FERTILIZER PLACEMENT FOR CANNERY PEAS

CHARLES B. SAYRE AND G. A. CUMINGS
ABSTRACT

THREE years' results show that applying fertilizer in contact with pea seed will reduce the yields, while the same amount of fertilizer applied separately from the seed will increase the yield. Unfortunately, the injurious method is the only placement of fertilizer possible with the types of drills commonly used in New York if the seed and fertilizer are sown in one operation. To avoid this injurious effect the fertilizer and seed must be sown separately, involving two operations.

An attachment for a grain drill has been devised by means of which fertilizer and seed can be sown in one operation so that the fertilizer will not cause any injury to the seed and so that the fertilizer will be advantageously placed for use by the plant. Photographs and a detailed description of this attachment are given from which growers and manufacturers might devise similar attachments to their drills for improving the method of placement of fertilizer for cannery peas or any drill-sown crop susceptible to early fertilizer injury.

One year's results are given showing the resulting yields of peas when fertilizers were applied at different distances to the side of the seed, in contact with the seed, above the seed, and with different fertilizer ratios and amounts. The advantages of placing fertilizer to the side of the seed from the standpoint of safety and ready accessibility to the plant are discussed.

The residual effect of a heavy application of fertilizer in rows for a crop preceding cannery peas was studied in regard to its possible effect on unequal maturity of the peas. Three hundred pounds or more per acre of a good fertilizer applied in side placement with the peas completely overcame any residual fertilizer effect and prevented unevenness of development.
BULLETIN NO. 659

FERTILIZER PLACEMENT FOR CANNERY PEAS

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Agriculture

INTRODUCTION

It is the object of this bulletin to present results with canny peas obtained from different methods of applying fertilizers and to describe an attachment to a grain drill by means of which fertilizer and seed can be sown in one operation and the fertilizer correctly placed to avoid all danger of burning the plants and where it will be particularly effective in stimulating growth of canny peas. Unfortunately, with the types of drills most commonly used in New York State for sowing canny peas, if fertilizer is sown with the peas, the only placement of the fertilizer that is possible, is in contact with the seed. It has been repeatedly shown with other crops as well as peas, and with a great variety of soils and fertilizers that the placement most likely to be injurious is to drill the fertilizer in contact with the seed. With the attachment described herein this disastrous effect was avoided and the fertilizer applied more effectively in field experiments.

In using commercial fertilizer for peas, the method of applying the fertilizer is fully as important as the kind or amount of fertilizer in affecting the yield. As shown in Table 1, experiments conducted at this Station over a period of years have shown conclusively that fertilizer drilled in contact with pea seed (a very common farm practice) usually results in reduced yields, whereas the same kind of fertilizer applied separately from the seed will increase the yield. Experiment station specialists and extension service workers frequently receive urgent calls from farmers or canners to analyze the cause of miserably poor stands of peas. Since the canners furnish the seed, there is a tendency for the farmer to accuse the canner of supplying him with poor seed, while the canner in turn blames the seedsman. In most cases it is found that the seed is perfectly good, but that the stand was ruined because the fertilizer had been applied in contact with the seed (Fig. 1).
FIG. 1.—RIGHT AND WRONG WAYS TO USE FERTILIZER ON PEAS.
The fertilizer should not be drilled in contact with the seed. View of the 1930 experiment.

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Method of application</th>
<th>Yield of peas per acre, lbs.</th>
<th>Gain or loss in lbs. compared with unfertilized peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 lbs. 4-12-4</td>
<td>Separate drill</td>
<td>1,883</td>
<td>+453</td>
</tr>
<tr>
<td>300 lbs. 4-12-4</td>
<td>Fertilizer sown with seed</td>
<td>1,217</td>
<td>-213</td>
</tr>
<tr>
<td>600 lbs. 4-12-4</td>
<td>Separate drill</td>
<td>1,991</td>
<td>+561</td>
</tr>
<tr>
<td>600 lbs. 4-12-4</td>
<td>Sown with seed</td>
<td>766</td>
<td>-664</td>
</tr>
<tr>
<td>No fertilizer</td>
<td></td>
<td>1,430</td>
<td></td>
</tr>
</tbody>
</table>

Alaska, 1928

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Method of application</th>
<th>Yield of peas per acre, lbs.</th>
<th>Gain or loss in lbs. compared with unfertilized peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 lbs. 4-16-4</td>
<td>Separate drill</td>
<td>1,815</td>
<td>+895</td>
</tr>
<tr>
<td>300 lbs. 4-16-4</td>
<td>Sown with seed</td>
<td>1,005</td>
<td>+85</td>
</tr>
<tr>
<td>600 lbs. 4-16-4</td>
<td>Separate drill</td>
<td>1,275</td>
<td>+355</td>
</tr>
<tr>
<td>600 lbs. 4-16-4</td>
<td>Sown with seed</td>
<td>440</td>
<td>-480</td>
</tr>
<tr>
<td>No fertilizer</td>
<td></td>
<td>920</td>
<td></td>
</tr>
</tbody>
</table>

Surprise, 1930

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Method of application</th>
<th>Yield of peas per acre, lbs.</th>
<th>Gain or loss in lbs. compared with unfertilized peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 lbs. 4-16-4</td>
<td>Separate drill</td>
<td>1,162</td>
<td>+249</td>
</tr>
<tr>
<td>150 lbs. 4-16-4</td>
<td>Sown with seed</td>
<td>934</td>
<td>+21</td>
</tr>
<tr>
<td>300 lbs. 4-16-4</td>
<td>Separate drill</td>
<td>1,494</td>
<td>+581</td>
</tr>
<tr>
<td>300 lbs. 4-16-4</td>
<td>Sown with seed</td>
<td>892</td>
<td>-21</td>
</tr>
<tr>
<td>600 lbs. 4-16-4</td>
<td>Separate drill</td>
<td>1,523</td>
<td>+610</td>
</tr>
<tr>
<td>600 lbs. 4-16-4</td>
<td>Sown with seed</td>
<td>765</td>
<td>-148</td>
</tr>
<tr>
<td>No fertilizer</td>
<td></td>
<td>913</td>
<td></td>
</tr>
</tbody>
</table>

Perfection, 1934

*Each treatment replicated three times. Yields given are the weights of viner-shelled peas and are the average yields from three one-fiftieth acre plats.
Cannery peas are a comparatively high cost crop, the seed alone costing $16 to $20 per acre. Consequently it is particularly important not to damage the stand by the incorrect use of fertilizer.

Unfortunately, the types of seed drills commonly used in New York State for sowing cannery peas are so constructed that the fertilizer and seed flow thru the same tubes and if the fertilizer and seeds are sown in one operation the fertilizer must be in contact with the seed. This is the placement of fertilizer which is most likely to injure the seed. This has been proved by a great number of experiments with various types of soils and with many other crops as well as peas.¹

Of course it is not necessary to sow the fertilizer and seed in one operation. The fertilizer can first be sown and then the peas sown in a separate operation. In this way the peas are not likely to be injured by the fertilizer (Table 1), but it requires going over the land twice with the drill, which increases costs and seems a needless waste of time and labor. Likewise it results in an irregular placement of fertilizer in relation to seed, in some places being too close and other places too far away.

It is plainly evident that there is an urgent need for a machine by means of which fertilizer and seed can be sown in one operation and the fertilizer kept separate from the seed and correctly placed so that it will be readily accessible but not injurious to seed. When this need was pointed out to machinery manufacturers they replied that thus far they had been given only negative information, namely, where not to put the fertilizer for peas, and that when it could also be demonstrated where the fertilizer should be placed to be most advantageous, then they would construct their machines to place the fertilizer correctly.

Accordingly, an attachment was devised (Figs. 5, 6, 7, 8, and 9) for a standard grain drill by means of which the fertilizer and seed could be sown in one operation but the fertilizer kept separate from the seed and also by means of which a number of different placements (above, below, and various distances to the side of the seed) could be compared. Very satisfactory results were obtained with this machine. So many requests have been received for detailed information regarding the construction of this attachment and the results obtained that it was decided to publish this information at this time.

Definite conclusions as to the exact placement of fertilizer for

¹For a detailed discussion of the causes of and nature of injury to seeds from fertilizer, see Tech. Bul. No. 231 of this Station.
cannery peas that will give the best results under all climatic and soil conditions cannot be drawn from one year's results; consequently, these results are presented as a progress report with full acknowledgment that under other seasonal and soil conditions somewhat different results might be obtained. However, it is believed that some important principles in the construction of a satisfactory machine have been developed, that valuable information concerning the most advantageous placement of fertilizer for cannery peas has been obtained, and that the information contained herein will enable anyone who so desires to construct an attachment to a grain drill by means of which fertilizers can be applied so as to eliminate all danger of injury to the seed from the fertilizer and so that the crop can get greater benefit from the fertilizer. Altho this attachment was designed for use with cannery peas, it should be equally effective for any crops sown with a grain drill.

RESULTS OF FERTILIZER PLACEMENT EXPERIMENTS WITH CANNERY PEAS IN 1935

Using the attachment to the grain drill described herein, field plantings were made on Ontario loam soil at Geneva comparing different fertilizers, different rates of application, and different placements of the fertilizers in relation to the seed. The fertilizer and seed were sown in one operation with the horse-drawn drill. The plots were 153 feet long and two drill widths (10½ feet) wide. Each treatment was repeated three times, the replications being systematically distributed to avoid any advantage of soil or location. The detailed yields by sieve sizes from three replications are given in Table 2.

The yields are the weights of the viner-shelled peas, and show the variation between replicates as well as the average yields of each treatment. The peas were harvested with a mowing machine when they were in "fancy" canning stage and made a "fancy" grade pack in the commercial canning operations at the Geneva Preserving Co.

ALL SIDE PLACEMENTS INCREASED YIELDS; ALL CONTACT PLACEMENTS REDUCED YIELDS

Twelve treatments were compared including no fertilizer. In Table 3 the treatments are listed in the order of the average yields obtained. It will be seen at once that six of the fertilizer treatments increased the yield of peas and that five of the treatments reduced yields. Referring to Table 3, it is readily apparent that in each case where
<table>
<thead>
<tr>
<th>Treatments, yields in pounds</th>
<th>A. 300 lbs. 4-16-4 with seed</th>
<th>B. 300 lbs. 4-16-4 above seed</th>
<th>C. 300 lbs. 4-16-4 1½ in. to side, 1 in. below</th>
<th>D. 300 lbs. 4-16-4 2½ in. to side, 1 in. below</th>
<th>E. 300 lbs. 4-16-4 3½ in. to side, 1 in. below</th>
<th>F. 150 lbs. 4-16-4 1½ in. to side, 1 in. below</th>
<th>G. 600 lbs. superphosphate 1½ in. to side, 1 in. below</th>
<th>H. No fertilizer</th>
<th>I. 300 lbs. superphosphate with seed</th>
<th>J. 300 lbs. superphosphate with seed</th>
<th>K. 150 lbs. 4-16-4 with seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve size</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
<td>2.5</td>
<td>2.5</td>
<td>2.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>No. 1</td>
<td>3.0</td>
<td>4.5</td>
<td>3.5</td>
<td>3.5</td>
<td>4.0</td>
<td>3.5</td>
<td>4.0</td>
<td>4.0</td>
<td>3.0</td>
<td>2.5</td>
<td>4.0</td>
</tr>
<tr>
<td>No. 2</td>
<td>6.5</td>
<td>15.0</td>
<td>11.5</td>
<td>15.0</td>
<td>13.0</td>
<td>12.0</td>
<td>13.5</td>
<td>11.5</td>
<td>12.5</td>
<td>10.0</td>
<td>13.5</td>
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<tr>
<td>No. 3</td>
<td>9.5</td>
<td>23.0</td>
<td>19.0</td>
<td>25.0</td>
<td>22.5</td>
<td>20.0</td>
<td>21.0</td>
<td>20.0</td>
<td>20.0</td>
<td>15.0</td>
<td>20.0</td>
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<td>No. 4</td>
<td>23.0</td>
<td>69.0</td>
<td>50.0</td>
<td>66.0</td>
<td>51.0</td>
<td>44.5</td>
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<td>44.0</td>
<td>46.0</td>
<td>24.5</td>
<td>38.5</td>
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<tr>
<td>Total weight, lbs.</td>
<td>43.5</td>
<td>113.5</td>
<td>86.0</td>
<td>112.0</td>
<td>91.0</td>
<td>82.0</td>
<td>108.0</td>
<td>81.5</td>
<td>83.5</td>
<td>54.0</td>
<td>78.5</td>
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<td>2.0</td>
<td>2.0</td>
<td>1.5</td>
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<td>No. 2</td>
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<td>3.5</td>
<td>2.0</td>
<td>1.5</td>
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<td>1.5</td>
<td>1.5</td>
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</tr>
<tr>
<td>No. 3</td>
<td>5.0</td>
<td>10.5</td>
<td>11.0</td>
<td>14.0</td>
<td>8.5</td>
<td>9.5</td>
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<td>9.5</td>
<td>8.0</td>
<td>7.0</td>
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<td>No. 4</td>
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<td>17.5</td>
<td>16.0</td>
<td>24.0</td>
<td>13.5</td>
<td>16.0</td>
<td>19.5</td>
<td>12.0</td>
<td>15.0</td>
<td>12.0</td>
<td>14.0</td>
</tr>
<tr>
<td>No. 5</td>
<td>9.0</td>
<td>31.0</td>
<td>37.0</td>
<td>53.0</td>
<td>28.0</td>
<td>40.0</td>
<td>61.5</td>
<td>30.5</td>
<td>52.5</td>
<td>26.0</td>
<td>45.5</td>
</tr>
<tr>
<td>Total weight, lbs.</td>
<td>22.0</td>
<td>63.5</td>
<td>69.0</td>
<td>96.5</td>
<td>53.5</td>
<td>68.5</td>
<td>96.5</td>
<td>52.0</td>
<td>80.0</td>
<td>49.0</td>
<td>69.0</td>
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<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>No. 2</td>
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<td>9.0</td>
<td>9.0</td>
<td>8.5</td>
<td>9.0</td>
</tr>
<tr>
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<td>12.5</td>
<td>20.0</td>
<td>19.5</td>
<td>19.0</td>
<td>21.0</td>
<td>24.0</td>
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<td>40.0</td>
<td>74.5</td>
<td>72.0</td>
<td>71.0</td>
<td>74.0</td>
<td>85.5</td>
<td>77.0</td>
<td>67.0</td>
<td>55.0</td>
<td>63.5</td>
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<tr>
<td>Total weight, lbs.</td>
<td>36.0</td>
<td>62.0</td>
<td>105.5</td>
<td>103.5</td>
<td>102.0</td>
<td>102.0</td>
<td>112.5</td>
<td>110.0</td>
<td>96.5</td>
<td>81.5</td>
<td>93.5</td>
</tr>
<tr>
<td>Average of 3 plats.</td>
<td>33.8</td>
<td>79.7</td>
<td>86.8</td>
<td>104.0</td>
<td>82.2</td>
<td>86.5</td>
<td>108.7</td>
<td>81.2</td>
<td>86.7</td>
<td>61.5</td>
<td>80.3</td>
</tr>
<tr>
<td>Yield per acre, lbs.</td>
<td>935.0</td>
<td>2,204.0</td>
<td>2,401.0</td>
<td>2,877.0</td>
<td>2,274.0</td>
<td>2,393.0</td>
<td>3,007.0</td>
<td>2,246.0</td>
<td>2,398.0</td>
<td>1,702.0</td>
<td>2,221.0</td>
</tr>
<tr>
<td>Order of yields...</td>
<td>12</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>
the fertilizer was applied to the side of the seed the yield was greater than where no fertilizer was used. On the other hand, in each case where the fertilizer was applied in contact with the seed or above the seed, the yield was less than that of the unfertilized peas.

**Table 3.—Effect of Fertilizer Placement on Yield of Cannery Peas in 1935, Geneva, N. Y.**

<table>
<thead>
<tr>
<th>Order of Yields</th>
<th>Fertilizer Treatment</th>
<th>Placement in Relation to Seed</th>
<th>Average Stand</th>
<th>Yield per Acre Vined Peas, Lbs.</th>
<th>Gain or Loss Compared with Unfertilized Peas, Lbs.</th>
<th>Cost of Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600 lbs. 4-16-4</td>
<td>1½ in. to side 1 in. lower</td>
<td>163</td>
<td>3,007</td>
<td>+761</td>
<td>$8.28</td>
</tr>
<tr>
<td>2</td>
<td>300 lbs. 4-16-4</td>
<td>2½ in. to side 1 in. lower</td>
<td>153</td>
<td>2,877</td>
<td>+631</td>
<td>4.14</td>
</tr>
<tr>
<td>3</td>
<td>300 lbs. 4-16-4</td>
<td>1½ in. to side 1 in. lower</td>
<td>153</td>
<td>2,401</td>
<td>+155</td>
<td>4.14</td>
</tr>
<tr>
<td>4</td>
<td>300 lbs. 16% superphosphate</td>
<td>1½ in. to side 1 in. lower</td>
<td>156</td>
<td>2,398</td>
<td>+152</td>
<td>2.40</td>
</tr>
<tr>
<td>5</td>
<td>150 lbs. 4-16-4</td>
<td>1½ in. to side 1 in. lower</td>
<td>153</td>
<td>2,393</td>
<td>+147</td>
<td>2.07</td>
</tr>
<tr>
<td>6</td>
<td>300 lbs. 4-16-4</td>
<td>3½ in. to side 1 in. lower</td>
<td>153</td>
<td>2,274</td>
<td>+28</td>
<td>4.14</td>
</tr>
<tr>
<td>7</td>
<td>No fertilizer</td>
<td></td>
<td>154</td>
<td>2,246</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>150 lbs. 16% superphosphate</td>
<td>With seed</td>
<td>159</td>
<td>2,221</td>
<td>-25</td>
<td>1.20</td>
</tr>
<tr>
<td>9</td>
<td>300 lbs. 4-16-4</td>
<td>Above seed</td>
<td>145</td>
<td>2,204</td>
<td>-42</td>
<td>4.14</td>
</tr>
<tr>
<td>10</td>
<td>300 lbs. 16% superphosphate</td>
<td>With seed</td>
<td>124</td>
<td>1,702</td>
<td>-544</td>
<td>2.40</td>
</tr>
<tr>
<td>11</td>
<td>150 lbs. 4-16-4</td>
<td>With seed</td>
<td>127</td>
<td>1,590</td>
<td>-656</td>
<td>2.07</td>
</tr>
<tr>
<td>12</td>
<td>300 lbs. 4-16-4</td>
<td>With seed</td>
<td>93</td>
<td>935</td>
<td>-1,311</td>
<td>4.14</td>
</tr>
</tbody>
</table>

Altho only one year's results are available with this machine placement of fertilizer for peas and it is likely that somewhat different results would be obtained under different soil and climatic conditions, there is much other supporting evidence to prove that side placement of fertilizer is always safer and will give better results than placement in contact with seed. This has been repeatedly demonstrated with beans (2, 5),2 corn (4, 8), cotton (6, 8), and potatoes (3, 8) under a great variety of soil and climatic conditions.

**Placement 2½ inches to side particularly effective**

To determine what distance to the side of the pea seeds the fertilizer should be placed to be most effective, a comparison was made of three distances (1½, 2½, and 3½ inches) to the side, using the same

2Reference is to Literature Cited, page 30.
amount of fertilizer (300 pounds of 4–16–4) in each case. The results are shown in a comparison of treatments 3, 2, and 6 as follows:

<table>
<thead>
<tr>
<th>Placement</th>
<th>Yield, lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 lbs. 4–16–4, 1½ in. to side, 1 in. lower</td>
<td>2,401</td>
</tr>
<tr>
<td>300 lbs. 4–16–4, 2½ in. to side, 1 in. lower</td>
<td>2,877</td>
</tr>
<tr>
<td>300 lbs. 4–16–4, 3½ in. to side, 1 in. lower</td>
<td>2,274</td>
</tr>
<tr>
<td>Unfertilized</td>
<td>2,246</td>
</tr>
</tbody>
</table>

It will be seen at once that all of the side placements of fertilizer increased the yield and that the placement 2½ inches to the side proved to be particularly effective in increasing yield. Throughout the growing season the three replications of this treatment produced a uniformly vigorous growth of vines that resulted in large yields. It was evident that the roots reached the fertilizer bands in this treatment at a time that was especially effective in stimulating vigorous growth.

Whether this placement would prove to be equally superior under other climatic conditions or in other soils remains to be seen. Doubtless such a placement would never result in injury to the plant from the fertilizer; yet it seems close enough so that the peas get an early start and the full benefit of the fertilizer which results in a vigorous, productive growth.

**Placement 3½ inches to side is too far away**

It is evident that placing the fertilizer bands 3½ inches to the side of the peas was too far away to get much benefit from the fertilizer. There was a slight increase in yield over the unfertilized lot, but the peas failed to get the vigorous stimulation early in the season which seems so essential to large yields.

No specific cause can be found for the fact that the placement of the fertilizer band 2½ inches to the side gave so much better results than the same fertilizer placed 1½ inches to the side. The only explanation is that the roots evidently reached the fertilizer band 2½ inches to the side at just the time or stage of growth when the fertilizer was peculiarly effective in stimulating growth. There is much yet to be learned about “timing” of fertilizer applications for greatest effectiveness. It is quite possible that this may vary with different soils and different climatic conditions.

That the spacing 1½ inches to the side was not close enough to cause “burning” or injury is shown by the high germination counts and by the fact that twice as much fertilizer (600 pounds of 4–16–4)
with the same placement greatly increased the yield and also gave the highest germination of any of the treatments (Fig. 2). This was also true in a similar experiment with Perfection peas (Table 5). Obviously, if there had been any injury from the fertilizer at this distance from the plant, it would have been accentuated by doubling the amount of fertilizer. In the future more comparisons will be made of the $1\frac{1}{2}$- and $2\frac{1}{2}$-inch spacings.

**Fig. 2.—Liberal Use of Fertilizer Correctly Applied Increases Growth and Yield of Peas and Does Not Reduce the Stand.**
1935 experiment.

**WHY SIDE PLACEMENT IS SAFE AND EFFECTIVE**

A peculiar fact about movement of fertilizers in the soil is that there is very little lateral movement as compared with the vertical movement. The soluble salts travel downward during periods of rainfall and upward in the periods between rains when moisture is evaporating at the surface. When the fertilizers are first applied in concentrated bands, there is a concentration of soluble salts in the soil solution in that immediate vicinity in excess of the plant’s tolerance and which would cause injury or death to the plant or seed due to plasmolysis. This concentration of soluble salts is gradually reduced by diffusion in the soil solution and fixation. In the meantime, for a critical period of a few days to a few weeks, depending upon the kind and amount of
fertilizer, the amount of soil moisture, and the type of soil, this excessive concentration of soluble salts is carried downward during periods of rainfall and would be toxic to seeds if the fertilizer had been placed above the seed; and it is carried upward during dry periods and would be toxic to seeds if the fertilizer had been placed directly below the seed. On account of the greatly restricted lateral movement of the soluble salts in the soil, seeds placed at one side of the fertilizer band will not be in the path of the excessive concentration of soluble salts. By the time the roots grow out to the side and reach the fertilizer band, the excessive concentration of soluble salts is reduced by diffusion and fixation. If the fertilizer is most effectively placed, the roots will not reach the fertilizer band or zone of greatest concentration of soluble salts until the concentration is no longer excessive.

The upward movement of fertilizer salts was plainly evident by examining the fields in this experiment during a dry period in the latter half of May. Deposits of fertilizer salts could be seen plainly on the surface of the soil at that time. These salts had been carried upward in the soil solution and were deposited on the surface as the moisture evaporated there. These bands of salt deposits were at the side of the rows in all the side placements and were at the base of the plants where the fertilizer had been placed in contact with the seed or above the seed. They were carried downward by subsequent rains and did not reappear.

CONTACT PLACEMENT MOST INJURIOUS

Treatments 2, 9, and 12 (Table 3) furnish an excellent comparison of three radically different placements of the same kind and amount of fertilizer (300 pounds of 4–16–4). Where this fertilizer was applied in contact with the seed, the yield was only 935 pounds of peas, or less than half the yield obtained where no fertilizer was used. The distressing fact in connection with this treatment is that this is a very common farm practice and is the only method whereby the seed and fertilizer can be sown in one operation with the types of drills most commonly used. This clearly emphasizes the object of this experiment. It is hoped that this publication will be of value in offering a means of correcting this unsatisfactory condition.

The more fertilizer that is applied in contact with the seed, the more injury is done to the crop and the less will be the yield. This is shown in Table 1 and in Table 3 (treatments 11 and 12). Where 150 pounds of 4–16–4 fertilizer were applied in contact with the seed, the yield was 1,590 pounds of peas (Table 3). When twice as much fertilizer
was applied in this manner, the yield was only 935 pounds, or about one-third less. This is in striking contrast with the increasing yields obtained from increasing amounts of fertilizer applied to the side (treatments 1, 3, and 5. Table 3).

Even superphosphate alone, which is less likely to cause injury to the plant, injured the peas to such an extent when applied in contact with the seed that the yields were reduced. The more superphosphate that was applied in contact with the seed, the more the yield was reduced. One hundred fifty pounds of 16 per cent superphosphate per acre applied in contact with the seed resulted in a yield of 2,221 pounds of peas, or 25 pounds less per acre than was obtained where no fertilizer was used (Table 3). When twice as much superphosphate (300 pounds) was applied in contact with the seed, the yield was only 1,702 pounds of peas, a reduction in yield of over 25 per cent.

On the other hand, where 300 pounds of 16 per cent superphosphate were applied 1½ inches to the side and 1 inch lower than the seed, the yield was 2,398 pounds of peas, a gain of 152 pounds over the unfertilized peas and a gain of 696 pounds over the same fertilizer applied in contact with the seed.

**Fertilizer Placed Above the Seed Is Injurious**

In treatment 9 the machine was adjusted so that ¾ inch of soil was placed above the seed before the fertilizer was deposited thru separate tubes. This placed the fertilizer directly above the seed but with ¾ inch of soil interposed so that the fertilizer was not in contact with the seed. This is similar to the placement obtained by certain commercial drills now on the market. The seed was sown about 2½ inches deep. There was some evidence of injury from the fertilizer in this placement and a slight reduction in germination. As a result, the yield of peas was 2,204 pounds, or 42 pounds less than was obtained where no fertilizer was used. Likewise, this was 673 pounds less than was produced where the same amount of fertilizer has been applied 2½ inches to the side. Experiments here (5) and elsewhere (8) with other crops (corn, beans, cotton, and potatoes) and on many types of soil have also proved that side placement of fertilizer is safer and more effective than placing the fertilizer above the seed.

**Germination Not Accurate Index of Yield**

Table 4 is a record of the comparative germination of the 36 field plats of peas in the 1935 experiments. It is evident from a comparison
of Table 2 with Table 4 that there was a general correlation between variations in stand and differences in yield. However, the germination was not an accurate index of differences in yield because there were rather marked differences in yields from treatments in which the stand was almost equal. This is because the germination counts do not give any idea of the relative vigor of the plants. In making the germination counts, all seedlings that appeared above ground in a given length of row were counted. In some of these treatments many of the seedlings were severely stunted and the root systems were greatly reduced by the fertilizer similar to the injury described in Technical Bulletin No. 231. These stunted plants were not productive, often having no pods at all or only one or two short pods poorly filled. On the other hand, from some fertilizer treatments there was no injury to the root systems of the peas, the plants were strong and vigorous and produced large well-filled pods.

A striking difference in yield from an approximately equal stand is shown in comparing treatments 2 and 8 in Table 3. In treatment 2 (300 pounds of 4-16-4 placed 2½ inches to side) the yield was 2,877 pounds of peas from an average stand of 153 plants per 30 feet of row. In treatment 8 (150 pounds of 16 per cent superphosphate in contact with seed) the yield was only 2,221 pounds from a slightly better stand, 159 plants per 30 feet of row. This made the very significant difference of 656 pounds per acre in favor of the slightly poorer, tho not significantly different, stand.

The difference in yield was due to the difference in the vigor of the plants which resulted from the kind and amount as well as the placement of the fertilizer. In the first case there was no root injury from the fertilizer and the plants made a strong, vigorous growth. By the time the roots had grown to the side and reached the fertilizer zone, the concentration of soluble salts of the fertilizer was sufficiently reduced by diffusion in the soil solution so that it was not toxic to the roots but stimulated vigorous growth of the plant. In the second case, an injurious concentration of soluble salts prevailed at the base of the plants for a considerable period from the fertilizer in contact with the seed, and this resulted in many stunted, unproductive plants.

Only three of the fertilizer treatments (Nos. 10, 11, and 12) caused a very significant reduction in stand, and this was accompanied by very significant reductions in yields. In these three cases the fertilizer was drilled in contact with the seed and resulted in severely stunted plants as well as reduced germination and the yield was greatly reduced.
<table>
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<tr>
<th>Plat No.</th>
<th>300 lbs. 4-16-4 with seed</th>
<th>300 lbs. 4-16-4 above seed</th>
<th>300 lbs. 4-16-4, 1 1/2 in. below seed</th>
<th>300 lbs. 4-16-4, 1 in. below seed</th>
<th>300 lbs. 4-16-4, 3/4 in. below seed</th>
<th>150 lbs. 4-16-4, 1 1/2 in. below seed</th>
<th>150 lbs. 4-16-4, 1 in. below seed</th>
<th>150 lbs. 4-16-4, 3/4 in. below seed</th>
<th>No fertilizer</th>
<th>600 lbs. Superphosphate with seed</th>
<th>150 lbs. Superphosphate with seed</th>
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<td>Total 3 replications</td>
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<td>Average stand per treatment</td>
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<td>153</td>
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<td>163</td>
<td>154</td>
<td>156</td>
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<td>1</td>
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</table>

*Each count represents number of plants in 3 feet of row. Count taken in alternate rows diagonally across the plats with 6-foot intervals between sections counted. Peas planted April 26, 1935. Stand counted May 20.
The germination counts shown in Table 4 were made in the following manner: Beginning 6 feet in from the end of a plat a yard-stick was laid along the second row of peas and all the seedlings were counted in that 3-foot section of row. Then going diagonally across the plat and taking each alternate row, skipping a 6-foot interval between, counts were made of 3 feet of row until 10 such sections had been counted. Using this empirical system, counts were sometimes made in a very poor 3-foot section of row and considerable variation in counts occurred. However, it was considered that the sum total of these 10 regularly spaced counts would give a more accurate index of the average stand than could be obtained by trying to pick out an "average" area to make a count. At least this system was absolutely impartial.

**INCREASING AMOUNTS OF FERTILIZER CORRECTLY PLACED INCREASED YIELD**

It has already been shown that increasing amounts of fertilizer placed in contact with the seed decreased the yield; but where the fertilizer was placed to the side of the seed, the yield was increased by the application of increased amounts of fertilizer. This is shown by comparing treatments 1, 3, and 5. In each case the fertilizer was applied 1½ inches to the side and 1 inch lower than the seed. The yields are given in Table 5.

**Table 5.—Effect of Increasing Amounts of Fertilizer on Yield of Peas.**

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Yield of Peas, Lbs.</th>
<th>Gain over Unfertilized, Lbs.</th>
<th>Average Stand</th>
<th>Cost of Fertilizer</th>
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</thead>
<tbody>
<tr>
<td>None</td>
<td>2,246</td>
<td>—</td>
<td>154</td>
<td>—</td>
</tr>
<tr>
<td>150 lbs. 4-16-4</td>
<td>2,393</td>
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<td>153</td>
<td>$2.07</td>
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<tr>
<td>300 lbs. 4-16-4</td>
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<td>153</td>
<td>4.14</td>
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<tr>
<td>600 lbs. 4-16-4</td>
<td>3,007</td>
<td>761</td>
<td>163</td>
<td>8.28</td>
</tr>
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</table>

Surprise Peas

| No fertilizer | 2,042               | —                             | 114           | —                  |
| 300 lbs. 4-16-4 | 2,547              | 505                           | 114           | 4.14               |
| 600 lbs. 4-16-4 | 2,871              | 829                           | 131           | 8.28               |

Perfection Peas

It is interesting to note that the heaviest rate of fertilizing resulted in the highest germination of any of the treatments. This clearly indicates that this heavy rate of fertilizing did not cause any injury to the
seed and greatly stimulated growth of the plants and emphasizes the fact that the method of applying fertilizer is of the utmost importance (Figs. 1 and 2).

Unfortunately, a comparison of different amounts of fertilizer spaced 2½ inches to the side was not included. This proved to be a particularly effective placement at the one rate (300 pounds of 4–16–4) at which it was used. It would be interesting to know if the yields would be increased proportionately with increasing amounts of fertilizer at this spacing. It was thought when the experiment was laid out that 1½ inches to the side would prove to be the best spacing. Consequently, most of the comparisons of different rates and kinds of fertilizers were with this placement. In the future more comparisons will be made using the 2½-inch spacing.

From Table 5 it appears that the 150-pound rate and the 600-pound rate gave the most profitable increases in yield with Surprize peas. For some unknown reason the 300-pound rate of application did not give a profitable increase over the 150-pound rate; but the 600-pound rate did give a profitable gain. This illustrates the limitations and uncertainty in trying to draw conclusions from one year’s results. It will be interesting to see how these rates of application compare over a series of years.

That the yield increases with increasing amounts of fertilizer correctly placed is again shown in Tables 5 and 7 giving the yields from a different experiment in 1935. In this experiment Perfection peas were planted (a) without fertilizer, (b) with 300 pounds of 4–16–4 placed 1½ inches to side and 1 inch lower than the seed; and (c) with 600 pounds of 4–16–4 similarly placed. The unfertilized peas yielded 2,042 pounds of fancy peas per acre. Three hundred pounds of 4–16–4 fertilizer thus placed resulted in a yield of 2,547 pounds, or a gain of 505 pounds due to the fertilizer. The fields receiving 600 pounds of this fertilizer yielded 2,871 pounds of fancy peas per acre, or a gain of 829 pounds due to the fertilizer. In each case there was a profitable increase in yield due to the fertilizer and increasing amounts resulted in increasing yields.

WHICH FERTILIZER TREATMENTS WERE PROFITABLE?

To answer this question definitely will undoubtedly require several years’ results under different climatic and soil conditions. However, every grower is vitally interested in this question and the comparative returns obtained in even this one year’s results will be of interest.
Without going into an involved discussion of the costs of producing peas, it appears that 4 of the 12 fertilizer treatments shown in Table 3 were profitable. Evidently treatment 2 (300 pounds of 4-16-4 applied 2½ inches to the side and 1 inch lower than the seed) was the most profitable treatment. In this case the cost of the fertilizer was $4.14 and it produced a yield of 2,877 pounds, or a gain of 631 pounds over the unfertilized peas, which was undoubtedly an economical gain.

The next most profitable gain was produced by treatment 1 (600 pounds of 4-16-4 applied 1½ inches to side and 1 inch lower). This fertilizer cost $8.28 and produced a yield of 3,007 pounds of fancy peas, or a gain of 761 pounds over the unfertilized peas.

The third most profitable gain was produced by treatment 5 (150 pounds of 4-16-4 applied 1½ inches to side and 1 inch lower than the seed). This fertilizer cost $2.07 and produced a yield of 2,393 pounds, or a gain of 147 pounds over the unfertilized peas.

A trifle larger yield at a trifle higher cost was produced by treatment 4 (300 pounds of 16 per cent superphosphate applied 1½ inches to side and 1 inch lower). In this case the fertilizer cost $2.40 and produced a yield of 2,398 pounds, or a gain of 152 pounds over the unfertilized peas.

The increased yield, 155 pounds gain, from treatment 3 (300 pounds of 4-16-4 placed 1½ inches to side and 1 inch lower) barely paid for the cost of the fertilizer ($4.14). None of the other fertilizer treatments were profitable.

SUPERPHOSPHATE MORE PROFITABLE THAN 4-16-4 FERTILIZER

Treatments 3 and 4 (Table 3) furnish a direct comparison of a “complete” fertilizer (4-16-4) and of 16 per cent superphosphate alone. In each case the fertilizer was applied 1½ inches to the side and 1 inch lower than the seed and there was an equal amount of phosphoric acid in each fertilizer. The yields from the two treatments were almost identical. The 4-16-4 fertilizer produced 2,401 pounds of peas and the superphosphate alone produced 2,398 pounds, but there was considerable difference in the costs of the two fertilizers. Three hundred pounds of 4-16-4 fertilizer cost $4.14, while 300 pounds of 16 per cent superphosphate cost only $2.40; consequently, the superphosphate was a more profitable fertilizer in this particular instance.

SUPERPHOSPHATE LESS INJURIOUS THAN 4-16-4 IN CONTACT WITH SEED

It has been proved by other experiments (5, 7) that nitrogen and potash fertilizers are more toxic than is superphosphate when placed
in contact with seed. This fact was also proved in this experiment (Fig. 3). Comparing treatments 8 and 11 (Table 3), equal amounts (150 pounds) of superphosphate and of 4–16–4 were applied in contact with the seed. The superphosphate (treatment 8, Table 3) produced 2,221 pounds of peas but was slightly injurious, for the yield was 25

Fig. 3.—NITROGEN AND POTASH ARE MORE INJURIOUS THAN SUPERPHOSPHATE IN CONTACT WITH THE SEED.

1935 experiment.

pounds less than the unfertilized peas, altho the germination was not reduced. However, the 150 pounds of 4–16–4 fertilizer in contact with the seed (treatment 11, Table 3) seriously reduced the germination and cut down the yield to only 1,590 pounds. In other words, adding the 4 per cent of nitrogen and 4 per cent of potash to the 16 per cent of phosphoric acid reduced the yield 631 pounds.

This is shown again in comparing treatments 10 and 12 (Table 3). In these treatments twice as much fertilizer, or 300 pounds, was used in each case. Where 300 pounds of superphosphate was used the yield was 1,702 pounds, or 544 pounds less than the unfertilized peas. But where 300 pounds of 4–16–4 fertilizer was applied in contact with the
seed, the stand was severely reduced and the yield was only 935 pounds, or 1,311 pounds less than the unfertilized peas. In this comparison the 4 per cent of nitrogen and 4 per cent of potash when added to the 16 per cent phosphoric acid cut down the yield 767 pounds.

In experiments elsewhere (8) with grain crops it has been shown that small amounts of superphosphate applied in contact with the seed were not injurious and increased the yield. From these results it is evident that less than 150 pounds of 16 per cent superphosphate must be used if this principle would apply to peas.

RELATION OF SOIL MOISTURE TO FERTILIZER INJURY

Injury to plants from fertilizer is always more severe when the soil moisture content is low. When the soil is very dry at planting time the losses from drilling fertilizer in contact with peas are always more severe. This is merely a matter of the relative concentration of soluble salts in the soil solution. When the moisture content is low, the concentration is greater and the injury to the seeds or seedlings from plasmolysis is more severe. On the other hand a high moisture content dilutes the concentration so that it is less injurious and eventually is stimulating to the plant, for it is only in dilute solutions that plants can take up fertilizer materials.

Soil moisture conditions for this 1935 experiment were very favorable for the contact placements for two reasons. In the first place, there was so much rainfall early in April that it was not until the last week in the month that the soil dried out sufficiently to be worked without puddling. The soil on which this experiment was located is rather heavy. In the second place, there was copious rainfall shortly after the peas were planted. Table 6 gives the rainfall record during the period the peas were growing; yet notwithstanding these favorable soil moisture conditions, injury from the fertilizer placed in contact with the seed was very severe and resulted in loss instead of profit from its use. This further emphasizes the advantages of placement of fertilizer to the side of the seed for profitable results.

ARE ROW-PLACED FERTILIZER RESIDUES INJURIOUS TO CANNERY PEAS?

Recent experiments (2, 3, 4, 8) have shown that with other crops, such as corn, tomatoes, beans, cabbage, and potatoes, growers can obtain greater increases in yield from fertilizer applied in bands close to the row than from the same amount of fertilizer applied broadcast. Undoubtedly placement of fertilizer in concentrated bands close to
Table 6.—Rainfall During Pea Growing Season, 1935; Peas Planted April 26.

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainfall, inches</th>
<th>Date</th>
<th>Rainfall, inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 28...</td>
<td>0.05</td>
<td>June 17...</td>
<td>0.84</td>
</tr>
<tr>
<td>29</td>
<td>0.10</td>
<td>19</td>
<td>0.09</td>
</tr>
<tr>
<td>30</td>
<td>0.55</td>
<td>20</td>
<td>0.12</td>
</tr>
<tr>
<td>May 4</td>
<td>0.58</td>
<td>21</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>0.11</td>
<td>22</td>
<td>0.47</td>
</tr>
<tr>
<td>6</td>
<td>0.08</td>
<td>24</td>
<td>0.08</td>
</tr>
<tr>
<td>7</td>
<td>0.85</td>
<td>27</td>
<td>0.03</td>
</tr>
<tr>
<td>10</td>
<td>0.10</td>
<td>July 2</td>
<td>Harvested Surprie Peas</td>
</tr>
<tr>
<td>13</td>
<td>Peas came up</td>
<td>4</td>
<td>1.14</td>
</tr>
<tr>
<td>28</td>
<td>0.04</td>
<td>5</td>
<td>0.02</td>
</tr>
<tr>
<td>29</td>
<td>0.03</td>
<td>6</td>
<td>0.16</td>
</tr>
<tr>
<td>June 4</td>
<td>0.72</td>
<td>7</td>
<td>0.82</td>
</tr>
<tr>
<td>6</td>
<td>0.04</td>
<td>8</td>
<td>1.41</td>
</tr>
<tr>
<td>7</td>
<td>0.03</td>
<td>9</td>
<td>0.07</td>
</tr>
<tr>
<td>8</td>
<td>0.14</td>
<td>10</td>
<td>Harvested Perfection Peas</td>
</tr>
</tbody>
</table>

the rows of cultivated crops will be practiced to an increasing extent as farmers learn the advantages of these new methods.

Naturally, pea canners might be apprehensive of adverse effects on the quality of cannery peas due to the residual effect of these fertilizer bands. Uniformity of maturity is of the utmost importance in obtaining high quality peas. Broadcasted (drilled) peas grown for canning might receive unequal stimulation from fertilizer applied in concentrated bands or rows for the crop preceding peas.

To determine the effect on maturity of peas due to residual fertilizer, cannery peas were drilled broadcast across a field that had been heavily fertilized for tomatoes the previous year. The fertilizer had been applied in concentrated bands at various rates up to 1,200 pounds per acre of 4–16–4 along the tomato rows which were 4 feet apart. Part of the peas were unfertilized, part received 300 pounds of 4–16–4 fertilizer, and part of the field received 600 pounds of 4–16–4 fertilizer. The tomatoes were grown during 1934, a very dry season, and were plowed under in the fall at which time the fertilizer bands were clearly discernible in the soil.

In the spring of 1935 this field was thoroly disced and harrowed and a good seedbed prepared for the peas. Six areas crossing the former tomato rows were planted to Perfection peas. Each area was 417 feet long and two drill widths (10½ feet) wide, or approximately one-tenth (1/9.95) acre. These plats received the following fertilizer treatments: No. 1 and No. 4, no fertilizer; No. 2 and No. 5, 300 pounds of 4–16–4 drilled 1½ inches to side and 1 inch below the seed level; and
No. 3 and No. 6, 600 pounds of 4–16–4 similarly placed. The yield records are given in Table 7.

When the unfertilized peas first came up they showed a marked difference in growth due to the residual fertilizer where the tomato rows had been. The residual effect was not apparent in the areas where fertilizers were applied with the peas (Fig. 4). Furthermore, within a

![Fig. 4.—Fertilizer Applied With Peas Overcomes Any Stimulating Effect from the Residue of Fertilizer Applied in Bands the Previous Season.](image)

...month the uneven growth of the unfertilized peas tended to be evened off and the residual effect of the previous year's fertilizer was no longer apparent in the growth of the vines.

Each lot was harvested separately the same day, and after vining, the peas were critically examined by commercial canners and canning technologists. All lots were rated "fancy" grade and these experienced pea canners could detect no difference in the quality or maturity of the different lots. Whether differences would have been apparent had the peas been allowed to grow longer or until they reached extra standard or standard stage of maturity, was not determined. The "Maturity Index" proposed by Boswell (1), as well as the percent-
### Table 7.—Yield Record and Sieve Sizes of Perfection Peas in Study of Effect of Fertilizer Residue.

<table>
<thead>
<tr>
<th>Sieve size†</th>
<th>No Fertilizer</th>
<th>300 Lbs. 4–16–4, 1 ½ in. to side, 1 in. deeper</th>
<th>600 Lbs. 4–16–4, 1 ½ in. to side, 1 in. deeper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pounds</td>
<td>Percent</td>
<td>Size x Percent</td>
</tr>
<tr>
<td>Plat No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1</td>
<td>4.0</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>No. 2</td>
<td>4.0</td>
<td>2.3</td>
<td>4.6</td>
</tr>
<tr>
<td>No. 3</td>
<td>12.0</td>
<td>6.8</td>
<td>20.4</td>
</tr>
<tr>
<td>No. 4</td>
<td>58.0</td>
<td>33.0</td>
<td>132.0</td>
</tr>
<tr>
<td>No. 5</td>
<td>97.5</td>
<td>55.6</td>
<td>278.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>175.5</strong></td>
<td><strong>437.3</strong></td>
<td><strong>4.37</strong></td>
</tr>
<tr>
<td>Plat No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1</td>
<td>5.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>No. 2</td>
<td>2.0</td>
<td>0.8</td>
<td>1.6</td>
</tr>
<tr>
<td>No. 3</td>
<td>16.0</td>
<td>6.8</td>
<td>20.4</td>
</tr>
<tr>
<td>No. 4</td>
<td>48.0</td>
<td>20.4</td>
<td>81.6</td>
</tr>
<tr>
<td>No. 5</td>
<td>164.0</td>
<td>70.0</td>
<td>350.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>235.0</strong></td>
<td><strong>455.6</strong></td>
<td><strong>4.56</strong></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>205.25</strong></td>
<td><strong>4.47</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Yield per acre, lbs.</strong></td>
<td><strong>2,042</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gain over unfertilized, lbs.</strong></td>
<td><strong>505</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Size of plats 10 1/2 x 417 feet = 4,378 sq. ft. = 1 acre.

†All lots made "fancy" grade when canned.

‡Lot 3C was located in a little swale of poor soil.
ages of the different sieve sizes, also indicate no signficante differences in maturity (Table 7).

**ROW FERTILIZATION OF PEAS COMPLETELY OVERCAME RESIDUAL FERTILIZER**

In the two areas where the peas received 300 pounds and also the two where they received 600 pounds of 4–16–4 fertilizer drilled 1½ inches to the side of the seed, there was at no time any evidence of stimulated growth from the residue of the previous year's fertilizer bands (Fig. 4). Apparently the fertilizer applied with the peas supplied the needs of the peas so adequately that it completely overshadowed the stimulating effects that would otherwise have been received from the fertilizer residue. The fertilized peas made a more vigorous and uniform growth and produced much heavier yields than the unfertilized peas (Table 7).

When fertilizer is applied at the rate of 1,200 pounds per acre in narrow bands for rows 4 feet apart, it makes a very large amount of fertilizer in a very limited area. It is inconceivable that cannery peas would ever be likely to be planted so that they would encounter greater fertilizer residues than this. Consequently, judging only from this one year's test, it seems that pea canners need have no fear of the effect on quality of peas due to the residue of fertilizers applied in concentrated bands to crops preceding peas. Certainly they need not worry if the peas receive a uniform application of fertilizer correctly applied.

**DESCRIPTION OF DRILL ATTACHMENT FOR FERTILIZER PLACEMENT FOR CANNERY PEAS**

For the benefit of machinery manufacturers, canners, and farmers who wish to equip their drills for placing fertilizer more effectively for cannery peas, a detailed description and photographs of the equipment devised for this experiment are given.

The drill used was a standard commercial make. The hoe type furrow opener was used because this type is more satisfactory on the stony land on which the experiment was conducted. The hoes were spaced 7 inches apart. For a disc type furrow opener a similar attachment could be used.

The drill was originally designed to place the fertilizer in the furrow with the seed. From a separate rear compartment of the hopper the fertilizer flowed thru a spout into the delivery tube with the seed.
The fertilizer dispensing mechanism was of the star wheel type. The quantity of fertilizer delivered was varied only by changing the speed of the feed wheels. By calibrating the distributor with each fertilizer used the application rates were accurately controlled. The calibration chart supplied by the manufacturer gave the adjustments for approximate rates of an average fertilizer, but such a chart is not applicable to fertilizers differing widely in apparent specific gravity.

Fig. 5.—Drill Equipped with a Special Set of Hoe-type Furrow Openers to Obtain Various Placements of the Fertilizer with Respect to the Seed.

A, special hoe assembly; b, end support of hoe draft rod; c, draft rod control arm; d, counterbalance spring; e, control lever connecting bar; f, control lever; g, shifter-arm control lever for staggering the regular seed hoes.

For placing the fertilizer in a band at the side of each row, an additional set of furrow openers was mounted at the front of the machine. The general design and mounting of the special attachment are shown in Figs. 5 and 6. Various details of construction are illustrated in Figs. 7, 8, and 9. The special furrow openers were mounted as a unit wholly under the regular draw-bars to permit convenient lateral adjustments.

Certain alterations of the drill were required to permit the use of the special attachments and to simplify their mounting and adjust-
ment. The regular hoes were moved rearward 5 inches by shifting the draft-rod or shifterbar supports (Fig. 8, r) and by making a corresponding change on the shifter-bar control lever (Fig. 5, g). The pressure rods (Fig. 8, x) then required greater curvature to avoid striking the hopper. The regular hoes were moved rearward for three principal reasons. First, it was necessary to mount the special hoes near the point under the main axle to insure ready flow of the fertilizer from

**Fig. 6.—Mounting of Control Lever and Separate Fertilizer Delivery Tubes for the Special Furrow-opener Assembly.**

E, control lever connecting bar; f, control lever; h, special fertilizer spout; i, flexible fertilizer delivery tube; j, special hoe; k, regular hoe.

the rear compartment of the hopper thru the flexible tube (Figs. 6, i and 8, i). Second, it was desirable to distribute the weight on each side of the axle to maintain proper balance of the machine. Third, it was not advisable to extend the attachment ahead of the front main frame member and thus lengthen the machine.

A special fertilizer spout (Figs. 8, h and 9, h) was required for each dispensing unit to divert the fertilizer into a separate delivery tube.
The regular fertilizer spout entered the seed spout near the hopper and could not be adjusted to divert the fertilizer into a separate tube. In order to obtain the necessary space for the special fertilizer spout, a portion of the seed spout was removed (Figs. 8, w and 9, w). The flexible steel ribbon delivery tubes permitted the delivery of fertilizer to different points on the machine.

**Fig. 7.—Special Furrow Opener Assembly for Depositing the Fertilizer**

B, end support of hoe draft rod; L, sliding center support; m, draft rod; n, draft rod set collar; o, drag bar; p, lifter arm; q, relief spring.

The special furrow openers were set 13 inches ahead of the regular hoes, which allowed sufficient clearances when the regular hoes were staggered. The furrow openers were not staggered in the experimental work. The draft rod, (Fig. 8, m) was held directly under the front frame member by end supports (Fig. 8, b) and a sliding center support (Fig. 7, L). When the collars (Fig. 7, n) at each end of the draft rod were loosened, the assembly could be easily shifted laterally to place the fertilizer hoes in line with the seed hoes or at any distance up to 3.5 inches to the side.

To obtain adequate clearance for the special furrow openers (Fig. 8, j) under the regular draw bars (Fig. 8, s) it was necessary to shorten the hoe boots (Fig. 8, t) 3 inches and remount the hoe points or shovels (Fig. 8, u). The break-pin type of hoe with a single projection at the top of the boot for attachment of the drag bar was used as the special furrow opener. It will be observed in Fig. 8 that the lower
projection (v) on the regular spring-trip hoe would neither permit moving the shovel upward 3 inches nor allow sufficient clearance above ground when the boot was shortened.

The drag bar (Fig. 8, o) was free to rotate about the draft rod against the pressure of the relief spring (q). Normally, the drag bar was held against the lifter arm (p) which was attached rigidly to the draft rod. Thus by rotating the draft rod the hoes were either raised or lowered by the lifter arms. The adjustment of the control lever (Fig. 6, f) connected by the bar (e) to the draft rod control arm (Fig. 5, c) determined the vertical position of the hoes. The weight of the hoes was largely counterbalanced by the spring (Fig. 5, d) thus permitting easy operation of the control lever.

To place the fertilizer in the furrow with the seed, the delivery tube (Fig. 8, i) was inserted in the seed boot (k) along with the seed tube.
To place the fertilizer in a band directly above the seed as obtained with attachments for certain makes of drills, the fertilizer delivery tube was mounted about 3 inches back of the seed shoe in such a position that the fertilizer reached the furrow at the point where the soil flowed in over the seed.

![Image of special fertilizer spouts under the hopper]

**Fig. 9.—Upward View of Special Fertilizer Spouts Under the Hopper.**

H, special fertilizer spout; i, flexible fertilizer tube; w, seed spout.

The placement of the fertilizer was satisfactorily controlled with the special equipment. When the fertilizer was placed at a distance of 1.5 inches to the side of the row, the seed-hoe, operating so near the furrow opened for the fertilizer, tended, in very firm soil, to enter the furrow. However, the occasional error in this placement was not great. This difficulty would probably not be experienced with certain types of furrow openers and could doubtless be largely eliminated by unusually rigid construction of the equipment employed. It did not occur when the machine was adjusted to place the fertilizer 2½ and 3½ inches to the side of the seed.

The experimental equipment described was designed for wide ranges of adjustment and to meet different requirements of the experiment. The mounting of such equipment and the alterations required on the machine would be somewhat different on another type or make of drill. If only one particular placement of the fertilizer is desired the special equipment required could doubtless be of simpler design. If a single placement is desired, it is recommended on the basis of experimental work to date that the machine be constructed to place the fertilizer 2 or 2½ inches to the side and 1 inch lower than the seed.
Altho no comparisons were made of different depths of placement when the fertilizer was drilled at the side of the seed, it is believed that the depth of placement used in these experiments (1 inch lower than the seed) is likely to prove very satisfactory. In any event the fertilizer should be placed sufficiently deep to be in moist soil and readily accessible to the roots. If placed too close to the surface, root activity will be limited for lack of moisture. On the other hand, a drill-sown crop such as cannery peas is not cultivated and there are more roots near the surface because the shallow roots are not cut off in cultivation. Consequently, 1 inch lower than the seed level seems a logical depth for best results for peas. This places the fertilizer in the zone of greatest root density.

CONCLUSIONS

The results obtained in this experiment may be summarized briefly as follows:
1. Placement of fertilizer in contact with pea seed is very injurious. Unfortunately, this is the only placement possible where the fertilizer and seed are sown in one operation with the types of drills commonly used in this State. It is better not to use fertilizer at all than to place it in contact with pea seed. Little injury occurs if the fertilizer and seed are sown in separate operations.
2. The attachments to a grain drill described herein proved very satisfactory for sowing seed and fertilizer in one operation so that there were no injurious effects of the fertilizer and the yields were increased by the use of the fertilizer.
3. Superphosphate alone is less injurious than a "complete" fertilizer when used in contact with the seed.
4. Placement of fertilizer above the seed is slightly injurious and reduces the yield.

The remaining conclusions based on only one year's results should be considered more as a progress report. These conclusions may be modified after additional results have been obtained under different soil and climatic conditions.
5. Superphosphate alone produced a more economical gain than an equal amount of phosphoric acid in a 4–16–4 ratio.
6. Placement of fertilizer 2½ inches to the side and 1 inch lower than the seed proved particularly advantageous.
7. Placement of fertilizer 3½ inches to the side was too far away to give an early stimulus to this quick-growing, early-maturing crop.
Consequently, this placement was not as effective as closer placement.

8. Placement of fertilizer 1½ inches to the side and 1 inch lower than the seed proved satisfactory, but the 2½-inch spacing proved better.

9. If a machine is designed for one specific placement, it is recommended that the fertilizer be placed 2 inches or 2½ inches to the side and 1 inch lower than the seed.

10. Increasing amounts of fertilizer placed to the side of the seed increased the yield and did not reduce the germination nor injure the plants.

11. From 300 to 600 pounds of 16 per cent superphosphate or of a 4-16-4 fertilizer placed 2 to 2½ inches to the side and 1 inch lower than the seed is recommended for peas.

12. The residual effect of a heavy application of fertilizer in rows for a crop preceding peas is not likely to result in unequal maturity of cannery peas. Any inequality in maturity due to fertilizer residues apparently can be prevented by fertilizing the peas, using 300 pounds or more per acre of a good fertilizer applied in side placement.

LITERATURE CITED


