WAUKENA WHITE . .

STEPHEN WILHELM

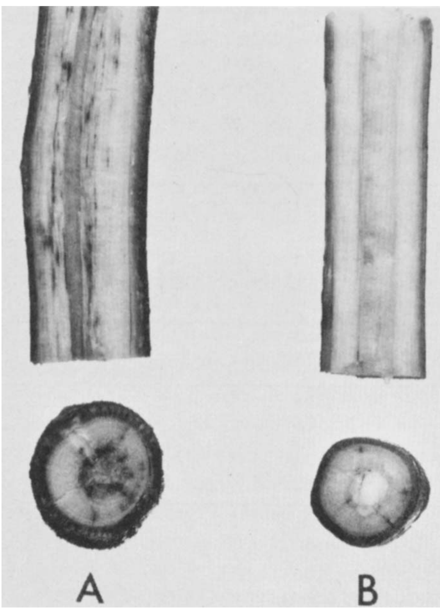
JAMES E. SAGEN • HELGA TIETZ

ALAN G. GEORGE

AN EXPERIMENTAL BREEDING LINE for a cotton resistant to Verticillium wilt, given the name "Waukena White," is described in this progress report. Limited tests in a wilt nursery maintained on the Don Davis ranch at Waukena, Tulare County, where the breeding line was selected, indicate that it has the capacity to yield 1.5 to 2.5, 500-lb bales of cotton per acre on heavily infested wilt land. The fiber quality is excellent, and the seed has a high oil content.

Verticillium wilt resistance previously has been available in such cotton varieties as Tanguis and Seabrook, but they are late maturing and low yielding under San Joaquin Valley conditions. Therefore, a new cotton with tested resistance, ideal plant type, and highly acceptable fiber, has potential value to the cotton breeding effort in California. Botanically this cotton has been identified as Gossypium barbadense L. **It has yellow flowers with red petal spots, and thus—as identified in section 347(a) of the Agricultural Adjustment Act of 1938—it is classed as extra-long staple cotton.**

Lack of Federal allotments for extra-long staple cotton in the San Joaquin Valley of California prevents cultivation there of Gossypium barbadense **and hybrid cottons derived from the species. However, the wide publicity it has received makes it advisable that it be described. This description is given in the hope that some day it may be useful in the development of improved varieties for the cotton areas of California now economically depressed because of wilt.**



Vascular discoloration of Waukena White cotton caused by infection of Verticillium is light, and typically confined to streaks in the central, or first formed, wood. It is heaviest near the base of the main stem, (A), and usually disappears at a height of about 18 inches, (B). In the root it rarely extends downward more than about 12 inches. The Verticillium fungus usually can be isolated in culture from the discolored tissues.

WAUKENA WHITE has a short history. Two plants of ten of an accession of seed received in 1964 through Dr. Paul A. Fryxell as Russian C.B.3153 survived heavy inoculation with the wilt fungus *Verticillium albo-atrum* Rke. and Berth. in the greenhouse in 1966. The other eight plants died from the disease. The surviving plants were infected by the wilt fungus and showed moderate to severe symptoms of wilt, but eventually made an excellent recovery. The accession C.B.3153 was scored as wilt susceptible but the two survivors which were designated as B55-49 and B55-56 grew to maturity in the greenhouse; flowers produced were selfed and seed that matured was saved.

The following year (1967) two groups each of B55-49 and B55-56 seedlings grown in peat pots were transplanted to the heavily infested wilt nursery at Waukena. The four groups comprised a total of fifty-seven plants and were part of a test in which nearly 300 different seedling groups, derived from survivors of greenhouse Verticillium inoculation tests and from known susceptible lines, were exposed to field conditions.

The plants were spaced about 18 inches apart in the row. Beginning in June and continuing at about monthly intervals until harvest, the plants were scored for symptoms of wilt. The petiole of a select leaf from each of five plants in every group was cultured for the presence of Verticillium (table 1). Leaves of some plants of B55-49 and B55-56 were infected by Verticillium when the plants were young. Thereafter the plants recovered and developed no symptoms of wilt. Vascular discoloration was light and usually confined to the central wood, and Verticillium could be readily obtained from the discolored tissues. Plants of B115, a wilt susceptible Upland strain of cotton used as a check, were severely affected by Verticillium wilt, and most were dead by June 15. The capacity to recover quickly from early-season infection by Verticillium proved to be a characteristic of the strain B 55.

Seed saved

Two of the twenty-eight plants of B55-49, namely numbers Bf35 and Bf265, produced a significant yield of 547 and 279 seed, respectively, and were saved upon advice of experienced cotton men; seed of all other, less fruitful plants of this strain was bulked. Of the B55-56 strain, one plant produced a modest yield but no plants were saved. The following year, on April 12, 1968, four 50-foot progeny rows were planted from seed lot Bf35, two rows from seed lot Bf265, and 18 rows from the bulked seed. Row spacing was 38 inches. This field received five irrigations. Harvest was delayed until the middle of November because of three early rains (see field photo). The capacity of the B55-49 progeny to yield approximately 2.5 bales of cotton per acre (table 2) was encouraging. It was also significant that the resistance to Verticillium wilt identified in the strain B55-49 by greenhouse tests at Berkeley stood up under severe field conditions.

a new cotton breeding line resistant to Verticillium wilt

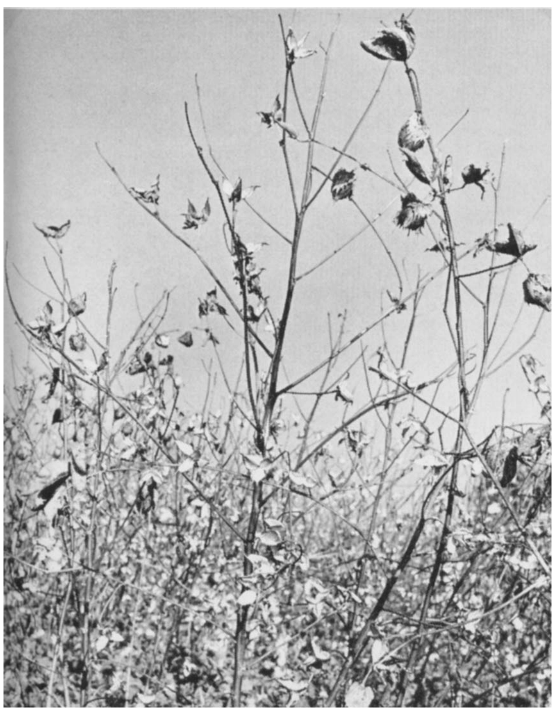
After harvest, 25 plants selected at random from each of the experimental strains, Bf35 and Bf265, were rated for intensity of vascular discoloration in the root, at the base of the stem, and 18 inches above the base—and were cultured at the three points for the presence of Verticillium (table 3). Vascular discoloration, ranging from light to moderate (ratings 0.5 to 3.0) was present at the stem base of each plant, but it tended to disappear 18 inches high in the stem and at 12 inches below ground level in the root. Verticillium was most frequently recovered from the base of the plant, where vascular discoloration was most intense.

Fiber quality

Fiber quality (saw-ginned) is detailed here:

Length	1.38 inches	G/Tex	22.0
UHM	1.40	Elongation	7%
Micronaire	4.3	Break factor 22's	2750
PSI	94.5	Trash	9%
Uniformity ratio	58		

After the first clean picking on November 11, 1969, Waukena White matured the remaining unopened bolls within two weeks. The upright, rigid habit of the plant makes harvesting easy.



Seed analyses gave these values:

Iodine value	107.2	Total lint	5.5%
Total gossypol	1.46%	Free fatty acids	1.2%
Moisture	7.8%	Quality index	100.0
Oil*	20.6%	Quantity index	114.92
Ammonia	4.6 %	Grade	115.0

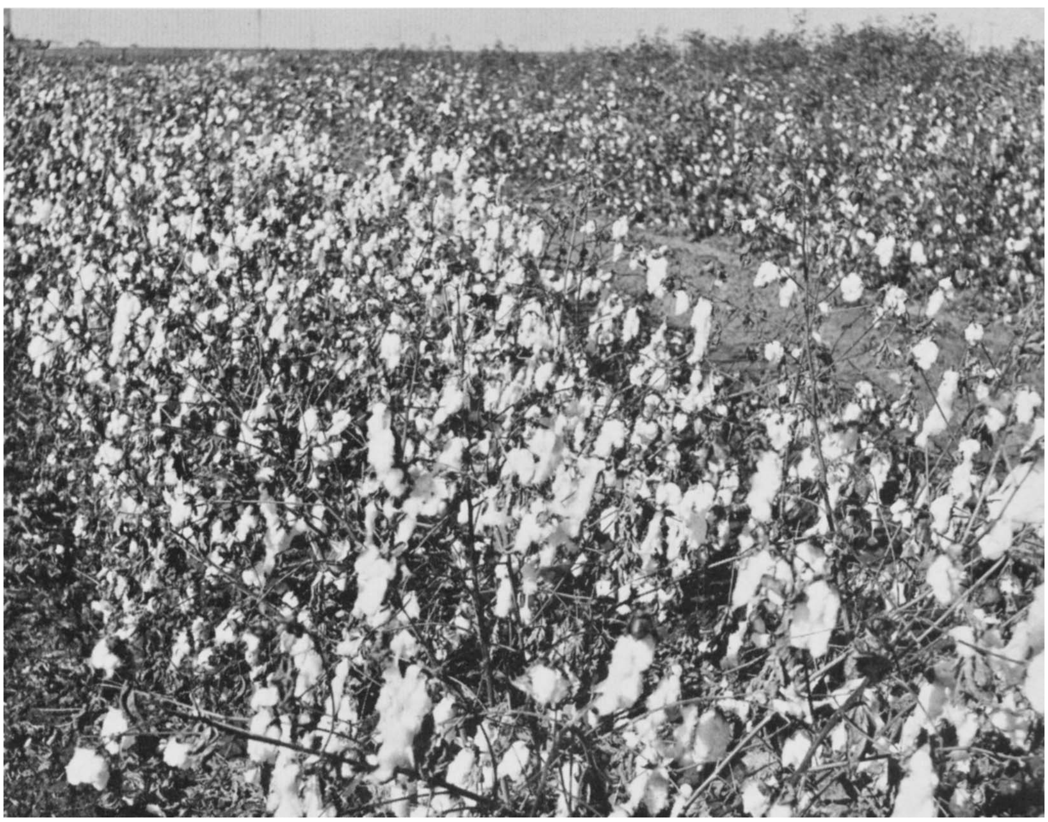
* Crude oil is very dark and highly pigmented, but refines to a light color.

Yields of seed products (assuming 2.5 per cent residual lint, 44.5 per cent protein meal, 1 per cent oil in meal, and 1 per cent oil in hulls), calculated in pounds per ton of seed, were:

Meal	977
Crude oil	398
Lint	62
Hulls	488
Loss	75

Yields obtained in progeny row tests of experimental cottons may greatly exceed the capacity of the cotton to produce when grown in one-acre or larger blocks. To study further the capacity of the experimental cottons to yield on wilt-infested land, two acres were planted with strain Bf 35 and one acre with strain Bf 265 on April 15, 1969, at the Don Davis ranch, Tulare County. Uneven soil moisture at the time of planting plus late spring rains and cold weather caused a poor stand. Heavy Lygus bug infestation blighted many of the first squares and induced lush vegetative growth. Extended periods of high temperatures during flowering in July and August may also have caused blossoms to shed. Rains fell on November 6 and 9, after which fog persisted until the middle of the morning of November 11, when harvesting began. A defoliant had been applied prior to harvest. The yield (table 4) was considerably below that of the previous year, with 780 and 675 lbs of lint for strains Bf35 and Bf265, respectively. The Tulare County average for Acala SJ-1 was 689 lbs of lint per acre.

A pair of 50-foot progeny rows of cotton strain B 55-49 (Waukena White) ready for picking. Three rains caused postponement of harvest until November 13, 1968. Plants of adjacent rows were cut away. Despite the rains, very little cotton was on the ground at harvest.



Chance contaminants, or hybrid plants, appearing in rows of Waukena White were easily detected in the seedling stage by the presence of the cotyledon spot (arrow). Waukena White lacks the spot.

The fiber quality of the new cotton (saw-ginned) was below that of 1968; average figures were:

Length (Fibrograph 2.5%)	1.26 inches
Micronaire	4.2
PSI	90.0
Uniformity ratio	48

After the 1969 harvest we began to refer to the new cotton by the name "Waukena White." Waukena White designates only the cotton derived from strain Bf35 of the accession B55-49.

TABLE 1. COMPARISON OF WILT SCORES OF WILT RESISTANT B 55-49 AND THE EXPERIMENTAL, WILT SUSCEPTIBLE UPLAND B 115, WAUKENA WILT NURSERY, 1967

Plant number	Symptoms of Wilt, and Cultures for Verticillium*					
	Leaf				Stem base† Oct.	Wilt score‡
	June	July	Aug.	Sept.		
B 55-49	**Derivative of Russian C.B.3153**					
24	0§	0	0	0	1	1
25	0	0	0	0	2	3
26	0	1	0	0	2	3
27	0	0	0	0	2	2
28	0	0	0	0	2	2
256	1	0	0	1	2	3
257	2	0	0	1	2	3
258	1	0	0	1	2	3
259	2	0	0	0	3	3
260	0	0	0	0	2	2
B 115	Gossypium hirsutum (**Botanical Garden, Bonn, Germany**)					
3353	2	–	–	–	3	5
3354	0	–	–	–	4	5
3355	4	–	–	–	–	5
3356	4	–	–	–	–	5
3357	4	–	–	–	–	5

* Symptom scores range from 0 to 4: 0 is healthy; 4, a dying or a dead plant; scores 1–3 are faint, moderate and severe disease reactions.

† Vascular discoloration is rated from 0 to 4: 0 is no discoloration; 1 is faint; 2, moderate; 3, medium heavy; 4, heavy.

‡ Final wilt scores range from 1 to 5. Plants with scores of 1–3 are resistant; 4–5, susceptible. The score of 3 is considered minimum adequate resistance for heavily infested wilt soils.

§ Light face figures indicate that cultures for Verticillium were positive.

TABLE 2. PROGENY ROW YIELD TESTS OF EXPERIMENTAL COTTON STRAINS DERIVED FROM B 55-49 ON HEAVILY INFESTED WILT LAND, WAUKENA, 1968

Cotton Strain	Row Length	Seed Cotton	Lint	Lint/acre	Yield	Density
	ft	lbs	lbs	est. lbs	Bales acre	Plants acre

* 479 pounds of lint = one 500-lb bale.

† Plants approximately 1 ft apart in row.

‡ Plants approximately 6 inches apart in row.

Reaction to Verticillium wilt

Waukena White is readily infected by the Verticillium fungus during the seedling growth phase and may develop prominent, early symptoms. One, two, or more of the lowermost leaves turn bright yellow and fall (see plant photo). However, Waukena White seedling plants have never been observed to die from the disease, as is common with Acala SJ-1. On the contrary, after the initial reaction of shock caused by the loss of the lower leaves, infected Waukena White seedlings *not only* recover, but make vigorous growth and remain free from symptoms thereafter. There is no evident stunting, no dieback of terminal branches or side shoots, and no dehiscence of flowers or bolls. Vascular discoloration of the wood is confined to the region invaded by the fungus during the early life of the plant (see stem photos). The early infection by Verticillium and the resultant loss of lower leaves may be a blessing in disguise because it provides for greater aeration near the base of the plant, and may be responsible for initiating early flowering. Thus, it is probable that Waukena White will yield better on heavily infested wilt land than on land which is free from the disease.

Low temperatures throughout the 1968 growing season favored Verticillium wilt in Tulare County. Soil temperatures (at the 6 to 10 inch depth from July 15 to harvest) were consistently below 80° F at the Don Davis ranch, and favored prior-to-harvest collapse of wilt-susceptible Acala cottons. Waukena White, though infected by Verticillium, withstood the wilt-favorable late-season conditions. In contrast to Acala cottons, growth and yield of Waukena White were not adversely affected by either cool growing or cool maturing conditions.

Cool conditions prevailing through June, 1969, favored early-season development of wilt. Acala SJ-1 suffered severe

TABLE 3. VASCULAR DISCOLORATION AND INFECTION BY VERTICILLIUM IN COTTON STRAINS Bf 35 AND Bf 265 AT THE END OF THE SEASON; WAUKENA, 1968

Plant Number	Vascular discoloration rating*			Wilt Score†
	Root 12 in.	Stem		
		Base	18 in.	
		Bf 35		
1	1	2‡	0	2.0
2	1	2	1	2.0
3	1	1	1	1.0
4	0	3	0	2.5
5	1	2	0	2.0
6	0	2	1	2.0
7	0	3	0	2.5
8	1	3	1	2.5
9	2	2	0	2.0
10	1	3	1	2.5
11	2	2	1	2.0
12	1	3	0	2.5
13	0	3	0	2.5
14	0	3	1	2.5
15	1	3	0	2.5
16	0	1	0	0.5
17	1	2	1	2.0
18	0	1	0	0.5
19	0	3	1	2.5
20	1	2	0	1.0
21	2	3	1	2.5
22	1	2	0	2.5
23	1	2	0	1.0
24	3	2	1	2.0
25	2	3	1	2.5
		Bf 265		
26	0	1	0	1.0
27	0	2	0	2.0
28	0	1	0	1.0
29	2	2	1	2.5
30	1	2	0	2.0
31	1	1	1	1.0
32	1	2	0	2.0
33	0	3	1	3.0
34	3	2	1	2.0
35	1	3	1	3.0
36	0	2	1	2.0
37	1	1	0	1.0
38	0	2	0	2.0
39	1	2	2	3.0
40	0	2	1	2.0
41	2	2	0	2.0
42	0	2	0	2.0
43	2	1	1	1.0
44	1	2	0	2.0
45	0	2	1	2.0
46	2	2	0	2.0
47	0	2	1	2.0
48	1	3	0	3.0
49	2	2	2	2.0
50	1	3	0	3.0

* Vascular discoloration is rated from 0 to 4: 0 is no discoloration; 1 is faint; 2, moderate; 3, medium heavy; and 4, heavy.

† Wilt scores ranging from 0.5 to 3.0 indicate resistance adequate for heavily infested soils. There were no symptoms of wilt evident beyond loss of a few lower leaves in June.

‡ Light-face figures indicate that cultures for Verticillium were positive.

Waukena White three weeks after showing leaf dehiscence from Verticillium wilt; June 26, 1969. Recovery from the disease at this point was complete, and new symptoms did not develop. Squares were beginning to form.

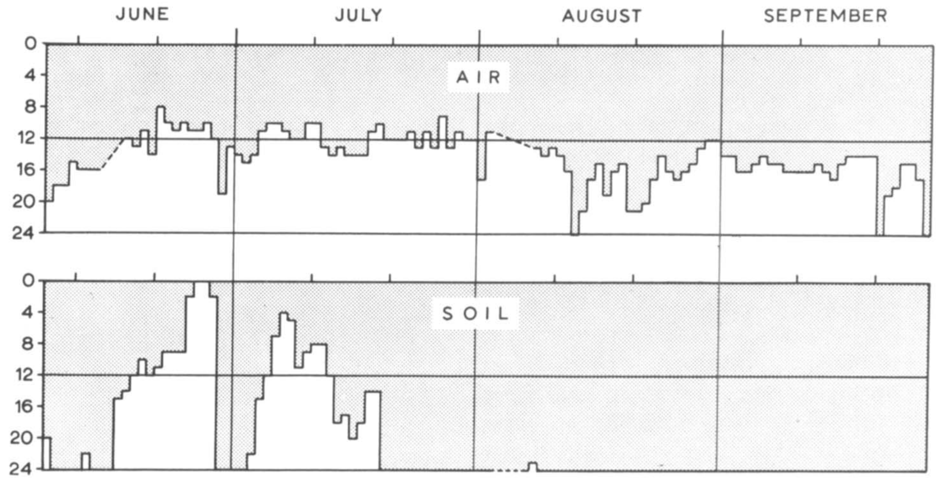
defoliation, and Waukena White showed mild symptoms. High temperatures prevailing from July 1 through September 25 favored recovery from wilt and delayed the onset of the typical late-season collapse of Acala SJ-1.

Observations in the field indicated that seed of Waukena White one year old or older germinated more uniformly than seed recently harvested, and that acid delinting, unless performed under very closely controlled conditions, may injure the seed. Seed is nearly devoid of fuzz. The seed also germinated readily at soil temperatures ranging from 60 to 90° F. In greenhouse studies the mean time required for seedling emergence at soil temperatures of 60, 70, 80, and 90° F was 8.5, 6.5, 4.5, and 4.0 days, respectively. These values indicate the rate at which seedlings were growing prior to emergence above the ground. Thus, at 60° F, a marginally low temperature for germination, the average number of days from planting to emergence of the seedling was 8.5. Prompt germination and vigorous growth of the seedlings in cool soils are valuable assets for a cotton variety in the San Joaquin Valley.

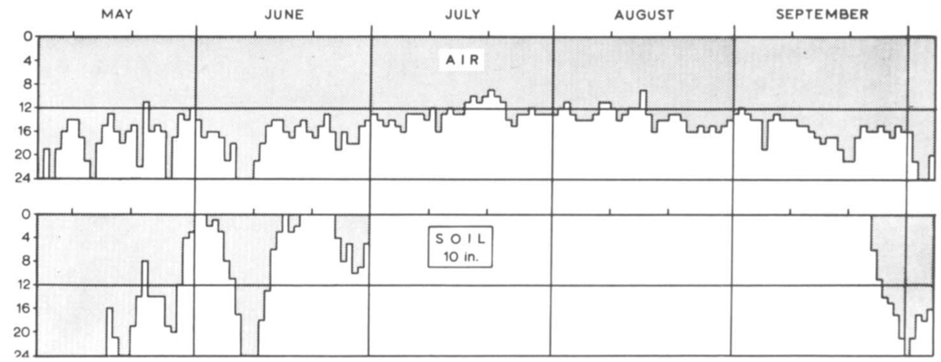
Waukena White has a deep, extensively branched tap root. Strong lateral roots branch from the entire length of the tap root, giving the plant a deep, branched, anchoring and absorbing root system. In contrast, roots of Acala SJ-1 branch primarily in the upper portion of the tap root, which results in an absorbing system more limited to the surface soil. The resistance of Waukena White to Verticillium wilt may result partly from a greater portion of the branch roots being deep in the soil—where there is far less Verticillium inoculum.

Waukena White six weeks after seeding in heavily infested wilt soil, showing loss of first few lower leaves from Verticillium wilt; June 5, 1969. Infected plants did not die from wilt, nor was growth inhibited, and the loss of lower leaves was a possible advantage later in the life of the plant.

HOURS PER DAY BELOW 80° F, WAUKENA, 1968



HOURS PER DAY BELOW 80° F, WAUKENA, 1969



Shaded areas show hours per day that air and soil (at 10-inch depth) temperatures were below 80° F, and thus favorable for infection and Verticillium symptom development.

A general characteristic of cotton plants of Upland or Barbadense varieties is a faint or prominent cotyledon spot, that is, a red dot at the point where the expanded cotyledon and its petiole join. The spot appears also in the leaves and its presence is associated with red pigmentation of the stem. Waukena White uniquely lacks this spot in both cotyledons and leaves and also is generally free from red pigmentation of the stem. This characteristic is valuable in keeping the seed lines of Waukena White pure. Any contamination of Waukena White seed with either an Upland or another Barbadense cotton, whether the contamination is due to chance hybridization or to mechanical mixing of seed, shows up immediately in the seedling stage (see cotyledon spot in seedling photos).

During the limited time Waukena White has been studied on heavily infested wilt land, observations were made regarding its culture and habit of growth which may be valuable when a cotton of the species *Gossypium barbadense*, or hybrid varieties derived from the species, can be grown legally in the San Joaquin Valley of California. Waukena White should be planted as early as possible to encourage infection by Verticillium. The first irrigation should also be applied early to favor development of wilt. To encourage fruit set, the field should be allowed to stress severely for moisture be-

TABLE 4. YIELD TESTS OF EXPERIMENTAL COTTON STRAINS Bf 35 AND Bf 265 ON HEAVILY INFESTED WILT LAND; WAUKENA, 1969

Row Pairs*	1st pick/ 2 rows	2nd pick Total	Plot Total	Lint yield	Density
	Pounds of Seed Cotton			lbs/† acre	Plants/ acre
	Bf 35—2.14 acres (22 quarter-mile rows)‡				
1	462				
2	450				
3	415				
4	410				
5	449				
6	436	860	5682	780	24,000
7	442				
8	449				
9	436				
10	455				
11	418				
	Bf 265—1.02 acres (10 quarter-mile rows)§				
1	430				
2	400				
3	389	420	2329	675	20,000
4	342				
5	348				

* Picking was done in pairs of non-adjacent rows.
† Gin turn-out calculated at 29.5%.
‡ Picking started at 10:45 a.m., and the first harvested cotton was moist from fog.
§ Picking started at 12:30 p.m., and the cotton was dry.

fore the second irrigation (under Tulare County conditions only). Waukena White should receive a pre-harvest irrigation.

Lygus

Lygus should be controlled to avoid the early loss of squares, which reduces yield and contributes to excessive vegetative vigor. As a young seedling, Waukena White may be moderately damaged by thrips, but recovery is usually prompt. Waukena White also appears to be resistant to spider mites. Under greenhouse conditions in Berkeley, where spider mites usually are more severe and more difficult to control than in the field, Waukena White was resistant. Under field conditions of these limited tests, treatment for mites was not necessary. Mites were occasionally observed on plants, however, and whether this indicates that a strain may develop which is capable of attacking Waukena White is not known at this time.

Waukena White may also be resistant to the so-called potassium deficiency disease complex. It was grown in an area where the disease developed severely in previous years on Acala SJ-1, and it remained free from the symptoms. Possibly the deep branching habit of the root system of Waukena White, in contrast to the shallow root branching of Acala SJ-1, is a factor in its freedom from the nutritional disease.

Clean harvesting

After rains of one-half inch or more prior to harvest of the experimental plots in 1968 and 1969, very little cotton fell to the ground. The upright, rigid habit of the plant facilitates clean harvesting. The leaves of Waukena White are glabrous and thus tend to reduce the problem of trash; Waukena White lint makes an attractive bale.

Growing Waukena White is illegal at present in our one-variety Acala district of California. It is hoped, however, that Waukena White will provide a germ plasma bearing resistance to Verticillium wilt that can be bred into improved upland cotton strains.

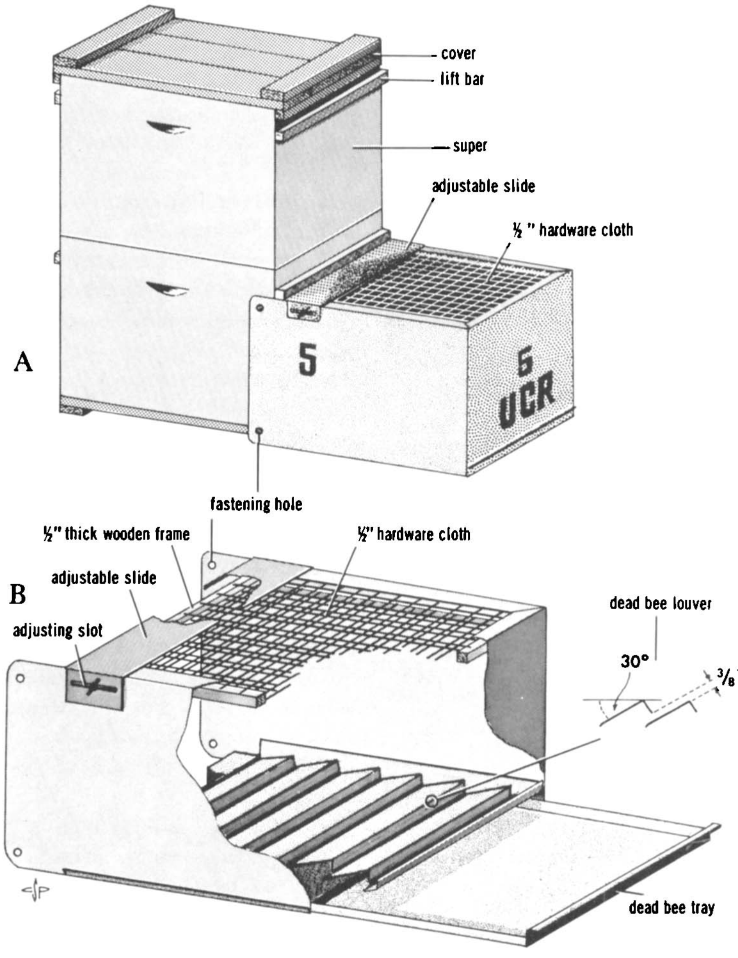
Stephen Wilhelm is Professor; James E. Sagen is Laboratory Technician; Helga Tietz is Assistant Specialist, Department of Plant Pathology, University of California, Berkeley. Alan G. George is Farm Advisor, Tulare County. Calcot Ltd. ran the fiber analyses and Ranchers Cotton Oil tested the seed. Dr. Douglas J. Phillips assisted with the soil-root studies.

HONEY BEE FIELD RESEARCH

aided by Todd dead bee hive entrance trap

FIELD RESEARCH on the effect of pesticides on honey bees has been conducted in California since 1952. F. E. Todd of the Bee Research Branch, USDA, ARS cooperated in these field tests through 1968. Several methods have been used to collectively measure the effects of pesticide treatments on honey bees. Of these, colony strength, forager bee visitation in the field, caged bees in the field, bioassay of foliage residues in cages using honey bees, and dead bees at the colony are the most useful, according to previous tests.

Bees dying at the hive provide a useful qualitative and quantitative index of larval and adult bee losses caused by pesticide applications. In addition, substantial quantities of poisoned bees can be gathered for chemical residue analyses,



The modified Todd Dead Bee Entrance Trap for honey bee field research.