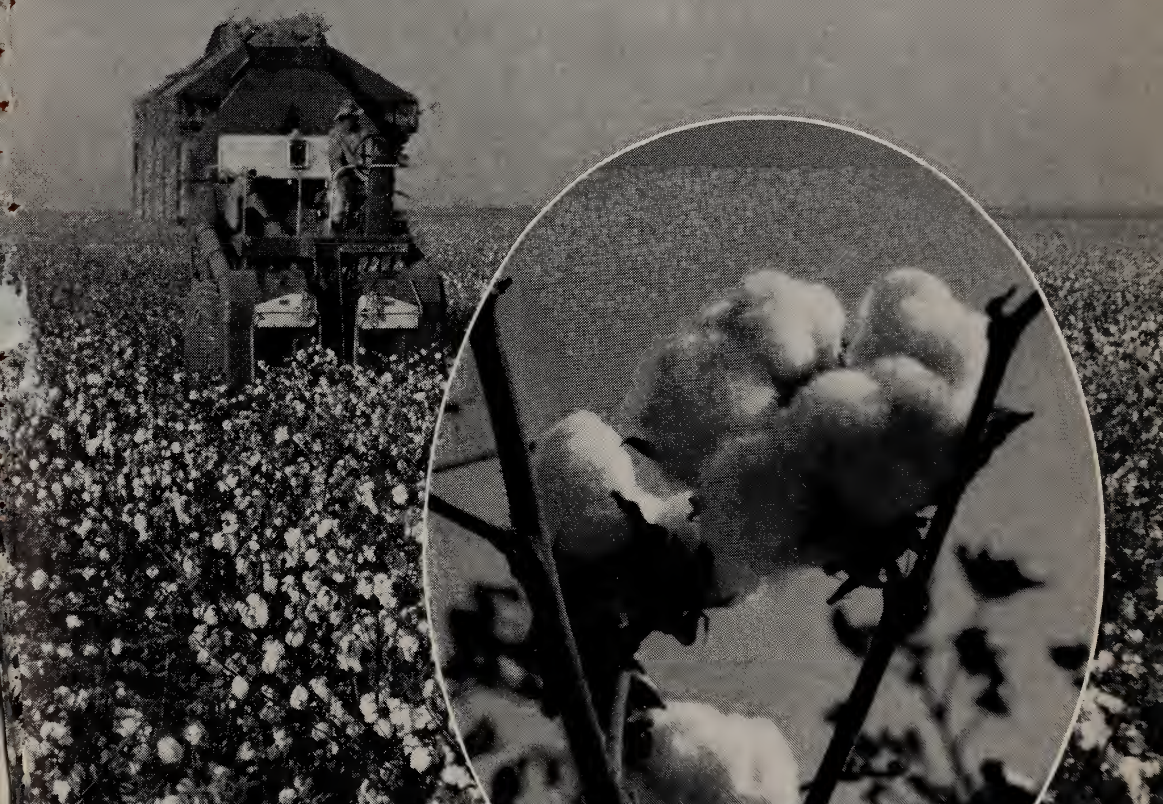
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

MECHANIZATION OF COTTON PRODUCTION



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Mechanization of Cotton Production[1]

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Since 1948 there has been a revolution in the methods of growing and harvesting cotton, California's leading cash crop. In that year a cooperative project was organized to study various phases of mechanizing cotton production. This work included the constructing and testing of new equipment, improving equipment already in use, and experimenting with various cultural practices. By 1962 mechanical pickers were used for 90 per cent of the cotton harvesting in California, compared to 10 per cent in 1948. Other hand labor in cotton growing had also been greatly reduced.

This bulletin describes the mechanization studies and summarizes their results.

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Results of Mechanization Studies:

As recently as 1948 cotton was a crop requiring a large amount of hand labor. Since that time, however, great progress has been made in eliminating such labor. An example of this is the development and use of mechanical pickers for harvesting. In 1948 over 90 per cent of the California cotton crop was harvested by hand. By 1962 over 90 per cent was harvested with mechanical pickers. Hand labor for thinning and weed control had also been greatly reduced.

A joint project of the Agricultural Engineering Department of the Agricultural Experiment Station at Davis and the Agricultural Engineering Research Division of the Agricultural Research Service of the U. S. Department of Agriculture was organized in 1948 to study different phases of mechanizing cotton production. The work under this project has included the designing, constructing, altering, and testing of equipment. Experiments with cultural practices that would reduce hand labor or make the use of machines more feasible were also conducted. Maintaining or increasing yield and quality of fiber was of prime importance in all the work. Most of the work was done at the U. S. Cotton Experiment Station at Shafter in Kern County. Some tests, however, were conducted on selected farms in other parts of the San Joaquin Valley.

This bulletin describes and summarizes the results of the major experiments conducted through 1962 under the project. Some of the experiments were carried on in cooperation with other Departments of the Agricultural Experiment Station and other Divisions of the Agricultural Research Service.

Fig. 1. Types of beds and method of irrigation used in test plots. A pipe through the ditchbank serves two furrows, but only one is irrigated at a time.

Method of Growing the Cotton for the Experiments at the Shafter Station

UNLESS OTHERWISE INDICATED, the cotton for the experiments at the Shafter Station was grown in the following manner. The land—Hesperia fine sandy loam—was double-disked after the stalk disposal of the previous crop, then plowed about 10 inches deep and disked again. Beds were formed in March, followed by a preplanting irrigation by the furrow method (fig. 1). Fumigation for nematodes, when needed, was also done prior to planting. Planting was done in April with a runner-opener-type planter having press wheels similar to that shown in figure 4. Acid-delinted seed (fig. 2), averaging about 3,500 seeds per pound, was planted at a rate of about 15 pounds per acre. No thinning took place, and the number of plants per acre averaged about 40,000. Rows were spaced 40 inches apart. Insect control and cultivation were practiced as needed. The fields were kept free of weeds. Irrigation was also performed as needed from about June 1 to September 1. Defoliant was applied 10 days to two weeks before harvest. In harvesting, a single-row, barbed-spindle-type picker was used. First picking was usually in October and the second picking in November or early December. The cotton was ginned at the station in a relatively new gin equipped with a drier, seed cotton cleaners, and a lint cleaner. Classing for grades was done by the regular classers in the U. S. Classing Office in Bakersfield.

Fig. 2. Types of cotton seed. *Top:* fuzzy or gin-run; *lower left:* mechanically delinted; *lower right:* acid-delinted.

Effect of Precision Tillage on Cotton Yield

PRECISION TILLAGE as used in these tests may be defined as deep tillage by means of a chisel point subsoiler directly under the plant row (fig. 3). The object of this tillage is to break any hardpan and to form a slot of loose soil. This allows the plant taproots to develop more quickly, and in some cases to penetrate to a greater depth. A number of tests were conducted both at Shafter and on selected farms in other areas to determine the effect of precision tillage on plant growth and yield.

The tests at Shafter were in coarse sandy loam soil and were conducted for three years. During the first two years a treatment called vertical mulching—a form of precision tillage—was also tried. Vertical mulching consisted of subsoiling directly under the plant row with a subsoil shank, modified by wings on the rear which made a slot about 4 inches wide at the top and 2 inches on the bottom (fig. 3). Chopped cotton stalks were blown down into the slot between the wings. The tillage was done prior to preplant irrigation at depths of 20 to 22 inches.

The tests on selected farms were located to include different soil types. Three were in Tulare County and three in Madera County. The soils ranged from loamy sand to clay loam. The precision tillage at a depth of 22 inches was done in March, prior to preplant irrigation. The soils at the time of tillage were relatively high in moisture because of heavy rains in February.

In all the tests at Shafter there was a significant increase in yield with both plain subsoiling and with vertical mulching, compared to the check plots (table 1). Plant growth as measured by plant height was faster and slightly greater at maturity with precision tillage. In the tests conducted on different soil types there was an increase in yield with precision tillage in the sandy soils but no benefit in the clay soils (table 2).

A test was conducted at Shafter one year to determine the effect of applying the precision tillage at three different times prior to planting. In this test the precision tillage was done in early March before preplant irrigation, in late March two weeks after preplant irrigation, and in April one day before planting. There was little difference between the yields for the three treatments. Precision tillage one day before planting gave a slightly higher yield than in the other two cases, but all yielded significantly greater than the check.

Fig. 3. Equipment used for precision tillage tests. *Left:* combination subsoiler and bedder with subsoil shank midway between lister bottoms; *right:* modified subsoiler used for vertical mulching.

Effect of Depth of Planting and Seed-Press Wheel on Plant Emergence

Tests were conducted in two different years to determine the effect on plant emergence of planting at various depths, using a planter with and without a seed-press wheel (also called a seed-firming wheel). The planter used was a conventional runner-opener type, equipped with wings fastened to the runners and a steel open-center, surface-press wheel (fig. 4). The depth of planting was regulated by the height of the wings above the bottom of the runners. The wings also scraped the dry soil from the tops of the beds so that the seed was planted in firm, moist soil. The seed-press wheel was 1 inch wide and 8 inches in diameter and was located immediately behind the runners. It rolled directly over the seeds on the bottom of the seed furrow and pressed them into firm soil.

The tests were conducted in sandy loam soil. Acid-delinted seed was planted at the rate of 15 pounds per acre. This was approximately 50,000 seeds per acre or about 4 per foot. The planting was done on May 4 in 1953 and on April 21 in 1954.

The results under these conditions showed that a planting depth of 1½ to 2 inches gave the best plant emergence. The seed-press wheel was a definite help in obtaining faster and greater emer-

Table 1

EFFECT OF PRECISION TILLAGE AND VERTICAL MULCHING ON COTTON YIELD AT SHAFTER IN COARSE, SANDY LOAM SOIL

Year	Treatment		
	Check	Subsoiled	Vertical mulched
	bales per acre yield	*bales per acre yield*	*bales per acre yield*
1960	2.54	2.84	2.92
1961	1.67	2.25	2.30
1962 (Test 1)	1.72	2.04	....
1962 (Test 2)	1.69	1.86	....
1962 (Test 3)*	1.27	1.49	....
Av.	1.78	2.10	....

* Non-fumigated, nematode-infested soil.

Table 2

EFFECT OF PRECISION TILLAGE ON COTTON YIELD IN DIFFERENT SOIL TYPES

Location	Soil type	Treatment	
		Check	Subsoiled
		bales per acre yield	*bales per acre yield*
Tulare	Clay loam	1.64	1.68
Tulare	Loam	1.76	1.67
Tulare	Silty clay loam	1.50	1.42
Madera	Fine sandy loam	1.47	1.69
Madera	Loamy sand	1.17	1.37
Madera	Fine sandy loam	.95	1.06

Table 3

COMPARISON OF EMERGENCE OF COTTON PLANTED AT VARIOUS DEPTHS WITH AND WITHOUT A SEED-PRESS WHEEL ON THE PLANTER

Planter type	Planting depth	Plant emergence count*					
		7 days		10 days		20 days	
		1953	1954	1953	1954	1953	1954
	inches						
Seed-press wheel	1.0	1	60	3	63	5	69
No seed-press wheel	1.0	0	30	0	36	1	36
Seed-press wheel	1.5	45	93	83	99	92	105
No seed-press wheel	1.5	22	81	59	96	68	96
Seed-press wheel	2.0	31	84	110	102	121	105
No seed-press wheel	2.0	17	66	94	81	115	84
Seed-press wheel	2.5	18	24	91	66	101	69
No seed-press wheel	2.5	8	12	71	39	95	45

* Number of plants which emerged in 39 feet of row or .003 acre.

gence (table 3). The differences in the emergence between the two years can be attributed to the weather conditions after planting.

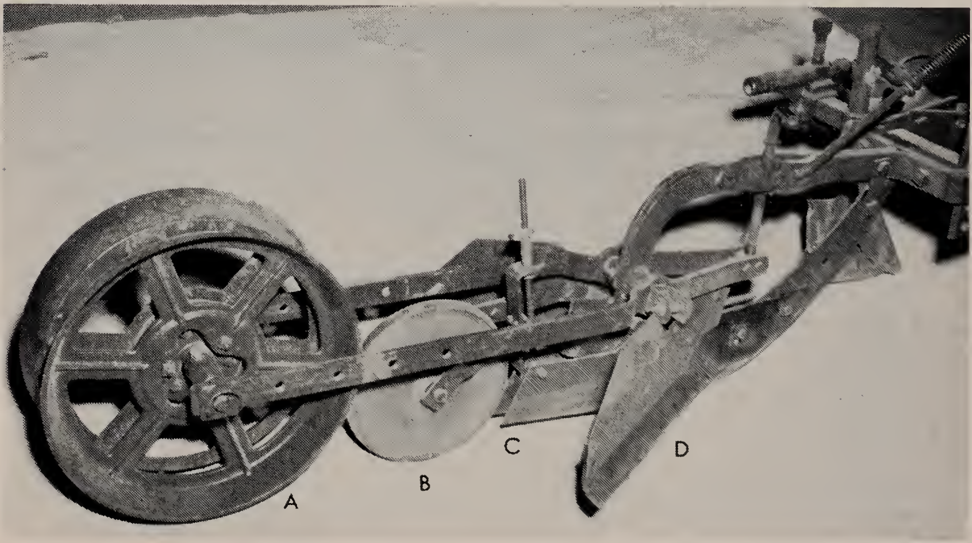
Thinning of Cotton

THINNING OR CHOPPING of cotton to leave single plants from 8 to 12 inches apart was the common practice for many years. This operation was done by hand-hoeing, and usually required from 5 to 7 man-hours per acre. Studies were made to determine whether thinning could be done mechanically or could be eliminated, by planting the cotton to a stand, without affecting yield. Optimum population for best yield and adaptability for mechanical harvesting were also determined. Comparisons were also made between types and makes of choppers for mechanical thinning.

Results showed that thinning can be eliminated or done mechanically without detrimental effect on yield, provided the final plant population is above a certain minimum. With hand-thinning, this minimum is about 20,000 plants per acre (8-inch spacing), while with mechanical thinning or planting to a stand it is nearer 30,000 plants per acre. The reason for this difference is that, with the latter methods, the plants are not so uniformly spaced and there are more clumps with two or more plants together. Yield tended to decrease with populations above 60,000 per acre, with all three methods.

First-fruiting node height is the distance from the soil surface, at the base of the plant, up the main stalk to the node (base) of the first branch having a fruit or boll. This height varied directly according to differences in the plant populations, in all the tests. It ranged from as little as 2 inches with populations of less than 10,000, to as much as 10 inches with populations of more than 60,000 plants per acre. Type of plant growth also varied with different populations (fig. 5). With low populations, the plants were bushy and had relatively large main stalks and lateral branches. With larger populations, the plants were more spindling, and had fewer and shorter lateral branches.

Fig. 4. Planter used in planting tests. (A) steel, open-center surface-press wheel; (B) seed-press wheel; (C) runner-openers; (D) wings to scrape dry soil from beds and to regulate planting depth.



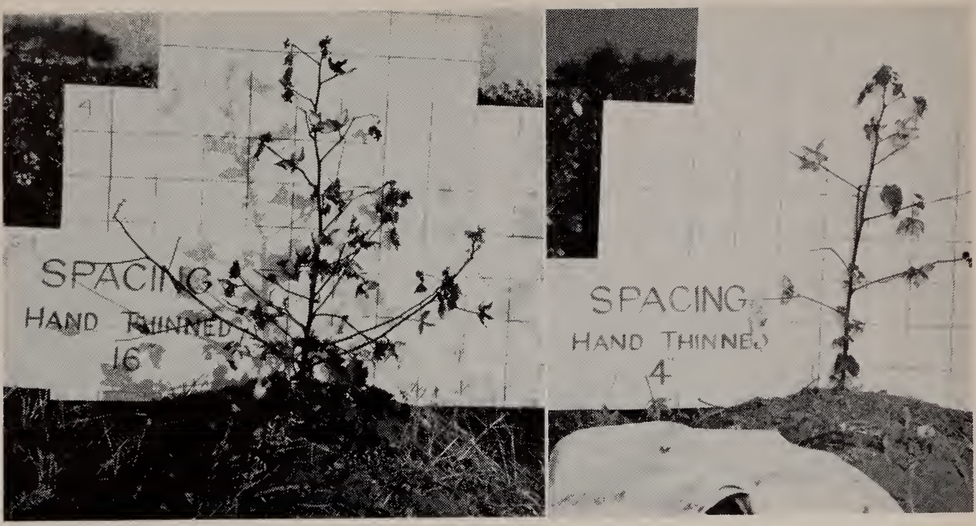


Fig. 5. Effects of spacing on plant characteristics. *Left:* 16-inch spacing; *right:* 4-inch spacing.

Picker efficiency was highest with the greatest plant populations. While the differences were not large, they were consistent in all tests. The increased efficiency is attributed to the greater height of the lower bolls and to the smaller lateral branches on the plants.

Trash content of the seed cotton in the various tests ranged from 4 to 8 per cent for first picking, but did not vary consistently with the plant populations. In general, the largest amount of trash was obtained with the higher populations. This was partially due to the fact that less defoliation was accomplished because of the denser growth.

A test comparing mechanical thinning by different makes and types of choppers with hand-thinning was conducted. The choppers were both ground- and power-driven types, some with rotating and others with oscillating blades (fig. 6). Results (table 4) showed that the plant population left after thinning, rather than any effect of the chopper, determined the yield. While some of the choppers did a cleaner job of thinning than did others, there was no indication that one chopper gave better results than the others when the number of plants per acre after thinning was the same. With hand-thinning there were no spaces over 12 inches between plants. With mechanical thinning, when the remaining plant population (20,000 per acre) was approximately the same as the hand-thinned, more than 20 per cent of the spaces were over 12 inches. When over 30,000 plants per acre were left by mechanical thinning, less than 10 per cent of the spaces were over 12 inches. A thick, uniform stand is essential for mechanical thinning to ensure a desirable final stand with a minimum of long spaces between plants.

Flaming for Weed Control

WEED CONTROL in cotton by flaming consists of subjecting the weeds to heat by flame from a specially designed LP gas burner. It has proved to be an effective supplement to other methods of weed control. It is most effective on weeds in the seedling stage. Because of possible damage to the cotton, it is limited to use between the time the cotton plants are about 6 to 8 inches in height and the time when the first bolls open.

Experiments were conducted for 10 years under the mechanization project to determine whether flaming damages cotton plants. (Actually, weeds were not a problem in any of the plots, including the check.) In the experiments, the number of flamings in the different years varied from three to nine, with an average of five. The initial flaming was done during the first week in June when the cotton averaged about 8 inches in height. The average yields for all the tests were 2.64 bales per acre for the flamed cotton and 2.62 for the check or non-flamed. There was no significant difference in yield in any one of the experiments.

Tests were conducted over a three-year period to determine the effectiveness of flame in controlling annual grasses. Barnyard grass was purposely seeded in the plots for the tests. The treatments consisted of regular sweep cultivation and cultivation plus flaming. Considering 10 as perfect weed control, the flamed plots had a rating of 6.4 compared to 1.8 for the regular cultivation.

The use of flame for best weed control and least damage to the cotton requires proper equipment, proper adjustment of the burners, proper timing of the application, and proper tractor speed. Recommendations for the construction, adjustment, and use of flamers is given in detail in California Agricultural Experiment Station Bulletin 791, WEED CONTROL IN COTTON. That bulletin, published in December, 1962, also gives information on other methods of weed control.

Fig. 6. Two types of cotton choppers. *Top:* ground-driven; *bottom:* power-driven.

Table 4

COMPARISON OF HAND-THINNING AND MECHANICAL THINNING OF COTTON

Type of chopper	Plants after thinning	Plants per hill	Spaces over 12 inches	Yield
	per acre	*av. no.*	*per cent*	*bales per acre*
Hand-thinned	23,600	1.2	0	2.84
A—Rotating, ground-driven	45,700	2.6	5	2.92
B—Weeder wheel, ground-driven	45,100	2.3	1	2.92
C—Oscillating, power-driven	27,100	2.3	8	2.86
D—Rotating, power-driven	30,800	2.1	8	2.72
E—Rotating, ground-driven	29,100	1.9	13	2.78
F—Rotating, power-driven	19,200	1.8	23	2.63

Topping Cotton to Prevent Lodging

Topping cotton is the practice of cutting off the terminal bud of the main stalk to prevent further growth. Cotton is topped to reduce its tendency to lodge (fall over), something which often occurs with tall, rank-growing plants (fig. 7). Lodged cotton is difficult to defoliate and to harvest, either by machine or hand labor. Lodging also results in conditions more favorable for boll rot.

Topping can be done either by hand or by machine. Only the terminal bud of the main stalk is removed in hand-topping. In machine-topping, all the lateral branches above the height of the topper blade are also cut off. Various

Fig. 7. A field of lodged cotton. The cotton being held erect shows the actual height of the plants.

TABLE 5

EFFECT OF TOPPING ON YIELD, PICKER EFFICIENCY, AND LODGING*

Treatments	No. of tests	Yield	Picker efficiency	Degree of lodging	
				Range	Av.
		bales per acre	*per cent*	*per cent*	*per cent*
Check (untopped)	6	2.75	92.9	0–75	43
Machine-topped at 42"	6	2.61	94.4	0	0
Check (untopped)	9	2.54	92.3	5–75	44
Machine-topped at 48"	9	2.55	93.9	0–8	1
Check (untopped)	4	2.54	....	5–75	30
Machine-topped at 52"	4	2.55	....	0–20	10
Check (untopped)	8	2.59	93.1	0–75	28
Hand-topped	8	2.68	94.5	0–25	5
Check (untopped)	5	2.47	91.4	0–75	30
Variable-height topping by machine	5	2.45	92.3	0	0

* Figures shown are the average of all the tests for the given treatments.

Fig. 8. A four-row cotton topper mounted on a high-clearance tractor. Topping is done by horizontally revolving blades under the frame on the front.

types of topping machines have been built, but the type shown in figure 8 is the most common. It consists of four horizontally revolving blades (one blade to a row) mounted under a frame on the front of a high clearance tractor.

From 1951 through 1960, experiments were conducted to determine the effect of machine-topping at various heights, and of hand-topping, on lodging, yield, mechanical-picker efficiency, seed cotton trash, and lint grade. The tests were conducted at the Experiment Station at Shafter, and on selected farms in that locality. The time of topping varied from as early as July 22 to as late as August 26, but most years it took place during the first week of August. The height of the plants at the time of topping varied from about $3\frac{1}{2}$ to over 5 feet. In some tests, plant height was fairly uniform, whereas in others it varied considerably in different parts of the individual plots. In some years there was no lodging in the check or untopped plots, but in others as much as 75 per cent of the untopped cotton lodged. In some tests, mechanical topping was done with fixed settings of the topper blade at heights of 42, 48, and 52 inches. In other tests the topping height was varied while the machine was in operation, so that from 4 to 6 inches were cut off regardless of plant height. The results of the experiments are given in table 5.

Yields varied in the different tests and treatments, depending on the time of topping, the height of the cotton when topped, and the amount of lodging. Yield was reduced in the plots topped at 42 inches. This reduction was statistically significant in only one test, but the trend was evident in four out of six tests. Reduced yields appeared to occur in the plots topped relatively late in the season. There was no difference in the average yield between the check plots and those topped at 48 and 52 inches. In the several tests at these heights, there was one significant increase in yield from a midseason topping (August 3), and one reduction in yield from a late topping (August 16). Hand-topping had a tendency to increase yield, but this trend was significant in only two tests, and the average increase was slight. Variable topping (cutting off only 4 to 6 inches) had no effect on yield.

The degree of lodging, rather than the kind or height of topping, determined the efficiency of mechanical harvesting. When there was lodging in the check plots, picker efficiency was always lower than in the topped plots. With severe lodging, the difference was as much as 3.5 per cent.

There was little difference between the check and the topped cotton in seed-cotton trash and lint grades. When lodging occurred, there was some tendency for the trash percentage to be higher and the grade lower.

Lodging in the check cotton varied in the different tests from none to as much as 75 per cent. There was no lodging in any of the cotton topped at 42 inches nor in that topped at variable heights. In the cotton topped at 48 inches there was lodging in only one test out of nine. This occurred in only one of the four replicates in that test. In two tests with machine-topping at 52 inches, and in two with hand-topping, some lodging occurred.

Topping cotton eliminated or greatly reduced lodging. Yield was not reduced by mechanical topping when not more than about 6 inches of the main stalk was removed. Topping to a height of about 48 inches gave the best results in these tests on the basis of lodging, yield, and picker efficiency.

Effect of Harvest-Aid Chemicals on Yield and Mechanical Harvesting

DEFOLIATION OF COTTON before harvest has become a common practice since the development of the mechanical picker. Most of the chemicals used for defoliation are designed to cause the leaves to drop from the plant. Some, however, are the desiccant or herbicidal type, which cause the leaves to dry but remain on the plant. Tests were conducted five different years to determine the effect of no defoliation (check), defoliation, and desiccation on yield, mechanical picker efficiency, seed cotton trash, and grade of cotton. The tests were conducted in cotton which had been planted to a stand and which averaged from 3 to 4 feet in height when harvested. Harvesting was done each year before frost occurred. In the defoliated plots, from 70 to 95 per cent of the leaves had dropped from the plants. Table 6 gives the results of the tests.

Yield was reduced both by defoliation and desiccation in all years except 1953. In 1953, first picking was not done until November 9, while in the other four years first picking was done in October. It is thought that the later picking date allowed more cotton bolls to mature before the application of the chemicals. There was no significant difference in picking efficiency between the three treatments. The defoliated cotton had slightly less seed cotton trash and averaged slightly higher in grade than the other two treatments, but the differences were not significant. In 1961, tests of the fiber properties of the cotton showed no detrimental effects on staple length or fiber quality with either defoliation or desiccation.

TABLE 6

EFFECTS OF HARVEST-AID CHEMICALS ON YIELD AND OTHER FACTORS IN MECHANICAL HARVESTING

Year of test	Treatment		
	Check (no defoliant)	Defoliated	Desiccated
	YIELD		
	bales per acre	*bales per acre*	*bales per acre*
1952	2.27	2.09	2.22
1953	2.45	2.48	2.46
1954	2.90	2.78	2.70
1961	2.91	2.71	2.85
1962	3.15	2.84	2.99
Av.	2.74	2.58	2.64
	PICKING EFFICIENCY		
	per cent	*per cent*	*per cent*
1952	95.4	95.4	93.9
1953	95.0	94.0	92.5
1954	94.8	95.1	95.1
1961	90.1	89.5	89.3
1962	94.1	95.6	94.9
Av.	93.9	93.9	93.1
	SEED COTTON TRASH CONTENT		
	per cent	*per cent*	*per cent*
1952	7.3	4.6	7.0
1953	...	...	...
1954	6.8	6.7	6.4
1961	9.8	9.0	9.1
1962	8.7	8.5	9.3
Av.	8.1	7.2	8.0
	GRADE INDEX*		
1952	98.5	100.0	98.5
1953	100.0	100.5	95.5
1954	99.0	100.0	99.5
1961	100.0	100.0	100.0
1962	....	....	....
Av.	99.4	100.1	98.4

* Middling = 100; strict low middling = 94.

Effects of Spindle-Moistening Agents on Picker Efficiency and Cotton Quality

MOISTENING AGENTS are used in cotton pickers to keep the spindles clean. They also aid in the picking by increasing the adhesion of the cotton to the spindle. The latter is necessary for the smooth-spindle pickers. The agent generally recommended by the picker manufacturers is water plus a detergent to reduce the surface tension. The amount of water used varies according to picking conditions but is usually between 3 and 7 gallons per bale of cotton. Some picker operators use a textile oil—light, volatile mineral oil—instead of water. The advantages claimed for its use are less volume required (a ratio of about one pint or less of oil compared to one gallon of water), cleaner spindles and picker head, no danger of freezing in cold weather, and no clogging of the tubes from the tank to the moistening pads. There has been, however, some question as to the effect of the textile oil on the efficiency of picking and also on the quality of the cotton. To determine these effects tests were conducted two different years at Shafter. In these tests the moistening agents used were plain water and water plus a detergent, each at a rate of 2 to 8 gallons per bale; and textile oil at a rate of 1 to 7 pints per bale. The picker was a single-row, barbed-spindle type. The harvesting was done in October. The weather was clear, calm, and relatively dry. The temperature ranged between 55°F and 80°F and the humidity between 30 and 60 per cent. The cotton during the first year (1955) was 3 to 4.5 feet in height, standing erect, and about 70 per cent defoliated; it yielded about 2¼ bales per acre. The cotton during the second year (1956) varied from 3 to 6 feet in height with some rank, lodged portions. Defoliation varied from about 50 to 90 per cent. Yield was about 2 bales per acre.

Picker efficiency both years was lower with the textile oil than with water. The reduction in efficiency varied inversely with the amount of oil used, ranging from 1.0 per cent with 7 pints of oil per bale to about 4.0 per cent with 1 pint per bale. When water was used, there was no difference in picker efficiency between the lowest (2 gallons per bale) and the highest (8 gallons per bale) rates, nor was there any difference between plain water and water plus a detergent.

Neither the kind nor the quantity of moistening agent had any effect on the trash content of the seed cotton and lint, nor on the classer's grade. The only noticeable difference in ginning was light blue smoke from the drier exhaust with the use of textile oil. This indicated that some of the oil was removed in the drier.

Measurements of the fiber, spinning and finishing properties of the lint in the 1955 tests showed no difference in quality between the treatment with oil or the treatment with water. In the 1956 tests there was a slight reduction in the dyeing quality of the cotton harvested with the high rate of oil.

The oil did an excellent job of keeping the spindles clean and also was better than water for the general cleanliness of the picker head. Both the plain water and water plus a detergent did a reasonably good job of keeping the spindles clean, particularly with the higher rates. Water plus a detergent was somewhat better than plain water. Picker head trash was less with oil than with water.

Increase in Seed Cotton Moisture Due to Spindle-Moistening Agents

A CERTAIN AMOUNT of the spindle-moistening agent is absorbed by the seed cotton during harvest. This has been of some concern because high moisture content adversely affects the storage, ginning, and grade of cotton. Tests of the seed cotton made during the spindle-moistening-agent studies showed an increase of 1 to 3 per cent of moisture during picking. Even with the oil, there was an increase of as much as 2 per cent. In these tests the increase came not only from the moistening agent but also from green material that was harvested with the cotton. To more accurately determine the amount of moisture absorbed during harvest, special tests were conducted. In these tests a tracer material was mixed with the moistening agent. The tracer absorbed by the cotton was recovered, and from the known percentage in the agent the amount of moisture absorbed was calculated.

In one series of tests, water and water plus a detergent were used as the moistening agents at rates of 2, 5, and 8 gallons per bale. The tests were made with both a barbed-spindle and a smooth-spindle picker (fig. 9). The results showed no significant difference in the amount of moisture absorbed by the seed cotton, whether the agent was water or water plus a detergent. The seed cotton moisture increased less than 1 per cent with both types of pickers when 2 gallons of moistening agent per bale were used. When 8 gallons were used, the increase was 2 per cent with the smooth-spindle picker and 2.5 per cent with the barbed-spindle picker.

In another series of tests, both water and water plus a detergent were used at a rate of 5 gallons per bale. The object of these tests was to determine if the amount of moisture already in the cotton on the plants had any effect on the amount of moistening agent absorbed in harvesting. The results indicated that the amount absorbed increases according to the amount of moisture already in the cotton. An increase of about $1\frac{1}{2}$ per cent in moisture content was obtained

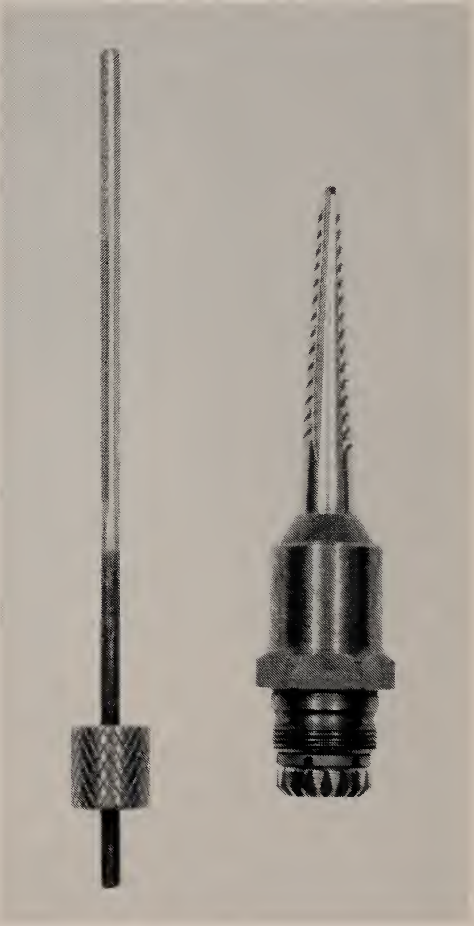


Fig. 9. Cotton picker spindles. *Left:* smooth rod; *right:* barbed cone.

when the cotton on the plants already had 5 to 7 per cent moisture content, compared to a little over 2 per cent increase when the cotton already had 8 to 10 per cent moisture content.

The general recommendation for best ginning is that the seed cotton have less than 10 per cent moisture content. The results of the tests indicated that, to meet this requirement, only enough water should be used to keep the spindles clean and harvesting should not be done when the seed cotton moisture on the plants is more than approximately 8 per cent.

Effect of Pressure Plate Adjustments on Cotton Picker Performance

THE PRESSURE PLATES or compressor sheets on the barbed-spindle-type cotton pickers are hinged pieces of sheet metal that force the cotton plants into a narrow opening so that the spindles can reach practically all parts of the plants. They are held in position by spring tension so that they will yield when the pressure of the plants against them is greater than the spring tension. The springs are fastened to a vertical shaft, and the tension can be adjusted by turning the shaft (fig. 10). Adjustment may also be made for the clearance between the plates and the tips of the spindles.

To determine the effect of different pressure-plate yield pressures and spindle clearances on the performance of a high-drum, single-row, barbed-spindle cotton picker, a series of tests was made. In these tests the pressure was varied in four steps from light to stiff with clearances of ¼ inch and ¾ inches, respectively.

The pressure or force required to cause the plates to yield was measured by a spring scale attached to the hinge connecting the two halves of the plates (fig. 10). This point is the narrowest part of the throat opening. An attempt was made to have the yield pressure on the front and rear plates as nearly equal as possible with the adjustment steps provided. The four pressure settings used in the tests would normally be considered as light, medium, medium stiff, and stiff.

Four different tests were made to determine the effect of the pressure plate settings on the picking efficiency, trash content, and grade of cotton. One other test was made to determine the effect of the settings on the amount of green bolls knocked off the plants. The cotton in the

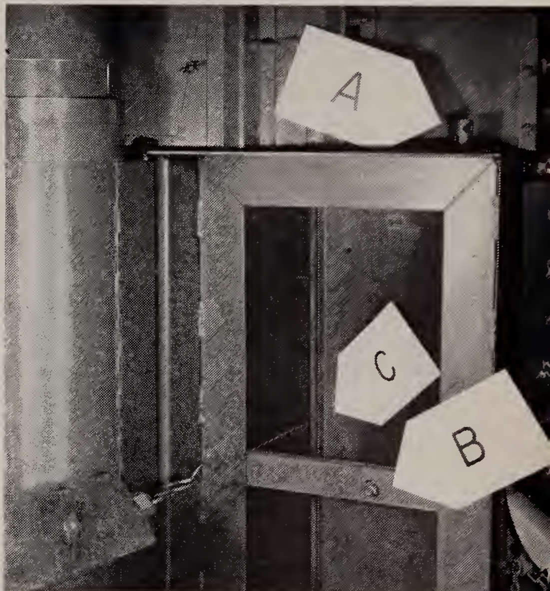


Fig. 10. A view of the back side of a pressure plate, showing (A) the spring tension adjustment; (B) the spindle clearance adjustment; and (C) the equipment for method of determining the yield pressure.

tests varied from well-defoliated, medium-sized plants to rank, tall plants, some of which were lodged and only about 50 per cent defoliated. The variations in the plants occurred both in the different fields in which the tests were made and within the same field in a given test. The yield varied from about 1½ to 3 bales per acre, most fields yielding between 2 and 2½ bales per acre. Dry weather conditions prevailed during all the tests. The results of the tests for picker efficiency are shown in table 7 and figure 11.

TABLE 7

EFFECT OF PLATE-YIELD PRESSURE AND SPINDLE CLEARANCE ON COTTON PICKER EFFICIENCY*

Plate yield pressure, front — rear	Picker efficiency	
	¼ inch clearance	¾ inch clearance
lbs.	*per cent*	*per cent*
17 — 20	88.6	85.8
30 — 30	90.2	86.8
46 — 44	90.6	87.2
55 — 58	91.9	88.1
Av.	90.3	87.0

* First picking.

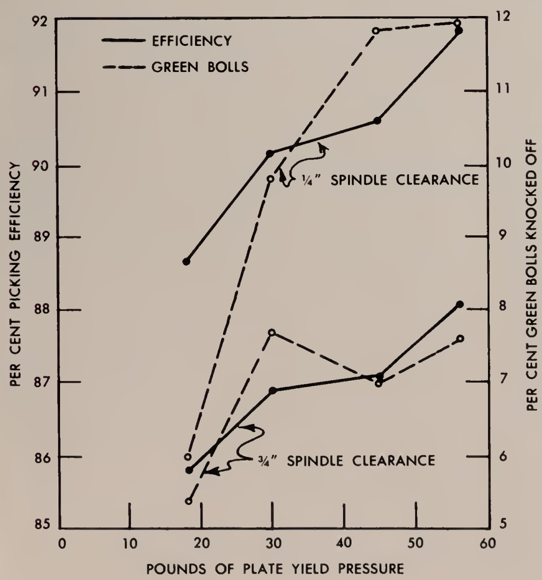


Fig. 11. Graph showing the effect of different pressure-plate settings on picking efficiency and green-boll loss.

The picker efficiency was significantly affected by both the yield pressure and the spindle clearance. There was an increase of 2½ to 3 per cent in picker efficiency between the lowest and highest pressures. The ¼ inch spindle clearance gave 3 to 4 per cent higher efficiency than the ¾ inch clearance. The unharvested cotton was about equally divided between that left on the plants and that dropped on the ground.

The percentage of green bolls knocked off the plants was also significantly affected by both pressure and clearance (fig. 11). With ¼ inch clearance, the green-boll loss increased from 6 to 12 per cent between the lowest and the highest pressure settings. With ¾ inch clearance, the loss increased from 5.4 to 7.6 per cent. The different pressure and clearance settings had no significant effect on the amount of seed cotton or lint trash nor on the grade of cotton.

The results obtained in these tests show that the optimum setting of the pressure plates depends on the amount of green bolls on the plants. When there are few green bolls, the plates should be set with a high yield pressure and close spindle clearance in order to obtain greatest picking efficiency. When there is a large number of green bolls, a light to medium pressure and a ¼ inch to ½ inch spindle clearance would give best results. This would reduce the picking efficiency, but that would be offset by the loss of fewer green bolls.

Effect of Unsynchronized Speeds on the Performance of a Cotton Picker

ON ONE OF THE large cotton farms in the San Joaquin Valley, the picking speed of barbed-spindle cotton pickers was reduced from 2.1 mph to 1.5 mph by changing the low-gear ratios in the cotton picker tractor. The speed of the spindle drum drive, however, was not affected by this change. In operation, therefore, the spindle drum was not synchronized with the forward speed of the tractor. With this unsynchronized arrangement, an increase in picking efficiency was claimed over normal operation. A test conducted on this farm with two of these unsynchronized pickers in 1957 showed an average of 2.5 per cent increase in picking efficiency over machines operating with synchronized or normal speeds.

In order to check the effect of the unsynchronized speeds under more controlled conditions, tests were conducted for three years at Shafter—1957, 1958, and 1959. A single-row, barbed-spindle-type cotton picker was used. While different pickers were used each year, they were all of the same make. The same picker was used for all tests in any one year. In the 1957 tests, three combinations of tractor and spindle drum speeds were used, one synchronized and two unsynchronized. The synchronized consisted of operating the picker with normal low-gear speeds. One of the unsynchronized combinations was obtained by reducing the low-gear tractor speed from 2.1 mph to 1.5 mph and retaining the normal low-gear spindle drum speed of 80 rpm. The other unsynchronized combination was obtained by operating the tractor at the normal low-gear speed of 2.1 mph and the spindle drum at the normal second-gear speed of 113 rpm. In the 1958–1959 tests, another synchronized combination was added—that of operating the picker with normal second-gear speeds.

The cotton harvested in the tests varied in yield from 1.5 to 3.0 bales per acre. The plants were 3 to 5 feet in height, standing erect, and 75 to 90 per cent defoliated. The tests were conducted in October of each year during clear, dry weather.

The results of the tests are given in table 8. The picking efficiencies of the two unsynchronized speed combinations were greater than those of the synchronized speed combinations in all tests. They ranged from 1 to 3 per cent higher. The highest efficiency was obtained with the unsynchronized speeds of 1.5 mph and 80 rpm. The lowest efficiency was obtained with normal low-gear synchronized speeds. There was no significant difference in the trash content of either the seed cotton or the lint, nor in the grade index. No differences in damage to the plants could be observed in any of the tests.

Table 8

RESULTS OF TESTS WITH A COTTON PICKER HAVING SYNCHRONIZED AND UNSYNCHRONIZED TRACTOR AND DRUM SPEEDS

Year of test	Speeds		Picker efficiency	Losses		Trash		Grade index of cotton*
	Tractor	Drum		On plant	On ground	Seed cotton	Lint	
	mph	*rpm*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	
1957	2.1†	80†	94.9	2.8	2.3	5.5	3.3	95
	1.5	80	95.8	1.9	2.3	6.9	4.3	94
	2.1	113	95.9	2.1	2.0	7.2	4.0	95
1958	2.1†	80†	89.9	4.7	5.4	7.5	3.4	95
	1.5	80	92.9	2.9	4.2	7.5	2.8	96
	2.1	113	92.2	3.0	4.8	7.3	3.4	96
	2.9‡	113‡	91.1	3.8	5.1	7.1	3.2	96
1959	2.1†	80†	92.9	2.9	4.2	10.3	3.4	98
	1.5	80	95.4	1.7	2.9	9.6	3.5	99
	2.1	113	94.7	1.6	3.7	10.3	3.5	99
	2.9‡	113‡	93.6	2.5	3.9	9.3	3.7	100
Average: 3 years	2.1†	80†	92.6	3.5	4.0	7.8	3.4	96
	1.5	80	94.7	2.2	3.1	8.0	3.5	96
	2.1	113	94.3	2.2	3.5	8.3	3.6	97

* Middling = 100; strict low middling = 94.
† Normal low-gear speeds (synchronized operation).
‡ Normal second-gear speeds (synchronized operation).

Cotton Stalk Cutters

During the past 10 years a machine shop in Bakersfield, California, developed a cutter which not only shreds the stalks but also pulls up and shreds the roots. The machine consists of a blade that cuts off the roots from 8 to 14 inches under the ground surface; a pair of rollers which grasps the plants and pulls them out of the ground and forces them into a chamber above the rollers; and two horizontally revolving blades in the chamber which shred the plant (fig. 12). It does a good job of both removing and cutting up roots as well as stalks. But it is more expensive and requires more power than cutters which shred only stalks. At present it is made only as a single-row machine.

A test was conducted comparing this machine with a conventional cutter using only a horizontally revolving blade. The results of this test are given in table 9. The root-and-stalk cutter removed and shredded all the roots, which were 20 per cent of the total plant weight. It also finely shredded or cut into lengths of less than 6 inches 83 per cent of the plant, compared to 38 per cent with the conventional cutter.

The shredding of the roots practically eliminated any interference they might cause in the planting and cultivating of the succeeding crop. This was due to the fact that the smaller pieces caused less trouble and that they also decayed more rapidly.

TABLE 9

DISPOSAL OF COTTON PLANTS BY ROOT-AND-STALK CUTTER COMPARED TO CONVENTIONAL STALK CUTTER

Disposal of plant	Root-and-stalk cutter	Stalk cutter
	per cent of total plant weight	*per cent of total plant weight*
Roots not shredded	0	20.0
Finely shredded	35.5	13.5
Cut into lengths less than 6″	47.5	24.5
Cut into lengths 6″–12″	14.0	23.5
Cut into lengths 12″–18″	2.5	9.0
Cut into lengths over 18″	.5	9.5
Total	100.0	100.0

Fig. 12. Stalk cutter which removes and shreds roots as well as stalks.

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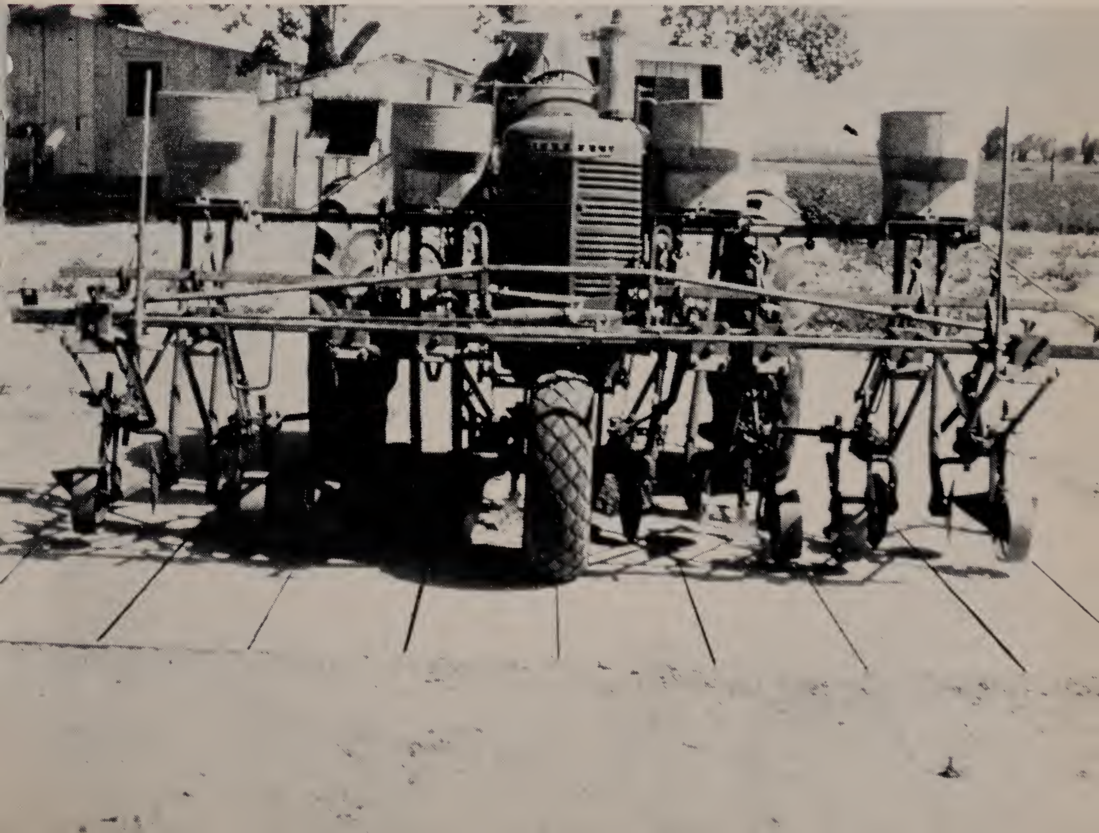
Fig. 13. Line diagram on concrete slab used for setting equipment before going into the field.



Appendix

Line-diagram method of setting farm implements

Row-crop farming requires accurate setting of implements for such operations as listing, planting, cultivating, and the like, to obtain greatest efficiency and speed. Setting in the field is often difficult and time-consuming because of the uneven conditions. The line-diagram method was developed in 1948 at the Delta Branch Experiment Station, Stoneville, Mississippi. It requires a smooth, level surface marked with parallel lines representing the plant rows and the middles between the rows (fig. 13). For example, with 40-inch row spacing there would be lines 20 inches apart. The equipment is run onto this surface with the wheels exactly over the lines representing the middles. The ground-working tools to be used are then set as desired in relation to the plant rows. When the implements are properly set, little if any final adjustment is necessary in the field.

A wooden floor or concrete slab is best for laying out the diagram with painted lines. The diagram should be large enough so that all the equipment to be set will fit over the lines, which should be accurately spaced. It is helpful to have the lines representing rows a different color from those representing middles.

A method for determining plant population

It is often desirable to know the approximate plant population in a stand of cotton. A simple and quick method of determining the number of plants per acre is to count the plants in a length of row equal to .001 acre, and multiply that number by 1000. For example, if the number of plants counted is 32, then the plants per acre would be 32×1000, or 32,000. The following are lengths of row equal to .001 acre, for the common cotton row spacings:

ROW SPACING	LENGTH OF ROW FOR .001 ACRE	
inches	*feet*	*inches*
36	14	6
38	13	9
40	13	1
42	12	5

A stick or light chain of the proper length for the row spacing to be measured can be used to mark off the length of row for the count. Counts should be made on a number of rows and in several locations in the field to get an average of the plant population.

The average spacing of plants in the row, where the distribution is reasonably uniform, can be determined from the following:

AVERAGE PLANT SPACING	ROW SPACING			
	36-inch	38-inch	40-inch	42-inch
inches	*plants per acre*	*plants per acre*	*plants per acre*	*plants per acre*
2	87,000	82,500	78,400	74,700
4	43,500	41,200	39,200	27,300
6	29,000	27,500	26,200	24,900
8	21,700	20,600	19,600	18,700
10	17,400	16,500	15,700	15,000
12	14,500	13,700	13,100	12,500

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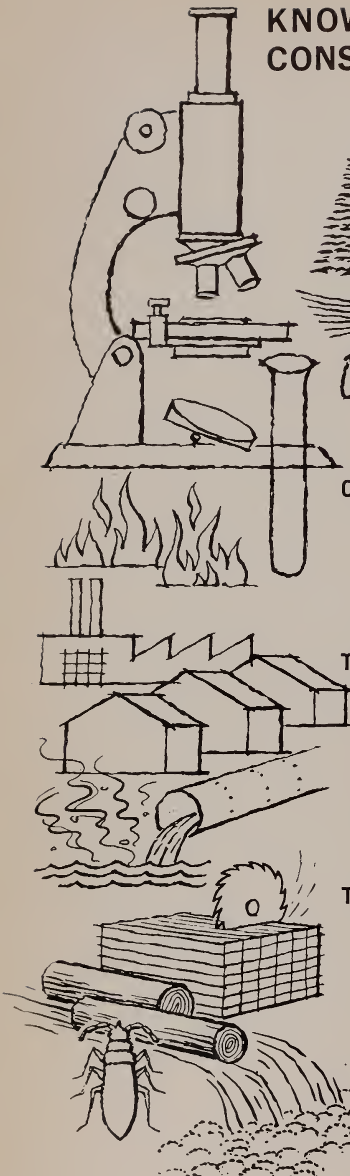
KNOWLEDGE GAINED BY RESEARCH CAN HELP CONSERVE CALIFORNIA'S WILDLAND RESOURCES



CALIFORNIA WILDLANDS . . .

- 65 million acres of mountains, foothills, canyons, rivers, lakes, and sea coasts.
- a giant "farm" for timber and forage.
- a vital source of California's water supply.
- an "outdoor playground" for millions of vacationers.

THE THREAT: the onslaught of . . .

- population growth.
- urban and industrial expansion.
- increasing demand for water, lumber, forage.
- wildfires.
- insects and plant and animal diseases.
- waste.

THE SOLUTION: coordinated research on using wildland resources to realize their full potential . . .

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- usefulness of timber cut could be doubled by new products made from current waste.
- forage production for livestock and game could be tripled.
- watersheds could be made to yield more usable water and cause fewer floods.
- tens of millions of dollars lost to fire, insects, diseases could be saved.
- timber, forage, and recreation uses need not exclude each other.

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TO KNOW IS TO LIVE IN ABUNDANCE . . .