



Irrigation plots in the above photo are receiving a pre-plant irrigation which will wet the soil profile to a depth of six feet to field capacity.

IRRIGATION AND NITROGEN FOR COTTON

... a yield surface and optimum combinations on a Panoche loam soil

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Studies on Panoche clay loam soil showed the effectiveness of irrigation water and nitrogen fertilization for cotton to be highly interdependent. A lint yield equation was calculated to determine the combination of irrigation water and nitrogen that would minimize costs for specific yield levels and input cost conditions.

THE MANAGEMENT OF IRRIGATION water and nitrogen fertilization influences cotton production on any soil in the San Joaquin Valley. In past years most of the data obtained have come from studies where only one of the two factors was included as a variable treatment, while the other was held at some presumably "optimum" level. However, developments in economic-agronomic studies have recently demonstrated the feasibility of using empirical crop yield equations which facilitate the use of production economics principles. (The term "yield equation" is used in this report to designate the total lint yield resulting from specific quantities and combinations of irrigation water and nitrogen fertilization.) These principles greatly assist in the determination of optimum use levels and least-cost combinations of resources used in production.

Panoche soil

During 1966 an experiment was conducted on a soil classified as Panoche clay

loam at the West Side Field Station to determine the influence of different irrigation and nitrogen fertilization levels on the production characteristics of two varietal strains of Acala cotton.

TREATMENTS

Irrigation	
I_1 —Pre-plant + 7/22-23 (11 acre-inches)	Total water applied in addition to pre-plant (11 acre-inches).
I_2 —Pre-plant + 6/10 (7.3 acre-inches)	+ 7/22 (8.0 " ")
	+ 8/23 (8.5 " ")
	Total water applied in addition to pre-plant (23.8 acre-inches).
I_3 —Pre-plant + 6/10 (5.0 acre-inches)	+ 7/1 (5.0 " ")
	+ 7/15 (4.0 " ")
	+ 8/1 (7.0 " ")
	+ 8/22 (6.5 " ")
	Total water applied in addition to pre-plant (27.5 acre-inches).
Nitrogen	
Nitrogen rates were 0, 50, 100, 200, and 400 pounds of nitrogen per acre.	

Irrigation water was measured on each plot from gated pipe. Sufficient water was added at the pre-plant irrigation to wet the soil to field capacity to a minimum depth of 6 ft. Seasonal irrigations (irrigations that followed the pre-plant) rewet the soil to the 6-ft depth. Nitrogen was side-dressed as ammonium sulfate on May 25.

Varietal strains

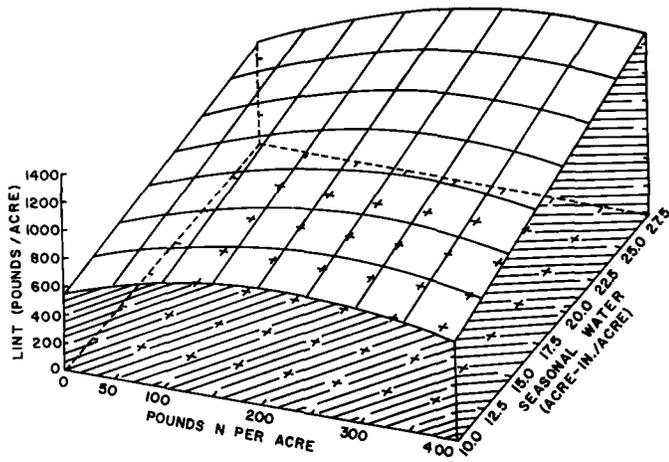
Because the varietal strains (Acala 4-42 and Acala SJ-1) did not differ appreciably in their yield response to the imposed treatments, data from both varieties were composited to better evaluate the effects of irrigation and nitrogen fertilization.

Lint yield surface

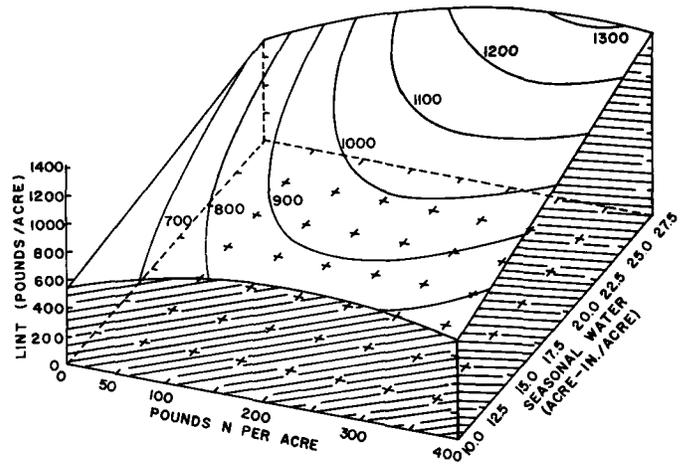
An empirical yield equation was determined from the data obtained in this study and is shown graphically (graph 1). The surface "grid" shows the calculated lint yield associated with any combination of seasonal irrigation water and nitrogen fertilization—within the amounts of these factors included as treatments in the study.

Additional increments of seasonal irrigation water resulted in proportional or "straight line" increases in cotton lint yields at given levels of nitrogen fertilization. For example, where no nitrogen was added, increasing the seasonal irrigation water from 11 to 27.5 acre-inches increased lint yields from 553 to 711 lbs of lint per acre, an over-all increase of 158 lbs of lint per acre. Where plots received 300 lbs of nitrogen per acre, increasing the seasonal water from 11 to 27.5 acre-inches increased yields from 850 to 1300 lbs of lint per acre, or an over-all increase of 450 lbs of lint per acre. From these data it is evident that, on soils of this nature, a maximum yield response to increased water availability is possible only when adequate nitrogen is also supplied.

Within the treatment range of nitrogen additions, the highest yield increase per unit of nitrogen was obtained at the lowest level of added nitrogen. Where only 11 acre-inches of seasonal irrigation water were added, the highest yield was obtained when 250 lbs of nitrogen was



Graph 1. Yield surface for lint yields as influenced by seasonal irrigation water and nitrogen fertilization.



Graph 2. Yield surface showing isoquants or the combinations of water and nitrogen required to produce a specific yield.

applied. At this level of N-fertilization, an increase of 315 lbs of lint per acre over plots receiving no additional nitrogen occurred. On the other hand, where 27.5 acre-inches of water were added, the maximum yield resulted from the addition of 332 lbs of nitrogen per acre. This level of fertilization increased lint yield by 594 lbs per acre over plots receiving no additional nitrogen—demonstrating that the yield level obtained from either additional irrigation water, or nitrogen, is dependent upon the level of availability maintained for the other factor under consideration.

Alternatives for production

The studies show that the production of a given yield is possible by several different combinations of irrigation water and applied nitrogen (graph 2). In this illustration the "grid" of the yield surface in graph 1 is replaced by a series of curved lines connecting the many different combinations of irrigation water and nitrogen which produced a given indicated level of lint. For example, the 1000-lb-per-acre yield level can be obtained from the combination of 27.5 acre-inches of water and 90 lbs of nitrogen per acre, from the combination of 16.3 acre-inches of water and 270 lbs of nitrogen per acre—or from an infinite number of combinations intermediate between them. The lines connecting points of equal yield are called *isoquants* and their calculation makes it possible to determine the combination of water and nitrogen at which a designated yield can be obtained at the lowest cost to the producer.

The different combinations of water and nitrogen given by the curved lines for a specific or constant yield are more

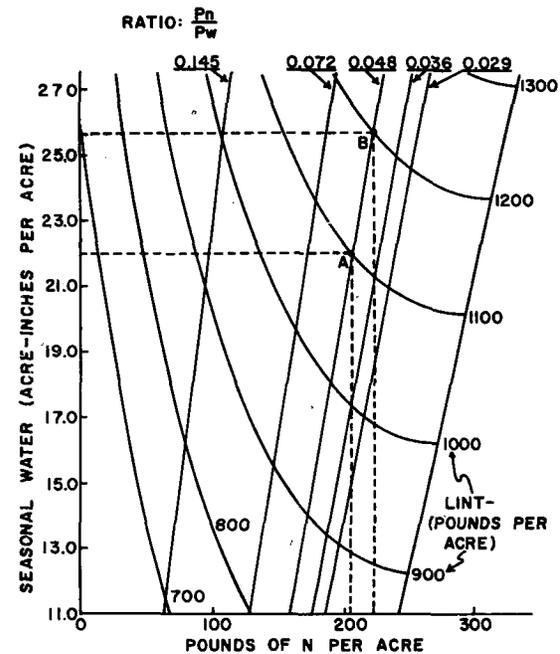
easily seen in graph 3. The fact that a given yield can be produced by different combinations of water and nitrogen can be thought of in terms of substitution of one factor for another. There is, of course, no substitution in terms of the chemical or physiological role of these factors; nevertheless, there is substitution in terms of lint yield. As shown in the graph, increasing amounts of nitrogen are required to "substitute" for a given quantity of water at lower levels of water addition. Conversely, at lower levels of nitrogen fertilization, more water is required to "substitute" for a pound of nitrogen while maintaining a constant yield.

The yield equation resulting from this study does not have a determinate solution in terms of establishing an optimum quantity of irrigation water. Previous studies have shown that maximum or near-maximum lint yields were attainable in this area by the addition of 25 to 30 acre-inches of water during the season (in addition to a pre-plant irrigation). Conditions during the 1966 season were such that the water requirements were increased above normal, and the addition of 27.5 acre-inches was therefore insufficient to establish an optimum level with certainty.

Cost-minimizing combinations of irrigation water and nitrogen for specific yield levels and price conditions are shown by the straight diagonal lines in graph 3. These lines are called *isoclines* and are obtained from the yield equation and prevailing cost of irrigation water (P_w) and nitrogen fertilizer (P_n). Assuming a nitrogen cost of \$0.12 per pound (applied), and irrigation water costing \$2.50 per acre-inch (\$30.00 per acre-

Yield	Price per unit		Ratio	Optimum quantity	
	Pounds of lint per acre	Pound of nitrogen		Acre-inches of water	Pounds of nitrogen
1200					
"					
"					
"					
1100					
"					
"					
"					
1000					
"					
"					
"					
"					

Graph 3. Yield isoquants and isoclines. The isoclines connect points of equal slope on the isoquants and show combinations of water and nitrogen having the least cost for different price combinations.



foot), a Pn/Pw ratio of 0.048 is obtained, making the diagonal line designated by this ratio. Starting at the bottom and following the line upward and to the right, the line passes through levels of increased lint production. At the 1100-lb lint-yield level, the cost-minimizing combination of 22 acre-inches of water and 205 lbs of nitrogen per acre is indicated by the connecting dashed lines (point A). At the 1200 pound lint yield level, the cost-minimizing combination (point B) of 25.7 acre-inches of water and 222 lbs of nitrogen is illustrated for the same prevailing cost conditions.

The table shows a series of optimum rates and combinations of water and nitrogen for yield levels of 1200, 1100, and 1000 lbs of lint per acre for several different cost conditions. The Pn/Pw ratios were obtained by varying irrigation water costs. However, the ratios may be obtained by varying either the cost of water or nitrogen.

The optimum amounts of nitrogen shown in the table are somewhat greater than those normally recommended for these soils. Cotton grown in 1966 was preceded by safflower in 1965 with minimal fertilization; therefore, very little nitrogen carryover from the previous application was in evidence.

Previous studies have shown that cotton may grow excessively vegetative or "rank" on many soils when more than adequate amounts of either water or nitrogen are added. The "rankness" may depress yields by creating an unfavorable fruiting pattern. Under the soil and climatic conditions of this study, yields were depressed only by relatively high rates of nitrogen addition.

These investigations are being continued with some changes to place greater emphasis on obtaining a more generalized yield equation covering a greater variety of soil types.

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INSECT DAMAGE TO ... and control

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(1) Adult western flower thrips, *Frankliniella occidentalis* Perg.

(2) Cloth cages enclosing sesame flowers, into which thrips were introduced.



Studies of both the flower thrips and lygus bug indicate that they caused no serious sesame plant injury, reduction of pod set, or seed loss at the populations existing under the conditions of these experiments. It appeared that much larger population densities of these pests would be necessary to contribute to the poor pod set and low yields observed recently on untreated field plants. The green peach aphid caused up to 27% seed loss when present in moderate to large numbers, however. The aphid was effectively controlled by use of two applications of either oxydemetonmethyl or endosulfan.

THE PREVALENT lack of pod set and low yields experienced in the production of an indehiscent strain of sesame (S. I. 151) prompted this evaluation of the effect of a few pest insects on this plant in California. A preliminary survey made in 1963 showed that the most plentiful insect pests were lygus bugs, *Lygus hesperus* Knight, western flower thrips, *Frankliniella occidentalis* (Pergande), and the green peach aphid, *Myzus persicae* (Sulzer). Later in the growing season, a striped flea beetle, *Systema* sp. nr. *bitaeniata* Lec. was present. The ability of these pests to damage sesame was studied the following year.

Thrips damage

During 1964, flower thrips (photo 1) were introduced onto flower buds enclosed by fine-mesh cloth cages (photo 2) at 5, 10, and 20 adults per bud. Thrips were introduced July 28, and produced young for the next 13 days while the flowers were blooming. A maximum of 90 nymphs were produced on one flower, as determined by hand counting an extra set of caged flowers to which thrips had been