increased costs during a longer ginning season under the TOD schedule, since less gas use will occur each month in the low-cost, high-use blocks. Labor costs, however, will fall because a shorter work week will reduce overtime costs. Our analysis includes the effect of these additional price changes as well as the more obvious changes in electricity costs.

We computed the percentage change in profit for each hypothetical operating schedule, using the baseline schedule with a mid-October start-up as the base value in the percentage change calculations. We calculated the profit effects of the six alternatives for each gin using its estimated length of ginning season for the 1980-81 to 1984-85 crop years (table 1). For the PG&E-supplied gins, mid-September start-up raises energy costs 3.8% on average compared with mid-October start-up, because a greater volume of cotton is ginned under expensive summer peak rates. The loss in profit is about 25¢ per bale.

A November 1 start-up on the baseline schedule reduces energy costs 4.4% on average, relative to mid-October start-up, because all ginning takes place under winter rates. The profit gain is 30¢ per bale.

More substantial savings are achieved under the TOD schedules. Labor cost reductions average 12.9% because of less overtime. Energy savings average from 13.1% to 15.4%, depending on the start-up date. The start-up date is not as important under this schedule, because usage is always in the off-peak period. The profit gains in the TOD schedules range from $2.44 to $2.60 per bale.

A November 1 start-up date for SCE gins produces insignificant savings relative to mid-October start-up under the baseline schedule, because winter rates are in effect in either case. Otherwise, the cost penalty for September start-up and the savings from the TOD schedules for the SCE gins are comparable to those for their PG&E counterparts.

Conclusion

This study of California's cotton ginning industry showed potential economies of size, with each 1% increase in throughput raising gross profits by about 1.1%. These economies suggest possible benefits to expanding or merging gins, which must be weighed in each instance against possibly higher field-to-gin transport costs.

Profit gains ranging up to $2.60 per bale were shown to be attainable for gins that modify operations to conform to utilities' time-of-day pricing schedules. These savings amount to about $8 million, based on the 1987-88 crop, or about $2,600 on average for each of the state's 3,000 cotton growers. These savings, too, must be weighed against possible costs associated with the longer ginning seasons implied by the TOD schedules. The TOD schedules are most realistic for gins that receive cotton in modules allowing for relatively costless on-field storage.

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Weed control in crucifer crops with nitrogen fertilizers

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Only one or two herbicides are available for selective weed control in crucifer crops (broccoli, cabbage, cauliflower, brussels sprouts). With the cancellation of nitrofen, a postemergence herbicide, growers have resorted to hand-weeding of several herbicide-resistant weeds, such as little mallow (*Malva parviflora*), shepherds-purse (*Capsella bursa-pastoris*), and hairy nightshade (*Solanum sarrachoides*).

Hand-weeding costs ($150 to $200 per acre) and the unlikelihood of new herbicides being registered have stimulated research on alternative methods. One possible alternative is the use of liquid nitrogen fertilizers for weed control. These fertilizers have contact-weed-control properties, and crucifers have a protective waxy surface (cuticle) that allows for selectivity.

Experiments were conducted during 1982-87 on broccoli and cauliflower in central California's Salinas Valley to evaluate the effectiveness of liquid fertilizers in killing weeds. The investigation included weed susceptibility, crop tolerance, application technique, volume of application, and the influence of previous pesticide treatments.

Earlier experiments were conducted with shielded-type sprayers to prevent the liquid fertilizers from contacting crop leaves. In later experiments, directed applications with low-pressure nozzles (8002LP) at 15 pounds per square inch (psi) afforded minimal leaf exposure and allowed for applications in 3- to 4-inch bands on either side of the crop plant.

TABLE 1. Weed susceptibility to liquid ammonium nitrate at two stages of growth — summary of 13 field experiments.

Weeds	Control* 1-4-leaf	Control* 5-7-leaf
	%	%
Annual bluegrass	0	0
Barnyardgrass	0	0
Black mustard	92	47
Burning nettle	5	65
Chickweed	97	51
Common groundsel	98	68
Hairy nightshade	96	72
Lambsquarters	0	0
Little mallow	99	77
London rocket	95	54
Nettleleaf goosefoot	0	0
Pineapple weed	98	62
Purslane	0	0
Redroot pigweed	96	58
Shepherds-purse	95	41
Sowthistle	32	0

* Determined from counts of weed per 2 square feet.

Weed control

The band applications along the crucifer row killed emerged weeds. Weeds dried rapidly, allowing for sprinkler irrigation within 48 hours to leach the fertilizer into the root zone.

In studies comparing three forms of nitrogen fertilizers, selectivity was highly consistent with ammonium nitrate (20-0-0) and ammonium thiosulfate (12-0-0-24), but variable with urea/sulfuric acid solutions (15-0-0-16). Additional field experiments were limited to the liquid 20% ammonium nitrate fertilizer.

Rates of 50 to 60 gallons per acre of undiluted 20% ammonium nitrate were effective in killing weeds. Although weed susceptibility varied, results of 13 experiments (summarized in table 1) show that weeds up to the four-leaf stage were more susceptible than larger weeds. Timing the application to control the weeds when smaller usually allowed broccoli or cauliflower plants to reach a suitable treatment size of two to four leaves.

Crop response

Tests compared broccoli and cauliflower tolerance to directed sprays and "topical" applications (spray solution applied over the entire plant). Undiluted ammonium nitrate was applied at 55 and 90 gallons per acre (table 2). Cauliflower was more sensitive than broccoli. Cauliflower yields were significantly reduced with the topical application when compared with the directed spray. The fertilizer solution injured the growing point, resulting in distorted curd development.

Seven broccoli varieties were evaluated to determine their tolerance to ammonium nitrate applied as a directed or topical spray (table 3). The ammonium nitrate treatments were compared with a hand-weeded control. Stands of Futura were significantly reduced by both direct and topical sprays. Plant dry weights 14 days after topical treatment showed significant differences in all varieties except Green Duke. Excalibur, Futura, Premium Crop, and Shogun plant weights were reduced with the directed spray. Spear weights of all varieties except Green Duke were significantly lower at harvest in the topical spray treatments.

Crop-environment

Environmental influence on crucifer tolerance to liquid ammonium nitrate is not completely understood. A summary of four experiments shows the seasonal effect on crop selectivity (table 4). Broccoli tolerance was significantly reduced when ammonium nitrate was applied as a directed spray during January and February. During this period, maximum temperatures ranged from 50° to 60°F with lows of 30° to 35°F. Crop injury symptoms were bleaching of the treated leaves and stand mortality. In midsummer experiments conducted in the Salinas Valley, with maximum daytime temperatures of 65° to 75°F and lows of 40° to 45°F, crop tolerance of broccoli was greatly improved. Leaf symptoms of marginal burning were sometimes evident, but crop stand was not affected.

Another factor influencing crop selectivity is the preceding pesticide application. Using wetting agents at various intervals before ammonium nitrate application reduced broccoli tolerance (table 5). Ammonium nitrate treatment within 24 hours of applying a wetting agent solution resulted in a 69% loss in dry weight. Treatment 48 hours after a wetting-agent application reduced broccoli dry weight by 48%. Delaying the ammonium nitrate spray for 72 hours gave results similar to those in control plots (no wetting agent). For optimum selectivity, a 72-hour interval should thus be allowed between applications of insecticides or fungicides and of the nitrogen fertilizer solution. The wetting agent in these sprays apparently alters the crop's leaf surface so that the differential wetting selectivity is reduced.

TABLE 2. Broccoli and cauliflower yield response comparing two methods of spray application with 20 percent ammonium nitrate

		Broccoli*			Cauliflower*		
Treatment	Rate	Percent harvest	Avg. lb./100 ft of row	Avg. spear wt	Percent harvest	Avg. lb/100 ft of row	Avg./head wt.
	gpa	%	*lb*	*lb*	%	*lb*	*lb*
Control	0	82 a	73 a	0.30 a	94 a	129 a	1.74 a
AN-20 directed	55	92 b	88 b	0.41 b	96 a	132 a	1.80 a
AN-20 directed	90	95 b	99 c	0.36 b	94 a	127 a	1.84 a
AN-20 topical	55	90 b	99 c	0.38 b	85 b	103 b	1.78 b
AN-20 topical	90	96 b	102 c	0.40 b	82 b	91 b	1.51 b

* Values followed by the same letter are not significantly different at the 5% level by Duncans multiple range test (DMRT).

TABLE 3. The response of hybrid broccoli varieties to foliar applied liquid ammonium nitrate at 80 gallons per acre

Method of application	Emperor	Excalibur	Futura	Green Duke	Green Valiant	Premium Crop	Shogun
				Percent stand*†			
Control	98 a	96 a	99 a	99 a	98 a	98 a	97 a
Directed	98 a	99 a	91 b	93 a	97 a	98 a	99 a
Topical	96 a	98 a	89 b	91 a	96 a	96 a	98 a
				Dried weight (g. per plant)‡			
Control	21.1 a	39.3 a	27.7 a	19.7 a	26.4 a	29.9 a	25.0 a
Directed	21.3 a	31.9 b	24.3 b	20.7 a	25.4 a	24.1 b	20.0 b
Topical	15.2 b	26.8 c	20.6 c	19.2 a	20.4 b	23.1 b	18.4 b
				Mean spear weight grams			
Control	132 a	136 a	128 a	125 a	133 a	130 a	133 a
Directed	128 a	131 a	104 b	123 a	128 a	126 a	128 a
Topical	118 b	121 b	86 c	121 a	113 b	118 b	120 b

* Stand evaluations were made on pre- and post-ammonium nitrate sprays and pre- and post-weeding.
† Values followed by the same letter are not significantly different at the 5% level, DMRT.
‡ Plants sampled 14 days after treatment.

TABLE 4. Seasonal influence on response of Futura broccoli to 20 percent ammonium nitrate spray

		January-February*		July-August*	
Treatment	Rate	Plant dry weight†	Stand count/ 30 ft	Plant dry weight	Stand count/ 30 ft
	gpa	*g*		*g*	
Control	0	36 a	111 a	45 a	122 a
AN-20	55	22 b	81 b	40 a	116 a
AN-20	90	15 c	65 c	35 b	109 a

* Values followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test (DMRT).
† Crop evaluations taken 14 days after treatment.

TABLE 5. Tolerance of broccoli to ammonium nitrate applied to leaves at specified times after treatment with a wetting agent

Wetting agent	Delay*	Avg. dry wt./plant†	Phytotoxicity
	hours	*g*	%
None		44 a	16 a
X-77‡	72	40 a	15 a
X-77	48	23 b	58 b
X-77	24	14 c	92 c

* Delay between wetting agent and ammonium nitrate application. Both applied at broccoli two- to three-leaf stage. (Ammonium nitrate applied at 55 gal/acre.)
† Values followed by the same letter are not significantly different at the 5% level, DMRT.
‡ Applied at 0.5% v/v.

Conclusions

The effect of ammonium nitrate spray solution on crucifer crops is related to several factors, including the number and size of the leaves, the plant height, variety, absence of dew on the leaves, and application method. Other factors that appear to be related to selectivity, but are not documented, include the level of waxiness of the leaf and the stress condition of the crucifer plant at the time of application.

Susceptibility of broadleaf weeds is related to species and size. Several weeds with waxy leaf surfaces tolerated liquid ammonium nitrate at a rate of 50 to 60 gallons per acre in these tests. Nettleleaf goosefoot, lambsquarters, purslane, and sowthistle were resistant. The optimum size for control of susceptible weeds is one to three leaves. Once weeds such as shepherds-purse reach a six- to eight-leaf stage, leaf burning is evident but regrowth will occur. Grassy weeds such as annual bluegrass are not affected by the ammonium nitrate solution.

Changing from sidedress nitrogen fertilization to directed spray banding of undiluted 20% ammonium nitrate at 50 to 60 gallons per acre resulted in significant weed control in these tests. Although the fertilizer is not registered as an herbicide, its weed control characteristics in addition to its fertilization value could result in cost savings.

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