Sugar Beet Seed

Ware

SUGAR BEET SEED

A Work for FARMERS, SEEDSMEN and CHEMISTS, Containing Historical, Botanical and Theoretical Data, Combined with Practical Directions for the Production of Superior Sugar Beet Seed.

By LEWIS S. WARE, M. E.,

Editor of "The Sugar Beet," Author of "The Sugar Beet," "Various Sources of Sugar, "Production, Requirements and Selection of Sugar Beet Seed;" Member of the American Philosophical Society, Fellow of L'Ecole Centrale des Arts, Agriculture et Manufactures, Association des Chimistes Paris, etc.

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PUBLISHER'S NOTE.

This book has long been in preparation, and the manuscript was in the publisher's hands for some months before it was printed. The work embodies not only the results of 20 years' studies and experience with the subject, but in its preparation the author has visited nearly every beet-seed farm and similar institution in the world. The illustrations are mostly from wood engravings originally made for this work.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

SUGAR BEET SEED.

CHAPTER I.

Historical Consideration and Origin of European Varieties of Beets.

The name *Beta* has a Celtic origin, and is shown to have existed several centuries before Christ. It was then evidently a sort of mangold. Just whether it comes from a wild variety, existing in Southern Europe, and to which is given the name *Beta Maritima*, no one can decide. A fact of importance is, as pointed out by Schindler, that the flower of the existing sugar beet has many points in common with its early ancestor whose descendants are in existence to-day.* The pollen grains are, however, smaller, and the wild beet has many more lateral roots than the ameliorated types. French writers claim that the beet crossed the Alps from Italy. Oliver Serres mentions beets as early as 1590.

Beets were planted everywhere in Europe after the appearance of Marggraf's pamphlet in 1747. The white and rose varieties were then mentioned. The most important of all these experiments were those

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*It is interesting to compare the early or wild beet with existing improved varieties:

	Wild Beet. (Wray)	Existing Sugar Beet.
Potassa	[illegible].1	3[illegible].3
Soda	34.2	7.0
Lime	3.1	7.0
Magnesia	3.2	4.6
Chlorine	18.5	3.8
Sulphuric acid	3.8	2.2
Phosphoric acid	3.5	9.3
Silicic acid	3.0	7.0

of Vilmorin in 1775, in Russia during 1800, and subsequently. Experiments under Conrad Adam were carried on in Vienna in 1799. F. C. Archard, in 1786, at his farm, experimented with not less than twenty-two varieties of beets; and, as a result of these observations, his book on the manufacture of beet sugar was issued. Other authorities declare that it was brought to Germany from Holland. In Austria it was certainly known during the last century. To follow the sugar beet through the various stages of its history is almost an impossibility; but it was not until the 18th century that a standard name was applied to this root; its use at that period was almost entirely for feeding purposes.

Beet seed sold in 1837 for 25 to 75 cents per pound. The early Vilmorin selection in France assumed a serious aspect in 1830; a few years after this, Ziemann of Quedlinburg, Saxony, followed the example of the French. The Vilmorin method, based upon apparent sugar percentages of pieces of beet in saline solutions, was improved upon by the use of the polariscope for exact sugar determinations. However, the real impetus given to the whole question of amelioration of the saccharine quality of sugar beets was largely due to the Prussian fiscal laws. In Germany for many years they did not hesitate to declare that the Vilmorin seed was the best, and Professor Maercker placed it beyond all others. This is made evident, for even as late as 1877 the Vilmorin Original sold for about 35 cents per pound while the Quedlinburg was worth about 6½ cents.* The Klein-Wanzleben, however, stood next

*According to the "Deutsche Zuckerindustrie," the prices of beet seed on the German market in 1877 were:

Vilmorin Original, 50 kgs	140 marks
Vilmorin Amelioree, 50 kgs	28-36 marks
Klein-Wanzleben, 50 kgs	90 marks
Electoral Knauer	48 marks
Imperial Knauer	40-42 marks
Quedlinburg Original	21-27 marks
Commercial	18-20 marks

to the Vilmorin, but that variety brought freely only 22 cents per pound.

However, beets of those days were so different from the kind now used for sugar-making that they need no more than a passing notice. Knauer, with some authority, maintains that all existing varieties of sugar beets have five important starting points: 1st, Belgian; 2d, Quedlinburg; 3d, Silesian; 4th, Siberian, and 5th, the Imperial beet. Hundreds of varieties differ, not only in shape, but in the size and form of their leaves, which, also, are so many characteristics, to which must be added sub-varieties with varied colored skins, necks, etc. At the present time those who have centred their efforts on one variety, like M. Legras, have created a type that would be recognized anywhere; also the German, Klein-Wanzleben, which has undergone certain changes, but still retains its original characteristics. The type was created by the old firm Rabbethge and Giesecke in 1859. Vilmorin, the well-known French seed producer, created the White Silesian and the Ameliorated, as well as the green and rose neck varieties. The Desprez beets are known as white or rose, with hard skins, white or rose intermediate skins, and the green neck, soft skins, with several early maturing varieties; Simon-Legrand has the white rose, white conical neck, all of which are the so-called ameliorated types of the German seed growers. The most important, besides the ones mentioned in the foregoing, are the Knauer, Old Imperial, Rose and White Ameliorated Imperial and Electoral. The Dippe Brothers have produced a type based upon the Klein-Wanzleben, Imperial Ameliorated, and the Most Rich. The Austrian beet of Jules-Robert is much liked; the varieties are few.

It is not necessary to discuss the claims of each seed grower, for the practical results do not agree with their assertions.* In Europe great changes have occurred in types of beets used. From 1850 to 1859 the white skin varieties were the most popular; from 1860 to 1874 the rose necks and skins were in vogue. There were several varieties of these, but for some unknown reason the German sugar manufacturers refused them. The farmers then declined to continue planting them. They were, however, said to possess great maturing qualities; the white varieties have superseded all others. And, strange as it may seem, there are many authorities who have proved beyond cavil that, when comparisons are made between the best types, let them be of white or rose skins or necks, the sugar percentage and the coefficient of purity remain about the same.

Upon general principles, we may admit that most of the existing varieties are connected in some way with the Vilmorin French seed or with the Klein-Wanzleben with some variation. Among the outcome of the latter may be mentioned Tieder, Nordstemmer, Uffingen, Staessener, Schaustedter, Edderitger, Glausiger, Einbecker and Sallovitger, followed by hundreds of others which are mentioned under the names of various dealers, to which, however, we may add the Koppy and Strander.

The olive-shaped beet, such as the Buchner, never met with the success at one time hoped for it. A variety one now hears very little about is the Bestehorn, which is rather rich in sugar. From it were created other varieties. The white Magdeburg beetof Schlieckmann is very like the Bestehorn variety. From the Vilmorin types many varieties have also been created, and the existing standard is a combination of the original Vilmorin with a German variety, thus correcting the irregular shape that originally existed, and

*In the appendix of the book we give names and addresses of all the leading growers, and in special cases a general outline of their varieties and claims as to sugar percentage and yield.

the color of the skin. For many years these very rich Vilmorin beets were irregular in color, shape, etc. Mention must also be made of the Brabant beet, which was the starting point of many varieties which were popular for some years in France and Belgium.

Concluding Remarks.

Taking the beet-seed question as a whole, great improvements are still being made, for in Germany in 1882, the average sugar in the beet was 13.1; sugar in the juice 14.6; ten years later, in 1892, the average sugar in the beet was 15; sugar in the juice 16.7. True, the kind of soil, etc., have important influences on the variety of beets that may be the most desirable to use, but the question remains, Can many of the seed growers keep their varieties pure under their existing methods of selection and cultivation? The writer thinks not, for reasons which shall be discussed in the following pages. The difference in price per pound between good and bad seed is not sufficient to permit of any hesitancy in the choice—and the results with superior seed will always be more satisfactory in the end. It is to be regretted that some American seed dealers are offering to their customers imported beet seed at ten cents per pound. It is well to call attention to the fact that we doubt if superior beet seed can be produced in Europe and shipped to the United States at that price. More care should be taken in purchasing beet seed than hitherto. Reliable dealers or producers alone should be applied to.

In the pages which follow we enter into considerable detail respecting the science of selection, showing the importance of its continuance from year to year. If neglected, there is sure to follow a degeneration in the varieties under study, owing to atavismistic forces asserting their presence, for which facts the ordinary seed dealer does not allow. Then both the farmer and manufacturer who have had confidence, suffer.

The mixing of worthless seed with superior seed has become an industry in several European centres. If beet seed is offered at seven or eight cents per pound, it is well to have it tested by some chemist who thoroughly understands the requisites of germination. Samples should be taken only from bags that have been closed by the seedsman, and opened in the presence of witnesses. It is better to have no dealings with agents, but only with the seed producer. Let this question be thoroughly considered by our farming population contemplating beet cultivation. In most agricultural centres of the United States there are experiment stations, and the question is, Whether their laboratories could not render excellent services by testing beet seed for farmers and manufacturers, as is done with fertilizers? It often happens that seed is sown and its inferior quality is discovered when it is too late.

CHAPTER II.

Botanical Considerations Respecting Beet Seed.

The *Beta Vulgaris*, as the sugar beet is called, is the most important of the many hundred varieties of the *Chenopodiaceae* family to which it belongs. The sugar beet comes under the head of the hermaphrodite series, which originally was annual and through cultivation has become bi-annual. During the first year of its vegetation its function is to utilize its entire effort in sugar elaboration through the intervention of leaves, etc. During the second year there is a transformation of many of these organic principles, the result being seed formation; by this process the texture of the root proper becomes very much more fibrous, during which period there is a growth upward of stems or stalks, which are frequently five feet in height; upon these appear elongated leaves (Fig. 1), which are, however, roundish in shape. The stems throw out branches on which are ears of seed. These are frequently located between the leaves and are generally in clusters of three (Fig. 2), as shown in the enlarged engraving; each agglomeration of flowers contains one to six or seven flowers, in most cases only three, and these are attached or stuck together.

Historical Facts Relating to the Fertilization of Plants.

Before going into details of the manner in which the flower of the beet is fertilized, it is interesting to recall several facts relating to the past. The ancient authorities had very vague views of the whole question. It was only during the Middle Ages that botanists commenced to realize the relative part played by the stamens and pistils, and it was not until the 17th century that there seemed to be any certainty on the question. The well-known authority, Tournefort, declined to admit the facts as then presented; after his death, however, Sebastian Vaillant, in his speech at the "Jardin du Roi," showed the physiological function of stamens and gave practical demonstrations of the truth of his assertion. This was in 1716, hence this date becomes an important historical one in the whole botanical science, and to France is due the main credit of the new departure. Some eight or ten years afterward Linne

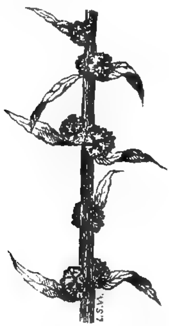

FIG. 1. Appearance of seed and leaves on stalk or stem.

FIG. 2. Outward appearance of a three-seed cluster.

popularized the Vaillant truths—it was even then noticed that if the stigmas were withdrawn the ovums of the ovary could not be fertilized. The crossing of plants of the same family was daily practiced in botanical laboratories. On the other hand, there exists, then and now, one important exception to these fertilizing facts, for we are told that in the Kew Gardens of London they have a plant which yields seed from year to year, yet there is no indication of its having stamens. Upon general principles, we may admit that the time or period that the fertilization of plants occurs is when their odor reaches its height; it is when their color is most brilliant, and in theory, it is when the pollen is most actively absorbed by the organs of the pistil. In the case of beet seed, the special characteristic odor just mentioned is, according to Wiesner, due to an organic base known as trimethylamine.

Description of the Flower.*

The engravings (Figs. 3 and 4) give an excellent idea of the flower taken as a whole. and the

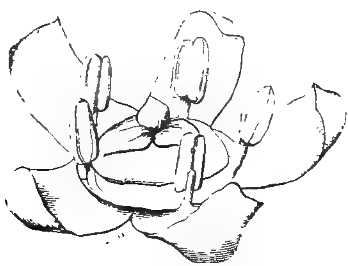

FIG. 3. Perspective view of the flower as seen from top.

section shows its appearance before and after maturity. The flower proper, when looked at with a strong glass, is shown to consist of the petals

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*DEFINITIONS.

Carpel—Another name for the leaves of the pistil; it is frequently applied to one of the leaves of which the pistil is composed.
Corolla—The leaves of the flower within the calyx.
Calyx—The outer sac of the floral envelopes or leaves of the flower.
Cotyledon—The first leaves of the embryo.
Embryo—The rudimentary undeveloped plantlet in a seed.
Endosperm—Another name for the albumen of seed.
Micropyle—Closed orifice of the seed.
Ovule—The body, which is destined to become a seed.
Ovary—Part of pistil containing the ovules of future seed.
Pericarp—The walls of the fruit matured.
Pistil—Organ to be fertilized and bear the seed; if we consider from the bottom it consists of the ovary, the style and the stigma.
Plumule—The small bud or first shoot of a germinating plantlet, above the cotyledons.
Receptacle—The axis or support of the flower.
Style—Part of the pistil which bears the stigma.
Stigma—Part of the pistil which receives the pollen.
Stamens—The fertilizing organs and consist of two parts; the filament or stalk and the anther.
Testa—The outer and usually the harder coat or shell of seed.

(Fig. 8, *c*) forming the corolla. They are slightly colored green and placed behind the five stamens; these petals bend over themselves as the season advances. The beet flower taken together is cup-like in shape, (Fig. 3). The stamens are attached at their base around an inverted saucer-like pistil placed in the centre. The

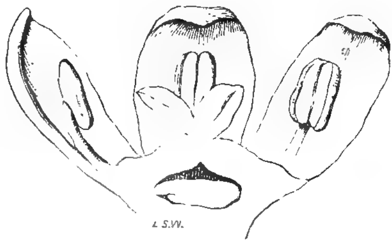

FIG. 4. Section of flower showing embryo and stigma.

general arrangement is better shown in the diagram of the flower (Fig. 5). The anthers (Fig. 8, *m*) have two lobes or cells which open vertically, their section is

FIG. 5.
Plan or diagram of flower.

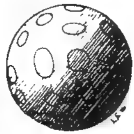

FIG. 6.
Pollen.

FIG. 7.
Section of pollen.

shown in engraving (Fig. 9); the filament or stalk to which they are attached is kept in constant motion by any air disturbance.

The pollen* granule of the sugar beet is spherical

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*Stiff has recently analyzed the pollen from beet flowers and finds that it contains: Water 9.78, albumen 15.25, nitric elements non-albuminous 2.5, fatty substance 3.18, starch and dextrine 0.80, pentosane 11.06, other extractive substances but not nitrogenous 23.7, cellulose 25.45, ash 8.28. In 100 parts of the pollen ash there is 5.8 potassa and 6.65 phosphoric acid.

in shape (Figs. 6 and 7), and when the proper time arrives is most abundant, more so than with any other plant of which we know. The pollens have a diameter of 20 micro-millimeters, but in some cases this may be from 13.3 to 25.8 m. m. The exterior surface of these granules is

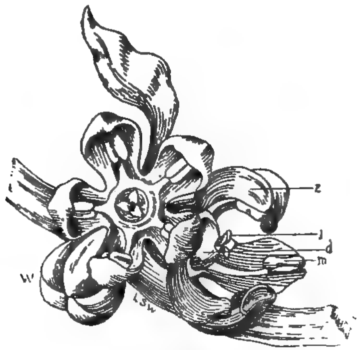

FIG. 8. Flowers at various stages of maturity.

smooth, with about thirty-five pores, which have special function during the fertilization of the ovum. The pistil is advantageously placed to receive the pollen on top of the style (Fig 8, *j*), called stigma. The pistil consists, as it were, of three small leaves, or carpels; these communicate with the ovary. There is only one

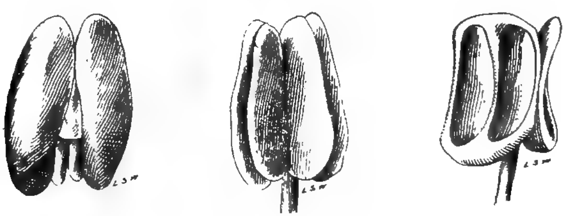

FIG. 9. Stamens (detail of anthers).
Back view. Front view. Section.

ovum in each ovary. The fruit, so-called, when only casually examined seems one, but closer observation shows it to be several distinct seeds, which in number correspond to the fertilized ovum of each flower. The engraving (Fig. 8), shows several flowers in different states of maturity, all adhering to the same stem; at the same time their pericarps are nearly blended together, and when completely matured they frequently form one.

Fertilization.

When the proper time approaches and the anthers are in a perfect condition of maturity, a very little air

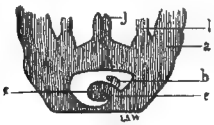

FIG. 10. Section of flower through pistil.

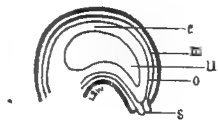

FIG. 11. Section of nucleus.

is sufficient to carry the pollen from their surface. What seems strange respecting the hermaphrodite plant, such as the beet, is that the male portion of the plant does not, according to Darwin, mature at the same

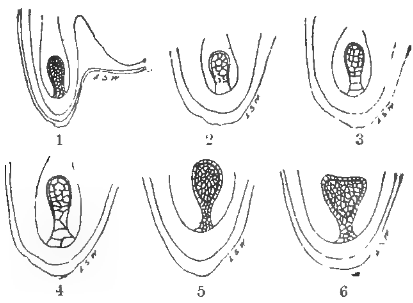

FIG. 12. Seed development.

time as the female; the consequence is that seldom, if ever, the beet flower is self-fertilized, but it is the pollen from some other flower which happens to be blown in contact with the pistil, to be communicated by the style to the embryo. This assertion coming from any

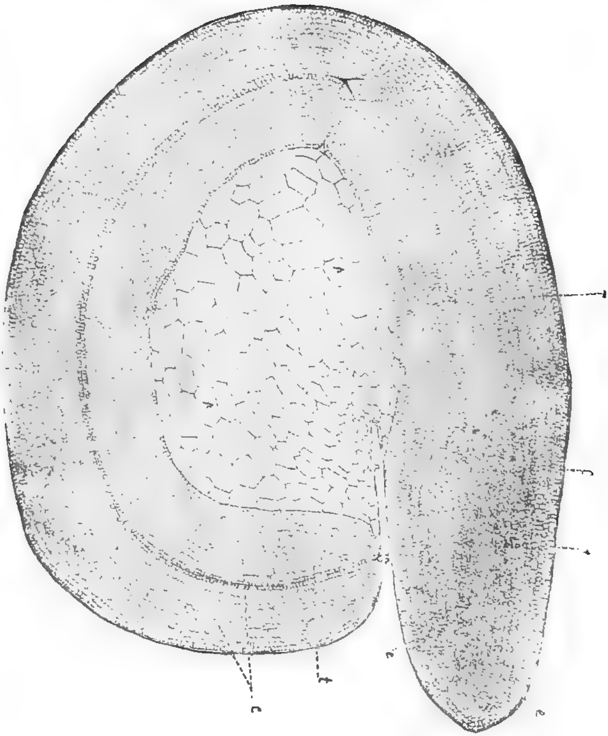

FIG. 13. ENLARGED MICROSCOPICAL SECTION OF BEET SEED.

botanist other than such an eminent authority would be refuted, for the anatomy of the beet's flower appears to be particularly favorable for its own fertilization, the abundance of the pollen on the one hand and a single ovary on the other. When the proper conditions are reached, the stigmas become moist and sticky, so as to hold the pollen granules that may fall upon them either from the same flower or another close at hand, or, in many cases, very far off. Unlike many other plants, the anther of the beet flower opens freely. The phenomenon of projection of this pollen is of more than usual interest, as mentioned in the foregoing; the period the plant is most active in its fertilization is when the perfume is the most characteristic; the mois-

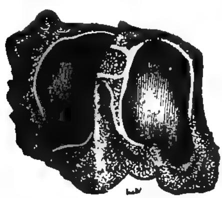

FIG. 14. Section of pericarp of seed.

FIG. 15. Seed taken from hard outer covering.

ture then to a large extent leaves the anthers, a contraction of the cells holding the pollen follows, the cavity of anthers becoming smaller, and the granules are forced out and thrown a considerable distance. The stigmas retain on their surface a large number of the pollen granules; these, being on a thin absorbing surface, soon swell and are absorbed by osmosis; the pollen then extends itself and the style (Fig. 10, *j*), allows its passage into the ovary through the micropyle.

A section of the flower through the pistil and ovary shows just how the communication is made; the petals are visible. The ovum (Fig. 10, *s*) has a certain slant on its plane which is the same as that of the carpels. The various stages (Fig. 12, 1, 2, 3, 4, 5 and 6) of the ovum development from the period of its first fertilization are shown herewith. These are taken from Kruger's observations—the final (Fig. 12,6) drawing shows the ultimate seed in its sac. The ovum considered separately undergoes constant changes even before it is fertilized. The ovule consists of a central cone or nucleus (Fig. 11, *n*), around which there are several layers of cells (Fig. 11, *c*, *o* and *m*). The growing is around the nucleus and over it, with the exception of the small opening (Fig. 11, *s*) or micropyle. One cell has expanded very much at the expense of the others and soon occupies the greater part of the nucleus. This becomes the embryo-sac, but its formation depends upon the presence of the pollen

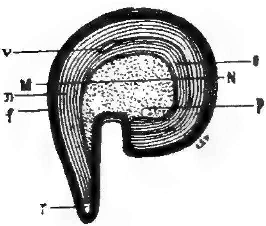

FIG. 16. Section of seed.

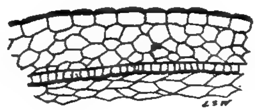

FIG. 17. Appearance of testa magnified.

tubes. After they have touched the dark spot on top of the nucleus, a membraneous cell wall forms around the protoplastic contents of the sac; these cells divide and sub-divide, and finally develop the embryo. During this period, in the lower part of the embryo-sac an indefinite number of minute cells are forming; these are the starting points for the albumen. We neglected to mention that the ovules are generally produced on the outer edge of the capillary leaf: the spongy thickening is known as the funicle.* As the partitions or

*The above is only a conjecture. There are numerous cases of plants with one-cell ovary, when the ovule is developed from the floral axis.

cells form, they attach themselves to the narrow part of the sac, the larger part forming the cotyledon.

Enlarged Microscopical Section of the Entire Seed.

The engraving (Fig. 13) is a section of beet seed made by Drs. Westler and Stoklasa. It shows what the conditions are much more satisfactorily than the drawing we have made and described in this writing. *C* are the two cotyledons; *r*, radicle; *p*, perisperm; *e*, endosperm (albumen found inside the embryo-sac); *t*, testa. The endosperm in most cases consists of only one layer, while the testa has two: 1st, the yellow, which consists of a single layer of cellulose; 2d, the brown, which is possibly made up of two flat layers. The curved germ *r*, radicle, and *c*, its two

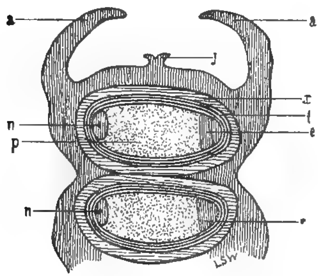

FIG. 18. Section M. N.

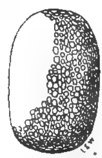
FIG. 19. Starch cell.

cotyledons, retains the perisperm tissue; the cells are very fatty, and the starch granules appear round or elliptical. The lower portion of radicle (*r*) is covered with a layer (*l*) of endosperm, which may be detached, and consists of one layer of elongated cells. The cells of which the radicle and cotyledons consist, hold fatty but not starchy granules.

It frequently happens, just as it does in animal physiology, that the ovum is not fertilized; it then withers and disappears, the explanation of which continues to be a mystery. The petals and stamens, once their functions are completed, dry up, and in case of beet seed they frequently persistently remain.

Botanical Examination of Beet Seed.

If we examine the seed as found on the market, we find a rather hard substance with a very rough surface and very irregular in shape. By slicing with a knife this so-called seed in one direction, we obtain a section as shown (Fig. 14); if from these sockets, which we examine, the seed proper is withdrawn, we find it has the appearance shown in Fig. 15 as seen in front; on top and side the shape is somewhat triangular and the surface smooth and brown in color; the side view shows it to be convex and generally measures in length 3 m. m. and 1.5 m. m. in width. This seed has no difficulty in penetrating the outer covering through a small opening when the proper conditions of heat and moisture are furnished in the soil. On the outer covering, or pericarp, is frequently found what remains of the carpels, and also, in most cases, the dried petals. A section of the seed, made with a knife, and looked at with a strong glass, reveals its arrangement, the same as shown in section (Fig. 16); at *e* may be seen the cotyledons and at *v* the plumule, or the first bud from which will form the shoot of the germinating plantlet above the cotyledons. The root subsequently develops from *r*. Droysen declares that at *r* may be found eight to fifteen layers of cells which contain granules of protein in an oleaginous mass. The brown color of the seed comes from its testa covering; this is in several layers, the principal ones being the exterior and interior. Its botanical structure is rather difficult to get at, but under the microscope its appearance is about as shown (Fig. 17), this being many hundred times magnified. The outer layer mainly has for its principal function that of regulating the germination of the seed, by allowing moisture, etc., from the environment in which the seed may be, to enter by osmosis in the proper proportions.

Drs. Westler and Stoklasa have made a very thorough microscopical and chemical examination of the testa, and have discovered that the tissue is largely made up of crystals of oxalate of lime, from which it is concluded that nearly all the calcium of the seed is found in the outer and inner layers of the testa. (The inner cellular layer of the exterior of the testa consists of small cells almost round. The inner yellow ochre layer, on the other hand, consists of a single layer of polygonal elements, which are smaller and not so flat as those of the outer portion of the testa.) It has been possible to extract several grains of the lime oxalate from the testa, and this substance has served for the estimation of pentosanes, by the Tollen-Kruger method. From the quantity of phlaroglucide, that of the furfurol may be calculated. On a basis of dry substance, it was found that there is 10.24 per cent. furfurol for 18.85 per cent. pentosane. These figures show that the testa is very rich in pentosane; it is said that these substances form a chemical combination with the cellulose of the testa.*

While the exterior coating is dark brown and consists of two layers of cells which are very flat, some authorities declare that seed which will not germinate is yellow green; on the other hand, seeds that have great germinating powers have the tip end of their root of a color which approaches violet. The seed, *M*, *N*, (Fig. 16) taken as a whole, is blue white. If we

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*These ligno-celluloses, according to Gross and Bewan, have the following formula:

$$\underbrace{4C_6 H_{10} O_5}_{\text{cellulose}} \qquad \underbrace{\underbrace{C_5 H_{10} O_5}_{\text{Pentosane}} \qquad \underbrace{C_{10} H_{18} O_8}_{\text{Keto-hexan groups}}}_{\text{Non-celluloses,}}$$

make a section through *M*, *N*, as the seed was with its outer covering, or pericarp, we have a most excellent example of how the seeds are separated, and their respective positions. The petals (Fig. 18, *a*) are visible on top, the cotyledons *e*, the root *n* and testa *r* are shown in section; *j* is what remains of the carpels.

The endosperm or albumen *p* is white in appearance and is made up of a series of starch cells, different, however, from those found in the potato; they are geometrical in shape. One of these starch grains is

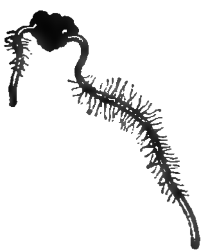

Fig. 20. Seed with descending root.

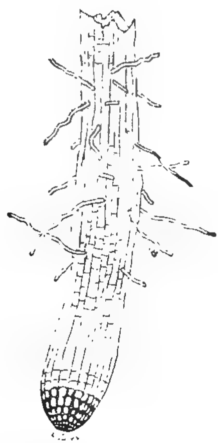

Fig. 21. Tip end of root showing the plant cells as seen under microscope.

shown in Fig. 19; its diameter is 0.068 to 0.140 m. m. They are very fragile and break under a very slight pressure into small particles; they measure only 0.004 m. m. In certain cases they appear to have a molecular motion.

Planted Seed (Botanical).

The bladder-like cell of which the final embryo consists, multiplies, as before said, into a series of subdivisions; the process continues after sprouting and

FIG. 22. LEGRAS BEET WITH STALKS AND SEED.

even when the beet has attained its maturity, the building-up of cell structure continues, the first or last cell being essentially the same. The plantlet before appearing above ground is like the engraving (Fig. 20), as seen to the eye, but under a strong microscope the structure of the root is made visible; the tip end shown in Fig. 21 gives some important idea of just what the cells in question look like.

Upon general principles, we may admit that vegetable growth consists of two things: Expansion of a cell until it attains its full size, then multiplication of the cells in number. As the outer layers are worn away by the root forcing itself through the soil, they are renewed by inner layers, which in turn are replaced.

Maturity.

This in reality means the changes which occur from the time the embryo is formed until the grain may be taken from the stalk. The fruit proper, until that maturity is reached, is living just as live the leaves of plants, viz.: During the day a different respiration from that of the night. When the maturity is completed, the tissue changes and the fibro-vascular detaches itself. The cellulose of the fruit loses its carbon and hydrogen and becomes starch; by the addition of water, this is changed to sugar. When the maturity is complete, the seed throws out the carbonic acid formed at the expense of the sugar. Seeds on the lower part of the stalks are said to be the first to mature; those on top are last to ripen and frequently do not ripen. When planted, these often germinate with difficulty.

The engraving (Fig. 22) shows the appearance of the entire root, with the stalks, when the beet matures after the second year. The appearance of the seed when matured upon its stalk is also of interest; as shown (Fig. 23), the petals are still adhering and when further dried will hide the seed proper almost from sight.

A. F. Jesnez claims that he has noticed that in years when the maturing period was excessively hot, the seed ripened too soon. This fact may be demonstrated by cutting the seed in two and examining with a strong magnifying glass. It will be noticed that many of the seed cells are empty. The excessive heat is supposed to have closed the plant cells before their maturity, leaving, however, the outer surface very hard, which in many cases frequently misleads, and even when the

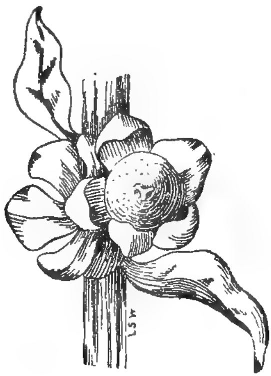

FIG. 23. Matured seed with dried petals on stalk.

germ exists, the sprouts in the germinator do not appear as soon as they do under ordinary conditions of growth.

Physiological Functions of the Embryo and Albumen.

We are all aware that albumen forms a food supply for the young plant during its early development; but this question considered from a physiological and chemical standpoint is a new departure. A portion of what follows is the conclusion of Drs. Westler and Stoklasa.

These examinations offer great difficulty, owing to the close adherence of the perisperm (albumen) and the embryo. The data relating to the analysis of the entire seed are not sufficiently accurate for any positive scientific conclusion. Herewith, however, is the analysis of seed without the exterior testa, as all the inner layer of the testa could not be separated or removed: Total nitrogen, 4.32 per cent.; nitrogen in the shape of albumen, 3.85 per cent.; fatty substances (not including lecithin), 20.02 per cent.; lecithin, 0.46 per cent.; cellulose, 2.31 per cent.; pentosane, 2.26 per cent.; starch, 37.31 per cent.; ash, 3.52 per cent. Composition of ash; potassium monoxide, 20.14 per cent.; sodic monoxide, 8.01 per cent.; magnesia monoxide, 11.2 per cent.; calcic oxide, 3.83 per cent.; ferric oxide, 0.47 per cent.: phosphoric acid, 43.27 per cent.; anhydrous sulphuric acid, 9.02 per cent.; silicic acid, 2.8 per cent.

The localization of the reserve food is as follows: Albuminoids are in the embryo, in quantities that may reach 24 per cent.; these same substances, but in inactive form, become soluble during germination, owing to the influence of enzymes. According to Neumeister, this ferment has the same reaction as animal pepsin, when in a slightly acidulated solution and in the presence of organic acids. The enzymes can never be found on seed during germination. The fatty matter contained in beet seed is an oily substance. It is found not only in the embryo, but also in the perisperm (albumen) and has very important physiological functions to fulfill during germination, as it is energetically consumed under the influence of the enzymes, and thus helps the formation of new and living molecules.

The plantlets, during germination, when reaching the first stage of development, contain only 1.6 per cent. of fatty substances (not including lecithin and cholesterin), while the quantity in the inactive primitive seed is 20 per cent. It has been determined by the thorough investigation of years previous that the lecithin is exclusively found in the embryo. Starch, on the other hand, is mainly contained in the perisperm. The percentage, 2.26 of pentosane, calculated on the basis of furfurol, is not absolutely invariable, as from recent investigations it is shown that many substances contained in the organism of plants, such as starch, fructose, etc., also nitrogenous substances, such as nuclein, etc., also supply furfurol. It is possible to admit that the hemi-celluloses are found in the cotyledons, which contain pentosane, also galacton. It is claimed that this substance, during germination, under the influence of diastasic fermentation, is changed into galactose and arabinose. The mineral matter, as determined by the analysis of beet-seed ashes, is mainly combined with the organic substances in different parts of the seed. Phosphoric acid is found in very small quantities, and the same may be said of sulphur, iron and magnesia. These four elements, phosphorus, sulphur, iron and magnesia, are harmoniously united and located in the embryo. On the other hand, it is most difficult to determine the exact portion of the seed where the protoplasm is to be found. Messrs. Westler and Stoklasa say that all leads to the supposition that it is not far from the carbohydrates; that is, in the perisperm. The protoplasm of the embryo, as soon as it commences to show signs of life, secretes enzymes; these have a certain action on the reserve plant food and facilitate their assimilation by the protoplasm. The assimilation and dissimulation go on very rapidly during the first periods of germination, and reach a maximum on the fifth day, providing all the conditions of heat, moisture and temperature are favorable. The vital energy developed by the embryo during this stage has apparently considerable influence on the formation of certain nourishing substances upon which protoplasm depends. After this formation, the taking up of organic combinations by the embryo ceases.

It is an important biological fact that the embryo of beet seed is very susceptible to any change of temperature and moisture. One might conclude that nature had in view the protection of the seed against these variations, when the testa be considered, for under its influence the variations, whatever they be, are necessarily retarded. These pathological influences are excited in proportion to the inclination of the microbes of the seed to nourish themselves upon the radicle of the embryo, when the germination is first starting. The exterior cover of beet seed contains an indefinite number of microbes; for one gram these have been found to number 300,000. Hence, it is proposed to increase the germinative power of beet seed by steeping in a weak 0.1 per cent. solution of chloride of mercury; this should be followed by a washing in sterilized water. It is claimed that through this antiseptic treatment the young plant is protected in advance against many diseases to which it is constantly exposed. The preparing of seed before sowing is very thoroughly discussed elsewhere in this writing.

CHAPTER III.

Requirements of Sugar Beet Seed.

Preliminary Remarks.—If one were to read all that has been written on the question of sugar-beet seed, only a general idea could be formed of what care and science, combined with experience, are required not only to produce a seed of a given quality, but to retain its high standard of excellence, which competition compels a seed grower to maintain. Some years ago, it was claimed that the soil of France was not suited to the cultivation of superior beets, the Germans having been supposed to have had a monopoly in this respect. Since 1884, circumstances have changed. The new law, now in existence for over fourteen years, has encouraged farmers to devote their energies to beets rich in sugar. This, as may be imagined, gave an impetus to the problem of superior sugar-beet seed production, and at present among the best customers are those who were previously so much dreaded. The selection of beets with the view to their amelioration in sugar percentage, is a branch of agriculture for which France can justly claim priority. While other countries have followed in the paths shown them, the methods have remained the same. The water process for sugar determination, so generally adopted both in Germany and France, is also of French origin. It is not claimed here that all French seed is superior to all German varieties, for such is not the case; inferior seed exists in France, while in Germany much remains to be done, there being in both countries numerous seed growers who are thoroughly ignorant of the elementary requirements for success.

As the financial returns of a sugar factory depend very largely upon the quality of beets furnished by the farmers, it is in justice to the grower that he have at his disposal those varieties of seed that will give the most encouraging results. It is a disgraceful fact that many beet-seed dealers have furnished on several occasions, and continue the practice, seed that either would not germinate or else is a mixture of fresh and old seed, or, again, of a quality other than that ordered, the buyer being misled by the label on the bag. It has frequently happened that the demand has been greater than the supply, and without hesitation the difficulty has been met by dishonest methods of purchasing from some other seed grower the requisite amount, and mixing this seed, obtained elsewhere, with the kind delivered under the name of the seller.

From what has just been said, the first question to be considered when purchasing beet seed is the scientific methods of selection adopted by the grower, and the next questions which are of equal importance, is to determine whether all seed sold under a grower's name is or is not actually produced by him, whether it has the age claimed, or whether it is of the variety represented to be by the contract of sale. In what follows in these pages, an outline is given of what a superior seed consists, with rules regulating the sale, the best methods for moisture, impurities and germination determinations. If these tests are made, the purchaser will have some protection, and not be misled as he has frequently been. Upon general principles, it may be admitted that seed growers who have not a specialty cannot give the same attention to beet-seed production as a specialist, and all arguments to the contrary are simply misleading. During the past twenty years the editor of *The Sugar Beet* has watched the results obtained from seed furnished by European and American dealers, and, strange as it may seem, there are not more than five growers in the world giving entire satisfaction to all interested. Just why this has been the case has already been hinted at in the foregoing. It is a great mistake to purchase beet seed through a second or third hand, as the chances of fraud are then always greater, and when they do occur the seed grower is at a disadvantage, as his name is connected with the product sold.

The several existing varieties of beets are named after their originators, and as they have not the same external characteristics, they may be distinguished one from the other; consequently, there is evidently some important relation between the methods of selection and the ultimate shape of the root created. Beet seed of superior quality is frequently furnished by seed growers one year, but the second supply is disappointing. Then again it also happens that experiments are made upon soils to determine their adaptability for sugar-beet cultivation, excellent seed being used. The resulting roots show very high sugar percentage, but they are irregular in shape, which is supposed to be the result of faulty working of the soil. Laboratory investigation of such beets would be misleading, as they could not be worked at the sugar factory, and their irregular contours are innate characteristics. The problem in seed production consists in obtaining a variety that will give a regular, elongated beet, containing 15 per cent. sugar, with a yield that may be depended upon. Of late years very little is said about those early maturing varieties that were destined to revolutionize all others. In this whole question of many varieties claiming certain yields and adapted to special soils, are issues that have very little practical value, since, with changed environment the promises held out are not realized, and consequently the time and energy expended in creating these new and varied types may be considered lost.

It is only in very exceptional cases that the seed grower with his Nos. 1, 2, etc., good, better and best, can continue to create under like conditions; it may, for example, be admitted that Mr. A's elongated yellow top, averaging 14 per cent. sugar and giving a yield of eighteen tons to the acre, has actually existed, and that there is unlimited evidence to prove that A's assertions can be relied upon. Unfortunately, however, the patch devoted this year to mothers of type No. 2 is not the same as previously. The conditions not being the same, on account of the variance in composition of the fertilizer between one patch and another, the seed obtained will no longer be the same as in previous years, and therefore cannot be called No. 2. Alas! whatever might have been the conditions in the beginning, they are no longer true as soon as new elements enter to modify the environment. These difficulties will continue to exist as long as the many-variety system of seed growing continues. Purchasers will receive for their money hybrids of the original types. One need only visit the beet-seed plantations coming under the writer's notice to appreciate the ignorance and mistakes on the one hand, and the intelligence and exact science on the other. A botanical principle that seems too frequently forgotten is, that when two plants of the same family, one of a superior and the other of an inferior variety, are cultivated side by side, or within reasonable limits of each other, the ultimate effect is that the types are altered; the new creation will be of a lower variety than those previously existing. Hence, How can a seed grower, from a rational standpoint, hope to create a reliable kind of beet seed when his methods of production depend upon so many variable conditions? From what has been said in the foregoing, success for quality means constancy of conditions, within reasonable limits.

Those methods of seed production depending upon the planting of mothers in a new country, satisfactory or not, only suppose that selections are made every two years, as the seed obtained from the exported mothers is planted again at home and the mothers from these furnish seed to the trade. In theory, this method may have many advantages, since the stimulated effects from a change of climate hundreds of miles away may then strengthen the beets and have an important influence on the resulting seed. But where the fallacy comes in, is the use of grandmothers for the production of seed, rather than selected mothers. It would be impossible to declare that this latter method has ever been carried out on any extensive scale. There are very few seed growers who would be willing to give a guarantee that their entire crop of seed was produced under the same conditions. Is it not natural to conclude that the simpler the scientific methods of seed production, the greater the chances for success? Concentration of effort to produce one type instead of many is the true basis, notwithstanding the fact that many argue to the contrary. That will lead to success and will yield results which in the long run may be relied upon. In conclusion, it is well to remember that as all countries are not equally suited to the production of beet seed, the actual facts should be known as a certainty before too much time and labor be expended.

The Advantages of One Variety of Beets.

In theory, it is all very well for growers to declare that they furnish seeds that are adapted to special conditions of soil, climate, etc; in practice, however, the results obtained are not up to promises. The time given to selecting or creating many varieties, if the interest of the beet-sugar manufacturer be considered, had far better been concentrated on one type. It is claimed that for rich and deep soils a late-maturing beet is needed, while the early-maturing types are adapted to cold soils without much depth. How is all this to be accomplished? Will seed produced in one country yield beets having the same characteristics as their grandmothers in another environment? Will the early and late maturing tendencies remain the same in the United States, with very hot summers and cold winters, as they were in the temperature of France, Germany, or Austro-Hungary? Upon general principles, one can say positively they will not. It must, however, be admitted, in justice to the seed grower, that he is at frequent disadvantage. He may furnish diagrams, with circulars giving details for planting, and other data, but the farmers pay little or no attention to such instructions, it being difficult enough to prevail upon them to adhere to rules laid down by the manufacturer by whom they are bound by contract, without attempting a still more complicated issue. If each seed demands a special method of cultivation, the question from an agricultural standpoint not only becomes confusing, but discouraging for all interested. If special temperatures, elevation, soil, etc., are needed for each variety of beets furnished, the question becomes so complicated that it seems almost useless to attempt any cultivation. Furthermore, it is constantly maintained that the period of maturity of a given beet must occur in a certain number of weeks. This, also, is very misleading, as the total degrees of heat are the only basis. That there exist types of beets maturing one month before another variety, is very doubtful.

However, this question for many years was discussed and investigated by Ch. Violette and Desprez. In France, as a general thing, it may be admitted that beets attain their maturity during October; as a result, the campaigns are very short and the limited time for harvesting does not allow a preparation of the soil for the crop that is to follow. Evidently, if a race of beets could be created maturing, as a certainty, in September, excellent service could be rendered; this has been accomplished with the potato, etc.; apparently there is no reason why the results should not be equally promising with beets. The early maturing beets of an inferior quality were introduced in 1866; these beets had smooth skins, small necks, etc., and were very susceptible to the slightest variation of temperature or moisture. It is claimed that the persistency of farmers in using that inferior type of beet brought about a great decline in the sugar industry of France. The attempt to solve the problem was by depending upon exterior signs and chemical analysis. The basis of maturity was constancy in weight; experiments showed that there was a variety which in September remained constant and from it was obtained the variety known as early maturing.

It is claimed that while this type yields less in weight per acre than the later maturing kind, they possess the advantage of allowing them to be used at the factory a month earlier than would have been otherwise possible. The writer's observation respecting the question is, that the results not being reliable, the variety is not to be recommended.

From what has just been said, it becomes evident that the best results can only be reached by allowing many of the complicated requisites to take care of themselves. If it is impossible to produce one variety of beets suitable to all soils, it is still more difficult to create a special variety that is to be adapted to a soil which is thousands of miles away, and of which a general analysis has not been made, or any special description given by the owner as to what kind it belongs, and hence, subsequent attempts at beet cultivation are frequently complete failures. On the other hand, for a beet possessing all-round qualities, such as shape, sugar percentage, etc., created by a seed grower who has only one idea, and that is to obtain a regular tapering root rich in sugar, the chances for success are far better than when too many intricate questions are involved, there being no possibility of hybrids, no temptation to cheat. How frequently it happens that one variety is all sold and yet more supposed to be of the same kind is furnished, by a simple change in the label on the bag. How frequently it also happens that seed producers purchase their seed from a competitor, who is less known in the market than themselves, this seed being then sold not under the grower's, but the seller's name. As manufacturers are largely in the hands of seed producers, it is to their interest that they insist upon simpler methods of selection and requirements. There are two kinds of seed growers; one is, where the selection is followed according to certain rules, and the other, where efforts are made to produce a special race, to which the grower attaches his name. The latter are more satisfactory; but unfortunately, they have to contend with rural growers, who use the best types at their disposal, but not following strictly the technical lines of selection that they should, there is a constant reversion to lower forms, as the atavism has its full influence as soon as there is the slightest departure from the methods of selection and regeneration adopted during a period of years.

Advantages of Early Selection.—The mistake made by most seed producers is, that they take too long to accomplish what they have in view, the consequence being that beets that were destined to become mothers give discouraging results and are rejected; rapidity in selection is the keystone for success. There certainly do not exist many examples in the whole animal or vegetable kingdom where tardy selection produces superior progeny. Beets are not an exception to the rule; when they are harvested they have a latent energy or vitality that remains dormant during a period of months, to return to life, as it were, with renewed vigor. If, when taken from the soil, they are rich in sugar, the seed that they will ultimately germinate will be possessed of their mother characteristics. As they must be kept in silos during a period of months, certain transformations occur, which are thoroughly independent of the ultimate results. The innate sugar characteristic, the outcome of man's creation, will continue, with, however, a constant tendency toward a return to the lower forms, this tendency requiring several generations to develop, as the interval between the first and second year's growth has no material influence. Whatever may be the care given to siloing mothers, there is always a sugar loss during their keeping, and in December the saccharine percentage may be fourteen, while in March only twelve, and by the prolonged delay in selection this individual beet would be rejected, yet its sugar percentage at the time of examination would be very misleading; for the December characteristic should have been the prevailing issue to be considered.

One frequently sees circulars of seed growers who contend that they make several hundred thousand analyses in their beet selections; in most cases this extends over a period of six months, which means, during this time that the silos have been opened and closed daily, which practice has certainly a very considerable influence on the nature and quality of the roots being analyzed. The mode of analyzing beets for mothers, selecting those which have remained siloed during so long a period, is a practice which should certainly be abandoned. The theory that keeping in silos has the advantage of allowing an ultimate selection based upon the keeping qualities, does not compensate for the disadvantage of the practice, and in cases where the silos have been poorly ventilated and badly constructed, very misleading results would be obtained. The rise in temperature means second growth and corresponding loss of sugar; through this and other causes just mentioned very superior beets might be rejected.

M. Lemaire, a French seed grower, attaches great importance to a double method of selection, one in December and the other in March; it is possible, then, within reasonable limits to determine just what the keeping powers have been. Experience seems to show that this question of retaining vitality during a period of months is more pronounced with some beets than it is with others; furthermore, this is a hereditary condition and is one of those elements too frequently overlooked, but far too costly to put into practice. If a variety of beet could be created with special resisting powers, it would render sugar manufacturers great service during those years when the beet crop is abundant, as then the beets could be siloed until used, thus giving a very extended period to the sugar campaign. Dippe Brothers, Saxony, keep 100,000 beets in silos during the entire winter; 33,000 are kept for mothers and 67,000 are fed to cattle; great stress is placed on the keeping qualities.

The selection by the Knauer method does not take place until March or April, the final classification being into three varieties, good, better and best. The good ones may be irregular in shape, but are not used for seeding purposes. The writer considers that if the entire selection of mothers could be made the day of harvesting, the science of selection would have reached its zenith; but while this cannot be done with existing facilities, the nearer we approach it, the nearer we will be to the perfection aspired to. These assertions are not theory or passing conclusions, but facts based upon experience. In most mother-selecting laboratories, not more than 2500 analyses can be made per diem, while at the Laon sugar factory 10,000 are within the limits of possibilities of the existing laboratory facilities. This could never have been attained had not the most recent innovation, meaning progress, been resorted to. This working of the said laboratory is described in some detail in the present writing. It is interesting to contrast the results obtained in two months with those extending from harvesting to replanting, as is most generally practiced. During the current year there will be not less than 255,000 analyses made during an interval of sixty days. These will show about as usual that there were 27,000 beets testing between 14 to 16 per cent. sugar; nearly 30,000 polarizing 15 to 16 per cent.; 19,000, 16 to 17 per cent.; over 35,000 between 17 and 18 per cent.; 10,000, 18 to 19 per cent., and 2000, 19 to 20 per cent. Besides which, must be mentioned 4500 analyses made outside of the ordinary or regular laboratory work. Those beets known as Elite, testing 20 per cent. and more, are analyzed for the second time to make sure that the first observations were reliable.

The most experienced seed producers have now come to the conclusion that it is a waste of time to attempt ameliorating the saccharine quality of beets when 20 to 22 per cent. sugar is attained. Every experiment, made with the greatest care to increase the latter, resulted in comparatively inferior roots, containing about 17 per cent. sugar. This is self-evident, as there exists a physiological law, that when a certain degree of perfection is reached by a well-organized selection, there is a constant tendency to revert to the inferior condition. Special care is always given to these high testing beets. They must be kept separate and watched—as sometimes they are stolen. They may be used for regenerating the race. Determining just which these superior beets are, may be accomplished under far better circumstances by early rather than late selection. The type of these very

Elite beets, say of even 19 per cent. sugar, has yet to be created by Legras. There are, as we have just said, great difficulties to overcome; but it is possible that success may be attained in the end, but not, however, upon the existing basis of selection, as described in what follows.

Conclusions Respecting Selection in General.

One fact is certain, that superior seed cannot be obtained as a continuous certainty unless all scientific principles known about the subject be adhered to. The farmer and the manufacturer must work together, since their interests are the same. Theories, however absurd they may seem, however much they may be in opposition to existing beliefs, should be given a fair trial, unless the same lines of research have already been thoroughly investigated; then it would be a loss of time to go over the same ground. If a seed producer hopes to rival his neighbor by honest means, he must necessarily be familiar with all his competitor's methods of selection, sale, etc.; respecting the latter, exact information is almost impossible to obtain. It must not be forgotten that if a seed grower attains a certain degree of excellence in the saccharine qualities of his beets, and is contented with the results obtained, and does not continue his selection from year to year with the view of realizing a still greater amelioration, after an elapse of a reasonable interval, complaints will surely pour in from customers, that there has been a most unsatisfactory crop of beets obtained from seed furnished, that the season, etc., have been favorable and that seed from other sources have given excellent results. Consequently, when one centres his efforts upon the continued creation of not many, but of one variety of beet adapted to most soils, he is doing more towards the progress of the beet-sugar industry than another who attempts to mislead the purchaser by a lot of high-sounding names of varieties almost without limit, supposed to give excellent results upon any and every soil in most varied climes. In justice to those who purchase beet seed, the foregoing may be of interest; all other issues respecting variety of seed, what kind existed, who their growers were, etc., have been discussed in previous writings. Let the American manufacturer think twice before he experiments with a variety of beet that has not been accepted by the European beet-sugar manufacturing syndicates.

Annual Beets.

Normal sugar beets, as used for sugar manufacture, go to seed only after the second year, and for that reason are known as bi-annuals. Many of their roots, however, produce seed the first year, and these are known as annuals. The exact cause of this abnormal phenomenon has never been entirely accounted for. The reversion to lower or original forms is due to atavism and it, with faulty methods of selection, may be considered the two main causes. The fact is, that roots having small, conical necks have generally an annual tendency; the age of the seed used is also a factor not to be overlooked. Beets, when scientifically selected, should furnish roots which never give more than 2 per cent. annuals.

As a general rule, it has been noticed that annuals are more numerous on fields which have been sown early. The fact is, the same seed, sown upon the same soil, under exactly the same conditions, but at different times, at intervals of a few days, will give a different percentage of annuals. If there are open spaces in fields due to too early planting, or other reasons, it is better to fill in these by late sowing and thus reduce the percentage of annuals which would possibly follow; beets from late sowing would be perfectly normal. When we compare the conclusions drawn about early sowing just referred to, with practical experiments in this direction, we find very contradictory facts. If early planting is followed by annuals, then nearly all beets from seed thus planted should be annuals; but since they are not, the theory advanced is not borne out by facts.

The highest authorities, however, assert that neither the depth nor time of sowing has the slightest effect on the atavism of the root. It is admitted that certain meteorological conditions may have a decided influence, due to the disturbance in the natural development of the beet; also certain varieties of beets, with close, compact skins, resembling, as it were, the original wild beet, appear to have certain annual tendencies. Beets which have been frozen and left in the ground, suffer in no small degree from the effects of cold; their vitality is somewhat diminished, and the beet then frequently goes to seed; exactly on this principle may be explained why it is that the higher the saccharine quality of the root, the greater its annual seeding tendency. Those inferior and hardy beets are never annual in their seed formation. Whether the size of the seed has or has not an influence, authorities do not agree; but many experimenters have asserted that the smaller the seed the greater the tendency to produce annual beets. In direct contradiction to this are the assertions of an Austrian agronomist, who claims that large seed, maturing very much later than the smaller, tends to give annuals. If this hypothesis be true, it may be explained by the fact that small seed produces small and delicate roots, which, as before stated, will go to seed abnormally more readily than the larger and coarser varieties.

Some growers say that the occasional occurrence of annual beets in their fields is an almost certain indication that the average saccharine percentage of the crop will be satisfactory. Too much reliance should not be placed on this theory, as the depth at which the seed is planted may have its influence. This will evidently have a retarding effect, corresponding to a loss of vitality, which in many cases might result also in the formation of annual beets. When the questions of selection are not properly looked after in the laboratory, there may be annuals among the mothers chosen, and, as a certainty, these will produce seed which in turn give a whole generation of annuals. No better method exists that renders possible for the observer to learn whether the seed growers are what they pretend to be, than the number of beets going to seed the year of planting. If this is, say, 10 per cent., the advice to those interested is to cease all relation with this so-called seed grower who has been so misleading in his dealings.

A certain dealer in seed, who had hitherto an honorable reputation, delivered seed of which 50 per cent. went to seed the first year; he attempted to prove by a long series of experiments that his seed was not the cause, but there were other conditions. He got several sacks which had been left over from the unfortunate factory owner to whom he had delivered the seed in question; these he distributed among many well-known farmers and experimental stations in many sections of France, and where the climatic conditions were very different; the outcome of this investigation was, that not more than 1 per cent. were annuals, and the year previous one-half of the total amount used was shown to be in this abnormal condition.

Experiments have been made to determine whether the degree of maturity of seed has not a certain influence. Experiments were made upon seed, large and small; after a third generation of annuals it was found that 60 per cent. of each gave annuals. Consequently, it is concluded that the degree of maturity or development of seed has very little influence.

Pagnoul asserts that there is not much difference in the percentage of juice in normal bi-annuals and annuals; in fact, the purity of the beet is much greater in the latter; which is explained by the passage of many of the alkaline salts, and even phosphoric acid, to the upper part of the root, or neck, to meet the requirements of seed formation. During the flowering period the entire effort of the plant is centred on the flower and the resulting fruit. The sugar found in the leaves of normal beets is 0.16 per cent. to 0.53 per cent. and 1.07 to 0.46 per cent. in annuals. In beets in general, the sugar is formed in the leaves and descends to the root; this descent is evidently not so complete in annuals. Correnwinder's experiments show that seeds from annuals contain very little albumen, which fact partly explains why annuals, even after the formation of seed, have a normal sugar percentage. The seed from annuals yield very poor beets. The cellulary tissue is transformed into fibrous, which renders the utilization of such beets almost impossible at the factory, and they should always be rejected. All efforts in the direction of suppression of the stalk as soon as it appears seem to be futile, and such beets for sugar manufacture would be inferior to roots where the conditions of seed formation are allowed to continue. A series of experiments were undertaken by Contamine, which showed that the expense of the suppression was considerable; furthermore, the annuals become even more fibrous than they were, with the stalk frequently four feet in height.

Some interesting experiments have been made with the view to determine the influence of the weight of mothers upon the number of roots going to seed the first year, and obtained from seed grown under same conditions and having same sugar percentage. Those beets, weighing about one-half pound each, for some unknown reason had the annual tendency to a far greater extent than roots weighing nearly 2½ lbs. each. The annual tendency, then, could be explained by the possible want of vitality in very small beets.

This is strangely in contradiction with what might be supposed; for the original annuals from which the bi-annuals have been created were evidently large in size. Those theories maintaining that early or late frosts after sowing have an important influence, have not been sufficiently proved to be worthy of any special consideration. That there is a retarding influence upon the plant's development when the nights are cold soon after planting, seems plausible, but this question of annuals is not a retarding but a hastening tendency, for in a few months there must be accomplished what under ordinary circumstances demands two years.

One fact is beyond cavil, that seed from annuals gives an enormous proportion of annuals, and it is possible from a selection of such seed to create a variety of beet that goes to seed the first year. Among the most interesting experiments to determine if it were not possible to do away with annuals entirely, may be mentioned that of a second planting of bi-annuals which have not flowered after the second year. Such roots actually produced seed the third year, and this seed gave roots perfectly normal in their sugar percentage, and had far less annual tendencies than have beets grown from regular first-class seed. Rimpau's experiments showed some years since that such beets contained 13.8 per cent. sugar and 82 p. c. It is further claimed that it would be possible after a period of years, by using the three-year beets, to create a variety which would lose entirely its annual tendency. One fact is never to be overlooked respecting annuals, viz.: If they appear in any great number upon any special field, avoid the roots for mother selecting, even within distances of a half-mile, for the chances are that the annual tendency will prevail, owing to the possible fertilization with pollen from an annual.

Some authorities declare that the annual beet issue is easy to contend with in dry and warm countries, such as Italy, Spain, and even in southern France. This is in direct contradiction to the writer's observation, for it is then of all other times and places that the principle of atavism has the most force, the environment being favorable for it. It is further claimed that this annual tendency was greater in France in 1894 than it was ever known to be before or since. It was also noticed that those annuals showing themselves in July and August were not as rich in sugar as when they appeared later. It is true that, do what one may, the difficulty will always exist and the manufacturer, if he look after his own interest, will accept the situation and meet it by using such beets in the factory the best way he can. Stronger and more powerful cossette cutting knives would overcome the difficulty.

CHAPTER IV.

Races and Types of Sugar Beets.

Preliminary Remarks.—The races and types of people are so characteristic, that seeing one of them in a foreign clime, it is possible to declare to what part of the world he belongs, and even after a long sojourn in any environment and intermarriage, or whatever combination is made, the characteristic of the race is transmitted to the progeny through several generations. What is true of man and animals is also true of beets in every particular. Even when taken from the mother country and planted in an entirely different soil, under different conditions, the persistency of the type remains, with slight variations; after a time, however, through neglect, it disappears.

It would hardly be possible to give a single example of any vegetable or organic structure, in which this principle does not prevail. Just how the races and types originated in nature has never been satisfactorily determined; one fact is certain, however: Man has it within his power to create types, or even races, entirely different to those previously existing. An important example to the point is the bi-annual domesticated sugar beet, as compared with the wild annual root. There is an important difference between that which man accomplishes and those processes of evolution worked out by nature's law. The one starts from a form already existing, and the other is the gradual change from a protoplastic condition to a perfect race.

Darwin partly declares that there is one and only one method of ameliorating, and that is, not by crossing races, but by a constant effort to improve the race already in existence. The sugar-beet specialists, having this idea in view, commenced their work in France and Germany as early as 1830. At Magdeburg, the efforts were mainly centred on the varieties obtained trom Erfurt and Quedlinburg seed. The early papers read by Vilmorin upon the subject were in 1850, 1851 and 1856.

While a beet grower is able, within his own sphere, to produce a special type to which he gives his name, the variety always undergoes certain modifications by a change of conditions; while these variations are not sufficient to materially affect the root after the first year's planting, the deterioration is sure to follow, unless the blood of the beet is kept constantly replenished from its original source; roots showing the first signs of change must be thrown out. In other words, with all the success attained by selection, atavism* is a force impossible to overcome. The variations which occur with plants left to their own devices are necessarily very different from those which are the outcome of man's efforts; hence, the reason why the labors of a conscientious seed grower are incessant and never-ending. When the selection is properly looked after, the reversion to lower forms seldom occurs; on the contrary, the characteristic of the type sought after becomes more and more pronounced. Is it not just that a specialist, who furnishes superior beet seed, from beets of his own creation, should claim considerably more money for his produce, than does an ordinary seed grower who gives neither time nor money equivalent for what he sells, and in the end becomes a dealer in bastards, due to the fact that he has resorted to variation in the methods of selection, as compared with the specialist?

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*Showing the influence of one beet upon another, the experiment has been tried of planting side by side, a superior white beet with an ordinary red beet. The beets from the seeds of white beet were apparently of every possible variety, some of these being red, rose, etc., and their sugar percentages varying from 7 to 17.

Technical Considerations.

Hereditary and individual characteristics are the two main questions to be considered. Heredity gives the characteristics of the race to which it belongs. The individual question differs from the race in many particulars. The hereditary influence may be divided into three divisions: 1st, the direct power or force, which means that the progeny resemble the nearest parent in a direct line; 2d, the conservative atavism, which tends to force the resemblance to a whole series of individuals, of which the race consists; 3d, the retrograde atavism, which means an influence which tends to take after the original parent. If the first and second influences work together, there is a tendency to branch out and form an individual type.

If the individual differs very materially from the general characteristics of his race, the direct heredity and the atavism will, in a measure, work in opposition to each other. The direct heredity is the most powerful force with which to contend, and while its influence may not for a while be noticed, it is only a question of time before it re-establishes itself on regular lines. The atavism, on the other hand, is slow in its influence, but it at once exerts its force when there is any neglect on the part of the seed specialist. That individual types can be created and their characteristics transmitted through several generations, is an absolute fact. Upon general principles, it is far easier to transmit a fault than a quality. The individual type permits a physical selection and materially helps in the chemical or laboratory selection.

It must never be forgotten that the sugar percentage of a beet is not alone a sure basis for the creation of a type! The particular root under examination may have had special advantages of soil, plant food, distance in row, etc. The individual selection alone is a mistake, for the conditions of environment may bring about changes in shape, size of leaves, etc., which are overlooked. The hereditary question must not be overlooked. All those beets which have undergone any change from the starting point must be thrown out; under which conditions it is possible, in the end, to obtain a type that will be transmitted through several generations. There is, respecting this question, an issue sometimes to be considered, and that is, the production of a variety to meet the special legislative variations of the country where there is a demand. The principal races are, however, not interfered with. From this fact we draw the conclusion of the importance of having beets in the preliminary process of selection cultivated under exactly the same conditions; hence, the reason the manufacturer can never hope to rival the specialist.

In the Klein-Wanzleben family, for points of departure there are new and pronounced characteristics. During several generations they are either from one mother or the outcome of a group of mothers, and must be kept entirely separate. The selected mother is at first planted; the seed obtained is sown, and the resulting roots are selected again and again. The selection among this newly created family must also continue, so as to keep out all variations either in sugar percentage or leaves, etc. It frequently happens that after considerable trouble and expense, a family is created and promises well for the future, when the sudden appearance of a bastard necessitates abandoning the type. Under these conditions the number of real and reliable varieties must be very restricted. Those beets which retain their characteristics of mothers are kept at the point of departure.

Standards.—In all experiments of beet selecting it is important to have a standard row of comparisons. These standards are upon every patch; if variations occur in the patch they should vary with the standard.

The roots from these experimental patches allow a basis of comparisons that should be made in October, before the final regular selection. It is most important in the formation of superior types to keep in a tabulated form the entire history of the beets which promise favorably for the creation of a race, the outcome of the individual type. Photographs should be taken so as to make doubly sure that the shape is retained in the family that follows. The work of planting the resulting seed and repeating the selecting from the beets obtained, demands a series of years and great patience. The seed from each special mother should be planted apart; thus forming numerous fields of experimental research. When the best type is determined upon, the creation of the race can commence upon a solid basis. The race obtained through man's persistency differs from the natural race; while the latter transmits its characteristics with extraordinary tenacity for a long period of years, the artificial race is very much influenced by any change of conditions.

Respecting this question, it is interesting to call attention to the theory of Prof. Nowoczeck, who, in a special work, suggested that the typical Vilmorin be crossed with the typical Knauer, and the result would possibly be advantageous to each. For, while the Electoral is suited to calcareous soil, the Vilmorin has other advantages. Well, the certain result which would follow will not be any typical beet, but a mixture of hybrids, of endless shapes, differing in the color, shape of leaves, etc. Even in the Vilmorin selection, which commenced some forty years ago, the original parent *Beta's* characteristics are plainly visible, as shown by its yellow leaves. Proving that, even with endless care, atavism still remains a force with which to contend.

Varieties.—Whatever be the care in selection, there is always the necessity of refreshing the original conditions. It is interesting to call attention to the same evil effect in intermarriage between cousins, as is so much seen or practiced among the royal families of Europe; there have followed various disorders and bodily weaknesses. In beets the regeneration offers no difficulty, owing to the exceptional size of the pollen and its abundance during the long flowering period. This, combined with the fact that there is but a single ovum, its fertilization is always a certainty as compared with like botanical conditions of other plants.

The pollen has its absolute effect only after it has left the anthers; hence, the reason why the hybridization is most common and becomes one of the greatest difficulties to contend with during windy seasons. If these varieties which are of so frequent occurrence be allowed to continue,* the ultimate result will be a very poor seed, possessing very little germinating power. The remedy consists in crossing with better types, which must belong to the same race; otherwise, hybrids would be created and these possessing special atavismistic tendencies, the difficulties would be greater than before. Knauer gives an important example in this question by declaring that the Ameliorated White Imperial may be used to regenerate the Klein-Wanzleben and vice versa; the latter, to regenerate the former for the simple reason that the Wanzleben race is the same as the Knauer, they having a common parent. In other words, it is the main essential to get a pure ultimate race; if the creation is a bastard the progeny will be bastards.

The Knauer Imperial variety, created in 1850, held its own for many years, and was once, without doubt, the best variety in existence. Then came the

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*An example may be given of Derrombesque's experience in France. His main object was to create a superior beet; he crossed an ordinary hardy beet with an acclimated Silesian. From the resulting seed, he obtained, apparently, a hardy beet rich in sugar; after the third planting the Silesian characteristics had nearly disappeared and there was an absolute reversion to lower forms.

Knauer Improved Imperial; this was later on superseded by the White Ameliorated of Vilmorin. But Knauer, himself, was not satisfied with his results and started with a French beet cultivated in the north; from it, the race known as Electoral was created. This had an advantage which the original types had not, viz.: It would flourish in soils of ordinary depths, while the Imperial demanded special conditions. As the origin of these two beets is different, one cannot be used to refresh the other.

Even Vilmorin, during his early methods of selection, made (as some consider) an evident error by using the Mangold beet as a means of giving a new life to the beet that needed to be refreshed. At the present day there are writers who argue that the Mangold was the starting-point for all existing varieties. It would be very difficult to lay down any special period at which the regeneration should be practiced; but it is certainly not desirable to wait until there are indications of the degeneration of the type of beets under observation. Many practical experts claim that two to three years' limit is a satisfactory basis upon which to work.

The regeneration, as adopted by some growers, is effected by importing from a distant clime a beet about the same and of the same race type, as the one having proved satisfactory. The seed of the latter and former are mixed, planting follows in the regular way, and as they are sufficiently close, their influence will be felt; or better still, plant each seed separately and select mothers from the resulting beets, plant these in the same field, and there will be an interchange of pollen resulting in the creation of the expected variety. However, this operation, while apparently easy, offers many difficulties in practice. Many similar examples from recent practical experience could be given, but the question is, Do they offer all the advantages claimed? Some growers alternate between Germany, France, Belgium and Holland, in which countries the climates differ. The mothers are carried in boxes, keeping them so that they will not be bruised. Under these conditions there are constantly new varieties created, and the question becomes so complicated that the original types are lost sight of.

However, with certain care, satisfactory results may be obtained; in some of our early writings we suggested what might be accomplished in the United States by importing beets from Germany, after having selected a suitable soil for their planting. This plan seemed preferable to that of sending seed to a foreign clime and then bringing back the resulting beets to their native soil for their second year's growth. We can hardly agree with Walkhoff, who proposes to improve the quality of a beet by sending it or the seed from a warm to a colder latitude. In conclusion, we would say that for many years an idea continued to prevail that the best way to obtain superior beets was by a careful system of preparing the soil, by the use of special fertilizers, etc.

While all these may be, in their way, very essential, they are of secondary importance when compared with the necessity of sowing superior seed from the start, and without which careful agricultural methods are of little avail. However, upon the same soil and under exactly the same conditions, there is an enormous variation in the sugar percentage; this may be 7 per cent. on the one hand and 19 per cent. on the other. The explanation of this is simply, that while every seed has a tendency to resemble its nearest parent, yet, at the same time, as explained in the foregoing, it has a certain affinity for an ancestor, more or less distant, and this retrograde atavism declares itself when least expected, when in the hands of a novice who uses seed obtained from dealers that make claims which mislead the purchaser. The identity and value of a seed can only be determined after its having been put to a practical test upon the field.

CHAPTER V.—PART I.

Selection of Beets with a View to Seed.

Preliminary Observations.—To obtain a beet rich in quality, yet giving a satisfactory yield, is a far more intricate problem than many of the would-be beet-seed growers seem at first to realize. The details of selection, if properly carried out, can never become very remunerative, owing to the expense, and must therefore be, within reasonable limits, a labor of love. A visit to the laboratories where thirty to forty people are employed, and the details connected with the work, not only from a chemical but a physical standpoint, would discourage many from the start, and even if superior seed should sell for twice the sum that it now does, it would hardly be an operation that one could depend upon for a living. If the details of selection could be made once for all, and if the seed obtained would retain that degree of excellence through generations to come, the question would be a simple one; but, unfortunately, the tendency of the beet being constantly to go backward rather than forward, the quality depends upon pains taken in the selection, and, if neglected, the roots would contain very little sugar and be worthless for sugar extraction. Most seed growers, if the yearly selections are neglected, rely more on their past renown than upon their reputation that is to come. There cannot be a shadow of doubt that many of the existing methods for beet selection are fallacious. M. Legras starts in on a new basis, which anyone without money and property at his disposal could not think of attempting.

One need only read Darwin's work on the selection of species to realize the wisdom of M. Legras's method. A child, for example, resembles his father and mother more than his grandfather and grandmother. In other words, our own characteristics are more pronounced in our own children than in our grandchildren, and the further they are removed from the original parent, the greater will be the difference between the progeny and the ancestor. True, there is a constant tendency toward reversion; but this is only a tendency and not an actuality unless continued through long periods of years. What rules can be evolved from the animal kingdom must generally apply to the vegetable; hence, the reason why it is maintained, and has been frequently proved, that the true and only method of selection with the view to seed production is, that the seed comes directly from the mothers that have been actually selected in the laboratory. It is customary among seed growers to plant the mothers selected the following spring, the seed obtained being not sold, but sown with a view to obtain beets which furnish seed for the trade. Such being the case, it becomes evident that all beets existing grown from seed supplied by dealers, with the exception of M. Legras's, are grandchildren of selected mothers. The new plan proposed was to sell seed obtained from the beets selected in the laboratory. It was difficult to put into practice, and at first, on the Besny farm, there were only 50 or 60 acres devoted to this special purpose. On the other hand, in 1896 the yield of seed of one variety was 500,000 lbs.

Physical Selection of Mothers.

Preliminary Remarks.—When one attempts to compare the physical attributes of mothers and their influence upon their progeny among the higher classes of the world's creation with those of the lower forms, we find a resemblance which is simply appalling. A lock of white hair, or an ungrown tooth, may continue through hundreds of generations; that the talents or special characteristics may jump a generation or more, every one knows, but this may be a freak of nature, and is certainly the exception. What applies to man is also applicable to sugar beets. Selection according to exterior signs only may, perchance, lead to excellent results, but it is not desirable to put too much faith in such methods. The real and only road to success is a continued selection through all times, and not for a period of years. An ultimate race or variety of sugar beet is the outcome, not of physical selection alone, but of physical and chemical combined. Nature frequently accomplishes this in another manner; for example, in fever districts. On the banks of the Amazon, only the stronger live; the weaker disappear, the outcome of which is a race that is not affected by the local environment; and if we examine into the antecedents of these special individuals, we would find that a physical foundation has been laid, and the good effects are realized years later.

Legras's Physical Selection—and Discussion as to Other Methods Based Upon Small Beets, etc.

As previously explained, in sugar-beet selection, the object is not so much to obtain a root rich in sugar, but one that is regular in shape, and offers no difficulty in cleaning. Hence, the starting-point in physical selection is to have a regular elongated beet, one that presents no difficulty during slicing at the factory, and retains its tip end. How many examples could be given of beets rich in sugar, but irregular in shape, and, therefore, the slicing poorly done! The cossettes in the diffusion battery do not give satisfaction; the juices

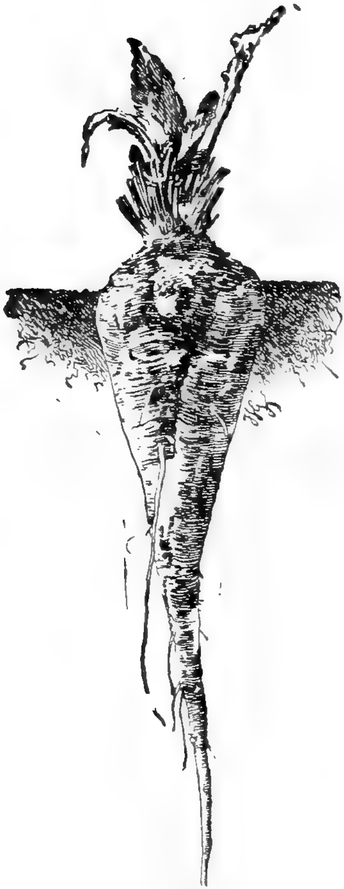


FIG. 24. A TYPICAL LEGRAS SUGAR BEET.

are impure, owing to the dirt, etc., that have not been eliminated during the process of washing. If the manufacturer purchases such beets, as the farmer claims he must, owing to a binding contract, he gets more sugar, apparently, in the beet, but this sugar costs more to extract than it is worth, and, consequently, there follows a money loss in the end. It is much to be regretted that, as a rule, the manufacturer and seed producer are two separate individuals. Sometimes, however, the seed grower is also a beet-sugar manufacturer; among others we could mention Legras, in France, and Wanzleben, in Germany. The purchaser of such seed derives a benefit from the care given to create and maintain a variety of beet that is destined to give heavy sugar yields at the factory, and satisfactory returns at the farm.

The Legras beet has only French antecedents, straight leaves with very pronounced nerves. The selection on the field is done with scrupulous care; the persons having this work in charge have been trained through a series of years, and have strict orders to adhere to regular rules. Some years ago, not more than one beet in twelve was sent to the laboratory to be analyzed; now the selection is an easy matter, for the roots that do not possess the physical requisites are the exception. The salt-bath selection made by many seed growers is on a basis having the sugar percentage only in view, and it is misleading, for a large proportion of such roots are rejected upon chemical examination; hence, it is labor lost. From what has just been said, the field of selection is the starting-point to success, and whatever be the exterior characteristics, the seed is sure to transmit them. However, there are exceptions, and a beet that promises favorably from exterior signs may be rejected after having been analyzed, weather, soil, etc., having had some mysterious effect.

The type of Legras beet for which general preference at Besny is given, is shown in the engraving (Fig. 24). The shape is regular, with lateral depressions, and it is readily harvested. It is important to note that there are several preliminary selections. When the final roots are determined upon, they are placed in circular piles, with necks and leaves on the outside. As soon as possible, the leaves are removed, and a still further selection follows.

The roots selected for mothers weigh between 400 to 900 grams (14 oz. to 2 lbs.) each. Many seed growers never use mothers weighing more than 300 grams each, but this is evidently a mistake, as has been many times proved by the results. However, there is ample authority for asserting that when the chemical selection has been properly looked after, it does not matter whether the beets are small or large, provided the shape has been well considered. A German authority argues that as mothers are only an intermediate between the seed and the soil, there is no advantage in using large beets, as the plant food required is taken from the soil. Some growers, as previously mentioned, are most enthusiastic over the small mother theory, and roots destined for this purpose are cultivated at distances of four inches apart, and in rows eight inches from one another, 100,000 beets being thus obtained to the acre—none of which would weigh more than three-quarters of a pound. Prof. Marek's experiments, extending over several years, showed that there was very little advantage, if any, in using small mothers for seed production. The small-beet method offers certain advantages of economy not to be overlooked; the beets may be rapidly harvested, occupy less space in silos, cost less for transportation, and it is possible to replant them on a field which has been used the same year for another crop.

It is claimed, also, that small beets have stems which mature early and give greater yields of seed.* Without doubt, the type of such roots, owing to their size, is very uncertain, and frequently the object in view, viz., that of creating a race, is not attained; furthermore, the conditions not being perfectly normal, the quality is sure to suffer in the long run. The formation of numerous stalks of very uncertain height and development is more frequent on large than on small mothers. On the other hand, when the latter are used, there are many central high stalks, and few lateral ones; they all hold their own, and do not lean over on the soil for support when the seed is formed, as is the case with large mothers. It seems self-evident that large mothers cannot be desirable. They may occasionally contain considerable sugar, but this is an exception and not the rule. If seed growers are not careful, they will certainly be misled on this question. The two-pound weight, as suggested by some, is, from the writer's standpoint, a very dangerous limit. At the Klein-Wanzleben seed-growing farm, where they have 6500 acres devoted to beets, preference is given to roots weighing 700 to 800 grams (1.5 to 1.7 lbs.) and four pounds is not uncommon. Beets weighing but one pound are looked upon as being abnormal and worthless for seeding purposes.

	Grams.
Classification according to weight	600 to 650 650 to 700 750 to 800

Each variety of 50 grams demands a different and separate classification. These groups are analyzed separately.

As regards this question of weight, it has been suggested that an average be taken of several thousand selected roots, and, once for all, settle the question, and greatly aid in the physical selection. It is evident

*See chapter "Special Original Methods for the Production of Superior Seed," where the question of small beets is discussed in full detail.

from what has been said in the foregoing, that there is much contradiction, and the Besny types, which are certainly not of the small kind, give very superior results. This question of weight of mothers and the yield of beets from the resulting seed is a paradox, practical experiments having proved that they may weigh one-fifth of a pound, or 2½ lbs, and yet the yield to the acre of beets from the seed in each case will be about the same. However, it is far better to be within rational limits.

As regards the physical selection on the fields, it must be remembered that there are two kinds of selection; the one on an average beet field intended for the factory, and the other from beets which have been cultivated from selected mothers; greater care is necessary in the latter than in the former case. It is a great mistake to adhere to the practice of sowing such beets very near together so as to dwarf their size; better let the development continue under normal conditions. Under general principles, whatever be the physical method selected, under no circumstances is it advisable to use a beet which, during its early stages, has been attacked by insects. These ravages always produce a retarding effect upon the development of the root, from which it never recovers.

Selection by Appearance of Leaves.

The value of physical selection based upon appearance of leaves, has more importance than is generally attributed to this mode. In Russia it is maintained that sugar beets in a fine healthy condition, having pale leaves and changing color early in the season, are riper and contain more sugar than those roots with dark green leaves. At Knauer's, the argument is just the reverse. They prefer a dark, rather than a light green. Furthermore, beets with reddish leaves are of a poorer quality than those with pale green leaves. The sugar percentage of beets seems to increase with the number of leaf-circles. Eight to ten is considered a good indication. The wrinkles of the leaves seem also to be a quality characteristic; the greater the number of wrinkles, the higher the saccharine percentage of the root. In normal beets, when the leaves are of an oblong shape rather than round, so to speak, the roots are richest in sugar.

When the leaves are very pointed the beets to which they belong are never very rich in sugar, and in some cases denote a certain malady of the root. Very few of such beets are ever noticed on the field. While a luxuriant vegetation and a fine green surface seem essential for sugar elaboration, practical experience shows that the soil and excessive use of a nitric fertilizer have important influences and would, in most cases, be very misleading. Iron, for example, is said to influence the intensity of the green coloring. Beets with outspread leaves, covering considerable area, are generally richer in sugar than those roots with upright leaves, where the sun has great difficulty in penetrating.

However, on this question experts very much differ, and the mistake they frequently make is, that the samples they select for comparison are not alike; for care should be given that the beets compared be at the same distance from adjoining beets in rows.

Marek's analyses on thirty beets gave the following result:

	Standing Leaves.	Low Leaves.
Av. weight of beet	0.74	0.55
Density	6°	6.5°
Dry Substance	14.6	15.8
Polarization	13.00	14.4
Non sugar	1.69	1.4
Purity Coeff	88.47	91 4
Proportional value	11.5	13.1

The quality of beets seems to increase with the number of leaf-circles. In this respect Pellet has made some important observations, showing that there is a relation between the number of leaves and the saccharine quality of the beet.

	Per Cent. Sugar in Beets	Number of Leaves
Vilmorin seed.	15.7 14.8 13.8 12.2 11.7	42 39 31 23 19

This appears to be also true for the weight of leaves; with various kinds of seed the results were as follows:

	Weight of leaves for 100 lbs. beets	Sugar Per cent.
Vilmorin seed..............	56 lbs.	14.5
Senior Legrand seed....	33 "	13.3
	20 "	11.8
Various seed.............	58 "	15.4
	63 "	15.2
	52 "	14.1
	62 "	14.7
	31 "	13.3
	26 "	18.8

These results would tend to show that there is to be found in leaves some excellent and practical means for physical selection. At Madgeburg, beets that are selected for mothers have but few outer leaves, and these are flat and grow near the ground; at their centres they are in a cluster, and their general tint is bright green; they are not spotted or fringed with red.

Knauer gives preference to those roots which have a central cluster of leaves arranged in a sort of horizontal bouquet; the leaves are of an average size, with rather fragile borders, the outer leaves being large and bent over. He places great stress on the physical selection based upon the leaves. Wychinski declares that the best beets have small delicate leaves. The nerves on leaves also appear to play an important role. Large nerves in the centre of the leaf, and with latent nerves which do not intercross, are beets very inferior to those with delicate leaves, three central nerves and partially developed latent nerves; such roots will generally contain 15 to 18 per cent. sugar. The observations in this direction are destined to lead to excellent results. It is generally found desirable to throw out all beets having large or small, deformed or badly shaped leaves.

While Kneifel, in his special study on beet leaves, declares that there is no relation between the shape of beet leaves and the sugar percentage of the root, Doerstling asserts that his observations tend to show that the size of a leaf is of very great importance; those beets having leaves of 316.7 sq. c. m. contain 14.2 per cent. sugar, while others with leaves of areas of 170 sq. c. m. polarize only 13.5 per cent. This seems rational to us; furthermore, we are convinced that large leaves help the beet very considerably to attain its full development. This leaf growth is most rapid during the first month after planting; the leaves that follow are smaller and none of the latest formed appear to remain more than six weeks, and as the size of these decreases, their number seems to increase. All these questions of shape, wrinkles, nerves, fringed, etc., should be noted by sugar-beet seed specialists, and correct notes made, for these items are of great importance in the selection. Such botanical considerations are of great help, for after many years of constant attention, one can create an individual type through this assistance, combined with other requisites, which shall be very thoroughly examined in chapters that follow in this present writing.

Exterior Signs as Indications of Quality.

Those who have observed the almost certain relations existing between the exterior signs indicating qualities or defects of organism, both in men and in animals, will not hesitate to admit that the entire vegetable kingdom is controlled by similar laws. Vilmorin says that the shape and general appearance of a beet which has attained its normal development should be considered before any other selection; beets of irregular shape should not be considered worthy of attention. In selecting the shape that is to be the ultimate type, it is important to have it almost as regular as that made in a mold. The uniformity will be to the ultimate advantage of the manufacturer, who constantly seeks a raw material of the same condition of texture and composition, thus very much facilitating the process of manipulation in the factory. What is true of products in general is also true of the beet in particular; its juices, when regular in composition, simplify the many phases of purification. The farmer has also better returns for his crops. It must be said, however, that even Vilmorin during his early selection entirely neglected the question of shape or variety. The roots could have red or green necks, with regular or irregular leaves; the main and only issue for the selection was the sugar percentage, upon which basis, even with the so-called ameliorated, all kinds, all varieties, were once to be found—no individual type or shape. In other words, the originals of Vilmorin roots were very irregular and the question of forked beets was soon the subject of general discussion. It is evident that in many cases a forked beet is richer in sugar than is a long tapering root, for it may be considered as two beets joined. These irregular roots are difficult to harvest and almost impossible to work at the factory.

The external appearance of a good or superior beet is long and conical, flattened on the sides growing entirely beneath the surface. There should always be two spiral depressions starting from the neck, filled with a hairy growth; the skin may be white, gray, slightly green or rose, and rather thick and rough surface. The texture of the beet should be hard, breaking easily, and giving no juice unless under pressure.

The central pivot should be hard and very pronounced, the fibro-vasculary tissue very well developed and the concentric rings not more than 12 m. m. in width. The beets not forked and with small necks. The juice should taste either salty or sweet.

On many previous occasions attention has been directed to the influence of soil, fertilizer, seed, etc., upon the final shape of the beet. We know, for example, that if the soil has been thoroughly plowed, roots have greater facility of growth, attain greater length and grow less above ground than when the

FIG. 25.

upper surface only is at their disposal. If the sub-soil offers too great a resistance, the portion above ground is as great as that beneath the surface, and from a manufacturer's point of view, very inferior roots are the result. A beet in growing, if of superior quality, in its desire to obtain the requisite plant food, will surround, as it were, a small stone, which may have been an obstruction to its descending development.

The farmer, in delivering his crop at the factory, cannot be expected to select only those advantageous to the manufacturer, regardless of his own interests.

But what he can do is to learn the best shape of a sugar beet, and endeavor to produce such form. Frequently, farmers grow sugar beets from seed they purchase,* and the roots prove to be of an inferior quality. The truth, if plainly told, is simply that the supposed sugar beet was a sort of hybrid rutabaga, containing but 3 to 4 per cent. of sugar, instead of 12 to 13 per cent., as would have resulted if there had not been misconception of some kind. The good and bad shapes for beets are shown geometrically herewith. Suppose an axis, A B (Fig. 25), and a line, *c d*, form-

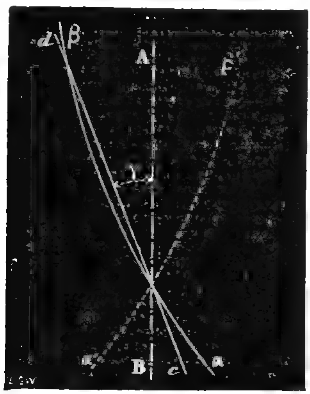


FIG. 26.

ing an acute angle with the same; evidently, if this revolves it will depict a cone, which surface is the type of the tip end of average beets for sugar manufacture. Again, if a curve *d B* (Fig. 26) is substituted for the line, *c d*, we shall have a different surface, convex in its character, and the type of the mangel-wurzel, rutabaga, etc., not advantageous for sugar extraction. If the curve, d b, (Fig. 27) is convex, and we suppose

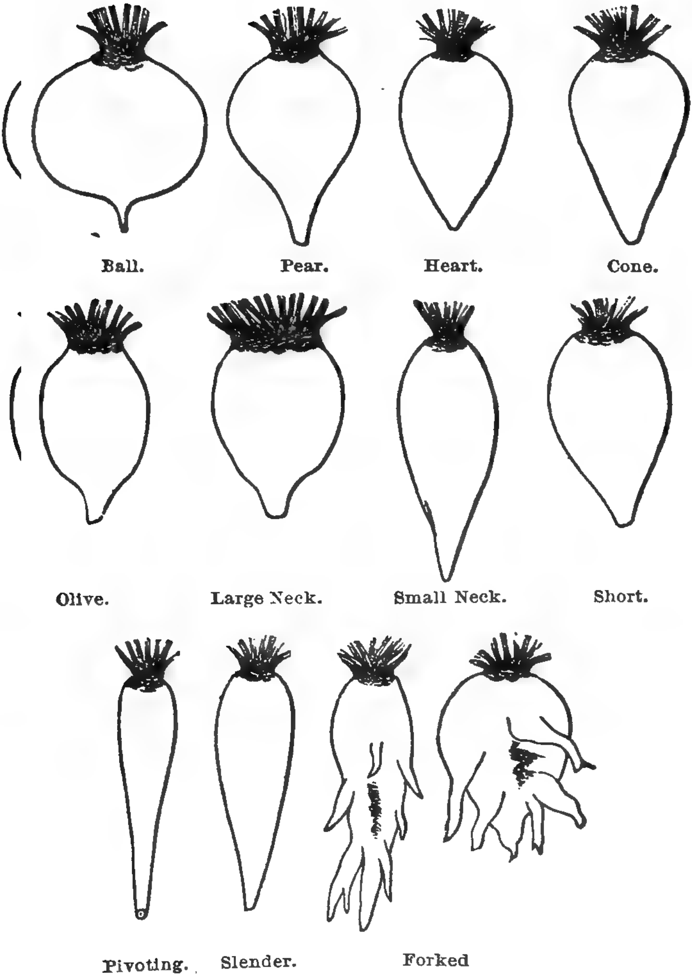
* An important example of this is the experience at the Rome factory, where many of the beets were red, had low sugar percentages and were worthless for the purpose intended.

the same conditions as previously mentioned, we shall have a concave surface, representing the tip end of beets containing 15 or 16 per cent. of sugar. The necks in the latter case are short and small, but in the previous example, long and thick. It is not well to confound a hairy surface on the outside of sugar beets with small adhering roots, as frequently found. They both, it is true, have the same object in view—extracting from the soil the maximum amount of plant food; but small adhering radicles are frequently an abnormal condition of growth, while the

FIG. 27.

hairy portions are the necessary and essential means of plant or root absorption. During the processes of harvesting, washing, etc., the hairy portions disappear almost entirely before the roots are sent to the slicer; while adhering radicles are generally sufficiently large to resist any operation to which they may be submitted, and subsequently, as previously explained, lead to inferior results in the slicing process.

In regard to the depression and hairy growth, it is interesting to note that it is generally on the side where there is the greatest distance between roots.



SHAPES OF BEETS.

If the distance between beets is very much the same as between rows, the tendency then is for the hairy growth to form on all sides. Dubrunfaut declared that there is torsional action of the beet during its development, and the movement follows the sun. Mehay says that the hairy beets contain 3.5 per cent. dry substance; for lateral root tissues this is 4.5 per cent.

The shapes of most of the existing varieties come under the heads given by Knauer in the classification on the preceding page.

Many of these shapes have now become obsolete. The Silesian, or pear type, for a long period of years held its own, but is now no longer in vogue. The olive, also, had its day. The very long, pivoting types have generally a high polarization; however, the juice percentage is not what it should be, and, furthermore, their harvesting is most difficult.

Desprez contends that there is a positive relation between the quality of roots and the hardness of their skin. We are inclined to believe the assertion, as it has been practically demonstrated. Many of our readers, who have seen Desprez's skin classification, may possibly be astonished at this curious theory; but we know that the larger the root, the lower its saccharine quality; hence, large beets are more watery, with tissues more open than are those of small roots, with a corresponding hardness of skin. Leplay has frequently argued that the quality of a beet depends largely upon the amount of calcareous substance combined in its tissues, tending also to lessen the proportional decrease in sugar as the root increases in size. Here we have a kind of explanation of the hardness of skin previously mentioned; and the reason shown why it throws a certain amount of calcareous product on the surface of the clay loam.

CHAPTER V.—PART II.

Chemical Selection of Mothers.

History of Chemical Selection.—While the physical selection of beets with the view to seed production has its importance, it is always considered secondary to the chemical selection, either in laboratory or on the field. Dubrunfaut was among the first to insist upon some method for the selection of roots rich in sugar; it was he, who, in 1825, declared that, volume for volume, the heaviest beets were the richest in sugar. The roots were weighed in air and water, and the calculated density thus obtained was sufficient for the selection of roots that were subsequently to furnish seed to the sugar manufacturers. The fact is, as before stated, France during a period of years was the centre for superior beet seed; Russia, Germany and Austria imported their seed from French growers. In 1850, Vilmorin published his pamphlet on the proposition to increase the sugar percentage of beets. However, some years prior to this, other issues were discussed, with considerable foresight in regard to the possible future. Baths of saline water were used, the classification being based upon the strength of the bath—the roots were well washed before immersion, and those sinking were kept for mothers. In justice to Vilmorin, it is interesting to note that, in 1852, he realized that his method was not exact. Why the salt water baths are objectionable will be subsequently explained. It is now generally admitted that the actual selection of beets with the view to seed production, as now accepted, was in 1856, for then for the first time, the question of creating a new variety was discussed. Numerous methods having the same object in view were subsequently proposed, and these may be classified as follows: 1st, Density of the entire root; 2d, density of a piece of beet; 3d, density of the juice of the beet; 4th, estimation of sugar in the juice by chemical methods; 5th, estimation of sugar in the beet by means of the polariscope, in connection with which have been proposed: (a), the alcoholic method; (b), hot and cold water methods; (c), cold water, using a special rasp, with subsequent weighing of the pulps, (d), cold water, with a special sampler, without weighing.

It is important to pass in review these various methods: 1st, Density of the entire root. The discussions relating to this subject extended over several years. The baths at first had densities which varied from 10 to 6° Bé. Those beets sinking and of a close texture were kept for seed. The discovery by Vilmorin of a frequent air cavity in the neck of beets made evident the fallacy of the method he was using, and besides there is another objection not to be overlooked, viz., the densities of the baths are not constant, because after a short time dirt, etc., adhering to the roots, and subsequently remaining in the tanks, will considerably alter the results, notwithstanding the care bestowed in washing the beets.

The Knauer method for mechanically dividing the beets into piles, according to their weight, for some time attracted considerable attention. This had certainly a great advantage over the mode previously adopted, as it was hardly possible to determine the weight of all the beets on the field before sending them to the factory. Furthermore, it was evident that if the roots were left on the ground after harvesting, they would have a certain amount of moisture which would undoubtedly alter the results. The difficulty of properly removing the leaves was evidently another source of error which had been too frequently overlooked. It was, however, recommended that they be twisted off rather than be submitted to a slicing process, which had led to many irregularities in the results. Instead of a salt water bath, molasses was used as a medium. Beets weighing about 1½ lbs were thrown into it, there being several baths of increasing densities, which allowed a certain classification. While the method has been abandoned for years, there are many experts who still insist upon the weight being a basis of selection, for when the weight of beets increases, the density of juice, total dry substances, the sugar percentage, the purity coefficient and the proportional value decrease.*

	Small	Medium	Large	Very L'rge
Weight, kilos	.222	0.410	0.795	1.497
Density of juice†	6.2°	5.9°	6°	5.8°
Dry substance, per cent.	15.139	14.428	14.666	14.190
Sugar, per cent.	13.49	12.56	12.14	11.65
Non sugar, per cent	1.64	1.86	2.53	2.54
Purity coefficient	89.1	87.	82.7	82.1
Proportional value	12.	10.8	9.9	9.5

The analyses of 1000 beets in the Desprez laboratory gave the following results:

Beets	Weights on Aver., kilos	Sugar % kilo contains
27	0.533	11 to 12
23	0.528	12 to 13
84	0.621	13 to 24
226	0.603	14 to 15
252	0.523	15 to 16
270	0.496	16 to 17
106	0.477	17 to 18
12	0.370	18 to 20
1000		

From which we conclude that while small beets, as a general rule, contain more sugar than large, this is by no means invariable. For in this list it may be noticed that the average weight of 226 beets was 0.603 kilo and averaged 14 to 15 per cent. sugar; roots

*Influence of the weight of beets on their saccharine quality (see Z für Zuckerindustrie in Bohmen Jan. 1884). See for more important detail the work of Marek.

†The degrees given here are according to the French—To convert into specific gravity prefix 10 and remove the decimal point two places to the left, e g: 6.2°=1.062 specific gravity.

very much lighter, the average weight being 0.533 kilo, contained only 11 to 12 per cent. Vilmorin, during his early efforts at selection, introduced the method of taking from the beet a cylindrical piece with an instrument similar to an apple-corer.

2d. Density of a Piece of Beet.—That the sample could be taken from the beet without changing its keeping qualities, providing that the hole made be at once filled with sand, was an important progress compared with the old methods. The cylinders of Blount were placed in a series of vases and filled with sugar and water; these solutions contained 7, 8, 9, 10 to 15 per cent. of sugar.

The selection of roots based on the density of the core taken from the beet continued to be in vogue for many years, the baths subsequently used having densities of 105.0, 106.0, 107.0 and 108.0;* the small cylinders were frequently cut into four pieces. Dervaux-Ibled devised a method of selection, using saline baths in tanks of much smaller dimensions than those previously described. It had been noticed that if a sample of root be taken perpendicular to the axis, at about one-third the height from the neck, its density would be one degree to 1.2 degrees less than the juice. If the samples were floated in a saline bath of 106, the conclusion then was that the beet had a density of 107 to 107.2. The roots were first selected on the fields by exterior signs alone. The small vases, containing only 200 to 300 grams of salt water, were placed in numerous hands, which allowed 3000 to 4000 beets to be selected per diem. The evident advantage over the whole-beet method was, that the roots were not necessarily cleansed or the leaves removed, while the economy of time and labor was considerable. The baths

*The above manner of writing the densities instead of placing the decimal after the first figure, was that adopted by those who were working by that special method of selection.

could be kept at almost constant density. The Dervaux method of classification was, that beet samples floating in the bath of 105 density were rejected and those which sank in that of 105.5 were subsequently sent to the laboratory for further examination. On the other hand, those which were of a density of more than 105, and yet less than 105.5 were siloed and planted the following year and gave seed for the trade. The roots to which preference was given weighed from 700 to 900 grams.

Respecting the Dervaux method, we would say that the results obtained by it are more reliable than by the Vilmorin system, where several errors exist, the most important being the effect of endosmosis of the solution, and the atmospheric effect produced upon the small cylinder in passing from one vase to another, a series of solutions of different strength being used.

The other errors were noticed by Champonnois, and were due to a certain volume of gas contained in the tissues of the piece of beet, or in the entire root. The volume of these gases varies from 9 to 50 c. c.* per kilo of beets. Its composition is, nitrogen, 63; carbonic acid, 37. The following table shows that the volume of these gases varies considerably.

Density of beet in salt water.	Density of juice.	Volume of gas per kilo.
1016	1045	26 c. c.
1012	1048	36 c. c.
1005	1040	35 c. c.
1012	1050	32 c. c.

Vibran made a new departure, and instead of taking the cylinder from the beet, he took the density of the tip end as a basis of estimation. Rimpau showed by a series of well-conducted experiments that the method was not reliable. Several beets which were examined sank in a saline solution of 104.8; their sugar

*Dubrunfaut admits that it may reach 113 c. c. per kilo of beets. Opinions very much differ respecting the composition of the gas; M. A. Heintz declares that it consists of nitrogen, 66.8; carbonic acid, 32.8; oxygen, 0.35; and the volume varies from 130 to 150 c. c. per kilo of beets.

percentage varying from 11.98 to 14.3; average 13.4; beets with tips of lower density also gave 13 per cent. sugar. The fallacy of the method was also demonstrated by Marek, who tested tips from beets containing 9 to 15 per cent. sugar and they all floated. Notwithstanding this fact, Dippe Brothers, the well-known seed producers of Germany, adopted the tip-end method as a basis of their selection. The end was broken off and immersed in a saline bath of 6¾° Bé. If it floated, the beet would be thrown out; if it sank, it would be placed in a second bath, 7½° Bé; if sinking again, a third bath would be used, etc. A fact apparently overlooked by them, is, that during the period that beets remain siloed, the tip end is frequently the first to undergo organic changes. Consequently, if the end is not examined, either by polariscope or in the series of baths just mentioned, at once after harvesting, it will be found that its sugar percentage will be very much too low to be a safe guide.

In conclusion to what has been said in the foregoing, there appears to exist a relation between the juice of the beets sinking and those which floated, the former being the heavier. Or, more clearly speaking, just as Mehay and Scheibler say, there must be a proportion between roots and their juices, and investigations in this direction showed that it is desirable to take the density of the juice rather than that of the beet, the latter method, however, being more rapid. From 1872 to 1874, the selection of mothers attracted special attention and many factories all over Europe had special laboratories for seed production. However, twenty years before this, Vilmorin had already used the juice as a basis of selection.

3d. Density of the Juice in the Beet.—The core was reduced to a pulp and gave about 7 to 10 c. c. juice. A complete apparatus was used. This method was in vogue for some time and is now interesting from an historical standpoint.

The sample was rasped and its juice extracted by twisting the pulp, held in a piece of cloth, between the fingers. The density of the juice obtained was determined by a hydrometer (or by the displacement method, which consisted in weighing a silver lingot in the juice, density being then calculated), the temperature of the liquid being kept at 15 degrees C.; he recommended that beets having a density of 1.050 should not be used for mothers; special tables were arranged with corrections, etc. These underwent several changes, until, finally, it was suggested to submit the sample of beet to a strong pressure and polarize the juice obtained. But to this many objections could be found, for the pressed beet does not give juice of the same composition as when rasped. By all these methods it was necessary to make certain calculations, in order to compare the juice examined with 100 grams of beet.

It was soon pointed out that the percentage of foreign substances contained in beet juice decreases as the specific gravity increases. While the methods of selection based upon the density of juice were not generally adopted at the time, they have many advocates, even at the present day. Herles, for example, has a special apparatus for mother selection; it consists in using a very small portion of the beet, and only 5 c. c. of the juice, its density being at once determined. It is maintained that this density gives a far better idea of the sugar percentage of the beet than the polarization of juice from a very small sample. By this apparatus, 1200 analyses may be made in 24 hours, and it has met with some success. The first hints as to the possibility of ameliorating the quality of beets were given by the increase in specific gravity of juice from generation to generation. From the third generation of selected beets, the juice had a specific gravity of 1.807, which corresponded to 21 per cent. sugar.

The hereditary tendency was then no longer in doubt. The selection based upon the hardness of the skin of beets has certain original characteristics, for experience has long since shown that the richer the beet, the tougher the skin. An instrument consisting of a rod with a dial indicator at the other end has been employed. This, pressed against the root, gives in one reading the resistance to penetration; the greater this is, the richer the beet!

General Remarks Respecting Juice of the Beet.

The question of the percentage of juice in the beet is also very important in selecting roots with the view to seed production. This percentage varies very considerably with the condition of the weather at the time of harvesting; if very rainy, the beets evidently weigh more and contain more juice than after a drouth. Furthermore, there is an element of variety; hence, the percentage of juice of one should be compared with another; after such comparison, the sugar percentage should be determined. There are, accordingly, several very misleading factors with which to contend.

What is true for moisture is reversely true for excessive dryness. Then the percentage of juice would be less and the sugar percentage apparently greater. Hence, the admitted average of 95 per cent. juice is open to discussion. In most cases there may be certain advantages in estimating the percentage of juice by indirect methods, admitting that the total sugar of juice is the same as the total sugar of the beet; which, in other words, means that it is possible to calculate in the laboratory all the sugar in the beet solely from the juice by pressure.

Consequently, the weight of the beet multiplied by the per cent. of sugar is equal to the weight of the juice multiplied by its per cent. of sugar. If these calculations are made, it will be found that there is a frequent variation of 5 per cent. in percentage of juice under observation, not only with different beets, but with the same varieties. Mothers should not only be rich in sugar, but rich in juice. As a basis of comparison, it is proposed to determine the sugar percentage by the water method, then to repeat the experiments by the Violette copper mode, and divide these results one by the other. It is claimed that this calculation would give an excellent idea of the juice percentage of the beet examined. Furthermore, it is recommended to give preference to those beets which give the highest product when the per cent. of sugar is multiplied by the per cent. of juice. Respecting this mode, it seems to the writer that it would be too long and expensive for root selecting, in seed growers' laboratories.

4th. Estimation of Sugar in the Juice by Chemical Methods.* All these methods require the sugar to be transformed into glucose and the proportion of glucose then determined by the use of a standard alkaline copper solution. When all the copper has been reduced by the glucose, the solution is no longer blue. Special stress is placed on the weight of the oxide of copper found, or even on the weight of copper which has undergone a proper reduction. While these methods were in vogue for the estimation of sugar in the beet, they demanded too much care and time for general use. Furthermore, they have proved to be inaccurate in the hands of the average chemist. In the selection of beets with the view to

*The process of manufacture would be very simple if juice contained only sugar, but there are many salts in dissolution, all of which exert considerable influence on the ultimate crystallization. Hence, it is very important to know the proportion between sugar and total solid substances; this relation is known as the purity coefficient. The per cent. of solid substances is determined with a hydrometer. If a juice contains 16 per cent. solid substances, of which 14 per cent. is sugar, then $\frac{14\times100}{16}$= purity coefficient=87.5. This should never be lower than 80, otherwise the working of such roots into sugar could not be made profitable.

seed production, the Violette method had a very extended application in many laboratories, and a description of this mode is of special interest.

Violette Method.

This mode of analysis, like the Fühling, is based on the amount of copper reduced by glucose; the sample taken from the beet is rather larger than is actually required. The early sampler consisted of a simple steel apple-corer; the direction given to the appliance should be such as to meet the axis of the beet at a point one-quarter* of its total length from the crown of the root; it may be perpendicular or slanting, providing it passes through the centre corresponding to *h* (Fig. 28). The sample should be sliced into small pieces, precaution being taken to remove the outer skin.

These should be weighed. Exactly five grams of these slices are carefully placed in a flask of 100 c. c. (this weight and flask selection has many advocates); to it are added 10 c. c. of normal sulphuric acid, then 40 to 50 c. c. of distilled water. The flask and contents are gradually heated for 15 to 20 minutes, under which circumstances, all the sugar of the sample is converted into glucose; the liquid is allowed to cool

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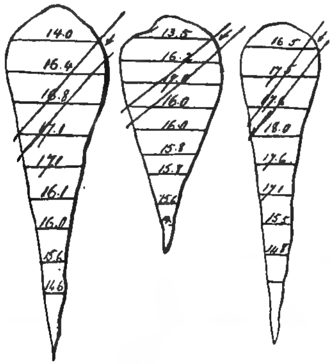
*For mathematical reasoning of same, see "Ware on Sugar Beet," Pages 181-182, which is as follows: Mr. Violette supposes the beet an exact surface of revolution engendered by the triangle A B C (Fig 29), and that the sugar contained increases in an arithmetical progression from D to C. If LM be an infinitesimal cylinder parallel to the axis, CD, according to the theory just mentioned the point S, middle of LM, will have an average amount of sugar for the small element under consideration. The same argument will apply to O, when the cylinder having the axis DC is considered. If O be joined to A and B, evidently the lines OA and OB will be the line of all the averages of small cylinders possible to imagine as existing in the interior of the beet, and the centres of OA and OB, or X and X′, will represent the exact position of the average of all the averages, and if each horizontal slice contains the same amount of sugar, we could write,

$$\frac{OY}{YD} = \frac{OX}{XA} = 1. \text{ Then } OY = YD = \frac{CD}{4}$$

Some German chemists recommend that the sample be taken as shown in the engraving.

until it reaches 15 degrees C. It is then desirable to add 10 c. c. of a normal soda solution, in order to neutralize the free acid; distilled water is added to complete the



Slassy's Method for Taking Sample, Showing also Distribution of Sugar in Superior Beets.

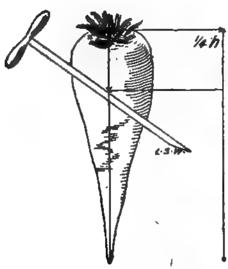


FIG. 28. Sampling.

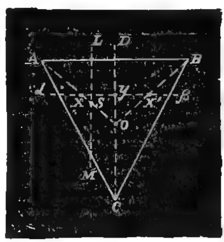


FIG. 29. Diagram of Violette's theory.

100 c. c.; thorough agitation is necessary in order to have the solution homogeneous. Filtration follows; 10 c. c. of the filtrate is emptied into a graduated burette (graduation of one-tenth c. c); 10 c. c. of the Violette copper solution* are accurately meas-

*This liquor consists of 36.46 grams crystallized sulphate of copper dissolved in 100 c. c. of distilled water, 200 grams seignette salt, 90 grams caustic soda. This formula varies slightly. Great care is required in its preparation; it must be kept in the dark, etc.; as it is very sensitive to light it is best to prepare it as needed.

ured with a pipette and emptied into the test tube, and then heated over a gas jet. This volume of the blue liquor requires 0.05 grams of glucose before becoming completely decolorized. Several cubic centimeters of the sugar solution are dropped into the test liquor; repeated heating brings about changes in color, passing from yellow to red, etc.

After boiling for a few seconds, there will be noticed a red deposit at the bottom of the test-tube. This is the sub-oxide of copper which has been thrown down; a few more cubic centimeters of the sugar solution are again added and the liquid is boiled; the addition of the sugar solution and the boiling are repeated from time to time, until the liquor becomes colorless. If the sugar solution is used in excess, there remains a yellow tinge, the intensity of which depends upon the quantity above what was needed. Note is taken of the number of cubic centimeters used to complete the copper reduction. If this, for example, had been 7.3 c. c., it would correspond to 0.05 gram of glucose, equivalent to the glucose obtained in the inversion of 0.0475 gram of sugar. In one cubic centimeter there would be $0.05 \div 7.3$, and in 100 c. c., in which have been dissolved the sugar from five grams of beet, there is $0.05 \times 100 \div 7.3$, or $5 \div 7.3$, which equals 0.685 gram glucose, corresponding to 0.651 gram sugar. Consequently, in 100 grams of beet there is 20×0.651, equal to 13.02 per cent. of sugar.

Practical Application of the Violette Method.

Some years ago, one of the leading beet-seed growers introduced the Violette method into his laboratory. A special machine worked by a pedal gave the sample, the beet being placed beneath in a slanting position; there were four cutting blades. The introduction of the weighed samples into the flasks of 100

c. c. and the subsequent covering with diluted sulphuric acid, or the heating in the sand bath, were as usual.

The latter, however, is composed of two circular plates, A and B (Fig. 30), of sheet iron covered with sand. To these plates a rotary movement is given; to one of them direct from a train of wheels like a clock movement, and to the other by means of an endless chain; both move with the same velocity. Underneath these circular disks is arranged a series of gas jets; 50 flasks can be at once heated in this manner. The work is so conducted that the flasks upon one of the disks

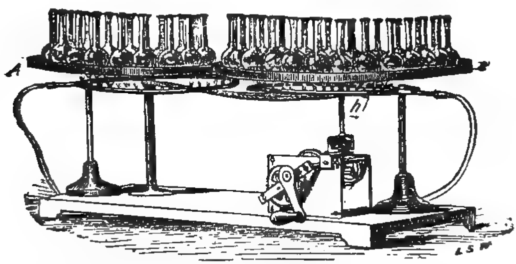


FIG. 30. Heating flask revolving machine.

are nearly empty, while those on the other are almost full. Each flask, as may be imagined, is numbered.

The analyzing apparatus is composed of a stand with a central vertical support, upon and around which five horizontal arms can revolve. These arms serve for holding the test tubes and burettes, the former containing the copper solutions, etc., and the latter the invert-sugar solutions. The lower horizontal arms just mentioned are covered with wire gauze, upon which rest the ends of test tubes; each arm can hold five tubes. In the second series of arms are holes in which the test tubes are placed, and held in vertical position. The upper series of arms hold the burettes directly over the tubes containing the Violette solution. The operator places in front of him one of the arms containing five tubes, each of which is at once filled with 10 c. c. of the copper solution.

In the burettes are placed the invert-sugar solutions from samples of beets, as previously mentioned; and a certain quantity of the inverted liquor is allowed to drop into the copper solution. The tubes are at once placed over a series of small gas jets, which soon bring the mixed copper and sugar solutions to a state of ebullition, resulting in the precipitation of a portion of sub-oxide of copper. During this operation the next series of five tubes is being prepared and is also subsequently heated. When the 25 tubes have had

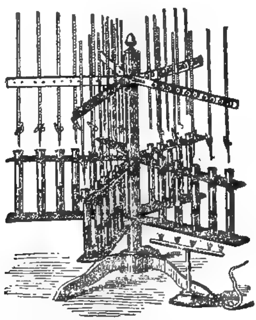


FIG. 31. Pipette stand.

their copper solutions completely decolorized, the heating and addition of inverted sugar solution must cease.

As the main object is to throw out all beets not up to a given standard, certain tables are used. If in the tables we find that 6.3 c. c. of juice (which has been prepared by transforming the saccharose into glucose) is needed to precipitate the copper of the Violette solution, this means that the beet under consideration contains 15 per cent. sugar. Consequently, if this volume is prepared in advance and the reaction is not complete, the conclusion is that the sugar percentage is less and more juice is needed, say 7.9 c. c., which corresponds to 12 per cent. sugar. If this volume of the invert-sugar solution is required to discharge the blue color of 10 c. c. of the Violette reagent, the beet is not suitable for a mother and is rejected.

General Remarks Respecting the Method.

The boiling of juice with acids demands considerable care, and should be watched from the start, as the surface frothing is excessive. To obviate, in a measure, this difficulty, it is proposed to add the acid only at the end of the boiling. Then again, some chemists recommend that acetic instead of sulphuric acid be used, under which circumstances, at least 10 to 15 c. c. are needed. There is always a danger of the sulphuric acid combining with substances other than sugar; consequently, it is an evident mistake to bring the acid in direct contact with the beet slices.* The juice and acid lead to the best results. Even in this case, there are sources of error, as beet juices always contain a substance very like glucose, which has, itself, an influence on the copper solution which evidently forces the results; under the best of circumstances, the Violette method is only approximative.

Another objection to the method is, that artificial light cannot well be used; the expense of chemicals, gas, etc., are items not to be overlooked when seriously undertaking laboratory selection on a large scale. Furthermore, looking at the method from a practical standpoint, it is entirely too intricate and leads to the best results only in the hands of experts, who should

*M. Pellet says the action of the acid on tissues of the beet may be avoided in working as follows: Divide the operation in two parts; make up with the beet and boiling water a volume of 200 c.c., from which is taken 100 c.c. of juice. After filtration and decantation, invert with sulphuric acid and dilute until the volume is 200 c.c.; consequently, there are 10 grams of beets in 400 c.c. These manipulations are tedious and do not avoid the errors, which may be 0.2 to 0.7 per cent. in certain beets not having attained their full maturity, or even 1 to 1.5 per cent. in beets of inferior quality, or which had undergone changes during keeping.

use it, with the view of a comparatively rapid method of comparison for sugar estimation, remembering never to examine the color of the solution by holding it up to the light, but, on the contrary, against a white wall; the colors due to refraction, etc., are thus avoided.

5th. Estimation of the Sugar in the Beet by Means of the Polariscope (*a*) Alcohol Method.—Among the first to introduce alcohol in the laboratories for sugar estimation was Scheibler (1878). However, one must go back to 1762, when Margraff gives the first description of how he boiled alcohol with dried slices of beet, and the filtrate was subsequently left to crystallize during several weeks and the product obtained was again washed in alcohol, etc. From one-half pound of beets he got half an ounce of sugar. Then, in 1825, Dubrunfaut introduces another method which did not differ from Margraff's in its essential workings.

In the Peligot process, alcohol at 90 degrees was used, and from this time on also by Payen, Scheibler and Soxhlet. The digestion by cold alcohol, as used by Stammer, the cold-alcohol process, has still many advocates in Germany. In beet selection laboratories the alcohol need not be stronger than 80 to 85 degrees. This later was changed to a hot-alcohol process. The various appliances having alcohol as a basis are too numerous to mention. However, certain selecting laboratories use them, not for general selection, but as a final determination of sugar percentage for beets in cases where the roots are shown to be of very superior quality, by previous methods. A certain number of such beets of each classification are sent to the second laboratory to undergo a second analysis. From the results there obtained it is possible to determine to which series the mother belongs. The per cent. of sugar by the first test does not, however, appear on the said list, so that the second chemist can have no possible indication of what the conditions are. The quantity of pulp to be weighed is either 16.29* grams or 26.048 grams, according to polariscope used. This sample is placed in a vertical tube over a flask in which alcohol is being boiled. The vapors of alcohol falling upon the beet pulp will carry back to the flask the sugar dissolved; as the evaporation goes on, the sugar solution becomes denser and denser, and ceases when the pulp has been entirely exhausted of its sugar. The usual polarization follows. By the German polariscopes, one knows in one reading what the sugar percentage is. If it is found necessary to make a large number of analyses at one time, the Soxhlet appliance may be arranged in the battery, and several flasks heated at the same time to a temperature of 95 degrees C. Evidently, the great objection to any of these appliances based on the alcohol method of extraction, is that the operation must always be repeated in order to obtain accuracy in the final results. Another source of error, unless in expert hands, is the danger of adding an excess of sub-acetate of lead, which chemical, according to Pellet, has a tendency when in the presence of alcohol to diminish the rotatory power of sugar, or even in certain cases to precipitate a portion of it. There is always a certain amount of alcohol lost, which adds considerably to the expense. By all alcohol methods, hot or cold, it is most essential to have the pulp in a cream-like condition; otherwise, with all possible care, the sugar percentage will be less than the reality.

(*b*) Hot and Cold-Water Methods.†

The hot and cold-water methods for the analysis of samples of beets have of late years undergone many

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*At the congress of chemists held in Paris during 1896, it was concluded that the weight for French polariscopes should be 16.29; this has yet to be officially accepted, but we have adopted it.

† We have not used the term aqueous for the simple reason that the word is not altogether in keeping with the general practical style of the present writing.

changes which have rendered the methods excessively simple.

Hot Water.—It is interesting to note that M. Barbet in 1879 applied this method. A certain weight of beet pulp is diffused with three times its volume of water, the whole boiled for 15 minutes, then cooled, weighed, decanted and lightly pressed in a linen cloth. The density of the juice is then taken; this is followed by polariscopic examination. It is necessary, in this method, to correctly weigh the insoluble residuum; the error, however, is very slight.

In 1883 Pellet called attention to a new hot-water method of analysis, in which the beet sample was placed in the neck of a flask having a special shape. Water was poured over the pulp and a small quantity of sub-acetate of lead added, the supposed volume of liquid being 200 c. c. A few variations of this method will be described at present writing.

Von Niessen proposed to replace the alcohol by water; 100 grams of beet cream are placed in a flask of 400 c. c. capacity, and 4 c. c. of lime water are added. This is heated in hot water 30 minutes; cooling follows; then add 386 c. c. water and 12 c. c. acetate, complete to 400 c. c. and allow to settle for 12 hours before polarizing.

(*c*) Using Pellet and Lamot Rasp.

Cold Water Method.—Since the early history of beet-sugar-making no process has so completely changed laboratory methods as the cold-water method for beet analysis. The idea has for many years been discussed in the laboratories, but it has been modified and simplified under the instruction of Pellet. One of the greatest difficulties with which to contend is the production of pulp sufficiently fine to meet the requirements of perfect diffusion. It is interesting to pass rapidly in review the appliances and advantages they offer—the importance of which is self-evident. The errors made by the hot-water method, when using a pulp which has not been properly prepared, are not as great as by the cold-water process, for the simple rea-

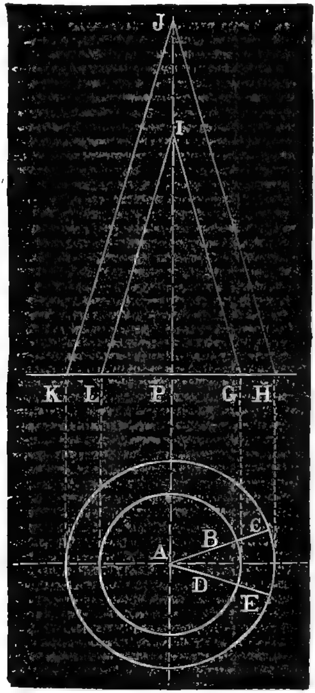
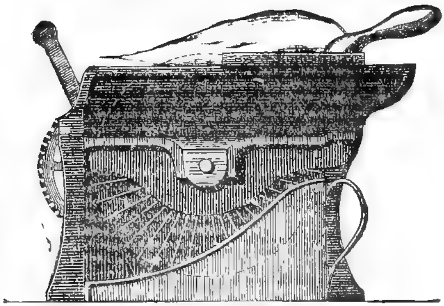


FIG. 32. Diagram of the theory of Pellet and Lamot rasp.

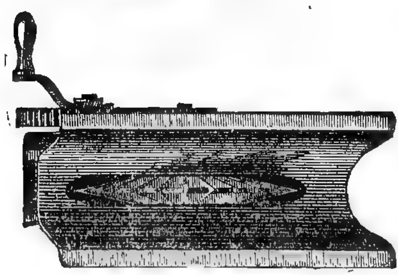
son that the diffusion is within a given time, say a half-hour's boiling, and is more complete.

We shall examine, first of all, the method by which the Pellet and Lamot rasp is used, in which case the sample is taken from the entire length of the beet and in quantities which are proportional to the total weight of the beet.



Side view.

End View.



Top View.

FIG. 33. PELLET AND LAMOT BEET RASP.

If two beets are represented by two regular cones, *K J H* and *L I G* (Fig. 32), and in plan by two concentric circles, it is evident that if an angle *C A E* be taken on the beet *K J H*, and another, *B A D*, on the beet *L I G*, they will have the same opening, or 30 degrees. The section in each cone thus obtained bears the same relation to the entire root. It becomes evident that if the slice taken is limited by the axis of the beet, the sample will be one-twelfth of the entire root, a result which could be obtained by cutting the beet in two, then again into halves, etc. The practical working of the rasp is better understood by examining the apparatus shown in the engraving (Fig. 33)

The apparatus was at first a sort of circular saw, but since has been considerably modified. The beet is held in position by lateral knives, in such a way as to bring the limit of rotating blades exactly on the axis of the root; the latter is pushed forward with one hand, while the gear wheels are put in motion with the other. For special purposes the opening of the rasp may be regulated to suit the requirements.

Experience has demonstrated that the pulp obtained from this rasp has the same density as that made by rasping half a beet by hand. To have accuracy in the analysis of one beet, it is found desirable to turn the root over, so as to secure another sample from the same beet; consequently, with this conical rasp it is possible, not only to get an average sample of pulp from a series of beets, but also of the same beet. The dry pulp obtained should be thoroughly mixed; if small lumps are found in the mass these should be taken out and finely chopped. The rasp, after being used, must be brushed off, not washed with water. It is interesting to note that the circular disk was originally bronze, but is now constructed entirely of steel; its surface is not unlike a coarse file used for wood. A velocity of 400 to 500 revolutions per minute is obtained without difficulty.

Experiments of Pellet show that both sides of the beet have not necessarily the same composition; hence, for accurate results it is very desirable to turn the beet over and take two or three samples from it, until the weight is above 16.20 grams, for French polariscopes; if only the large diameter—the beet having always a depression on one side — is sampled, the result obtained will be in excess. Practical experiments show that with the large diameter the average sugar per cent. is 13.43, while with the small diameter the per cent. is 13.23. The amount of pulp obtained in the case of the large diameter is nearly double that of the smaller section. While a rasp of this kind would not be suitable for the selection of beets which are to be subsequently used for seed production, it is destined to render excellent services in experimental work, where it is desired to determine the value of various experimental patches of families, having certain characteristics, before commencing the final selection of the root proper. It must be noted, however, that if the fractional vertical slices for seed production become popular, the rasp would possibly find some application in beet-selecting laboratories.

The Poliakowsky method, if it had been more thoroughly studied, would have led to the water process that Pellet subsequently discovered. An important essential for success by this method is, that the pulps be excessively fine and cream-like. It is not desirable to weigh more than 26.048 grams for the German polariscope, for a volume of 201.35 c. c., or 25.87 grams for a volume of 200 c. c. The pulp is washed in a special flask of 200 c. c. capacity; 5 to 7 c. c. subacetate at 30 degrees Bé are added, then a few drops of ether. Considerable agitation of the flask and contents is necessary to avoid frothing. The 200 c. c. are completed with water; filtration and polarization as usual. It is recommended before polarizing that a few drops of acetic acid be added. By using a tube of 400 m. m. in length the saccharine percentage is obtained at one reading. This cold-water process gives most excellent results, excepting during very cold weather; then it is found desirable to slightly heat the water.

(*c*)2. Special Rasp (Keil and Dolle) with Subsequent Weighing of Pulps.

It is interesting to examine in some detail the cold-water method for selection, as combined with the Keil and Dolle rasp. The general arrangement for laboratories is shown in Fig. 36. The motion of the rasp is given either by hand in turning a wheel, or by a gas or other engine, under which circumstances the upper arrangement of pulleys is not changed, as by suitable belting the desired velocity is reached direct from the motor on the floor, replacing the hand appliance; the rasp proper is very simple in its appearance; it may be single or double and has well-arranged brakes and pulleys, allowing almost instantaneous stoppage. The fly-wheel on the shaft regulates the movement. The point of the rasp is a cone with teeth very like those used on wood files. In this point there are three openings, *Q* (see detail of point, Fig. 34) into which the cream-like pulp enters. In the original type of these machines it was necessary to unscrew the cylinder on which the conical rasp is fastened; the cylinder had to be emptied and then thoroughly washed before taking a sample from another beet. Under these circumstances it was not possible to make more than 1000 analyses per diem.

Movable cylinders inside the rasp for a time were used, these being replaced by others during washing. This change in the method increased, in a measure, the working capacity of the apparatus, but did not entirely meet the requirements for rapid analysis. At last a very simple method, which is most practical and does away with the movable cylinder, washing, etc., was introduced. It consists in having a rod *R* fastened to the rasping point; at end of the rod is a circular disk *D* of the same diameter as the cone of revolving shaft. When the cone is unscrewed it carries with it the rod and disk, the pulp cylinder falling into a special capsule, care being taken to leave behind the portion of pulp near the disk, as it is the remains of a previous operation and has been pushed back by the new pulp from the last beet from which a sample is taken. Experience shows that only four-fifths of the contents of cylinder should be allowed to fall into the capsule; by this means 3000 analyses may be made in twenty-four hours.

Certain practical precautionary measures are essential. One must be careful to bring the mother

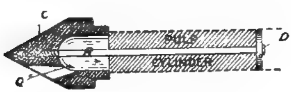


FIG. 34. Detail of rasp point.

FIG. 35. Wide neck flask.

in contact with the revolving rasp very slowly; furthermore, when the penetration through the beet is nearly complete, the revolution of the rasp should be lessened, otherwise there would be danger of bruising the beet on the other side. Suitable brakes must be used so as to stop the apparatus at once, as soon as the belt is thrown on the loose pulley. When the mothers are arranged on a table near at hand, the sampling can commence. The rasp is put in motion by moving the lever commanding the belting; as soon as completed, that is, as soon as the sample is taken, the reverse movement is given to the lever so as to stop the general motion, while a special brake with spring attachment stops the rasp instantly. If there are two rasps on the same shaft, they must revolve in the same direction, otherwise there would result considerable complication.

Pellet makes some important observations respecting the use of the Keil rasp. It should penetrate the beet one-fourth of its length without neck. When the cutting portions of the rasp are sharp and in good condition, the pulp obtained is sufficiently fine to give accurate results by the cold-water process of analysis, but if the pointed rasp works badly the conditions are changed. If the velocity of the rasp is too slow, or if the motion is reversed, the pulp obtained is not sufficiently fine for the purpose intended. It is important to note that the hole made in the beet by the Keil and Dolle rasp is 14 m. m. in diameter, that it in no way destroys the keeping qualities of the mother root; also that at least 300 perforations may be made per hour, or 3000 a day; this cannot be reached at first and requires considerable experience. To make sure of conditions, a comparative test by cold and hot water should be made. Place beside the rasp the tray holding ten capsules, or small receptacles for the reception of the pulp. Each of them has a number and the mixing is done in them, or in a larger receiver.

Weighing the Pulp.

It is then emptied into a nickel capsule of a known weight. It is desirable to have several on hand, so as to avoid errors. The pulp, after being thoroughly mixed, is weighed in capsules. One-quarter of the normal weight required for the polariscope is sufficient for the test; at least 1000 of such weighings can be done in ten hours on ordinary scales, and for special seed laboratories five or more scales are in active use.

Filling of Flasks with Pulp.

The flasks used have a capacity of 50 c. c. (Fig. 35), with a very large opening. The pulp is washed into them with 25 to 30 c. c. of water, from a reservoir three to five feet above the table; its capacity depends upon the requirements. The water is mixed with 30 to 40 c. c. of sub-acetate of lead, 28 to 30 Bé.* (A), per liter capacity, and is well stirred. A tube, either of glass or rubber, connects the reservoir within easy reach of the table, on which are the empty flasks waiting to be filled. A special funnel is placed in the flask. The funnel has an upper opening of 6 c. m., and is 7 c. m. in length, its smaller dimensions being considerably less than the neck of the flask; it is held in position by suitable wire attachments. The capacity of the funnel being at least 100 c. c., there need then be no danger from splashing when being filled with the entire contents of capsule; under these circumstances the air from the flasks escapes without difficulty during filling.

A very important precaution is to thoroughly moisten the pulp in the capsule before washing it into the funnel over the flask. Great care should be taken to have the flasks filled exactly to the 50 c. c. mark of the flask; if necessary, by reason of excessive frothing, better add a few drops of acetic acid, so as to make sure that the desired volume is obtained, or allow for excess in subsequent calculations. The flask, with pulp and water, is thoroughly shaken. The filtering can be conducted on a very large scale, the arrangement of the apparatus varying with circumstances.† The glass funnels should be of a suitable size. The clear filtrate is collected in a conical-shaped tumbler; to it are added a few drops of acetic acid; when it is filled, it is taken on a tray with twenty others to the table of the polari-

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*A satisfactory formula for the preparation of lead acetate is as follows—325 to 350 grams neutral acetate of lead, 100 grams powdered litharge, to which is added 900 grams water. It is necessary to boil for one-half hour to completely dissolve the litharge, add water until the volume is one liter. Another formula given by a well-known chemist is—350 grams neutral lead acetate, 55 c. c. ammonia, 800 grams water; dissolve the acetate in water and then add the ammonia; the specific gravity should be 25 degrees Bé.

†See description of M. Legras's laboratory.

scope. Great care is needed to have each numbered, the number in question corresponding to that of the beet from which the juice was obtained.

Practical Working by the Keil and Dolle Rasping Method.

The general plan (Fig. 36) gives an excellent idea of a well-organized laboratory, working by the Keil

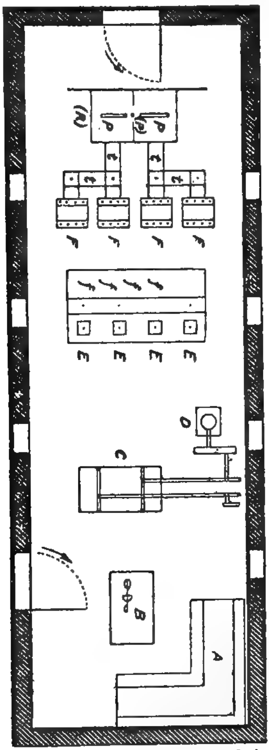


FIG. 36. Plan of a beet-selecting laboratory.

and Dolle rasping method. The beets are brought to Table B, where they are weighed. Those roots within the prescribed limit of weight are taken to Table A, consisting of a series of shelvings about six feet in height. On each shelf there are compartments for twenty beets; each has a number, to which is also appended the number of the shelf. The rasping is done by the two double rasps at Table C. The motor for the rasps is shown at *D*. There are four small scales, *E*, on which the cream-like pulp is weighed; the flasks are filled on the other side of the same table, *f*, *f*, *f*; the necessary distilled water and subacetate of lead are obtained from reservoirs suspended from the ceiling. The filtering tables are shown at *F*; the funnels are all held in a fixed frame, while the glasses receiving the filtrate are on tables with wheels, which may run on tracks, *t t t t*; these each hold twenty glasses, ten on each side. When the filtering is complete, they in turn are run over to *R*, which consists of two rooms with polariscopes, having a common light, *p*. It is interesting to note, that as soon as the sample is taken from the beet at Table C, it is returned to its respective compartment at Table A. Considerable system is essential for satisfactory working. The 50 c. c. flasks, when filled, are carried in wire baskets, in series of ten, to the filtering tables. As the variations of sugar percentage need be only between the limits of 14 to 16 per cent. of sugar, no very great accuracy is required for weighing pulp or filling flasks; it can, consequently, be done with considerable rapidity. After the analyses tables have left the chemists' hands, the beets which are not kept are taken from the compartment of *A*. For 5000 analyses per diem, 28 persons are needed; this includes the overseer and the boy to keep the laboratory clean.

(*c*) 3. Analysis with a Special Sampler, Without Weighing, as Adopted by M. Legras.

This method depends upon the use of the Hanriot machine, and also upon a sampler worked

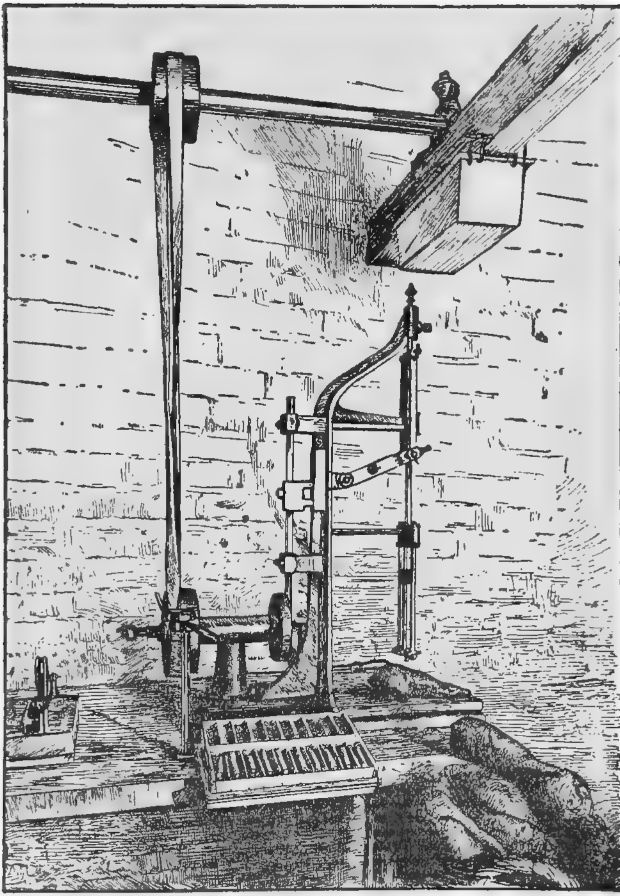


FIG. 37. VERTICAL SAMPLER.

by steam. The doing away with the tedious details of weighing expedites matters. And the rapid analyses of beets, before siloing for the winter, demands that the daily analyses reach a maximum. After the physical selection on the field, the roots are gradually brought to the laboratory and each placed in a special compartment. The Laon laboratory is divided into two parts, parallel to each other, there being less confusion with this arrangement. There are two series of shelving, each with 300 compartments, 15 rows vertically, and 20 horizontally; the sizes of these, taken as a whole, are: Length, ten feet; width, nine inches; height, six feet; distance between compartments, five inches vertically, and six inches horizontally. For each series there are two Hanriot appliances, and one vertical sampler worked by steam, which is sufficient for the entire laboratory. The arrangement of the sampler is shown in Fig. 37. It is capable of giving 70 vertical strokes per minute, but this would be entirely too rapid for the laboratory work, not more than 15 to 20 strokes per minute being necessary.

Great precaution is required in order to give the beet the proper slant during sampling. It should be so arranged, as previously explained, that the perforations be made at one-fourth the length of the beet, without the neck. It is desirable to keep a rubber band beneath the beet on the table during sampling. This precaution obviates mutilating the beet by the passage of the knife. The cut sample remains in place and is removed by hand. The cylinder obtained from the beet has a diameter of about 12 m. m. ($\frac{1}{2}$ inch), and a length which varies from 60 to 80 m. m. (2 1-3 to $3\frac{1}{4}$ inches). The cylinders are placed in special frames, as shown in the engraving, these frames having 20 divisions each. There are five of these frames in constant use for each series of the laboratory; as 100 beets are being examined at a time, it is better to have at least seven for each series of 100 beets. For each series of the laboratory in turn, the small cylinders obtained are placed in regular order, one alongside of the other, and cut at equal length by a parallel blade-slicer of special construction, capable of cutting 1200 per hour.

The samples are then replaced in their respective numbered compartments of the frame. It is an astonishing fact that these small cylinders have nearly the same weight, and the error committed is so slight that its influence upon the whole series of experiments need not be considered. The exact weight for the demands of these analyses should be 6.512 grams or 26.048÷4 grams.* With the view of determining what their exact weight is, 100 were weighed in five series of 20; the average for each series was 6.506 grams, 6.512 grams, 6.503 grams, 6.527 grams, 6.518 grams, or a variation of 0.01 to 0.02 grams; an approximation quite sufficient for all practical purposes.

It is interesting to note that several preliminary weighings are necessary; the slicing blade is adjusted accordingly, and, when once arranged, can be relied upon. The Hanriot machine (Fig. 38) in which these small cylinders are placed and reduced to a fine pulp, consists of a conical box, *H*, made of hard bronze, with lateral tube, the appliance itself being mounted on a tripod, which may be screwed upon a table, *z*, *z'* and *z*." Inside the bronze box are a series of grooves, made in the direction of the generatrix of the cone. Against this surface revolves, at a velocity of 2200 to 2500 revolutions per minute, a solid cone, which has a series of teeth all at an angle of 45 degrees to the axis of revolution, thus facilitating the exit of the pulverized beet, and also of the water during washing. The cylinder

*This weight varies with the polariscope used. For the French apparatus it would 16.29÷4=4.07 grams.

from the sampler is placed in the apparatus through a lateral orifice. As soon as the solid cone revolves, it is, by a well-combined lever, *P*, worked by hand, forced against the outer cone, the lower part of which is a funnel-shaped hopper, *H*, connecting with the flask, *F*, having the same number and serial divisions as the sample being crushed. In connection with the interior of the machine is a rubber appliance, *R*, its capacity being 80 c. c., filled with water; by pressing it the water is forced between the inner and outer cones and empties itself into the flask, *F*, of 105 c. c. capacity. It is of interest to notice that on top of the rubber appli-

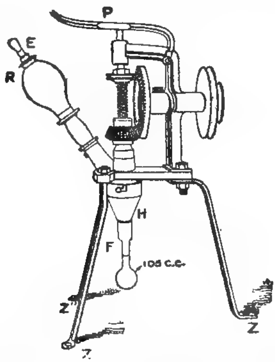
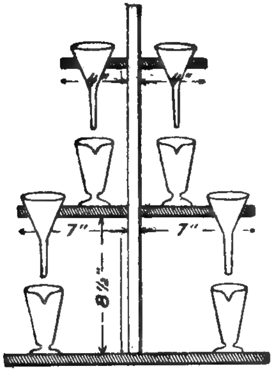


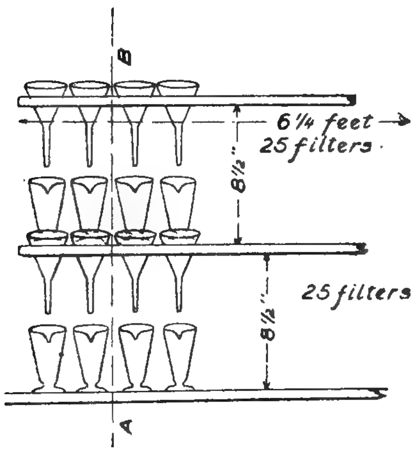
FIG. 38. Hanriot crusher for beet sample.

ance, *R*, there is a projection, *E*, which may be connected with a reservoir of water.

There are special frames or baskets to hold twenty flasks, each compartment of which is numbered. The flasks are carried to a table where 1.5 c. c. of subacetate of lead are added, the quantity being accurately obtained by the use of a special hand measure. The flasks are then filled with water up to the 100 c. c. mark, a few drops of ether on the surface removing the froth that generally exists. The flasks must be thoroughly agitated prior to filtration, which opera-



(Section AB) End View.



Side View.

FIG 39. FILTERING TABLE.

tion takes place on a special table. The filtering-room in the Legras laboratory is most important and well combined, the benches for the double series of shelving, arranged back to back, as shown in the engraving (Fig. 39). Each double series holds 100 filtering tunnels and 100 conical glasses holding the filtrate; consequently, there are 200 filtrations going on at the same time. Experience shows that rather more than this number are necessary, and it is better to have 240 working, or 120 on each side of the table, so as to be able to reach 800 analyses per diem. Not less than 320 flasks and 320 glasses are needed; this makes allowance for breakage.

Some of these are used to receive the filtrate, and others wait their turn on the chemist's table. The filtering paper used is a kind which has been mechanically folded in advance. Strange as it may seem, practical experience has shown that the glasses do not need washing, and the error committed by having them cleaned for each analysis would be greater than if left untouched for the whole series of operations for which they are used. This fact may be explained by the reason that there is a very slight difference in the composition of the juices being filtered, and which follow one another in regular order.

Classification.

All observations made in regard to the sugar percentage are noted on special sheets of five double columns of twenty polarizations each, or 100 per sheet:

Year 1898.. Serial No. 822.

Date.	No.	Polarization.	No.	Polarization.	No.	Polarization.	No.	Polarization.	No.	Polarization.
Feb. 17.	1	14.4	21	....	41	....	61	....	81	....
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....	....	....	....	....	....	....	....	....	....	....
....	20	....	40	....	60	....	80	....	100	....

The arrangement is shown herewith: First double column, with number of observation and polarization; the second, etc., series follow: as each sheet contains 100 observations for 10,000 polarizations per diem, 100 sheets would be required; these are separate and complete.

From these tables is combined another, giving a synopsis for the 100 analyses made, and the number of mothers having a special polarization, and the number rejected:

Synopsis.	Series of the Day.	Aggregate of Previous Days.	Total.
No. of roots rejected................	....	....	....
No. of mothers testing 13 per cent..	....	....	....
No. of mothers testing 14 per cent..	....	....	....
No. of mothers testing 15 per cent..	....	....	....
No. of mothers testing, etc..........	....	....	....
No. of mothers testing, etc..........	....	....	....
Total	100	30,600	30,700

If 10,000 polarizations are made, 100 sheets like this are necessary. One sheet being continuous of the other, the final sheet would give the exact condition of the day's work.

It must not be forgotten that the Legras mother-selecting laboratory is the most important in France, if not in the world. With proper assistants, 10,000 analyses may be made in twenty-four hours. By the present arrangement, however, 34 persons are employed: To carry beets, 2; sampling, 2; filling trays with samples, 1; working sampler, 1; Hanriot appliance, with assistants, 6; acetate of lead, ether, etc., manipulations, 2; juice measurers, 2; juice filtration, 4; carrying glass jars, etc., 2; for the two polariscope observations, 6; for classification of results, 2; arranging beets and general cleaning, etc., 4. M. Legras says that under the condition of the Laon environment with the laboratory at the sugar factory, he can make an analysis of mothers for three-fifths of a cent, which, however, does not include cost of plant, etc., but is for labor and chemicals only. One fact is certain, that the cost of the cold-water method of analysis is just one-half the cost of the Fühling or other oxide of copper modes. The laboratory where all these observations are made is 43x20 feet, a special space 9x9 feet being needed for sample trays and for the three-horse-power engine which works the sampler. These are very crowded quarters, and would have to be very considerably increased for 15,000 analyses per diem, as contemplated. To accomplish such extraordinary results in so limited a time demands almost a military system of working, since the goings and comings of so many hands would mean great confusion and failure unless all were well disciplined.

(*c*) 4. Sachs' Direct Method.

During the writer's visit to Brussels he was shown in the Sachs laboratory a very much simplified cold-water digestion mode for rapid beet analysis, arranged by Sachs. It does away with flasks and many manipulations which in reality demand far greater care and precautions than was at first thought necessary. The production of a very fine pulp with the Keil and Dolle rasp introduced considerable volume of air into the pulp, which is most difficult to get rid of, even with alcohol or ether. The errors may vary from 0.3 to 1 per cent. of sugar, an item of considerable importance to farmers when beets are purchased by the manufacturers on the basis of a sliding scale depending upon sugar percentage. By this new method the beet sample must be a very fine pulp, obtained as usual with the rasp just mentioned; 26.048 grams are weighed in a capsule of a known weight, 5 c. c. of sub-acetate of lead and 172 c. c. of water are then added, giving a total of 177 c. c.* The capsule is covered and is then thoroughly agitated; polarization follows after having added a few drops of acetic acid.

The complete apparatus, shown in engraving (Fig. 40), consists of a reservoir, *L*, of distilled, or rain water, connected by a rubber pipe with pinch cock, *V*, to the tube, *C*, of the pipette (see Fig. 41). The flask, *M*, contains subacetate of lead in communication with pipette, *B*, by means of a rubber pipe, on which is the pinch cock, *V*. When the pipette is too full, the overflow can run through *A* into flask, *S*, on the lower level. The flask, *O*, contains acetic acid, which is used to clean the pipette, which latter is held in a vertical position by a suitable support. *T* is the capsule in which the rasped pulp is weighed, and into which the contents of the pipette are emptied. This arrangement can be made to suit the special demands of any laboratory. One precaution is very important, viz., that the flask, *M*, be not higher than six inches above *B*, so that the flow be not too rapid, and so that the 5 c. c. mark may be under mathematical observation. The water reservoir should be at least three feet higher than the pipette, so as to allow for its rapid filling.

The pipette is filled in the following manner: One-fourth of a turn of *K* opens communication with *M*;

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*Experiments show that beets contain 4.75 per cent. marc, or for 26.048 grams, 1.24 of marc and 24.81 grams of juice. If juice has an average density of 1.07, there will be 23.18 c. c. or 23 c. c., making allowance for the lead deposits. If 177 c. c. water is added, this makes up exactly 200 c. c. and no allowance need be made for froth.

when the subacetate reaches *I*, the cock is turned another one-fourth of a revolution, which allows the water from *L* to enter the apparatus. As soon as the water commences to run over at *H*, *K* is again turned,

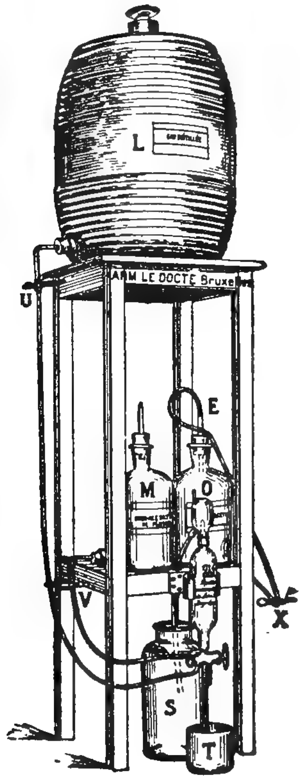

FIG. 40. Complete apparatus.

and by completing the revolution the contents of the pipette fall into *T*, containing the pulp. This is covered with a rubber disk and is held in position between the hands; after a few minutes, shaking and filtration follow. By smearing a little vaseline over the surface of the rubber, one obtains a perfect joint; furthermore, it prevents adherence of the liquid to its surface. It is desirable to leave the capsule with its contents in

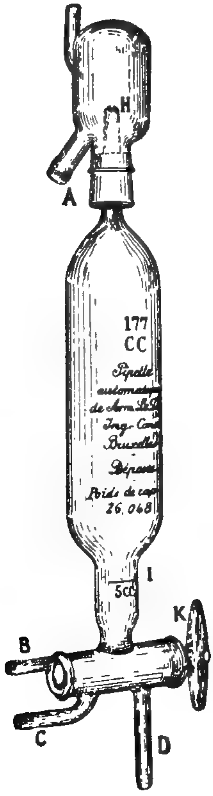

FIG. 41. Detail of pipette.

repose for a few minutes, to make sure that the diffusion is complete.

The method may be still further simplified by doing away with flask *M*, and having the subacetate solution in reservoir *L*. This mixture is prepared by adding to 1000 c. c. of water, 29 c. c. of subacetate at 30° Bé., followed by careful agitation; under these circumstances the cock, *K*, is turned a half-revolution for each filling of the pipette. One of the objections to this mixing in advance is that as considerable volume must be prepared, and if not done under the direct care of the chemist, there would be no certainty as to results, while by the mode described in the foregoing, the proportions would be accurate for each experiment; hence, the desirability of having a separate subacetate flask. We take pleasure in calling attention to the fact that this apparatus is also constructed for the Laurent polariscope, in which case the pipette has a capacity of 171.4 c. c., and double the normal weight (16.29 grams), or 32.58 grams is weighed in the capsule. The simplicity of the analysis places it within reach of the rural population, who, without any special technical education, could soon learn to use the polariscope and estimate for themselves just what percentage of sugar their beets contain.

General Remarks on Laboratory Requisites for the Selection of Mothers by the Cold-Water Method.

A general idea of a selecting laboratory was shown in a plan on page 95. The arrangement, however, varies very much with the facilities one has at his disposal; however, there are certain essentials from which no great departure must ever be made.

Under all circumstances, there should be plenty of room around a central table containing 100 samples of juice being filtered. The going and coming being very considerable, the distribution of light is important, not only during the day, but at night. For it frequently happens in laboratories visited by the writer, that the capacity is doubled by working night and day, under which circumstances, it is possible, with an installation for 5000 analyses per diem, to work 10,000, but with different chemists and general help.

It is always desirable to have several rooms, and these of a size to permit doubling, if necessary, the work to be done during twelve hours. It is best to have the polariscopic examination in a separate place from where the filtering or sampling is done; not so much on account of being obliged to use an artificial light, as to be away from the noise, which always has a distracting effect upon the observer, who, after an interval of time, becomes more or less fatigued. An ample supply of water in all cases is necessary in order to keep the laboratory thoroughly clean. As stated in previous pages, it is desirable to make the first selection of beets upon the fields, depending entirely upon exterior characteristics. It is, however, important to make another selection as soon as the silo is opened, for certain roots always undergo alterations during their keeping. Then, again, other roots are thrown out, owing to their size, shape, etc. This final sorting reduces by nearly one-half the beets which had been selected for analysis after harvesting. The beets remaining are carried by hand or cart, depending upon the country, to the reception-room, which should be very spacious, as frequently 1000 beets are spread out, covering considerable area. It is important to have the reception-room divided into several rooms, thus keeping very superior beets entirely separate.

It is not necessary to have on hand the whole number of beets for one day's analyses; if for a laboratory suited for 4000 analyses per diem, about 800 beets only need be waiting their turn. This requires eight series of shelving and compartments of 100 roots. These may be arranged in sub-divisions, A, B, C and D, each of which is sub-divided in two series.

Division A	1st series, 1, 2, 3, 4, 5, 6	100
	2d series, 1, 2, 3, 4, 5, 6	100
Division B	1st series, 1, 2, 3, 4, 5, 6	100
	2d series, 1, 2, 3, 4, 5, 6	100

The reception-room during a day's working in the present case is filled and emptied five times. Each beet of any division or series has a number, which it retains during the entire manipulation of the sample in the laboratory. Before being taken to the sample-room, it is weighed on an ordinary spring scale, no great accuracy being necessary; it is then placed in the pigeonhole, waiting its turn, as not more than one-fifth of the roots are retained during the early periods of selection; for one day there would remain but 800 individual beets of the 4000 analyses made. It is important, after the sample is taken from the root, to fill up the hole made with clay or wood charcoal. The mothers are thus in a measure protected against rot, etc., even after several months in the silos.

After the chemical selection has been completed, the beets are placed in special silos until the planting season. The help needed for 2500 to 3000 analyses per diem with one polariscope having a continuous tube attachment, using the Keil and Dolle rasp, according to Pellet, is as follows:

Rasping	To classify beets	1
	To work the rasp	1
	To serve rasp	1
Weighing	To carry capsules to scales	1
	Weighers	4
Filtration	Flask filters	4
	Gaugers	1
	To look after filters	2
Polarization	To use polariscope	2
	Assistants	2
Two women should be kept constantly at work, washing capsules, giving a total of		21

If it is intended to analyze 4000 to 5000 beets per diem, an extra rasp would be needed. There would be required about seven or eight additional hands: Rasping, 1; weighing, 2; filtering, 3; to accomplish nearly double the work. These analyses may be made for about one cent per beet examined. By the Hanriot method, the weighing being done away with, the help needed is considerably reduced. For 4000 to 5000 analyses:

Sampling	To operate the sampler	1
	To serve the sampler	1
Hanriot Machine.	Cutting samples	1
	To operate the apparatus	1
	To carry juice in flasks to filtering tables	2
Filtration	Flask filters	[illegible]
	Gaugers	2
Polarization	To use polariscope	2
	Assistants	2

Including two women to wash capsules, etc., we must estimate at least 20 persons.

In the analyses of 10,000 beets per diem, by the Keil rasping method, there are needed 56 persons instead of 20 for 3000. By the Hanriot machine, 30 individuals are necessary to do the work. It would be a great mistake to take any of the figures as being exact to the letter, for experience is a great factor; the climatic influence of the environment is also a question not to be overlooked; and there are great doubts if any mother-selecting laboratories of the United States could at first reduce the number of hands to within the limits given in the foregoing.

The persons employed in the Legras laboratory, being in many cases boys and girls under the charge of competent persons, are more numerous than if the training of the individuals had been going on during a period of seasons, which would be difficult to realize; the laboratory should not be in full activity more than a few months of the year.

Apparatus Necessary for a Laboratory Capable of Analyzing 2500 to 3000 Mothers Per Diem by the Keil Rasp Method

One rasp, 1 motor (gas, petroleum or hand motor), 1 polariscope, 200 numbered capsules, 4 chemical balances, 8 nickel capsules, 4 weights (one-fourth normal weight), 4 nickel funnels, 4 water reservoirs, 500 flasks of 50 to 55 c. c. capacity, 500 funnels, 500 tumblers, 200 numbers with pinches, 2 continuous tubes of 400 m. m. in length, 3 baskets to hold 20 flasks each, 6 ether dropping flasks, 6 acetic acid dropping flasks; a certain quantity of subacetate of lead, acetic acid, nitric acid, filtering paper, etc., depending upon the size of laboratory. For 10,000 analyses per diem, the above would have to be doubled. M. Pellet recommends that a certain number of flasks of 100 to 110 c. c. and 200 to 205 c. c. capacity be kept on hand, so as to make comparative experiments by the hot and cold methods; a certain number of sand baths are always necessary.

By the Hanriot method the apparatus necessary is: 2 Hanriot apparatus, 1 sampler, 1 knife, 4 nickel funnels, 2 water reservoirs, 1 balance, 2 small nickel capsules (one-fourth normal weight), 500 flasks of 50 to 55 c. c. capacity, 500 funnels, 500 tumblers, 200 numbers with pinching attachments, 1 polariscope, 2 continuous tubes 400 m. m. in length, 3 baskets for 20 flasks, 6 ether dropping flasks and 6 acetic acid dropping flasks.

It is interesting to compare these with the practical working of the Legras laboratory mentioned in previous pages. Under all circumstances, a good supply of chemicals, mentioned in foregoing, viz., ether, acetic acid and subacetate of lead, are needed. For 10,000 analyses per diem these appliances must, in nearly every case, be doubled. It is hardly necessary to go into details of the numerous motors that are in use or that have been suggested for laboratory work. The principal point to be kept in mind, is, that 2000 revolutions of the Keil rasp, or the Hanriot apparatus, must be maintained; otherwise, the work accomplished would be very poor in beet selecting; the root would be so mutilated that its keeping would be almost impossible. Most of the glass funnels, flasks and tumblers could be furnished by most any dealer of chemical appliances; it is, however, very essential that the flasks should have the capacity mentioned in the description of the cold-water method of analysis.

The Hanriot apparatus, as described and illustrated elsewhere in this writing, is a very unique design, and it should be obtained from the maker. The same may be said of the Keil and Dolle rasp and the continuous tube for polariscopes. In Germany, many modifications have been made, but to the writer's knowledge none have given the satisfaction of the original Pellet combination.

German Selecting Laboratory.

By way of comparison with the Legras laboratory, just described, one may take the Braune (Biendon, Germany). laboratory, which, up to 1889, worked as we shall describe herewith, but has since introduced the cold-water method. However, there are certain conditions which have not changed. The beets are analyzed in February, and by the end of April the work is finished; the physical selection having been carefully done the year previous. The beets at the time of harvesting are selected by the 16 degrees Brix salt-water selection; all beets sinking and weighing at least 500 grams are subsequently polarized, as it is supposed that they contain at least 16 per cent. sugar. The work is done by men of long experience.

The February laboratory work is better explained by following the engraving herewith (Fig. 42). The rasp used gives a fine pulp. This is submitted to a pressure in the powerful press (1); two-thirds of the resulting juice is used for polarization, the remaining third being used later. Four c. c. juice (2) is poured into a flask of 10 c. c. capacity; then the flask is filled up to the mark with diluted subacetate of lead. Filtration follows; the 100 m. m. tubes of the polariscope (3) are filled with the filtrate. All beets polarizing more than

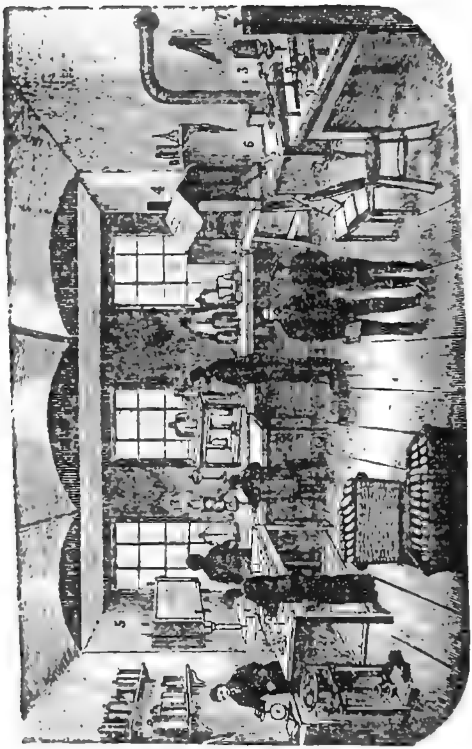

FIG. 42. INTERIOR VIEW OF BRAUNE BEET SELECTING LABORATORY.

14 per cent. sugar are taken to a second laboratory, where other chemists continue the work. The 2 c. c. of juice remaining from the sample above referred to (the total volume being 6 c. c.), are thoroughly defecated in a Stammer oven (4), heated by steam. The weight of dry substance and the sugar percentage give the purity coefficient. If this purity coefficient is higher than 85, the beet is perforated for the second time, and with the new sample of pulp obtained, the Soxhlet-Sickel (5) extractor allows one to determine very accurately the sugar percentage.

In 1890, instead of obtaining the juice under pressure and extracting by alcohol (6), the cold-water process demanded the use of the Keil rasping method (7, 8 and 9). Fifteen grams of pulp are thus obtained; one-half of normal weight are weighed, and the sugar percentage is determined as previously described. It is admitted that this French method has made the work much simpler, and the results are more satisfactory. It is not necessary to enter into other details regarding this laboratory, as there are several of the same importance in many beet-seed producing centres of the country.

Polariscopes for Mother Selection.

The type of polariscope for selection of mothers should not be the same as that used for sugar polarizations, where the right-hand polarizations reach 100 degrees. As the tubes used in the beet-seed selecting laboratories are 400 m. m. in length, and as only 16.29÷4 grams of pulp are used at a time, it is preferable to have the vernier graduated only to 25 degrees, for example, and at the other end starting from 12 degrees.

The plan of having a special electrical attachment to the vernier of a polariscope is very simple, and has rendered considerable service. The adjustment in question is arranged for polariscopes with dials; the first stop is not far from the zero point, the other is near the division, 30 degrees; the distance between stops is regulated by suitable screws. When once arranged, they are in electric communication with two bells. As each has a different pitch or sound, it is possible under these circumstances to make several classifications; for example, below 15 to 16 per cent., or from 17 to 18 per cent., etc.

If the right or left bell rings, the chemist knows that the juice being examined has a certain sugar percentage without it being necessary to do any actual reading. However, careful work demands a certain observation. If, when either bell rings, the disks are neutral, or of some tint depending upon polariscope used, it would show that the stop on the vernier corresponded exactly to that percentage; if, on the other hand, the black disc is to the right when the left bell rings, it would show that the juice under observation was of a lower percentage than the limit required for the selection; if to the left when the right bell sounds, this would convey that the sugar percentage was higher than the limit for which it was adjusted. Over 1000 observations may be thus made in a very short time and with very little fatigue.

In the zero, as compared with an ordinary instrument, these differences may frequently be 0.2 to 0.3. It is generally desirable to make several observations on the same juice before commencing regular work. After having polarized, the results are noted; during the interval the assistant fills the funnel, etc. The work has twice the rapidity it had with an ordinary tube. In mother-selecting, it is possible to reach ten a minute. Certain difficulties may arise and many precautions are necessary, among which, mention may be made of the following: The liquid being examined must be very clear and ample light must be used; if the tube does not fill rapidly, or the funnel does not empty itself, the difficulty may be overcome by slightly increasing the slant of the tube, by raising the funnel. If the flask is too low, there is danger of siphoning the tube; the funnel is then lowered. Precaution must be taken to have the curved glass tube, at the emptying extremity, of a suitable length. When the day's observations are finished, the tube should be washed with distilled water and kept full until again used; then the washing should be done with acidulated water and a saccharine liquor of about the same strength as the sugar solution to be analyzed.

M. Pellet recommends that the washing be done in another room from where the polarizations are to be carried on. The reason being that the difference of temperature of the water used and the room would be sufficient to leave traces along the inner surface of the tube, which might alone be sufficient to influence the results. For washing the tube before using, it is proposed to use the liquid from the flask, *K* (Fig 43), which may be considered as an average for the day's observations. This funnel continuous-tube attachment may be applied to any polariscope, but should be made to exactly suit the requirements. The space necessary is about 25 to 30 m. m. greater than would be needed for an ordinary tube.

Continuous Polarization.

In beet-seed selecting laboratories, the Pellet continuous tube for polariscope has been a most important innovation. By the use of a polariscope and an ordinary observation tube, in the hands of an expert, 1000 readings have been made in twelve hours. Several assistants are frequently needed to accomplish these results, since about 50 such tubes are necessary. These have to be carefully filled, screwed together, emptied and washed; frequent accidents occur and the item of expense is considerable. There are two kinds of continuous tubes, viz., with funnel, or with siphon. For each of these models may be used two tubes; one with an interior diameter of 7 to 8 m. m. and containing 13 to 18 c. c. of liquid suitable for beets as they are received at the factory; or the other type, which is much smaller, containing only 6 to 7 c. c. of liquid and having a diameter of 5 m. m., while with the latter the weight of pulp under observation need be only 16.29÷4 grams.

A few words of explanation respecting the funnel continuous-tube attachment is most important. The general arrangement is shown in engraving (Fig. 43).

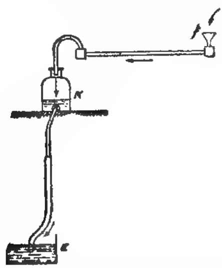

FIG. 43. Continuous tube for polariscope.

The funnel (*f*) is attached to the slanting tube of the polariscope by a suitable rubber joint; at the other extremity is a slightly curved glass tube. When the tube is placed in position, it should be filled with water slightly alkaline, which removes all traces of grease. Through the tube is then run 200 c. c. of distilled water, containing a few drops of acetic acid; the excess of water runs into flask *K*, and subsequently into bucket *E*. Either the tube contains air bubbles, or it does not; if not, it is then ready for active work. Considerable care is needed in adjusting the tube, so that the reading of the polariscope will be zero. There is always danger of leaks, consequently the pressure necessary on the ends may, in a measure, be changed.

Analysis of Beet Juices in the Legras Laboratory.

The polarization is unique, rapid, and most interesting, two instruments being in constant use, and in connection with them the Pellet continuous tube* is employed. It, however, differs from the one just described, and is known as the siphon method; it is shown in engraving (Fig. 44). The arrangement is most simple, a rubber emptying tube at one end, and at the other a covered glass tube with rubber attachment. To the filtrates in glasses are added a few drops of pure acetic acid; the glasses are carried to the saccharimeters in six baskets of twenty compartments each. The number assigned to the beet at the commencement when it entered the laboratory is carefully continued through the entire series of manipulations to which the samples, juices, etc., are submitted.

The assistant places the rubber tube in one of these conical glasses, precaution being taken to slightly slant the glass, so as to give a greater depth of penetration to the juice. On the emptying tube is a Mohr pinch-cock; this is opened when the chemist is ready to make a new observation and the sugar solution is siphoned into the continuous tube. The assistant changes the glass for another with a fresh sample before it is entirely empty; otherwise, there would be a loss of time, due to the siphoning of all the juice in the circuit. About eight observations may be made per minute. Precautionary measures must be taken to screen the observer's eyes from the brilliant light of a lamp placed in front of the instrument; this excellent arrangement is shown in the engraving. Under these

*It must never be lost sight of, that the continuous method requires great care for its first working, that is to say, that the tubes with their attachments must be made by a person thoroughly familiar with the requirements. Many mistakes have been made by depending upon some contrivance furnished by a novice; furthermore, the results may vary with the chemist in charge, who had best make a preliminary practice on sugar solutions of known strength. The method is most excellent for mother selection, and is recommended by Pellet for all classes of polariscope work.

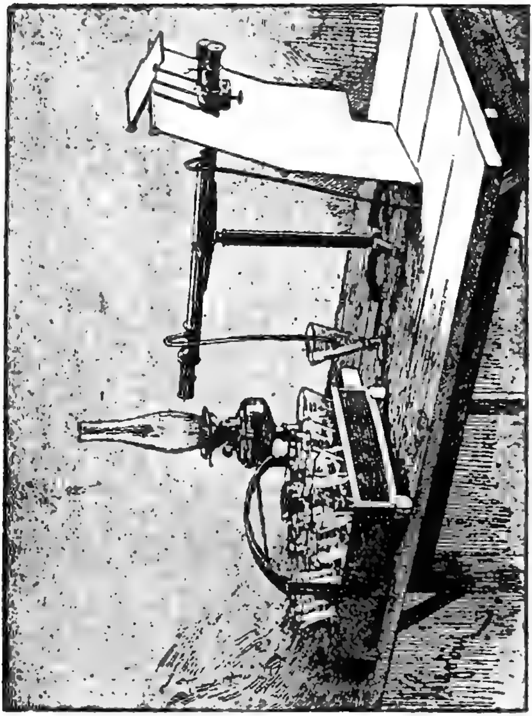

FIG. 44. POLARISCOPE WITH CONTINUOUS TUBE. ALSO BASKET CONTAINING GLASSES PARTLY FILLED WITH JUICE TO BE ANALYZED.

conditions the fatigue from this constant work is very much lessened; many chemists use a large black obstructor. The reading of the vernier depends upon the light thrown upon it from an upper reflecting mirror. It is most desirable that the chemist doing the work be absolutely in the dark, and, as he is under great pressure, he should be relieved every few hours. Whenever the observer is changed the zero point of the instrument should be verified.

CHAPTER VI.

Soils for Seed Production.

There are two questions to be considered which are important in beet-seed production: 1st, Soil that is to receive the so-called "Elite" seed, and that which is intended for the reception of mothers; we might add a third variety, that which is intended for close planting, with a view to growing beets which are to have only a physical selection. From these there would follow the production of seed for the trade. There are certain special conditions for each case, but for the present we must consider them only from a general standpoint. It is desirable to have a rich, deep homogeneous soil; some agronomists go so far as to recommend one that is rich in organic matter, which, from our point of view, is a mistake. When possible, a typical soil should be rather dark in color and of an argillo-sandy texture. The subsoil should as nearly as possible have the same composition as the surface soil, and be possessed of a certain porosity, permitting easy drainage, which allows its working during all kinds of weather.

If beets be cultivated on soils too highly manured or fertilized, or even of a gravelly texture, without depth, the shape of the resulting root will, necessarily, be irregular, and consequently, worthless for seed production, and would be thrown out during physical selection. We have heard it freely argued that when the question of soils for mothers is discussed, that the plant foods play only a very secondary role during seed development, that is, during the second year, so that most any soil answers the purpose for mother-planting.

This is evidently very misleading, for if such were the case, the leading seed producers would in Germany, France, etc., be found in many sections of the country, when, in reality, they centre around certain districts of Saxony, at Quedlinburg, or in the northern part of France, at Laon, for example. Furthermore, in Saxony the principal seed farms are on hills and never on bottom lands; so that it is only in very exceptional cases where ordinary beet lands should be devoted to seed production. Those soils which have yielded beets which were attacked by insects are most objectionable, either for sowing of Elite seed or transplanting selected mothers, etc.; the same attacks or ravages would necessarily continue, thus destroying all prospects of success.

There are many other conditions in question of location of beet farms; for example, it must be miles away from anyone cultivating beets of any kind, or any plant that is likely to give a pollen which might form a hybrid with beets. It should be well protected against the winds. However, in this issue we differ with Knauer, who claims that winds in some cases are desirable, as they carry off the loose seed, leaving spaces for the remaining seed, which results in a stronger grain for those still adhering to the stalk. (There is in some centres a special money system of insurance against such losses through winds, etc). The location should be such as to receive directly the solar rays, meaning a southern exposure.

It has been frequently noticed that soils shaded by trees do not permit mothers to grow in a satisfactory manner; hence, their inferior yield in seed under such conditions. The soil should not be too damp, as this latter state would make the growth too hardy. Under no circumstances should the location be near a town or village. With a proper soil, the mothers develop without much care when once started. They require land well and deeply worked in the fall, as the successful seed development, the second year, depends largely upon the looseness of the soil which is in close proximity to the roots. Autumn plowing to assure action of the winter ice, snow, etc., should never be neglected. It must not be forgotten that from superior seed on a poor soil, very inferior results are obtained to those given by average seed upon superior soils. Recent experiments show that seed obtained from mothers testing 19.8 per cent. sugar on a poor, gravelly soil as a sub-stratum, yielded beets weighing only 160 grams and testing 14.6 per cent. sugar. On the other hand, on a rich, swampy soil the beets weighed 8.76 grams and polarized 13.6. The general characteristics of these two beets were so different, no one would have supposed for one instant that they had the same origin, or common parent.

Advantage of Uniformity in Composition of Soils.

It does not necessarily follow that because the environments are not favorable now, that they cannot be made so by patience and the scientific use of fertilizers. No better example could be given of the possible transformation of soils by scientific treatment than at Besny (Aisne), France. The writer has followed, since 1889, these methods as applied on the Legras beet-seed plantation, and the evolution during the past 25 years would hardly have been thought possible, unless actually seen. Before the period when artificial or mineral fertilizers were known it could not have been done.

The management of this farm, with a few patches here and there demanding special attention, was once far more difficult and complicated than at present, when the conditions are almost of a complete uniformity, the fertilizers having been so combined that one field or another offers about the same fertility and composition—and may be considered as a uniform whole. The entire area is only 750 acres, which seems small as compared with a western ranch in the United States, but it is not desirable that this seed growing be conducted on too extensive a scale, as the details could not then be thoroughly watched. The advantages of this uniformity in soil composition are manifest when analyzing beets cultivated upon it, as the sugar percentage of the resulting roots is nearly the same in one spot as in another. A mother when planted, will give seed of a variety that may be said to be standard or typical.

If it were possible to introduce upon a large scale what has been accomplished at Besny, it would do away with all discussions between the manufacturer and farmer, as the roots furnished by one grower would be almost exactly the same as those furnished by another. However, this is not possible under existing American conditions, where each cultivator has his own views, and, in his own estimation, knows more than science can teach him. The difference in the sugar qualities of beets from the same seed may be 2 or 6 per cent., and the price paid for the roots varies proportionally. The problem M. Legras set out to accomplish was not an easy one; for portions of his land were poor, and, furthermore, covered with weeds, which had to be eradicated before intensive cultivation could be thought of, as fertilizers would only still further increase or stimulate their growth. Herein was the wisdom of the owner, whose argument was: "What money I spend on the one hand I shall reap on the other," and this has been accomplished, for there was hardly a weed visible between the rows of beets or mothers during the writer's last visit. The money saved now more than compensates for the first outlay for land cleaning.

Fertilizers for Elite Seed and Mothers.

When considering fertilizers for Elite seed, great care must be taken when using barnyard manure the fall before sowing, in order that there be no unfermented particles of straw, for these might be the cause of considerable difficulty, resulting in very irregular beets. At certain French farms visited by the writer, oil cakes of various origins appear to be very popular; these are distributed in the spring, just before sowing, in quantities of 1000 pounds to the acre, and should, under all circumstances, be thoroughly pulverized. The use of lime has rendered great service, for it destroys the bad effects of certain clays, about five tons to the acre being used, on an average. In October there should follow a thorough plowing.

It is evident that the plant foods needed for beets to develop are not the same, as regards quantity, as required for mothers with the view to seed formation. It is to be regretted that this question has hitherto been neglected by seed growers. From what has been said in previous pages, the main effort always is to obtain a special fertilizer, suited to each section of the farm, so as to bring the whole up to a uniform standard. This can be accomplished only by strict watching of what has been taken away in potassa, phosphoric acid, nitrogen, etc. The question of fertilizers for beets has been discussed by many writers, but few agronomists have touched upon mothers in seed production during their several months in soil after planting. If the question of fertilizer has been neglected by seed growers, it it partly because information has been wanting. The decline in the fertility of a soil is always followed by deterioration in the quality of seed obtained; hence, success largely depends upon this plant food issue. The question has been thoroughly examined by M. Legras.

It is by the analysis of seed and stalk that one can learn exactly what the conditions are:

...	Full Flower.	Complete Maturity.
Weight of stalk and seed	2.16 lbs.	2.48 lbs.
Weight of stalk and seed when analyzed	1.87 "	2.05 "
Composition of 100 lbs. dry matter.		
Nitrogen	1.551	1.675
Phosphoric acid	0.550	0.435
Potassa	1.868	1.636
Lime	0.820	0.860
Magnesia	0.806	0.806
Total ash	10.050	9.750

From this analysis it may be noticed that considerable transformation occurs between flowering and complete maturity of the seed; nitrogen and lime increase while all other elements decrease. The excess of nitrogen is evidently found in the germs of the seed. The most marked change may be noticed in the potassa. As these elements are extracted from the soil, they must be returned. No account need be taken of the mothers, which, after the stalks and seed have been cut off, may be considered as the corpses of their previous state, they having completed their functions in acting as an intermediary between the soil and the growing stalk, and retain nearly all their original salts, etc., nitrogen alone having diminished. If these are plowed under, they take away nothing; if not, other facts must be considered. [An ordinary crop of 16 tons of beets averaging 11 per cent. sugar will extract (no allowance being made for leaves) per acre about: Potassa 105 lbs., phosphoric acid 21 lbs., soda 30 lbs., lime 16 lbs., magnesia 6 lbs., chlorine 27 lbs., sulphuric acid 9 lbs., silica 44 lbs., nitrogen 97 lbs., organic substances 1590 lbs., water 29,000 lbs.]

By the Legras method of cultivation each mother can draw its plant food from about nine square feet. Along the edge of the field must not be counted; consequently, it is not desirable to allow for more than 4000 plants per acre. Such being the case, the seeds and stalks will extract from the soil: Nitrogen, 123 lbs.;

potassa, 120 lbs.; phosphoric acid, 32 lbs.; lime, 63 lbs.; magnesia, 59 lbs. It would be a great mistake to adhere strictly to these figures, and it is evident that the fertilizer for mothers must be very intensive. The mixtures used on the soil at Besny are the outcome of considerable experience. To retain the general uniformity in their composition, after the crops of seeds are harvested, there is added per acre 130 to 180 lbs. sodic nitrate (containing 15.5 to 16 per cent, nitrogen), 130 to 180 lbs. potassic chloride (containing 56 to 57 per cent. potassa), 180 to 260 lbs. double sulphate of potassa and magnesia (containing 27 per cent. potassa, 25 per cent. magnesia), 70 to 75 lbs. nitrogenous substances (blood, oil cake, etc.), 540 to 600 lbs. furnace slag (18 per cent. phosphoric acid), which is several times in excess of what is needed.

It is interesting to note that M. Legras insists that 90 lbs. nitrogen per acre is an excess, the difference between it and what has been or what will be absorbed may be subsequently added. This precaution is necessary to make sure that the seed will mature in the regular number of months, excess of nitrogen seeming to retard maturity; the same cannot be said of phosphoric acid, for the plant absorbs what it requires for its complete development, and no more.

On the fertilizer question for mothers there is certainly a great difference of opinion; for example, Dippe Brothers give preference to one containing 176 lbs. sodic nitrate, 350 lbs. guano (4 per cent. nitrogen, 13 per cent. phosphoric acid). At Wanzleben and at Gröbers (Knauer), they favor green manuring, vetch, peas, etc., which are planted and plowed under, so that the land remains fallow during a considerable period. It is claimed that the weeds contained in the soil are smothered, and there is a very large quantity of nitrogen absorbed. In combination with the green manuring, potassa and phosphates are used in the spring before planting. In certain French districts visited by the writer, the fertilizers for mothers which are most popular are used in the following quantities, calculated to areas of one acre:

1	Barnyard manure	16 tons
	Sodic nitrate	350 lbs.
	Superphosphate of lime	396 "
	Colza oil cake	132 "
2	Barnyard manure	20 tons.
	Ammonia sulphate	246 lbs.
3	Barnyard manure	20 tons.
	Sodic nitrate	330 lbs.
4	Barnyard manure	16 tons.
	Sodic nitrate	350 lbs.
	Superphosphate	508 "
	Potassic chloride	132 "

Whatever be the system of the fertilization of the soil, it is desirable not to use the plant food in excess, since this would result in a second growth of stalks and a corresponding decrease in the quality of seed.

Relations Between Soils and Fertilizers.

The formula of a fertilizer should vary with the composition of the soil upon which it is to be used. Without going into extensive arguments respecting soils and fertilizers in general, it will be far more interesting to give an example taken from practice. The beet plantation of M. Legras, as previously explained, was made up of small areas having very different textures and compositions, the variation being far greater than a general survey of the land would lead one to believe. The maximum and minimum of the five essential elements requisite for fertility, as determined by chemical analysis of these soils, are here given:

	Maximum.	Minimum.
Nitrogen	0.13	0.08
Phosphoric acid	0.25	0.06
Potassa	0.40	0.22
Lime	13.40	0.90
Magnesia	0.51	0.15

There were to contend with: 1st, argillo-calcareous; 2d, sandy; 3d, very calcareous soils. The fertilizer used had to increase or diminish these elements so as to create uniformity. Consider, for example, the case where there was only 0.06 phosphoric acid as compared with 0.25 per cent. contained in another patch. On the farm at Besny it was found desirable from the start to use 2500 lbs. of furnace slag per acre, which was well plowed under. The results obtained were up to expectations, showing that science and practice do pull together. To follow, in its intricate details how the typical fertilizer was determined in each case by numerous experiments and observations, would carry the reader too far away from the general subject now under discussion. The conclusions, upon general principles, were that for argillo-calcareous and very calcareous soils, nitrogen and potassa must predominate, while for sandy soils phosphoric acid plays a most active part. A system of rotation has been adopted; hence, the use of fertilizers, such as blood, waste from woolen factories, etc., may be advantageously applied a year or more previous to mother planting or beet cultivation.

On most American farms fertilizers receive but a secondary consideration. Compare this condition with the annual use of 1760 tons of barnyard manure, 220 tons of leaves and necks from a crop of beets, 950 tons defecation scums from beet-sugar factories, 52 tons sodic nitrate, 15 tons sulphate of ammonia, 30 tons fish guano, 60 tons oil cake, 161 tons woolen waste, 10 tons dried blood, 24 tons potassic chloride, 21 tons double phosphate of potassa and magnesia, 108 tons furnace slag, 60 tons phosphate and 9 tons superphosphate. All this for 750 acres of land. As regards rotation of crops, no definite method has been adopted at Besny; the beet, however, appears most frequently, and by the scientific use of fertilizers, 250 acres cultivated in beets average 12 tons to the acre and 16 per cent. sugar.

Sowing of Seed for Mothers.

This question of sowing seed for mothers should in reality be discussed from many points of view, for there are numerous kinds of mothers to be considered. If the question of beet-seed production is taken up from the start, then the seed must be purchased elsewhere; thus the sowing would be of one variety. After mothers are selected and the first crop of seed has been obtained from them, there are many different systems of sowing. We refer not only to spacing, but to the distance between the lines; the Elite are kept much closer together than those roots which have been analyzed, but yield, say 15 per cent. sugar, and which are to furnish seed for the beets only after the third year. On the other hand, the Elite, on which the seed producer centres his attention, demands special care, not only in the manner in which the hand sowing is done, but during every stage of the plants' development; open spaces, etc., are most carefully avoided.

Upon general principles, better results are obtained by hand sowing than is possible through the careful use of a seed drill; the spacing can be made almost mathematical. Those roots that are raised in the general field from purchased seed, or from seed of all kinds that has been produced on the farm, which are separated from the rest, should never be included in the observations for physical or chemical selection. Their conditions of development being different, would lead to poor results as the work progressed in the creation of a special type. The square method of sowing, consequently, has greater advantages over beets cultivated in rows, where their spacing is not the same as the distance between rows; the misses then (by square methods) have not the same importance, for the roots are all absorbing from the soil about the same amount of plant food. In France, it is recommended that the sowing be done as soon as possible. If the temperature is lower than 8 degrees C (46. 4° F.), germination is not satisfactory; in the Elite sowing, they constantly use 44 lbs. to the acre, and keep the lines about eight inches apart.

There is a great difference of opinion in regard to the spacing of Elite seed. With the view of keeping down the size of the roots, some growers attempt a distance of four to five inches; then again eight inches in every direction, or eight inches between lines and four inches between beets in the rows. The number of roots is estimated to be 174,000 per acre, but such numbers are in reality never realized. After sowing, the seed is covered by three-fourths inches of earth, followed by rolling. In Germany, there seem to be many advocates of sowing seed for mothers directly after wheat in the rotation. There also are many advocates of successive rollings of the ground after sowing; at Gröbers, they plant their rows from twelve to fourteen inches apart. Successive and frequent hoeing is everywhere very popular; this, on many European farms, is done by women. The hoes used are about 4½ inches wide; later, they frequently use a hand-pushing cultivator, increasing the depth each time the operation is done. The spacing demands some experience, and cannot be conducted by novices, such as used in ordinary sugar-beet cultivation. When the roots have a certain size, and show certain indications of degeneracy, they are, in some cases, removed from the field, and replaced by others cultivated under the same conditions on special patches.

A fact which must never be overlooked, is the great care to be given at every stage, up to the time of harvesting, which is done as under ordinary circumstances of beet cultivation.

Preparing Soil, Planting of Mothers, and Care During Their Development.

When the cultivation for the reception of mothers is considered, it is generally found that the best results are obtained when these beets follow wheat in the rotation. We shall now take as an excellent practice, that which we found at the Besny farm. It must not be forgotten that sugar-beet cultivation for an adjoining factory at Laon has attained a degree of perfection quite equal to that of the separate agricultural question of seed growing. For, if mothers

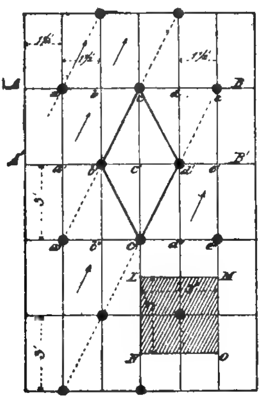

FIG. 45. Plan of field, showing position of mothers.

are not of a high saccharine quality, the resulting seed will not be, and, as by Legras's method of selection, all roots under 14 per cent. sugar are not used, the average obtained is considerably above fourteen.

To attempt the creation of a variety of beet that demands great depth of soil, would certainly never have become popular, and would have been a mistake, but to centre all efforts on an average type suitable to a soil not too deep, nor too shallow, fulfilling the requirements of most cases, is what has been sought after, and what has been attained, on the farm visited by the writer. The method of cultivation adopted is, as before mentioned, to give a thorough plowing during the winter prior to planting, after the fertilizers have been well plowed under. As regards plowing, it is interesting to note that this should not be done during wet weather, and the upper surface should be thoroughly harrowed, the vegetable strata, so to speak, thus becoming greater every year. The operation of marking the position for each mother is then commenced. A special cultivator is used, the distance between colters being three feet during first horizontal direction, then, when tracing the vertical lines, 1½ feet. This operation is made clear by referring to the diagram (Fig. 45). The lines meet at a, b, c, d and e, a', b', c', d' and e'. Mothers that have been waiting for several months in the silo are brought with great care to be planted (the nearer the silo is, the better the result) at a, c, and e, on line $A\ B$, and at b′ d' on line $A'\ B'$, thus alternating for all other rows. The mothers are consequently placed at the angles of a lozenge, $cb'\ c''d'$, the distance $c'\ c''$ being three feet, while $c'\ d'$ is 1½ feet. The beet can draw its plant food from an area of nine square feet.* The respective position of the beets permits the frequent use of the cultivator in the direction shown by the arrows in the diagram (Fig. 45). The position of the roots is such, that even after a prolonged drouth they remain in a flourishing condition; this is, in part, due to the careful selection of mothers, since, under all circumstances, the roots weigh from one to two pounds each, very small roots not being

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*This distance between beets is a very variable question. On Knauer's farm he gives preference to distances of 63 to 78 c. m. (24.6 to 30.4 inches). Squares of two feet are said also to give satisfactory results. The roots are planted on the angles of said squares. Fühling, however, contends that the rectangle, 24 x 34 inches, gives the best results. The marking of the field is done with a harrow in two directions, and at the intersection of lines the mothers are placed. For digging holes to place the mothers a special spade is used.

used. Very small roots are never to be relied upon, because they mean a stunted growth, and will yield seeds that would give mothers possessing the same characteristics.

We have always insisted upon the fact that, in many cases, there were great advantages in the cultivation in hills. Herr Marek, in very extended experiments, has shown that beets selected for mothers which have been obtained in hills, are richer in sugar, and transmit their qualities with greater ease than beets obtained by flat cultivation.

The planting is done in March, this varying somewhat according to years, but under all circumstances it should be as early as possible, and the roots used for mothers must be thoroughly matured. During the first stage of the plant development, a hand hoeing between the rows 1½ feet apart is very important, as later on the cultivator cannot reach these points; after four or five days, this hoeing is followed by a second hoeing. As soon as the stalks commence to appear, a powerful cultivator, drawn by oxen, is run between the rows as frequently as possible, this operation being discontinued only when the passage is obstructed by the luxuriant vegetation; the stalks should not, in any way, be disturbed after the flower forms. The natural result of this working is to open up the soil, and thus place it in an excellent condition for the mothers to draw all the plant food they require.

This planting of mothers is also a very delicate operation. The mothers which have been selected must be free from bruises of any kind; they are carried to the fields in baskets, in gangs; a special spade is used for making the hole to receive each mother. It is generally found desirable to plant the mothers in a slanting direction; in this manner they are better able to resist the action of variable winds. The tip end of the mothers may, when too long, be cut off, but it is, in all

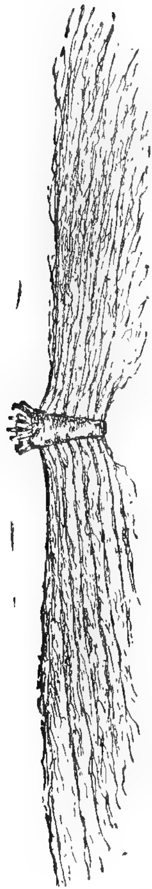

FIG. 46. MOTHER WITH TOP AND END REMOVED, SHOWING THE HAIRY GROWTH AND RAMIFICATIONS AFTER THREE MONTHS FROM TIME OF PLANTING.

cases, desirable not to turn them under. Before pressing with the foot, it is thought advisable to throw a certain amount of earth near the neck. This earth should cover the necks to a depth of 1, $2\frac{1}{2}$ to 3 c. m. (0.39 to 1.18 inches), with the view of protecting the mothers against the frequent late frosts after planting season. Instead of earth around the necks, it is frequently customary to mix the earth with pulverized bone. Hilling up, from time to time, is also advisable. This planting of mothers may be done in France for $2.00 an acre.

To many it may be a surprise that such a large area, *L*, *M*, *N*, *O**, (Fig. 45) of nine square feet, is necessary, but an inspection of the engraving (Fig. 46) shows the ramifications of mothers during their effort to secure from their environment all the essential elements for the development of stalks, flowers, and seed. These lateral radicles run from the root proper a distance of three feet, so that even allowing the enormous volume of earth of a surface area of $1\frac{1}{2}$ feet, in all directions, the plant food is drawn from the soil far beyond the prescribed limits previously mentioned, and, such being the case, all the roots of the field are apparently in communication one with the other. It is interesting to note a custom which has led to excellent results, which consists of twisting or breaking off the lateral and central stalks, it being maintained that this custom favors flowering.

As these mothers have considerable money value, endless means are frequently resorted to for their protection during seed development; nematode invasions might, in some cases, be a serious issue. Hence, the reason why chicory is planted on the outer

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*The Chinese have for hundreds of years understood the importance of these small roots for many plants which they cultivate. When planting bi-annuals, small slices are made in the root proper, thus increasing the number of radicles which soon develop.

limits of a seed farm; this acts as a trap for the enemy and answers the purpose. At Klein-Wanzleben and in other centres, excellent precautions are taken for protection against climatic conditions, which consist of a wire roof covering over the entire field of Elites. This should be sufficiently high to allow a free passage under; outer wire fences are also used to keep off rabbits, etc.

Harvesting.—The harvesting of mothers cultivated for special laboratory purposes, does not, on general principles, very much differ from the harvesting of beets for an ordinary sugar factory. Special harvesters, or plows, may be used for the purpose, the beets collected with great care and placed in baskets; the slightest bruise may have a very important influence. The cost of this harvesting in France is about $13 per acre. The harvesting of seed is a more complicated question. It must not be put off too long and should be done during dry weather, for if the seeds and stalks are wet when taken indoors, the ultimate value will be decreased, owing to a decrease in the germinating power.

The first sign of maturity is when the fruit commences to turn brown, and if, weather permitting, this changes to yellow, the ripening process may even continue later. The determination of percentage of dry substances is an indication of maturity; 60 per cent. is the standard. Knauer says that beet seed are ripe when they have a flour-like taste when bitten into. If the complete maturity is awaited, a considerable number of seed will necessarily be lost, owing to their very slight adherence to their stems; hence, the reason why many recommend that the stalks be harvested green. The cutting of stalks, or stems, on the field is shown in engraving (Fig. 47). An ordinary sickle and not a spade is used; the principal objection to the latter is the excessive shaking of the stalk. It is advisable to

FIG. 47. SICKLE CUTTING OF STALKS WITH SEED AT RISNY.

put off as long as possible the cutting of green stalks, as they mature better on the beet proper. The cutting gang is followed by another, who collect the stems, or stalks, on the ground and tie them into bundles. They are stacked vertically upon the field and left to dry.

Practical experience shows that this drying is more complete when the bundles face the north, thus taking advantage of northerly winds. When the drying is sufficiently complete, several weeks being often necessary, they are taken to special sheds. The appearance of stacks is shown in engraving (Fig. 48).

The writer thought it of interest to be on the Legras farm prior to harvesting. The sight of the fields is never to be forgotten, it being very unique, and differing from any other crop known to the farmer; it is unlike wheat, corn, or cereals in general, leaving, as it were, open spaces, through which light penetrates, so that the ground can be seen between many plants or stalks at the same time. The field seems to form a uniform whole, consisting of a mass of green, soft, and velvety substance, the centres at regular intervals being clearly defined. The clusters of seed upon the stalks were like gems distributed in myriads, reflecting the rays of the sun. The stalks appeared to be so loaded with seed that they were bent over toward the ground, those of one mother having joined hands with its neighbor, apparently asking for support. M. Sagnier, in the *Journal de l'Agriculture*, says that during his visit to Besny he counted eighteen to twenty-three stalks per mother.

As an example of the amount of seed that roots may yield, five clusters were counted, the average seed being one pound per root. In regard to the mother planting, it is interesting to note that it always follows a crop of beets. Upon general principles, if it is simply desired to produce beet seed by ordinary process, the question of economy in space upon the fields is of sec-

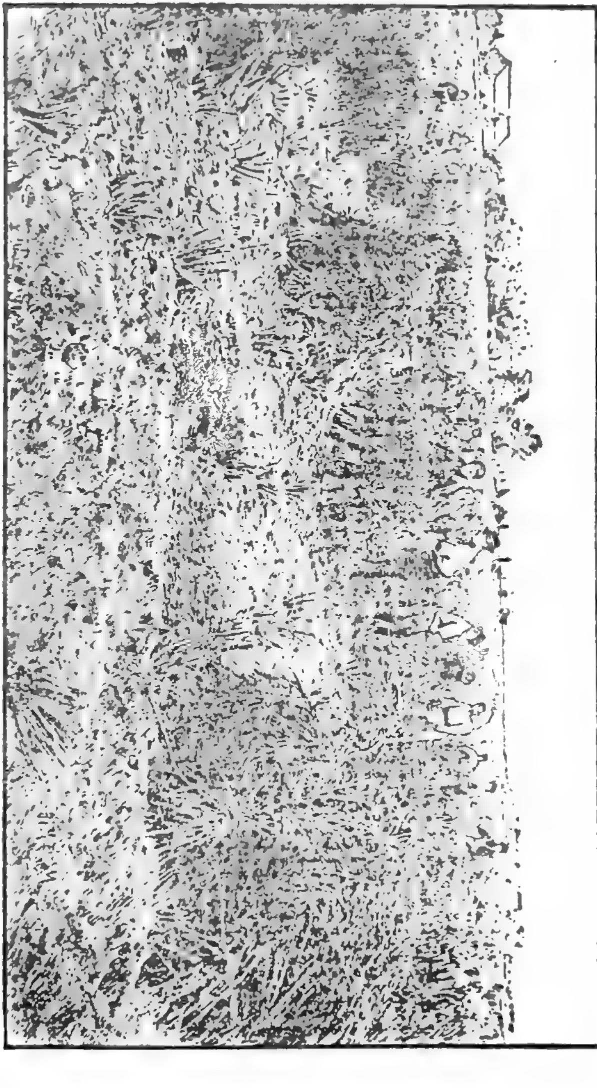

FIG. 48. STACKING BUNDLES OF STALKS WITH SEED AT EBSNY.

ondary importance, but when each beet is selected with special care, and destined to furnish seed for the trade, all conditions favoring its development during seed formation should be thoroughly examined and attended to. Under these conditions, from 2000 to 2600 lbs. of well-cleaned beet seed may be obtained per acre.

Above 2000 lbs., the yield is considered very good; below 1600 lbs., poor. (This yield of 2000 lbs. costs, in France, under best conditions, 34 cents per lb.* Besides this, some allowance must be made for interest of money during the keeping, and on the capital which remains idle during the several years the selection is being made. By Legras's method, results are obtained much more rapidly, but the cost of laboratory analyses is greater, etc., hence, the reason why such seed commands a high price on the market.) Such yields, through the exceptional care given, have been obtained even in exceedingly dry weather, as the soil, having been so thoroughly worked, remains moist, even during long periods of drouth. The crop that follows the mothers is wheat. It is necessary to remove the corpses of mothers, also the stems; then use the extirpator, followed by the cultivator and harrow. The economy of time and work are important facts to be considered, and the cost of land preparation for mothers should be borne by the crop that follows. It is important to note that if mothers follow beets in the rotation, they will be attacked by some insects, and the seed will subsequently suffer. If the insects attack the flower of the beet, no remedy is better than solutions of two degrees Bé. of tobacco juice, spread by a pulverizer, emulsion of petroleum, benzine, charcoal powder, saturated in tobacco juice.

* But on most seed-producing farms not more than four cents. In the case of A. J. Legras, the product is frequently all sold in advance and very difficult to procure even in quantities sufficient for experimental purposes.

It is interesting to note that the time when the flowers appear depends upon the country and the total heat the mothers have had at their disposal during their second year's growth. It may be said, however, that those appearing during the first of August should be pinched off, as they will, in general, yield inferior seed. Fühling recommends the harvesting of all matured stalks. The ends of the remaining semi-green stems are also pinched off; this practice tends to hasten maturity. Some agronomists recommend the cutting of stems from the roots and leaving the latter in the ground as a manure; but this practice is a mistake. The mothers, having been separated from the stems, form but a poor fertilizer. Insects are attracted by them, and frequently deposit their eggs therein; and resulting larvae are likely to do much harm to the subsequent crop. On some beet farms roots and stems are harvested together; it is advisable to shake them over a linen receptacle, and in this manner the loose seed is separated from the stem. The roots and stems are then hung up to dry, the vegetation continues for some little time, and the non-matured seed is soon entirely ripe.

It is generally desirable to do the shelling during very dry, cold weather. The operation required some skill in former times. Archard advised rubbing the stems between the hands, and to subsequently pass the whole through a sieve, in order to eliminate the dried leaves and other impurities. The operation of shelling, as is now practiced; is carried on by women and children. The stalks with seed are drawn through two jaws with saw-like teeth; the upper jaw is held with the left hand, and a slight pressure is given.

It is customary to give the stalks before this operation a preliminary threshing on the floor; a practice about which there is much to be said. The objection to the hand shelling is, that it takes so long, and in countries where labor is high this is evidently a very objectionable feature. Mechanical shelling is used by some and much condemned by others. The main objection is, the very broken or mutilated condition in which the seeds are left; a thorough fanning is most important. Seed may be partly separated from their stems by the use of an endless oscillating moving apron; this is fed from a hopper. The seeds roll off, while the impurities adhering to the apron are thrown upon the ground at the other end of the machine; a system of sorting may be combined with this. The idea is to have a double slanting apron, the heavy seeds traveling the farthest.

The shelling and cleaning may be done at one-half cent per pound. The cleaned seed is now kept in some dry, well-ventilated room, beyond the reach of rats and mice. On many farms it is hung up in bags to the ceiling, and when dried, is kept in bags or barrels, as the case may be. When in piles, it should be constantly turned over, so as to bring it as much as possible in contact with the air. Of late years it is found desirable to submit seed to a hot-air drying process, so that it may, within the least possible interval, have the standard per cent. of moisture. There remain in the way of stalks about 3000 lbs. to the acre; this residuum is rich in potassa and contains, also, phosphoric acid. It may be used as bedding for animals at the farm. On the other hand, the waste from beet seed cleaning may render excellent service in cattle feeding.* In conclusion, we would say that we recommend that all beet-seed producers submit their seed to a germinating test before allowing them to leave their premises. Furthermore, we insist that the purchaser make his test on the same lines as the seed

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* See Chapter on "Old Seed Utilization."

grower, thus avoiding numerous subsequent discussions.

Approximate Cost and Yield of Seed in Germany and Austria.

Between 135 and 140 days are required for the seed to develop and to be harvested, from the time the mother is planted. The yield in Austria and Germany is 2000 to 3500 lbs. of seed per acre. A single beet is known to have given 43,000 individual seeds, but this is an exception. According to Briem, the yield of beet seed in Silesia averages 1832 kilos per hectare (1612 lbs. per acre); in Bohemia, 1945 kilos (1711 lbs. per acre). The success depends upon many causes, among which are fertilization, soil, etc.

The cost of cultivation is approximately as follows:

1st year, 27,000 mothers—cost of planting 0.6 acres.....$	36.00	
Value of the roots	35.00	
Harvesting, selecting, siloing, etc.	125.00	
		$ 196.00
2d year, selecting	337.00	
Planting 2½ acres, grandmothers	120.00	
		457.00
3d year, 20 acres seed		800.00
4th year, 200 acres, mothers—general expense		10,000.00
Other expenses, chemists, etc., etc		1,977.00
		$13,430.00

With no allowance for interest and packing.

The yield of seed would be 200x2000 lbs., equal to 400,000 lbs., which means that the cost per pound is about 3¼ cents, or more correctly, allowing for other expenses, four cents per pound. This supposes, as these calculations show, that we start out with a small area devoted to mothers; the production of these is not considered in the calculation. The sowing of seed the third year is on an area many times that began with, and the fourth year only the seed is obtained.

Silos for Mothers.

The requisites for the proper construction of silos for mothers, are very much the same as for beets to be worked at the factory; there are several essential conditions, however, which must not be overlooked. The cost of keeping beets that have been selected for seeding purposes is very slight, once the silos are made; but the care in placing them in piles being greater than ordinary conditions, the item of additional labor is not to be overlooked. There are really three silos in connection with beet-seed growing. One made up with beets which have undergone the physical selection on the fields, and the others after final physical and chemical selection combined. As such beets frequently contain 18 to 19 per cent. of sugar, special care should be given to their keeping and to the silos containing beets which are to furnish seed for the trade. Under ordinary conditions of seed production, the beets which are to be used for this special purpose are simply beets which have been obtained from the seed of selected mothers; in other words, the second generation of those roots which underwent laboratory chemical selection.

Silos in this case are made on the level of the ground, in the direction of the beet rows. Spaces of about 90 to 120 feet should be left between each silo. Beets on most beet-seed farms are siloed with their leaves; the piles are 4½ feet at the bottom, 2½ feet at the top, and about three feet in height, which means that the sides are slanting. The whole is covered with 2½ feet of earth; suitable vertical ventilators are necessary, and under no circumstances should these be overlooked. From one acre the beets can be placed in silos of a total length of about 300 feet; the cost of the operation in several European centres is about $10 per acre. We consider that it is certainly a great mistake to let the leaves stay on the beets. The best results are certainly obtained by cutting them off with a knife about an inch above the neck, care being taken not to mutilate the heart. On most German farms visited by the writer, the silos for mothers are much smaller than the French types just mentioned. In most cases they have a capacity of only a few tons, the laboratory selection taking place in the spring.

These silos are sunk 1½ feet in the earth and are four feet wide, the necks slanting upward; about 18 inches of earth are piled on top; the covering should be flat, so that some moisture from rains, etc., may readily penetrate. Knauer claims that if the root be moistened it will keep better in silos; precaution alone being necessary to prevent stagnant water. During very dry seasons, the piles of mothers may be watered; the water carries the earth down to surround each beet. When the total covering of silos with 2½ feet of earth is finished, during very cold winters, it may be found desirable to still further cover with barnyard manure. The opening of the silos depends upon the method of selection. Knauer says that selected beets in well conducted silos should be placed one against the other, and not one on top of the other. This covering, upon general principles, would seem to be a bad practice; for the weight of earth has a tendency to crush the beets and thus bring about considerable changes in the entire pile; this is the reason why many advocate straw and a thin covering of earth.

Considerable experience is needed to know just when to place the beets in silos. Better select a very dry day; if rainy, the beets siloed in their wet condition would in most cases undergo fermentation. On the other hand, if exposed to the sun too long, the roots wilt and the chemical selection that follows would be very misleading, as the sugar percentage would appear to be higher than the reality. Under all circumstances, loss of sugar percentage occurs during the months the roots are kept; hence the reason why the chemical selection should take place early. Arguments in favor of late selection, showing which roots have keeping qualities, are not as reliable as one would wish. Expe-

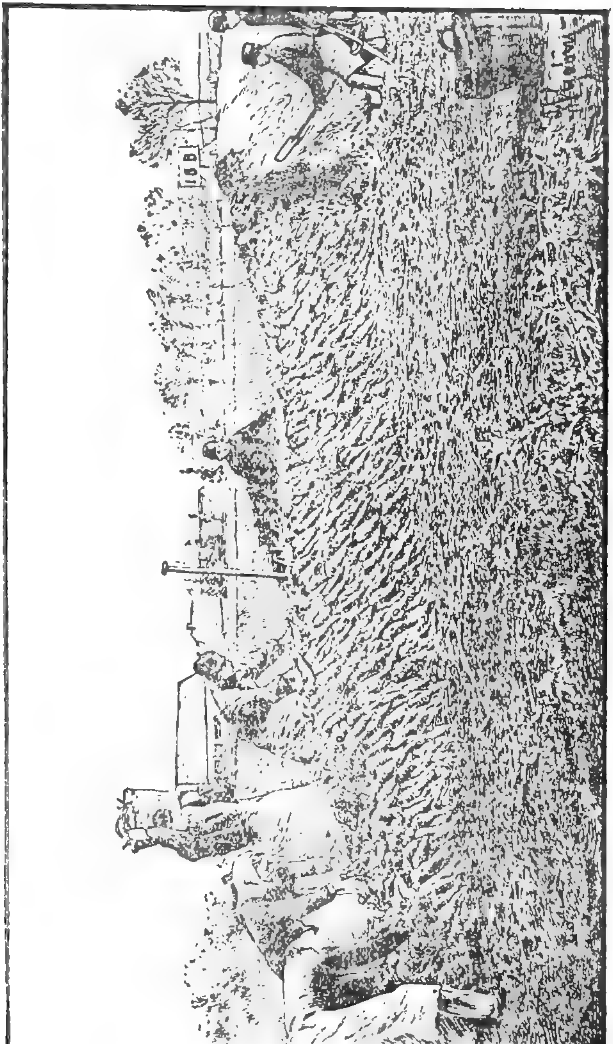

FIG. 49. CONSTRUCTION OF A SILO FOR BEETS THAT HAVE BEEN SELECTED IN THE LABORATORY AND WHICH ARE TO FURNISH SEED FOR THE TRADE.

rience has shown that it is not to the seed producer's advantage to attempt the creation of the very elongated varieties. They are difficult to properly arrange in silos and their tip ends are most always broken during harvesting, and if not then, they would be broken when placed in silos.

At the Laon beet-selecting laboratory, the main object in view is to commence analysis as soon as possible and to have the roots well siloed before the very cold weather. Herewith (Fig. 49) is shown how the piles are made, and the necessary care given to their construction.

The beets are brought in baskets direct from the laboratory and then piled with necks pointing outward. It is not desirable to make these piles more than three feet high; their section is that of a triangle, and when of the desired height and shape they are covered with earth, and remain during the several months of cold weather until March or April, when planted. The slow method adopted in most selecting laboratories necessitates the opening and closing of the silo made upon the field during the entire winter; this practice, as may be imagined, is followed by many complications and poor results; all of which, by Legras's method, is avoided, as the analyses commence in January and finish in February, after the sugar campaign has terminated. It must never be forgotten that there are certain precautions to be taken in the laboratory in order to assure the keeping of beets in silos, viz., the hole made by the rasp or sampler should be most carefully filled with clay or charcoal, and the roots handled with care, so as to prevent bruises. The slightest mutilation means organic changes during the several months they remain covered awaiting planting season.

Chemical Changes During Second Year's Growth.

Do mothers, after seed is harvested, still retain sugar? This question is frequently asked and many discussions have followed respecting it. The weight of authority appears to be that the sugar has entirely disappeared. If this issue be examined on a rational basis, it will be found that the life of the beet terminates with the seed; the functions being complete, the root soon rots—no sugar can then be found. However, cases have been cited when one to one-half per cent. appears to remain. A simple experiment to show that the sugar disappears as the stems, etc., continue their development, is to cut off the stems as fast as they appear; it will not require many months before all the sugar will have left the root. M. H. Leplay has given the subject considerable attention, and it is interesting to follow what is said upon the subject and the conclusions drawn.

The beets upon which the observations were made were in an excellent condition, and had been cultivated on a calcareous soil. When harvested, the leaves were twisted off and then remained untouched; the roots were planted in May and examined during various periods of their vegetation. The density of the juice constantly decreased in the root; when the mothers were planted it was 1050.7; June 7, 1042; June 30, 1037; July 17, 1033; August 22, 1021. During the same period there was an increase of the density of juice from the stalks and then in the leaves. Analyses of different parts of the plant just at the period when the leaves were forming, gave the following:

Portions Analyzed.	Weight.	Density of Juice.	Sugar Per Cent.
Root........................	610 grams.	1.020	0.85
Neck........................	210 "	1.020	0.75
Stems........................	1.090 kilos.	1.027	....
Leaves........................	0.500	1.034	....

As mentioned above, when the period of development advances, the sugar percentage diminishes as soon as the leaves appear, then remains constant. Then comes a time after the seeds are formed that more sugar is formed in the stems and leaves; little remains in the root proper. (Even during the early history of the beet-sugar industry Peligot insisted that sugar disappears as soon as seeds are matured.) Respecting seed formation through the intervention of the stems, very little is known. One might conclude from the fact just mentioned that the seed had absorbed the sugar, but such is not the case, it having been proven that most of the sugar passes into small side roots, which always show themselves.

Salts and vegetable acids, with a basis of potassa, exist in the juice of different portions of the plant. The quantity contained in the beet, after completing its second year's growth, is about double what it was after the first year. Lime, salts and soluble vegetable acids, and lime of an insoluble organic combination, are to be found in all portions of the plant. The tissues of the leaves and their stems appear to contain more of the lime combinations the second than during the first year's vegetation. Green seeds also contain a large amount of lime in an insoluble combination. During this second year, there is, without doubt, an upward movement of potassic and lime salts contained in the soil, and this in passing through the leaves and stems has the seed ultimately in view. During this period, carbonic acid and bicarbonates contained in the soil enter the root by the adhering radicles; the transformations which occur appear to be very like those of the first year.

As the mothers can supply only one-tenth of the potassic and lime salts needed for seed formation, the remaining nine-tenths must be drawn from the soil. The potassa has for its principal function the formation of the seed, while lime helps in the formation of tissue. A question we hear constantly asked is, Have not these salts some direct and constant relation or important influence upon the quality of seed obtained, considered from a basis of sugar percentage in the mothers? In the recent writings of Strohmer and Stift, they declare that the mothers during the second year's growth produce large quantities of new organic substances; the root has not within itself sufficient resources; these must be furnished. Phosphoric acid is utilized in the production of the stems and leaves, and nitrogen for the seed.

CHAPTER VII.

The Selection and Sampling of Beet Seed.

Preliminary Remarks.—It may be an excellent precautionary measure, when intending to purchase beet seed from the dealer or grower, to learn just what the conditions of cultivation have been. The great trouble with most seed dealers is that they attempt too much and the customer suffers. Our advice is to give preference to those producers of beet seed who cultivate nothing else and who make a specialty of selecting, etc.; furthermore, to those who realize the importance of not having patches of fodder beets in the vicinity. It is well not to be misled on this subject; a distance of over a mile between one farm and another may be a reasonable limit. Yet cases are known where the pollen has been carried by the wind or insects, which thus completed the fertilization of the plant, and there follows a hybrid, the existence of which the farmer and manufacturer soon realize.

The very best seed must be planted under the best possible conditions, and the care that follows during plant development and sugar elaboration should continue until the beets are delivered as raw material at the factory. The sugar is made on the field and the manufacturer is simply an extractor; hence, the reason why we have always recommended that when conscientious farmers carry out instructions to the letter they should be furnished from the start with the very best procurable seed. The extra cost of same is a mere trifle as compared with the satisfactory money returns for all interested.

The fire test for determining the vitality of beet seed appears to offer some advantages. The seeds are placed on a red-hot shovel; if they burn slowly, one may conclude that they are old and almost worthless. The operation should be repeated upon several samples taken from the same sack; if the same results are obtained, the bag should be refused. On the other hand, if the seeds jump and produce a cracking sound or noise, they may be considered worthy of undergoing the germinating test. A series of experiments of this kind would soon show just what the proportion was of new and old seed in the sample.

Influence of the Size of the Seed on the Quality of the Beet and Yield Per Acre.

For many years past, there has been considerable discussion to determine whether or not the size of the seed has an influence on the resulting roots. Whether, in other words, large seeds yield beets of a higher saccharine percentage than small ones; whether the farmer has any advantage in using one size rather than another. For it must never be forgotten that seed which is known as beet seed, as previously explained, is, in reality, a cluster of several seeds, and the germs from some are extremely varied. Hence, the reason why there is such a variety of opinion upon this subject. The early experiments of Simon Le Grand were apparently very conclusive in favor of small seed—100 large seeds weighed 3.2 grams, 100 small seeds weighed 0.425 grams.

		Weight. Average for Four Beets.	Sugar Per Cent.
Large Seed	August 11	66 grams.	....
	" 20	75 "	11.4
	" 31	125 "	....
	September 16	325 "	11.8
Small Seed	August 11	30 "	....
	" 20	50 "	12.0
	" 31	75 "	....
	September 16	233 "	12.5

Other experiments of the same kind were made by Marek. During the early stages, the results appeared to be in favor of large seed, but toward the end of the season, certain changes occurred and no difference could be noticed. The area of experiment was small.

	Large Seed.	Small Seed.
Number of beets obtained	550	571
Specific gravity of juice	1.044	1.050
Dry substances	10.857	12.285
Polarization	7.247	8.732
Purity coefficient	66.74	71.16

These results appear to be in direct contradiction to his early experiments. Walkhoff is decidedly in favor of large seed, as he declares that the resulting beets are more hardy.

It seems to us that the strong argument in favor of large seed is, that the young plants, the outcome from them, can better resist the variations of the weather than the small. This is explained in various ways: Hollrung argues that small seeds mature early, owing to their greater facility to germinate. The average yield per acre is evidently greater with large than with small seed, owing, as we have just said, to there being a larger number of sprouts or germs per individual seed used. The pericarp is necessarily very much greater for large than for small seed. From this fact, Knauer concludes that the actual weight of seed proper is very much greater in small than in large seed. This outer covering for large seed represents 75 per cent. of its total weight, while for the small seed only 72 per cent. If the large and small seed be put to a germinating test, the argument appears to be in favor of small seed. With five grams of large seeds may be obtained 283 sprouts, while with the same weight of small seeds 469 sprouts are obtained.

Briem has also given this subject more than usual attention and his conclusions are worth recording. He admits that seed may be divided into three classes, large, medium and small. These all gave very great variations in results; a synopsis of the same is as follows:

	Weight of Beets. Kilograms.			Sugar Per Cent.		
	Aver. for Experiment.	Maximum.	Minimum.	Aver. for Experiment.	Maximum.	Minimum.
Large seed	0.390	0.850	0.120	13.18	15.4	10.3
Medium "	0.392	1.090	0.150	13.	15.5	10.9
Small "	0.339	0.810	0.140	12.70	15.6	10.2

So it becomes evident that very little stress can be attached to the question of size of seed. It is far more important to give special attention to the condition of development of the seed proper than to whether they are large or small. Furthermore, it has been conclusively demonstrated that germs, even from the same seed, may give beets of a very different composition and yield. In the experiments in question, the weight varied from 55 to 835 grams, yet they were planted under exactly the same conditions.

Briem declares that these variations are due to the physiological condition of the flower, the various portions of which have not been fertilized at the same time, or under exactly the same conditions. It is interesting to add that during these intervals of time, climatic influences have exerted their effects; furthermore, the beet itself, during this period, undergoes great variations, which bring about changes in the flowering of what becomes an ultimate seed with several germs. The same variations have been noticed with numerous other plants in the whole botanical realm.

Actual Weight of Beet Seed.

Notwithstanding that this question has been under discussion for many years, there yet remains much to be done, on account of a great want of uniformity in the methods of investigation. The ballast, or outer covering (pericarp) of the seed varies so much with the size of the seed, and the difficulties in certain cases of determining, if observations are being made, on what might be considered a single seed with about five germs, or whether it is composed of two seeds held together, which, collectively, have five germs. The Nobbe experiments would tend to show that the seed, or germ proper, represents 31 per cent. of the seed, while the ballast, or pericarp, is 68.8 per cent.

The data furnished by other agronomists upon this subject differ somewhat from these figures. None are more reliable than those of Knauer, and he declares that, notwithstanding all the precautionary measures taken to determine the weight, the data obtained are certainly not mathematical. In the experiments 200 seeds weighed 6.099 grams, of which the ballast weighed 4.487 grams, or 73.6 per cent., and the seed proper 26.4 per cent. There can be no doubt but that the weight of the germ increases with the weight of the seed. The experiments at Gröbers were upon 50 seeds, but to make these results more readily understood, we have based our calculations upon 100.

Size of Seed.	Weight of 100 Seeds.	Number of Germs.	One Germ Weighs.
Large	4.622 grams,	346	3.3 M. G.
Small	3.702 "	326	3.0 "
Smaller	2.496 "	260	2.7 "
Smallest	1.378 "	176	2.7 "

Knauer declares that it is a mistake to suppose for one instant that the large seed is simply a combination of two of the smaller seeds; a close examination reveals that such is not the case. For in these large seeds may be found, side by side, much smaller, yet too large to fall through the holes of a 7 m. m. mesh. The same argument applies to the smallest seed of the table.

Upon general principles, it may be admitted that one hectoliter of beet seed weighs 27 kilos (about twenty pounds per bushel). There is a great variation in the weight of seeds, considerd as a whole. Dr. Bretfeld has declared that there may be 14 to 103 seeds per gram, which means that their weight may vary from 0.0097 grams to 0.0714 grams. It is to be noted that such variations in weight do not exist with any seed in the whole field of botany. Pagnoul says that the average number of seeds per two grams is 105, which means that the average weight of individual seeds is about 0.018 grams. One bushel of beet seed weighs only sixteen to twenty-one pounds. Without doubt, the varieties of beets and the methods of cultivation have certain influences on the size of the beet seed. The period of duration of flowering must also not be forgotten.

Another fact not to be overlooked is, that the size of the seed depends upon the number of germs it contains; the average may be considered as five. These vary, being one, two, three, and even ten. Briem declares that he has in his collection a single seed which weighs 0.249 grams. While Pagnoul admits that 105 seeds weigh two grams, Bretfeld, an equally high authority allows only 90. However, the difference is very slight between these two authorities, as by the latter it is admitted that 100 seeds weigh 2.22 grams. With small seeds during certain years it requires 103 to weigh one gram, while, on the other hand, 24, or even 22, of the largest may also weigh one gram. Hence, the reason why, some years ago, there was a thorough understanding that large seed should be those in which forty-five were equivalent in weight to one gram; small seed those where this number is greater. This leads to entirely different results, from the purchaser's standpoint, to those which would be obtained by the Knauer size of seven m. m. to five m. m. method mentioned in previous pages. This authority declares that the weight of beet seed is largely influenced by its condition, or degree of its maturity. One liter of Imperial Knauer (eleven per cent. moisture) weighs 185.34 grams (seven ounces per quart).

Numerous authorities have taken upon themselves to determine the number of sprouts given by one gram. Sempolowski declares that the following is about an average, and may be an excellent basis of classification:

Those seeds which give	81 to 112 sprouts, per gram	Excellent.
" " " "	55 to 80 " "	Good.
" " " "	40 to 54 " "	Average
" " " "	less than 40 should be considered	Bad.

This differs from Knauer's early classification, where superior seed were considered to be those where there were only sixty sprouts per gram, and an average quality less than fifty. The germinating power is not the only fact which should be considered.

Selection of Seed.

The farmer, when purchasing seed in general, has some basis to work upon which is sufficiently accurate for general practical purposes. On the other hand, with beet seed he is at a great disadvantage. That the color, the impurities, odor, etc., are characteristics upon which certain reliance may be placed, no one for an instant doubts, but these are not sufficient to decide in advance the money value of the product being examined; hence, the subject is of more than ordinary interest. The seed formation and its maturity is a most variable factor, even on the same stalk to which the matured seed adheres more or less firmly. Some seeds fall as soon as the stalk is touched, while others adhere with moderate or excessive firmness, and can be separated only by the use of a special instrument, the moderately adhering type representing three-fourths of the total seed obtained. M. Legras has cultivated beets from the latter and does not hesitate to assert that they yield roots 0.60 per cent. richer in sugar than either the loose or tenacious kind; this may be a starting point for still further selection and is certainly well worth looking into.

By Chemical Analyses.

Laskowsky, a Russian, at Moscow, has tried to demonstrate that the saccharine quality of beets is in direct ratio to the fatty substances of the seed—that large seed contain more fatty substances than small. The mass of testimony of Briem, Strohmer, etc., does not agree with that assertion, and shows that there is no relation between the two. Furthermore, the Mangold seed is very rich in fatty substance. Zaikiewitsch, another Russian savant, determines the fatty substance, phosphoric acid* and albumen in the seed. The phosphoric acid was estimated in the entire seed, and the fatty substance and albumen in the seed proper, without outer covering. These experiments were upon a great variety of French, German and Russian seed; in these analyses the percentage of albumen varied from fourteen to twenty per cent; fatty substances, eleven to fifteen per cent; phosphoric acid, 0.4 to 0.9 per cent. in beets testing an average of 15.5 per cent. sugar. From such results it was concluded that no constant relation exists between the composition of the seed and the sugar percentage of beets. It is interesting, however, to note that seeds from France and Germany contains less albuminoids and fatty substances than do Russian seeds; on the other hand, the latter are very much poorer in phosphorus.

Other interesting discussions have been continued for a period of years to decide if the composition of the seed in general has not an influence on the resulting roots. For if such should be the case, an analysis of seed would settle a very important ques-

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* As regards the phosphoric acid, M. Pagnoul, in France, came also to the conclusion that there is not the slightest connection between it and the sugar per cent. of the resulting root.

tion. The experiments of Pellet with large and small seeds of several varieties were as follows:

Variety of Seed.		Weight of Seed.	Water Per Cent. Normal Substance.	Nitrogen Per Cent. Normal Substance.	Ash Per Cent. Normal Substance.	Sugar Per Cent. in Beet.
Vilmorin	large	4.13 gr	10.9	2.66	5.4	15
	small	0.54 "	11.0	3.07	5.3	"
German Varieties, Rose neck, small seed, average		0.77 "	11.2	2.8	8.2	0
Gray neck, large seed, average... Green neck, large seed, average		4.745 "	12.2	2.46	6.5	10
Forage Varieties	Large seed	4.647 "	12.5	2.38	7.0	4 to 6
	Small seed	0.560 "	11.4	2.55	9.0	"

The richer the beet, the greater the per cent. of nitric elements and the smaller the per cent. of ash.

In a same variety of seed, the small seed contained more nitrogen than the large.

So, apparently, a classification, according to quality, could be made on the basis of nitrogen or ash estimation. It is very doubtful, however, if this method can be considered thoroughly reliable. Many years ago, Dubrunfaut declared that from his observation superior beet seed gives less ash than the inferior varieties. He maintained that sugar-beet seeds had about four to six per cent. ash,* while in forage beets this ash percentage varied from six to 14 per cent; furthermore, sugar-beet seed appears to contain more phosphoric acid.

* Chemical composition of beet-seed ashes, Champion Pellet:

	Ordinary Seed.		Vilmorin Improved Seed.
	1.	2.	
Potash	21.1	16.4	24.2
Soda	8.9	10.4	12.8
Lime	25.4	20.2	17.2
Magnesia	13.5	11.5	10.1
Sulphuric acid	4.0	2.8	4.3
Chlorine	4.7	4.1	4.1
Phosphoric acid	8.4	9.3	17.4
Silica	13.4	.....	.....
Oxide of iron	1.2	26.4	11.
Magnesia	0.7	.....	.....
	101.3	101.1	101.1

During our visits to many beet fields in Germany, some experts declared themselves in favor of the selection of seed by density, using for the purpose special saline baths; those sinking would give the best yield as to quality and tonnage. It remains to be proven if this method can be considered reliable, for certain seeds, large or small, under certain conditions of porosity of their outer covering, would absorb more or less water. If the solution changes color to any great extent during the few minutes which the test lasts, that would be a certain indication that the seed in question is old.

Color and Odor.

The color of the seed is not a question upon which much reliance can be placed, as the condition of the weather at the time of harvesting has a most important influence, and examples may be cited where the seed was very dark in color yet proved of a satisfactory quality. This is explained by the fact that in the seed one of the germs or sprouts may be dead and influence the color of the pericarp. However, there is a certain characteristic shading which is an evidence of quality, determined, however, through considerable experience. The small leaves, so to speak, adhering to the hard portion of the outer covering of the seed are, within a reasonable limit, indications of quality. While at first moisture has very little effect on the germs proper, after a time the amount absorbed brings about certain fermentations, which have a very great influence on the germinating power and the ultimate color.

The atmospheric influence is so great at the period of harvesting and maturity, that the color of the seed varies between great limits, from very light to nearly black. It is generally admitted that a slight green or yellow color is a favorable indication of quality. In most of the European experiment stations, very little importance is attached to color. On the other hand, the odor of seed is a reliable basis and certain dependence may be placed on it; it should be very much like hay. Again, when the smell is rather mouldy, it would indicate that the seed had been kept in a damp place or had not been properly handled after harvesting; the odor from the decomposition of the organic portion of the plant is very offensive. Old seeds have a characteristic smell, which permit one, with a little experience, to recognize them at once. Those who make a practice of mixing these seed with their new crop take the precaution of disguising the smell by the use of aniseseed oil, or a weak solution of permanganate of potash.

Impurities.

Five to ten grams of the seed are carefully weighed and then spread upon a sheet of paper. Each seed is pushed to one side and counted. The weight of the seed used, N grams, and the weight of the clean seed, n grams, are substituted in the following formula in calculating the percentage of impurities, I:I=(N—n ÷ N) 100. This estimation of impurities at first seems very simple, but in reality it offers many difficulties, as the results obtained frequently do not agree. The shaking of the bottle containing the sample demands certain precautions; if always in one direction, the deposit will be found in one spot, while if shaken with cork down, to one side, etc., the impurities are evenly spread through the entire mass of seed. An important question is, Whether the leaves and adhering stems should be separated and counted as impurities or left on and not considered? Many discussions occur relating to this custom, and in one case the impurities may be found to be four per cent. and in the other only two per cent. However, when that question is settled, it is well to repeat the operation of impurity estimation at least three times and to take an average.

A given weight of the seed is well shaken in a sieve, allowing the dust, also mineral and organic particles, to pass through. What remains in the sieve is placed upon white paper or porcelain, and with a small brush those seeds taken as samples are pushed to one side. The impurities remaining are added to those passing through the sieve and this total is weighed; the percentage of impurity to total seed is then calculated. The stems, empty seed, small stones, etc., of which the impurities consist, are seldom more than 3 per cent. of the whole, it being sometimes only 0.7 per cent., while again in efforts at fraud it has been 30 per cent.

It is interesting to note that the question of impurities of seed is no longer the subject of discussion it once was—special and well-constructed ventilators removing all the dust and light particles that are always adhering to beet seed after having been dried. The seed dealers who attempt fraudulent methods very seldom resort to the mixing of seed with the impurities which have been previously removed.

Moisture.

All seeds have a moisture of their own, and there never need be the slightest dread of the seller adding water, as fermentation would follow. The natural moisture varies, according to year, from 12 to 15 per cent.; if more than 15 per cent., the seed gets mouldy and loses its germinating power. The seed grower should always take the precaution not to keep his seed fresh from the field in piles, more especially so if harvested in rainy weather; on the contrary, it should be spread out in a thin layer upon the floor of a well-ventilated building.

As before explained in these pages, the absorbing power of large seed being greater than that for small seed, it is evident that under the best of circumstances there is a higher percentage of moisture in large than in small seed. It must never be forgotten that the moisture percentage is undergoing constant variations with the hygrometric conditions of the ambient atmosphere.* The moisture of a sample of seed is determined by weighing a given quantity before and after drying at a temperature of 105 degrees C. (221 degrees F.) during a period of 465 hours. If five grams are heated in a platinum capsule, the loss of weight multiplied by twenty gives the weight of water contained in a hundred grams of seed. This amount it is important to know, as if in excess of 15 or 18 per cent. it indicates a bad conservation, which is a very objectionable feature.

An interesting fact which has recently been brought to light is, that there seems to be some practical relation between the moisture of the seed and its power of germination. These experiments were mainly undertaken by Dr. Bretfeld. It is concluded by him that the germinating power increases with a decrease in percentage of moisture. However, the following data show that the variations are very slight and no great importance need be attached to them. The experiments extended over a period of four years; with 13 per cent moisture there were 159 per cent. of germs (each seed containing several); with 12.5 per cent., 194 per cent. of germs; 13.6 per cent., 133 per cent. of germs; 13 per cent., 153 per cent. of germs. The great variations in moisture of seed depend upon their origin; the age, etc., is made evident by the following series:

Per Cent. Moisture.					
Large Seed.		Medium.		Small Seed.	
Large. Per Cent.	Small. Per Cent.	Large. Per Cent.	Small. Per Cent.	Large. Per Cent.	Small. Per Cent.
16.8	20.5	10.3	9.2	13.6	12.4
18.3	18.2	9.5	8.2	13.7	11.3
28.3	29.0	5.1	3.3	14.6	12.6
17.7	17.3	9.8	8.9	13.5	13.1
Average..........				13.8	12.3

From which we conclude, with some degree of cer-

* See our remarks on moisture under heading "General Considerations Respecting Germination."

tainty that small seeds, whatever be their classification, contain less moisture than do the large. Hence, if there actually exists some relation between moisture and the sprouting power, small seed should sprout more readily than large seed. We think that the practical tests in germination will show that this is not true.

Sampling for Germination.

It is most difficult to get what may be called an average sample of beet seed, and those who have not looked into the question would be surprised to learn of the extreme care necessary, and the difficulties to be contended with. It must not be forgotten, as previously mentioned, that what is generally termed beet seed is in reality not a seed, but an aggregation of seeds held under the same shell or husk. An explanation from a botanical standpoint is rather complicated, but one fact is certain, that there seems to be very little relation between the sprouts and the total number of germs a seed may contain. It is interesting to note what agronomists of the European world have done, Messrs. Nobbe, Maercker, Weinzierl and Pagnoul, for Germany, Austria and France. While complete uniformity does not exist in the observations by the many methods in existence, they are interesting and worthy of a trial. It would be impossible, even in a special volume, to pass in review all the various methods of sampling, including laboratory germination, for the complete data would not be procurable.

Upon general principles, this sampling should be done in the presence of the purchaser and dealer, or their agent. When purchasing on a large scale, it is important to open several bags, noting whether the appearance of the centre is about the same as the outer border. In France, it is recommended that samples be taken from each of five bags when the sale is limited to ten bags, from ten when twenty bags, and twenty samples when there are fifty bags, etc., for over 500 bags, one in every five. The seeds thus obtained are placed in a flask, well corked, and remain there until needed for analysis in a germinator. If several samples are to be taken from the large sample, the seeds are spread out on a table and divided into as many parts as there are tests to be made.

The unique sampling is more accurate, for the more the seeds are manipulated, the greater will be their loss of impurities. The germinating power of the seed varies from year to year; owing to existing frauds, it is most difficult to get an average sample. There is great need of some uniformity of method of purchasing and testing seed. However, when making the first sampling from the sacks of seed, an average should be obtained from the start; it would be a mistake to select only from the upper surface, as the seed there is the lightest, but samples should be taken from the bottom, middle and top, so that the total seed obtained should weigh at least 10½ ounces, or 300 grams. The ultimate selection may be made from this preliminary sample.

By the Nobbe method 300 grams are thoroughly mixed and then emptied into a funnel-shaped hopper, the bottom opening of which is sufficiently small to permit very few seeds to pass through at a time. At regular intervals, timed by a watch, samples of seed are taken, which are received in a special spoon. After a given number of spoonfuls are obtained, they are spread over a black surface, from various parts of which are taken twenty or thirty seeds, this operation being repeated about twenty times, until 600 seeds are obtained, which are divided into three lots of 200 each, and are respectively used for the determinations of moisture, impurities and germination.

Another method for sampling differs from the foregoing in many respects after the first selection is made from the sacks. The seed is emptied into special pasteboard boxes covered with black paper. These boxes are 13½ inches in length, about 10 inches in width, and 1½ inches in height. The seed in these boxes must be very evenly spread over the bottom, so that only one layer is obtained. Samples are taken with spoons, so as to obtain a sufficient quantity for subsequent examination. The Maercker method is among the most accurate and interesting (Fig. 50).

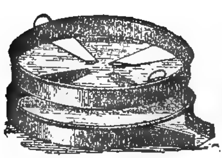

FIG. 50. Maercker sampler.

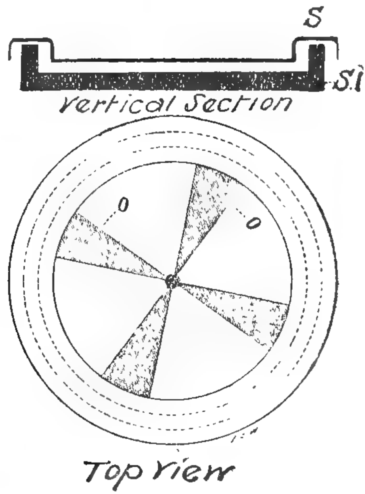

FIG. 51.

The samples from sacks are emptied into a special dish with a cross-like opening at the bottom; this dish fitting exactly into a second one. The seed should be evenly spread out with the hand, exerting no pressure. The dish is then withdrawn behind, and there remains in the under receptacle a lot of seed, arranged geometrically, corresponding to the opening in the bottom of the dish removed; from it are taken the final samples for germination, etc.

In the Bretfeld method of obtaining a sample, the arrangement is very like that we have just described, and is shown herewith (Fig. 51). It consists of a sheet-iron disk, *S*, which fits inside an earthen receptacle, *S'*. The seed is placed in *S* and falls through the opening, *O*.* When *S* is withdrawn there remains the geomet-

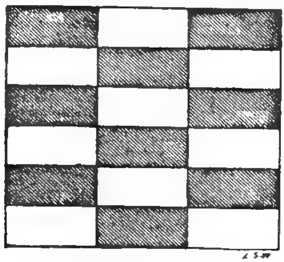

FIG. 52. Divider paper.

rical figure shown herewith. The operation should be again repeated with a smaller appliance of same kind. About 200 seeds are selected; these are placed on a sheet of black paper, divided into squares or rectangles; as each of these is divided in two, each half will contain 100 seeds.

* Some experts recommend that *O* correspond to 5 grams in weight of seed. The Austrian method can hardly be considered as exact as the foregoing. It consists in spreading the sack sample upon a black circle, from which are taken, with the horn spoon, segments of the circle which represent the final samples.

CHAPTER VIII.

Germination.

Preliminary Remarks.—Seeds before being planted are kept in some dry place for periods of time which are very variable; until when placed in a suitable environment, they remain in a semi-dormant condition. Their vitality manifests itself when certain conditions are fulfilled; none are more important than heat, moisture, air and light. The germinating power of beet seeds depends upon their age, and some authorities claim that even after ten years'* keeping, a certain number will appear above ground; however, the resulting roots would never reach their normal development. As seeds retain, in the form of albumen, the requisite plant food for the first few days after sprouting, it is self-evident the older the seed, the greater will be the alterations in the composition of this stored-up food, and with age the vitality of the plantlet during its first struggle to gain the surface becomes less.

Heat.

We shall not for the present consider the heat of the soil as affecting germination, but heat as having its influence upon the seed, as is possible to determine by laboratory research. As these investigations are limited, it is important to place special stress upon those made by Knauer. Eleven samples of 100 seeds were placed in a copper receptacle heated by hot air; the temperatures varied from 40 degrees C. to 120 degrees C. The seeds were subsequently cooled, then

* One cannot help contrasting the vitality of beet seed with certain varieties of Egyptian, which were several thousand years old.

placed on moist sand for determining their germinating power. The experiments were again repeated with eleven other samples, to determine the influence of time upon the heating. The conclusions were, that the germinating power of beet seed submitted for three hours to a temperature of 50 to 60 degrees C. was considerably increased; the same seeds, at a temperature of 115 to 120 degrees C. lost their power to germinate, and this loss of vitality increased with increase of temperature. A moist heat produces also a beneficial effect, for seed, exposed to moist, hot air for six hours, from 40 to 50 degrees C., had its germinating power considerably increased. However, changes occur at 70 degrees C., and with an increase of temperature the vitality is completely destroyed. Consequently, it is very important to keep in mind that there are certain limits which should not be surpassed.

Hot water is more destructive to the germinating power of beet seed than is hot, dry or moist air. Seed in hot water at a temperature of 60 degrees C. will no longer germinate, and even at 55 degrees C. only three or four out of 100 will give signs of life; as this limit is not reached in the soil, it need not be dreaded.

Moisture.

The moisture of beet seed is an extremely variable question, and while certain limits are fixed when seeds are purchased in the market, the idea is mainly to prevent fraud when the sale is by weight, as it always should be. Furthermore, moistened seeds lose their keeping powers; consequently, if that system of fraud were allowed, the purchaser would be the loser. Nobbe allows an average of 13.3 per cent. moisture; Maercker admits that 20.5 per cent. is not uncommon, while, at the other extreme, 4.4 per cent. is considered an average, which limit is simply absurd.

Knauer made a special study of the question. The experiments were upon seed containing from 11.8 to 12.6 per cent. moisture, when brought to the laboratory after harvesting. To show that the moisture of the room in which seeds are kept has an influence, the above seed, when kept on the ground floor, soon had 16.7 per cent. moisture, while after remaining for three days in a room heated to 22° C. (71.6° F.) their moisture was only 10.1 per cent. When one considers that the daily variations of the ambient air is very considerable, it becomes manifest that certain allowances must be made for the same. Experiments were made upon seeds of four different sizes.* With a relative moisture of the air, which varied from 61 per cent. to 94 per cent., the total increase of moisture for the four seeds was 0.53 per cent., 0.40 per cent., 0.28 per cent. and 0.36 per cent.

These observations are of special moment when it is desired to make a commercial examination of beet seed. If the sample is sent by mail it is very important that it should be contained in a hermetically sealed box. The amount of water that the seed absorbs when in water depends upon the temperature and time of emersion. Our own experiments showed that at 40 degrees F. the absorption was 71 per cent., while at 68 degrees F. it ran to 110 per cent.† Knauer's experiments for 144 hours showed that the absorption for the four sizes of seed mentioned in foregoing was 136 per cent., 114 per cent., 149 per cent. and 172 per cent. It is concluded that seeds of smaller size take up water more rapidly, proportionally, than large seeds; the absorption is the greatest during the first 24 hours and during the first six hours of the test.

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*In the Knauer seed the classification is as follows: Those remaining in the sieve with 7. m. m. mesh, will weigh, for 100 seeds, 4.597 grams, or 109 seeds for 5 grams; those remaining in sieve with 6. m. m. mesh correspond to 143 seeds per 5 grams. The third size are those which are retained by 5 m. m. mesh and give 194 seeds for 5 grams, and the fourth, 313 seeds per 5 grams.

†See Ware, "The Sugar Beet."

If seeds are freed of their pericarp, the water absorption no longer remains the same, for under such circumstances the conditions are much changed, and the moisture taken out is very much less, which fact in itself shows the very important role of the outer covering. The differences are still more striking when seeds in their natural condition are compared with those where the pericarp has been partly removed by simple friction between fingers, and finally with those seeds from which the pericarp has been entirely removed. These seeds, after remaining for three days submitted to watery vapor, had increased in weight 23.6 per cent., 15.7 per cent. and 11 per cent. respectively. The time needed for seed to absorb water is very much greater with the pericarp than without it; in the latter case, the total absorption is completed in seven hours, while in the former, at least twenty-four hours are required, from which fact the very important function of the outer covering of the seed is manifest, as the embryo can draw from it its moisture during its early stages of development.

Light.

The principal action of light is after the seed leaves have appeared above ground; this will be discussed under another heading; but as regards the direct action of light, it is not as important as one might suppose. True, with some plants the germination of seed has a certain dependence upon light, but experiments with beet seed show beyond cavil that the differences between the effects of germination in the dark or by a strong light are so slight that they need scarcely be considered. Knauer's experiments upon 100 seeds in light, after 14 days, gave 268 sprouts, and in complete darkness, 262. The same may be said of various colored lights. The germinating power of beet seed varies very much from year to year. Dr.

Bretfeld, in Germany, has compiled some important statistics during 1880-83, which are as follows: 1880, 18 per cent. of the seed did not germinate; in 1881, 16 per cent.; in 1882, 29 per cent.; in 1883, 21 per cent.

Just the time at which seeds have the most of their germs is by no means a settled question. In Kruger's experiments, he obtained the following:

Number of Seed in Germinator.	Number of Sprouts Per Diem.											
	3d	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th
200 large.....	31	191	81	28	5	4	4	12	11	8	7	4
200 small.....	5	87	66	45	26	7	9	3	4	1	0	5

Prof. Nobbe later took up the question and started from the number of sprouts after the sixth day, per 100 seeds. The results offer no special interest other than showing what is already known: That the number of germs varies with the size of seed, for, as Knauer points out, while with 100 large seeds weighing about 4.67 grams, there were 143 sprouts after six days, and 122 after 14 days, or a total of 265; with 100 small seeds weighing 1.44 grams, there were 127 sprouts in six days and 134 after 14 days.

Germinators.

Upon general principles, it may be said that the best results are obtained in germinators where the temperature is kept at about 25 degrees C. This is very difficult to regulate, under which circumstances it is evident that the question of determining the germinating power of beet seed is more laboratory than farm work. However, when the farmer has a well arranged greenhouse, the regulated conditions may be obtained. If only a flower pot, and this be placed in a closet with a few lights constantly burning, the desired temperature will soon be reached, providing, however, that there be sufficient ventilation.

There is a great variety of germinators, only a few of which need here be described. An important fact to keep constantly in mind is, that when comparative germinating tests are made upon seed of the same origin, the difference between the results obtained should never be greater than 15 per cent. after six days, nor more than 10 per cent. after two weeks. The accuracy of these observations does not depend alone upon the selection of the final average sample, but also upon the germinator used; the layers of seed, their respective positions, etc., are all factors not to be overlooked. Long practical experience is necessary before satisfactory results can be obtained, and, if in the hands of a novice, the purchaser and seller may both be at a disadvantage. For sprouting, various mediums are used, of which may be mentioned: Earth, peat, sawdust, paper, and various kinds of sand. For an earth test it is desirable that the earth be of a very light, sandy texture, one that will not cake on the surface by repeated watering.

The advantage of sand is, that it has always about the same composition. Respecting this material, it has been noticed that in comparative germination tests with sand, the number of germs obtained is 15 per cent. higher than in other mediums; hence, the importance of the kind of germinating medium that is used. It is desirable to use fresh sand for each test, or at least to submit it to excessive heat in order to destroy all germs.* The most simple of all germinators consists of a receptacle containing sand saturated with water; as the surface is, to a certain extent, hard, the seeds remain in place when once in position. They should, however, be sunk sufficiently in the medium to disappear from sight.

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* There is a great difference of opinion as to whether seed retains its moisture during two weeks. Bretfeld says it does, while Knauer shows that there is a loss of 2 per cent. In all sand germinators there is always a difficulty in keeping the sand at a standard condition of moisture, say 25 per cent. Knauer recommends that 200 grams—140 c. m. sand, be placed in the apparatus; after shaking, a perfectly horizontal level is obtained; 52 c. m. water are then added.

It is desirable to sprinkle a little dry sand on the surface before placing the seed in position. In this case, about 100 average seeds are used; the receptacle is covered by a sheet of glass and left for about two weeks. So as to obviate the ordeal of counting, a special hand-roller has been constructed by Breuer. By simply using it as one would a blotter of the same shape, 100 depressions are made in the sand, in 10 rows and 10 in each row. The best practice, however, demands that the seed sprouted be constantly removed and the number of days noted; a match stick or piece of wood is placed where the seeds were taken. After the end of the germination period, it is desirable to examine with a magnifying glass the seeds which do not give signs of life, to ascertain to a certainty if this

FIG. 53. Breuer marker.

may be attributed to fraud or accident. Some experts recommend that after counting the sprouts of each seed removed, that they be again placed in a second germinator for another period of eight days; other sprouts will then appear.

In the earth test, square boxes, about 20 c. m. (8 inches) inside measurement, and 10 c. m. (4 inches) in depth, are used; these are filled with earth nearly to the top. On the surface are arranged, parallel to each other, strips of tin 1 c. m. (0.39 inches) in width, the distance between each being 1 c. m. Perpendicular to these are other strips of tin arranged in exactly the same manner, their points of intersection being soldered so that they retain their respective positions. In the openings left, 1 square c. m., the seeds are placed and covered with 1 c. m. of earth, so that the sprouting is done in a medium of 1 c. c. m. The surface is then sprayed with water. The natural advantage of this arrangement is, that the counting of seed offers no difficulty. During the interval of 14 days the seed should be watered three times with an atomizer, it being very important that the soil be not too moist during the test.

The use of a porous terra-cotta plaque, with several parallel openings in the bottom to keep the seed in position, may, for some practical purposes, give satisfactory results; the moisture requisite is absorbed by the terra-cotta from the water in which this plaque is placed. Many of the existing germinators are earthenware; respecting their use, it is considered important not to use them for a second time, as organic substances collect in the pores of the material, which soon become centres of infection; as a result, the seed, instead of germinating, will simply rot. While by heating the terra-cotta plaque it is possible to destroy all germs, the porosity of the receptacle would soon disappear and it would become worthless for the purpose intended.

The Marek germinator consists simply of earthen plates about eight inches in diameter, and one to two inches in depth; they are filled with fine sand combined with 5 per cent. of muddy substance. The surface is moistened, and compressed to one-third of an inch with a special instrument. The surface is divided into regular intervals in two directions, and at the point of intersection the seeds are placed, their number being counted, and then covered with sand falling from a sieve. All sand above the outer border of the plates is removed by running a ruler over its surface; the depth of covering above seed is about one-third of an inch. Great care should be taken to keep moisture within reasonable bounds. The seeds and sprouts are counted as usual after the prescribed interval of seven days.

In France, it is proposed to use porous earthen plates; rich vegetable soil is used as a germinating medium. It appears that earth, such as collects in the trunks of old trees, offers special advantages. The spacing between seed is determined by the use of a wire cloth with 1 c. m. (one-third of an inch) mesh; a seed is placed in the centre. The large seeds are kept separate from the small; these are then covered with 2 to 4 m. m. earth. These dishes are kept in a warm place in the laboratory, and the earth is moistened with rain, or distilled water, at regular intervals.

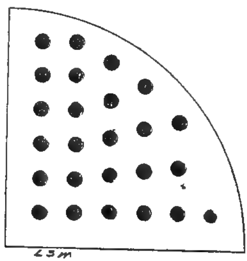

FIG. 54. Arrangement of seed. $6 + 6 + 5 + 4 + 3 + 1 = 25$

It is recommended not to use too much water, so as to avoid mildew.

The Maercker method is also interesting. Ordinary porcelain plates are used; these are filled with calcined sandy quartz, and about 40 per cent. water is necessary for the preparation of the layer, or 100 c. c. for 500 c. c. of sand. The circular surface is divided into four equal sectors, to facilitate the counting. In each sector two rows of six seeds are arranged, and alongside of them other rows containing five, four, three and one seed respectively, or a total of twenty-five seeds for a sector, meaning 100 seeds per plate (Fig. 54).

The seed must always undergo six hours' preliminary soaking. The plates are covered with a wire gauze, then with a sheet of glass, which prevents evaporation, the whole being subsequently covered with an inverted plate. No water is added during the test. It is claimed that this is one of the simplest and best germinators, and gives far more reliable results than the blotting-paper method and has not the inconvenience of the latter, in removing the seed with the fingers; furthermore, the moisture remains nearly constant during the week, which it does not by the paper method.

By the paper method the seeds to be germinated are soaked for six hours in distilled water, then carefully arranged on a sheet of blotting-paper, with the borders turned up. This should be moistened and covered with a double sheet of the same paper, which is also dampened. The seeds with their paper environment are placed in a special receptacle and covered by a sheet of glass to prevent evaporation. After the seventh day the sprouts are counted, and all seeds showing signs of life are removed. Those not germinated are placed for a second time between moistened paper, and after another interval of seven days they also are counted; the sprouts of the first and second weeks give the total for 100 or 200 seeds under examination. Notwithstanding the unpopularity of this method in Germany, in France it has many advocates; so much so, that at the Paris Agronomic Institute it was customary to make tests upon 700 seeds at a time. These were in seven different germinators containing 100 seeds each. The seeds were moistened on filter-paper during twelve hours, then placed in ovens for eighteen hours a day at 20 degrees C. and six hours at 28 degrees C. The average was taken for the whole experiment.

Another very simple germinator (Fig. 55) consists of a porcelain receiver, in which is placed a porous receptacle, R, to hold seed to be tested. The requisite humidity is supplied by filling W with water. The carbonic acid formed during germination, which, if permitted to remain, would retard the action sought after, is absorbed by caustic potassa placed in cups, P The cover, C, does not prevent fresh air from entering to supply the requisite oxygen for the development of the germ. The temperature of the seed is determined by a thermometer, T, placed in the centre of the cover, and kept in a vertical position by a cork. After a few days have elapsed, the germination is complete.

The Pagnoul germinator consists of a tin box, twenty-six inches long, eight inches high and 5½ inches wide, covered with another box of the same kind, twenty-seven inches long, eight inches wide and 1½

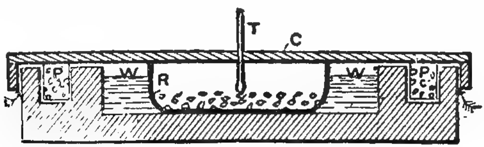

FIG 55.

inches high. The bottom of the latter has five openings three-fourths of an inch in diameter, upon which are soldered tin tubes six inches in length. In these tubes are placed moistened cotton cords, which hang down into the water of the box beneath. In the upper box, over the end of the cotton wicks, about three-fourths of an inch of sand is placed. It is evident that the sand remains constantly moist, owing to the capillary attraction of the cotton.

A thermometer is placed in the centre tube; the other four are covered by tin frames six inches long, 5½ inches wide and 1½ inches high. Under each of these the seed to be tested are placed. The frames last mentioned may be covered with a sheet of glass, permitting the progress of the germination to be watched.

The advantage of this arrangement is economy of construction, and the sand remaining constantly moist, the seeds do not require watering. The only precaution necessary is, that the water in the lower tin compartment never be allowed to entirely evaporate. If the ambient temperature is lower than 50 degrees F., a lamp or candle would keep the water at the desired temperature. When the seeds to be tested are planted, the date, etc., are recorded. After four days the number of seed having germinated is counted. The operation lasts about twelve days, and all seeds not having then given signs of life are considered worthless. Insects soon attack beet seed if germination is too slow.

The Michel germinator consists of a square zinc box about eight inches long and 1¼ inches high. In this box is placed a plaster slab resting on four short feet; on its upper portion are sixteen parallel ridges, in which are placed the seed to be tested. The cover, also of plaster, with a central hole, is used to protect the slab against light and too rapid evaporation. The slab, owing to its porosity, absorbs sufficient moisture for the germinating test.

The Israél germinator has also some advocates; it is a zinc box about three inches in length, eight inches wide and five inches high, and is covered with glass. In this box are several—three to six—germinating boxes, on the bottom of which are strips of some woolen material for the absorption of water; these hang over the boxes, absorbing water at one end and dropping it out at the other; by reason of the siphonage, the seeds are thus kept constantly moist.

A fact not to be overlooked is that, notwithstanding all the precautionary measures taken to procure an average sample of seed, and submitting it to germinating tests in germinators placed side by side, there will be a variation in the number of sprouts after the fifth day of about 15 per cent. and a final variation of 10 per cent. at a maximum.

One fact is certain: There is a great need of some uniformity in these germinating tests, and notwithstanding all possible care given to the subject, the dealer is frequently at a great disadvantage. Dippe, of Quedlinburg, calls attention to observations made on his seed in Germany; when tested at Veffingen the result was 132 per cent.; at Brunswick, 178 per cent.; at Halle, 222 per cent. The same variations were noticed in percentage of moisture. We maintain it is urgent that purchasers keep their seed under the most desirable condition for preservation, as to heat and moisture. One of the most recent innovations in the way of germinators is a method of heating for eight hours a day, at a temperature of 28 degrees C. This is supposed to have the same effect as would light upon the germ development.

Mistake in Using Number of Seed in Germinating Tests.

Beet seeds are not sold according to number, but by weight; hence, the reason why germinating tests should be conducted on this basis. A great objection to conducting these tests upon 100 seeds rather than 100 grams is, that the tendency always would be to select only the largest and best seeds, and the results obtained would be very misleading, while by weight all seeds, regardless of size, etc., are submitted to the germinating test. It is customary to count the number of germinating sprouts in beet seed; but this leads to erroneous conclusions, for one seed gives several sprouts. What farmers most wish to know is, the chances of a given weight of purchased beet seed appearing above ground after once planted, for if one seed gives many sprouts only one is allowed to remain.

Consequently, it is essential to know the number of plants it is possible to obtain from a given weight of seed, and the number of seeds, simple or complex, that will germinate in 100. One would be led into considerable error if the number of sprouts alone were taken as a basis. For example, in 100 grams of ordinary seed there are 5250 separate seeds, and if each of these gave only one sprout the outcome would be 5250 beets, providing all conditions were favorable. M. Pagnoul takes an interesting example from every-day practice, based upon the supposition that a seed dealer has mixed 50 grams of fresh-selected seed of the best quality, with fifty grams of inferior old seed. In fifty grams of good seed there are about 1750 seeds, and if each of these gave three sprouts, we would have 5250 sprouts, or the number that would be acceptable. We may suppose that in fifty grams of old dead seed there are 3500 individual seeds that will not sprout, and yet this total, 5250 sprouts, after germination tests, would be most satisfactory. As only one plantlet is allowed to remain by practical experiment in planting, one would get 1750 beets instead of 5250, as expected. Consequently, if seed-testing stations accept the sprouting as a basis, they encourage fraud by the seed dealer, who will resort to a much-abused practice of mixing old seed with new very much under the conditions just described.

CHAPTER IX.

Preparing the Seed before Sowing

Seeds in their normal state fall to the ground after a reasonable time subsequent to maturity. They remain in a sort of dormant state; having outlived the variations of the weather, they give signs of life as soon as the favorable season returns. If we compare these seeds with those gathered and dried, the time needed for their germination in soil would necessarily be greater; the interval allows weeds, insects, etc., to take advantage of the circumstance. Hence, the importance, in most cases, of artificial means to stimulate the growth. As the exterior coating of the seed is frequently hard, some recommend a rolling between boards, which not only separates the seed, but allows the natural moisture of the soil to more thoroughly assist the embryo in its development. Practical experiments show that 100 seeds that have been rubbed on a board by simple hand pressure gave 230 germs, while those planted without having been thus prepared gave only 200 germs. Submitting seed for twelve hours to an air bath of 40 to 50 degrees C. had about the same effect as friction.

A certain amount of moisture is necessary, and if this can be given to the seed before sowing it will be that much time gained. If seeds are left for too long a period in water, much harm will follow, as the essentials for development during plant growth would be dissolved. Furthermore, there is also danger of very great evaporation when sown in dry soils, which soon absorb the moisture from the seed and after first sprouting, during a period of drouth, the embryo perishes. Special stress must, however, be given to the importance of steeping the seed in water when the sowing has, for various reasons, to be done very late in the season, which operation helps to regain lost time.

During 1894 to 1897 there appeared only one important method for preparing seed, and this was Jensen's hot-water method. Seeds are steeped during six hours in water at the ordinary temperature; they are then taken out and left for ten to twelve hours, when they are steeped for from five to fifteen seconds in water at 53.5 degrees C. This operation is repeated thirty times in five minutes; the seeds are then rapidly cooled and dried. While the method does increase the germinating power, Dr. Hollrung shows that it offers no advantage over cold water. Furthermore, it is demonstrated that after 50 days, seeds prepared in hot or cold water, if not done to excess, are in exactly the same condition as they were prior to steeping. On the other hand, it is not desirable to have too rapid growth, and the practical farmers with whom we have discussed the question declare that there is nothing to be gained by seed preparation, as the forced plant is more delicate and is destroyed by any climatic change. However, where steeping is practiced it is desirable to get rid of the excess of liquid absorbed by the seeds which remained in water for several hours; they may be rolled in plaster or ashes. Sowing can take place after a few days; a certain precaution must be taken so as to prevent one seed becoming attached to another, also that the plaster be not used in excess; otherwise, the ultimate germination would be impossible. From the plaster in a dry state it has been suggested to use it as a liquid; two pounds of plaster combined with two quarts of water for four pounds of seed is said to give excellent results. In practice, about thirty pounds of seed are prepared at a time; they are subsequently left to dry after being spread on the floor. By turning them over several times during the day, they will not adhere to one another.

The plaster method has undergone certain variations. When prepared on a larger scale, about 200 lbs. of plaster are diluted in twenty-six gallons of water, to which are added 100 lbs. of Peruvian guano; 250 lbs. of seed are rapidly combined with the product, precaution being taken to thoroughly mix the mass. The seeds are then spread out to dry. It is claimed that the vegetation will be considerably accelerated. There need be no apprehension of the seed being attacked by mice; the outer shell, or covering being well filled, there is no danger of holes, etc., offering shelter to insects, which, under ordinary circumstances, is too frequently the case. The question arises, What were the actions of the sulphuric acid? Practical experiments appear to point out that caustic lime combined with eight times its weight of water will destroy the germinating power of seed.

Pagnoul has shown that sulphuric acid diluted in sixteen parts of water has a beneficial effect upon germination. Chloride and superphosphate of lime have also been tried, but it appears that the chlorine took an active part. As Humboldt and others have proven that the germination of steeped beet seed is accelerated by the action of that chemical, the rule appears to hold good, even for old seed; sixteen parts of water and one part of hydrochloric acid slightly decreases the germinating power. If the water is only acidulated with the acid, the contrary is the case. Nitric acid, 1-100 solution, prevented three-fourths of all seed planted from germinating. All seeds, even after twenty-four hours in the above solutions, retained their germinating power; furthermore, it is maintained that the sprouts were more hardy than if they had been steeped in pure water.

It has been proposed to use sulphurous acid and chlorine to hasten germination; great care is necessary in order not to destroy the germs. Hot, moist air is used, under which conditions the chlorine appears to oxidize the sulphurous acid, with formation of sulphuric acid and hydrochloric acid, which, in turn, would attack the vegetable fiber unless great precautions be taken. It has been shown that sodic carbonate and sodic nitrate, or even sodic sulphate, in one-eighth solution, are not desirable stimulants.

Boettger has declared that germination is considerably hastened by steeping the seed in weak solutions of soda, potassa or ammonia; in fact, two degrees Bé solution of ammonia sulphate resulted in 71 per cent. of seed germinating in a week; possibly the ammonia from barnyard manure has a like effect. On the other hand, ammonia carbonate in one-eighth solution destroys completely the vitality of the seed; with a solution of 11 per cent. chloride of sodium the stimulation was no greater than it was with distilled water. Alum appears to be favorable to germination. Pagnoul experimented with the following substances, all considered separately: Phenic acid, 0.2 per cent.; potassic arsenate, 1 per cent.; zinc sulphate, 2 per cent.; sulphate of copper, 2 per cent.; also with magnesia sulphate, 5 per cent. in 100 parts water; with the last the best results were obtained, the steeping lasting only five minutes.

With 5 per cent. chlorate of ammonia.
77 out of 100 germinate in........................15 days.
39 per gram " " .... "

Saltpeter is highly recommended by some experts, as 85 per cent. of seed germinated in a week. Of the metallic salts which appear to influence germination, white sand, if mixed with 10 per cent. ferric-sulphate, will completely destroy the vitality of the seed; even 2 per cent. had an important influence, which disappears entirely when only one-fifth per cent. is used.

We would say, respecting these chemicals, that, even admitting that certain advantages are to be derived, they are hardly within easy reach of the average farmer. We believe, all facts considered, that if seed be steeped in equal volumes of water and urine for about thirty hours, then piled up on the floor and covered with defecation scums, satisfactory results can be obtained. The addition of a few drops of mineral oil to keep off insects, may have its advantages. The effect of the urine appears to stimulate the growth of the leaves; however, the question is not at present entirely settled.

The preparations existing on the market for the stimulation of germination, quality of roots, etc., are, on the whole, very worthless, but are interesting from a scientific point of view. Many claim that the preparation of seed results in a decrease in the saccharine percentage of the resulting roots; with urine the reduction is 0.4; potassic carbonate, 0.25; a mixture of saltpeter and potassic carbonate, 0.5. On the other hand, Russian experiments show that there is an increase of 0.4 per cent. with superphosphate and an increase of 1.20 by the use of sodic nitrate in the preparation.

The Dippe prepared seed attracted some attention, but from experiments of Breim it was discovered that the preparation was ammonia sulphate and a phosphate; the latter used to furnish plant food as soon as the sprouts appeared. The Hodek method was to steep the seeds in warm water 30 to 40 degrees C., and adding 2 per cent. phenic acid; such seed must be soon planted to avoid complications.

Experiments with other methods of preparing the seed are most interesting, viz.: Covering them with a weak solution of glue, and putting them into a fertilizer, so that the latter adhered to the outer surface of the grain. There can be no doubt but that this process diminishes the number of germinating seed and retards germination in general. The complete covering of the seed with an artificial fertilizer results in an increased development of leaves. It is thought that the elements of which a fertilizer, or liquid in which the seed is steeped, is composed should be of the same nature as the food of the seed itself.

Respecting this question, we can pass in review the Ladurean experiments upon five lots of Vilmorin

1st	Water	10 liters.	15 hours.
	Ammonia sulphate	5 kilos.	
	Seed	2 "	
2d	Water	10 liters.	15 hours.
	Sodic nitrate	5 kilos.	
	Seed	2 "	
3d	Water	10 liters.	5 hours.
	Superphosphate of lime	5 kilos.	
	Soluble phosphate	12 per cent.	
4th	Water.	10 liters.	
	Sulphate of ammonia	5 kilos.	
	Superphosphate of lime	5 kilos.	
5th	Water	10 liters.	
	Sodic Nitrate	5 kilos.	
	Superphosphate of lime	5 "	

seed. In all cases the beets appeared above ground at about the same time. The resulting beets from these seed were analyzed, and as a result, it was shown that those roots from the fifth parcel, having in the early stages of development soluble phosphoric acid, nitric acid and soda; in other words, the three elements that beets assimilated with the greatest ease were the best for sugar making. It was further noticed that those roots which had soluble phosphoric acid at their disposal during their early stages were the best, consequently the practice of using this preparation is highly recommended. It is able to furnish nourishment during the period of transition from seed to root. It is well-known that those fertilizers which have combined in them Peruvian guano and bone superphosphates, with ash rich in potassa, etc., give excellent results. Many advocate the sowing of seed which have been previously sprouted.

The preliminary operation for sprouting consists in soaking the seed in warm water for twenty-four hours, then drain and stir the saturated seed three or four times a day; in four days the sprouts will be visible. They are then ready for sowing. If the weather does not permit such preparation, they are in the meantime placed in thin layers on marble slabs in a cool place. The object of this is to retard sprouting. The seed, when sown, appear above ground in about five days, if the temperature is favorable. Evidently under these conditions, the plantlets are sufficiently large to resist the ravages of insects. As regards the sowing of sprouted seed, it may be of interest to call attention to the slight depth, not over one-third of an inch, at which it should be placed in the soil. The farmer should keep before his eyes the following advice, given by the editor of *The Sugar Beet*: "Plant your seed early; use your own judgment regarding the possibility of a frost. If the latter has not to be contended with, the resulting roots will be much benefited, as they will have had a longer period of growth, thus permitting their complete maturity. If a cold snap should destroy your early crop, sow the second time, immediately; the loss then will be of your seed only. If this precaution be not taken to save the cents, you will lose the dollars."

The dangers to the entire crop from a continued dry spell, subsequent to sowing, are less for prepared seed than for that planted by the customary methods. In one case, the soil during the early growth, say for at least ten days, is sufficiently moist to permit the ascending sprout to appear above ground; while in the other, often intervals of eighteen days will result in a surface crust which the young sprout cannot penetrate.

Beet Seed Sowing for Sugar Factories.

The time of sowing depends upon the country. Where the seeds are planted in Europe this is done between the middle of April and May, when possible, in March. This period gives the beets plenty of time for their development before harvesting. In California the factories work at a different period from anywhere else in the world, hence the time of planting also differs. There, the climate being mild, the period of sowing is not the same as in Nebraska, for example. In California the time of planting is from January to June; while in Nebraska, April 15 to May 20; New York, May. The possibility of early frost should never be lost sight of; when it is contended with, a second sowing should be made without loss of time. We, for many years, were not in favor of the principle, but we have concluded that it is better to lose the seed than to lose the crop for that season.

From a technical point of view, Walkhoff's idea of determining the most desirable time for sowing, by making several observations as to temperature of soil, offers advantages. In France, an average mean of 6 degrees C.* (42.8 degrees F.), at a depth of about three inches, is considered an excellent guide; for the young root would have reached that depth the tenth day after sprouting. The question of preparing the seed prior to sowing has been discussed previously. No question has been more urged during the past twenty years than the importance of not economizing the seed. Notwithstanding this, circular after circular is sent to farmers, by those who should know how to look after their interests better than they do, by recommending ten pounds to the acre, while in Germany, forty pounds is not uncommon; however, we repeat here what we have constantly asserted, that twenty pounds is a safe average. The mechanical spacing between lines leads to far better results than if the so-called thinning-out method be adopted.

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*What we wish to convey by average mean is the average of observations taken morning, afternoon and evening:

Supposing at....	6 A. M.	36°F.
	12 P. M.	48°F.
	6 P. M.	42°F.
		126°F.

The average mean for the day is $\frac{126}{3}=42°F.$

Sowing broadcast has now been generally abandoned for regular beet cultivation. However, when transplanting is considered, this method offers special advantages. During the early part of the present century, Mathien, Dombosle, Gasparin, and others, advocated this method, as it gives a longer period for the plants' development, and we have frequently pointed out this advantage. Some experience is required. The transplanting should be done on a cloudy, damp day; if not, the roots must be watered with a weak urine solution. Several days may elapse between the time the young roots are taken from the ground and transplanted; it is important, however, to keep them in earth, with a small quantity of salt, in a vertical position. A hole is made in the ground, at a position determined by strings, which cross at mathematical intervals. It has been proposed to use a special appliance known as a transplanter.

The most simple of all methods is to make a cut in the soil with a spade, and the soil is then closely pressed with the foot,—or in hills made by two plows; precaution must be taken to keep the neck well above the surface. It is generally found desirable to cut off the small, outer leaves, for these generally wilt and perish after the transplanting, under which circumstances they would interfere with the healthy development of the young root. The enormous yields obtained by Koechlin would tend to show that there may be some very practical advantage, for he obtained sixty tons per acre. In this case, the seed for the same were sown broadcast in January, and transplanted in April. It is claimed, that under these conditions the annual beets are avoided, and that the roots obtained are so hardy that they can resist almost any variation of temperature. It is further maintained that the extra expense of the method is not as great as one might suppose, for the work can be done in January or February, when most farming hands have finished at the factory.

However, there is much to be said against the method, unless it be in cases of seed production, and then the advantages are very numerous. As during the transplanting, the tip end of the beet is left in the ground, the chances are, as the roots develop in their new environment, they will be forked. Another fact to be considered is, that transplanted beets are very hairy in their nature, which, in the end, means expansion without depth, and decreased sugar percentage.

What appears, to us, to be the principal role in this question of transplanting, is the possibility, when growing beets in the regular way, of filling open spaces, and many farmers place one-tenth of their entire field with beets which are to be subsequently used for this special purpose. On the other hand, many claim that this is unnecessary, for during the operation of thinning out, there are always more beets left over than are possible to utilize. This would be a mistake, for the thinning operation should be done rapidly.

The hand sowing, at marked places on the field, in which are placed several seed, is not to be recommended, on account of expense. It has been shown that machine-sown seed always give better results than hand methods, it being more regular in its working; the depth, etc., being more constant. The seed drills, which work at regular distances, and by clusters, are only in a measure to be recommended. The objection to them is, that if the lines are eighteen inches apart, and spacing of beets in lines ten inches, if one of these clusters is attacked by insects, there remains a space of twenty inches on the line, which would mean very large beets, and small sugar percentage. Upon general principles, it is very doubtful if the cluster method of sowing is ever to be commended; for the thinning-out that follows necessarily weakens the surrounding soil of the plantlet that remains. Far better sow in lines and space mechanically; great care must be taken to keep the roots in very straight lines; a practice difficult to convince our American farmer.

We shall later discuss the seed-drill question. Seed may be planted in three positions: Squares, lozenges, and rectangles The engravings (Figs. 56-59) give the reader an idea of the amount of space lost by each method; the space lost is less in Fig. 56 than in the other cases, the circle representing the limit that

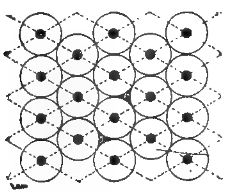

FIG. 56.

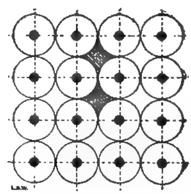

FIG 57.

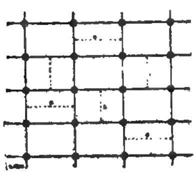

FIG. 58.

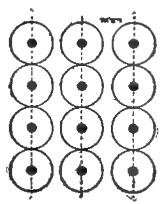

FIG. 59.

each beet may draw its plant food from the soil. The square method may be used in certain cases, as for seed production on the Legras farm, but for American growers it would be too expensive; the rectangle method is preferable. Upon general principles, it is better to have not less than sixteen inches.

It has long ago been demonstrated that both the farmer and manufacturer have advantages in planting the beets as near together as the nature of the soil will allow. Great distance tends to increase the size of the beet, and diminish its saccharine quality, while on the other hand, the nearer together the roots are, the more numerous they are, on a given area, and their total weight per acre is not much inferior to that obtained with greater distance. The importance of keeping the roots with the least possible space between one and another was a question insisted upon nearly 100 years ago, and since then each country has taken up the question in turn. In France, the Pellet experiments

Distance Between Rows.	Weight of Roots.	Sugar Per Cent.
20 c. m. (7.9 inches)........	354 grams (12.4 oz.)	14.2
30 c. m. (11.8 inches).........	460 " (16.1 oz.).	14.7
60 c. m. (23.6 inches).........	1,200 " (2.6 lbs.)	13.6

On the other hand, Pagnoul arrived at similar results.

Distance Between Rows.	Distance Between Beets.				
50 c. m.	33 c. m.	1.	830 grams.	9.5	Yield sugar per acre..3,000 lbs
		2.	800 "	10.2	Salts absorbed.........0.76 %
33 c. m.	25 c. m.	1.	701 "	10.	Yield sugar per acre..4,400 lbs.
		2.	490 "	13.3	Salts absorbed.........0.6 %

The most important series of investigations yet made respecting spacing are those of Petermann (Belgium).

The experiments were about as follows:

Variety of Seed,	1st Series.		2d Series.		3d Series.	
	45 c.m. x 30c.m. (17.7″x11.8″) Yield Hectares (2½ acres).	Sugar in 100 c. c. Juice.	40 c. m. x 25 c. m. (15.7″x9.8″) Yield Hectares (2½ acres.)	Sugar in 100 c. c. Juice.	35 c. m. x 18 c. m. (13.7″x7″) Yield Hectares (2½ acres).	Sugar in 100 c. c. Juice.
Breslau.........	37 tons.	10.96	47 tons.	11.30	46 tons.	11.60
Rose Neck.....	41 "	10.00	47 "	11.00	45 "	10.80
Vilmorin seed.	30 "	13.64	32 "	13.88	32 "	14.93

with Vilmorin seed showed that at 7.9 inches between rows the beets weighed 12.4 ounces and contained 14.2 per cent. sugar, while at 23.6 inches they weighed 2.6 lbs. and contained 3.6. From which it may be concluded that the best results are at 15.7 x 9.8 inches; less than this is not desirable. Schultz (Germany) claims that the best results are at distances of 14.4 inches between rows and 12 inches spacing of roots in rows. One fact is certain, that if only 13.7 inches are between rows and seven inches between beets, most of the agricultural implements now in existence could not be used. Consequently, upon general principles, it is desirable to adapt one's self to local conditions, arranging so that an average cart can have free circulation between rows. If beets are in any way bruised there is sure to follow a loss of sugar.

It is claimed that beets cultivated near together have greater maturing powers than those far apart, and that they are better able to resist the prolonged drouth. It is very essential under such conditions that the soil be worked at a considerable depth. It is self-evident that when fertilizers are used their assimilation by the plant during its development must necessarily be greater at short than at long distances. During the latter condition, the drainage soils carry off a large portion of the plant food, producing material effects upon the root. Realizing the importance of cultivating beets close together, the manufacturer frequently offers prizes,* the value of which varies with the number of plants obtained to the acre. In theory, it would be possible to calculate the amount of seed required, but the results obtained would be very misleading.

Some German experiments show that the coefficient of purity increases by planting near together. The experiments were:

	18x16 Inches.	12x12 Inches
	C. P.	C. P.
No. 1	89.1	90.4
2	86.9	90.3
3	85.4	88.6
4	86.1	87.2
5	85.9	88.6
6	82.9	88.2

The fertilizers were made to vary on each patch; for example, in No. 1 Record there were 12.8 lbs. nitrogen in the form of sodic nitrate, and 51 lbs. phosphoric acid,

*For example :

For 30,000 beets to the acre	$0.25 per ton
" 40,000 " " "	0.40 " "
" 50,000 " " "	0.60 " "

while No. 6 had 76.8 lbs. nitrogen and 115 lbs. phosphoric acid. An interesting conclusion respecting these results is, that by planting near together the bad effects of sodic nitrate, when used in excess, may in a measure be overcome.

The sixteen to eighteen inches between rows and ten-inch spacing in rows appears to be the most favored among Continental beet farmers of Germany, Austria and France. This arrangement allows about nine beets per square yard, or one beet per square foot, corresponding to nineteen to twenty tons to the acre, supposing each beet weighs one pound. When efforts are made to obtain ten to twelve beets upon the same area, the results are not, as a general rule, very satisfactory. The idea of 16 x 16 inches, so as to allow a thorough working between rows by use of the cultivator, would result in large roots, but of a doubtful quality. When it is desired to have only five to six beets per square yard, under almost the conditions just mentioned, the best results appear to be obtained with 15.7 x 16.4 inches.

Germination in the Soil.

In previous pages we have mentioned the fact that from the time the seeds are placed in the storerooms to dry, etc., until they are planted, they remain in a condition of torpor, from which they awaken as soon as they are placed in the proper environment for exciting a return to their former vitality. The germ and its requisite food are made visible under the microscope. When the three requisites, air, moisture and heat, are furnished, the white point, showing the first signs of life, soon finds its way through the pericarp. The age of seed has a very important influence upon the vitality; a few words respecting this question are of interest.

Mr. Fred Knauer has made some interesting experiments in this direction. Eight beet seeds of average size, from a factory in Poland, collected in 1846; after an elapse of 37 days, one plant appeared above ground, after five months there were ten. From these experiments, it is concluded that seeds retain their germinating power during a very long period, but they require considerable time to waken from their long torpor; even after two years, this tardy germinating tendency is evident. On the other hand, Marek has made a series of very important observations.

Age of Seed.	Number of Sprouts per 100 Seeds, 14 Days.	Number of Sprouts per Kilo.	Value of Seed. Normal is 100.
0 year	158	66,700	100
1 "	174	63,600	100
2 years	150	56,400	100
3 "	131	51,685	97.7
4 "	146	68,731	100
5 "	135	63,800	100
6 "	124	54,846	97.5
7 "	112	47,466	94.9
8 "	101	43,773	75.5
9 "	88	27,200	54.2
10 "	95	33,600	61.0
11 "	34	15,250	34.5

From this table we realize how important it is not to use seed over five years old, for after that age their deterioration is rapid, notwithstanding several assertions to the contrary mentioned elsewhere.

Moisture.

Without moisture, germination is impossible, and with an excess there are other difficulties to be dreaded; opinions very much differ as to the advantage or disadvantage of having the moisture on the surface or at some inches below. If the soil is perfectly dry, the seed remains dormant. On the other hand, if there is a natural moisture, germination will commence, and if there be a sudden change in weather, there are dangers of a complete destruction of the young plant during this embryonic development. These difficulties may, in a measure, be overcome by a preliminary preparation of the seed, in which case the soil with natural moisture gives the best results. Even in cases of prolonged drouth, in the several inches of soil through which the ascending sprout has passed, there will be found sufficient moisture for the requirement.

Many of these difficulties are overcome by a thorough working of soils intended for beets. The ambient temperature has a great influence on the amount of moisture a soil retains; while the actual temperature beneath the surface is lower than in the air, the difference is not as great as might be imagined. However, experiments have been made in this direction and we can conclude that during twenty-four hours at 73.5 degrees F., the surface will have lost one-fourth of its total moisture; after the second day, the drying process will have extended to a depth of one-tenth of an inch. Consequently, if seed be placed in the ground at a depth of one to two inches, depending upon the texture of the soil, during an unusual dry spell, it would not penetrate to the strata where is lodged the seed during the first ten days after sowing.

Briem's experiments on moisture of soils are important. He used two kinds of seed, one dried in the air and the other steeped in water; his results were as follows:

Moisture of Soil.	Days Before Appearance Above Ground.	
	Normal Seed.	Prepared Seed.
22.3 per cent.	0	
19.7 "	11	
17.1 "	4	
15.0 "	5	
12.8 "	4	6
11.8 "	5	4
9.9 "	5	4
7.3 "	8	4
6.2 "	15	6

From these experiments it is concluded that if the soil contains 22 per cent. of water, germination is not possible; from 19 to 20 per cent., very slowly; from 7 to 17 per cent. of moisture, the soil appears to be in the best condition. Below 5 per cent., germination is impossible, unless the seed has been previously prepared, which again shows the practical advantage of steeping seed.

The experiments of Schultze-Fleeth, as regards the power of absorption of soil,* are as follows:

100 lbs.	Absorb lbs. Water.	Lose in 4 Days at 65.5° F. % of Water.
Sand	25	88.4
Clay	40	52.
Pure clay	70	31.3
Fine calcareous	85	28

We cannot conclude from these data that the time and manner of sowing must depend upon the soil being used and the country where this special cultivation is practiced. If there is danger of abnormal heat during the first few weeks after sowing on sandy soil, the operations should be conducted as rapidly as possible. Herein is one of the important reasons why fall plowing is preferable to spring plowing, for the rains just before winter saturate the soil with moisture, and this surface is turned under. The ice and snow form a covering and the moisture is retained until the sowing period comes around, leaving at the same time, air passages, a condition essential for healthy germination.

Heat.

Which, in other words, means life. Just as the luxuriant vegetation of a tropical clime differs from the northern regions of our planet, so does the change of season affect plants. The sap that had gone into the roots now returns to give the new life to that portion which had remained dormant during several months. The hand of man in this question can help nature. By many authorities it is admitted that 130 degrees C. (266 degrees F.) are needed for seed to germinate in the soil. However, this must not be taken to the let-

*The soils of Chino, California, have considerable moisture at a great depth; the roots in that dry climate, in search of the moisture, need to penetrate several strata and are very elongated and rich in sugar. On the other hand, soils near Lehi, Utah, are irrigated during the early stage of the beets' development, and very satisfactory results are thus obtained.

ter, for practical experiments show that when the ambient temperature remains at 48 degrees F., about twenty days are needed for seed to appear above ground. While, on the other hand, at 63 degrees F., the rows are distinctly visible in about three days. Consequently, on general principles, it may be admitted that the rapidity of germination is in direct ratio to the ambient temperature.

It is claimed that in preparing beet seed, it is possible to give a certain number of degrees of heat in advance, and in connection with this matter, there would be a gain in the number of days for sprouting.* For soils in general, the requisite time for germination may be considered inversely proportional to its temperature. The cold has an important effect, and an early frost will kill the germs of a large number of seeds planted; hence, the desirability of being very liberal with the quantity of seed used. It is admitted that germination ceases at about 3 degrees C., or at a maximum, 30 degrees C. The heating and cooling of soils during the spring of the year has an important influence not to be overlooked. The warmth during the day and the cooling at night are said to have an accelerating effect on germination. It must be thoroughly understood that the action of low temperature on beet seed is very slight, providing germination has not commenced, and is very destructive after the first signs of life have manifested themselves. The best authorities admit that seeds germinate under the best conditions

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*If seeds, for example, remain two days in a liquid at 22.5° C., the total heat thus given would be 45° C.; the remaining number of degrees to be furnished then becomes 130° C.—(minus) 45° C.=85° C. If during draining of seed the ambient temperature is 15° C. the heat left to be furnished would be 70° C. If the temperature of the soil is 10° C. and remain constant, then germination would take place $\frac{70}{10}$ or seven days. If there had been no preparation, the number of days for germination would have been $\frac{130}{10}$=13 days. The preparing of seed has thus been a gain of six days.

when the average temperature of the soil remains about 7 degrees C. (37.6 degrees F).

Air.

When we consider that nearly one-fourth of the total vegetable earth is air, it becomes evident what an important role air plays. Therefore, certain precautions must be taken to sufficiently work the soil, so that the air circulation is not too free, as it would soon evaporate all the moisture, and thus do more harm than good. Evidently, without oxygen, seed cannot germinate. During the action of heat and moisture, life cannot exist unless there is oxygen to help the plant; during its feeding process the albumen at the disposal of the germ cannot undergo the requisite transformation. That certain microscopic organisms help this transformation, there is not the slightest doubt. Moisture carries these ferments into the centre of the embryo and the action of the diastase completes the first stages of plant development. Experiments have been made with the view to substituting other gases for air, but they led to very secondary results.

Light.

As soon as the young leaves appear above ground, light has an important part to play. The chlorophyll then brings about the interchange of certain gases, and, furthermore, helps to decompose or to transform those elements of which the vegetable organism is made up. These chlorophyll granules, which consist of green-colored protoplasm, bring about these changes which result in starch formation, which will be subsequently distributed through the root. The chlorophyll, separating the carbon from the carbonic acid taken from the air, liberates the oxygen absorbed and supplies the carbon to form a carbohydrate, such as starch, by combining with the hydrogen and oxygen of the water of the soil taken up by the rootlet. It must never be overlooked that these transformations cannot occur unless the plant be supplied with iron. We all know, also, that with the absence of light the chlorophyll pigment is not formed. It is interesting to follow the plantlet from its very first appearance above ground.

Growth of the Planted Seed.

The seed of the sugar beet, if placed in the ground under favorable conditions (heat, air and moisture),

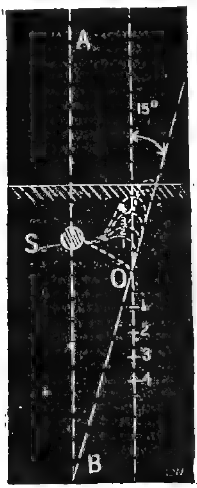

FIG. 60.

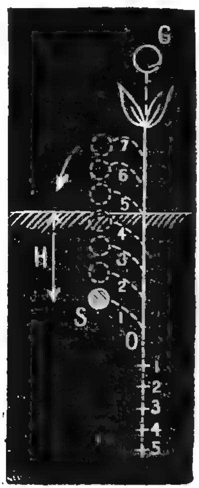

FIG. 61.

germinates; the outer or harder portion becomes softened, and thus permits the penetrating of the descending root, which shoots in a given direction until it reaches O (see Fig. 60), from which point the ascending root becomes apparent. The latter diverges at an angle of about 15 degrees, while the former continues in its downward course, the growth upward corresponding to it. If the depth, H (Fig. 61), at which the seed has been planted, be not sufficient, or if the soil be too loose (which is the case when proper rolling has been neglected), there will be a considerable change when O is reached.

Instead of the seed, S, remaining underground and the ascending root gradually finding its way upward, as in Fig. 60, the seed will be carried upward and occupy the various positions, one, two, three, four,

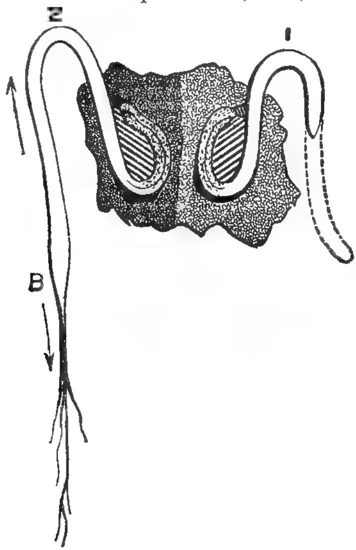

FIG. 62.
Diagram shows two germs on the same seed which have sprouted on different days.

etc. When gravity does not separate the hard covering from the plantlet, it will still adhere, as shown in G; under these circumstances, the plant generally perishes. If we examined even more closely, we could follow the development of the seed leaves.

Nos. 1 to 5 (Fig. 61) show five positions of the growth of the ascending and descending root; the seed leaves remain wrapped around the albumen, so-called, which furnishes the nutritive matter the plant requires during these first stages of growth. The root absorbs water and the dissolved mineral substances of the soil. This water reaches to the cell of the leaves; in its passage it passes from cell to cell and along some of the

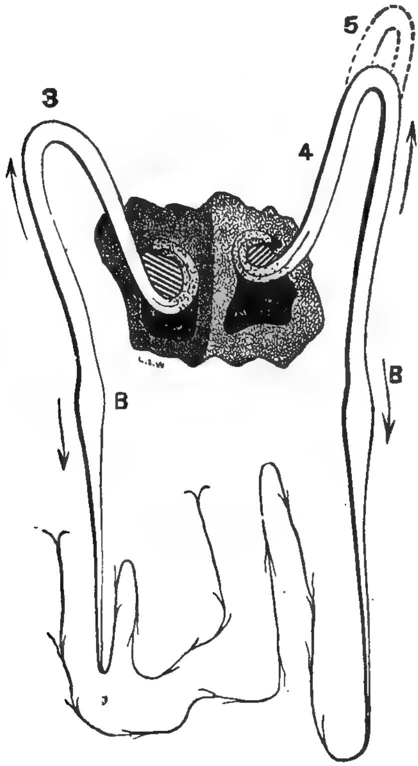

FIG. 63.

tubes of the vascular tissue. During this upward motion, it meets starch, which is traveling downward. Under the influence of protoplasm, in some way or another, nitrogen is formed, from which, with sulphur and the starch constituents, albuminoids are produced.

These are essential for protoplasm development, of which the plant cells are made up.

The seed leaves, as shown in Fig. 61, penetrate the surface soil doubled, and have a natural tendency, in consequence thereof, to rotate with some force,—to assume an upright position. This seems to be assisted by the inclined position of the ascending root. The seed leaves then have not yet opened. This takes place in two ways: Either directly, as shown in Fig. 65, or as in Fig. 66, where they are at first convex, and assume their natural position after some days.

Interesting experiments to determine the most desirable depth at which to plant beet seed have

FIG. 64.

FIG. 65.

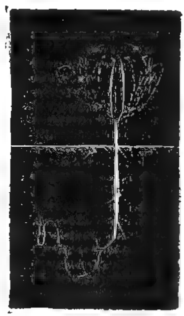

FIG. 66.

resulted in some practical facts; among these we may mention, that seeds were planted to a depth of three inches, and uncovered after 200 days. As soon as exposed to the air they gave evidence of full vigor. In most cases, however, when the soil was damp, germination took place at this depth; but these germs being unable to come to the surface, died, never having gone beyond the first stage of their existence.

It is evident that if the seed be at too great a depth it cannot reach the upper surface. After an interval of time, if the resistance to the ascending shoot is overcome, as it has been retarded in its development, it will frequently perish. And yet, when too near the surface it will be exposed to the variations of the weather. Hence, the importance of some approximate idea of just what the most desirable depth for planting should be. No definite rule can be given, as it varies with the climate and soil, and in many cases should be determined by practical experience. Groven's experiments give some idea of the variations in the number of plantlets appearing above ground after a period of days and at various depths.

Depth of Planting.	First Plants Made Their Appearance	Number After 8 Days.	Number After 16 Days.
0.39 inch.	5 days.	19	24
0.78 "	5⅓ "	14	21
1.18 inches.	5½ "	15	23
1.57 "	6½ "	15	17
1.97 "	6¾ "	8	18
2.76 "	8⅔ "	4	14
3.54 "	10 "	1	7

He, therefore, concluded that about one-half to one inch was the best depth. On the other hand, Walkhoff took up the subject and concluded that if we admit that the soil has a temperature of 15 degrees C. (59 degrees F.), the number of days for seeds to appear above ground at various depths was as follows:

For seed at a depth of 6 m. m. (0.24 inch)..............13 days.
" " " " 13 m. m. (0.51 inch).............. 9 "
" " " " 19 m. m. (0.74 inch).............. 9 "
" " " " 26 m. m. (1.02 inches)........... 9 "

When the surface of the soil is caked for one reason or another, the seeds are unable to penetrate it, even when one-tenth inch in thickness. Hence, the importance of keeping the soil in a thoroughly open condition. If the seed is not sufficiently covered it will rot; if too much covered, it does not show itself. Consequently, it is a question of texture of soils; if very light, the sowing should be at a certain depth; if heavy, near the surface.

CHAPTER X.

Production of Superior Seed.

One of the original methods for improving the quality of selected mothers, consists in furnishing such roots with increased amounts of nutrients required for the amelioration of the seed to be formed. A perforation is made in the root and this is filled with sugar, starch, etc., or any nitric element needful for plant development, with a view to seed production. In the case of sugar beets the cavity may be filled with sand and 50 per cent. pure sugar. Experiments show that it does not matter how the sugar is supplied; this substance leads to seeds possessing hereditary principles, from which may be grown beets rich in sugar.

According to another rather strange method to obtain beets very rich in sugar, the roots are to be grown from selected seed raised in conservatories heated artificially, and in which large quantities of carbonic acid gas are introduced. At night such greenhouses are to be lighted by gas or electricity. The mothers, when selected, are to be planted and tended in the usual manner. We may also mention the Braune steam method. The steam is circulated through pipes that are buried in the ground. Between the rows are other pipes, which distribute carbonic acid. During the night, electric lights are kept burning. With the view to preventing a second growth due to late rains, the beets may be covered by special glass frames, such as are used in patch gardening; these do not prevent a free circulation of air.

The results obtained by this method have never been brought to our notice. However, this is a hint in a direction that might possibly lead to some very important results. In the patented method of circulating carbonic acid through pipes, the gas escapes through special holes; the quantity of gas used increases as the beets become larger. It is essential also to have artificial light during the night; such roots are said to be very superior and may be sent to a mother-selecting laboratory.

Production of Beet Seed by Use of Very Small Mothers.

As we have previously pointed out the general opinion prevailing that very small beets are not desirable for beet-seed production, it is of interest to consider, in some detail, the small-beet method as used in Austria, and which, in many cases, has led to most satisfactory results. Beet seed, as it is found on the market, is either the direct outcome of selected mothers, or is from mothers obtained from the descendants of a selected beet after several generations. The expense and difficulties of seed production by direct methods have led most dealers to use the latter system, which, unless extreme care is used, is open to many objections. The more atavism gains in strength, the further the seed is from the original parent; however, numerous cases may be cited where even after the fourth generation, the results continue to be satisfactory. In Germany, the so-called patch method continues to be used with success, without any special complaint from manufacturers. In the best cases, seeds are sown from selected mothers, and the resulting roots furnish seed for the trade. In Bohemia, some variations have been made from the German method, and the craze for very small mothers has been pushed to an excess, and it frequently happens that the seed furnished is worthless.

The best results, however, appear to be obtained on soils that have been properly prepared. Small roots must be of regular shape. The supposed objection to small beets is, that they mature badly and bring about great irregularity in the crop of seed. But, by having the patches arranged in several categories, large, average and small, it is possible, even with small beets, to obtain a maturity of considerable regularity; those of the large are followed by the middle size, and last of all, the very small mothers.

In fact, from Schaaf's experiment, it is shown that small mothers obtained by close planting of seed from selected beets have the following advantage: They very much increase in size when they are planted in the spring, and they penetrate to a considerable depth in the soil, which is followed by many strong lateral roots before the portions above ground show much sign of life. During very windy weather, they remain in position, and owing to their excessive soil penetration can struggle very considerably against excessive drouth. The roots of mothers which are planted the second year, and which have obtained their full development during their first year's growth, will undergo very few comparative changes, while above the surface the vegetation is excessive. With certain varieties of beets these mothers are forced out of their position by a very slight cause, and in most cases the vibration is constant and continued, leaving a funnel-like space between the root and soil, and as a result their points of contact with the ground are very few in number.

Some of the practical experiments with seed from very small roots and from normal beets have led to the following results:

	Normal Beets 600 to 700 grams (1.3 to 1.5 lbs).	Small Beets (0.06 to 0.2 lbs).
Density (Brix)	23.0	23.7
Polarization	20.2	20.3
Purity	87.0	85.4

From which it is difficult to see just in what the advantage consists.

Another table of special interest shows that with small roots the weight of seed obtained is greater than with large roots.

	Large Mothers.	Medium.	Very Small.
	Grams.	Grams.	Grams.
Weight when planted	442 to 337	72 to 66	29 to 10
Weight after seed has been harvested.....	972 to 710	417 to 400	690 to 160
Increase of weight during seed formation..	530 to 271	351 to 328	676 to 143
Weight of seed obtained per beet.....	375 to 177	470 to 120	475 to 96
Total increase of weight of the root, seed, stalk, etc......	1,423 to 398	1,200 to 351	1,171 to 374

From which it is concluded that small beets weighing 29 grams (one ounce) to 10 grams (0.35 ounce), when planted in patches, increased in weight 1171 grams to 374 grams (41 ounces to 13 ounces), and furnished 475 to 96 grams (16.6 ounces to 3.3 ounces) seed per beet.

Very small beets, when planted, demand that the soil be well prepared and that a proper fertilizer be used. It is claimed that small beets give fewer small stems and small seed than do large beets. The stalks of these have rapid and excessive development, thus absorbing the plant food in reserve in the neck of the mother. If excessive heat and dry weather follow, the root in the soil has no longer the strength to meet the demand of the stalk, nor can it withdraw the requisite plant food from the surrounding soil; the stalks are consequently in a condition to yield poor seed. Just the reverse of these conditions is found with the small mothers, which, as before explained, the development of the root and stalks being in harmony with each other, are in a better condition to meet the climatic variations with which we frequently have to contend.

Reproduction of Beets and Seed from Buds, Leaves with Skin, and Also from Fractional Slices.

The beet has undergone endless changes through generations, and the many existing types and varieties show just what man can accomplish in helping nature in her evolutionary methods, when superior seed production is aimed at.

1st. The essential is to use beets having as nearly as possible the same exterior characteristics and the same physiological tendencies.

2d. To prevent formation of hybrids during flowering.

3d. To give special care to agricultural methods, thus allowing the plant to complete its normal evolution.

The usual German and French methods of superior seed production consist in planting the best type of superior beets separately, and the seeds from these form the basis of special patches; constant observations are made during their development. If only a few roots in each patch promising the most favorable results were alone kept, the method of selection would be very costly and the results obtained would be doubtful. While this method, under proper care, keeps out all roots showing signs of atavism, it is not desirable, in most cases, to push the selection beyond the third generation. The systematic bud method is not only feasible, but promises considerable success. It is also possible to graft pieces of skin on other beets. It frequently happens that necks of beets after harvesting are sliced off and left on the field; these are exposed to the frosts, etc., of the winter and still retain their vitality and in the spring will actually take root and yield seed.

Beet Seed from Buds.

We were among the first to call attention to the new departure in the production of beet seed from buds, introduced in 1890 by Professor Novoczek, which had been applied to many other plants, but not to beets. While several years have now elapsed since then, and numerous experiments have been made, the question still remains to be satisfactorily understood. We called attention to the fact that the saccharine quality of beets increases with the number of its concentric rings; to each of these correspond leaves which are subsequently followed by buds. "It consequently follows that the richer the beet, the more numerous are the buds and the better suited are such roots for the multiplication of their species." Later, we said, "It is shown that after the buds have been planted in a suitable soil, after about two weeks leaves develop; and a hairy growth corresponding to lateral roots soon appears." To which we may add, that while these roots, as planted by some investigators, have a very different shape from the original mother, they are said to be possessed of exactly the same characteristics. However, it is claimed that there may be obtained seed, which, in time, will yield roots which tend more and more to be the shape of the original parent.

On some farms visited by us, the mother, after being selected and found to contain about 16 per cent. sugar, is planted, with its upward leaf development kept under control by suitable horizontal frames; this has a tendency to increase the bud formation, under which circumstances it is possible to obtain 280 buds from a single root. It is not desirable, however, in most cases, to use more than forty of these, which some agrarians recommend should be planted as soon as they appear, while others declare that they should be taken off at night and planted the next day. The precaution of not watering the soil for two days must not be overlooked, and great care is necessary to remove all particles of skin adhering to the parent beet, as from these other roots would soon grow.

The scar made on the mother by the bud removal should be cauterized with charcoal. It is also urged that when buds have attained sufficient size, which means two months' growth under glass, the air ventilation should be gradual. Transplanting is the next operation, pinching off the larger leaves, also part of their hairy growth. The hole made to receive these bud plants should be sufficiently watered; better select a cloudy day for the transplanting. Recent experiments appear to demonstrate beyond cavil that it is possible to plant a series of buds side by side, under exactly the same conditions, and obtain roots very irregular in shape, but yet having a greater resemblance to each other than is now obtained by most improved methods of physical and chemical selection in ordinary beet-seed production.

This production of beets from buds and without seed was patented in Germany and introduced on a very extended scale by Knauer at Gröbers. It was claimed that the force of the beet was strengthened, and there was less danger of atavism, and little or no danger of the creation of bastards or hybrids. Just where the bud was to be taken was, for a certain time, a question of experimentation; the bud from the neck is found to be the best. Doerstling, a chemist in charge of the Knauer farms, says that at Gröbers there is, first, a physical selection, according to the shape, size, etc., of the beet. These are numbered and put aside in silos until the following spring, when a slight topping is necessary. The temperature of the mothers in silos should not be higher than 15 degrees C. At the end of February and in March, the planting is continued; after four or five days the buds appear. At intervals of ten days the buds are detached; however, the first taken should be two weeks after their appearance. The skin taken off with the bud should be just sufficient to hold the leaves together. Experience shows that it is far better to break than to cut off the bud, and allow it to wilt during the night before planting.

A mother beet can furnish buds during several months, but those of July do not appear sufficiently vigorous. These sprouts are placed under glass; those having, after five or six weeks, developed roots are placed in a medium consisting of a mixture of earth, sand and wood charcoal. As soon as they have sufficient strength, the transplanting follows; the cultivation during their growth does not differ from that necessary for ordinary sugar beets. During the period of the past four years at Gröbers, 1242 mother beets have been used for this operation; out of this number only nine did not give buds; the 1233 remaining gave 56,155 buds, or forty-five from each mother. Notwithstanding the care bestowed upon these plants, every year a certain number perish before the roots are formed. One may rely on 10 per cent. of buds. It has been noticed that beets that come from buds have absolutely the characteristics of their mothers, in shape, leaf formation, color, etc. About 92 per cent. of these beets obtained by Knauer are rose color, the others slightly yellow.

The main fact to be noticed in this method of selection, is the care and time needed to achieve the results looked for. And while it allows one to reproduce beets like a very high standard or Elite, each beet of itself can give birth to a whole family which will retain their superior qualities for a considerable number of years. Hence, the reasons why each beet from which the bud is taken must be considered separately, numbered, cataloged, tabulated, etc. It is claimed that it is not the richest beet that gives the greatest number of buds, but the heaviest. When considered from a leaf standpoint, it has been noticed that those leaves with long stems, those high or low, those fringed or even with dark green borders, all give good results.

On the other hand, those roots with very high or long necks are not desirable. At Gröbers it is concluded that the question is still in its experimental stage, and that at least ten years will be required before practical results from a commercial standpoint can be obtained.

Numerous experiments in France, in planting buds, show that roots of the same line are almost identical in shape and in the formation of their leaves, while the roots obtained keep well in a properly constructed silo during a period of many months. It must never be lost sight of, however, that nitric fertilizers should never be used alone; that under all circumstances superphosphates should be added. The objection to nitrogen in excess is, that it maintains the vegetative action for too long a period and retards very considerably the maturity of the beet; under which circumstances, there is danger of a second growth, with a corresponding loss of sugar.

In America, in 1891, the Nebraska Experiment Station took up the question of production of beets from buds. "High-grade beets were selected and buds started in a greenhouse. After rooting, they were removed from the greenhouse and planted in the garden." The beet obtained was not very satisfactory in appearance, nor sufficiently long to yield much sugar. These experiments were continued again later; the roots obtained from buds were planted as mothers; most of them failed to produce seed, certain diseases and insects being contended with. Other experiments from buds were most satisfactory.

Grafting Method.

It is claimed that by the Wohanka method of selection, by which beet buds are grafted on beets, there need never be the slightest danger of atavism, as all descendants come from a common parent. The advantage of the grafting method is, that seeds may be obtained in one year instead of two, as by the early bud methods; furthermore, it is maintained that there is a sort of refreshing influence of the beet sap. Two varieties of beets have been created; these are known as, first, rich in sugar (W. Z. R.); second, rich in yield and sugar (W. E. R.).

Experiments upon 10,000 beets, during 1896, were to determine just what this Briem grafting meant. Some of the beets were from seed obtained in the ordinary way; others were the bud-grafted seed. Those beets from the regular seed gave 53 per cent. as rich in sugar and general characteristics as the parent beet; 15 per cent. of a superior quality, and 32 per cent. of an inferior quality. On the other hand, the grafted beet seeds gave 77 per cent. equal in quality to the parent; 17 per cent. of a superior quality, and only 6 per cent. of an inferior quality. It is remarked that these results are not only superior, but that they are much more rapid. It is evident that great experience and observation are necessary to carry this out; the Wohanka work has now been going on for six years. It is to be noted that the main difference between the new and old method is, that by customary selections, the individual characteristics are the first arrived at, and beyond which there is no control, no way of preventing analytical errors or action of atavism. On the other hand, the bud method is the starting point, after which atavism has no influence upon the descendants, as they all come from the same mother and must necessarily have the same characteristics. The advantage of grafting is, that seeds are obtained the same year, while by the bud method, when used alone, the seeds can be obtained only the second year. There is a "renewing of the blood" by grafting. Such is a general outline of what is claimed by this well-known seed producer.

Beets from Leaves and Adhering Skin.

The efforts to produce beet seed without going through the regular methods has led H. Briem to make a series of experiments, by planting beet leaves with a small piece of adhering skin from the mother beet. The first question to be looked into, is that of planting, as early as possible, very superior seed on a selected and well prepared soil. When the leaves of the result-

FIG. 67.
Leaves with adhering skin.

FIG. 68.
Final appearance of root.

ing beets have attained three to four inches in length, they are cut off with a very short knife; the separation should be made in such a way that there will be adhering a small piece of skin, as shown in Fig. 67. The planting is not done until next day; after a reasonable number of weeks (two and a half months), the appearance will be as shown in Fig. 69.

It is important to note that the leaves used should have a certain stiffness, and be entirely grown and no longer possessing their youthful vigor. While a certain amount of water is necessary, this should not be pushed to excess. During very sunny or hot weather it is

FIG. 69.
Root formed from leaf with skin after two and a half months.

generally found desirable to cover the growing leaf with other leaves. After two and a half months the transplanting should be done to the regular field; after the growing has continued for a few months longer, the appearance of the root is shown in Fig. 68. Though we consider it very doubtful if any special results could possibly be obtained by this method, it is interesting as being or forming an important departure from regular methods.

Beets from Sectional Vertical Slices.

A new departure has recently been made, which is, that instead of using the bud root for seed, the beet is sliced vertically, and each slice planted separately. These will yield seed, as do so many separate mothers, as many as twenty new seed-forming centres being thus obtained from one beet root. It must not be forgotten that these slices must undergo considerable special attention in a greenhouse before being planted in the open field. It is important to dress the wound with an antiseptic of some kind, or with wood charcoal powder, or even chloride of mercury may give satisfactory results. This precaution does not appear necessary when the vertical sections are limited to four; then the planting should be just as is customary for mothers in seed production, the distance between rows being rather closer. These slices must, in some way, be held up in a vertical position, otherwise the wind would blow them over.

CHAPTER XI.

Home-Grown Beet Seed.

Of late, special sugar journals have recommended that we produce all the beet seed needed for home consumption. In theory it is a capital idea, but in practice most difficult to carry out. No one writer more than this author has urged and maintained the theory that special seed should be grown for special environments. It was, furthermore, argued, that if it were possible to devote special money to the practical working of the suggestion, it would, in time, be found very remunerative; and the complicated mother selection might be worked on a scale which would be to the advantage of all interested. Many instances could be given of special beet seed retaining the names of factories where this local seed cultivation has met with success, and without borrowing instances from Germany or France; the Alvarado achievement in this direction is an important example to the point.

Just whether the best results that could beobtained have as yet been reached, either in California by private parties, or under Government supervision at experiment stations, remains to be proven. Every one who has looked into the subject of beet cultivation, knows that by proper selection excellent seed may be obtained. It would certainly be possible to produce in the United States all the beet seed needed for existing factories. If such a course be followed, it would at present be ruinous to the American beet-sugar industry, unless undertaken by or under control of the factory. Those who discuss the problem have frequently only a very limited knowledge of it. A visit to a European beet farm would make the question very much clearer in their minds.

The scientific selection of mothers demands, as has been shown in previous pages, a very complete laboratory installation, a chemist and several assistants. It means this one question and very little else: To use a soil that happens to be within easy reach, and cultivate beets upon it; then to make selections of these beets, with the view to seed production, regardless of fertilizer and numerous other requisites. This would, after a term of years, end in obtaining a race of beets very inferior to the mothers representing the original parent. The money outlay for a beet-seed farm under these conditions would be a losing operation, in view of the limited number of factories in the country. Later on, when the industry is more advanced than at present, when at least fifty factories shall exist, some enterprising seed specialist should take the matter in hand; but not until then.

It has been argued by some writers, that if the beet-manufacturing countries of Europe should refuse to furnish us with beet seed, our factories must cease working. This would require a joint action on the part of Austria, France, Germany and Russia; and for what purpose? To prevent enterprising Americans making their few pounds of beet sugar, which, up to the present, has absolutely no effect upon the world's sugar market! Every country of Europe is interested in developing the beet-sugar industry in the United States, with the hope that it may create a demand for their sugar machinery; and no better method can be adopted to attain this end than by sending us all the beet seed we may need for years to come. Hence, there need be no apprehensions on that point.

American Experiments in Beet-Seed Production.

Of the interesting American experiments in the production of beet seed, mention must be made of those at Schuyler, Neb., which station was established with the view of improving the quality of beets, etc. The physical selection from roots was obtained from a standard variety of seed; the beets were divided into three classes: 1st, those of not less than 12 per cent. and not more than 15 per cent.; 2d, those from 15 to 18 per cent., and 3rd, the Elite class, those containing over 18 per cent.

As a result of the analysis, 5091 beets were accepted for the production of seed and 1179 were rejected. (Certain changes occurred during siloing with Vilmorin's Improved, there being apparently an increase of 0.1 in sugar percentage! With Desprez and Klein-Wanzleben, there had been no change.) The roots selected were put in the ground, which had been properly prepared. Great care was taken to keep the higher grades at a considerable distance from the others, so as to prevent contamination by the distribution of pollen from one plant to another.

The weather being very dry and the temperature high, the seed matured rather earlier than was expected, the quantity and yield being thus reduced. In 1892, also, experiments were made; the calculated yield of seed to the acre was 968 lbs. On the other hand, the yield of 1893 was smaller, it being 863 lbs. On account of the high quality of the seed, it was sold to the Oxnard Beet Sugar Company at a price far in excess of that paid for the best imported seed. The sum received for the seed was at the rate of $172.60 an acre; this was only for the low grade, the high grade being kept for the experimental work of the future. Owing to the limited area devoted to the experiments, no exact data could possibly be obtained as to its cost of production. Seeds worth $150 an acre can be produced in America. This is the issue upon which the Department of Agriculture places special stress.

Dr. Wiley, in a recent Bulletin, No. 52, discussing the experiments we have just referred to, says: "In the experiments conducted at the station at Schuyler during the season of 1893, a comparison of the beets grown from domestic and imported seeds was made. The plants from the native-grown seed seemed to have a higher vitality and to be better suited to the climatic conditions of the locality than those grown from imported seeds. They showed during the growing season a more abundant foliage and a better development of roots. This higher vitality and quality of the beets grown from domestic seed illustrate in a forcible degree the advisability of the production of our beet seed at home. Even granting that seeds produced in foreign countries have the same high qualities, it must be admitted that their vitality is in danger of being very much diminished during shipment to this country. The moist air of the holds of the ships in which they are transported often produces moldiness and incipient germination, which tend to greatly diminish their value. Not only did the beets produced from the home-grown seed have a higher percentage of sugar, but they also afforded a higher yield per acre, as determined in the experiments at Schuyler. The mean tonnage per acre from the home-grown seed was 21.1 and from the imported seed 17.9. The mean pounds of sugar produced per acre from the home-grown seed was 5891 and from the imported seed 5185. This shows an increase of about 12 per cent. in the actual quantity of sugar per acre when domestic seed was used. These data should be carefully studied by all those who are interested in the production of the beet sugar in this country."

A fact apparently overlooked is, that scientific experiments have proven that the germinating quality of seed is hastened by change of climate. We refer not so much to the seed itself, but to the seed outcome of mothers from the imported product. So what apparently is a higher vitality is the natural outcome of an established principle; the rule, in all probability, would work both ways. Several establishments in France change about in growing their seed; for example, Carlier regenerates his seed in Masloffka, Russia, and, as a result, he claims that the germinating power is so much increased that the seed sown upon the same soil, and under the same conditions, will appear above ground five days before the indigenous production. That the yield per acre was higher, that the sugar percentage was higher, may also be explained by a longer vegetation and stimulation, produced by the new environment. The Schuyler experiment station was abolished and all remained in *statu quo*. The Elite roots could not, after the many years' interval, be further watched and developed.

By a new decision of the Secretary of Agriculture, it is decided to continue the work abandoned five years ago. This means that all must be commenced over again. Whatever progress is made, whatever work is accomplished, there remains ahead the possible suppression of the work, by a change of administration. The researches at the Nebraska station, if they had continued, would possibly apply to Dakota, Iowa and Minnesota. On the other hand, the elevated plateaus of the arid regions of Utah, Colorado, Nevada, Montana, New Mexico and Arizona offer conditions entirely different, and a second station should exist for those regions.

Furthermore, a third station is needed on the southern coast valley of California; a fourth station, to study the climatic and other conditions of northern New York, Ohio, Indiana, Illinois and southern Wisconsin, including Michigan. These stations should not have annual appropriations, but a fixed sum, determined in advance, as this capital would then be beyond the possibility of political intrigues at Washington.

The only solution would be for those states most interested to come forward and appropriate the required amount. A fact also that must be thoroughly looked into, if one or more of these stations be established, and from them serious work is to be expected, is: That the chemist in charge of each particular station be not a novice, as is often the case, in the special work he has to do. Let him spend a year or more at Halle sur Salle, Germany; then another year at one of the French stations; let him bring over with him one or two practical hands for the physical selection of mothers, men who have been employed in this special work for twenty years or more; otherwise, great injustice will be done to the head chemist at Washington, who is responsible for the whole work. It must be understood that nothing of any great importance in the way of sugar-beet types can be accomplished under seven or eight years. It took over twenty years to put the standards as now used in Europe on the solid basis they now are.

The extended correspondence we have had with numerous experiment stations reveals very little. At Cornell University, many experiments are under way; nothing yet is decided. Iowa Agricultural College has some experiments in the production of beet seed in progress, "but the investigations are not yet far enough advanced to enable us to make a report." At the factories in Alameda, they declare that they produced seed for many years (in 1893, 10 tons; 1894, 20; and 1895, 15 tons; about half of which they used), but one fact remains, namely: It is far cheaper to purchase the product in Europe than to attempt one's own selection. At Watsonville, they declare that their experiments are too recent to be worth publishing. The Pecos valley sugar factory argues very much in the same way.

From Mr. Oxnard, we learn that they carried on sugar-beet-seed production in Nebraska for a period of years; the yield per acre did not prove profitable; they obtained about 15 tons, which cost about twice as much as the same seed could have been imported for. The climate around Grand Island appears to be too windy for beet seed. We have great doubts that the difficulty can be overcome by planting rows of corn between the beet rows, as suggested; for the mothers in growing need all the plant food the soil can furnish, and even at distances of three feet the roots are all in communication, one with the other. To introduce corn would complicate matters, and certainly not for the better.

Utah Beet Seed Selection.

In reply to our letter, Mr. C. A. Grager, Superintendent of the Utah Sugar Company, sends us the following satisfactory account of their methods of selection. There are certain original features about the way the work is conducted, which are well worth recording. Here, again, too much importance must not be placed as yet upon the early germinating characteristics, for reasons which we explained when reviewing, in the foregoing, the Schuyler, Neb., experiments.

"We consider that good seed is the first essential toward the success of a beet-sugar plant. Good seed or poor seed may mean the difference between success and failure. It has not been our effort to produce a cheaper article than the imported, but to grow as good a seed in all respects, and better in some, than the best imported seed; and in this we feel that we have been thoroughly successful. The sugar content and purity of the beets grown from our own seed have never fallen below that of the beets from our very best imported seed; and in germination, which we consider a very important point, our seed is the quicker by from two to four days, produces a stronger germ, gives from

5 to 6 per cent. more plants, and about fifty more germs per 100 seeds.

"Our mothers, or seed beets, are carefully selected from special fields of beets, grown for the purpose from the best imported seed. At harvest time, each beet is first carefully inspected by hand with a view to having all of uniform size, symmetrical in form or shape, and free from disease or injury. Of the beets thus examined, only about 5 to 8 per cent. will pass the test and are taken to the laboratories, where a small cylindrical sample is taken from each one and its specific gravity tested; this gives an approximate idea of its sugar content. All those not reaching a certain standard are discarded, or thrown away, while the few chosen ones are very carefully packed away by hand in dry sand. They are kept from heating or freezing during the winter by a system of ventilation, and are taken out of the sand in the spring, apparently as firm, fresh and crisp as when laid away in the fall.

"As planting time approaches, in the spring of the year, the piles of mother beets are opened and the actual and definite test of their sugar qualities is made by taking out a second sample diagonally through the centre of the beet and a direct polarization made of it. All beets showing less than 16½ per cent. of sugar are rejected; those going above are planted for seed. Out of all that are thus polarized, about 25 per cent. go below the requirement of 16½ per cent. sugar; the average of those retained for seed reaching for the past season 18.7 per cent. sugar and 86 purity.

"The preparation of the soil for the mother beets is commenced in the fall, when it is plowed very deep; in the spring it is replowed, but shallow this time, and the surface made smooth and firm. The beets are then planted by hand in rows three feet apart and at a distance of three feet from beet to beet in the row, thus allowing cultivation in every direction. The several seed branches or stalks from one beet do not all ripen at the same time, consequently cannot all be harvested at once. This necessitates going through the field and cutting by hand all ripe seed stalks, which are carefully laid away and allowed to 'season' in the shade and are afterward threshed. It requires a second and third cutting before all the seed is gathered. After threshing, the seed is passed through a special machine, which removes all bits of dirt, sticks and blighted seeds, leaving only the full plump seed to be sacked for use.

"The germination is carefully tested early in the spring, before any seeding is done, by planting in a hothouse several lots of 100 seeds that are taken without any selection whatever and represent an average of the whole. A careful watch is kept of the process of germination and a full record made of the date of the appearance of the first plant or plants, the number appearing each succeeding day up to and including the twelfth day from date of planting, and finally, the total number of germs resulting from each 100 seeds. The average germination of Lehi seeds for the past season was 96 per cent. with 218 germs, over two germs or plants for each seed. Such seeds can be safely guaranteed on going into the hands of beet growers. Any haphazard or unscientific methods in the production of seed would immediately be followed by disastrous results, for high-bred plant life, like 'high-bred' animal life, will degenerate very rapidly unless preserved with intelligence and skill."

This last assertion is very true, and the future success of the Utah beet selection will depend upon these very facts, as previously mentioned. The whole issue may appear very promising for a few years, but when once atavism asserts itself, the first warning that some thing must be done is reached. Sugar-beet-seed selection depends upon many very difficult problems, and some of these are fully explained in previous pages of this writing.

We were recommended to write to Mr. Deeringhoff regarding his experience in sugar-beet-seed production. In reply, we learn that in his district, Uniontown, Washington, the soil is too dry, at certain seasons, for the satisfactory development of beet seed. The quality of seed obtained was, in a measure, satisfactory, but the yields were far below what they should have been. It is claimed, furthermore, that it is far more difficult to keep the beets over winter than it is in Continental Europe. He has no faith in California as a state that has a great future for superior seed cultivation. He declares that in a few years, they would possibly produce annuals; this, from our standpoint, is good reasoning. The intention, however, of C. C. Morse & Co., in California, is to give the subject of special seed production their careful attention. They have been urged to take up the question by several of the leading agronomists of the state.

The very low price at which foreign seeds may be brought to America is an issue difficult to overcome. The success of Russian seeds in France and Germany, the importance of producing seed in a colder climate, and bringing it finally to a milder one, have been for years most successful. It remains to be proven what the future will be in creating a type of beet in an environment such as California. The experiments of the past, either at Alvarado, or in other centres of the state, are not sufficiently conclusive, owing to their limited duration, to predict as a certainty what the outcome will be. However, we do not hesitate to make the assertion that there will be an enormous tendency to create annuals. No district of Europe has given more attention to beet-seed production than Saxony, so we conclude that a general outline of what is done there, as a starting point, is most important as a guide for those who have the beet-seed cultivation specialty in view.

Saxony Methods for Field Testing of Beet Seed.

The main object is to study the different varieties of seeds from local and foreign sources, and to determine the most desirable soil and fertilizer for each case, allowance being made for any climatic influence that might be contended with during the progress of the experiment. It must be understood that such experiments are not necessarily conducted at the experiment station; but on various farms at considerable distances from one another. The selection of seed is made by an official, sent to the seed grower's farm; that the sample may be an average one in each case, it is taken from a volume of seeds weighing 1½ tons. The samples are sealed in sacks by the expert and forwarded to the agronomic laboratory, where germinating tests are made, after which they are distributed among farmers, who offer their services for such experiments. Under all circumstances, the tiller must have no special seed of his own, nor in any way be informed of the origin of the seed he is to plant.

The area of land devoted in each case to such experiments is about one-half an acre. When the harvesting season comes, the beets to be tested are marked, counting the hundredth beet from the first row, then the second hundredth, etc. As in the parcel there are about 23,000 individual roots, this gives 230 roots for laboratory observation. These are classified according to size, shape, etc., and then arranged in series; every other one is taken, so that there remain 115 roots leaving the farm, to be shipped in special bags to the agricultural station, where the number is again reduced by one-half. The laboratory experiments give the percentage of sugar in the beet and juice, the dry extract of the juice, purity coefficient and substances other than sugar. The Keil and Dolle rasp is used to obtain an average pulp from the sixty beets. This pulp is collected in a special receptacle and thoroughly mixed; one-half of it is taken and submitted to a pressure of 300 atmospheres, so as to extract the juice. From one quarter of the half of the remaining pulp 500 to 700 grams are taken, which are used as final samples.

The alcohol-digestion method is used to determine the sugar percentage. For this purpose, the alcohol used tests about 90 to 92 per cent; at least half an hour is needed before it has penetrated the pulp. The polariscope observations follow. A Brix hydrometer gives the solids, and the apparent purity coefficient is obtained by dividing the sugar percentage by the total solids; the non-sugar is the result of a subtraction of the sugar percentage from the Brix indicator. A series of tables is filled out for germination, the arrangement being as follows:

Varieties of Seed.	Moisture of Soils.	Number of Seed in One Gram.	W.	Nitrogen in 100 Grams of Dry Substance.	Number of Sprouts per 100 Seeds After		Number of Sprouts After 14 Days from One Gram Clean Seed.
					7 Days.	14 Days.	

The general classification of varieties, according to their saccharine quality, is done in a table about as follows:

Varieties.	Saccharine Per Cent. of Beets.	Saccharine Per Cent. Juice.	Purity Quotient.	Net Yield Per Acre.	Yield of Sugar Per Acre.	Annual Beets.

When the factory is to determine what variety of seed is best suited for the environment, the method is a little different. Great precautions are necessary, that the experiments be conducted under exactly the same conditions as regards soil, fertilizer, etc. The spacing of roots must be identical in all cases; the soil should have been well plowed the season before; sowing of all varieties of seed under observation, and the analyses of the resulting roots must be done on the same day. During the plant development the various patches of beets should be carefully examined, so as to make sure that their appearance above ground is about the same in each case; it is also urgent to keep the soil free from weeds. Each beet must be weighed and analyzed separately, and it is important not to have one sample of each, but an entire row taken from the same exposure from each patch.

When undertaking the production of seed, it is not generally realized what a long, tedious affair the method is, and if not conducted on a scientific basis, it will be a money loss to all concerned. After the selections are made there are three principal classifications. The first on the list should be planted to produce seed which would yield beets for selection the following year; the second classification could also be used for the same purpose in an emergency; those remaining could furnish at once a limited amount of seed for general farmers' usage, while the main supply would be obtained a year later from beets which had undergone only an ultimate physical classification. For example, the mothers selected in 1894 would be from seed which had been produced in 1893. The planting of mothers, in Europe, is done the following March, 1895; in October of 1895 the seeds from the planted mothers would be harvested; in April, 1896, the seeds are sown, and in October of the same year the resulting roots are harvested and siloed. In February, 1897, a second selection and classification of mothers, March planting, October harvesting of seed; April, 1898, sowing of seed, and in October, beets are harvested and sent to the factory. So nearly four years elapse before the manufacturer gets the full benefit of his efforts. Under these circumstances, satisfactory results would evidently be obtained, but the expense is an important point to be considered.

In our pamphlet published some time ago, we made the following calculation: If 20 lbs. of seed are used per acre, there would be needed, on an average, 35 mothers to produce this seed. A factory working 30,000 tons of beets must have under control not less than 3000 acres, and the seed needed would be 60,000 lbs. To obtain this, 105,000 mothers would be required. If the method of selection is that adopted by M. Legras, at first not more than one beet in three could be used, so that the number of analyses would be 315,000. If we admit that each analysis costs one cent, the total cost for this work in the laboratory, without considering wear and tear on plant, would be $3150 per annum. To obtain seed from the 105,000 mothers, at least 30 acres, at 4000 roots per acre, planted at three feet in all directions, would be required, and such beets could not be properly looked after under $60.00 an acre, or $1800. The allowance of one cent for actual cost is entirely too low; it would in reality be double that amount, bringing the cost of such analyses up to $6300, and a total cost of the experiments at $12,450, which might be a slight saving on the market price of seed. However, we are convinced that there would be considerable money loss to the manufacturer if conducted on the lines that the actual conditions of science demand. On the other hand, if the question of seed production be gradually developed by factories that have the patience, success would, in time, follow. If the ordinary method of selection be adopted, then the chemical analysis is made only every two years, and seed could be obtained at about eight cents per pound, or less.

Any enterprising chemist attempting this work, however, would find, after a few years of enormous expenditure of energy, that there would be certain disappointments. Complete laboratories with this idea in view require considerable capital. We must in time create an American variety of beet seed, but has that time yet arrived? If it has, let the work be done by a person who has in view only the specialty of seed production, and not by general seed dealers, who combine the question with other branches of their trade.* One who, furthermore, has the technical knowledge for the work to be done, which demands a thorough grounding, not only in the principles of botany, but also in the use of the microscope. Much remains to be discovered from a botanical standpoint; and laboratories where botany is a basis of their selection, will, in time, take the lead. As matters now stand, most of the ten or more leading beet-seed producers of Europe have vegetable organic development and changes under constant notice; so much so, that in connection with their laboratories are works of Darwin and other leading investigators of plant life and requirements.

For creating a special type of beet, a certain number of years is necessary, as before explained, but the thoroughness of the subject is a lifelong study. From what we have just said, it stands to reason that many of the newly created varieties from

*Since the above was written, a well organized beet-seed selecting laboratory has come under our notice, where last year there were made 337,389 analyses in forty-one days, or an average of 8227 analyses per diem. By the use of two polariscopes, the cost for actual labor was $576, appliances, etc., $503, or a total of $1079, to which must be added the interest, wear and tear, etc., of $700 cost of plant. There were 263,567 beets kept for mothers, and the cost of the selection is about one-half cent per beet kept. This means more than half the help are women, at fifteen cents a day.

growers who have been in the business but a few years are not to the advantage of the manufacturer, and simply mislead the public in general. For such beets, when planted, will show great variations, not only in their sugar percentage, but also in size, even upon the same soil, under the same climatic conditions and the same care for their cultivation. Such conditions would not exist with the Vilmorin, Legras, Wanzleben and Knauer, for example.

Vilmorin, on the one hand, and Klein-Wanzleben, on the other, have more reasons to complain of the infringement on their prerogative than any other beet-seed creators. They have added originals to their types, which make an important mark of distinction. There are possibly thirty very serious specialists who have taken the beets of these two promoters as a starting point in their selection, and have created not only what are excellent varieties, but very important departures from the old routine.

CHAPTER XII.

Beet Seed Production in France.

A very strange fact relating to the statistical data of such an important question as beet seed in Europe, is that there has been little or nothing published. It is estimated, however, that the consumption of beet seed reaches 35,000 tons, produced in France, Germany, Russia and Austria. There is considerable export of German seed to France, and France sends to Germany, and elsewhere. Russia of late years has brought about some changes in the German export, which once was 3500 tons. In France, there are 200,000 to 230,000 hectares (500,000 to 600,000 acres) devoted to sugar-beet cultivation; there is needed for this at least 6000 tons of beet seed (13,440,000 lbs.), to produce which demands an area of 2200 hectares (5500 acres), which would represent 1 per cent. of lands devoted to beets cultivated for the sugar factories.

The exports and imports of beet seed to and from France during several years, are as follows:

Years.	Imported from Germany, Russia, etc.	Exported.
1887	1,491 tons.	971 tons.
1888	1,685 "	1,142 "
1889	1,523 "	1,453 "
1890	1,847 "	1,716
1891	?	?
1892	1,373 "	2,203 "
1893	2,647 "	2,631 "
1894	2,053 "	2,355 "
1895	2,896 "	1,202 "

The French growers were thus protected by a duty of a fraction less than three cents per pound, but this has been found to be too small, and the low duty has since been changed. Before 1884 there were no seeds imported, as there was no encouragement to cultivate superior beets. The roots then contained 7 to 9 per cent. sugar, but in 1885-86, the percentage was 9.2 to 11.2 and is now 13.3 to 15. Up to 1884 the French producers had, in a large measure, been neglecting their methods of selection. When it was necessary to resume their position held in the past, whole districts were abandoned, owing to the influence of hybrids that were freely cultivated. The growers have now regained the ground lost in the production of superior seed, but one fact still remains, the importation continues. The districts near Lille and Valenciennes, as early as 1846 (the fertile plains of Cysoing and Pont a Marcq), were devoted to beets; now about 5000 acres are employed for special sugar-beet-seed production.

Old Beet Seed and Wastes Utilization.

As the demand for seed some years was not equal to the supply, the European grower had in stock a quantity of seed that he could not dispose of unless it was by mixing, and thus cheat his customers. This would not be of so frequent occurrence if some means could be proposed for the utilization of old seed. The most practical suggestion is to feed it to cattle, which has been done on many farms, and has met with considerable success.

Pagnoul gives the comparative analyses of hay and beet seed as follows:

	Hay.	Old Beet Seed.	
Water	19.24	12.60	17.56
Amylaceous substances	26.95	21.54	22.04
Nitrogenous "	5.83	9.19	8.53
Non-nitrogenous "	1.36	2.19	1.54
Fatty "	2.44	5.88	5.10
Extractive "	16.72	11.54	11.83
Raw cellulose	22.54	28.70	28.30
Ash	4.93	8.36	5.10
	100.00	100.00	100.00
Phosphoric Acid	0.438	0.84	0.64

By the way of comparison, it is interesting to give Pellet's analyses of old beet seed:

Water	14.14
Fatty substances	4.26
Starch	1.56
Cellulose	16.31
Albuminoids	11.94
Mineral substances	6.94
Cortical substances	45.30
Total	100.00

Mr. Petermann, who has also given the question of seed utilization some thought, says that it makes very little difference if the seed be of a superior or inferior grade.

	Variety.	
	Klein-Wanzleben.	Yellow Mangolds.
Water	5.69	9.70
Fatty substances	5.96	5.72
Raw albuminoids	10.19	9.86
Carbohydrates	30.64	33.58
Cellulose	38.75	33.12
Mineral substances	8.77	8.02
	100.00	100.00
Containing pure albuminoids	9.95	9.44
" potassa	1.65	1.43
" phosphoric acid	0.67	0.72

It must be noted that the fatty substances in hay are only 2.44, and in beet seed they vary between 4.26 and 5.96, or 5.88 in old seed. The same difference exists for nitrogenous and non-nitrogenous substances. In France, excellent results have been obtained by feeding seven pounds old seed flour combined with 100 to 170 lbs. beet pulp, and two pounds hay per diem; beeves thus fed increased in weight about 90 lbs. a month. Very encouraging results have also been obtained by forming with old seed a ration for hogs.

It must, however, be noted that certain precautionary measures are necessary; the animals must become gradually accustomed to the stuff; hence, the ration should at first be only one-fourth of what it is to be finally. In the same line of argument, the wastes or residuum, after cleaning beet seed, have an important utilization in cattle feeding. According to Besler, the average composition of these wastes is:

Water	12.12
Albumen	11.06
Fatty substances	3.80
Cellulose	23.33
Ash	26.58
Non-nitrogenous extractive substances	23.14
	100.00

It is found desirable to form a mixture of this product with other residuum from beet-sugar factories; or, with oat straw, for sheep it has rendered excellent service. It is estimated that fodder of this kind is worth seventy-five cents per 100 lbs.

Conditions of Beet-Seed Purchase in Different Countries.

The revised law of Germany, 1896:

(1) One kilo of seed should give, after fourteen days, at least 70,000 sprouts.

(2) Of these total 70,000 sprouts, at least 46,000 should be visible in six days.

(3) For 100 seeds at least seventy-five should show signs of germination.

(4) Fourteen per cent. moisture is considered normal; 14 to 17 per cent. moisture may be delivered, but allowance must be made for the weight of water.

(5) Three per cent. may be allowed for foreign substances; seed may be delivered containing 5 per cent. moisture, but allowance must be made for this extra weight.

If even one of these five conditions is not complied with, the seed may be refused. If there is a difference in the analyses of interested parties, an average is taken between the results obtained by a new analysis and another made at the laboratories of the Sugar Manufacturers' Society.

In Austria, some few modifications have been made:

(1) The impurities (leaves, stems, stones, etc.) must not be more than 3 per cent.

(2) Moisture not over 18 per cent.

(3) One hundred seeds should give in six days 125 sprouts.

(4) After twelve days, with gradual heating, 100 seeds should give at least 150 strong and healthy germs.

(5) Of 100 seeds, at least eighty should germinate.

(6) One kilo of seeds should give 70,000 sprouts. Seeds may be refused if they contain more than 4 per cent. impurities, and more than 17 per cent. moisture; and if 100 seeds, after the two days, contain less than 140 sprouts, or if with normal moisture one kilo of seeds gives less than 68,800 sprouts, and if 100 seeds yield less than 76 seeds which sprouted.

Example of Calculations of the Juice of Seed.

If we suppose the seeds had been sold for eight cents per pound and that these seeds contain 4 per cent. impurities, 15 per cent. moisture, and that 100 seeds gave 140 sprouts, and that one pound gave 31,000 sprouts, and 76 seeds of 100 have sprouted:

For impurities.. $\frac{8\times 96}{97} = 7.9$ **cents.**

For germination.. $\frac{7.9\times 140}{150} = 7.38$ **cents.**

Sprouts total .... $\frac{7.9\times 31.000}{31.800} = 7.7$ **cents.**

Per 100 seeds .... $\frac{7.9\times 76}{80} = 7.38$

An average is taken......... $\frac{7.38+7.7+7.38}{3} = 7.48$ **cents, which is the price at which seeds would be purchased per pound.**

Bohemia.—The seeds should contain 3 per cent. impurities, and a maximum of 15 per cent. moisture; of 100 seeds, seventy at least should germinate after six days and eighty in less than fourteen days. From 100 seeds in six days, at least ninety-five germs should be obtained, and in fourteen days not less than 150 germs. Seeds may be refused if surrounded with mildew, or if containing more than 18 per cent. moisture and more than 4 per cent. impurities; if, under germinating test, 100 seeds give less than eighty-eight sprouts in six days and less than 140 sprouts in fourteen days, and if from 100 seeds there are less than sixty-five sprouts in six days and less than seventy-six in fourteen days.

Gratification.—If seeds contain from 3 to 4 per cent. impurities, the price undergoes some changes; this is also true if the moisture percentage is between 15 and 18. If 100 seeds give eighty-eight to ninety-five germs in six days, the weight of the seeds is reduced 0.33 per cent. for each germ less than ninety-five. If 100 seeds give within fourteen days 140 to 150 sprouts, a deduction of weight of 0.66 per cent. per germ less than 150.

If there are only sixty-five to seventy seeds in 100 that germinate in six days, 0.5 per cent. is deducted for each seed not germinated below seventy. If there are seventy-six to eighty seeds in 100 that germinate within the period of fourteen days, 1 per cent. of the weight for each seed not germinated below eighty will be deducted. In Bohemia, the testing of seed is generally made by two chemists, or in laboratories of experiment controlling stations. If the analyses show a difference which is not greater than 1 per cent. in the impurities, 1 per cent. of moisture, six sprouted seeds and twenty germs, the average is taken of the two analyses. Otherwise a third chemist is selected.

Those purchasing inform the seller by telegram or registered letter as soon as the seed sent reaches its destination; if the seller does not send his representative within six days, the buyer alone takes upon himself the question of analysis. Two samples of twenty-five grams are placed in closed flasks for moisture determination; two samples of 500 grams (1.1 lbs.) in small bags for other investigations; a sample of five kilos for agricultural purposes to determine the variety. This experiment is upon an area of ten acres (120 square yards); the soil is determined upon by both interested parties.

It is interesting to point out the difference in the contracts of various countries; there is almost complete accord on issues of 3 per cent. impurities. However, in Germany and Belgium, up to 5 per cent. impurities is allowed, while in Austria over 4 per cent. is not admissible. Every country, with the exception of Austria, allows that 17 per cent. moisture is a good average. Upon general principles, the distinction between small and large seed still continues in Belgium, while everywhere else it has been done away with. In Bohemia and Germany, the chemist must reside in the country of purchase, while in Belgium, and a part of Austria, it is admitted that the chemist may reside in the country where the seed is produced.

Standard.—While in previous pages we have discussed what appears to be the important conditions for the purchase of superior seed, it is interesting to add the following table, which may be considered as standard from year to year:

Kind of Seed.	Impurities.	Amount of Moisture.	Sprouts.		Seed.		
			100 Seed.	Per Kilo.	Dead.		In 1 Kilo.
					Per Cent.	In 1 Kilo.	
Normal	3.0	15.0	150	70,000	20		
Superior	1.1	13.2	234	90,550	3	4,160	38,700
Excellent germination but very few seeds per kilo	0.7	12.7	227	60,250	6	1,600	26,550
Inferior, very poor	2.4	12.4	67	28,475	55	23,375	42,500
Limited germination but many seeds per kilo	1.3	1.36	135	74,900	18	10,000	55,000

Varies.—European beet-sugar countries have come to certain understandings as to rules and requirements, among which may be mentioned that the seed should be from the last crop. It is admitted that one pound of seed contains 23,000 to 31,000 sprouts. During 1895 the official German and Austrian conditions were very much the same as the French. They were as follows:

	Vienna.	Magdeburg.
Impurities, maximum	3%	3%
Moisture	15%	12 to 15%
100 seeds must give { 7 days	125 sprouts.	
100 seeds must give { 14 days	150 sprouts.	150 sprouts.
100 small seeds must give		130 sprouts.
Lifeless or dead seeds, maximum	20%	
Lifeless or dead seeds { 14 days { large seed		20%
Lifeless or dead seeds { 14 days { small seed		30%
Sprouts per kilogram (2.2 lbs.)	70,000	50 to 70,000

It is interesting to note that in Vienna, seed is not classed according to size, as in Magdeburg; on the other hand, in Vienna the sprouts are counted after intervals of seven and fourteen days, while in Magdeburg the sprouts are counted after the entire period of the test, which lasts two weeks. It is claimed that the Vienna standards are very favorable for the purchaser, and not for the seller. For example, if we use twenty-two pounds of seed to the acre, there should be 700,000 sprouts. If we suppose that the yield is ten tons and each beet weighs a pound, this would be 22,000 beets; or 22,000 sprouts, or a very small fraction of the 700,000; this gives a satisfactory margin against insects, etc.

Calculating Results.

Upon general principle, the bulletins of seed laboratory examinations should be very simple and contain:

Moisture per cent., impurities per cent., seeds per gram beets.

Number of seeds germinating in seven days	Per Gram.
" " " " " fifteen days	Per Gram.
" " germs " " seven days	Per Gram.
" " " " " fifteen days	Per Gram.
Number of seeds germinating in seven days	100 Seeds.
" " " " " fifteen days	100 Seeds.
" " germs " " seven days	100 Seeds.
" " " " " fifteen days	100 Seeds.

M. Vivien at the Desprez laboratory had a very simple way of calculating results. We may take his example and admit that 100 kilos of seed contain:

		100 Kilos.
22.29 kilos large seed corresponding to		1,311,000 seed.
73.67 " small seed	" "	5,262,000 "
4.04 impurities		
100.00		

Moisture is found to be 8.75 kilos.

Average weight per seed........ { Large seed.........0.017 grams.
Small seed.........0.014 "

And that the germination was upon four grams of seed, an average sample:

$13.11 \times 4 = 52$ large seed weighing....0.89 grams.
$52.62 \times 4 = 211$ small " " ....2.95 "

Together ....3.84 grams without impurities.

These seeds are placed in germinators { 48 of the large seed germinate.
182 of the small seed germinate.

Consequently, in 100 seed 92.3 per cent. of large germinate.
86.24 " " small "

The germination per 100 kilos is...... { $22.29 \times 92.3 = 20{,}57$ kilos large seed.
$73.67 \times 86.24 = 63.53$ " small "

The bulletin then becomes 20.57 kilos large seed germinated.
63.53 " small " "
11.83 " dead seed.
4.04 impurities.

100.00

Remarks.—If the number of seeds had been considered instead of the weight, and if a proportional amount of small and large seed had been taken, then $92.3 \times 22.29 + 86.24 \times 73.67 \div 95.96 = 87.65$ per cent. would have apparently germinated; when, in reality, this would have been but 84.100 kilos of seed germinating in 100 kilos, showing again the importance of estimating by weight and not by number.

It is also important to note that certain German authorities claim, with a certain reason, that allowance must be made for the number of seeds as well as the weight. Under these circumstances, it is proposed to multiply the germinating faculty of 100 seeds by the number of seeds contained in the unit weight and divide the result by 100. For example, if 100 seeds gave 125 sprouts and had a purity of 98.5 per cent., the old method would give $125 \times 98.5 = 123.12$ per cent. as the value of the seed. On the other hand, Dr. Sempotowski supposes five grams of seed contain 256 seeds and that five grams were the unity of weight; then $123.12 \times 256 = 315.18$ per cent. as the actual value of the seed. Other calculations appear to show that what would have been in most cases considered acceptable by the old method is in reality worthless by the new.

APPENDIX.

Notes Upon and List of European Beet-Seed Growers.

The sugar beet, through long cultivation, becoming so pliable, so willing to meet the requirements of the environment in which it is placed, has resulted in the creation of hundreds of types and varieties. Many manufacturers have taken upon themselves the production of their own seed; this plan for a period of years was popular, and even now there are thirty-five factories in Germany where the practice is continued. There must be connected with this an outside market; for example, these factories just mentioned have special arrangements with other factories to supply them with the beet seed they may require.

In foregoing pages we have shown how much care there is needed in the selection and sub-selection. So many details cling together that its successful realization, by sugar manufacturers in general, is hardly practicable, as they have too frequently discovered after an interval of possibly five years. What is true regarding the manufacturer is equally true in cases of small dealers or growers, who attempt what they can only, in a measure, accomplish. They must have invested considerable capital, which yields no interest for a period of years; when first starting, furthermore, sufficient capital is needed to bridge over partial crop failure, caused by climatic influences, or very low selling price, caused by a frequent overproduction. The laboratory appointments must be up to modern requirements and standard, so as to create new types and varieties characteristic of one's own special work. The variations in market price are made evident by a single example. In Germany, in 1893, beet seed suddenly rose in price from 40 M. per 50 kilos (nine cents per pound) to 100 M. or 22 cents per pound.

The names given in the lists herewith are those with whom we have corresponded, and, in some cases, personally visited the farms, taking notes on the spot. We trust that the facts given will be of more than usual interest.

Vilmorin-Andrieux & Co.

This well-known firm needs no introduction. We, nearly twenty years ago, were the first to give general publicity to the type known as Vilmorin's White Improved sugar beet, which is one of the richest, if not the richest, beets in the market. It is cultivated all over the world and almost everywhere with success, on account of its numerous qualities. We cannot do better than to give here an extract of Dr. Wiley's pamphlet on the sugar beet, published by the United States Department of Agriculture in February, 1897.

"This beet is the result of thirty-five years of methodic and persevering selection based upon the right principles. In regard to its preservation, it is recognized that it holds its sugar content better than any other variety. In those factories in which the Improved Vilmorin is manufactured in connection with other varieties, it is the custom to reserve this variety for the end of the season and to work up the less reliable beets at an earlier date. It is also said to resist better than any other variety the unfavorable influence of certain characters of soil and of certain manures. In black soils, rich in organic matter, it gives great industrial results, while most other varieties of beets become watery or saline in excess. Excessive quantities of nitrogenous fertilizers, which are carefully excluded from ordinary varieties, can be applied with safety to the Improved Vilmorin, as a great number of experiments has shown that this can be done without serious deterioration in the quality of the sugar and with a considerable increase in weight. From thousands of analyses it has been established that the percentage of sugar that can be obtained with this variety is about sixteen. Its average yield under favorable conditions can be stated to be from 12 to 16 tons per acre."

We may add that late rains, so much to be dreaded in many countries, appear to have far less influence on the Vilmorin Improved than on most beets. On account of the extensive way in which Vilmorin's Improved is cultivated, the seed can be purchased at ten cents per pound. Thousands of analyses show that it can be depended upon to furnish 15 per cent. sugar and a yield of 15 tons of beets to the acre. The other varieties put out by this firm, such as French Very Rich, Red Top, Early Red Skin, Gray Top, etc., were very fully described in the author's work, "The Sugar Beet," and no further mention of them need be made here. Some of these have precocity, while others are noted for their keeping qualities. M. Vilmorin thinks that beets require a deep loam, or even a clay soil, if not too deep. A clayey subsoil is very desirable if it be covered with at least 15 inches of surface soil. He emphasizes the fact that thorough drainage is imperatively demanded. It should be added, that the special agents for supplying Vilmorin's sugar-beet seeds to the sugar-beet industry in the United States, are Willett & Gray, 91 Wall street, New York.

Klein-Wanzleben Sugar Factory Company.

Some years ago, we visited the Wanzleben factory, located at Wanzleben, and realized then the superiority of the sugar-beet seed there cultivated. Through long, careful observations and experiments, those in charge of the agricultural experiments of the locality were able to create a variety of beet that is connected by blood to nearly every type in existence, the characteristic advantage being the satisfactory yields obtained on any given area, combining also quality and suited to most soils. The early growers of this beet were Rabbetge and Giesecke, who were also proprietors of the Wanzleben sugar factory, which had a capital of nearly $700,000. The factory still remains in the hands of Giesecke and a partner, but the seed or agricultural section is now a complete and separate company.

A few words respecting the production of Klein-Wanzleben Original are not without interest. It was in reality created in 1860, and the type during these thirty-seven years has been strictly adhered to. However, there are constantly new varieties being created from force of circumstances. The physical selection plays a most important role, entirely independent of the chemical cold-water selection in the laboratory. All beets not possessing the typical characteristic must be thrown out. As mentioned a few lines above, there are new types which promise favorably, and these must be followed up with certain combinations of photographs, to determine if some desirable new departure may not be found necessary. As soon as a degeneration or atavism manifests itself, the work in that special direction is at once abandoned.

It is interesting to note that in some special cases a variety is obtained, from generation to generation, the amelioration of which shows a strong characteristic tendency. It is to just such a type that the Klein-Wanzleben owes its value and existence. To keep up the purity of the blood, so to speak, every few years interbreeding from the new standard varieties is found necessary.

The Wanzleben Company claim that they are able, through their very multiple selections, variations from the Original, to meet all the requirements of soil, fiscal laws, etc., of countries with which they are in correspondence. If such scientific problems could be solved, the progress in that direction is far greater than we ever thought possible. When one considers that the fiscal laws of a country are constantly changing, to meet these conditions at a moment's notice is very creditable and an extraordinary achievement. It must not be forgotten that ten years is a comparatively short period in which to create a new type. The Wanzleben laboratory can make 7000 analyses per diem, besides which must be added the analyses for high testing beets, these acting as a tally on work previously done. In previous pages we have given several items showing, and, at the same time, highly recommending, the methods adopted.

The Klein-Wanzleben Original demands a soil that has been previously worked. The best results are obtained on bottom lands, with sandy subsoil; manuring the autumn before planting, at time of sowing using sodic nitrate and superphosphate of lime; frequent use of the cultivator between rows, and one of the most important of all essentials is to keep beets near together in rows. Do not be in a hurry to harvest this type of beet. American agents for this firm are Meyer & Raapke, of Omaha, Nebraska.

M. Knauer, Gröbers, Germany.

With a few exceptions, no person in the entire Continental Europe has done more to improve the quality of beets than Knauer; the very name of beet seed and Knauer appear to be linked in some mysterious way. The firm has gone from father to son. However, the son has introduced many important changes of the most deserving kind. The individual cultivation for beets was first introduced into Germany, now forty years ago, by Ferdinand Knauer. The existing varieties may be considered now established on a very firm basis, for certainly time of more than twelve years is a most important factor. The Knauer seeds take three years to produce. Selection is made on the field from forms of types used as standard of comparison; these roots are kept in the soil and not analyzed until February or March the following year.

It was Knauer who fought the Vilmorin theory respecting individual power of plants. It was he who pointed out in the original selection that the Mangold was one of the parents (this fact, we believe, was never entirely admitted by Vilmorin, but at the same time was never denied). Such being the case, Knauer concluded, some years ago, that he would make a new departure, using the Mangold as a basis. The results obtained were far more rapid than at first could have been thought possible; under which circumstances, after ten years, with the so-called refreshing of the blood five times, the new beet was finally placed upon the market. It was soon noticed that this newly created variety had a very high percentage and apparently matured early. The difficulties at first in introducing this Mangold sugar beet were very like those M. Vilmorin had to contend with—the shape was not always the same, there was a want of uniformity, yet the texture of the epidermis was better than any of the existing types of beets used (this was considered a great advantage from a manufacturer's standpoint), the slicers could work them better and diffusion was more satisfactory.

From long observation and determination, the form or shape has now been corrected, and it is only in very exceptional cases that any fault is found with the shape. A strange fact relating to this variety of beet is, that the leaves apparently still retain the Mangold characteristic. This beet appears at present to be playing an important role. Besides the type just mentioned, attention must be called to the Electorale and Imperiale.

The latter appears to be suited to fertile soils; on the other hand, the Electorale renders great service on soils not so well suited for beets. These seeds have such well-known reputations that they need no introduction in these pages. The Mangold I apparently holds its name against all competition. The Knauer Wanzleben, or Improved, is also a very popular variety. At the society of Central Agriculture, of Tabor, Bohemia, in a contest with sixteen other varieties, the Mangold gave nineteen tons to the acre; later, in 1895 and 1896, the experiments were again resumed and Knauer's beets showed 16.6 per cent. sugar and 15.3 tons to the acre. The experiments conducted under the direction of Dr. Wiley at Washington show 16.3 per cent. sugar and 15.2 tons to the acre. The American agent is H. Cordez of Evansville, Indiana, who grew beets in 1897 showing these percentages of sugar:

	Mangold.	Imperial.	Electoral.
Sept 24	14.9	14.9	14.3
Oct 10	16.5	15.9	15.0

J. W. Ustyanowicz, R. F Zmigrodzki & Co., Kieff, Russia.

They have a very complete laboratory for selection. The physical selection receives special attention. The minimum weight for the Klein-Wanzleben type is 500 grams, while beets of the Vilmorin origin weigh 450 grams; beets are arranged in glasses of 500, 600, 700, 800, etc., grams; each of these receives special attention. A special Behl press is used to extract the juices. About 5000 beets are examined daily; these analyses commence in January. There are 300,000 beets that receive the attention of the chemists in the laboratory. The planting of the second grade selected beets for the production of seed for the trade is done in rows ten inches apart, with spacing of four inches in the rows. The annual production is 600 tons. The characteristic of their Klein-Wanzleben types is abundant growth of light green leaves, slightly fringed on the outer border; the pulp and skin are very white. The Vilmorin type has darker green leaves, very little fringed on edges; the roots are rather long, skin hard, and at times has reddish spots.

They claim that the richer the beet the greater the number of leaf rings, and corresponding sugar cells of the root. Hence, the reason why preference is always given in the selection to those roots having many circles of small leaves. Production of beets from buds has also been given an extended trial. Fifty buds are taken from each mother; these are planted in sand in greenhouses—not heated; when large enough they are transplanted, and their subsequent weight frequently reaches five pounds. About thirty out of the fifty give seed which will yield beets as rich in sugar as the original mother. Grafting has had a fair trial and has met with success; the root upon which the portion is grafted is called a nurse, for it takes care of the portion attached far better than could the root from which it was taken. The influence of the nurses is carefully watched and their buds are all removed. The seed from these growers has gained considerable reputation all over Europe.

Florimond Desprez, Capelle, France.

At one time, not many years ago, this firm held its own against all comers and promised a greater future than any special seed producer in the country, having a very excellent laboratory and all that science could offer. Just what the conditions are now, we are not prepared to say. One fact is certain, very superior seed has been created by the Desprez producers, and they were the first to establish a laboratory on a very extended scale. They claim to sell, annually, 100 tons of beet seed obtained directly from selected mothers. Their early maturing varieties attracted for a time some attention. They also attempted, with more or less success, to create varieties suitable for every soil and climate. But the conditions of environment in many countries render doubtful if the idea has much practical value. The very rich variety is known as Marque I; its object being to obtain the greatest possible yield of sugar to the acre, soils of an average depth being needed for a continuous period of four years. In a very careful observation, the sugar percentage was shown to be 16. There are also Marque I bis and Marque II. The former demands a very deep, well worked soil and yields twenty tons to the acre; the latter twenty-five tons to the acre and 15 to 10 per cent. sugar. On a soil of average fertility, maturity is possible in 150 days. Then follow Marques 2 bis, 3, 3 bis, 4 and 4 bis, etc. Besides which there are many varieties intended for beet distilleries. Agents for the United States and Canada, J. F. Hem of Buffalo, New York.

A. Janasz, Dankow (par Mogielnica, Gov. Varsovie, Russia).

This is a general seed grower, but who, however, has met with success in his sugar-beet-selecting methods. The laboratory is well equipped for the selection. They start from a variety they call Supra-Elite; from it are obtained the Elite. They furnish to the trade annually over 200,000 pounds of beet seed. In competitive tests made with several German and

Austrian varieties, they came out first. The starting point in the Janasz selection is the creation of families having a common parent; on the field it is possible to determine the value of each family as regards yield and sugar percentage from these. In the autumn 60,000 to 100,000 roots are selected; their analyses in the laboratory are made the following February, they being kept in silos, with necks upward, in one layer, There then follows a second selection from exterior appearance of the roots; there is at least 40 per cent. of the total then thrown out. The Keil rasp is used for sampling. There is a slight modification of the Pellet cold-water method; to a given weight of pulp is added a known volume of water. Filtration and polarization follow in a regular way. It is claimed that most accurate results have been obtained. For mixing water of known volume with weighed pulp, special glasses are used. The classification of the beets for mothers does not end with their analysis, as they have to undergo another severe classification as to weight, shape, etc., followed by other analyses by alcohol digestion. Not more than 5 to 8 per cent. of all beets examined come under the head of Class I, from which, in two years, are obtained mothers of special selection. About 70 per cent. of the beets examined in the laboratory form the Class II.

The silos for these mothers of Class II consist of several layers of roots separated by a suitable layer of earth, in the middle of which is a layer of straw. These roots are planted at a distance of 60 c. m. (23.4 inches), the soil being constantly worked by cultivator and spade. The seeds and stalks, when harvested, are tied up in bundles and allowed to dry for two weeks on the field; the separation of seed from stalks is done by a steam threshing machine. The Janasz company do a very little advertising and most of the crop finds its way to Russian Poland. The work is known as C. C. or

A. I., also P.C. or A. I. 2. The latter are larger than the former and give heavier yields. This seed is not sold, but is sown the following spring rather close together, so as to keep down the size, distance between rows 40 c. m. (15.6 inches), and between beets in row, 10 c. m. (3.9 inches).

Gustav Jaensch & Co., Aschersleben, Germany.

These growers are well known and make a specialty of beet seed. Their varieties are the outcome of the Vilmorin and Klein-Wanzleben. The selection is made with considerable care, being based as usual on the shape, weight and percentage of sugar. From year to year, they claim that their methods undergo slight changes—the outcome of experience.

Fouqier D'Herouel, Vaux-sous-Laon, France.

This well-known seed producer, who has been before the public for twenty years, has only one variety to which his name is given. The claim is, that great stress is placed upon his methods of selection. The sugar percentage is from 15 to 18 and the yield about fifteen tons to the acre. It is claimed that there is a considerable demand for this seed in Belgium, where it competes under favorable circumstances with the well-known German imported seed.

Zadislas Mayzel, Brzozowka, par Stopnica, Poland, Russia.

A seed grower of considerable reputation, established in 1873; many farms are connected with the enterprise. The chemical laboratories connected with the selection are most active many months of the year. The cold-water method of selection is used, with some few modifications, which are considered most important. Each mother is analyzed twice, and it is only when both analyses show the beet to be very superior that the root is kept for seeding purposes. This, combined with the genealogical tables of selected beets during a period of years, has allowed the production of the very superior seed as now furnished by this producer. About 1700 acres are annually devoted to seed growing, the farms being very far apart, one in the southern part of Russia. Climatic conditions in that section are said to be such that the beets resulting from such seed mature very early, and are very rich in sugar. The two types are the Vilmorin Amelioree and Klein-Wanzleben. The first mentioned are known as mark O, very hard skin, short leaves, very fine. The mark I, the second mentioned, has in some respects the advantage of the first, while the skin is hard. It has entirely a different characteristic; the leaves remain adhering to the beet late in August, and even until early September.

G. Schreiber & Sohn, Nordhausen, Germany.

The main effort of these growers is to create a typical beet of high sugar percentage and satisfactory yield, and which will be possessed of certain staying qualities, which will be affected only to a limited extent by atavism. Schreiber & Son are sugar manufacturers as well as growers; their laboratories for selection are at Heringen. The grandmothers should, in theory, weigh about one pound (400 to 500 grams) and contain from 17.6 to 18.5 per cent. sugar, but from a practical standpoint it is found that two pounds is a better weight and the sugar percentage limit 15.10 to 17—the final selection being made by the alcohol process. The number of polarizations has also reached a considerable sum, 46,000 of the Schreiber Original, 49,700 Schreiber Klein-Wanzleben Amelioree and 5000 of the Specialité Riche; the total by alcohol method, 28,800. These analyses showed that 22,000 contained more than 17 per cent. sugar of the Original, known as S. O.; the others are types S. K. W. and S. S. respectively. In a practical way, some very satisfactory results have been obtained with the Schreiber seed, with yields of eighteen tons to the acre and 16 per cent. sugar. Four thousand tons worked at the Heringen factory gave nearly 13 per cent. sugar of all grades.

D. Blary-Mulliez, Templeuve, France.

This producer has many customers among the sugar factories. A case is cited where a lot of ten tons proved most successful, the average sugar percentage was 14.7 and purity coefficient 85.4. For mother selection, preference is given to beets weighing above 650 grams. All beets other than those testing 18 per cent. are thrown out; analyses commence in November and finish in March; he claims that during 1897-98 he will make 170,000 analyses. These mothers furnish seed from which beets are obtained that yield seed for the trade. The farms are seven miles from all others where beets are cultivated. He is the only producer in that district. Special stress is put on the fact that much care is given in the selection. American agent, Alfred Musy, 3713 Rhodes avenue, Chicago, Ill.

E. Kommer, Quedlinburg, Germany.

This producer has considerable determination in wishing to create a variety of beet that will give at the same time heavy yields and high sugar percentage. He claims that most of the very rich beets are wanting in regularity of shape. The beet he has created is said to overcome some of these difficulties. The type Z is a Wanzleben Amelioree Blanche, suited to average soils; type E, same name of seed. These seeds have attained considerable success in the north of France, where in a contest of eighteen different growers the Kommer came out best, with 17 per cent. sugar in the beet, purity coefficient 89.2 and a yield of fifteen tons to the acre. An interesting feature about this grower is, he is willing to have seed returned if germination of product furnished is not up to the desired standard, providing the discovery is made within a reasonable period after sale. Some of these seeds have already been tried by the sugar companies of the United States.

H. Hornung & Co. and Schlitte & Co. have grown sugar-beet seed for over sixty years. Their long experience as practical seedsmen, also as important manufacturers of sugar from beets, enabled them to produce unexcelled grades of seed. Their standard is a beet of great weight and highest sugar contents, assuring the greatest possible acreage yields. The unvaryingly excellent results achieved with their seeds have made them justly famous and sought for in all sugar growing countries. "They developed the famous Klein-Wanzlebener, they improved the French Vilmorin, and created the Non Plus Ultra variety, a cross of the two first named." The sole American agents for these seeds are H. A. Fischer & Co., of 173 Front street, New York city.

August Rölker & Sons, of 52 Dey street, New York city, are among the prominent American houses that import beet seed for both the trade and to sell direct to the consumer. They publish a circular giving full particulars and directions for beet culture, as well as prices of beet seed.

European Beet-Seed Growers.

GERMANY.

M. Knauer ....Grobers
Gustav Jaensch & Co. ....Aschersleben
G. Schreiber & Sohn ....Nordhausen
E. Kommer ....Quedlinburg, Saxony, Germany
O. Schlieckmann ....Auleben
Carl Schobbert & Co ....Quedlinburg
A. A. Baumeir ....Kl. Schierstedt
Otto Licht ....Magdeburg
C. Braune ....Biendorf
W. Rimpau ....Lagenstein
Martin Grashoff ....Quedlinburg a Harz
David Sachs ....Quedlinburg
Otto Breustedt ....Schladen am Harz
C. A. F. Degering ....Quedlinburg
Sam. Lor. Ziemann ....Quedlinburg
Schlitte & Co ....Aumuhle bei Gorsback
H. Hornung ....Frankenhausen
Henry Mette ....Quedlinburg
Gebruder Dippe ....Quedlinburg
Klein-Wanzleben ....

AUSTRIA-HUNGARY.

Wohanka & Co ....Prague
Heinrich Maria Jirku ....Birnhaum bei Austerlitz
E. von Proskowetz ....Kwassitz (Moravia)
I. Zapotil Vetristic ....Boztok (Bohemia)
Proprietes Blahotitz ....Schlan (Bohemia)

RUSSIA.

J. W. Ustyanowicz ....Kieff
Ladislas Mayzel ....Brzozowka, par Stopnica, Poland
Comte B. Tyszkiewicz, Pliskoff-Androuchofka, Poland
Klein & Soukoffsky ......Bielany Beresovka, Podolie
A. Janasz ....Dankow, par Mogielnica (Gov. Varsovie
K. Buszczynski and M. Lazynaki..Niemiercze, Poland
Louis Walkhoff ....Kalinovka (Gov. Podolie)
A. Horowitz ....Macharinzy, Kasiatin (Podolie)
Prop. du la Comtesse M. Branicka....Olszana, Kiew
Starorypinski Karabezejowka ....(Podolie)
Proprietes du Comte I. Potocki................Antonin
I. Czarnomski ....Komarowka (Podolie)
G. Gluski ....Wierzbica (Gov. Kielce)
Prop. du la Comtesse Potocki ..Stazow (Gov. Radom)
E. Zaleski & Co ....Gole (Gov. Varsovie)

FRANCE.

Florimond Desprez, Capelle, near Templeuve (Nord)
Fouquier d'Herouel ....Vaux-sous-Laon (Aisne)
D. Blary-Mulliez ....Templeuve (Nord)
Vve Bulteau-Desprez & Fils ..Font-a-Marcq (Nord)
Vilmorin-Andrieux Co ....Paris
Dransar & Beauvois ....Faumont (Nord)
Degand-Nacfer ....Templeuve (Nord)
Laude-Postel ....Hornaing (Nord)
Ubald-Simon ....Orchies (Nord)
C. Denaiffe ....Carignan (Ardennes)
E. Carlier ....Orchies (Nord)
Celestin Bonnet ....Coutiches (Nord)
Gossart & Dhainaut ....Coutiches (Nord)
Poutrain-Lotte ....Capelle
C. Chuffart-Betaille ....Fretin (Nord)
Laurent-Mouchon ....Orchies (Nord)
Jules Lemaire-Dubois ....Nomain (Nord)
E. Eloir & Co ....La Madeleine-lez-Lille (Nord)
Simon Le Grand ....Vivaise (Aisne)
Jules Legras ....Besny (Aisne)
F. Demesmay ....Cysoing
Deletrez-Dennetieres Fils ....Orchies (Nord)
A. Wallez ....Valenciennes (Nord)
F. Geerts-Collette ....Camphin-en-Pevele(Nord)
Wagnies-Le Grand ....Establishments
L. & G. Begard ....La Neuville (Nord)
Carbon-Mocq ....Bersee (Nord)
Vitrant & Cannonne ....Cambrai
L. Guislain ....Nomain
Association Deutsch ....Paris
Carbon-Menet ....Genech
Ch. Allart ....Arras (Pas-de-Calais)
J. Ballet ....Capelle (Nord)
F. Haye ....Fortez, near Seboncourt (Aisne)

BELGIUM.

H. Malcorps ....Alleur, near Ans

INDEX.