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SUGAR-BEET PRODUCTION IN UTAH

By

F. S. HARRIS and N. I. BUTT

CIRCULAR NO. 34

Utah Agricultural College
EXPERIMENT STATION

Logan, Utah  December, 1918
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Utah is one of the pioneers in the beet-sugar industry. The first sugar factory was brought into the State in 1852, but, like all the early attempts to produce sugar from beets in the United States, the enterprise was unsuccessful. In 1891 a factory was erected at Lehi when there were less than a half a dozen factories in the United States. From this time on Utah has been one of the few states of the Union important in the manufacture of beet sugar. Since soil, climate, irrigation, and labor conditions are favorable to the crop, it is probable that sugar-beets will continue to be raised in large quantities in Utah.

CONDITIONS FOR BEET PRODUCTION

Probably no other common crop should be more closely confined to regions adapted to its growth than should sugar-beets. This is due in part to the fact that considerable expense is required to raise an acre of beets, and, where natural conditions are unfavorable, the returns for this expense and labor are small. Another important item to be considered is the fact that sugar-beets are not raised by isolated farmers; there must be a sufficient number of beets in a region to justify the erection of a factory. A large amount of capital is thereby tied up in a manufacturing plant. This will be wasted if beets cannot be raised successfully.

New tracts of land are sometimes offered for sale at fabulous prices with the statement that the soil is adapted to the raising of sugar-beets. Farmers should, however, consider these claims carefully before obligating themselves. It does not usually pay to raise beets on new land. Cheaper crops should be used for bringing the soil into a productive condition. Sugar-beets are raised to best advantage under intensive methods and the farmer should see that his soil is in proper tilth, that his water supply is ample, and that sufficient labor is available before contracting to raise a large acreage of beets.

As far as the climate is concerned, most parts of Utah will raise good beets; hence the prospective beet raiser’s problems are confined to soil condition, water supply, farm help, and a market for his beets. If all these conditions are favorable he will probably be able to raise beets successfully. Of course he must also consider costs and profits in comparison with other crops.
The fact that sugar-beets may often be raised for several years on the same land without a decrease in yield has led many farmers to believe that the productivity of the land can be maintained without either the application of fertilizers or changing the crop. The opposite point of view, that beets are very hard on the land, is sometimes held. Neither of these extremes is true. Where sugar-beets are raised continuously a certain amount of plant-food is carried away. Particularly is this the case if the tops and crowns are removed since they contain the greater part of the mineral salts of the entire plant. An unreplenished deposit of money in the bank, no matter how large, will in time be exhausted if continually drawn upon. The plant-foods in the soil may be considered in much the same way.

Fortunately, most Utah soils are high in mineral plant-foods; further very little of this mineral matter is lost if the by-products from the beets are returned to the land. Yet, the maintenance of fertility of the soil, thereby insuring a high yield, is one of the chief problems of sugar-beet production.

All crops use the same foods, but they do not use these foods in the same proportion; as a result, various crops have different fertilizer needs. Of the seven mineral foods used by crops, all are present in most soils in sufficient quantity to meet the needs of the crops except nitrogen, potash, and phosphorus. In a few exceptional soils other minerals are lacking, but they form no important need. The following table gives the amount of these
scarce plant-foods used by sugar-beets in comparison with other crops:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>Nitrogen</th>
<th>Potash</th>
<th>Phosphoric Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar-beets</td>
<td>10 tons</td>
<td>30.0 pounds</td>
<td>70.0 pounds</td>
<td>14.0 pounds</td>
</tr>
<tr>
<td>Potatoes</td>
<td>6 tons</td>
<td>47.0 pounds</td>
<td>76.5 pounds</td>
<td>21.5 pounds</td>
</tr>
<tr>
<td>Wheat</td>
<td>30 bushels</td>
<td>48.0 pounds</td>
<td>28.8 pounds</td>
<td>21.1 pounds</td>
</tr>
<tr>
<td>Barley</td>
<td>40 bushels</td>
<td>48.0 pounds</td>
<td>35.7 pounds</td>
<td>20.7 pounds</td>
</tr>
<tr>
<td>Oats</td>
<td>45 bushels</td>
<td>55 pounds</td>
<td>46.1 pounds</td>
<td>19.4 pounds</td>
</tr>
<tr>
<td>Corn</td>
<td>40 bushels</td>
<td>56 pounds</td>
<td>23.0 pounds</td>
<td>21.0 pounds</td>
</tr>
<tr>
<td>Meadow hay</td>
<td>1.5 tons</td>
<td>49 pounds</td>
<td>50.9 pounds</td>
<td>12.3 pounds</td>
</tr>
<tr>
<td>Red Clover</td>
<td>2 tons</td>
<td>102 pounds</td>
<td>83.4 pounds</td>
<td>24.9 pounds</td>
</tr>
</tbody>
</table>

This table shows that sugar-beets use relatively large quantities of potash but not so much nitrogen or phosphoric acid.

Studies of the effect of the various fertilizers on plant growth have shown that excessive nitrogen stimulates leaf growth. Potash is closely associated with photosynthesis in the formation of sugar in the leaves, whereas phosphoric acid is required in large quantities in the formation of seeds. Since the work of producing sugar must be carried on in the leaves, this may explain in part the high potash requirements of sugar-beets.

Various means may be used in maintaining the productivity of the land. Probably no system is complete that does not include returning to the land at least a part of the mineral matter removed by the crop. This may be accomplished by the use of barnyard manure or by the addition of the substances in the form of commercial fertilizers. The plowing under of green manure may also help in making available certain elements that are contained in the soil in large quantities but in a condition that the crop cannot make use of it. In cases where legumes are used for green manure, there is also a direct addition of plant-food in the form of nitrogen. Every good system of keeping the soil productive will include a rotation so arranged that the maximum returns will be secured and, at the same time, maintain the soil in good condition. In general a practical method of maintaining the fertility of sugar-beet soil will combine all the ways mentioned. Farm-yard manure will be supplemented by the wise use in a commercial form of elements necessary to balance the needs of the crop on any particular soil; and a crop rotation which will include some legumes will be practiced. With this combination, the productivity of the soil should not only be kept up but should actually be increased.

In deciding on a rotation it must be remembered that no one rotation is good under all conditions; soil type, climate, markets,
and many other factors must be considered. A number of cardinal principles if kept in mind will, however, be of considerable assistance.

It is first necessary to decide what crops can best be grown under the conditions and what area of each crop it is best to grow. The following principles should then be observed: (1) raise about the same acreage of each crop every year; (2) have at least one cash crop; (3) include a legume crop in the rotation; (4) alternate tilled and non-tilled crops; (5) alternate deep and shallow-rooted crops; (6) alternate exhaustive and restorative crops; (7) include crops that together will make the best use of irrigation water, labor, and equipment; (8) a forage crop should be included; (9) follow the best sequence of crops; and (10) add
manure to the right crop in the rotation. It is not always possible to conform to all these rules, but they may serve as useful guides.

Some of the factors that influence the rotation are: (1) kind of soil, (2) the kind of crops that can be raised profitably in the region, (3) the proportion of the farm that is to be planted to beets, (4) the amount of fertilizer available, (5) the number of livestock kept on the farm, (6) the presence of pests and diseases, and (7) the amount of labor that is available.

In several beet-producing areas where beets have been raised almost continuously for many years the nematode has made it impossible to continue the crop unless a rotation is introduced. In planning a rotation for these conditions, it is necessary to eliminate plants that will foster this pest. The following crops will not foster the nematode in the soil: cowpeas, soybeans, clover, rye, millet, tomatoes, asparagus, lettuce, canteloupes, cucumbers, melons, strawberries, barley, corn, lima beans, wheat, potatoes, tobacco, flax, and alfalfa. A few of these crops will allow scattered colonies of nematode to live on them, but the pest will not thrive. Surely from this list of crops a satisfactory rotation can be worked out for an infested area.

In Utah, several canning crops, such as peas, beans, and tomatoes, are used in the rotation. These crops taken with alfalfa, potatoes, sugar-beets, and grain enter into most of the rotations. Under these conditions it is a rather common practice to allow alfalfa to grow until the latter part of May, then plow under the crop and after thoroughly working down the land, plant potatoes or corn. The next year beets are planted. The organic matter plowed under with the alfalfa adds to the humus supply of the soil and enriches it in nitrogen.

A farmer with eighty acres of land wishing to raise twenty acres of beets and having as other possible crops, alfalfa, potatoes, tomatoes, peas, beans, and the small grains, might arrange his crop into a rotation something like this: alfalfa four years followed by potatoes, corn, or tomatoes one year, beets one year, peas or beans one year, beets again one year, grain as a nurse crop with alfalfa one year. This would give an eight year's rotation with the following acreage each: alfalfa forty acres, corn, potatoes, or tomatoes ten acres, beets twenty acres, peas or beans ten acres, and wheat, oats, or barley ten acres.

A variation of this rotation would be to put the two beet crops together and let the peas or beans follow; or if it was desired to have as large an acreage of beets as possible, the peas and beans could be eliminated and the beets raised three years
continuously if well manured, giving a total of thirty acres of beets. If the farm were small, the same general arrangement could be maintained, only it is probable that the relative area planted to beets would be larger. The rotation could readily be extended or shortened a year or two by increasing or decreasing the length of time the land was in alfalfa.

Fig. 3.—Feeding beet pulp to cattle. Beet raising promotes the livestock industry so essential to permanent agriculture.

Where alfalfa does not thrive, the same general plan could be carried out with some other sod crop, such as clover or grass. In a rotation of this kind the use of manure is usually most effective if applied just previous to the beet crop. In plowing up alfalfa, it is usually better to plant some crop such as corn or potatoes for a year before planting beets because of the interfering action of the coarse alfalfa crowns and the growth of alfalfa plants that are not killed. Clover and grass land may often be planted to sugar-beets at once, especially if fall plowed.

CONTRACTS

It seems desirable both for the sugar company and for the farmer to have a contract on the raising of beets signed before the crop is planted. The farmer would have no market for the crop of beets if the sugar company did not buy them. He should be sure, therefore, before planting the crop that the sugar company will take it; otherwise he runs the risk of a heavy loss. Likewise, the sugar company needs to know early in the season the approximate tonnage of beets that it will have to slice in order that necessary equipment and supplies may be secured. These conditions have led to the universal practice of contracting in advance all beets that are raised for the factory.
The contracts used by different sugar companies vary in their content. Some go into considerable detail and specify every point; others cover only the more important or general questions. Items that are included in some contracts for raising beets are the following: amount of seed to be planted to the acre, price of seed, price of seeding, price of beets, provision for the supervision of growing by the factory agriculturist, specific directions regarding cultural methods, time of digging, methods of topping, method of weighing, method of taking tare, standards for condition and composition of the beets, time of payment, provision for furnishing labor, and a number of other points.

**PREPARATION OF SEED-BED**

The seed-bed is the home of the young plant. If that home is favorable the plant gets a good start and has a fair chance to make a satisfactory growth; if it is unfavorable the plant is doomed. No matter how good the seed or what provisions are made for caring for the crop later, a satisfactory yield cannot be obtained unless the plant has a favorable condition in which to begin its life and to grow during the period when it is tender. In outlining methods for obtaining a good seed-bed, it must be remembered that conditions differ widely so that no practice will fit all conditions. The object is to make the soil a suitable home for the young plant and the practice that will produce this result in any locality is the one to use.

In discussing the question for all conditions, only general suggestions can be offered; the details must be worked out locally.

The methods of preparing land for sugar-beets cannot be discussed independent of the previous crop. If a sod crop is followed by beets, every effort must be made to kill the sod plant and to promote the decay of roots and crowns. Considerable attention must also be given to stirring the land deeply in order that the beet root may have a mellow soil in which to grow. If potatoes or a root crop have been on the land, the soil will already be loosened to considerable depth and there will be no coarse residues to care for. Under these conditions the preparation of a seed-bed for beets is comparatively simple.

As a rule, it pays to plow for sugar-beets in the fall rather than in the spring. Fall plowing is desirable because it turns up the deep soil which winter-freezing mellows and makes congenial to crops; it secures a more complete decomposition of organic matter; it breaks up a cloddy and compact condition; it allows more of the winter rainfall to be stored; it gives time to establish capillary connection between the plowed portion and sub-
soil; it makes possible the earlier use of sod land for the beet crop; it exposes and kills many insects and fungous pests; and by giving better conditions for decay it allows the best use to be made of manure applied in the fall.

One decided advantage of fall plowing in regions having heavy winter and spring rains is that the beet crop can be planted much earlier with fall plowing than with spring plowing. If the farmer must wait in the spring till the land is well dried before plowing, the season is far advanced before seed can be planted. Harrowing and leveling should follow plowing, after which enough time should elapse for the soil to settle before seeding. By this time the surface soil is so dry that the seeds must be planted too deep in order to get the moisture necessary for germination.

In many regions it is the custom to plow beet land shallow in the spring after fall plowing. This has the advantage of killing weeds that come up early in the spring, and it leaves a mulch on the surface. It has the disadvantage of drying out the surface; it also entails considerable extra expense. Farmers in many of the leading sugar-beet areas find that spring plowing can well be dispensed with, particularly on heavy soils. If spring plowing is necessary, as it occasionally is, it may usually be done shallower than fall plowing.

In many regions it has been found that heavy land that was planted to beets or potatoes the previous year may be put in good shape by a system of harrowing that puts the surface of the land in good condition. While this method seems to eliminate plowing, it does not in reality do so since the digging of the potatoes or beets is practically equivalent to a fall plowing and the treatment is not recommended except for heavy land that has raised these crops the previous year. One difficulty with spring plowing is its tendency to dry the land at the time when moisture is so much needed to germinate the seed.

All seem agreed that for beets deep plowing is desirable since the expanding roots require a soil that may be moved readily; but just what deep plowing is, seems to be entirely a matter of local judgment. In one place ten to twelve inches would be called deep plowing; in another locality nothing less than eighteen or twenty inches would be so designated.

Ordinarily, where mechanical traction power is available, the land is plowed deeper than where horse power is depended on. In some sections an attempt is made to plow all beet land twenty to twenty-four inches deep. Other sugar-beet areas find half this depth ample. The nature of the soil and other local conditions are doubtless important considerations in this connection.
The length of time the land has been cultivated must also be taken into consideration. It would be unwise to plow land twenty inches deep when it had previously been plowed only eight inches. The amount of raw soil thus turned up would probably render the land almost wholly unproductive the first year, particularly if the deeper soil were heavy and compact.

The use of the sub-soil plow was highly recommended for sugar-beets in the early days of the industry in America, but now there is little said of it. In some areas it doubtless pays to sub-soil, but usually sub-soiling cannot be recommended as a regular practice in connection with plowing. When digging beets the land is in reality sub-soiled; this is ordinarily all that is necessary. In some soils that have never produced beets a sub-soiling would probably do good, but it certainly is not necessary to success in raising beets and it is an expense that should therefore be eliminated.

Conditions in each locality must determine what depth land should be plowed, but for a great part of the sugar-beet area a thorough plowing to a depth of ten to fifteen inches is ample. Where experience demonstrates that deeper plowing will pay for the extra expense it entails, greater depth should be had; but the extra cost should always be considered.

Much depends on the final preparation of the land for planting. Good plowing counts for little if it is not followed by tillage methods that put the seed-bed in a condition that will favor a quick germination of the seed and a rapid growth of the young plant. This means that the top few inches must be fine and mellow and at the same time firm and moist. This preparation should be done early in order to make possible early seeding.

If the land is too dry in the spring to respond well to tillage it may be irrigated, but this irrigation must be given early. Usually irrigation will not be required before seeding, but where necessary it should always be given before the seed-bed is finally prepared since it enables the farmer to make a much finer, more moist, and better bed for the germinating seed.

Definite directions cannot be given regarding the implement to use. The tool that does the best work is best. The nature of the soil will determine whether disk harrow, spring-tooth harrow, spike-tooth harrow, float, or roller should be used. Often a combination of several of these implements is required to get the best results.

It must be remembered that the young beet seedling is extremely tender, and too much care cannot be given to prepare the land for its initial growth. Thorough disking, harrowing, and
floating are the successive steps usually followed. The float may often be followed to advantage by some implement to firm the soil just below the surface, for it must be remembered that sugar-beet seed is not planted very deep. A number of good implements are available for this firming. Finally, a light harrowing makes a thin surface mulch and kills the weeds that are newly germinated. Sometimes a corrugated roller is used for this purpose.

The weed problem must be kept definitely in mind in this final preparation, because if all the weeds are not killed about the time the beet seed is planted they will get ahead of the beets and cause much trouble.

**PLANTING**

Early seeding has many advantages and some drawbacks. If the seed is planted early and for any reason the stand is poor, there is still time to re-seed. There is also the advantage that the young plant can use the early spring moisture to germinate and get up before hot weather causes a crust to form. If seeding is done too early there is danger of the seed remaining in the cold soil so long that it rots before there is sufficient heat for it to germinate. Dates of planting must also be selected so that the seedlings will not be at a critical stage during the season when regular unfavorable winds occur. Where large areas of beets are raised, seeding is sometimes distributed over several weeks in order that all the thinning will not be ready at the same time.

The distance between rows varies from eighteen to thirty inches; twenty inches is the ordinary distance. If land is poor or if water is scarce, the beets must be planted farther apart or they do not continue a vigorous growth throughout the season. Under any conditions the rows must be far enough apart to permit horse-drawn cultivators to go between them. In each locality the distance is usually uniform in order to allow an interchange of machinery. Tillage implements are made to cultivate a number of rows at a time, consequently the spacing should be regular.

The amount of seed planted varies from about twelve to twenty pounds to the acre. More seed is required if the land is not in a condition to hasten germination. The size of seed also affects the amount to be used. It is poor economy to save unnecessarily on beet seed since a good stand is so indispensable to a good yield. For the ordinary soil that has been well prepared about fifteen pounds of seed to the acre gives excellent results.

The depth of planting is very important. It is easy to get the
seed too deep and thereby reduce its vitality. The seed of the sugar beet has little food stored in it. If planted deeply, this reserve is used up before the plant is able to manufacture its own food. The depth of moisture necessary to germinate the seed must also be considered. Seed planted in dry soil will not germinate, and it is better to have a plant that is weak due to deep planting than to get no plant at all because of planting in dry soil. Usually seed is planted between three fourths of an inch and one and a half inches deep. If the condition of the soil permits, shallow planting is to be preferred. This is particularly true on heavy land that is likely to crust.

Many types of beet drills are on the market. No type is best for all kinds of soils. In some cases the seed is planted one seed in a place and scattered regularly along the row. In some sections a type of drill that drops the seed in hills to facilitate thinning is finding favor.

A good stand of beets is so important that every means should be used to secure it. If for any reason the first seeding does not produce a uniform stand, it is often desirable to re-seed. It may be that the crop will have to be planted several times. One of the chief causes of a poor stand is the formation of a crust at the surface after the seed is planted and before it comes up. If the seeding is light, the single plants may have difficulty pushing through, whereas a heavier seeding would place several plants near each other and together they could break through the crust.
Many kinds of mechanical devices are used to break the crust. The roller is often employed. A very effective implement consists of special wheels running directly over the rows. These have spike points or knives which penetrate the crust sufficiently to enable the tender plants to come through without disturbing the soil enough to injure the seedling.

Fig. 5.—Siloing beets to be used for seed production. Seed raising requires much care and labor.

THINNING

The first requisite to a good job of thinning is an even stand of beets. A satisfactory crop cannot be raised if only half the beets come up. In some soils no treatment is necessary from the time the seed is planted till the beets are ready to thin. It is found advisable in some sections, however, to roll the land soon after the beets come up and before they are thinned. Some disagreement exists as to the value of this rolling, but many farmers believe it to be of decided benefit on some soils.

The practice of beginning cultivation as soon as the beets are up enough to show the rows has many advantages. It helps to conserve the moisture; it keeps in check weeds that come up so abundantly at this season of the year; it gives to the rapidly-growing young plants the supply of air needed by their roots; and it facilitates thinning.

No operation in the entire process of beet-raising is more important than thinning. Losses resulting from poor thinning are
not easily apparent; for this reason the danger is greater. At the time the beets are thinned the farmer is rushed with other work, and since this operation is very slow and tedious, the tendency is to hurry over it. If each farmer could do his own work, sufficient care would probably be taken, but most thinning is done by contract labor or by children, and as a result it is usually far from perfect.

Where the work is contracted, at least part of the pay should be based on the acre-yield of the crop instead of entirely on the area thinned. Where a flat rate for an acre is paid, it is difficult to get satisfactory work. Where children are used, careful supervision is necessary since they do not realize the difference in yield resulting from careful and slovenly work.

Beets should be thinned about the time they have four leaves. Before this time it is impossible to tell which will be the strong plants. Later, the shock to the plants that are left is so great that they do not easily recover. Much more damage is done by leaving beets too long before thinning than by thinning them too early. Where the farmer has a large acreage, he must begin a little too early and continue a little too long in order to get most of the plants when they are the proper size. Planting on two or three dates is advisable with large acreages in order to make thinning at the right time possible.

The distance apart to leave plants depends on a number of conditions. If the land is rich the beets may be closer together than if it is poor. If the season is short they may also be left closer in order to hasten an early maturity. Under some conditions the highest yield and sugar content are obtained where the beets have from 144 to 160 square inches of surface to the plant. With the rows twenty inches apart, the plants would be about eight inches apart in the rows. This would give 39,200 plants to the acre. If the beets weighed one pound each a perfect stand would give a yield of 19.6 tons to the acre. The beets are left as much as eighteen inches apart in some localities, but so great a distance as this usually results in a decreased yield. In a few places where the beets grow exceptionally large, this distance may be justifiable.

Where the beets are close together the yield may be higher, but the extra work of handling the smaller beets often makes the farmer satisfied with the lower yield. The whole question of distance of spacing is so much dependent on local conditions that the farmer is safer in following local practice than any general advice. It is probable that the distance is more often too great than too small, since in thinning more ground can be covered if
the beets are far apart and the tendency is to stretch ten inches to twelve or fourteen. Under average conditions from ten to twelve inches is about the right distance.

After deciding on the time to thin and the distance between beets in the row, the next thing is a good sharp hoe with which to do the blocking. This is done by cutting out all plants in the row except bunches that are left as far apart as the beets are to grow. From these bunches all plants but one are removed.

In blocking the beets, it is well to lay out a strip of land containing sixteen to twenty rows and proceed much as in plowing the land so as to leave a back furrow with dirt hoed from the furrow as seldom as possible. Later in cultivating the rows with the back furrow the soil and clods are thrown on the young plants and may injure them. Expert blockers with the right kind of a hoe can properly space the beets with a single stroke.

Next comes the tedious process of thinning in which all the plants except one are removed from the bunch. In every case the most vigorous plant in the bunch should be left. Experiments have shown an appreciable difference in yield where a comparison was made between leaving the weak and the strong plants. If two beets are left at a place, each interferes with the other, producing two under-sized and undesirable beets at harvest time.

**HOEING AND CULTIVATING**

Two hoeings by hand are usually required; three are sometimes necessary. This is the chief item of expense after thinning and topping. Much depends on having the hoeing done at the proper time in order that weeds do not get started and take the nourishment and moisture that are needed by the young beet plant. It is likewise important that the hoeing be thorough. This is much more important for sugar-beets than for a crop like corn that grows rapidly and soon shades the weeds. In the beet field it is the weeds that do the shading. Hoeing is often contracted in connection with thinning. This is very satisfactory since it gives opportunity to require a re-thinning where the work was done carelessly the first time.

Cultivation should begin as soon as the rows can be seen and should be continued till the leaves get so large that they are injured by the cultivator. Probably the most important single cultivation is that given immediately after the beets are thinned. If properly done, it enables the young plants to revive better from the shock they receive when their companion plants are removed and the soil is moved away from their roots. Under ordinary conditions the cultivations will be repeated about every
ten days. The time may be somewhat modified by rains or by irrigations.

Several good cultivators are on the market. These provide a number of attachments, varying from the "spider" to the weeding knife, to be used at different stages in the growth of the crop and for different conditions. Two-rowed and four-rowed cultivators are both used. The larger one is used almost exclusively for the larger acreages.

**IRRIGATION**

Most of the beets in Utah are raised by the furrow method of irrigation. In a few sections sub-irrigation is practiced. In furrowing out the beet field, several implements are used. Each community has its preference for some special implement. The
main thing is to make a good, clean, smooth channel. With the right implement five to ten acres can be prepared in a day by one man and a team.

Fig. 7.—Unlevel land makes flooding and therefore water-logging and sun scalding unavoidable. (See Figs. 8 and 9.)

The permanent field laterals should be so arranged as to allow the freest preparation and cultivation of the fields without interference. By making the field laterals conform to the contour of the land, the water may be evenly distributed through the furrows. On light soil difficulty is likely to be experienced with the banks cutting, causing more water to run down one furrow than another. Where this difficulty occurs, some form of permanent outlet may be provided to advantage. This insures fairly even streams. In many places small lath or galvanized iron tubes are put through the bank at the head of each row. These are long enough to protrude a little on both sides of the bank. Though these tubes are often helpful, they are not without objections. In a heavy soil devices of this kind are usually not required.

To run water the entire length of a long field is a mistake even where the slope of the land permits. On flat fields, cross ditches should usually be not more than two or three hundred feet apart, even on sloping ground, the distance should rarely exceed five hundred feet. Waste ditches at the bottom of the land should always be provided in order that use may be made of all the water that does not soak into the land. Allowing water to go to waste where it does no one good but causes injury cannot be too strongly condemned.

Where sub-irrigation is practiced, water is allowed to stand in deep ditches from which it soaks laterally till all the land is
moistened. This method can be used only where a rather open surface soil covers a layer that prevents water from percolating rapidly. Where these conditions prevail, sub-irrigation offers almost an ideal method of applying water.

Fig. 8.—Poor beets grown on water-logged and excessively moist land. (Compare with Fig. 9.) Such beets may also result from great quantities of coarse manure.

The amount of irrigation water required to produce a maximum crop of beets varies with the sunshine, wind, rainfall, type of soil, and a number of other factors. It is impossible, therefore, to say that any given amount of water should be applied.

The old ideas that it is necessary to withhold water until the beets suffer before giving the first irrigation and that irrigation should be discontinued five or six weeks before harvest, have been found to be false. If the plant suffers for water either early in the season or late, the yield of the crop will be reduced. The soil auger will be found valuable in determining the moisture condition of the sub-soil, and will thereby assist the farmer in judging when to irrigate.

The amount of water to apply in each irrigation is a subject of constant discussion among irrigators who seem unable to come to any definite agreement. This must vary with a number of factors, the most important of which are the depth and texture of the soil. A light irrigation of from one to two inches would be ample for a shallow sandy soil, whereas five or six inches might well be given a deep loam or clay. It must be kept in mind that the beet is a deep-rooted plant and that sufficient moisture should be added to moisten the land as deeply as the roots penetrate. Where the soil is suitable, a few rather heavy irrigations have given better results than many small ones. The irrigation
of beets is discussed in considerable detail in Bulletin No. 156 of this Station. Those desiring more information are referred to this publication.

Fig. 9.—Beets from level, properly irrigated land.

HARVESTING

The date of maturity of beets is not an absolutely definite point, but the general condition of maturity can be told rather easily. It is indicated by the browning of the lower leaves and a yellowing of all the foliage. At this time the leaves lose their vigor and have a drooping appearance. Ripeness is also indicated by the sugar content and purity, but it cannot be told by analysis alone since the composition of the beets is variable under different conditions. A beet may be said to be ripe when the foliage has the appearance just described and when analysis shows a satisfactory sugar content and purity.

The sugar company contracting for beets reserves the right to say when they should be dug. This is necessary in order that the beets may be received regularly during the slicing season and also because the company's agriculturists aided by chemical analyses are better able to judge the proper time to dig than the individual farmer who might allow the date of digging to be influenced more by personal convenience than by the condition of the beets. It is easy for the farmer, desiring to get his fall work closed off as soon as possible, to make the mistake of digging too early. It is difficult for him to realize that it is during the last few weeks of growth that the greater part of the sugar is stored
in the beet, and that the tonnage is also materially increased at that time. During its early stages of growth the beet plant is sending out roots and leaves, and most of its food is used in growth. Only when growth is nearly complete is the plant in a position to do any large amount of storing.

Under a number of conditions the beet plant may begin to ripen and store sugar, then later begin another period of growth when the sugar content would be reduced. These conditions are to be avoided. Every effort should be made to keep the plant growing up to the time of final ripening. A period of drouth in the early fall may promote ripening. If followed by warm rains or by an irrigation, the plant may then begin new leaf and root growth which uses part of the sugar that has been stored. It is therefore a mistake to let the beets become dry any great while before the time of digging. Some of the conditions bringing about this reduction in sugar are beyond the farmer’s control, but he should be watchful to make favorable the conditions of which he is master.

Two processes may be included under digging; namely, “lifting” and “pulling.” The lifting is done by means of some sort of implement especially made for the purpose. The ordinary plow can be used, but it is very wasteful of power and it causes considerable damage to the beets.

After the beets are lifted, they are pulled by hand and gener-
ally thrown into piles for convenience in topping. Sometimes the piles are made without regard to order in piling; at other times the beets are placed in such a way that all the tops lie in one direction. Without doubt this arrangement makes topping easier. If the beets are not taken from the ground immediately after lifting, there is a tendency for the soil to become compact again around the roots and increases the work of pulling.

Two beets are knocked together when they are pulled to remove as much of the dirt as possible. The dirt when handled several times with the beets adds considerably to the work involved, and it does no good since it is taken off as tare when the beets are finally delivered to the sugar company. Unclean beets are pulled and topped in one operation, but this practice is not common in Utah.

Topping is one of the important operations, and unless properly done results in considerable loss. It is an advantage to both the farmer and the sugar company to have the beets properly topped. The cut should be made right at the sun line. This is indicated by the coloring in the part of the beet that protrudes above the surface of the ground.

The crown is low in sugar and high in salts, which interfere greatly in the purification of the sugar. These salts must be removed before the sugar can be made to crystallize. The salts that are so troublesome to the sugar maker are some of the very salts that are desirable for plant food in the soil; it is to the interest of the farmer to have them retained on the land. The sugar company wants only the sugar, which is the part that comes from the air; the farmer needs the salts in order to keep his soil fertile. Proper topping serves the interests of both farmer and factory.

Where the beets are piled in windrows with the leaves all one way, the toppers can go along the windrows on their knees and do the topping without much bending. When the person doing the topping stands, he must do considerable bending in picking up the beets. This is in part overcome by having a hook fastened to the knife near the point. The hook is driven into the beet which is thereby picked up without the operator having to stoop.

Fig. 11.—Diagram showing sugar content of different sections of sugar-beet.
so far. Some object to the use of the hook since the wound it makes in the beet doubtless results in a slight loss of sugar. Whether the loss is enough to make up for the advantage is not known.

Fig. 12.—(a) topped too low, (b) properly topped, (c) topped too high.

After the beets are topped, they are piled on a place that has been cleared of tops. They are now ready to be hauled. If hauling is delayed the pile should be covered with tops to prevent evaporation of moisture which amounts to considerable weight on a hot day. Care should be taken that tops are not mixed through the pile of beets as they are very troublesome later on at the mill.

Many attempts have been made to get machines to do the digging and topping, but these machines have not been widely used in the past. It seems, however, that at present machines are available to do as good topping as can be done by hand and do it more quickly and at much less expense. Many of these are being manufactured and it is hoped that hand topping may soon be relegated to the past. If these machines are entirely successful, the labor question in sugar-beet raising will be greatly simplified.

**PESTS AND DISEASES**

With the increase in sugar-beet production, it is only natural that there should also be an increase in the pests that attack the plant. The gradual introduction of the enemies of the crop into new sections is continually making the crop more difficult to raise. Because the various troubles are likely to appear at almost
any locality, it is imperative that growers should be able to recognize them in order that they may be checked as completely as possible. Profitable sugar-beet production has practically ceased in certain sections because the seriousness of the pests was not recognized and control measures taken.

There are at least one hundred and fifty species of insects known to feed on beets; of these about forty are of economic importance. It is the leaves and not the marketable part of the beet that usually suffers; hence unless the proper functioning of the leaves is prevented, the injury passes without notice.

Ordinarily, injury is not great if proper methods are taken to prevent the incoming of pests; but if no attention is given to them and if farm practices are followed without regard to pest troubles, the damage is likely to be very considerable. Take for example the nematode injury when introduced into a region no one pays much attention to it, because of which it gradually infests the soil making beet growing impossible until suitable rotations are adopted. Insect troubles vary greatly from year to year. One year grasshoppers or army worms may devour everything in their way, but the next year they may be almost entirely absent.

Whenever there is a serious outbreak of any pest or disease in

Fig. 13.—Tops of beets eaten by the army worm in their spread over the field.
a locality, the State Agricultural College should be called on for help, and every agency should cooperate. The sugar factory agriculturist and the County Agricultural Agent will be able to give assistance with ordinary troubles. When a new pest or disease appears, experts from the State Experiment Station or the Department of Agriculture should be summoned.

A few general precautions known and utilized by all beet farmers would prevent a great part of the loss occasioned by insects. Weeds, especially those belonging to the same family as the sugar-beet such as the dock, lambsquarter, and cocklebur, are breeding plants of many of the most serious pests. Clean culture that eliminates these weeds greatly lessens the injury due to insects. Rotation of crops is practiced by many of the beet farmers, but a few stay with the one-crop system until the enemies of the beet become so numerous that the crop can no longer be grown. Much loss is occasioned by planting beets after grass or similar crops that harbor some of the worst beet enemies, such as the cutworms and wireworms. Fields are not ordinarily kept as clean of insect-harboring rubbish over winter as might be wished. In sections where cutworms bother it should be known that plowing either in the fall or in the spring lessens injury from this insect. Where attacks of insects become acute, sprays and insecticides save much injury.

Two general classes of insecticides are available: (1) contact solutions for insects such as plant lice, leaf hoppers, etc., which obtain their food by piercing the plant and by sucking its juice; and (2) poisons applied in solution to the leaves of the plant to kill such insects as caterpillars, beetles, and grasshoppers, which feed upon the outside of the leaves. The most effective contact spray is made of a solution of tobacco. For biting or chewing insects, sprays containing a poison such as the arsenicals are employed, the insects being killed by eating a part of the plant covered by some of the poison. The latter type of spray should contain a very active poison which will not easily run off the leaves of the plant and be wasted as frequently happens when not properly applied; hence arsenate of lead is one of the best.

Insect troubles vary from section to section; some of the most serious in one locality are not known in others. Certain insects, though present in a locality, may do very little damage even when serious elsewhere. Such insects as the leafhopper are greatly affected by geography. In some places they have made successful beet culture practically impossible, though in other sections the injury is but slight. Treatments must, therefore, be applied locally. No general description will suit all conditions.
The losses due to beet diseases have not been so great in America, probably because beets have been grown here only a few years and the diseases have required time for their spread. New beet areas have each year been opened up and these have been free from disease. The American beet raiser has come to look on the crop as being free from disease and requiring no attention in this matter. The time of complete freedom from disease, however, has passed. Already the fields in the older districts are infested; the fight must be taken up in earnest. We may feel thankful for past immunity, but now precautions must be taken to keep in check the diseases that menace the industry. Many fungous and bacterial organisms live on the sugar-beet plant, but only a few are of great economic importance. There are also a number of troubles that seem to be physiological. Any sign of disease observed by the farmer should be reported to the company agriculturist or to the Experiment Station.

BEET RAISING AND COMMUNITY WELFARE

In considering the value of the beet-sugar industry to the community, the indirect benefits of raising beets as well as the direct value of the crop should be considered. Those who have made a careful study of the subject are agreed that the introduction of sugar beets into the agriculture of a region results in good in many ways. In the European countries where beet raising has seen its greatest development, agriculture has a stability that is
not found in the newer countries where sugar-beets have not been introduced.

The fact that the farmer has a sure market for his crop at a price known in advance, enables him to judge more accurately the value of the land. Experience shows the approximate yield of beets he may expect; and since he knows the costs of produc-

Fig. 15.—Beet pulp silo. Thousands of cattle and sheep are fattened yearly using pulp as a main part of the ration.

ing the crop and the returns he is likely to receive from it, he is able to calculate rather accurately how much he can afford to pay for beet land of known quality. This reduces the rapid fluctuation in the price of land that is often met in regions where profits are less certain.

The raising of sugar-beets is not consistent with poor farming. Rye may be produced on land that is merely scratched; it needs but little attention in addition to the work of planting and harvesting. Sugar-beets, on the other hand, cannot be raised unless careful attention is given to every operation from plowing to the delivery of the crop at the factory. The expense of producing beets is so great that the farmer cannot afford to neglect any phase of the work; carelessness in thinning may reduce the returns by several times the amount of the cost of thinning. The farmer cannot afford to allow weeds to grow, since these pests reduce the yield not only by using moisture and plant-food needed by the crop, but they cause a decrease in sugar formation by shading the beet leaves. Thus in every phase of sugar-beet farming, thoroughness is demanded. This is bound to reflect in the raising of other crops and to cause a general improvement in the agriculture of the section.

In raising sugar-beets a great deal of hand labor is required. Much of this work can be done just as well by children as by
grown people; in fact, children often can thin beets better and more rapidly than their parents. They can be used to advantage also in weeding and in topping. This means that in regions where sugar-beets are raised, children who go to school during the winter can make good wages during vacation times.

In Utah most of those who raise beets live in towns and not on their farms. These towns provide many children who have no regular employment during the summer because small communities lack the industries found in large cities. Many of the inhabitants do not have land of their own; as a result their children are idle when not in school. If the farms of the region produce only hay and grain, no work is available for children; but when sugar-beets are added, these young people find healthful and paying employment instead of spending the summer on the streets. In this as in any other work for children, care must be taken to avoid the evils of child labor.

In all the farming communities work is more pressing in the summer than during the winter. In order to have sufficient help to care for crops during the busy season there is an excess at other times. This means that ordinarily some of the hands are idle and that winter wages are low.

If there is a sugar factory in the community, it uses a great number of men during the winter and the congestion is relieved. Those who would otherwise be idle are given employment and the entire winter wage scale for the community is advanced.

Sugar-beet raising calls for intensive farming. A given area of land producing beets will give employment to several times as many men as the same area devoted to hay or grain. With sugar-beets as an important crop, the farmer does not require so large an acreage in order to make a living as would be necessary with many other crops. This means that sugar-beet farming promotes a denser population. This has many advantages. It makes possible better educational facilities and more desirable social opportunities, thereby reducing to a minimum some of the chief disadvantages of farm life.

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