The proper spacing of rows, number of stalks per hill, and spacing of plants in drilled rows are questions of interest every year to sweet-corn growers. The introduction of each new hybrid brings up these questions anew. Moreover, some types of mechanical sweet-corn corn pickers seem to work better when the crop is planted in drill rows. How drilling will affect yields has thus become important. Then, after the plants are above ground, the stand may seem to be thin and irregular. A grower must then decide whether to disk up the crop and start over, or whether to let well enough alone.

**Recommendations for Two Open-Pollinated Varieties**

Altho a grower should make every effort to get a uniform drop when planting sweet corn, the fact that the stand varies widely from hill to hill should not tempt him to replant if the total stand is good. If, however, the irregularities in the stand are due to missing hills and there are many such in the field, it will be advisable to replant.

**Rates and Distances for a Cannery Crop**

Cannery growers want the largest ears possible because the cost of picking by hand is a major item in production costs. The following rates and distances have proved best for this purpose.

**Country Gentleman:** in check rows, 40 × 40 inches with 3 plants to the hill; or in drilled rows 40 inches apart with plants 14 inches apart in the row.

**Narrow Grain Evergreen:** in checked rows, 40 × 40 inches with 4 plants to the hill; or in drilled rows 40 inches apart with plants 14 inches apart in the row.
When Heavier Plantings Are Wanted

Extremes in planting distances and rates should always be avoided. But if a grower decides that within reasonable limits a heavier planting is desirable, he will find that increasing the number of plants per hill is usually a better way to get a heavier stand than spacing the hills more closely.

EXPERIMENTS WITH TWO OPEN-POLLINATED VARIETIES

If only one problem were involved in the relation between stand and yield, rather simple experiments would furnish growers with the information they need about the best planting practices. But many factors are involved. If, therefore, recommendations are to be of practical value they must take all known factors into account and make certain compromises between them.

It can be proved, for example, that a rank-growing variety of sweet corn, such as Narrow Grain Evergreen, planted as close as 36 X 36 inches, 5 stalks to the hill, will, if the weather is right and the soil fertile enough, give higher yields than when planted in wider rows with fewer stalks to the hill. Since, however, the weather is often unfavorable and soils are rarely at the highest level of fertility, the rates and distances recommended must be a compromise made to meet average conditions. The grower who has learned the limitations of his soil and climate and what the variety will do will know how to adjust his practices accordingly.

Experiments dealing with planting rates and distances are actually studies of plant competition and of mutual protection in relation to the environment. When planting is too thick, competition is too heavy and yields are reduced; when it is too thin, the unprotected crop is exposed to hot winds and unfavorable weather and may suffer. The precise points at which competition or lack of protection reduces yields vary from year to year and from field to field.

The results of experiments dealing with the problem of stands in relation to sweet-corn yields have been reported in detail in technical publications.¹

Plan of Experiments

Sixteen checked plantings and 12 drilled plantings were included in the final tests, which covered five years (1932-1936). Preliminary experiments extending over two years, were used as a guide for the final tests, which were laid out as follows:

<table>
<thead>
<tr>
<th>Checked rows</th>
<th>Drilled rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches between rows</td>
<td>Rate</td>
</tr>
<tr>
<td>42 x 42</td>
<td>2, 3, 4, and</td>
</tr>
<tr>
<td>40 x 40</td>
<td>5 plants per</td>
</tr>
<tr>
<td>38 x 38</td>
<td>hill at each</td>
</tr>
<tr>
<td>36 x 36</td>
<td>distance</td>
</tr>
</tbody>
</table>

The 28 plantings were replicated four times each year for each of two open-pollinated varieties, Country Gentleman and Narrow Grain Evergreen. Thus there were 112 plots of each variety each year.

The plots were harvested at the canning stage (70 percent moisture) each year, all ears being taken. After being sorted, the unhusked ears were weighed. The ears were then husked and sorted and the total weights and counts recorded.

How Planting Rates and Distances Affected Yields

An experiment as complex as this can usually be expected to give rather diverse results. Therefore careful statistical analysis is necessary. Such an analysis was made and the details published. Six yield components were analyzed. These consisted of:

- Weights of sorted unhusked ears
- Number of sorted unhusked ears
- Weight of prime husked ears
- Weight per prime husked ear
- Percent recovery of prime husked ears
- Weights of green fodder

The experiments showed that planting rates and planting distances favorable for the highest production of one of these yield components do not necessarily apply to the highest production of any of the others. For example, the number of plants per hill and the distance between rows that will produce the largest number of usable unhusked ears to the acre is often not the combination that will produce the largest ears. Accordingly the yield of one component under a particular set of conditions cannot be used to determine the yield of some other component.

1 Test rows or plots are systematically repeated in this way in order to reduce errors.
Also, the two varieties reacted quite differently to changes in planting rates and distances. So the behavior of one variety cannot be used to predict the response of another even under similar conditions. As these experiments were finished before sweet-corn hybrids came into general use, it is not known whether or to what extent different hybrids, even within the same variety, may differ in their responses to changing rates and distances of planting. Until more information is at hand, growers will have to assume that hybrids will react in the same way as equivalent open-pollinated types.

Plant competition was also studied. In checked plantings, the basis for comparison was the theoretical space occupied per plant; in drilled plantings, the actual space. The results again showed that the several yield components differed in their responses. In the checked plantings the responses to amount of space per plant differed from those in the drilled plantings. The nature of these variations suggested that while space per plant exerted a strong effect on yield, other factors had at least a partly independent effect. For example, certain combinations of distance and rate proved to be unusually favorable, especially to weight of green fodder and height of plants, both measures of plant growth. Such components as number of sorted unhusked ears, weight per prime husked ear, number of suckers per plant, and maturity as determined by date of silking—all seemed to depend on space occupied per plant.

How Planting Rates and Distances Affected Maturity, Number of Suckers, and Height

Maturity. In checked plantings, reducing the distance between hills tended to delay maturity slightly, while increasing the number of stalks to the hill caused a very appreciable delay.

In drilled plantings, the tendencies were very similar. Reducing the distances between rows had no consistent effect on maturity, but closer planting in the rows tended to delay it.

Number of suckers. The distances between rows in drilled plantings, or between hills in checked plantings had only a slight effect on number of suckers per plant.

However, as the distance between plants in drilled rows was decreased, or as the number of plants per hill in checked rows was increased, the number of suckers per plant was greatly reduced.

Plant height. In seasons when moisture in the soil was limited, closer spacing between checked hills or between drilled rows tended to reduce plant height. But increasing the number of plants per hill only slightly affected height.
When there was a normal amount of moisture in the soil, closer spacing in drill rows increased plant height but there was no appreciable effect in checked rows.

**Effect of Rate Compared With Distance**

*In checked plantings,* yields of Narrow Grain Evergreen were affected much more by changes in rate of planting than by changes in distance between hills. Yields of Country Gentleman, on the other hand, were about equally affected by rate and distance. Country Gentleman has proved much more responsive than Narrow Grain Evergreen to changes in both rates and distances. A grower of Country Gentleman will therefore need to be especially careful to set his planter at the proper distance and to have the correct plates for the grade of seed he intends to plant.

*In drilled plantings* there was little difference in the reaction of the two varieties, the distance between rows being of greater importance than the stand in the row.

The yields from drilled plantings are in no way inferior to those from checked plantings, nor do drilled plantings yield more green fodder to the acre.

**STAND IRREGULARITIES: AN EXPERIMENT WITH A HYBRID**

One of the criticisms of the experiments just discussed was that every precaution was taken to attain perfect stands, and perfect stands are never found in commercial plantings. A further experiment, in which there were plots with regular stands, irregular stands, and missing hills, was laid out and continued for three seasons (1937-1939).

All the mathematically possible stands between 0 and 4 plants per hill in a checked planting were included, allowance being made for a single variation in every other hill. Fourteen combinations were possible, as follows:

- 0 and 1
- 0 and 2
- 0 and 3
- 0 and 4
- 1 and 1
- 1 and 2
- 1 and 3
- 1 and 4
- 2 and 2
- 2 and 3
- 2 and 4
- 3 and 3
- 3 and 4
- 4 and 4

It was assumed that little information could be added by including stands of 0-1 and 1-1, which were therefore omitted, leaving 12 rates, three of which (2-2, 3-3, and 4-4) were uniform. The 12 rates were replicated 12 times and planted in a Latin square consisting of 144
Effects of Stand Irregularities on Yield and on Weight per Ear, 1937-1939

(Expressed as percentages of the means of all treatments)

<table>
<thead>
<tr>
<th>Number of plants per 2 hills</th>
<th>Type of planting rate</th>
<th>Percentage yield based on weight per acre</th>
<th>Percentage yield based on number of ears per acre</th>
<th>Weight per ear</th>
<th>Total weight of unhusked culls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unhusked ears</td>
<td>Prime husked ears</td>
<td>Prime cut corn</td>
<td>Unhusked ears</td>
</tr>
<tr>
<td>2</td>
<td>0-2, every other hill missing</td>
<td>72.62</td>
<td>72.30</td>
<td>73.37</td>
<td>69.34</td>
</tr>
<tr>
<td>3</td>
<td>0-3, every other hill missing</td>
<td>81.02</td>
<td>79.96</td>
<td>80.75</td>
<td>78.43</td>
</tr>
<tr>
<td>3</td>
<td>1-2, irregular stand</td>
<td>96.14</td>
<td>95.84</td>
<td>96.01</td>
<td>91.98</td>
</tr>
<tr>
<td>4</td>
<td>0-4, every other hill missing</td>
<td>86.05</td>
<td>85.19</td>
<td>85.59</td>
<td>85.98</td>
</tr>
<tr>
<td>4</td>
<td>1-3, irregular stand</td>
<td>101.78</td>
<td>102.76</td>
<td>102.07</td>
<td>98.29</td>
</tr>
<tr>
<td>4</td>
<td>2-2, uniform stand</td>
<td>106.58</td>
<td>105.98</td>
<td>105.42</td>
<td>103.13</td>
</tr>
<tr>
<td>5</td>
<td>1-4, irregular stand</td>
<td>103.86</td>
<td>103.55</td>
<td>102.98</td>
<td>105.73</td>
</tr>
<tr>
<td>5</td>
<td>2-3, irregular stand</td>
<td>102.95</td>
<td>102.90</td>
<td>103.08</td>
<td>102.23</td>
</tr>
<tr>
<td>6</td>
<td>2-4, irregular stand</td>
<td>113.20</td>
<td>113.68</td>
<td>113.98</td>
<td>115.07</td>
</tr>
<tr>
<td>6</td>
<td>3-3, uniform stand</td>
<td>110.93</td>
<td>111.91</td>
<td>112.44</td>
<td>111.06</td>
</tr>
<tr>
<td>7</td>
<td>3-4, irregular stand</td>
<td>114.37</td>
<td>115.55</td>
<td>115.26</td>
<td>117.80</td>
</tr>
<tr>
<td>8</td>
<td>4-4, uniform stand</td>
<td>110.41</td>
<td>110.37</td>
<td>108.93</td>
<td>120.96</td>
</tr>
</tbody>
</table>

Difference required for significance at 5-percent level | 8.49 | 9.67 | 9.48 | 5.66 | 6.34 | 3.98 | 3.67 | 27.13 |

The results of the experiment on stand irregularities was fully reported in the Journal of Agricultural Research, 67, 211-224, 1943.
plots. A uniform planting distance of $40 \times 40$ inches was maintained in all plots.

Country Gentleman had demonstrated its sensitivity to changes in planting rates and distances. Therefore the seed stock chosen was Illinois Country Gentleman hybrid $8 \times 6$, a single cross now in wide commercial use. Yields were taken with great care and data were obtained on the most essential components; yields of unhusked, prime husked, and prime cut corn.

A highly condensed summary of the results of these tests is given in the accompanying table. The yield for each treatment is expressed as a percentage of the yield of the whole field. This field is representative of a commercial field having a highly irregular stand with many missing hills, but averaging $2\frac{3}{8}$ stalks per hill.

**The experiment proved that within reasonable limits total stand is the important factor governing yield.** With the exception of missing hills, irregularity of stand has little to do with yield. Missing hills reduced the yields significantly in all cases. It should also be noted that nothing was gained by increasing the average stand of Country Gentleman to more than 3 stalks per hill, a conclusion which was reached from the earlier experiments previously discussed.

**Weight per ear is influenced mainly by number of stalks per hill,** the heavier stands having the smallest ears. The effect of the number of stalks to the hill on the weight of the ears is especially marked in any planting combination in which as many as 4 plants are left in the hill either in regular or irregular stands.

The yield of unhusked culls increases rapidly as the number of plants per acre increases; but the increase in culls seems to be independent of regularity of stand.

The conclusion drawn from the rate-of-planting experiments — that the recovery of prime husked ears and of prime cut corn is affected only by extremely heavy stands and then adversely — was substantiated by this experiment.

In this experiment, as in those on planting rates and distances, increasing the number of stalks per hill tended to delay maturity. Irregularity of stand, however, had no significant effect on maturity.

**APPLICATION TO HYBRIDS**

Since the conclusion of the experiments in 1939, a large number of sweet-corn hybrids have been introduced and commercial growers no longer use open-pollinated types. Some hybrids — Country Gentleman and Narrow Grain Evergreen, for example — bear a close resemblance
to the open-pollinated varieties from which they are derived. Many others must be regarded as entirely new varieties, Golden Cross Bantam being a good example.

Commercial growers will be able to apply the general principles concerning planting rates and distances and stand irregularities, worked out in these experiments, to present-day hybrids if they will think of the hybrids as divided into the following three classes:

**Early dwarf types.** Height not more than $5\frac{1}{2}$ feet; generally bushy; many have numerous suckers; generally resemble early flint corn. Spancross C4 × C13, Early Bancross, Marcross C6 × C13, and Improved Carmelcross are examples of these types.

In Illinois these early dwarf types are usually planted in rows 30 to 36 inches apart. Many growers drill the seed, spacing the plants about 8 inches apart in the row. Others plant in check rows 3 to 4 plants to the hill. It is doubtful whether planting any but the very earliest hybrids in less than 36-inch rows can be justified. The very early hybrids, which seldom grow more than $4\frac{1}{2}$ feet high, may possibly be planted in less than 36-inch rows.

**Midseason types.** Heights $5\frac{1}{2}$ to 7 feet; usually somewhat bushy; generally with fewer suckers than the early dwarf types; characteristics of flint corn are dominant. Golden Cross Bantam, Ioana, Purgold, Whipcross, Lincoln, Lee, and Silver Cross Bantam are typical crosses in this group.

These midseason types are usually check-planted $36 \times 36$ or $38 \times 38$ inches. In northern Illinois growers usually plant 4 plants to the hill, and in central Illinois 3 plants. In the absence of any experimental results, it may be assumed that these rates and distances are approximately correct.

**Late-season types.** Height 6 to 8 feet; suckers medium to few; resemble dent corn more closely than do the midseason types. Narrow Grain Evergreen hybrids, such as Illinois 14 × 13, Illinois 14 × 11, Illinois 55 × 11, and Jogreen 56, and all the Country Gentlemen hybrids belong in this group. Few yellow sweet hybrids are included. Illinois 10 is perhaps the best known of the yellows. Others are Golden Evergreen and Bantam Evergreen hybrids introduced under several different names.

The late-season types are almost always planted in checked rows $38 \times 38$ or $40 \times 40$ inches. In northern Illinois, stands will average close to 4 plants per hill; in central Illinois 3 to a hill is more common. These practices are in close accord with the above recommendations.