Commercial Thermal Defoliator Data	UNITS	Treatment Season 2008	2009	2011
Treated Area	acres	80	54	165.5
Treatment Rate	acres/hour	1.92	1.85	1.55
Fuel Use - Propane	gal/acre	30.2	18.9	22.0
Fuel Use - Diesel	gal/acre	3.1	2.7	3.2
Propane Capacity (499 gallon tank)	acres	16.5	26.4	22.7
	hours	8.6	14.3	14.6
Labor Cost (1 driver)	$/acre	$4.95	$5.14	$6.13
Fuel Cost (Propane)	$/acre	$48.30	$30.27	$59.21
Fuel Cost (Diesel)	$/acre	$9.55	$6.03	$10.74
Repair Cost	$/acre			$23.88
Variable Cost of Treatment	$/acre	$62.80	$41.43	$99.96
Operators		1		
Treatment Width (6 rows)		15 Feet		
Prime Mover		330 HP Diesel Engine		
Estimated cost to build today		$450,000		

Table 2. Various levels of propane consumption reported for thermal defoliation

Citation	State (City)	Cultivar	Cropping System	Propane Use gal/ac
Kent & Porterfield, 1967	OK (Tipton)	Paymaster 202	Irrigated	17
Batchelder et al., 1971	Miss, Okla, Tex	various	various	14
Funk et al., 2004a	NM (Mesilla)	Delta Pine 565	Irrigated	8
		Acala 1517-99	Irrigated	8
Funk et al., 2004b	CA (Shafter)		Irrigated	13
Funk et al., 2005	TX (Weslaco)	DP-5415-RR		17
	TX (Lubbock)	FM 989BR	Stripper (FC)	19
	CA (5 Points)	C-104	Irrigated	25
	CA (Shafter)	C-104	Irrigated	21
	NM (La Union)	Acala 1517-77	Organic	34
		Pima S-6	Organic	34
	NM (Mesilla)	Acala 1517-99	Irrigated	22
	NM (Mesilla)	DP 565	Irrigated	22

Table 3. Representative harvest aide combinations and costs

State	Crop/Climate	Tank Mix	Cost ($/acre)
CA	Pima	Prep (2 pt), Dropp (0.3 lb), Ginstar (10 oz), Harvade (8 oz) and Folex (2 pt)	$ 51.77
CA	Pima	CottonQuik (3.5 qt) & Ginstar (13 oz)	$ 45.71
CA	Acala	Folex (2 pt), Prep (2 pt), Defol 5 (1 gal) & Starfire (21 oz)	$ 37.21
AZ	Pima	Dropp (0.3 lb) + Def (2 pt)	$ 32.08
		Dropp (0.2 lb) + Def (1 pt) + Prep (1 pt)	$ 25.68
TX[1]	Dry	Gramoxone (16 oz) 2x	$ 4.88
	over 80°	Ginstar (8 oz)	$ 12.51
14"	Dry	Aim (1 oz) + COC	$ 5.79
	under 80°	ET (4 oz) + COC	$ 9.80
1 b	Wet	Gramoxone (32 oz) 2x	$ 9.77
	under 75°	Ginstar (10 oz)	$ 15.63
TX[1]	Dry	Gramoxone (16 oz) 2x	$ 4.88
	over 80°	Prep (21 oz) + AIM (1 oz) + ET (1.5 oz)	$ 17.83
20"	Dry	Ginstar (8 oz)	$ 12.51
	under 80°	Aim (2 oz) + COC 2x	$ 11.58
1.5 b	Wet	Prep (21 oz) + Ginstar (5 oz)	$ 16.18
	under 75°	Finish 6 Pro (32 oz) + Folex (1 pt)	$ 23.85
TX[1]	Dry	Prep (21 oz) + Def (16 oz)	$ 14.62
	over 80°	Finish (21 oz) + Ginstar (5 oz)	$ 19.36
26"	Dry	Prep (24 oz) + AIM (1 oz) + ET (1.5 oz)	$ 19.03
	under 80°	Finish (32 oz) + AIM (1 oz) + ET (1.5 oz)	$ 27.06
2 b	Wet	Ginstar (10 oz)	$ 15.63
	under 75°	Finish (42 oz) + AIM (1 oz) + ET (1.5 oz)	$ 32.56
LA	high temp	Leafless (10 oz) + Ethephon (21 oz)	$ 19.48
	once/twice	Aim (2 oz) + CottonQuik (2 qt) 2x	$ 26.08
LA	low temp	Def (1.5 pt) + Finish (1.5 pt)	$ 22.57
	once/twice	CottonQuik (3 qt) + Aim (1 oz)	$ 27.55
AL	T 70 - 90	Def (1 pt) + Dropp (2 oz)	$ 7.27
	Dry	Ginstar (6.5 oz)	$ 10.16
AL	T 70 - 90	Dropp (3 oz) + Eth (1.33 pt)	$ 9.30
	Normal	Finish (1.33 pt) + Ginstar (3 oz)	$ 16.39
AL	T 60 - 80	Finish (1.33 pt) + Def (8 oz)	$ 14.83
	Normal	Def (1.5 pt) + Eth (1.33 pt)	$ 17.14
AL	T 50 - 70	Def (3 pt)	$ 18.75
	Late	Finish (2 pt) + Ginstar (4 oz)	$ 23.85
GA	Early	FreeFall (0.2 lb)	$ 12.61
	70 - 90	Finish (1.33 pt) + Leafless (10 oz)	$ 23.52
GA	Mid	Def (1.5 pt)	$ 9.38
	60 - 89	Finish (1.5 pt) + Dropp (0.1 lb)	$ 19.72
GA	Late	Finish (1.5 pt) + Aim (1 oz)	$ 18.98
	50s - 70s	Ethephon (2.67 pt) + Ginstar (10 oz)	$ 31.23

Table 4. Conventionally-produced Pima cotton projected costs and returns

ITEM	PRICE		YIELD		BASE					TOTAL
GROSS RETURNS										
LINT	$1.23		750	LBS						$922.50
SEED	$0.07		1,200	LBS						$84.00
TOTAL										$1,006.50
PURCHASED INPUTS	PRICE		QUANTITY		PURCHASED INPUTS				FIXED COST	TOTAL
SEED	$1.22		25	LBS	$30.50					$30.50
NITROGEN (N)	$0.71		120	LBS	$85.20					$85.20
PHOSPHATE (P2O5)	$0.65		50	LBS	$32.50					$32.50
HERBICIDE	$33.37		1	X/ACRE	$33.37					$33.37
INSECTICIDE	$64.72		1	X/ACRE	$64.72					$64.72
CROP INSURANCE	$0.34				$0.34					$0.34
PUMP WATER*			0	AC. IN.						
CANAL WATER			33	AC. IN.	$87.00					$87.00
SUBTOTAL					$333.62					$333.62
PREHARVEST OPERATIONS	POWER UNIT		ACCOMPLISHMENT RATE		PURCHASED INPUTS	LABOR	FUEL & LUBE	REPAIRS	FIXED COST	TOTAL
DISC	140 HP		0.14	HR		$1.05	$4.10	$1.33	$1.65	$8.13
CHISEL	140 HP		0.20	HR		$1.50	$5.86	$1.57	$2.16	$11.09
PLOW	140 HP		0.38	HR		$2.85	$11.14	$4.60	$4.62	$23.21
DISC	140 HP		0.14	HR		$1.05	$4.10	$1.33	$1.65	$8.13
DISC & SPRAY	140 HP		0.17	HR		$1.28	$4.98	$1.80	$2.45	$10.51
FERTILIZE	140 HP		0.05	HR		$0.38	$1.19	$0.22	$0.33	$2.11
LISTER	140 HP		0.18	HR		$1.35	$5.28	$1.40	$2.01	$10.03
PRE-IRRIGATE			0.75	HR		$5.44	$0.00	$0.00	$0.00	$5.44
HARROW	40 HP		0.32	HR		$2.40	$3.65	$0.35	$0.23	$6.62
ROLLING CULT	40 HP		0.21	HR		$1.58	$2.40	$0.75	$0.43	$5.14
PLANTER	140 HP		0.26	HR		$1.95	$6.20	$1.56	$5.01	$14.71
HARROW	40 HP		0.32	HR		$2.40	$3.65	$0.35	$0.23	$6.62
ROLLING CULT (3X)	140 HP		0.63	HR		$4.73	$15.02	$4.30	$5.04	$29.08
ROTO BUCK (2X)	40 HP		0.03	HR		$0.23	$0.34	$0.03	$0.15	$0.75
ROPEWICK	40 HP		0.10	HR		$0.75	$1.14	$1.01	$56.69	$59.58
IRRIGATE (4X)			2.00	HR		$14.50	$0.00	$0.00	$0.00	$14.50
SUBTOTAL			5.88	HR		$43.41	$69.05	$20.59	$82.62	$215.68
HARVEST OPERATIONS										
CHEMICAL DEFOLIATION	CUSTOM				$38.00					$38.00
COTTON PICKER (2X)	2-ROW		1.24	HR		$9.30	$21.22	$8.87	$30.83	$70.22
COTTON TRAILER (2X)	HALF TON		1.00	HR		$7.50	$0.00	$0.73	$10.49	$18.72
GIN COTTON (CUSTOM)					$69.08					$69.08
SUBTOTAL			2.24	HR	$107.08	$16.80	$21.22	$9.60	$41.32	$196.02
POSTHARVEST OPERATIONS										
SHREDDER	40 HP		0.29	HR		$2.18	$3.31	$0.37	$0.55	$6.40
OVERHEAD EXPENSES										
DOWNTIME			1.42	HR		$10.61				$10.61
EMPLOYEE BENEFITS						$11.23				$11.23
INSURANCE					$1.25					$1.25
LAND TAXES									$9.11	$9.11
SUPERVISION AND MANAGEMENT						$76.04				$76.04
OTHER EXPENSES					$81.61					$81.61
SUBTOTAL			1.42	HR	$82.86	$97.88			$9.11	$189.84
TOTAL OPERATING EXPENSES			9.83	HR	$523.55	$160.26	$93.59	$30.55	$133.60	$941.56
NET OPERATING PROFIT										$64.94
INTEREST ON OPERATING CAPITAL			$201.63	@	7.00%	)				$14.11
INTEREST ON EQUIPMENT INVESTMENT										$50.10
RETURN TO LAND AND RISK										$0.72
BUDGET SUMMARY - CONVENTIONAL										
GROSS RETURN			$1,006.50							
VARIABLE OPERATING EXPENSES		$647.70								
RETURN OVER VARIABLE EXPENSES			$358.80	(GROSS MARGIN)						
FIXED EXPENSES		$133.60								
NET FARM INCOME			$225.20	(RETURN TO CAPITAL, LABOR, LAND & RISK)						
LABOR AND MANAGEMENT COST		$160.26								
NET OPERATING PROFIT			$64.94	(RETURN TO CAPITAL, LAND & RISK)						
CAPITAL COSTS		$64.22								
RETURN TO LAND AND RISK			$0.72							

*Pump water costs are shown under irrigation in the preharvest operation section.

Table 5. Organic (thermally defoliated) Pima cotton projected costs and returns

ITEM		PRICE		YIELD							TOTAL
GROSS RETURNS											
LINT		$1.83		685.00	LBS						$1,253.55
SEED		$0.07		1,096.00	LBS						$76.72
	TOTAL										$1,330.27
PURCHASED INPUTS		PRICE		QUANTITY		PURCHASED INPUTS				FIXED COST	TOTAL
SEED		$1.22		25	LBS	$30.50					$30.50
MANURE (including spreading)		$4.00		15	TON	$60.00					$60.00
CROP INSURANCE		$2.94				$2.94					$2.94
PUMP WATER*				0	AC. IN.						
CANAL WATER				33	AC. IN.	$87.00					$87.00
	SUBTOTAL					$180.44					$180.44
PREHARVEST OPERATIONS		POWER UNIT		ACCOMPLISHMENT RATE		PURCHASED INPUTS	LABOR	FUEL & LUBE	REPAIRS	FIXED COST	TOTAL
DISC		140 HP		0.14	HR		$1.05	$4.10	$1.33	$1.65	$8.13
CHISEL		140 HP		0.20	HR		$1.50	$5.86	$1.57	$2.16	$11.09
PLOW		140 HP		0.38	HR		$2.85	$11.14	$4.60	$4.62	$23.21
DISC		140 HP		0.14	HR		$1.05	$4.10	$1.33	$1.65	$8.13
DISC		140 HP		0.10	HR		$0.75	$2.93	$1.06	$1.44	$6.18
LISTER		140 HP		0.18	HR		$1.35	$5.28	$1.40	$2.01	$10.03
PRE-IRRIGATE				0.75	HR		$5.44	$0.00	$0.00	$0.00	$5.44
HARROW		40 HP		0.32	HR		$2.40	$3.65	$0.35	$0.23	$6.62
ROLLING CULT		40 HP		0.21	HR		$1.58	$2.40	$0.75	$0.43	$5.14
PLANTER		140 HP		0.26	HR		$1.95	$6.20	$1.56	$5.01	$14.71
HARROW		40 HP		0.32	HR		$2.40	$3.65	$0.35	$0.23	$6.62
ROLLING CULT (3X)		140 HP		0.63	HR		$4.73	$15.02	$4.30	$5.04	$29.08
ROTO BUCK (2X)		40 HP		0.03	HR		$0.23	$0.34	$0.03	$0.15	$0.75
IRRIGATE (4X)				2.00	HR		$14.50	$0.00	$0.00	$0.00	$14.50
	SUBTOTAL			5.66	HR		$41.76	$64.67	$18.62	$24.60	$149.66
HARVEST OPERATIONS											
THERMAL DEFOLIATOR		330 HP		0.57	HR		$4.24	$53.13	$23.88	$320.28	$401.52
COTTON PICKER (2X)		2-ROW		1.24	HR		$9.30	$21.22	$8.87	$30.83	$70.22
COTTON TRAILER (2X)		HALF TON		1.00	HR		$7.50	$0.00	$0.73	$10.49	$18.72
GIN COTTON (CUSTOM)						$76.58					$76.58
	SUBTOTAL			2.81	HR	$76.58	$21.04	$74.35	$33.47	$361.60	$567.04
POSTHARVEST OPERATIONS											
SHREDDER		40 HP		0.29	HR		$2.18	$3.31	$0.37	$0.55	$6.40
OVERHEAD EXPENSES											
DOWNTIME				3.56	HR		$26.68				$26.68
EMPLOYEE BENEFITS							$7.52				$7.52
INSURANCE						$1.30					$1.30
LAND TAXES										$9.11	$9.11
SUPERVISION AND MANAGEMENT							$102.98				$102.98
OTHER EXPENSES						$81.61					$81.61
	SUBTOTAL			3.56	HR	$82.91	$137.18			$9.11	$229.20
TOTAL OPERATING EXPENSES				12.31	HR	$339.93	$202.16	$142.33	$52.47	$395.86	$1,132.74
NET OPERATING PROFIT											$197.53
INTEREST ON OPERATING CAPITAL			(	$192.56	@	7.00%	)				$13.48
INTEREST ON EQUIPMENT INVESTMENT											$179.85
RETURN TO LAND AND RISK											$4.21

BUDGET SUMMARY - ORGANIC

GROSS RETURN		$1,330.27	
VARIABLE OPERATING EXPENSES	$534.73		
RETURN OVER VARIABLE EXPENSES		$795.54	(GROSS MARGIN)
FIXED EXPENSES	$395.86		
NET FARM INCOME		$399.69	(RETURN TO CAPITAL, LABOR, LAND & RISK)
LABOR AND MANAGEMENT COST	$202.16		
NET OPERATING PROFIT		$197.53	(RETURN TO CAPITAL, LAND & RISK)
CAPITAL COSTS	$193.32		
RETURN TO LAND AND RISK		$4.21	

*Pump water costs are shown under irrigation in the preharvest operation section.

Table 6. Breakeven prices for conventional and thermally defoliated organic Pima

Conventional Pima						
		Yield (pounds per acre)				
Harvested Area (acres)	Fixed Costs	500	600	700	800	900
50	$193	$2.04	$1.69	$1.46	$1.27	$1.13
100	$134	$1.85	$1.54	$1.32	$1.16	$1.03
150	$112	$1.79	$1.49	$1.27	$1.11	$0.99
200	$111	$1.77	$1.48	$1.26	$1.11	$0.98
Organic Pima						
		Yield (pounds per acre)				
Harvested Area (acres)	Fixed Costs	500	600	700	800	900
50	$718	$3.53	$2.95	$2.53	$2.21	$1.97
100	$396	$2.50	$2.08	$1.79	$1.57	$1.39
150	$286	$2.15	$1.79	$1.54	$1.35	$1.20
200	$241	$1.99	$1.66	$1.43	$1.25	$1.11

Figure 1. Commercial defoliator with major components identified. Only one person is required to operate the machine. (The second person in this photo is receiving training.)

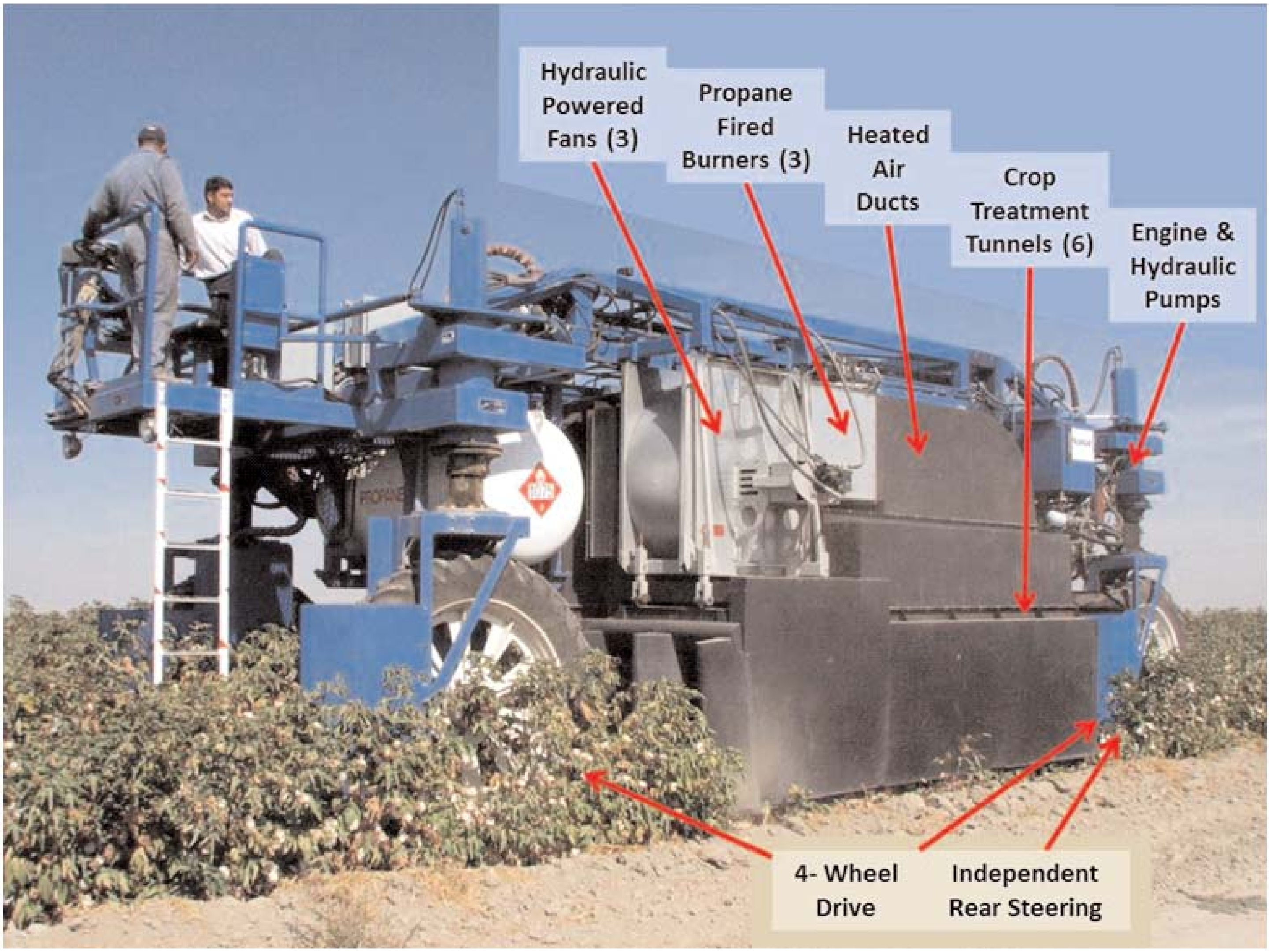

Figure 2. Commercial thermal defoliator treating organic cotton. Leaves in the foreground were treated earlier this day and were already discolored and desiccating.