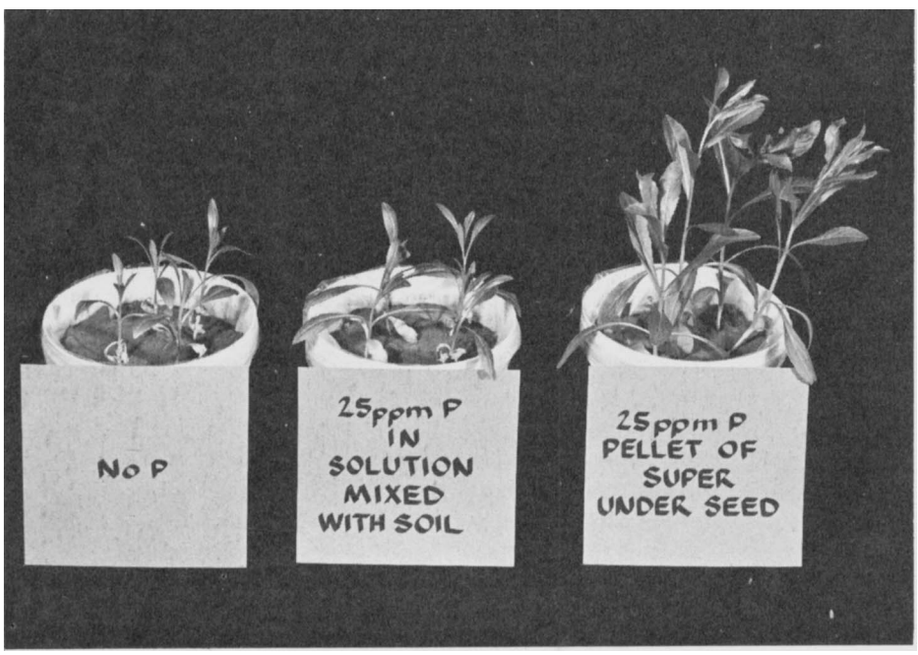
Answering the riddle of

POOR SAFFLOWER AFTER RICE

. . . banded phosphorus may be the solution



Effects of phosphorus placed under seed of safflower in geenhouse experiments.

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Field studies reported here have shown that poor growth of safflower after years of rice tends to be associated with acute phosphorus deficiency. Applications of treble superphosphate, 11-48 and 10-50 ammonium phosphate dramatically increased seedling growth and yield of grain when placed with, or 1 inch below seed. Applications of 200 lbs of 11-48 or 10-50 one inch below the seed were found safe and economic under conditions of these Colusa County experiments. Applications of 100 lbs of 11-48 or 10-50 in the seed row were also found to be safe and effective, as shown in tests in both Colusa and Glenn counties. Generalizations are not yet possible on such questions as: (1) why some rice soils are phosphorus-deficient for safflower; (2) the critical soil phosphorus level for safflower the year following rice; (3) the amount of P required for maximum yields; and (4) other nutrients or soil conditions affecting safflower performance on old rice lands.

SAFFLOWER HAS BEEN observed to yield poorly in many areas when planted the crop year after rice. Since the introduction of safflower as a crop that could be used in rotation with rice, growers have become more and more disappointed with the economics of safflower production when following rice. Determination of the causes of poor safflower growth is now particularly important since rice acreages are to be cut next season, and safflower is a particularly suitable crop to grow on diverted rice lands.

Normal growth

Safflower plants grow normally after rice for 4 to 6 weeks after germination. However, in problem areas, plants usually show chlorosis on the lower leaves at the time the first true leaves are developed. Leaf margins may become necrotic and give a burned appearance. Safflower usually is severely stunted and remains in a "rosette" without growth for three to four weeks. The decreased plant growth because of the problem may last throughout the growing season, causing delayed maturity and low yields. Safflower plants may partially recover if the problem is not too severe. The severity appears to depend upon the length of time the soil was in rice, and to some degree upon the soil type and previous fertilizer history.

Previous Field Observations

Observation of problem areas showed normal, or nearly normal growth where the aerated surface soil from the rice levees had been spread in preparing the land for safflower. Whether the problem was due to the rice crop per se, or to the flooding required for rice culture, was not entirely clear. The soil from under-

Photos above show examples of the effects of banded P treatment on early growth (left photo), and flowering stage (right) of safflower after rice, as compared with poor growth in check plot. Phosphorus placed with the seed, or in close proximity, increased plant growth dramatically.

neath the levees often produced as poor safflower as the soil where rice actually had grown—indicating that water-logging, and chemical-reducing soil conditions may be related to poor growth after rice.

The physical condition of the soil following rice is usually poor with large dense clods as compared with a more crumbly, friable soil in levee areas, or when following other crops.

Stunted seedlings

Field observations and samples taken from areas of poor growth after rice have shown stunted chlorotic seedlings to be low in phosphorus. Plants growing better on levee soil areas often contained two to three times as much total phosphorus. Field studies in Glenn County in 1967 showed that phosphatic fertilizers, broadcast and disked into the soil, gave some early growth responses. In these studies massive applications of up to 90 lbs of phosphorus per acre (200 P_2O_5) were applied but did not result in any significant increase in yields at harvest.

Greenhouse tests

Greenhouse studies have been carried out with soils from areas of safflower crop failure after rice. They have shown a striking response to fertilizer phosphorus if the P was placed with or near the seed. Little or no benefit was found if the phosphorus was mixed thoroughly with the soil. Coating safflower seed with phosphate fertilizer was very effective but toxic to seedlings in some cases. Results of greenhouse placement studies are illustrated in the photo of greenhouse pots.

1971 experiments with banded P

Safflower fertilizer experiments were established in Colusa and Glenn counties in the spring of 1971 to confirm, under field conditions, the results from previous greenhouse studies. These studies had the additional objective of determining the relative effectiveness of mono-ammonium phosphate and mono-calcium phosphate, and determining the optimum rate of phosphorus necessary. In these tests commercial phosphorus fertilizers were placed with, or slightly below, the seed as the seed was planted into moist soil.

In the Glenn test an International model 150 shovel press drill made available by the California Fertilizer Association was used. The drill used in the Colusa test was a John Deere grassland drill loaned by the I. G. Zumwalt Company of Colusa. Both had press wheels and were 8 ft wide, permitting easy field plot manipulation.

Both of the areas selected for testing had been in rice for 15 years and represented conditions where poor production of safflower could be anticipated. Phosphorus fertilizers used in these studies were treble superphosphate and two ammonium phosphates with analysis of 11-48-0 and 10-50-0; two rates of P applica-

An aerial view of the Glenn County plot shows growth of the treated plants; they are the dark rectangular areas. The diagonal dark strips are the former rice levees where safflower was growing normally.

tion were used in each test. Materials were donated by fertilizer producers.

Experiments were designed to use commercial harvesting equipment. Treatments were replicated four or five times in randomized block designs. Soil samples were taken for analysis from the untreated areas in each experiment. Soil bicarbonate values were 9.7 ppm P in the Colusa test and 11.0 ppm P in the Glenn test. The critical level for rice production is 5.0 ppm P.

Growth observations

Within a month after planting, startling results of fertilizer treatments became evident. Plants in untreated areas became stunted and chlorotic as expected.

Seedling samples were harvested in April or early May to determine relative growth and chemical composition. Results are shown in tables 1 and 2. In both the Glenn and Colusa County plots, seedling growth was greatly increased by P treatments and the amount of growth was in proportion to the phosphate-phosphorus found in the plants. The fact that the amount of seedling growth in both experiments was related to phosphorus content points to P as the probable cause of growth improvement.

Yields of safflower

The experiments were harvested on August 12th. Yields calculated as pounds per acre of seed are shown in tables 1 and 2. A considerable recovery of stunted safflower plants took place in the untreated areas with the result that yields were more than would have been anticipated from early seedling growth.

Yields from the Glenn County plot were increased about 30% by the best treatment or by 250 to 290 lbs of seed per acre. Ammonium phosphate (10–50), which had increased seedling phosphate-phosphorus the most, gave the highest yields.

Yields in the Colusa County plot were nearly doubled by the best fertilizer treatments. Ammonium phosphates produced greater increases in yields than did treble superphosphate. Maximum yield increases were over 1,000 lbs of safflower per acre, with highest yields from the 46 P (100 P_2O_5) treatments. Ultimate yields at harvest were positively correlated with the phosphate-phosphorus of the seeding plants on April 6th; (r=.9627).

Yields from individual plot treatments may be compared and differences evaluated by use of the L.S.D. values (least significant difference) shown at the bottom of the yield columns in tables 1 and 2. Similarly the letters which follow each yield indicate which treatments differ significantly.

TABLE 1. SAFFLOWER AFTER RICE—RESPONSE TO BANDED P
W. & E. Weller—Glenn County—15 years rice—Soil Test 11.0 Bicarbonate P, Marvin Loam pH 5.70, Variety Saffola 208.

Fertilizer treatments*					Seedling growth		Yield of safflower			
Total lbs/A	Material	Nutrients/A N	Nutrients/A P_2O_5 lbs	P	Weight of 100 plants 5/6/71 gms	PO_4-P ppm	Total lbs/A	Increase lbs	Value @4¢/lb	Approximate fertilizer cost $/A
—	None	—	—		20.6a†	475	970a			
40 lbs/A	Treble super (0-45-0)	—	18.0	7.8	41.8b	669	878a	—	—	$1.60
77 lbs/A	Treble @$80/ton	—	35.0	15.3	48.1bc	682	1162ab	192	7.68	$3.08
45 lbs	10-50-0	4.5	22.5	9.8	61.9bc	813	1224ab	254	10.16	$2.25
95 lbs	10-50-0 @$100/ton	9.5	47.5	20.7	102.2d	884	1264b	294	11.76	$4.75
LSD 5%					17.4	154	267	267		
Coefficient of variability					21.4%	14.6%	18.1%			

* Base preplant application of 90 lbs N-injected aqua-ammonia.
† Weights with same letters are not significantly different.

TABLE 2. SAFFLOWER AFTER RICE—RESPONSE TO BANDED P
Lee Bros.—Colusa County—15 years rice—Soil Test 9.70 Bicarbonate P
Lee Bros.—Colusa County—15 years rice—Soil Test 9.70 Bicarbonate P, Meyers clay pH 5.58, Variety: Gila

Fertilizer treatments*					Seedling growth		Yield of safflower			
lbs/A	Material	Nutrients/A N	Nutrients/A P_2O_5 lbs	P	Weight of 100 plants 4/3/71 gms	PO_4P ppm	Total lbs/A	Increase	Value @4¢/lb	Approximate fertilizer cost $/A
—	None	—	—		7.7a†	615	1630a	—		
133	Treble Super (0-45-0) @$80/ton	—	60	26.2	45.2b	1270	2230b	600	24.00	5.32
245	Treble super	—	110	40.0	54.9c	1478	2580bc	950	38.00	9.80
104	11-48-0 @95.00	12	50	21.8	57.5bc	1529	2510bc	880	35.00	4.94
208	11-48-0	23	100	43.6	61.2cd	1741	2820cd	1190	47.60	9.88
100	10-50-0 @100.00/ton	10	50	21.8	59.7cd	1688	2670bcd	1040	41.60	5.00
220	10-50-0	22	110	48.0	69.1d	1795	3170d	1530	61.20	11.00
LSD 5%					11.7	187	510	510		
Coefficient of variability					15.5%	8.7%	13.76			

* Base preplant application of 80 lbs N/ac injected Aqua-Ammonia.
† Weights with same letters are not significantly different.

The economic value of the phosphorus treatments has been preliminarily measured by calculating a value for the increased production of safflower, and comparing this value with the cost of each fertilizer treatment. For this purpose, safflower is valued at 4 cents per pound or $80 per ton. The costs used are the approximate quoted prices per ton of each fertilizer material, in truck-load lots with farm delivery.

On this basis, the increases in yield in the Glenn County plot were worth from $7.60 to $11.70 per acre, while the fertilizer costs were from $2.25 to $4.75. In other words the value of the increased production was two to four times the cost of the fertilizer.

In the Colusa County plot, the value of the increased production was from $24 to $61 per acre and was achieved at a fertilizer cost of roughly $5 to $11. It should be pointed out that in the Colusa test, all phosphorus treatments were profitable. The 10-50 and 11-48 ammonium phosphate treatments, which did not differ from each other significantly in yield, were more profitable than treble superphosphate. Studies elsewhere have indicated that some ammoniacal N tends to increase efficiency of phosphorus uptake if placed in the same band with the phosphorus.

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