Studies on the sterility in barley

II. On the relation between sterility and residual autumn habit,
with special reference to the translocation efficiency.

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秋播性を消失するに充分な低温処理（1℃、30日以上）を行っても、秋播大麦を春播した場合と同様に正常な開花、結実が行われて不稔の発生が少ない。これに反し低温処理期間が短く秋播性消失限界日数に近い場合（20～30日）には出穂が著しく遅延し、開花、結実も不良となり不稔の発生の多いことは第1図に示す如くである。更に、処理日数が極端に短かい場合（20日以下）には花芽分化及びその後の節間伸長等が行われず、葉錐の著しく低長化して所謂密閉現象を示すに至る。この最後の例からも明らかに確実な葉錐の乾長と考えるも単に結実力の低下と不稔の発生をはかるより、開花、結実の促進力は既に春播大麦の場合と同様、花芽分化後の節間伸長、糖の発育等の生産生長との相関に属する現象である。而して生産生長期の生育に伴う量的増加に必要な材料は殆ど自ら自ら生産する能力を持っていないからして、これ等の特質は栄養生長部である葉及び根により同化及び吸収され物質の転流したもののである。葉に於ける転流機能は一般的には葉面積従って又葉重にも比例すると考えられるから、根を一応考慮外にして、開花期に於ける生殖生長部の1日当りの乾物の増加量を葉重にて割った商数でdW/dW1は栄養生長部より生殖生長部への物質転流の効率を示すものである。従って反転流効率の不良なものは生殖生長の量的増加の著しいもの、即ち生殖生長の旺盛なるものと考えられる。此の様々な生殖生長の旺盛なものは生長生長に属する開花の機能も旺盛である事は容易に推察されるが、唯この場合小花数を考慮に入れなんだWo/W1の依存性は概して小花数に従い転流効率の増大を示し、転流効率の良いもの、即ち生殖生長と生殖生長との密接関係を示すものであって、C/L（C/L と称することにする）は出穂期に於ける大平均的な転流効率を示すものである。転流効率の良いものは繁殖生長を良好にし生産生長の旺盛なることを示すことは注目すべきである。出穂後及び栄養重等同関関全期転流生長の発生を行しない場合、繁殖生長と生殖生長との密接な関係を示すものであって、繁殖転流生長が関與している場合、繁殖生長の優位性が原因して転流効率が低下し、開花に必要なエネルギーの供給が不充分となり、開花機能が低下して病の不裂開又は花芽脱落不能を来たす。その結果不稔度となり不稔の発生をもたらすものと考える事が出来る。

Résumé

Previous works published by Sudo (1941) and by the present writer (1949) on sterility in barley indicate that the leading cause is non-pollination depending on the abnormal dehiscence of anthers, which resulted from their functional weakness at the flowering time.

The present work dealing with the residual autumn habit has been designed to obtain an
information on the mechanism of this functional weakness in flowering from the physiological point of view.

When winter barley variety is sown in spring, provided completely with the necessary conditions for cancellation of autumn habit by chilling for more than 30 days at 1°C before sowing, the flowering takes place normally, resulting in fewer occurrences of sterility. However, if the necessary conditions are not given sufficiently, that is, duration of chilling is in the range of 20 to 30 days, the flowering delays for about 2 weeks compared with that of the completely vernalized, and sterility occurs in considerably high percentage as shown in Fig. 1.

Moreover, when the chilling period is shortened to less than 20 days, the plants sown in spring fail to reach ear formation in that season and the formation of leaves and tillers is extremely promoted without setting any flowers, the plants remaining the “rosette” stage.

As seen from this “rosette” phenomenon, it will be obvious that vegetative growth and reproductive growth belong respectively to the essentially different phases in plant growth: The former includes the leaf growth and tillering, while the latter includes elongation of culm after the ear formation and the growth of spike. In the early stages, as the reproductive organs involving culm and ear have little, if any, ability to produce carbohydrates and other materials necessary for their growth in quantity by themselves, the materials employed for their growth are drawn from the vegetative organs consisting of leaves and roots.

When the amount of dry weight of the reproductive organs is plotted against days curves represented by Fig. 2 are obtained. The circles represent the 40 days treatment, the crosses, 20 days treatment. These curves show S figures on the whole, but nearly straight lines before and after flowering time. So the increment in dry weight per day, dWc/dt, is easily obtained by calculating the regression coefficient. In the 40 days and 20 days treatment, these values are 92.4 and 51.8 in mg. respectively.

The photosynthesis is, in general, proportional to leaf area, consequently to leaf dry weight. Therefore, the quotient dWc/Wl, where dWc and Wl denote the increment in dry weight of the reproductive organ per day and the leaf dry weight present at the measuring time of dWc respectively, comes to indicate the “translocat-
tion efficiency”. Indicating this quotient as percentage, 9.5% and 4.0% are obtained in the 40 days and the 20 days treatments respectively at the flowering time as shown in Table 1. The culm weight divided by the leaf, C/L or C. L ratio, is considered to be the mean values of translocation efficiencies which are seen in every stage of growth period between the time of ear formation and that of estimation of this ratio.

Table 1. Relation between the translocation efficiency and the sterilizing percentage

<table>
<thead>
<tr>
<th>Treat.</th>
<th>dWc/dt</th>
<th>dWc/fn</th>
<th>Translocation efficiency dWc/WI x 100</th>
<th>C. L ratio</th>
<th>Length of main culm</th>
<th>1000 grains weight</th>
<th>Total sugar weight in 100 lodiacules</th>
<th>Percent. of sterility</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 days treat.</td>
<td>92.4 mg</td>
<td>4.65 mg</td>
<td>9.8</td>
<td>1.1395</td>
<td>cm 105</td>
<td>54.8 g</td>
<td>mg 3.33</td>
<td>2.3</td>
</tr>
<tr>
<td>20 days treat.</td>
<td>51.8</td>
<td>1.95</td>
<td>4.0</td>
<td>0.7542</td>
<td>91</td>
<td>44.6</td>
<td>2.35</td>
<td>7.2</td>
</tr>
</tbody>
</table>

C. L ratio is, for the most part, of the same meaning as the formula of BEKUZEN’S “structural efficiency”, and is of equal value to the translocation efficiency as a criterion of efficiency indicating the intensity of material migration from the vegetative organs to the reproductive ones. It is likewise a more convenient method from the point of view of experimental procedures. 1.1395 and 0.7542 are, as C. L ratios, obtained in the 40 days and 20 days treatment respectively, and they correspond fairly well with the translocation efficiencies and are as parallel with the tendencies of sterilizing percentage as the translocation efficiencies.

In the present experiments, it should be noted that this C. L ratio means a direct antagonism between tendencies toward the dominance of vegetative or reproductive growth in plants. Accordingly, the higher the C. L ratio, the more superior is the reproductive growth to the vegetative one, and contrariwise the lower, the more inferior.

It is possible to consider that the increment in dry weight of culm and ear may be proportional to the amount of carbohydrates and other materials to be provided for flowering.

The organic matters provided for flowering per floret relatively decrease, as the florets of an ear increase in number. So it is very significant to calculate dWc/fn, where fn denotes the number of florets. In practice, dWc/fn values in each treatment are parallel with the total sugar weight, sum of reducing and nonreducing sugar, in lodiacules of the open florets. It is not unreasonable to assume that the osmotic pressure contributing to the necessary energy for flowering becomes lower as the sugar content in florets decreases, and consequently the function of anther dehiscence and pollen projection weakens.

A fact that the length of the main shoot and the weight of 1000 grains are greater and heavier in the 40 days treatment than in the 20 days proves the more migration of organic matters in the 40 days treatment than in 20 days, as the translocation efficiency also does.

Summarizing the results of these experiments, the following conclusions can be made; the translocation efficiency and its mean value, the C. L ratio, decrease corresponding to the intensity of the residual autumn habit, that is, to the unbalance between tendencies for the growth of the vegetative or of the reproductive organs in plants to dominate. The amount of materials migrating to the reproductive organs is proportional to the degree of the translocation efficiency, and slight increment in dry weight of the reproductive organ means the poor growth of that organ. The functional weakness of anther dehiscence and pollen projection due to the poor growth of reproductive organs is the leading cause of non-pollination and consequently of sterility relating to the residual autumn habit.