Thus, price competition is seen only as a temporary dark cloud in urea's future. Industry people can see the cloud's silver lining—great expansion in agricultural demand.

Chelates for Chlorosis

Biggest user is Florida citrus . . . Sales mount in other areas as products are modified to meet soil requirements

Florida citrus on left has moderate case of iron chlorosis. Tree on right has recovered from similar condition through iron chelate treatment. Ten to 20 grams of iron, applied as FeEDTA, brings about complete greening in six weeks

SALES OF SYNTHETIC chelating agents for agricultural uses this year may reach one million pounds. The sodium salt of the iron complex of ethylenediaminetetraacetic acid, first in the field, is still the most widely used agricultural chelate. Striking results were first observed on a large scale when chlorosis was corrected by soil application of iron chelates in the Florida citrus groves; Florida is still taking a big percentage of the output of agricultural chelates. One company spokesman estimates that almost 95% of his sales are there.

In addition to correcting iron deficiency chlorosis in citrus, soil application of FeEDTA is achieving these results: (a) improvement of fruit quality by increasing sugar content and lowering citric acid content; (b) higher iron content in fruit and leaves; (c) increased tree growth through development of additional flushes of growth and some increase in length in new flushes; (d) improvement in fruit color, especially in oranges; and (e) increased yield of fruit.

In extreme cases, trees entirely out of production because of severe iron chlorosis have yielded up to 600 pounds of fruit within one or two years after treatment with chelated iron. Over 50,000 acres of Florida citrus land have been treated with FeEDTA. One company alone is predicting sales this year of 0.5 million pounds of FeEDTA to Florida citrus growers. Recommendations depend on the local conditions, but usually 0.5 pound or less of the FeEDTA is used per tree. This is remarkable when one considers that applications of up to 100 pounds of iron sulfate per tree have failed to correct chlorosis.

In Florida FeEDTA is usually mixed with fertilizer and mechanically distributed as a side dressing. Other fertilizer constituents normally will not greatly interfere with the avilability of the iron. The chelate is frequently mixed with vermiculite which acts as an inert carrier and facilitates mixing and handling.

Not only citrus but vegetables and ornamentals in Florida have shown dramatic response to treatment with FeEDTA. The acidic nature of the soil is the key to the success in Florida. The iron complexes of a number of other chelates are effective in controlling chlorosis when applied to acid soils; among these are iron complexes of hydroxyethylethylenediaminetriacetic acid (HEEDTA), and of diethylenetriaminepentaacetic acid (DTPA). Only these latter two chelates have been found effective when applied to alkaline soils.

Spray Application Being Investigated

The demand for an effective and economical antichlorotic treatment in the alkaline soil areas is probably getting most research attention in this field now. One approach is to develop an aqueous spray treatment which will not be affected by soil conditions. As yet this has not been successful on a commercial scale; many of these materials are ineffective as leaf sprays because of phytotoxicity and poor leaf absorption.

Philip J. Westgate at the Central Florida Experiment Station has used iron chelates on vegetables and ornamentals both as spray and soil applications. Sprays applied at the rate of one pound of FeEDTA (12% Fe) in 100 gallons of water per acre have made possible vegetable production in fields that previously would not grow crops. At the Citrus Experiment Station at Lake Alfred, Fla., where Ivan Stweart and Chester Leonard made the first field soil application of iron chelates, inconsistent results have been obtained with spray treatments. They are recommending only soil application for citrus at this time.

Reports of this same inconsistent response to chelate-sprays of citrus grown on high lime soils comes from southwest Texas. But on the same soils excellent greening was obtained from spraying chlorotic St. Augustine lawns with FeEDTA solutions (concentration: 5 pounds per 100 gallons of water; rate: 1.7 gallons per 1000 square feet). Good color lasted for only 4 or 5 weeks, how-

Producers of Chelates for Agriculture

Company	*Trade Name of Products*
Antara Chemicals New York 14, N. Y.	Nullapons
Dow Chemical Co. Midland, Mich.	Versenes and Versen-ol
Geigy Agricultural Chemicals New York 8, N. Y.	Sequestrenes
Glyco Products Co., Inc. New York 1, N. Y.	Tetrines and Ferralkines
Refined Products Corp. Lyndhurst, N. J.	Perma Greens

ever. Foliage sprays of this material were effective there in treating iron deficiencies of gardenia, privet, photinia, hibiscus, bougainvillea and holly.

On the west coast a large paper concern has been experimenting with an antichlorosis product, presumably an iron chelate, on iron-deficient crops of pears, peaches, and prunes. The product is derived from paper mill waste materials. Spray applications have given very good results with no cases of leaf injury reported. Company officials say the new product will be available for limited commercial use during the 1956 growing season at prices substantially lower than those for products now being marketed.

In spite of initial difficulties and disappointments with chelate trials in alkaline soils, a number of compounds have been developed which give good results; chief among these are the iron complexes of HEEDTA. The success of these products seems to be assured by results of this year's growing season. One company official returning from a cross country junket reports increasing enthusiasm for chelate application west of the Mississippi river. Alkaline soils require a bigger dose but with any price decline at all bigger sales in these areas can be expected.

Future Prospects Bright

No one is predicting an immediate demand for chelates on field crops, but research now under way in several areas is examining this possibility. At the National Agricultural College in Pennsylvania and at the University of Nebraska, in particular, studies of this type are being made. Almost every state experiment station is studying one or more aspects of the application of chelates in agriculture.

Iron deficiencies in soils are widespread and herein lies the biggest market for chelates. Chelates can be formed with other metals but work best when supplying iron. The nature of synthetic chelating agents is such that they preferentially complex iron over other common metals. This is a stumbling block in using these compounds to correct deficiencies of other metals. On the other hand, promising preliminary results have already been obtained with zinc and manganese chelates.

In the long run, the package chelate business sold to the "little operators" and home growers may prove most profitable to suppliers. Already several companies are furnishing iron chelates in one pound packages. One company sales manager estimates 100,000 pounds will be sold in packages next year.

Full grown Hereford steer raised on stilbestrol ponders food he will never eat, because of increased weight gain and feed efficiency induced by the hormone

Hormone Feeding of Livestock

Definite advantages are derived from stilbestrol feeding, but additional studies are needed to eliminate confusion in some areas

OVER 5 MILLION stilbestrol-fed cattle were slaughtered through last month, according to an estimate of Eli Lilly & Co. A further indication of stilbestrol popularity is that Lilly, until this summer the sole manufacturer of the hormone, sells to 655 feed mixers in 42 states (recently, Charles Pfizer & Co. has marketed its brand of stilbestrol). The reason for stilbestrol's wide appeal: Feeding of 10 milligrams a day of the synthetic estrogen boosts gains in fattening steers to an average of 3.5 pounds a day, and results in an average improvement in feed efficiency of 16%. Economic calculations, based on growth and feed efficiency data from trials performed at many universities and by the two stilbestrol producers, show an average increased return per head of $10.

These advantages are agreed upon almost unanimously, but thereafter, as is true of most relatively new fields, the situation is in a confused state. A summary of the effects of stilbestrol shows that DES increases weight gain and improves feed efficiency, but does not increase fat deposition or improve carcass quality. Unknown and answerable only with time and further research are: the future of carcass grades and quality, shrinkage in live animals as well as carcasses, incidence of side effects, acceptability of meat and by-products, and the market price of live animals.

Pros and Cons

Much of current research is directed toward determining effects of DES supplement feeding on carcass grade and quality. As an example of the disagreement on this point, one study describes the results of feeding DES, dienestrol, and hexestrol to 10 steers for 123 days at a level of 10 milligrams per steer daily. According to this study, the best carcasses were those of steers which received no hormonal substances. On the other hand, another group of experimenters reported in a summary of six experiments that cattle carcass evaluations have been fully as good where diethylstilbestrol has been included in the feed as they were where carcasses were produced without the hormone addition.

Additional controversy exists about shrinking and dressing out of cattle. However, only a minimum of data is available on these points. Until more experimental work is completed, and as more stilbestrol fed cattle come to market discussion of these facets remains mostly speculative.

At times, some side effects have occurred, and the problem is being studied in two ways—when and what kind of side effects result from stilbestrol feeding, and the importance of these effects. Side effects observed include slight mammary development, changes in the loin and tailhead (of concern to feeders because they affect appearance of the animal), and recognizable increases in teat length, probably the most common side effect. Again, incidence of side effects varies. Some investigators have observed none or one of these, usually an increase in teat length; others have encountered each of them at one time or other. Incidence also varies within experimental herds, as well as among herds. A possible partial explanation for the variability in animal response may be due to the estrogenic activity of natural feedstuff, particularly legume pastures, silage, and hay.

Acceptability

Available data shows no hormone carryover into tissues of the animals. No threat of hormone ingestion by humans exists. The FDA has ruled that cattle should be taken off stilbestrol feeding 48 hours before slaughter, further obviating any possibility of potential carryover.

As to the market price of live DES fed animals, there is no set rule. Normally,