

indicate the upward escape of convectional heat, as in previous tests with orchard heaters—but to a much lesser degree than in the case of conventional stack heaters, because of the smaller heating units.

Stack heaters generally produce a temperature rise of 3° to 4°F when using at least 25 per acre at an approximate burning rate of ¾ gal/hour, or about 90,000 Btu/hour per heater. The heating equivalent would be ten coke bricks (8,000 to 10,000 Btu/hour, each) per each stack heater, or 250 bricks per acre. However, in this test, 150 bricks produced about the same response as 25 stack heaters. The previous year's data had indicated a similar result, despite the uncertainty of finding correct values for maximum field response because of the small plot size and winds which had greatly displaced the hot air plumes. This was also evident in the fourth test, run at 4:40 a.m. in this trial. At times, the hot plume moved out far enough to reach one of the control stations 200 ft away (which was then disregarded). This was no surprise since downwind frost protection has been experienced frequently in commercial orchard heating, and also in wind machine operations.

The results of these tests again confirm the advantage of many small heating units over a few large ones. In the trials reported here only 60% of the Btu's commonly required when using oil heaters produced similar rises in temperature. The possibility to further reduce this ratio of 150 bricks to 25 heaters is indicated in the last diagram where it appears that the number of bricks could be reduced toward the center, especially in light frosts. This suggestion is not feasible for oil heaters, because operating with less than 25 oil heaters per acre would leave large unprotected ("dark") spots.

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## SUMMARY

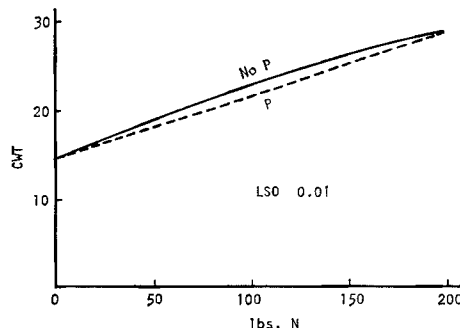
These tests, and other field observations, indicate that moisture is a key consideration in selecting a fertilizer program for safflower in the Valley. For dry-land soils or soils with low sub-surface moisture levels, 20 to 60 lbs per acre of N appear to be sufficient. Excess N may reduce yields.

Greater amounts of N may be utilized when safflower is grown under irrigation, or on soils with a high water table, or on deep soils filled with moisture. The effect of the previous crop is important here: when safflower follows rice or sorghum, up to 150 lbs per acre of N are generally adequate. However, when it follows a nitrogen-fixing crop such as alfalfa or vetch, smaller amounts may be sufficient. No reduction in safflower yield has been observed from excess N under high-moisture conditions.

Because safflower may not be irrigated, fertilizers should be placed in the moist root zone, at least 4 inches deep. If a nitrogen fertilizer is broadcast, at least 1 inch of rain or its equivalent in irrigation is needed to move it into the root zone.

Spring applications are preferable to fall applications. In a dry spring, aqua or anhydrous ammonia placed at a depth of from 4 to 8 inches can be expected to be more effective than broadcast dry materials. If dry materials are to be used, applications early in the spring are desirable to take advantage of spring rains.

THE EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZATION ON SAFFLOWER YIELD, SUTTER COUNTY, 1965



# FERTILIZER IN

**S**AFFLOWER rapidly gained prominence as an oil crop in the Sacramento Valley during the 1950's. Because the fertilizer requirements of the crop were largely unknown, trials were conducted in several counties. The following data constitute a progress report, summarizing some of the more important findings.

Like most other crops in California, safflower has been found to respond favorably to nitrogen fertilization. Table I shows the results of some nitrogen-rate trials conducted in several counties since 1960. The 1960 trials in Glenn and Colusa counties were planted after rice, using aqua ammonia and ammonium sulfate as the nitrogen sources. In both cases, 60 lbs of N gave the greatest increase in yield per unit of N. Moisture was not a limiting factor, because rice preceded the safflower and rain fell after planting. The 1963 trial in Yolo County illustrates a different situation, where moisture was in short supply. Safflower was grown after barley and without irrigation. The highest yield was obtained with 25 lbs of N; higher rates reduced yield.

When sufficient moisture was available, yields continued to increase with high amounts of nitrogen. This was illustrated by the excellent response to 150 lbs of N, obtained in a 1964 trial in Yolo County (planted after sorghum on a Sacramento clay with a high water table). A positive response was evident even with 240 lbs of N applied in 1966 in Sutter County.

## Time of application

The results of two tests illustrate the importance of the time of fertilizer application. In 1960, 100 lbs of N were applied in the spring and compared with applications made in the fall (table 2). The spring application of aqua was superior to the fall application. The reason for this is not clear, but it would appear that some nitrogen was lost by denitrification during the wet winter months. A total of 9.39 inches of rain fell from December to the planting date in March. On the other hand, the spring application of aqua was made 8 inches deep into moist soil and was almost immediately available to the

# TRIALS WITH SAFFLOWER SACRAMENTO VALLEY

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young safflower plants. The ammonium sulfate, broadcast in the spring, gave the poorest results, probably because it was not placed into moist soil; after the application, only 0.07 inch of rain fell during March, and it was not until April that a total of 0.95 inch of precipitation was recorded. Thus although the fertilizer was applied, the dry spring and consequent dry soil conditions negated its potential usefulness.

The superiority of a spring application in a good rainfall situation was again evident in the following year, when urea was used as the source of N (table 3). The material was broadcast and disked in. About 1.5 inches of rain fell shortly after application, giving the effect of a deep placement by moving the urea down into the soil. One hundred pounds of N applied in the spring gave a significantly higher yield than the 50-lb rate. When the material was applied in the fall, it made no statistically significant difference whether 50 or 100 lbs was used. Again, it would appear that an appreciable amount of N was lost during the winter.

## N fertilization and oil

A limited amount of reliable data indicate that increasing rates of N decrease the oil percentage of safflower by a small amount (table 4). In these two tests, 160 lbs per acre of N reduced the oil content by 1 to 2%, as compared with the check. This reduction in oil percentage is more than offset (economically) by the increase in seed yield of 1038 and 1120 lbs of seed per acre, respectively.

## Phosphorus

Test results and field observations indicate that generally no phosphorus response can be expected in the Sacramento Valley, as shown in the graph.

On some soils, safflower seedlings are yellow and stunted when grown immediately after rice. In tests, growth responses to P have been obtained, but to date insufficient yield data are available on the effect of P application. With the exception of these specialized problem soils, a soil level of 6 ppm or more of sodium bicarbonate-extractable P appears to be sufficient for safflower.

TABLE 1. EFFECT OF N FERTILIZATION ON SAFFLOWER YIELD  
(Yields in pounds per acre)

N lbs/A	Glenn 1960	Colusa 1960	Yolo 1963	Yolo 1964	Sutter 1966
0	1246	2008	1439	1371	1937
25			1721		
50			1684	2545	
60	1844	2459			
70				2825	
75			1598		
80				3151	2823
90		2422			
100	1913				
120		2526			
140					2998
150	2031			3659	3057
160		2667			
200					3116
240					45
LSD 0.05	95	254	82	211	45
Soil type:	Marvin si.cl.	Sacr. cl.	Rincon cl.l.	Sacr. cl.	Ramada cl.
N source:	aqua amm.	amm. sulf.	aqua amm.	aqua amm.	aqua amm.
Previous crop:	Rice	Rice	Barley	Sorghum	Rice

## Potassium

Potassium deficiency has not been a general problem in safflower production, with the exception of the Clarksburg area in Yolo County. Two tests conducted in that area have given positive plant and yield responses to K applications. Soil tests have proved to be effective in predicting the appearance of deficiency symptoms in safflower grown around Clarksburg. No response can be expected if the soil level of K is much over 100 ppm.

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TABLE 2. SAFFLOWER FERTILIZATION TEST, COLUSA COUNTY, 1960

N lbs/A	Date applied	N source	Total yield lbs/A	Yield increase lbs/A
0			1312	
100	12/9/59 (fall)	aqua	2064	752
100	3/18/60 (spring)	aqua	2453	1141
100	3/18/60 (spring)	ammonium sulfate	1973	661
LSD <sub>0.05</sub> = 242 lbs/A				
Soil type: Sacramento clay				
Previous crop: Rice				

TABLE 3. SAFFLOWER FERTILIZATION TEST, COLUSA COUNTY, 1961

N lbs/A	Date applied	Total yield lbs/A	Yield increase lbs/A
0		1447	
50	12/60	1813	366
50	3/61	2197	750
100	12/60	2060	613
100	3/61	2627	1180
LSD <sub>0.05</sub> = 249			
Nitrogen source: urea			
Rainfall after spring application: 2.9 inches			
Rainfall after fall application: 5.75 inches			
Soil type: Sacramento clay			
Previous crop: rice			

TABLE 4. EFFECT OF NITROGEN FERTILIZATION ON YIELD AND OIL CONTENT OF SAFFLOWER

N lbs/A	Yolo County, 1966		Sutter County, 1966	
	Yield lbs/A	Oil content %	Yield lbs/A	Oil content %
0	1303	44.1	1937	48.8
40	1760	43.3		
80	2006	42.4	2823	48.2
100	2024	42.7		
120	2165	42.5		
140			2998	47.6
160	2341	42.0	3057	47.6
240			3116	47.5
LSD <sub>0.05</sub>	282	0.90	45	0.64
Soil type	Capay clay		Ramada clay	
Previous crop	Rice		Rice	