G. W. Dean, C. O. McCorkle, Jr., and H. O. Carter

Economic aspects of fertilizing

High Value Crops

in California fields

California has less than 3% of the nation's cropland acreage, but nearly 10% of all commercial fertilizers used in the United States are applied to California's farmlands.

In 1959, more than two million tons of fertilizer were applied in California, representing a 30-fold increase over the 66,000 tons used in 1920. The national increase over the same period was only 3-fold.

The high value crops—cotton, fruits, vegetables, sugar beets and potatoes—occupying about one half of the total farmland fertilized in California, received 70% of the nitrogen, 47% of the phosphate, and 66% of the potash used in the state in 1959. On an average per acre basis, the high value crops received 84 pounds of nitrogen, 26 pounds of phosphate and nine pounds of potash. In comparison, the low value crops—mostly grains—receive an average of 43 pounds of nitrogen, eight pounds of phosphate and one pound of potash per acre.

Yield Response

A simplified example of the economic logic of fertilization is illustrated by potato yield response to one nutrient—nitrogen—in Kern County. Experiments show that application of the first 25 pounds per acre of nitrogen increases yields from 170 hundredweight per acre to 265 hundredweight—an increase of about 95 hundredweight. The second 25 pounds of nitrogen increases yields from 265 to 301 hundredweight—an increase of only 36 hundredweight. Each additional 25 pounds of nitrogen adds a decreasing amount to the total yield. So long as the added returns from the increased yield more than offset the added costs—fertilizer, application, harvest of the extra yield—fertilization is justified. With a potato price of $1.90 per hundredweight—less $0.90 harvesting costs—the last 25 pounds of 175 pounds of nitrogen per acre provides $4.00 added return for $3.75 in added cost. Increasing the nitrogen rate to 200 pounds per acre, at an added cost of $3.75 for the extra 25 pounds, would add only $3.00 in returns to the grower.

With a net potato price of $2.00 per hundredweight, 200 pounds of nitrogen per acre would be profitable with the last 25 pounds costing $3.75, but with returns of $6.00 per hundredweight. The most profitable level of fertilizer depends on the relative prices of the product and the fertilizer.

With a high value per acre crop—such as potatoes—the added yield is so valuable that very slight yield increases more than pay for added fertilizer costs. Therefore, fertilizer levels as high as 175–200 pounds of nitrogen per acre are profitable on potatoes. However, with a low value per acre crop such as barley, the added yield has such a low value that very substantial yield increases are needed to pay added fertilizer costs. High levels of fertilizer would not provide enough added returns to be profitable.

Crop Price Variability

The potato crop in Kern County also illustrates another critical point in the economic logic of heavy fertilization of high value crops which often exhibit extreme price variability within and between years.

The most profitable rate of fertilizing Kern County potatoes from 1953 to 1958 varied from 135 pounds to 200 pounds per acre, depending on the relative prices of nitrogen and potatoes. During the six-year period of 1953–1958, a total reduction of only about $12.00 in net returns per acre would have been realized by fertilizing at the 200-pound rate as compared with the most profitable rate in each year. However, had a 150-pound rate been used in each of the six years, the total returns would have been reduced about $32.00 per acre below that corresponding to the most profitable rate for each year. Losses from fertilizing below the most profitable rates were more than twice as high as they would have been from fertilizing at the highest rate.

Effects on Farm Income

A 100-acre Kern County potato enterprise, fertilized at only the 150-pound rate in a year of $3.50 potato net prices—gross price minus harvesting costs—would cost the grower about $2,100 in possible income not received. On the same farm, fertilized at the 200-pound rate—considered most profitable for high prices—the grower would lose only about $500 of potential income if the realized net price for potatoes was only $0.40 per hundredweight. Gains from fertilizing at the 200-pound rate in one year of high prices more than offset four years of losses from heavy rates in years of low prices.

Carry-over Effects

Another explanation for fertilizing at rates most profitable at favorable prices is the carry-over fertilizer response on the succeeding crop or crops.

Carry-over effects are particularly important in areas of double cropping, or where rotation crops are capable of eco-

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W. G. Wilde.....*Editor*

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nomically using the residual nutrients, as where grain sorghums are double cropped with potatoes. Carry-over effects are important also in areas where heavily fertilized annual crops—berries and vegetables, for example—are intercropped in new orchards or vineyards.

Product Quality

When high levels of fertilization are used on certain high value crops, a change in product quality may result, which is of such importance that additional considerations are required to determine the most profitable rates of fertilizer application.

Recent trials with potatoes have indicated that the percentage of U. S. No. 1-size A grade potatoes may decrease and the percentage of U. S. No. 2 may increase when high rates of nitrogen are applied. While larger tubers are produced, more are growth cracked and misshapen, which drop them from the U. S. No. 1 grade.

When the quality of additional potato yield diminishes, the product price per hundredweight is no longer a constant amount. The average price per hundredweight decreases as the proportion of U. S. No. 2 potatoes increases and the proportion of U. S. No. 1 potatoes decreases.

Another case of quality-fertilizer interaction can be illustrated with experimental data on fertilizing sugar beets in California. In several experiments, the increased per acre yields of beets were usually accompanied by a decreased sugar content. Grower prices are based on tonnage and on sugar content. Therefore, the most profitable rate of nitrogen application involves consideration of quality—percent sugar—of the additional yield as well as the amount. The exact nature of the relationship between yield level and sugar content has not been established.

The general principles involved in application of nitrogen fertilizer to potatoes and sugar beets are widely applicable to any of the high value crops.

G. W. Dean is Assistant Professor of Agricultural Economics, University of California, Davis.

C. O. McCorkle, Jr., is Associate Professor of Agricultural Economics, University of California, Davis.

H. O. Carter is Assistant Professor of Agricultural Economics, University of California, Davis.

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O. C. Taylor, L. H. Stolzy, and R. B. Harding

Soil properties and Citrus Production affected by management practices

Decline in production and in size of fruit is an increasing problem in southern California's citrus groves. Package plot experiments, under way for some time, have not solved that problem, but they have provided promising leads. This report is concerned with one phase of the project—the effect of various treatments on production, fruit size, and the physical properties of the soil within the plots. Treatments were made in: navel orange groves at Redlands, Highlands, and Riverside; Valencia orange groves at Olive and Santa Paula; and a lemon grove at Ventura. Two replications of four tree plots were used in the groves at Redlands, Highlands, and Olive; four replications of four tree plots were used at Ventura and Santa Paula; and five replications of two tree plots were used at Riverside.

Yield and Fruit Size

Only furrow irrigated groves were selected for the package plot experiments because the decline was most apparent under this environment. The most striking characteristic was the destruction of the feeder root systems in the irrigated middles, commencing at the furrow nearest the tree. Consequently, a portion of the research project involved the use of mulches, sprinkler irrigation, furrow irrigation, and soil fumigation with the nematocide D-D—all aimed at providing a more favorable environment for root development in the irrigated middles.

A sprinkling system—portable except at Riverside—was installed in a portion of each grove to provide even distribution of moisture over a greater percentage of the root system and avoid, as much as possible, the accumulation of moisture in any one location. It was hoped that this would provide a more favorable soil moisture condition for root health and perhaps prevent a localized environment favorable to root-rot organisms.

The change from furrows to sprinklers stimulated vegetative growth and fruit size during the first season, but the effect did not persist beyond that time. In the Valencia orange grove at Olive there was an indication that sprinkler irrigation may have improved production and fruit size in 1957. The method of irrigation, so long as the rate and interval of water application remained the same, generally had no effect on production or fruit size.

A rather heavy accumulation of salts developed on the leaves in the Riverside plot, where a permanent, overhead type of sprinkler system was used. The force of water droplets from the high sprinklers tended also to compact the soil surface and reduce the rate of water infiltration; this condition was reflected by a decline in production and fruit size. The wood shaving mulch in the sprinkled plots at Riverside improved water infiltration and tree condition in the sprinkled area. However, with the exception of this grove —where water infiltration was a problem—there was no evidence of benefit from the application of 4″ of wood shaving mulch. The mulches encouraged a very shallow root growth—extending into the mulching material—but this was not sufficient to cause a noticeable improvement in tree condition or production.

Decomposition of wood mulching material is often reported to cause nitrogen deficiency. However, in the mature citrus groves used in these experiments there was no visual evidence of deficiency or any reduced growth to suggest nitrogen starvation. This was confirmed by leaf analyses, which showed nitrogen to be as high in mulched trees—2.21% on a dry-weight basis—as in nonmulched trees—2.15%. Perhaps deficiency was prevented by the accumulation of nitrogen in the soil from ample applications in preceding years and continuous applications during the experiments.

The attempt to reduce the nematode population in a portion of the root area, by fumigation with D-D, resulted in a noticeable reduction in yield and fruit

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