Factors in Cotton Irrigation

quality of cotton fiber not materially affected by different irrigation treatments in experiments on three types of soil

J. R. Stockton and L. D. Doneen

Studies on the relationship between irrigation frequency and cotton yield have included various irrigation practices on a wide variety of soil types.

Investigations at the United States Cotton Field Station at Shafter were on a Hesperia sandy loam soil, and concerned a number of different irrigation treatments.

Under Treatment *A*—four irrigations—the cotton plants were allowed to definitely wilt prior to each irrigation.

Plants given Treatment *B*—12 irrigations — were irrigated frequently throughout the season.

The Treatment *C*—six irrigations—plot was irrigated with the first indication the plants were suffering from a lack of soil moisture. The first sign of stress was a color change in the foliage often accompanied by transient wilting visibly apparent the afternoon prior to the irrigation.

These three treatments have constituted the basic irrigation schedule for the work at the Cotton Station.

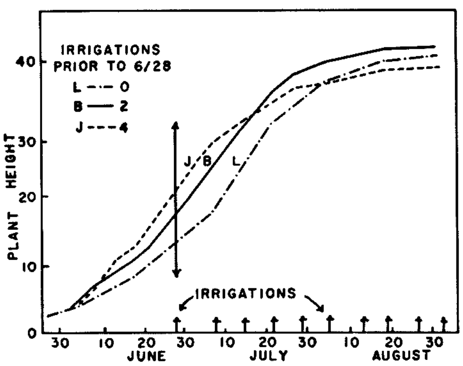
Treatment *C*—where the number of irrigations was cut from 12 to six—resulted in a significant decrease in vegetative growth, but no significant difference in lint yield. Similar results have been obtained for several years, and point up the possibility of using the plant as an over-all indicator for soil moisture deficit without reducing yields. In this case the plant integrates many soil moisture variables—nematodes, clay pans, hardpans, poor water penetration, and others—which are difficult to evaluate. The color change in foliage is due primarily to the lack of new terminal growth and appears to be a better indication of moisture stress on the light sandy soils than on the heavy soils.

Moisture Characteristics for Soils Used in Irrigation Tests

Location	Soil	% Soil moisture ME*	% Soil moisture PWP*	Avail. water inches per foot of soil
Shafter	Hesperia Sandy Loam	8.8	4.4	0.7
Button-willow	Merced Clay Loam	33.6	19.2	2.3
Corcoran	Tulare Clay	40.8	23.0	2.6

*ME = Moisture equivalent, and represents the maximum amount of moisture a well drained soil will hold—often referred to as "field capacity."

*PWP = Permanent wilting percentage, and is the lower limit of readily available soil moisture, where plants wilt or a cessation in growth occurs.



Varying the number of irrigations on the plant height in inches. Cotton Station, Shafter.

Yield in Bales and Plant Height for Three Irrigation Treatments, Shafter

Treatment	B	C	A
No. irrigations	12	6	4
Yield, bales per acre	2.79	2.67	2.09
Plant height, inches	42	37	31

The influence of these soil moisture regimes on insect activity appears to be significant. Lygus bugs are a serious insect pest of cotton in the San Joaquin Valley. To determine the abundance of this pest in the irrigation plots, sweep counts were made in treatments *A* and *B*, the extreme treatments in irrigation frequency. The number of lygus bugs caught in an insect net from 50 sweeps down a cotton row is commonly used as an index for determining control measures. If 10 or more bugs are counted, control measures are indicated. The average number of lygus bugs found in the four replications of the dry Treatment *A* was 4.8, and 10.9 in the more frequently irrigated Treatment *B*.

Preflowering Irrigations

Early irrigations were made by varying the number of irrigations prior to the initiation of flowering on June 28 and then irrigating frequently for the rest of the season.

In this study two additional treatments were included and compared with Treatment *B* which is the one usually practiced for the test area.

The additional treatments were:

Treatment *J*—14 irrigations—irrigated excessively prior to June 28—the initiation of flowering—after that date irrigation was the same as Treatment *B*.

The plot receiving Treatment *L*—10 irrigations—was not irrigated prior to the initiation of flowering. On June 28 the plants were severely stressed and received their first irrigation. After that date irrigation was the same as Treatment *B*.

The vegetative growth, as measured by height of plant, for these treatments throughout the season is shown in the graph on this page. On June 28 the plant heights for treatments *J*, *B* and *L* were 19″, 15″ and 12″, or a maximum difference of 7″, whereas on September 1 the difference between irrigation treatments was less than 3″.

Early Irrigations on Yield and Plant Disease, Shafter

Treatment	J	B	L
No. irrig. prior to 6/28	4	2	0
Yield, bales per acre	2.53	2.79	2.49
% plants infected with vert. wilt	18	6	2

The number of irrigations prior to June 28, lint yields and per cent plants infected with verticillium wilt are given in the following table. After June 28 all treatments received 10 irrigations and followed the irrigation schedule for Treatment *B*.

Complicating Factor

A complicating factor is the incidence of verticillium wilt as influenced by irrigation frequency early in the season. This was evaluated by determining the per cent plants exhibiting visual symptoms of the disease. The severity of the symptoms was more intense for Treatment *J* than for the other two treatments and may have been responsible for the yield being lower in this treatment. The yield reduction for Treatment *L* was probably due to the extremely small plants at flowering as these plants were suffering from a lack of soil moisture for more than three weeks. Consequently, with frequent irrigations after June 28, rapid vegetative growth occurred, and the boll set was late, followed by a delayed maturity of the crop.

The experiment was essentially repeated—with the exception that Treatment *C* was substituted for *B*—and after June 28 all treatments received five irrigations on the same schedule as Treatment *C*.

These additional treatments are as follows:

Treatment *K*—nine irrigations—irrigated with excessive frequency prior to June 28, after which it was irrigated the same as Treatment *C*.

Treatment *M*—five irrigations—was not irrigated prior to the initiation of flowering. On June 28 the plants were severely stressed and received their first irrigation. After that date irrigation was as for Treatment *C*.

These treatments were primarily concerned with the number of irrigations prior to June 28 and then irrigating for the balance of the season at the first signs of soil moisture deficit. The results of this experiment are given in the following table.

Varying the Early Irrigation and Irrigating by Color Change, Shafter

Treatments	K	C	M
No. irrig. prior to 6/25.	4	1	0
Plant height, in. 6/25..	20	16	11
Plant height, inches 9/1	36	37	35
Yield, bales per acre..	2.61	2.67	2.51
% plants infected with vert. wilt	15	8	1

Again, early irrigations have resulted in more plants infected with verticillium wilt. The plant height on June 25 showed wide differences between treatments, but by September 1 the differences were obliterated. Although vegetative growth and plant diseases are markedly influenced by early irrigations, the subsequent irrigations timed by color change of the plant, or Treatment *C*, had a tendency to reduce these variations by harvest.

Other irrigation trials were conducted on a Merced clay soil near Buttonwillow and on a Tulare clay soil near Corcoran, in the Tulare Lake Basin.

The irrigation treatments tested in these studies were:

Treatment *A*—dry—where the plants were allowed to wilt severely prior to each irrigation;

Treatm^nt *B* — wet—irrigated frequently all season;

Treatment *C*—intermediate—irrigated at a frequency intermediate between treatments *A* and *B*.

Treatment *D*—dry then wet—was severely stressed for moisture prior to the first irrigation and was then irrigated frequently. At Buttonwillow the first irrigation was applied on July 9 and at Corcoran on July 26.

The results for the various irrigation treatments at Buttonwillow on Merced clay soil are given in the following table.

Results of Irrigation Trials at Buttonwillow on Merced Clay Loam

Treatment	A	C	B	D
No. irrigations ..	3	4	7	5
Date, first irrig...	7/9	6/25	6/15	7/9
Yield, bales/acre	2.16	2.11	1.74	2.16
% plants infected with vert. wilt	48	35	71	38

Only Treatment *B* received two irrigations in June and consequently had a high soil moisture condition for the early vegetative growth. The severity of verticillium wilt appears to be directly related to this early June irrigation. However, general level of infection is much higher than on the sandy soils at Shafter. Apparently this disease is responsible for the 29% reduction in yield for the *B* treatment. Otherwise there are little differences in yield for the various soil moisture conditions as maintained by the different irrigation schedules. The vegetative growth shows differences, especially for Treatment *A*, which changed color or wilted before each irrigation and for Treatment *D* for a part of the season.

The experiments at Buttonwillow and at Shafter indicate that high soil moisture or frequent irrigations early in the season will increase the verticillium wilt in plants with a corresponding decrease in yield. This would be especially significant for seasons favorable for a high incidence of the disease.

The yields and the number of irrigations for the Tulare Lake Basin plots are given in this table.

At the Tulare Lake Basin location verticillium wilt was not a problem, which may be due, in part, to the lateness in June for the first irrigation on Treatment *B*.

Results of Irrigation Trials at Tulare Lake Basin on Tulare Clay

Treatment	A	C	B	D
No. irrigations ..	2	3	6	4
Date, first irrig..	7/26	7/15	6/23	7/26
Yield, bales/acre	1.15	1.95	2.07	1.72

This soil is extremely heavy and soil moisture extraction by the cotton roots was limited to the surface 18″–24″ of soil. Because of the poor soil structure, root development in the second foot of soil is variable and sparse. The yield, to some extent, reflects frequency of irrigation, but not to the degree that is indicated by the vegetative growth.

Plant Height

On July 29 the height of the plant for treatments *A* and *D* was 13″ as compared to 18″ for *C* and 27″ for Treatment *B*. The moisture stress early in the season was so severe for treatments *A* and *D* that a reduction in both yield and vegetative growth occurred even though Treatment *D* was irrigated frequently after July 26. Treatment *C* received half

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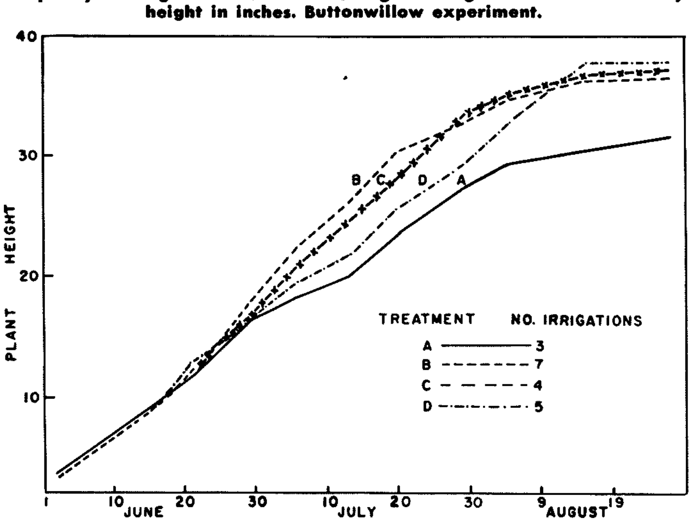
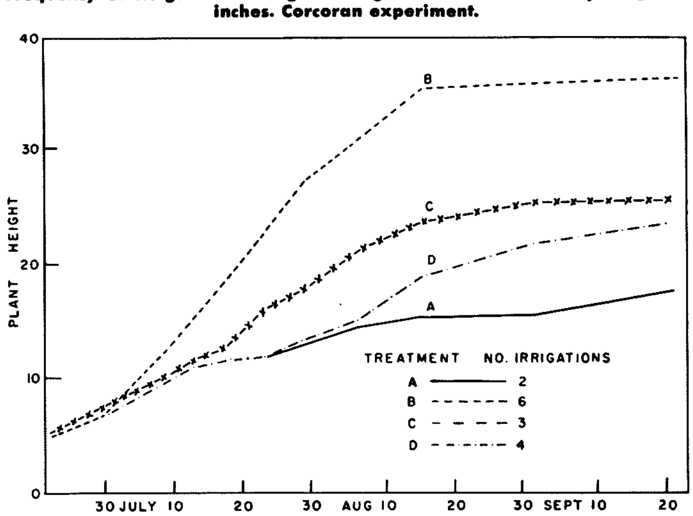
Frequency of irrigation in relation to vegetative growth as measured by height in inches. Buttonwillow experiment.



Frequency of irrigation on vegetative growth as measured by height in inches. Corcoran experiment.



Costs of Irrigation Water

distance of transport, height of lift and timing of pumping operations influence costs of irrigation water to farmers

L. J. Booher and M. R. Huberty

The price farmers pay for irrigation water depends to a large extent on the cost of constructing and operating the engineering works needed to deliver the water to their farms.

The cost of irrigation water varies from a few cents to more than $50 for each acre-foot of water used. The higher costs are where the water must be transported long distances or must be lifted against high heads.

The waters within the state—surface waters and ground waters—are presumed to be the property of the people of the state. However, farmers have spent considerable sums for legal actions relevant to establishing or protecting their rights to the use of water, and these sums are part of the development costs of an irrigation project.

Most of the early irrigation projects were situated in areas where surface waters could be easily diverted, or where shallow ground waters were available for pumping. The present cost of water delivered by these old established projects is, in many cases, the lowest to be found in the state. Some projects deliver water to farmers for less than $1.00 an acre-foot. The cost of water on other projects may range from $2.00 to more than $3.00 an acre-foot.

Water costs on more recently developed projects and for projects that are being proposed reflect the higher costs of constructing irrigation works needed to carry water great distances. Water from areas of excess supply is often carried several hundred miles to water deficient areas.

Under the Central Valley Project, costs of Class 1 water delivered at canalside vary from $2.75 to $3.50 an acre-foot. In addition, the farmers pay for the cost of the distribution works needed to deliver water to their farms.

Water costs under the Feather River Project will depend on the distance the water must be carried and the lift required.

Where surface waters are not available for irrigation, ground waters may be obtained by pumping from wells. There are some 75,000 such wells used in California, varying from less than 50′ deep and costing less than $1,000 to wells several thousand feet deep and costing $25,000 or more.

Pumping Costs

Costs for pumping water from wells include annual fixed charges for interest, taxes, depreciation and maintenance on wells and pumping equipment, and charges for energy needed to operate the power unit.

The energy required to pump an acre-foot of water depends on the efficiency of the pumping equipment and on the height of the lift—whether a few feet or several hundred feet. The cost of power is related not only to the amount of energy used but to the number of hours that the pump is operated each year. Because of the power rate structure in common use by utility companies in California, power costs will be less for a small pump operating long hours than for a large pump operating a few hours, even though both pumps use the same amount of energy and deliver the same amount of water with the same lift. Overnight storage reservoirs are used on many farms, to permit continuous operation of pumps tailored to the water requirments of the area to be irrigated. The reservoirs permit irrigating during daylight hours while taking advantage of reduced power costs. Joint use of a single pump by several farmers is another practice used to reduce pumping costs.

There are wide limits between the costs of pumping water in California. An average cost for power might be 2¢ an acre-foot per foot of lift plus a similar amount for fixed charges, making a total of 4¢. To lift water 100′—in this case—would cost $4.00 for each acre-foot pumped.

In many ground-water basins the amount of water being pumped is greater than the normal recharge to those basins. This has resulted in a lowering of the water table and increased pumping lifts with increased costs. Many farmers have found it necessary to lower the pumps in their wells as the water table recedes. During the past several decades, improvements in pump operating efficiencies and reductions in power rates partly compensated for the increased lifting costs, but the trend has been reversed during the last several years. There has been some increase in power costs and a considerable increase in the cost of pumping equipment.

With some high income crops, water costs may be only a minor part of the total production costs. In such cases a considerable increase in water costs may not greatly affect the farmer's operations. On the other hand, with many low income crops, the cost of water is an important item, and any increase in the price a farmer pays for irrigation water may make his operations nonprofitable or place him at a disadvantage in competing with areas where water costs are less.

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COTTON

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the number of irrigations as compared to Treatment *B*, yet the reduction in yield was only 6% whereas a 29% reduction occurred in vegetative growth. This is an excellent example of where a soil condition limits root development and the relationship between irrigation frequency on yield and vegetative growth when compared with results obtained on the Buttonwillow plots where root development was better.

In all three locations and extremes in irrigation treatments the quality of the fiber was not materially affected. Lint from Shafter and Tulare basin showed no differences in either grade or staple length even for the extremely dry treatments where the yields were severely reduced. After the lint was spun into yarn there were no outstanding differences. However, the less frequently irrigated treatments did show a tendency to have slightly stronger yarn with a better appearance index which is probably a reflection of less trash in the seed cotton and fewer nappy thin walled fibers.

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