PRINCIPLES OF SOIL MANAGEMENT AND SUGAR BEET FERTILIZATION

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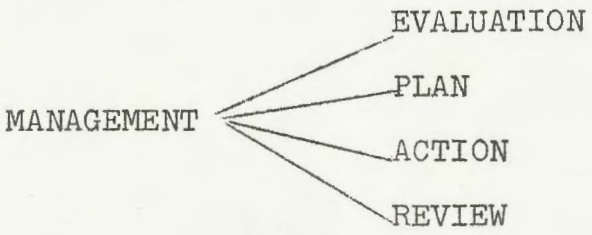
Fundamental principles seldom change. If they do change, the rate of change is slow. Therefore, if man understands the principles of sugar beet growth and can evaluate how well the soil serves its functions, he is in a good position to know "how" to manage a given soil for top sugar production.

Soil Management

Soil Management for sugar beet production is the use of knowledge, man, equipment and materials to create a suitable environment for rapid seed germination and plant growth.

Soil management is a four-phase process as shown below:



The first phase is one of evaluation. This involves an inventory of soil conditions, manpower, equipment, and so on, as well as the establishment of a realistic yield goal. (Soil testing is an inventory process.) This phase includes the accumulation of knowledge about the soil, the crop, and the interactions that occur between the two.

The second step is a plan of action, based upon the evaluation or inventory phase. This is the "how-to-do-it" or "recommendation" phase. This phase realistically interprets the conditions - physical, chemical and biological - that exist in the soil. It suggests methods pertaining to how the characteristics of the soil can be modified to create a better environment for the sugar beet plant.

The third phase of management involves action. A plan is of little value unless it is put into effect. The action phase includes the timely and economic use of men, equipment, and materials

The last step in soil management is a process of review or re-evaluation. It represents an analysis of the results that were obtained. It is a method of looking backwards in an effort to learn where errors in judgment were made. It serves as a basis for "how to do it better" in the future. This phase in management is frequently overlooked. It should not be, because it often is as important as any of the other three.

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Functions of the Soil

The primary function of the soil is to serve as an anchor for the sugar beet root. If the soil is not compacted, it will serve this function well. The leaves will be held high and easily absorb both heat and light from the sun.

The soil also acts as a storehouse for water and plant nutrients. A deep, loose, mellow friable soil not only receives rain water and fertilizer nutrients easily and rapidly, but also stores these in a condition and location that is easily accessible to the sugar beet rootlets.

Soil compaction is a major problem in some areas. Under these conditions, the soil does not serve well the functions of mechanical support for the plant and a warehouse for available oxygen, water and plant nutrients.

The ideal soil for sugar beets is one that is very loose and porous. Much could be said about the importance of adequate pore space, oxygen diffusion rates, water infiltration, and so on, or about the effect of different kinds of tillage tools upon the soil. However, space does not permit this.

In view of the need for brevity, consider for a moment how the growth of a sugar beet root affects the structure of the soil. If it can be assumed that a good sized beet has a volume of 0.1 cubic feet and that a perfect stand of 19,000 plants per acre are involved, this means that during the growing season all of the beets displace a total of 1,900 cubic feet (approximately 70 cubic yards) of soil per acre. This represents a tremendous adjustment for the soil. This is reflected in a decrease in air space and water infiltration rate. This demonstrates the need for planting seed in a very porous soil.

Functions of the Leaves, Stems and Roots

Soil management operations sometimes are made without realizing that damage - physical, chemical or biological - to any of the plant parts may result in less than desired yields. Therefore, the function of the three major parts of the sugar beet plant are briefly reviewed.

The leaves serve one major purpose - to manufacture sugar. Carbon dioxide from the air is chemically combined with water from the soil within the leaves as sugar. Therefore, anything that encourages the early development of leaves or any practice that protects the leaves from damage is theoretically likely to result in increased sugar production. Insects, disease, cultivation blight, and so on, are perpetual problems. Regular and systematic inspection of sugar beet fields is strongly encouraged.

The stem serves two major functions - that of keeping the leaves upright and exposed to the sun and that of an avenue for translocation of nutrients and water from the roots to the leaves and as a conduit of manufactured food from the leaves to the root. Sugar beet fields should be managed in such a way that the stem can well serve these functions. Damage from the use of cultivators, sprayers, fertilizer applicators, and tractor tires is common.

One function of the roots of the sugar beet plant is unique. The root serves as a storage organ for the sugar. In addition, the root system anchors the plant firmly in the soil so that the stem can hold the leaves upright into the air and so that the rootlets can absorb oxygen, water and plant nutrients. Anything that can be done to create a better root environment so that these functions can be efficiently effected is likely to result in better production.

Soil Management for Sugar Beets

Soil management may conveniently be divided into ten parts as is illustrated in Figure 1. As with a chain, yields may not be satisfactory unless each link is recognized and is strong. As actually occurs in a chain, each management factor is either directly or indirectly connected with the other.

In the Eastern Region water is a problem. At planting time, there frequently is too much and in August too little. Therefore, adequate drainage as well as a spongelike porous structure is desirable. Excessive shallow tillage results in soil compaction and is considered as a real hazard in the Eastern Region.

The tilth problem is closely related to water control and some of the disease problems; for example, blackroot. The soil around the sugar beet seed should be firm, but not packed. The soil between the rows should be loose and porous.

Soil reaction is generally not a problem except as related to the availability of micronutrients. Modern sugar beet production techniques involve soil testing. Soil acidity and the need for lime is not general except in the southern part of the Eastern sugar beet region.

Weeds are still a problem. However, the problem is not as great as a few years ago. The use of the minimum tillage principle, as well as the use of some of the newer chemicals, help greatly.

With today's technology, there is no excuse for producing beets that are deficient in nitrogen, phosphorus, or potassium. Recommendations for fertilizer based upon soil test results should be followed closely. There is increasing evidence to suggest that excessive rates of nitrogen and phosphorus, if not directly injurious to the beet crop, may indirectly restrict or even reduce yields of some of the crops that follow sugar beets in the rotation

Soil erosion caused by water is seldom a great hazard in sugar beet land, except on fall plowed ground. Wind erosion is an increasing hazard for several reasons, including the fact that generally surface soils are worked into a very fine condition. Too many of the producers still consider the seedbed to be the entire surface soil. Wind erosion problems are greatly reduced where relatively large soil aggregates are on the surface of the soil.

Soil organic matter has been referred to as the life of the soil. The man who grows high yields of other crops in the rotation usually produces high yields of sugar. Errors in judgment or management are not as evident on soils high in organic matter.

Diseases, insects and pests are problems that are reduced with superior management. Such problems are usually closely related to crop sequence. Every field man recognizes the hazard of growing beets after beets, yet there are still instances where this is done.

Research by many individuals in the field, the greenhouse, and the laboratory supply the basis for the principles that have been discussed. The data in Figure 2 shows what has occurred on the Ferden farm in Rotation 6. These yields are from the "high fertility plots". Rotation 6 is a cash crop rotation, involving barley, beans, wheat, corn and sugar beets in this sequence. These yields are five-year averages.

The yield increases, from 1941 to 1964, are associated improved management and a better understanding of the requirements of the sugar beet crop. During this period of time, new and improved varieties were grown. Seed was greatly improved. In 1948, supplemental nitrogen was used for the first time. In 1951, the original fertilizer rate was doubled. In 1953, minimum tillage methods were first used. In 1963, the fertilizer rate for sugar beets was doubled again.

In this data, notice that the yields did not change greatly during their first ten years of the experiment. Yields changed only after superior seed, extra nitrogen, the use of minimum tillage methods, and extra fertilizer were incorporated into the experiment.

Summary

Superior soil management has to be based upon an understanding of the principles of sugar beet growth pattern and upon the interactions that occur between the soil and the sugar beet plant. With today's modern technology, it is necessary to recognize that many interrelationships exist as is shown in Figure 3. This diagram suggests that increased rates of fertilizer will not be effective unless soil water, soil tilth, soil reaction, and organic matter, as well as weeds, erosion, disease, insects and pests are regulate or actually controlled.

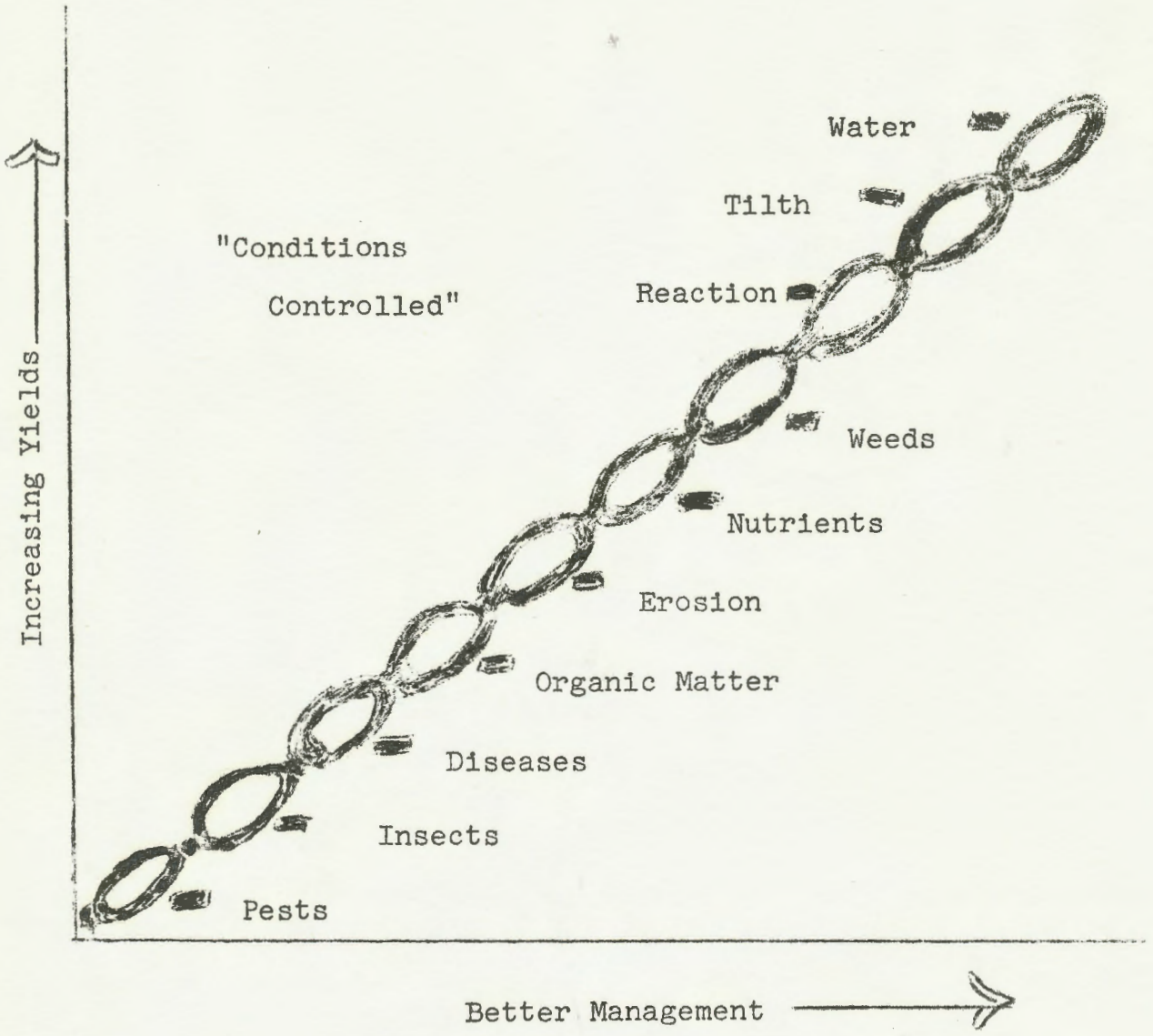

Figure 1. Interactions in soil management factors

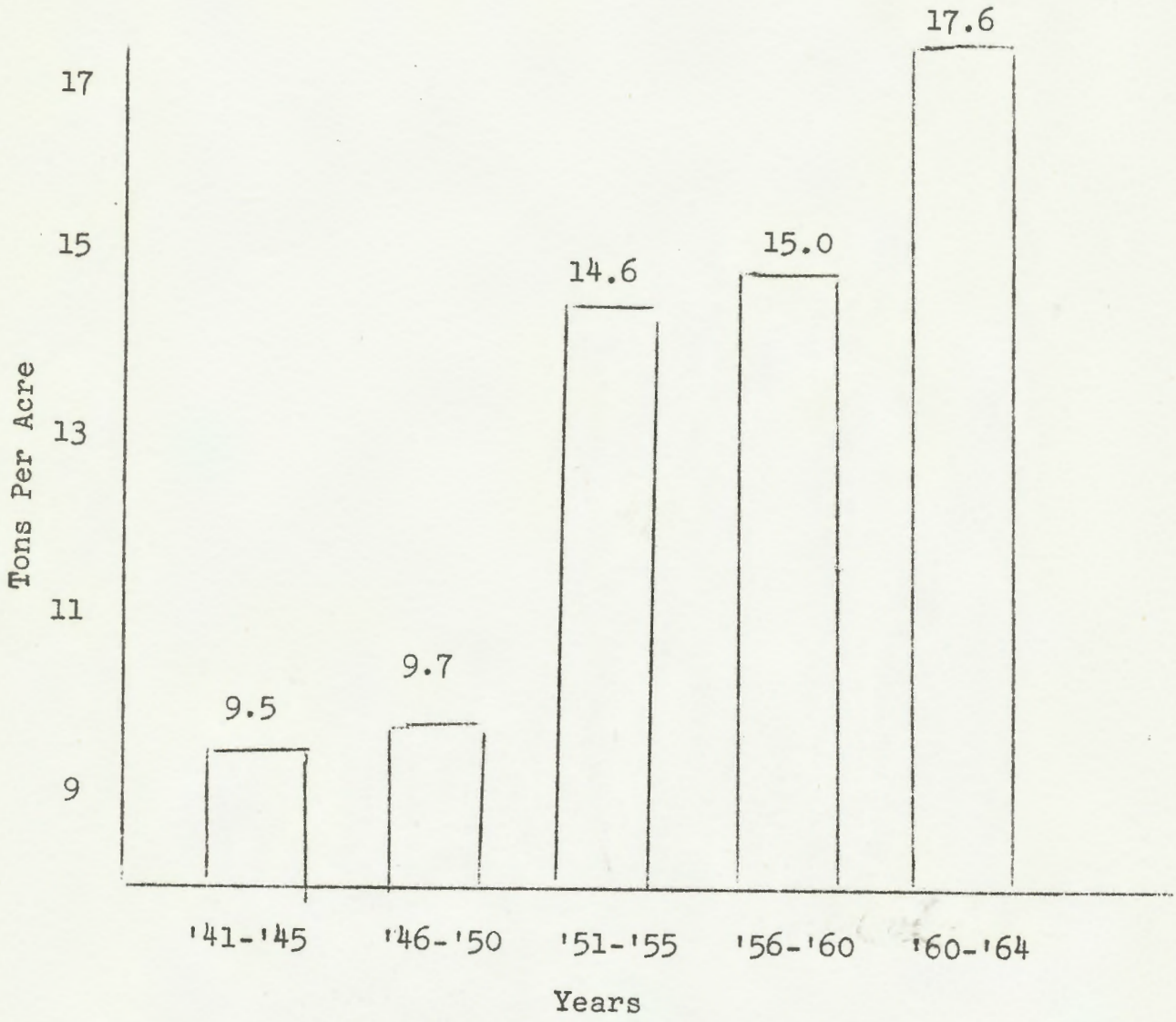

Figure 2. Sugar Beet Yields from the Ferden Farm (Rotation 6 - High Fertility)

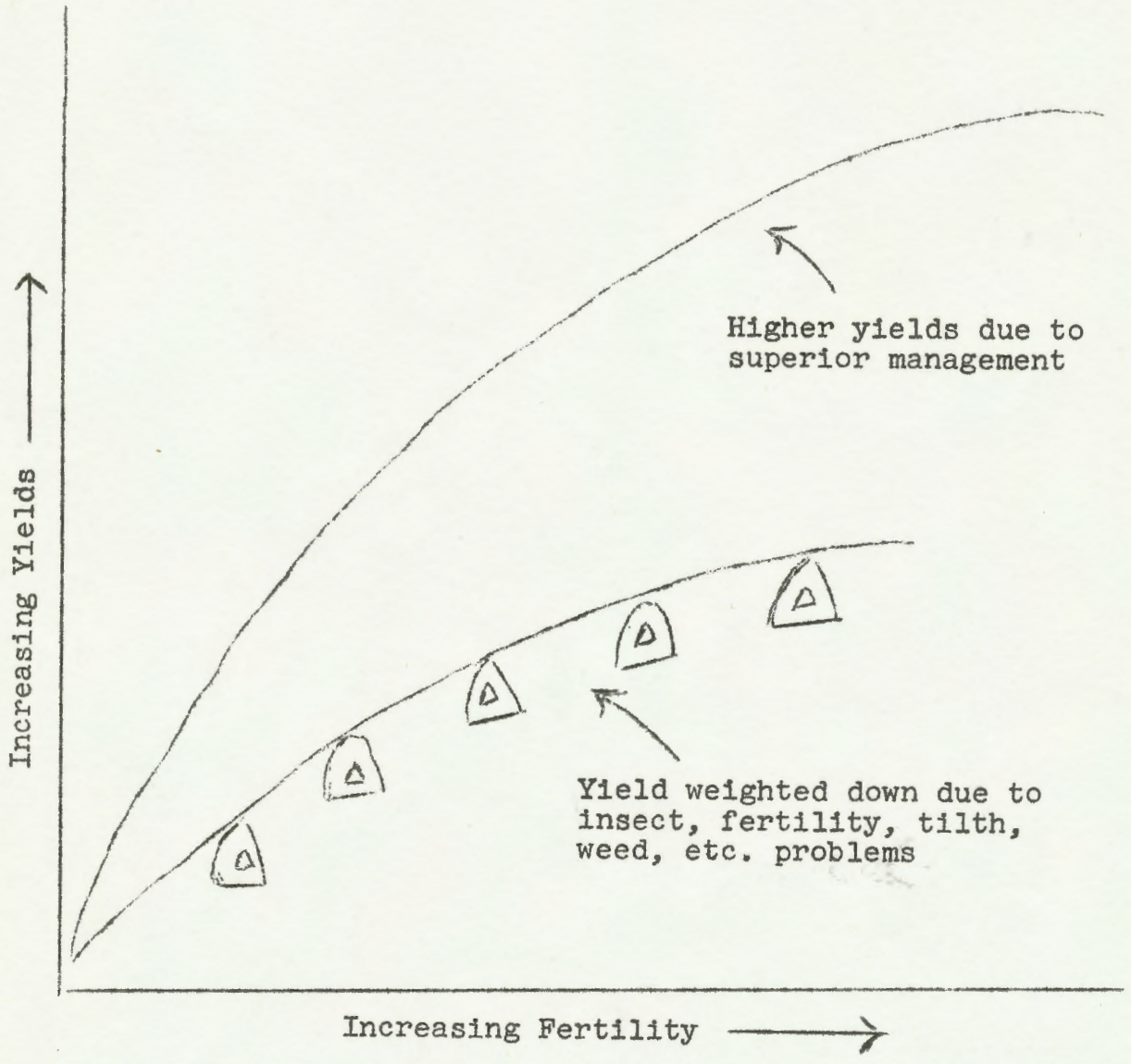

Figure 3. Superior management is reflected in higher yields