Cotton research personnel and growers have often observed that some insect pests are more abundant in parts of a cotton field or in entire fields where plant growth is rank and succulent. The research reported here was initiated to test this observation. Three different regimes of irrigation water and nitrogen, tested in factorial combinations brought about distinct differences in growth patterns between various plots. Throughout the course of the study the lygus bug, *Lygus hesperus* Knight, was found significantly more abundant in plots with high irrigation and nitrogen levels, than in plots receiving minimum applications of either variable. A complex relationship was found to exist between cotton lint production, vegetative plant growth, insect numbers, and water and nutritional management. The implication of these tests is that cotton growers may reduce the threat from insect pests through management of their irrigation and fertilization practices.

INSECTS *as affected irrigation fertilization*

THOMAS F. LEIGH · DONALD W. GRIMES · HIDEMI YAMADA

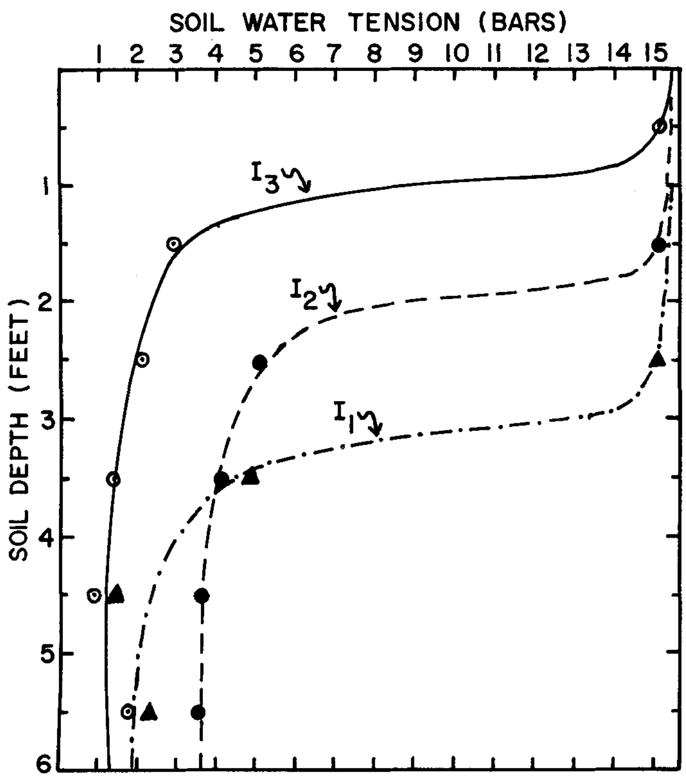
WATER AND FERTILITY MANAGEMENT influences the vegetative and fruiting growth of crops in arid climates and also influences the nutritional aspects of plants as hosts. Since insects are known to respond differently to changes in environmental conditions, they should also be expected to respond to conditions in a crop ecosystem brought about by modification in the use of either water or fertilizer variables. This progress report deals with an evaluation of the influence of irrigation water and nitrogen fertilizer variables on plant growth, the resultant insect populations in the crop canopy, and lint production.

The investigation is being carried out in field plots at the U.S. Cotton Research Station, Shafter, and the University of California West Side Field Station, Five Points. Soil at the Kern County location is classified as Hesperia sandy loam and at the Fresno County location as Panoche clay loam. The results obtained at the two locations from the four years of study are similar and therefore only the 1968 experiment at the West Side Field Station is reviewed here.

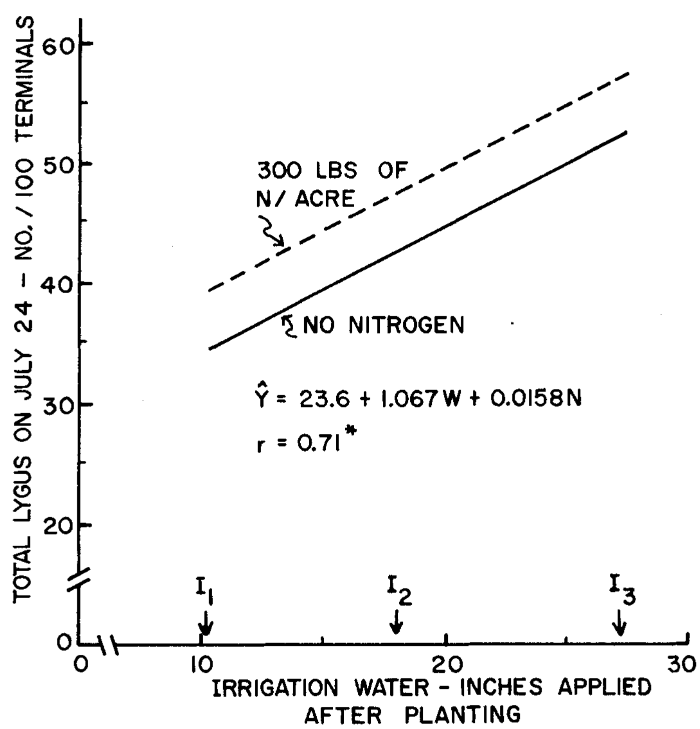
Treatments

In the 1968 experiment, treatments consisted of a factorial combination of three irrigation schedules and three levels of nitrogen application in a split-plot randomized complete block design with irrigation treatments as whole plots. All plots were uniformly irrigated before planting to wet the soil profile to a depth of 6 ft. Differential water availability was induced during the growing season by irrigating once (I_1), twice (I_2), and four times (I_3) as follows:

Plot	Water applied	Total water in addition to pre-plant irrigation
I_1—7/16 (10.3 inches)		10.3 inches
I_2—7/1 (8 inches), and 8/7 (10 inches)		18.0 inches
I_3—6/17 (5.2 inches), 7/9 (8 inches), 7/31 (8 inches), and 8/20 (6 inches)		27.2 inches



Graph 1. Soil water tension before irrigation for each of three irrigation treatments—Tension levels for the I_2 and I_3 treatments are an average of all irrigations for the specific treatment.



Graph 2. Total lygus population found within plots receiving differential irrigation and nitrogen management.

IN COTTON

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practices

DICK BASSETT · JOHN R. STOCKTON

The frequency and amount of irrigation during the season was determined by the water-holding capacity of the soil and by the known water requirements of cotton. Soil water tension levels attained immediately before irrigation for each of the three treatments are shown in graph 1.

Nitrogen levels consisted of no added nitrogen (N_0), 75 lbs of nitrogen per acre (N_1), and 300 lbs of nitrogen per acre (N_2) sidedressed as ammonium sulfate in late May. The nitrogen levels were selected with a knowledge of the response characteristics of the soil. Where irrigation is optimum, maximum lint yields have been obtained from the highest level used while the 75-lb rate may be expected to produce a yield intermediate between no applied nitrogen and the maximum.

Insect and spider mite counts (of natural population increases were made on several dates during the summer. No insecticides or miticides were used in this experiment. A vacuum (D-Vac) insect sampler was used to sample the insect fauna; this provided a measure of all insects that were present in significant numbers in the upper portion of the plants. While more than 20 species of insects were present, the comparative abundance of only two is reported here: the lygus bug, *Lygus hesperus* Knight, which is a major pest of cotton; and the big-eyed bug, *Geocoris pallens* Stal, a major predator. Spider mites, *Tetranychus pacificus* McGregor, were also sampled by a chlorox-wash method and differences in abundance determined.

Total lygus bug numbers and nymphal numbers on July 3 were greatest in all fertility levels of the I_3 plots, as indicated in the table. This differential appeared to reflect the greater growth of plants irrigated at the earliest date. By July 24, plant growth differences were evident among all plots receiving the varied irrigation and nitrogen fertilization levels. On that date there were significantly fewer lygus in the I_1 plots than in either the I_2 or I_3 plots. The relationship between total lygus numbers and the amount of irrigation water and nitrogen applied during the growing season, (determined from the data in the table), is shown in graph 2. While the total amount of water indicated had not been added by July 24 when insect counts were made, plant growth differences reflecting these treatment differentials were well established. An increase in water availability shows a striking increase in lygus abundance. Increased lygus abundance was also noted with higher levels of applied nitrogen but this effect was not as great as with the increased water level. By late summer, lygus numbers became more variable between irrigation and fertility differentials.

The big-eyed bug was present in sizeable numbers, particularly on the July 3 and July 24 sample dates (see table). Both total and nymphal numbers were greatest on July 3 in the I_2 treatment which showed the lowest counts of lygus. They were least abundant in the I_3 plots which had the highest lygus counts, and were intermediate in abundance in the I_1 plots. By July 24, the big-eyed bug was most prevalent in the low water treatment (I_1) and least abundant in the wet (I_3) treatment. On July 24, a significant negative correlation ($r = 0.68^*$) between total lygus and big-eyed bug numbers was observed.

Spider mite infestations developed late in the season. Nevertheless, on August 21 they were significantly more abundant in all fertility levels of the I_1 and I_3 plots than in any of the fertility levels of the I_2 program. The average number of spider mites (predominantly *Tetranychus pacificus* McGregor) per leaf on August 20, 1968 in plots treated at three levels of irrigation and nitrogen fertilization was:

Nitrogen treatment	Irrigation treatment		
	I_1	I_2	I_3
	Average number per leaf		
N_0	112	79	102
N_1	166	48	201
N_2	116	89	166

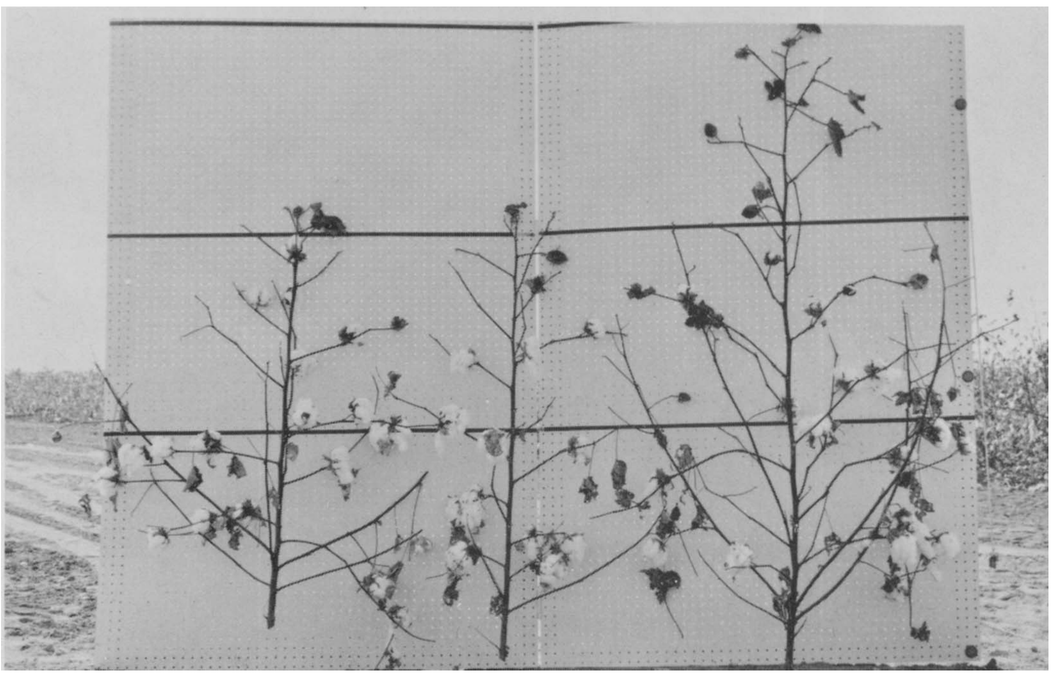
In the I_1 and I_3 programs, mites were most abundant at the N_1 level of fertility and the lowest numbers were encountered in the N_1 fertility level of the I_2 treatment. Results obtained in other years of this study indicate there are distinct reproductive differences in the mite populations relative to nutrient composition of the leaves. However, as with lygus, the abundance of predators may have a strong relationship to the numbers of mites present.

Cotton lint production

Cotton lint production resulting from individual treatments is shown in graph 3. Addition of nitrogen increased lint production only at the lowest irrigation level I_1. Lint production was depressed when nitrogen was added to the I_2 and I_3 irrigation treatments. Increased irrigation water (I_2) improved yield over I_1 only at low levels of added nitrogen (N_0 and N_1). The wet I_3 irrigation treatment reduced yields at all levels of nitrogen fertilization.

The observed lint production trends from the various irrigation and nitrogen

Typical plant growth is illustrated in the above photo with three plants selected from plots fertilized with 75 pounds of nitrogen per acre and from left to right: 1, 2, and 4 irrigations.



AVERAGE NUMBER OF LYGUS BUGS (LYGUS HESPERUS KNIGHT) AND BIG-EYED BUGS (GEOCORIS PALLENS STAL) PER 100 PLANT TERMINALS ON JULY 3 AND JULY 24 IN PLOTS TREATED AT THREE LEVELS OF IRRIGATION AND NITROGEN FERTILIZATION

	July 3			July 24		
NITROGEN TREATMENT	IRRIGATION TREATMENT					
	I_1	I_2	I_3	I_1	I_2	I_3
	TOTAL LYGUS					
N_0	16	14	30	40	44	45
N_1	19	12	34	26	59	50
N_2	13	12	26	32	53	59
	NYMPHAL LYGUS					
N_0	0.0	0.8	5.0	4	23	15
N_1	2.3	1.3	6.8	7	28	19
N_2	1.3	2.0	2.8	10	23	23
	TOTAL GEOCORIS					
N_0	53	93	31	70	29	15
N_1	61	74	31	90	53	35
N_2	54	75	27	77	33	33
	NYMPHAL GEOCORIS					
N_0	6	22	1	15	6	6
N_1	7	15	2	29	8	10
N_2	9	12	4	20	6	8

levels in this experiment differ considerably from the responses obtained when detrimental insect populations are controlled. Under controlled conditions on this soil, optimum production has been obtained from approximately 20 inches of irrigation water, in addition to the water that was applied preplant, and from about 250 lbs of nitrogen per acre.

Where insect populations (especially lygus) are not controlled, a highly complex relationship was found to exist between cotton lint production, vegetative plant growth, insect numbers, and water and nutritional management. This relationship accounts for the differential response characteristics where there was no control of insect populations. The relation between lint production and plant growth (as expressed by final plant height) is illustrated in graph 4. Increased lint production was associated with increased plant growth in a plant height range of from 100 cm to about 125 cm. Increased plant growth and yield in this range were produced by added nitrogen in the dry (I_1) treatment or with no nitrogen at the I_2 irrigation level. Increased plant growth above approximately 125 cm was strongly associated with declining lint production and resulted from increased water and/or nitrogen availability.

At this point, a logical assumption might be that an increasing lygus population would be associated directly with declining lint production. In considering the 1968 data, however, only a small nonsignificant negative correlation was observed. However, a significant positive correlation was found to exist between lygus numbers on July 24 and final plant height. The absence of an overall direct correlation between lygus numbers and lint production was accounted for by the fact that treatments which increased plant growth and lygus numbers also increased lint production to a certain point, but decreased yield thereafter.

Conclusions

Highly significant differences in the abundance of lygus bugs, big-eyed bugs, spider mites, and some of the other insects are evident for each of the years of this study. Direct cause-and-effect relationships between lint production, plant growth, insect populations, and water and plant nutrition management were found difficult to identify. Nevertheless, growers can reduce the likelihood of lygus attack on their cotton by utilizing "controlled" amounts of irrigation water and nitrogen—and could enable production of the most efficient crop with little or no use of insecticidal chemicals.

Manipulation of agronomic practices as a means of modifying insect populations and reducing pest problems is a continuing program in this approach to pest control. Irrigation and fertilizer studies appear to offer great promise as a method of maintaining a more favorable level of insects in cotton. These cultural manipulations can also add to the value of such additional pest management practices as varietal selection, host plant resistance, cultivation, and biological and chemical control.

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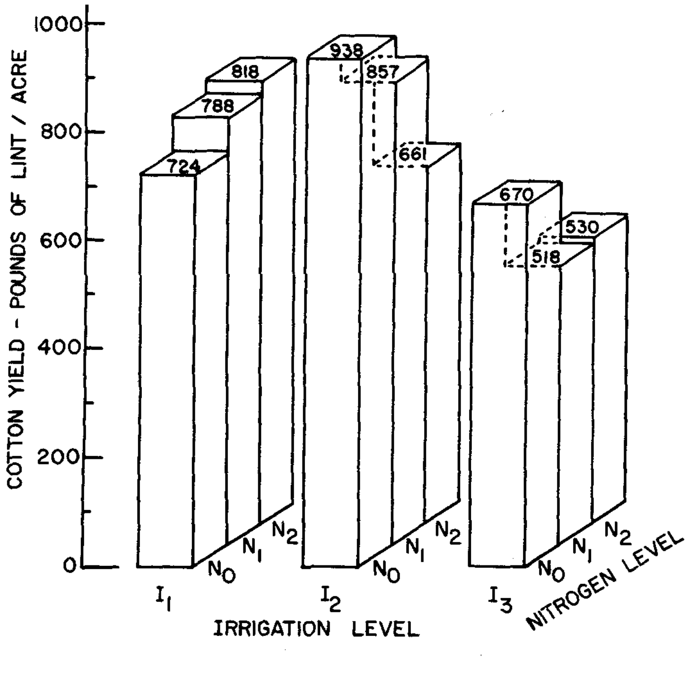
Graph 3. Cotton lint production from varied levels of irrigation and nitrogen fertilization under conditions of no insect control. The indicated yields are averages of all replications.



Graph 4. A relationship between cotton lint production and plant height. Each point plotted on the graph is an average of four replications.