California Sugar Beet Research

data obtained by scientists and applied by growers effectively increased production efficiency and yield

Paul F. Sharp, Wayne F. Weeks and W. G. Wilde

The following article is based upon extracts from reports of research on sugar beets conducted in the College of Agriculture by the Department of Home Economics and the Divisions of Agricultural Economics, Agricultural Engineering, Agronomy, Animal Husbandry, Botany, Dairy Industry, Entomology, Food Technology, Irrigation, Parasitology, Plant Nutrition, Plant Pathology, Poultry Husbandry, Soils, and Zoology.

The successful application to commercial sugar beet growing of the research reported herein is due to the co-operation of sugar processors, local growers and the United States Department of Agriculture with the University of California.

The controlled environment laboratory equipment study is being conducted through the co-operation of the California Institute of Technology, the Beet Sugar Development Foundation, and the Earhart Plant Research Laboratory in Pasadena.

The rise in California sugar beet production—from some 6½ tons an acre in 1925, when the curly top disease was a major problem, to nearly 19 tons in 1949—was due largely to the application by growers of the findings of agricultural research.

It is impossible—under field conditions—to control every environmental factor which affects plant growth. Sometimes years must pass before all of the various climatic factors influencing plant growth and behavior can be studied. Under such circumstances it would be necessary to conduct long-range extensive experiments before a sufficient amount of information concerning varying conditions of climate, soil fertility, moisture status, plant development and other variables could be collected.

The completion of the Earhart Plant Research Laboratory at the California Institute in Pasadena enables research workers—for the first time—to create artificially and to change at will environmental conditions in which a plant is grown. The new equipment makes it possible to study separately each factor which influences the transformation of chemical compounds within the sugar beet—temperature and light, wind, rain and fog, humidity and gas content of the air, as well as essential elements of the soil.

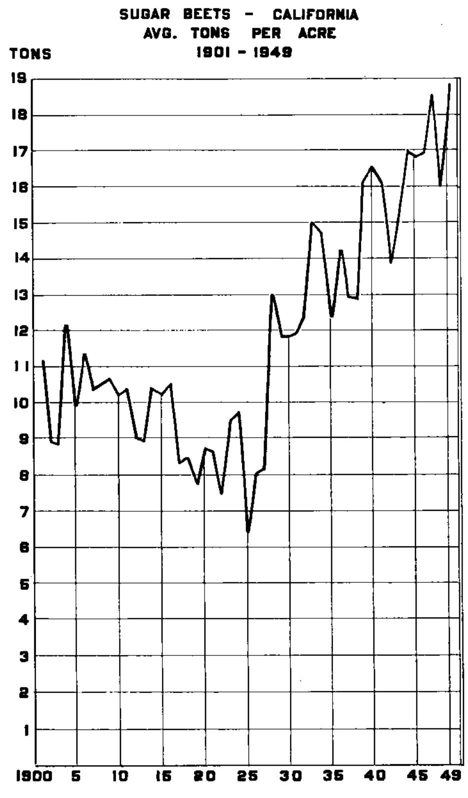
Once the required nutrient range has been established for a particular kind of plant, the petiole test—laboratory analysis of plant tissue such as leaf stalks or blades—may be used for:

1. Establishing the kind of nutrient deficient in a soil.

2. Estimating the time and amount of fertilizer to be applied.

3. Guidance in maintaining soil fertility.

An extensive plant analysis project studied approximately 50 fields where sugar beets were grown—in the interior valleys, the coastal valleys, and in the desert sections of southern California.



Observations were made regularly as to moisture, pests, disease and cultural practices. Leaf samples were collected at three-week intervals for chemical analysis to determine the nutrient status of each field of beets.

The availability of nitrogen to the beet plant is due primarily to biological activity of soil organisms which may be influenced by soil moisture and other soil factors.

Moisture Requirements

Sugar beet roots will not grow into dry soil. They will utilize all the readily available moisture to a depth of about four or five feet—with an intricate root system occupying all the soil mass between the rows. The sugar beets may grow into the fifth- and sixth-foot depths, practically the limit of their root development. The plants must have an adequate supply of soil moisture throughout the growing period and water requirements vary with climatic conditions. In the interior valleys each beet will use about 20 gallons of water, equivalent to 20- to 24-acre inches.

In years—or in areas—of low rainfall, need for irrigation will increase. Under extremely dry conditions 30-acre inches or more of irrigation water may be required. Control of irrigation water is necessary as over-irrigation will leach the soil and under-irrigation will allow the plants to wilt.

Short irrigation furrows usually give better control of the water and permit a more uniform penetration of the soil. On coarse textured soils such as sand, the length of furrow usually should not exceed 400 feet; with loams, 600 feet; and clays, 800 feet.

Rodents, such as pocket gophers, may be troublesome by tunneling the furrow levees which will permit the water to flood into other furrows and by eating out local areas in the field.

Portable sprinkler irrigation systems have certain advantages, particularly on rolling topography and on land where considerable expense in leveling would be necessary for surface irrigation. Also it is of advantage where the water table is high—as in Clarksburg area—and it is desirable to apply only a limited amount of water or where there is excessive loss by percolation as in some of the sandy soils of Kern County. The disadvantage of a sprinkler system is its cost—purchase, operation and maintenance.

Penetration rates of irrigation water, the volume weight, and pore space of soil and the shape of the beet have been studied in a comparative investigation of seedbed preparation on plowed and unplowed soil. The study was made in a series of seven trials, extending over a period of four years and included yield, sugar content, purity and number of beets an acre.

The results showed that with the soil used in the experiments nothing was gained by plowing and cultivation is necessary for weed control only.

Weed Control

Weed control by pre-emergence chemical treatment has proved practical by the application of a general contact herbicide to the field prior to the seeding of the crop or to a population of weed seedlings before the emergence of the crop seedlings.

Usually only those weed seeds that are within the upper one-fourth to one-half inch of soil germinate. If the initial population of weed seedlings is destroyed—without disturbing the soil which would bring more weed seeds near the surface—there will be few weeds to compete with the crop plant seedlings.

The early competition between crop seedlings and weed seedlings is an important factor and it is believed that the underground—root—competition is more severe than that above ground. Consequently, a vigorous, healthy development of crop seedlings is enhanced by the absence of root competition from weeds.

To obtain the most economy and benefit with pre-emergence chemical weed control, the materials must be applied when the weed seedlings are from one-fourth inch to one inch tall. At this stage of growth the small seedlings are killed easily so the volume of materials required is low.

No satisfactory selective weed-killer has been discovered which will destroy weeds in a young stand of beets without serious injury to the crop itself. Investigations are continuing but in the meantime the hoe and mechanical cultivation remain the principal means of post-emergence weed control.

Eradication programs which include the use of pure crop seed; cleaning up fence lines, roadsides, ditchbanks and other such sources of infestation; the use of chemical weed killers and soil sterilants; the timing of operations to eliminate the maturing of weed plants; and, crop rotation can make weed-infested fields weed-free.

In the Central Valley, water grass is a major weed problem in sugar beets. It not only reduces yields, but seriously interferes with harvesting, particularly mechanical harvesting. Three methods of reducing the stand of water grass at harvest time are indicated:

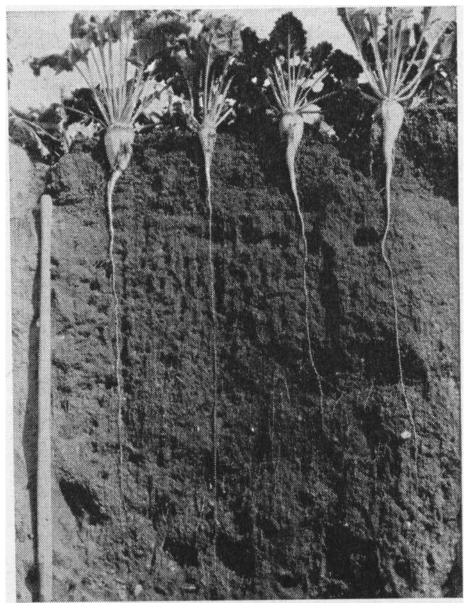
1. A late cultivation, even if it means the breaking down of irrigation ditches and their reforming.

2. Spraying with general contact herbicide in late summer even when beets cover the rows, utilizing protective shields on the sprayer.

3. Treatment with a selective herbicide.

Rotating grains with sugar beets in fields infested with water grass aids in the fight against the weed because of the dry soil condition at a time when the water grass seeds germinate. Alfalfa is another good rotation crop because of the crowding and shading by the alfalfa and the frequent cutting.

If sugar beets are ridge planted there will be fewer water grass plants in the rows because the tops of the ridges remain somewhat dry and the weed seeds do not germinate so readily as they do in the furrow.



Sugar beet roots will reach down five to six feet—practically the limit of their growth—to utilize the readily available moisture.

Another advantage of ridge planting over flat planting is that it lends itself to better irrigation practice. It permits irrigating the beet up without injury to the stand by blind furrowing or the flooding of the soil over the seed.

Seed Treatment

In addition to weed seeds many soils harbor soil-borne diseases and insects. As protection against these, as well as against certain seed-borne diseases, most growers treat sugar beet seed with fungicides and sometimes insecticides before planting.

A newly developed continuous spray-type seed treater has several advantages over the earlier treaters which dusted the chemicals onto the seeds.

The new treater gives uniform coverage of the seed by the fungicide or insecticide or in combination; the unit is completely enclosed to give protection to the operator against the chemicals; it reduces the dust nuisance in subsequent handling of treated seed as compared to dusted seed; and, the emptying and cleaning of the treater are simple.

Seed treating is an integral part of the mechanization of sugar beet production in California—where 85% of the crop was harvested mechanically in 1949 with a reduction in labor requirements from an average of 105 man-hours per acre to 35 man-hours per acre.

Hand labor in the harvest of sugar beets in 1948 in Monterey County, for example, cost $33.90 an acre while the labor cost was $6.39 an acre where a two-row harvester was used.

Because harvest by machine must be completed before the fall rains, which will keep the equipment out of the fields, the principles of engineering are being applied to each production operation to increase efficiency and reduce the time required.

The general mechanization of the sugar beet crop evolved the decortication process for changing the characteristic of the sugar beet seed from that of a multigerm seed ball to approach a single germ seed. Decorticated seed was put into commercial use in California in the season of 1947–1948 and during the past season was accepted nationally.

Until such a time as a single germ sugar beet seed is developed, through the application of the science of genetics, decorticated seed will be used.

Except for the singleness of germ, decorticated seed is superior to segmented seed; it handles better; and gives more uniform distribution, which in turn gives as many single plants per lineal foot of row as are obtained from segmented seed.

Improved stands resulting from processed seed and precision planting brought a saving in hand thinning labor of approximately 10-man hours an acre. Further savings are possible when mechanical thinning is further developed and accepted.

Fertilization

On California soils crop growth and yield responses to the application of nitrogen fertilizers are most common.

Some soils—mainly in the Salinas and Imperial valleys and parts of the Sacramento-San Joaquin Delta area—give response to phosphate, especially where it is applied early in the season.

Paying responses to potash on sugar beets are rare in California.

Some fertilizer materials are slow acting and require time to be changed into forms readily available to the plant. These materials—such as calcium cyanamide—should be applied well ahead of planting time. Similarly, ammonia or ammonium salts should be applied shortly before the crop is planted for the most benefit to young beets.

Nitrates are not fixed by the soil and should not be put on the land much before they are needed by the crop. If high rates of nitrates are applied at one time, some fertilizer losses may occur through leaching.

For mid-season nitrogen applications, the slower acting materials, particularly at high rates, should be avoided. The crop may not have time to utilize all of it and a depressed sugar content may be the consequence.

Phosphorus fertilizers usually produce their greatest responses on young beets during the cooler growing period. Often phosphate applied in the form of single or treble superphosphate or as ammonium phosphate is most satisfactory.

Fertilizers may be broadcast or banded in rows. Applications made in irrigation water are essentially broadcast on the area wetted.

Irrigation

The proper time and number of irrigations depend upon soil, weather, time of planting or harvesting, and general crop conditions.

After an irrigation when the downward movement of the water in the soil practically ceases the soil wetted is at what is known as field capacity. This wetted condition should extend below the limits of the root zone.

There are two causes of the drying of the soil—the first, is direct evaporation from the soil surface; the second, is transpiration. Evaporation is confined almost entirely to about the upper six inches of soil. In the process of transpiration the soil moisture is absorbed by the plant roots, passes upward through the plant to the leaf surfaces and is lost into the atmosphere. Transpiration accounts for about 95% of the moisture loss from the soil.

A beet plant can reduce the soil moisture to near the permanent wilting percentage—the lower limit of soil moisture readily available to the roots—and often there will be no significant reduction in final yield although growth does stop as soon as the plant wilts.

If wilting is prolonged for any length of time the older leaves will die. Then, even after irrigations, growth and sugar production are retarded until the plant develops new leaves to replace the dead ones.

In some localities—on very hot days when water loss by transpiration is excessive—temporary drooping or wilting may occur but as soon as the temperature for the day lowers, the plants recover. When plants do not recover in such cases the permanent wilting percentage probably has been reached and immediate irrigation is indicated.

Continued wilting might be attributable to the presence of one or more insect or nematode pests.

Insects

There are some 150 insects in the United States which feed on sugar beets but only 40 of them have caused economic damage and in California there are less than a dozen species which cause serious injury to large acreages of beets.

From the standpoint of the grower the pests can be divided into those which are present in or about the fields at the time of planting and those which migrate into the fields from outside.

Pests already in the fields at planting are chiefly soil inhabitants and include wireworms, nematodes, larvae of diabrotica beetles, cutworms, armyworms, beet root aphid, garden centipede and others.

Those pests which migrate into the fields and feed chiefly above ground include beet leafhoppers, adults of diabrotica beetles, grasshoppers, aphids, thrips, false chinch bug, web worms, flea beetles, crown borer, armyworms, cutworms, darkling ground beetles, and others. As an example: the beet leafhopper may carry the virus disease, curly top, many miles from one field to another. One year a field may have a severe infestation and the next year there will be no curly top, depending upon the flights of the leafhoppers.

Nematodes

The sugar beet nematode or the root knot nematode may be responsible for a partial or complete destruction of seedling stands when plantings are made after seasonal temperatures are favorable to these organisms.

In several areas in California the sugar beet nematode is a major consideration in planning a rotation program. A satisfactory rotation where this pest is involved must omit host plants for a period of three or four years. The host range is limited to the beet family including such weeds as lambsquarter and pigweed and to the cabbage family which includes cabbage, cauliflower, broccoli, radish, and mustards.

The root knot nematode has a much wider host range than the sugar beet nematode and the selection of satisfactory rotation crops is more difficult. Cereal crops such as barley, oats, wheat, milo or corn usually are the most satisfactory.

Certain insects such as aphids and leafhoppers may be the vectors of plant diseases which often reduce sugar beet production. New insecticide materials are being tested for control of aphids and red spiders on sugar beets.

Field work is under way in Riverside County on control of the bean aphid on sugar beets grown for seed—and in Imperial County on control of the green peach aphid on sugar beets grown for sugar. The beet root aphid is effectively controlled by crop rotation.

Most losses caused by insects and nematodes can be reduced to a minimum through the use of control measures.

Wireworms

Soil fumigants or residual chemicals are satisfactory controls—in the attack on wireworms, for instance—but some are costly and others may pile up undesirable amounts of chemicals in the soil.

Seed treatment can not entirely supplant the use of other wireworm control methods but treatment with lindane is successful and practical.

Sugar beets are relatively tolerant of lindane. In a field experiment, 16 ounces of 25% lindane to 100 pounds of sugar beet seed killed 93% of the wireworms within the seed area. At the same time the number of plants per foot of row increased from 0.69 plant where the seed was not treated to 1.63 plants where the seed was treated.

Continuous cropping to sugar beets offers the maximum opportunity for the increase of any soil-borne pest or soil-borne disease. The large tonnage of sugar beet leaves and roots and their high energy content are particularly favorable for the multiplication of certain types of organisms.

Crop rotation for disease control is expected to cause the organisms to die out or at least be reduced in number by withholding a host plant from the field.

The length of a rotation system needed to reduce a fungus or nematode population to a safe point depends upon two characteristics: the host range of the organisms; and the ability of an organism to survive and multiply in the absence of living host plants.

Fungi

Several different fungi may cause the damping-off disease of sugar beets. Some of them live from year to year in field soils and are widely distributed in most areas of California. One such fungus may be carried on sugar beet seed.

Combination of fungicidal and insecticidal seed treatments to prevent damping-off and to control insects are being studied.

Under conditions of high temperature and high soil moisture in certain late planted fields in 1949, loss of seedlings from the attack of soil fungi occurred despite seed treatment. Some types of soil treatment may be necessary under these conditions.

A study of the Cerocospora Leaf Spot outbreak in Hamilton acreage near Chico in 1948 revealed that serious loss occurred only in fields that had been in beets the preceding year.

The seedling disease referred to as Late Black Root or water mold is most severe in late plantings following certain seasons or in soils that are acid or near neutral. This seedling disease has not been controlled successfully by seed treatment. Early planting, following a non-irrigated crop such as grain, seems to be the most satisfactory control practice until more information is available.

Beet Mosaic, a virus disease which is transmitted by aphids, is not considered a serious problem to sugar beets produced for their roots.

Of the root rot diseases one of the most serious is the southern Sclerotium root rot. When one sugar beet becomes infected by the Sclerotium fungus the disease spreads quickly to other beets in the same block. More important is the fact that doubles or multiples are about three times as likely to become infected as singles in the same field.

Rotation planting of infested fields with non-susceptible crops such as wheat or barley or certain winter crops such as peas results in a rapid reduction of the Sclerotium population.

Application of nitrogenous fertilizers in infested fields have consistently reduced the percentage of Sclerotium. Ammonia sulphate and anhydrous ammonia, calcium nitrate, and cyanamide proved extremely effective when equivalent amounts of nitrogen were applied under favorable conditions.

Harvest

Maturity of the beets and time of harvest are determined by chemical analysis of root samples taken from the fields.

The last irrigation must be timed carefully in relation to date of harvest, as wilting before harvest may affect the sugar percentage and the growth of the beets.

Wilting of the mature beets will increase the sugar percentage until about half of the leaves are wilted. On the heavier types of soil, this period will extend over two to three weeks and may increase the sugar percentage as much as 3% to 4%—such as from 15% to 18% or 19%. On light soils a corresponding severity of wilting will occur in one week to 10 days and probably with a smaller increase in sugar percentage. Permitting the beet plant to wilt will actually decrease the total volume of sugar per acre even though the sugar percentage increases.

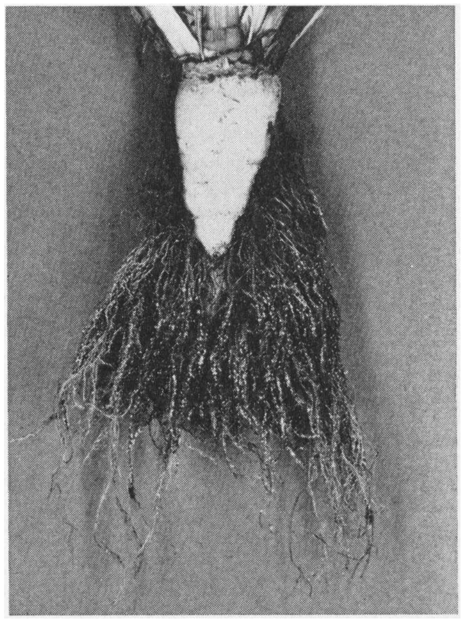
A loss of sugar occurs if topping of the beets is delayed after digging and harmful nitrogen is increased in the beets during the same period.

Several different types of mechanical harvesters, developed during and since World War II, are in common use.

A harvester developed at Davis and tested in dry, loam soil at Clarksburg gave 93.7% root recovery and only 6.8% dirt pickup.

The performance of harvesters is affected adversely by beets in multiple combinations, by a preponderance of small beets, and by beets of odd shape. These faults appear to be inherent, and their correction probably must occur through plant and cultural improvements—such as single germ seed, precision planting, weed control, and mechanical thinning—rather than in improvement in harvester design.

Experimental piling operations were carried out through two seasons with machine harvested beets. Fans circulated cool night air through the pile of beets to maintain an average temperature of 52° F. Results of the tests indicated that machine harvested beets may be piled for 30 to 40 days near the end of the harvest season before being processed.



Nematode infested sugar beet. The small white bodies attached to the rootlets are mature female nematodes. Crop rotation is the most satisfactory control of this pest.

Changes in methods of harvesting and the general use of mechanical toppers and loaders, have prompted some farmers, livestock feeders and manufacturers of farm machinery, to work toward better utilization of beet tops.

Beet Tops

Tops and siloed pulp are sugar beet by-products important as feed resources to the livestock industry.

The crude fiber content of beet tops is considerably lower than that of common roughages but the mineral content of the tops exceeds that in most feeds and helps explain their laxative nature. Tests show the weight of moisture-free tops to be about 10% of beet tonnage produced. The moisture of fresh beet tops is about 80%; in field dried tops, 20% to 30%; and in beet top silage, 70%.

Sugar beet tops harvested and siloed or field stacked contain total digestible nutrients equivalent to 450 pounds of barley or 700 pounds of alfalfa hay per ton. The dry matter averages 9.7% digestible protein; 59.2% total digestible nutrients.

Siloed beet pulp contains 8.9% digestible protein and 76.4% total digestible nutrients on a dry basis and can be stored with less fermentation loss if a small percentage of molasses is added and with greatly reduced total ensilage loss—where leaching is prevented—if 10% to 14% barley is added. The average dry matter yield of beet pulp is about 5% of the tonnage of beets processed.

The addition of 2½% and 7½% molasses increase the palatability to livestock—besides reducing the ensilage loss.

Pasturing beef cattle in a harvested field is a common method of utilization of beet tops. It is a simple but comparatively wasteful procedure.

Beet Pulp

The beet pulp resulting from the sugar manufacture provides excellent feed for dairy cows and when fed after drying is not injurious in any way to milk flavor.

Experiments indicate that as little as 5½ pounds of beet pulp in the form of silage fed two hours before milking caused objectionable flavor in the milk. When larger amounts of 40 to 50 pounds were fed, as long as five hours before milking, the feed flavor was also definite and objectionable. When silage was fed at a rate as high as 50 pounds per feeding immediately after milking, the flavor did not appear in the milk at the next milking twelve hours later.

Nutritionists experimenting with dehydrated beet pulp as a feed for poultry have reported a depressing effect on the growth of chicks when pulp is fed at levels in excess of 5%.

About one fourth of the human consumption of sugar in the United States—96 pounds per capita per year—is supplied by sugar beets produced in 21 states.

In California during the three postwar years of 1946–1948, an average of 150,000 acres per year—with a farm value average of $28,935,000—were planted to sugar beets, representing 2.4% of the total acreage and 4.8% of the farm value of all field crops planted in the state during that period.

Paul F. Sharp is Director of the Experiment Station, College of Agriculture, University of California.

Wayne F. Weeks is Associate Agriculturist, Agronomy, University of California Agricultural Extension Service, Davis.

W. G. Wilde is Editor, California Agriculture.