TIME OF YEAR TO PLANT MOTHER BEETS FOR SEED PRODUCTION*

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INTRODUCTION

In the development of the sugar-beet seed industry for this country, the quantity and quality of seed should be among the first considerations. Some American seed companies have failed or lost heavily because of insufficient yield or poor quality of seed, which may have been due to many causes, such as poor storage, unfavorable weather conditions, poor care, or late planting. At the Salt Lake City Station (Utah) the writer has found that the quantity and quality of seed produced may vary greatly with the time of the year when the mother beets are planted. Beets planted early produce abundant seed, while those planted later produce little or no seed.

MATERIAL

Beets of the same variety and uniform as to weight, per cent of sugar, shape, and physical conditions were selected, analyzed, stored over winter, and planted during the next summer. The beets planted as late as September were apparently in as good condition as those planted in March. The apparently perfect condition of all beets at the time of planting was indicated by the fact that an unusually high percentage of the beets grew, all living beets produced seed, and there were no "trotzers," this being the reverse of conditions experienced by some investigators who have had from 50 to 90 per cent vegetative and unfruitful beets.

EXPERIMENTS

During 1922 and 1923 similar lots of beets were taken from storage each month, from March to September, inclusively, and carefully planted in rows on the same plot of ground. The soil was kept at a uniform moisture con-

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seed produced; but it appears that this is true only when dealing with beets which tend to be vegetative or are "trotzers."

The increase in production of seed in proportion to the increase in number of seed stalks per beet agrees well with the results of other investigators.\(^1\) The increase in the number of seed stalks per beet is probably due to the inhibition of the terminal bud during the early growth period and the mobilization of an excess of available food material which gives the outer crown-buds time and favorable opportunity for development, thereby giving rise to an increased number of seed stalks. Further evidence of this is given by the fact that single or few seed stalks can be developed on beets at will. As a result there occurs the single or few seed stalk habit of annual or bolting beets, mother beets which are planted in the heat of summer, mother beets with outer crown buds destroyed due to excessive drying, and also annual or mother beets which are subjected to forced reproduction in the greenhouse at high temperatures. The factors which lead to the single or few seed stalk habit of beets are those which tend to immediate reproduction, thus forcing the terminal and retarding the outer crown buds.

Plate 1 shows that the seed spikes, seed balls, and floral bracts vary considerably with the period of year the beets are planted. Beets planted early tend to produce compact seed spikes and large seed balls, with small bracts or none. Beets planted later in the season tend to produce elongated floral stalks, smaller seed balls, and an increased number of larger seed bracts.

The seed bracts on the beets planted in July and August tend toward vegetative leaves, and are much enlarged. If beets planted as late as September produce seed stalks, they are of a vegetative rosette type, as illustrated in Plate 1, E. These data indicate that later planting results in a tendency for beets to be more vegetative even when producing seed.

The rate of development of seed stalks and seed is given in Table II. The reproductive development was greatly retarded in the beets that were planted early, as indicated by the days elapsing from time of planting to time of flowering. Beets planted in the heat of summer tended to produce seed within a short period, while beets planted in the fall were very irregular in seed production and did not tend to develop reproductive organs. Photo-periodism experiments were arranged in the hope of finding some explanation of this increased seed production resulting from early planting. Both individual beets and lots of beets were exposed to the various lengths of days during spring, summer, and fall. An increased length of days during the spring had no noticeable effect upon the beets up until June 1, two months after planting. It was evident that there were other more important factors limiting the growth of reproductive organs during this period. From June 1 on, the seed stalks of beets subjected to light were probably more of a seed type, and flowered about one week earlier than beets not subjected to light. Beets planted late in the season and exposed to increased illuminations made more rapid seed-stalk growth and tended toward more reproductive seed stalks with greater per cent of late seeds. This is well illustrated by an individual beet (pl. 2, A) planted in August, the right side of which was exposed to six hours extra illumination from Sept. 8 to Oct. 15. It thus appears that light is an important factor in the lengthening of seed stalks when other limiting factors are not present.

### Table II. Development of seed stalks and seed, 1922–23

<table>
<thead>
<tr>
<th>Time of planting</th>
<th>Time required to reach final height</th>
<th>Time after planting beet to date of first flowering</th>
<th>Length of flowering period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Days</strong></td>
<td><strong>Days</strong></td>
<td><strong>Days</strong></td>
<td></td>
</tr>
<tr>
<td>Mar. 1</td>
<td>120</td>
<td>113</td>
<td>17</td>
</tr>
<tr>
<td>Apr. 1</td>
<td>90</td>
<td>82</td>
<td>19</td>
</tr>
<tr>
<td>May 1</td>
<td>60</td>
<td>52</td>
<td>24</td>
</tr>
<tr>
<td>June 1</td>
<td>45</td>
<td>42</td>
<td>25</td>
</tr>
<tr>
<td>July 1</td>
<td>30</td>
<td>30 to 60</td>
<td>20 to 75</td>
</tr>
<tr>
<td>Aug. 1</td>
<td>30</td>
<td>Irregular</td>
<td>Indefinite</td>
</tr>
<tr>
<td>Sept. 1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The meteorological data as to wind movement, relative humidity, and evaporation, gave no further explanation than did the effect of increased illumination. While these are all of importance, there seems to be other more important factors which require consideration. It was not until the beet roots were removed at different periods during the season that it was learned that those beets which produced the best quantity and quality of seed had previously produced the most marked root development.

Plates 2 and 3 show the root development of beets planted from April to

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September. The root development of beets planted March 1 was similar to that of beets planted April 1. Beets planted in April and May showed some enlargement of the old root and especially a marked development of new side roots. These side roots on the beets planted early are many and robust, while they are few, very fine, and threadlike on the beets planted later in the season. In this connection it was learned from the soil and air thermograph records that the enlarged root systems were developed at a time when the soil and air temperatures were low, and that the meager threadlike root systems were developed when the soil temperature and air temperature were high. The mean air and soil temperatures for the year 1923 are given in Table III. Plate 3, C, shows extensive root development of beets planted in September, at a time when soil temperature corresponded to the soil temperature of May. It is probable that these beets would produce an abundance of seed if September and October were followed by months of high temperatures, such as June and July.

TABLE III.—Mean air and soil (6-inch depth) temperatures for 1923

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean air</th>
<th>Mean soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar</td>
<td>3.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Apr</td>
<td>9.8</td>
<td>9.0</td>
</tr>
<tr>
<td>May</td>
<td>16.7</td>
<td>14.8</td>
</tr>
<tr>
<td>June</td>
<td>18.2</td>
<td>16.2</td>
</tr>
<tr>
<td>July</td>
<td>21.5</td>
<td>21.5</td>
</tr>
<tr>
<td>Aug</td>
<td>22.6</td>
<td>20.7</td>
</tr>
<tr>
<td>Sept</td>
<td>18.1</td>
<td>15.6</td>
</tr>
<tr>
<td>Oct</td>
<td>11.6</td>
<td>9.7</td>
</tr>
</tbody>
</table>

In order to verify this effect of temperature more carefully, beets were planted under controlled moisture and temperature conditions ranging from 15° to 30° C. The result was that the more marked side-root development occurred between 15° and 30° C. The side roots developed at higher temperatures were thin and threadlike, as shown in Plates 2, B, and 3 A, B.

In order to verify more carefully the effect of illumination on side-root development, and indirectly on seed development, beets were planted under controlled moisture and temperature conditions favorable for side-root development, and the quantity of illumination varied. Beets exposed to short or long illumination periods produced more robust and more numerous side roots than beets exposed to darkness (pl. 4, A and B). The beets planted April 1, in the field and exposed to 24-hour illumination until June 1, showed no greater root development than a similarly planted lot exposed to only 12-hour illumination. It appears that under favorable temperature conditions the usual day illumination of April and May is quite sufficient for maximum side-root development, and that the amount of illumination may not be as important as the presence or absence of illumination.

It was learned that an abundant root-bud and side-root development could be forced under controlled temperature and moisture conditions by removing crown buds (pl. 4, C). It was also possible to force crown development by removing root-bud tissues. It was further noted that temperatures of 15° and 20° C. inhibited seed-stalk development, while these same temperatures favored the development of side roots and vegetative leaves. Likewise, temperatures of 25° C. retarded the development of side roots and vegetative leaves, due to the fact that it forced seed-stalk development. Even though vegetative organs, such as leaves and side roots, may lengthen faster at higher temperatures, these same organs develop best at lower temperatures.

DISCUSSION

In explanation of this increased seed production resulting from early planting, Briem states that the growth period of the beet from planting to blossoming time should be twice as long as the period from blossoming to ripening of seed, and that this period must have a slow, steady rise of temperature. Shaw concluded from his experiments that the beets must pass through a period of restrained growth, at a temperature between 2.75° and 10° C., in order for the flower buds to develop. That this is not necessary is shown by the fact that beets stored at 1.7° or above 15° C., and planted under high temperatures in June, July, and August were not “trotzers” and produced seed.

The true explanation of the relation of increased seed production with early planting of beets will probably be found in many influencing factors. It seems that certain fundamental factors, such as moisture, temperature, and aeration, must be supplied before the

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Time of Year to Plant Mother Beets for Seed Production

Plate 3

A.—Beets planted July 1  
B.—Beets planted August 1  
C.—Beets planted September 1
influence of minor factors can be considered. The best results are obtained when sound beets of good physical condition are planted early in the season. At this time the cold-air temperature inhibits seed-stalk and seed production and favors vegetative leaf production, while the cold-soil temperature is favorable for side-root production and food-mobilization processes in the beet. At this favorable soil temperature for side-root production the mother beet often shows extended enlargement with an abundant formation of new roots. This extended root system is necessary to supply water for the transpiration stream during the seed production period. In early spring the roots probably absorb limiting food materials from the soil which aid materially in the further development of the beets and especially the seed, as it is understood that the amount of available food materials in the soil varies considerably during the season. There is a further accumulation of available food materials in the beet by the digestion of the stored sucrose. These progressive changes are also accompanied by a vegetative leaf production, which undoubtedly aids in the accumulation of new food materials. As the season advances, the temperature of the soil rises to a point which is unfavorable for root production, while the temperature of the air rises to the optimum for seed-stalk and seed production. Under these conditions maximum seed production occurs, because the beet has an abundance of available food and absorption organs provided by the earlier development.

On the other hand, if beets are planted during midsummer, when the temperature of the soil is inhibitive to root growth and the temperature of the air is favorable for seed production, the beets are forced to immediate reproduction or death, and there is very little or no seed produced. In this case, all conditions are similar and favorable for maximum seed production, except that the beet has not previously passed through a period of food mobilization and vegetative development which is necessary to sustain the reproductive development.

**SUMMARY**

These investigations indicate that the second year's development of the mother beet should be divided into two distinct periods: The first period being characterized by food mobilization, vegetative foliage development, new root production, and absorption of soil nutrients; the second period by rapid utilization of mobilized food, development of seed stalks, and production of seed.

The optimum temperature for seed-stalk and seed development is higher than the optimum temperature for vegetative leaf and root development.

The cold air and soil temperatures during the first period inhibit the reproductive development, while these temperatures favor complete vegetative development.

The higher temperatures of the second period favor rapid reproductive development and result in the retarding of the vegetative development.

There is maximum reproduction when a plant passes through a first period of complete vegetative development in which the reproductive development is inhibited, followed by a second period of forced reproductive development in which the vegetative development is largely inhibited.

The first period is an essential prerequisite to the second.

The seed produced during the second period is directly proportional to the extent of development of the beet during the first period.