Information on the N needs of corn following crops other than corn is somewhat limited in Minnesota. Tight N supplies and high cost have dictated improved N efficiency which can perhaps be increased by crop rotation. With this in mind a study involving four crop rotations was initiated in the spring of 1974 on a Webster clay loam. The four rotations are: corn-soybean, corn-wheat, corn-wheat interseeded with alfalfa and continuous corn.

During this initial year, the crop sequences were started along with the application of the individual N treatments. The N rates on the corn plots will be 0, 40, 80, 120, 160 and 200 pounds/A. On both wheat systems 100 lb. N/A was used. Because this was the establishment year, yields and leaf samples were taken only to provide general production information of the crops on this site.

Soil samples from 0 - 24" were taken from all crop areas on October 22. Results from the nitrate analysis of these samples show considerable difference among NO$_3$-N levels following these crops (Table 1). Wheat showed the highest NO$_3$-N levels, whereas, soybeans and wheat interseeded with alfalfa showed very low levels—as low or lower than corn without any N. Corn, depending on the fertilizer N rate, was intermediate. These preliminary results lead one to speculate that significant mineralization may occur following the harvest of wheat in mid-August. The later growing alfalfa and soybeans may have utilized this late-season mineralized N. If these nitrate level differences remain into the 1975 season, substantial differences in N requirements of corn following these crops may be expected.

<table>
<thead>
<tr>
<th>Crop</th>
<th>N rate</th>
<th>NO$_3$-N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>Corn</td>
<td>0</td>
<td>46*</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>61</td>
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<td></td>
<td>120</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>160</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>107</td>
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<tr>
<td>Soybeans</td>
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</tr>
<tr>
<td>Wheat</td>
<td>100</td>
<td>97</td>
</tr>
<tr>
<td>Wheat &amp; Alfalfa</td>
<td>100</td>
<td>40</td>
</tr>
</tbody>
</table>

* Average of six samples
Alfalfa Fertilization at Waseca, 1974
W. E. Lueshcen and G. W. Randall

In 1969 an alfalfa P and K fertilization study was initiated at the Southern Experiment Station at Waseca. The results of this study, published in the 1973 edition of the "Bluebook", indicated only slight responses to fertilization. Since considerable Phytophthora root rot was present, the study was changed somewhat in 1973. The old trial was plowed and a new seeding established on the same site maintaining the integrity of the fertilization treatments. In the spring of 1973 'Vernal', 'Saranac' and 'Agate', the latter variety has good resistance to Phytophthora while the other two are susceptible, were established on the above mentioned site. The P and K annual fertilization rates were maintained as in previous years and are listed in the accompanying table. Yields were not taken in 1973 but three harvests were made in 1974.

Since 1974 was a relatively poor crop production year, yields were lower than normally expected. Due partially to this response to fertilizer application was limited. As can be seen in the accompanying table yield levels averaged over all varieties for 30 and 150 lb./A P₂O₅ were nearly identical for all cuttings. Soil test results taken in the fall of 1972 indicated soil phosphorus levels of 30 and 55 lb./A for the 30 and 150 lb./A rate, respectively. One would not expect a yield response to P at these soil test values.

Significant yield increases were observed in each cutting as well as the total seasonal production with the addition of K. Soil test results in the fall of 1972 indicated 160, 170 and 250 lb. K/A for the 0, 60 and 300 lb./A rates. The results reported herein for K applications are consistent with what one would have predicted for the soil test levels.

Although 'Agate' tended to produce more alfalfa than the other varieties, the differences among varieties were relatively small and nonsignificant. There also were no significant interactions between fertilization treatments and varieties with the exception of a small interaction between varieties and K fertilization in the second cutting.
Table 1. Influence of P and K fertilization on yield of alfalfa at Waseca in 1974.

<table>
<thead>
<tr>
<th>Variety</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>6/12/74 Cut 1</th>
<th>7/17/74 Cut 2</th>
<th>9/4/74 Cut 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vernal</td>
<td>30*</td>
<td>0</td>
<td>1.92</td>
<td>1.04</td>
<td>1.14</td>
<td>4.10</td>
</tr>
<tr>
<td>150</td>
<td>0</td>
<td>1.76</td>
<td>0.98</td>
<td>1.10</td>
<td>1.27</td>
<td>3.84</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
<td>1.78</td>
<td>1.10</td>
<td>1.27</td>
<td>4.15</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>60</td>
<td>2.00</td>
<td>1.17</td>
<td>1.28</td>
<td>4.45</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>300</td>
<td>1.95</td>
<td>1.19</td>
<td>1.31</td>
<td>4.45</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>300</td>
<td>1.94</td>
<td>1.14</td>
<td>1.36</td>
<td>4.44</td>
<td></td>
</tr>
</tbody>
</table>

| Saranac | 30   | 0   | 1.72         | 1.10         | 1.22         | 4.04  |
| 150     | 0    | 1.83| 1.06         | 1.14         | 4.03         |
| 30      | 60   | 1.77| 1.20         | 1.27         | 4.24         |
| 150     | 60   | 1.84| 1.27         | 1.37         | 4.48         |
| 30      | 300  | 1.90| 1.45         | 1.47         | 4.82         |
| 150     | 300  | 1.82| 1.44         | 1.45         | 4.71         |

| Agate   | 30   | 0   | 1.95         | 1.13         | 1.25         | 4.33  |
| 150     | 0    | 1.89| 1.15         | 1.25         | 4.29         |
| 30      | 60   | 2.14| 1.28         | 1.32         | 4.74         |
| 150     | 60   | 1.97| 1.22         | 1.39         | 4.58         |
| 30      | 300  | 2.03| 1.51         | 1.47         | 5.01         |
| 150     | 300  | 2.12| 1.45         | 1.43         | 5.00         |

Average of 3 varieties

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<thead>
<tr>
<th></th>
<th>30 lb. P₂O₅</th>
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<th></th>
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<td></td>
<td>1.91</td>
<td>1.22</td>
<td>1.30</td>
<td>4.43</td>
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</tbody>
</table>

<table>
<thead>
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<th></th>
<th></th>
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<td></td>
<td>1.91</td>
<td>1.21</td>
<td>1.31</td>
<td>4.43</td>
</tr>
</tbody>
</table>

<table>
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<th></th>
</tr>
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<td>1.08</td>
<td>1.18</td>
<td>4.10</td>
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<table>
<thead>
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<th>60 lb. K₂O</th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>1.92</td>
<td>1.20</td>
<td>1.31</td>
<td>4.43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>300 lb. K₂O</th>
<th></th>
<th></th>
<th></th>
</tr>
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<td></td>
<td>1.96</td>
<td>1.36</td>
<td>1.42</td>
<td>4.74</td>
</tr>
</tbody>
</table>

BLSD .05 for fertilizer treatments

<table>
<thead>
<tr>
<th></th>
<th>P rates</th>
<th></th>
<th></th>
<th></th>
<th>K rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>0.08</td>
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<td></td>
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<td>0.06</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.14</td>
</tr>
</tbody>
</table>

* lb./A
SPRING WHEAT NITROGEN FERTILIZATION AT WASECA, 1971 - 74

W. E. Lueschen and G. W. Randall

Experiments were established in 1971 - 74 at the Southern Experiment Station to evaluate nitrogen fertilization of three standard height and seven semidwarf hard red spring wheat varieties. In 1974 a durum wheat variety (Ward) was also evaluated. Soil type for these experiments was a LeSueur clay loam. Adequate P and K fertilizers were applied each year to prevent these elements from limiting yield and quality. Wheat plots followed soybeans each year. Ammonium nitrate was used as the source of N and was incorporated just prior to seeding on 4/16/71, 4/19/72, 4/20/73 and 4/19/74. Nitrogen rates and wheat varieties used each year are shown in Table 1. Variations in nitrogen rates were partially due to nitrate soil test results. Each plot consisted of a 6' x 50' strip which was harvested with a standard combine.

YIELD RESULTS

Yields were increased significantly in all years with the addition of nitrogen fertilizer (Table 1). Yield response of the standard height varieties was limited to the lower rate of N (40 lbs/A) while the semidwarf varieties, in some cases, gave a response (2 - 4 bushels/A) up to 80 lbs. N/A. Only in a few cases were yield responses observed for 120 lbs. N/A as compared to 80.

Nitrate soil tests taken prior to planting indicated a need for 40, 100 and 100 lbs. of additional N/A in 1972, 1973 and 1974, respectively (Table 2). As might have been predicted from the soil test results, a greater response to nitrogen occurred in 1973 and 1974 than in 1972. Even though response to nitrogen was greater, the nitrate soil tests in 1973 and 1974 overestimated the amount of nitrogen needed for optimum wheat yields when wheat followed soybeans. This was true even if one only considers the variety Era, one of the highest yielding varieties in the experiment. Soil nitrate data obtained throughout the 1974 growing season (Table 3) indicate a poor relationship to applied N. Perhaps this could have been influenced by dry conditions encountered in late June and during July. Because of the aforementioned inconsistencies, more data is needed to evaluate the nitrate soil test before it can be generally accepted as the guide for N fertilization in South Central Minnesota. While the nitrate test might serve as a guide to nitrogen fertilization, previous cropping history and the data herein should also be considered when determining N rates for spring wheat in South Central Minnesota.
As nitrogen was increased from 0 to 120 lbs/A the protein content of all varieties was increased each year (Table 4). In 1971 and 1973 the protein contents were approximately 1% higher than in 1972 while the proteins for 1974 were about a percent lower than in 1972. Protein contents in 1974 were low enough for the semidwarf varieties that substantial discounts (1¢/.1% protein less than 14%) would have occurred at marketing time, especially where no nitrogen was added. With Era in 1974 the discount would have ranged from 29¢/bu. with no nitrogen to 9¢/bu. where 120 lbs. was added. In the other years of the study, only slight discounts would have been realized with Era.

It is obvious from the data that N fertilization is important in increasing protein levels. With the exception of 1973, the greatest protein response to nitrogen was from the initial 40 lbs. N/A. The second and third 40 pound increments of nitrogen produced increases in protein content, however, the amount of increase was less than the initial 40 pounds. Increasing nitrogen levels beyond the level of yield response to increase protein would not appear to be economical since the increase in protein and the subsequent amount of reduction in discounts would not pay for the additional nitrogen added.
Table 1. Effects of N rates and varieties on yield of hard red spring wheat at Waseca, 1971-4.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>40</td>
<td>80</td>
<td>120</td>
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</tr>
<tr>
<td>Chris</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waldron</td>
<td>65</td>
<td>64</td>
<td>67</td>
<td>64</td>
</tr>
<tr>
<td>Polk</td>
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<tr>
<td>WS1809*</td>
<td>62</td>
<td>62</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>Era*</td>
<td>74</td>
<td>80</td>
<td>77</td>
<td>72</td>
</tr>
<tr>
<td>WS1812*</td>
<td>59</td>
<td>64</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>Bounty 208*</td>
<td>64</td>
<td>63</td>
<td>70</td>
<td>76</td>
</tr>
<tr>
<td>Bonanza*</td>
<td>60</td>
<td>57</td>
<td>64</td>
<td>70</td>
</tr>
<tr>
<td>RR68*</td>
<td>66</td>
<td>67</td>
<td>68</td>
<td>70</td>
</tr>
<tr>
<td>Olaf*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>II-64-33*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ward**</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10 Varieties</td>
<td>64</td>
<td>66</td>
<td>68</td>
<td>67</td>
</tr>
<tr>
<td>Std. Height</td>
<td>63</td>
<td>65</td>
<td>65</td>
<td>62</td>
</tr>
<tr>
<td>Semidwarf</td>
<td>65</td>
<td>66</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

BLSD N Rate 2.8 3.3 4.0 6.7
BLSD Var. 3.6 2.7 2.2 1.9
BLSD Var. x N 4.8 ns 5.7 ns

* Semidwarf Varieties
** Durum Variety
Table 2. Nitrate soil test values, N recommendations as determined by the nitrate test and the optimum N fertilization rates at Waseca, 1972 - 74.

<table>
<thead>
<tr>
<th>Year</th>
<th>Soil test N</th>
<th>N recommendation*</th>
<th>Optimum**</th>
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<td></td>
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<td>- - - - - lbs. N/A</td>
<td>N rate</td>
</tr>
<tr>
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<td>N/A</td>
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<td></td>
</tr>
<tr>
<td>1972</td>
<td>95</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>1973</td>
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<td>100</td>
<td>40</td>
</tr>
<tr>
<td>1974</td>
<td>50</td>
<td>100</td>
<td>40</td>
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</tbody>
</table>

* for yields greater than 50 bu/A  
** as determined by yields obtained

Table 3. Soil nitrates throughout the growing season of spring wheat as influenced by N fertilization at Waseca in 1974.

<table>
<thead>
<tr>
<th>N rate</th>
<th>Date 4/24</th>
<th>5/27</th>
<th>6/26</th>
<th>7/23</th>
</tr>
</thead>
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<tr>
<td>lbs. N/A</td>
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<td>lbs. NO₃</td>
<td>N/A</td>
<td>- - - -</td>
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<td>20</td>
</tr>
<tr>
<td>120</td>
<td>-</td>
<td>137</td>
<td>24</td>
<td>38</td>
</tr>
</tbody>
</table>

* average of 6 plots (3 reps x 2 varieties)
Table 4. Effect of N rate and variety on percent protein of hard red spring wheat and one durum wheat at Waseca, 1971 - 74.

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<th></th>
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</thead>
<tbody>
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<td></td>
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<td>lbs.</td>
<td>lbs.</td>
<td>lbs.</td>
</tr>
<tr>
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<td>80</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>40</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>40</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>Chris</td>
<td>16.8</td>
<td>16.4</td>
<td>17.4</td>
<td>15.3</td>
</tr>
<tr>
<td>Waldron</td>
<td>16.3</td>
<td>16.5</td>
<td>17.0</td>
<td>15.7</td>
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<td>Polk</td>
<td>15.9</td>
<td>16.3</td>
<td>16.3</td>
<td>14.9</td>
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<td>Fletcher*</td>
<td>15.3</td>
<td>15.2</td>
<td>15.4</td>
<td>14.7</td>
</tr>
<tr>
<td>WS 1809*</td>
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<td>16.8</td>
<td>16.8</td>
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<td>Era*</td>
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<td>14.0</td>
<td>15.0</td>
<td>13.1</td>
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<td>15.5</td>
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<td>16.0</td>
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<td>15.5</td>
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<td>Olaf*</td>
<td>-</td>
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<td>II-64-33*</td>
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<tr>
<td>Ward**</td>
<td>-</td>
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<tr>
<td>Hard Red Spring Summary</td>
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<tr>
<td>10 Var.</td>
<td>15.5</td>
<td>15.8</td>
<td>16.1</td>
<td>14.4</td>
</tr>
<tr>
<td>Std. Hgt.</td>
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<td>16.4</td>
<td>16.9</td>
<td>15.3</td>
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<td>Semidwarf</td>
<td>15.2</td>
<td>15.6</td>
<td>15.8</td>
<td>14.1</td>
</tr>
</tbody>
</table>

| BLSD N Rate (.05) | .35 |
| BLSD Var (.05)    | .37 |
| BLSD Var x N (.05) | ns |

* = Semidwarf Varieties; ** = Durum Wheat; 4 Reps 1971-72; 3 Reps 1973-74
IRON CHLOROSIS IN SOYBEANS

Waseca, 1974

Gyles W. Randall

For a number of years symptoms of iron (Fe) deficiency have been observed on soybeans grown on calcareous soils in southern and western Minnesota. In recent years soybean growers have reported that Fe deficiencies are occurring more frequently and the affected areas in fields are becoming larger. Much of this increase in severity of the Fe problem can be associated with the recent introduction of several new high yielding varieties which are not very tolerant of the conditions favoring Fe chlorosis. It is possible that higher rates of fertilization and changes in other management practices may also be contributing factors.

Foliar application of FeSO₄ has been the traditional method of treating Fe chlorosis on soybeans. This material is relatively inexpensive but limited research work and experience by farmers have shown considerable variation in the effectiveness of FeSO₄ treatments. A number of Fe chelates have been introduced in recent years. These materials have some advantages for foliar applications and may have economic potential for use in soil applications. The cost of a unit of Fe in chelates is greater than in FeSO₄ but the rates required are smaller.

Studies involving the foliar application of iron to iron deficient soybeans were conducted at five locations in 1973. Results were reported in the 1974 Soils Bluebook, Soil Series 91.

PROCEDURES AND RESULTS

Two types of experiments involving the foliar application of Fe materials to iron-deficient soybeans were established on seven farms in Blue Earth, Faribault, Nicollet and Waseca Counties in 1974. One experiment evaluated both commercial and experimental materials applied at two rates (Table 1). The other experiment involved three materials applied in single or multiple applications at two growth stages (Table 2). All trials were established on farmer-planted soybeans which had been showing definite Fe chlorosis symptoms for 5 to 7 days. Each treatment was applied to either one or two rows 25' long and was replicated from 5 to 8 times. All applications were made in a 15" band directly over the row by using a stainless steel 3-gallon hand sprayer. A spray volume of 30 gal/A and a surfactant (0.5% v/v) was used for all treatments.
Table 1. Soybean yields as influenced by the foliar application of Fe materials at two rates of application in south-central Minnesota (1974).

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate</th>
<th>Cooperators (Faribault Co.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb. Fe/A</td>
<td>Lorenz</td>
<td>Miller</td>
</tr>
<tr>
<td>Check</td>
<td>-</td>
<td>2.4</td>
<td>9.8</td>
</tr>
<tr>
<td>Fe-138</td>
<td>.10</td>
<td>5.8</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>.15</td>
<td>16.3</td>
<td>16.9</td>
</tr>
<tr>
<td>FeSO₄</td>
<td>.75</td>
<td>10.9</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td>8.1</td>
<td>11.8</td>
</tr>
<tr>
<td>GA-5-124</td>
<td>.10</td>
<td>-</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>.15</td>
<td>-</td>
<td>12.5</td>
</tr>
<tr>
<td>GA-5-125</td>
<td>.10</td>
<td>-</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>.15</td>
<td>-</td>
<td>8.4</td>
</tr>
<tr>
<td>GA-5-126</td>
<td>.10</td>
<td>-</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>.15</td>
<td>-</td>
<td>10.3</td>
</tr>
<tr>
<td>Hamp-Iron</td>
<td>.10</td>
<td>0.7</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>.20</td>
<td>2.9</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Significance: * ns
BLSD (.05) : 10.5
CV (%) : 117. 51.

Results in Table 1 show that a yield response to foliar-applied Fe occurred only at the Lorenz site. At that location the high rate of Fe-138 was the only treatment that significantly increased yields. Somewhat less but still profitable yield increases were noted with the low rate of Fe-138 and with both rates of FeSO₄. Hamp-Iron produced no yield increase but did result in some phytoxicity symptoms.

Yields were also increased by the higher Fe-138 rate at the Miller site, but the response was not statistically significant due to the high variability. At a third site (Trask, Nicollet Co.) no visual responses were noticed. In addition, beans were not taller than 12 inches at maturity. Thus, yields were not taken.

The growth stage of the plant at Fe application appeared to be important again in 1974 (Table 2). Significant yield responses were obtained with the early and the double applications of Fe-138 at the Fell and Pick sites. Waiting until the 5th trifoliate to apply the Fe did not result in a yield response. Yield responses were not obtained with FeSO₄ or with Hamp-Iron. Yields at the Pick site were extremely low due to the late planting (June 1) and the early frost.
Although a trend towards yield increases with Fe-138 was present at the Bluhm site, yields were not statistically different. No yield response was noticed at the Lindeland site although visual observations 10 days after application showed improved green color of the plants with both Fe-138 and FeSO₄.

Table 2. Yields as influenced by single and double applications of Fe at two growth stages of iron-deficient soybeans in south-central Minnesota (1974).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Material</th>
<th>Time</th>
<th>Cooperator and County</th>
<th>Bluhm</th>
<th>Nicollet</th>
<th>Waseca</th>
<th>Lindeland</th>
<th>Blue Earth</th>
<th>Pick</th>
<th>Waseca</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bu/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>trifoliate</td>
<td>Check</td>
<td>12.3</td>
<td>3.0</td>
<td>2.5</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe-138</td>
<td>1/</td>
<td>2</td>
<td>14.0</td>
<td>8.7</td>
<td>3.6</td>
<td>5.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>15.2</td>
<td>4.6</td>
<td>3.4</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,5</td>
<td>19.2</td>
<td>11.4</td>
<td>3.3</td>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FeSO₄</td>
<td>2/</td>
<td>2</td>
<td>11.1</td>
<td>4.0</td>
<td>2.0</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>10.8</td>
<td>5.2</td>
<td>2.5</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,5</td>
<td>14.0</td>
<td>5.9</td>
<td>2.6</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamp-Iron</td>
<td>3/</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,5</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance: ns * ns **

BLSD (.05): 6.0 2.1
CV (%): 36. 66. 70. 91.

1/ .10 lb Fe/A
2/ 1.0 lb Fe/A
3/ .20 lb Fe/A

Soil pH appears to be the major factor in the incidence of iron chlorosis in soybeans in south-central Minnesota (Table 3). In all cases where severe chlorosis has been prevalent, soil pH has been 7.8 or above. Farmers who have fields with a predominantly high pH should consider (1) corn or wheat as an alternative to soybeans or (2) growing a soybean variety that is tolerant to iron deficiency. However, if iron chlorosis symptoms do appear in the soybeans then foliar applications of Fe-138 at a rate of .10 to .15 lb. Fe/A shortly after the deficiency symptoms appear would be an economically profitable treatment.
<table>
<thead>
<tr>
<th>Year</th>
<th>County</th>
<th>Cooperator</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Faribault</td>
<td>Sendelbach</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>Waseca</td>
<td>Baer</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>Coy</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>Lohberger</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>Meyer</td>
<td>7.9</td>
</tr>
<tr>
<td>1974</td>
<td>Blue Earth</td>
<td>Lindeland</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Faribault</td>
<td>Lorenz</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>Miller</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Nicollet</td>
<td>Bluhm</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>Waseca</td>
<td>Fell</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>Pick</td>
<td>7.8</td>
</tr>
</tbody>
</table>
CORN TILLAGE STUDY
Waseca, 1974

G. W. Randall, W. E. Lueshcen and J. B. Swan

A field experiment was initiated in 1969 to evaluate tillage systems for continuous corn production in south-central Minnesota. Eleven tillage treatments were established in a randomized complete-block design with four replications. Each treatment has been super-imposed on the same plot since establishment. The experiment is located on a LeSueur clay loam soil with a 2-5% south-facing slope. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

A broadcast application of fertilizer (0+30+60 lbs. N+P₂O₅+K₂O/A) was applied on November 2 and was followed immediately by the fall primary tillage operations. Nitrogen (175 lbs. N/A as ammonium nitrate) was broadcast on the surface on April 25. The spring primary tillage treatments were performed on April 26 and the secondary treatments on May 2.

Corn (Minhybrid 4201) was planted at a rate of 24,000 ppA on May 3. A John Deere plateless planter modified with Allis Chalmers 2" fluted coulters was used to plant the plots which did not receive primary tillage. For those plots which did receive primary tillage, the fluted coulters were removed. Starter fertilizer (13+35+45 lbs. N+P₂O₅+K₂O/A) and an insecticide (1 lb. active Furadan/A) were applied at planting time. Chemical weed control consisted of 2.5 lbs. alachlor/A (A.I.) and 2½ lbs. atrazine/A (A.I.) applied preemergence. With the exception of the fall chisel-none and no-tillage treatments where too much surface residue prevented cultivation, each treatment was cultivated once. Yields were taken by combine harvesting the center four rows at each plot.

RESULTS

Results from previous years can be found in Soil Series 87, 88, 89 and 91, "A Report on Field Research in Soils".

In 1974, early plant growth, lodging, grain moisture at harvest and yield were affected significantly by the tillage treatments (Table 1). Emergence and tassel dates were not affected by the tillage treatments. However, small plant growth, an indication of early vigor, was influenced significantly. Two minimum tillage treatments (fall chisel-none and no tillage) showed significantly smaller plants than most other treatments. Plants were largest with the fall plow-conventional treatment.
Table 1. Influence of tillage treatments on continuous corn production at Waseca in 1974.

<table>
<thead>
<tr>
<th>Tillage Treatments</th>
<th>Moisture at Yield</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td>Fall Plow</td>
<td>None</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Field Cult.</td>
<td>24</td>
</tr>
<tr>
<td>Spring Plow</td>
<td>Conventional</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Field Cult.</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>24</td>
</tr>
<tr>
<td>Fall Chisel</td>
<td>Conventional</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Field Cult.</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>24</td>
</tr>
<tr>
<td>Spring Chisel</td>
<td>Conventional</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Disk</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>24</td>
</tr>
</tbody>
</table>

Significance: 1/

** and * = significant at the 99 and 95% levels; ns = not significant at the 95% level.

1/ Conventional = Disk and field cultivate

2/ ** and * = significant at the 99 and 95% levels; ns = not significant at the 95% level.
Plant population at harvest was not affected by any of the tillage treatments again this year. Lodging due to rootworm activity was prevalent throughout all treatments. The prolonged rainfall shortly after planting may have diluted the soluble insecticide resulting in poor late-season control. Highest counts, however, were generally associated with the spring primary tillage treatments.

Although significant differences in grain moisture were found, no consistent relationship to either the primary or secondary treatments existed. Moisture was highest with no tillage and lowest with fall chisel-conventional.

Yields among the tillage treatments were significantly different again this year. Highest yields were obtained with the maximum tillage treatments (fall moldboard plow and fall chisel with conventional secondary tillage). Poorest yields resulted from the no tillage, the spring plow and the fall chisel-none treatments. Again this year, spring disking appeared to be a good alternative to spring plowing, spring chiseling or no tillage if fall primary tillage was not completed. A significant correlation was found between early plant growth and grain yield ($r = .314^\ast$).

Other physical and chemical measurements as affected by certain primary tillage treatments were obtained during the growing season. Surface residue accumulation (mulch from the preceding corn crops) was shown to increase markedly with the chisel and no tillage treatments (Table 2).

Table 2. Effect of primary tillage treatments on the surface residue accumulation after five years of continuous corn at Waseca.

<table>
<thead>
<tr>
<th>Tillage treatment</th>
<th>Primary</th>
<th>Secondary</th>
<th>Surface residue T/A (Dry Matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall plow</td>
<td>None</td>
<td>None</td>
<td>Trace</td>
</tr>
<tr>
<td>Fall chisel</td>
<td>None</td>
<td>None</td>
<td>2.54</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
<td>None</td>
<td>3.46</td>
</tr>
</tbody>
</table>

The effect of this mulch on soil temperature is shown in Table 3. These measurements were obtained by using thermocouples installed at a depth of 4 inches directly under the corn. The minimum and maximum daily temperatures were averaged each day for approximately seven weeks. Over this 45-day period the fall plow treatment showed a 1.3 and 1.7°F advantage over the fall chisel and no tillage treatments, respectively. Daily differences between the fall plow and no tillage treatments were as high as 3.1°F.
Table 3. Influence of three tillage treatments on the 4-inch soil temperature during the spring of 1974 at Waseca.

<table>
<thead>
<tr>
<th>Period</th>
<th>Tillage treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall plow field cult.</td>
</tr>
<tr>
<td>5/15-17</td>
<td>54.3</td>
</tr>
<tr>
<td>5/20-25</td>
<td>57.1</td>
</tr>
<tr>
<td>5/27-30</td>
<td>63.4</td>
</tr>
<tr>
<td>6/3-8</td>
<td>65.8</td>
</tr>
<tr>
<td>6/10-14</td>
<td>65.4</td>
</tr>
<tr>
<td>6/17-20</td>
<td>67.0</td>
</tr>
<tr>
<td>6/24-28</td>
<td>72.5</td>
</tr>
<tr>
<td>45-day</td>
<td>64.0</td>
</tr>
</tbody>
</table>

Depth to the perched water table was monitored in two tillage treatments from mid-June thru early September with open-end, perforated, 2" plastic pipes. Depths were shallow with the no tillage treatment than with the fall plow treatment early in the season (Table 4). However, after mid-July no appreciable differences were noticed.

Table 4. Depth to perched water table under two tillage systems at Waseca in 1974.

<table>
<thead>
<tr>
<th>Tillage treatment</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6/24 7/1 7/8 7/15 7/22 7/29 8/5 8/16 8/26 9/2</td>
<td>inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall plow - field cult.</td>
<td>37* 45 51 55 59 64 68 72+ 72+ 72+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No tillage</td>
<td>24 36 45 52 57 62 68 72+ 72+ 72+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* each value is an average from 3 pipes.

Soil moisture data from the fall plow - field cultivate and the no tillage treatments were taken via neutron probe. Three stoppered Al tubes were placed in each of three replications. Complete sets of measurements were taken in July, August, and September (Table 5).
Table 5. Soil moisture of the profile under two tillage systems at Waseca in 1974.

<table>
<thead>
<tr>
<th>Depth (inches)</th>
<th>7/18 Fall plow</th>
<th>7/18 No field cul. tillage</th>
<th>7/30 FP</th>
<th>7/30 NT</th>
<th>8/26 FP</th>
<th>8/26 NT</th>
<th>9/4 FP</th>
<th>9/4 NT</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>18.9*</td>
<td>22.2</td>
<td>17.5</td>
<td>19.5</td>
<td>30.9</td>
<td>31.2</td>
<td>26.4</td>
<td>28.0</td>
</tr>
<tr>
<td>12</td>
<td>24.0</td>
<td>26.7</td>
<td>22.3</td>
<td>23.6</td>
<td>34.6</td>
<td>35.3</td>
<td>30.7</td>
<td>33.3</td>
</tr>
<tr>
<td>18</td>
<td>26.1</td>
<td>26.2</td>
<td>23.2</td>
<td>21.5</td>
<td>30.4</td>
<td>31.8</td>
<td>29.1</td>
<td>29.6</td>
</tr>
<tr>
<td>24</td>
<td>30.8</td>
<td>30.2</td>
<td>26.0</td>
<td>23.6</td>
<td>28.8</td>
<td>28.0</td>
<td>28.1</td>
<td>27.7</td>
</tr>
<tr>
<td>30</td>
<td>34.3</td>
<td>35.1</td>
<td>28.1</td>
<td>28.7</td>
<td>28.2</td>
<td>29.0</td>
<td>27.7</td>
<td>27.9</td>
</tr>
<tr>
<td>36</td>
<td>36.5</td>
<td>36.5</td>
<td>31.5</td>
<td>33.3</td>
<td>28.4</td>
<td>32.0</td>
<td>28.7</td>
<td>30.2</td>
</tr>
<tr>
<td>42</td>
<td>36.7</td>
<td>37.9</td>
<td>34.3</td>
<td>36.1</td>
<td>30.8</td>
<td>34.6</td>
<td>31.1</td>
<td>33.8</td>
</tr>
<tr>
<td>48</td>
<td>36.4</td>
<td>37.2</td>
<td>35.4</td>
<td>35.7</td>
<td>33.6</td>
<td>32.4</td>
<td>33.0</td>
<td>33.6</td>
</tr>
</tbody>
</table>

* each value is an average from 9 tubes.

Soil moisture at the 8 and 12" depths was somewhat less in the fall plow treatment than with no tillage. At depths of 18 inches or greater differences between the tillage treatments were minimal. The only exception was in late August and early September when slightly more water was present at the 36 and 42" depths with no tillage. This could have been due to the less vigorous crop which required less water on this treatment.

Earleaf samples were taken at tasseling from four treatments (Table 6). Leaf N, K and Ca were influenced by the tillage treatments. Micronutrient, P and Mg concentrations were not affected. The disk only treatment resulted in significantly lower leaf N than the other three treatments. No differences were observed in leaf N between the fall plow, fall chisel and no tillage treatments. Leaf K was significantly higher from the fall plow treatment than from the conservation tillage treatments. This apparently reflects the distribution of soil K with these treatments as shown in the 1973 report found in Soil Series 91, page 156, Table 7. With the minimum or no tillage treatments much of the added K has accumulated in the 0 - 2" layer; whereas, K is distributed evenly throughout the profile with moldboard plowing. During a dry period such as in July when the 0 - 4" layer was very dry, this problem is magnified. These results suggest that perhaps soils on which continuous corn is grown should be plowed every few years to evenly distribute the fertility and incorporate the surface residues.
Table 6. Nutrient concentrations in the ear leaf as influenced by tillage methods at Waseca in 1974.

<table>
<thead>
<tr>
<th>Tillage treatment</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Cu</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall plow - field cult.</td>
<td>2.98</td>
<td>.30</td>
<td>2.31</td>
<td>.89</td>
<td>.57</td>
<td>295</td>
<td>40</td>
<td>20</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Fall chisel - field cult.</td>
<td>2.92</td>
<td>.28</td>
<td>1.91</td>
<td>1.02</td>
<td>.66</td>
<td>270</td>
<td>39</td>
<td>17</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Disk only</td>
<td>2.78</td>
<td>.30</td>
<td>1.99</td>
<td>1.04</td>
<td>.70</td>
<td>300</td>
<td>40</td>
<td>17</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>No tillage</td>
<td>2.94</td>
<td>.28</td>
<td>1.88</td>
<td>.94</td>
<td>.63</td>
<td>275</td>
<td>32</td>
<td>20</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Signif: */ * ns * * ns ns ns ns ns ns
CV (%): 2.6 14.0 8.0 6.2 9.8 8.1 20.1 12.9 10.7 9.2
BLSD (.05): .12 .26 .10

1/ * = significant at the 95% level; ns = not significant at the 95% level.

Soil samples of 0 - 24" were taken from three of the treatments on October 22, 1974 and were analyzed for nitrate-nitrogen. Results shown in Table 7 indicate somewhat less NO3-N with no tillage than with plowing or chiseling. These results are consistent with those found in 1973.

Table 7. Influence of primary tillage treatments on nitrate-nitrogen content of the 0 - 24" soil profile at Waseca in 1974.

<table>
<thead>
<tr>
<th>Tillage treatment</th>
<th>NO3-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Secondary</td>
<td>lb./A</td>
</tr>
<tr>
<td>Fall plow field cult.</td>
<td>70*</td>
</tr>
<tr>
<td>Fall chisel field cult.</td>
<td>66</td>
</tr>
<tr>
<td>None None</td>
<td>52</td>
</tr>
</tbody>
</table>

* each value is an average of 4 samples (1 per rep).

1970-1974 YIELD SUMMARY

In four of the five years significant yield differences have been found (Table 8). However, the highest yields have not always been associated with the same treatments. Climatological differences among growing seasons have largely been responsible for this year to year inconsistency. For instance, 1971 was extremely dry and highest yields were obtained from
the fall plow and chisel tillage treatments without any secondary tillage. In other years, secondary tillage following chiseling generally increased yields. Five year averages show highest yields to result from fall moldboard plowing or fall chiseling with secondary tillage. Perhaps in fields that are more poorly drained or are level to north facing the fall moldboard plow would be advantageous because of warmer spring soil temperature and hastened early plant development. Spring chiseling and no tillage generally produced the lowest yields.

Table 8. Yields from continuous corn tillage experiment at Waseca from 1970-1974.

<table>
<thead>
<tr>
<th>Tillage Treatment</th>
<th>Primary</th>
<th>Secondary</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>5-Yr. Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall plow</td>
<td>None</td>
<td></td>
<td>164.7</td>
<td>114.8</td>
<td>135.3</td>
<td>141.2</td>
<td>97.9</td>
<td>130.8</td>
</tr>
<tr>
<td></td>
<td>Conv.</td>
<td>1/</td>
<td>166.8</td>
<td>104.7</td>
<td>131.8</td>
<td>144.9</td>
<td>103.4</td>
<td>130.3</td>
</tr>
<tr>
<td></td>
<td>F. cult.</td>
<td></td>
<td>163.7</td>
<td>102.8</td>
<td>136.2</td>
<td>144.1</td>
<td>99.7</td>
<td>129.3</td>
</tr>
<tr>
<td>Spring plow</td>
<td>Conv.</td>
<td></td>
<td>161.5</td>
<td>100.6</td>
<td>134.9</td>
<td>140.5</td>
<td>90.4</td>
<td>125.6</td>
</tr>
<tr>
<td>Fall chisel</td>
<td>None</td>
<td></td>
<td>164.2</td>
<td>106.6</td>
<td>130.8</td>
<td>155.1</td>
<td>99.2</td>
<td>131.2</td>
</tr>
<tr>
<td></td>
<td>Conv.</td>
<td></td>
<td>156.7</td>
<td>110.5</td>
<td>133.1</td>
<td>145.7</td>
<td>92.1</td>
<td>127.6</td>
</tr>
<tr>
<td></td>
<td>F. cult.</td>
<td></td>
<td>161.1</td>
<td>116.2</td>
<td>126.2</td>
<td>134.3</td>
<td>90.4</td>
<td>125.6</td>
</tr>
<tr>
<td>Spring &quot;</td>
<td>Conv.</td>
<td></td>
<td>150.2</td>
<td>100.1</td>
<td>139.9</td>
<td>138.4</td>
<td>92.1</td>
<td>124.1</td>
</tr>
<tr>
<td>Spring &quot; Disk</td>
<td>159.5</td>
<td>110.2</td>
<td>133.6</td>
<td>131.5</td>
<td>95.7</td>
<td>126.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Disk</td>
<td>155.9</td>
<td>96.2</td>
<td>130.1</td>
<td>133.4</td>
<td>85.9</td>
<td>120.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero &quot;</td>
<td>157.9</td>
<td>104.1</td>
<td>130.8</td>
<td>145.8</td>
<td>93.7</td>
<td>126.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Signif: 2/
* + ns ** ** *
CV (%): 3.6 5.9 5.1 4.4 5.9 3.8
BLSD (.10): 8.3 9.7 7.7
BLSD (.05): 9.9 9.0 9.0 7.7

1/ Conventional = Disk and field cultivate
2/ **, *, + = significant at the 99, 95 and 90% levels;
   ns = not significant at the 90% level.
Objective:
To measure differences in soil physical properties between a conventional fall plow system and a no till system.

Properties measured:
Data is included on bulk density, water content, saturated hydraulic conductivities, air filled porosity and earthworm burrows. In addition data was collected on matric potentials, and earthworm numbers.
Tillage, Waseca

May 24, 1974

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Bulk Density, g/cm³</th>
<th>Water Content, g/g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall Plow</td>
<td>No Till</td>
</tr>
<tr>
<td>0-10</td>
<td>.97</td>
<td>1.11</td>
</tr>
<tr>
<td>10-20</td>
<td>1.10</td>
<td>1.26</td>
</tr>
<tr>
<td>20-30</td>
<td>1.16</td>
<td>1.34</td>
</tr>
<tr>
<td>30-40</td>
<td>1.29</td>
<td>1.32</td>
</tr>
<tr>
<td>40-50</td>
<td>1.28</td>
<td>1.38</td>
</tr>
<tr>
<td>50-60</td>
<td>1.35</td>
<td>1.40</td>
</tr>
<tr>
<td>60-70</td>
<td>1.40</td>
<td>1.45</td>
</tr>
<tr>
<td>70-80</td>
<td>1.39</td>
<td>1.50</td>
</tr>
<tr>
<td>80-90</td>
<td>1.44</td>
<td>1.60</td>
</tr>
<tr>
<td>90-100</td>
<td>1.51</td>
<td>1.59</td>
</tr>
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</table>
### TILLAGE, WASECA

September 26, 1974

<table>
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<tr>
<th>Depth cm</th>
<th>Bulk Density g/cm³</th>
<th>Water Content g/g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall Plow</td>
<td>No Till</td>
</tr>
<tr>
<td>0-10</td>
<td>1.00</td>
<td>1.23</td>
</tr>
<tr>
<td>10-20</td>
<td>1.04</td>
<td>1.29</td>
</tr>
<tr>
<td>20-30</td>
<td>1.15</td>
<td>1.26</td>
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<td>30-40</td>
<td>1.27</td>
<td>1.29</td>
</tr>
<tr>
<td>40-50</td>
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<td>50-60</td>
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<td>60-70</td>
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<td>1.36</td>
</tr>
<tr>
<td>70-80</td>
<td>1.36</td>
<td>1.36</td>
</tr>
<tr>
<td>80-90</td>
<td>1.34</td>
<td>1.41</td>
</tr>
<tr>
<td>90-100</td>
<td>1.39</td>
<td>1.46</td>
</tr>
</tbody>
</table>
TILLAGE, WASECA
SATURATED HYDRAULIC CONDUCTIVITIES CM/HR
1974

<table>
<thead>
<tr>
<th>Depth cm</th>
<th>Fall Plow</th>
<th>No Till</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>May 20 (1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5-15.0</td>
<td>38.2</td>
<td>11.7</td>
</tr>
<tr>
<td>30.0-37.5</td>
<td>19.2</td>
<td>19.9</td>
</tr>
<tr>
<td><strong>July 10-11 (2)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-10</td>
<td>16.3</td>
<td>0.6</td>
</tr>
<tr>
<td>12-20</td>
<td>1.1</td>
<td>3.2</td>
</tr>
<tr>
<td>22-30</td>
<td>3.5</td>
<td>9.3</td>
</tr>
<tr>
<td>32-40</td>
<td>17.2</td>
<td>22.3</td>
</tr>
<tr>
<td>42-50</td>
<td>20.1</td>
<td>11.6</td>
</tr>
<tr>
<td>52-60</td>
<td>4.7</td>
<td>13.4</td>
</tr>
<tr>
<td>62-70</td>
<td>5.1</td>
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<td>72-80</td>
<td>11.0</td>
<td>15.5</td>
</tr>
<tr>
<td>82-90</td>
<td>16.2</td>
<td>3.2</td>
</tr>
<tr>
<td>92-100</td>
<td>21.4</td>
<td>2.7</td>
</tr>
<tr>
<td><strong>September 20 (1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5-15</td>
<td>39.2</td>
<td>66.6</td>
</tr>
<tr>
<td>30-3.75</td>
<td>46.8</td>
<td>34.1</td>
</tr>
</tbody>
</table>

(1) Values are averages for 24 samples in corn row
(2) Values are averages for 8 samples from interrow
### Tillage, Waseca

Porosity, cm$^3$/cm$^3$

at $\psi = 20, 50$ and $100$ mb.

1974

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Fall Flow</th>
<th>No Till</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>May 20 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5-15.0</td>
<td>.118</td>
<td>.177</td>
</tr>
<tr>
<td>30.0-37.5</td>
<td>.051</td>
<td>.085</td>
</tr>
<tr>
<td>July 11-12 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-10</td>
<td>.072</td>
<td>.153</td>
</tr>
<tr>
<td>12-20</td>
<td>.045</td>
<td>.087</td>
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<td>22-30</td>
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<td>52-60</td>
<td>.008</td>
<td>.063</td>
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<td>62-70</td>
<td>.007</td>
<td>.046</td>
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<td>72-80</td>
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<td>.037</td>
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<td>82-90</td>
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<td>.031</td>
</tr>
<tr>
<td>82-100</td>
<td>.021</td>
<td>.035</td>
</tr>
<tr>
<td>September 26 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5-15.0</td>
<td>.122</td>
<td>.172</td>
</tr>
<tr>
<td>30.0-37.5</td>
<td>.060</td>
<td>.099</td>
</tr>
</tbody>
</table>

(1) Values based on averages for 24 samples in corn row.

(2) Values based on averages for 8 samples from the interrow.
### Tillage, Waseca

Earthworm Burrows  
**No./M²**

#### 1974

<table>
<thead>
<tr>
<th>depth (cm)</th>
<th>Fall Plow</th>
<th>No Till</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;3 mm</td>
<td>2-3 mm</td>
</tr>
<tr>
<td><strong>May 20 (1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5-15.0</td>
<td>105</td>
<td>123</td>
</tr>
<tr>
<td>30.0-37.5</td>
<td>142</td>
<td>274</td>
</tr>
<tr>
<td><strong>July 11-12 (2)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>65</td>
<td>130</td>
</tr>
<tr>
<td>40</td>
<td>455</td>
<td>780</td>
</tr>
<tr>
<td>50</td>
<td>32</td>
<td>325</td>
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<tr>
<td>60</td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>70</td>
<td>32</td>
<td>130</td>
</tr>
<tr>
<td>80</td>
<td>97</td>
<td>227</td>
</tr>
<tr>
<td>90</td>
<td>195</td>
<td>162</td>
</tr>
<tr>
<td>100</td>
<td>130</td>
<td>162</td>
</tr>
<tr>
<td><strong>September 26 (3)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5-15.0</td>
<td>27</td>
<td>64</td>
</tr>
<tr>
<td>30.0-37.5</td>
<td>46</td>
<td>283</td>
</tr>
</tbody>
</table>

(1) Values based on counts from a surface area of 2189 cm².
(2) Values based on counts from a surface area of 300 cm².
(3) Values based on counts from a surface area of 1094 cm².
A field experiment was initiated in 1974 to evaluate tillage systems under a corn-soybean rotation in south central Minnesota. Twelve tillage treatments were established in a randomized complete-block design with four replications for corn and four for soybeans each year. The two crops simply rotate from one area to the other each year. The experiment is located on a Webster clay loam with a 0 - 2% slope. Tile lines spaced 75' apart lie perpendicular to the rows.

Fall primary tillage operations were conducted November 2, 1973. Nitrogen (150 lb. N/A as ammonium nitrate) was broadcast on April 25 to the corn area. Soil test P and K were very high (52 & 420, respectively); consequently broadcast P & K were not used. The spring primary tillage treatments were performed on April 29 and the secondary treatments on May 8 for corn and May 23 for soybeans.

Corn (DeKalb XL-43) was planted at a rate of 24,000 ppA on May 7. A John Deere plateless planter modified with Allis Chalmers 2" fluted coulters was used to plant the plots which did not receive primary tillage. For those plots which did receive primary tillage, the fluted coulters were removed. Starter fertilizer (13+35+45 lbs. N+P2O5+K2O/A) and an insecticide (1 lb. active Furadan/A) were applied at planting time. Chemical weed control consisted of 3 lbs. alachlor/A and 2 lbs. cyanazine/A applied preemergence. With the exception of the no-tillage treatment where too much surface residue prevented cultivation, each treatment was cultivated once.

Soybeans (Corsoy) were planted at a rate of 7.9 beans/foot of row on May 23. The planter, procedures used and starter fertilizer rates were the same as those described above for corn. Weeds were controlled with 3½ lbs. alachlor/A and 2½ lbs. chloroambe/A. All treatments, except the no tillage treatment, received one cultivation.

EXPERIMENTAL TREATMENTS

The 12 tillage treatments are listed in Table 1. Six of the treatments (No. 1, 2, 6, 7, 9 and 10) are conducted continuously; regardless of crop. The other six treatments take on a "systems" approach to tillage whereby the primary tillage method varies with the crop in the rotation.
Table 1. Tillage treatments in the corn-soybean rotation tillage study at Waseca in 1974.

<table>
<thead>
<tr>
<th>Trt. No.</th>
<th>for SOYBEANS following CORN</th>
<th>for CORN following SOYBEANS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td>1</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>2</td>
<td>Fall Plow</td>
<td>f. cult.</td>
</tr>
<tr>
<td>3</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>4</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>5</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Fall Chisel</td>
<td>disk</td>
</tr>
<tr>
<td>8</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>9</td>
<td>Spr. Chisel</td>
<td>&quot;</td>
</tr>
<tr>
<td>10</td>
<td>Spr. Disk</td>
<td>&quot;</td>
</tr>
<tr>
<td>11</td>
<td>Fall Chisel</td>
<td>f. cult.</td>
</tr>
<tr>
<td>12</td>
<td>Fall Disk</td>
<td>disk</td>
</tr>
</tbody>
</table>

RESULTS: CORN

Data from one of the replications were discarded because of severe ponding of water received in an intense storm on June 20. Hence, data from only three reps are reported (Table 2). Emergence, early plant growth, tassel date and the final population were not affected by the tillage treatments. However, smallest plants were found in the continuous no tillage and spring plow systems. Both lodging and grain moisture were affected significantly, but a consistent pattern with primary tillage could not be established.

Yields were significantly reduced by the continuous no tillage and spring plow systems. Other systems that yielded less than average were no. 8, the fall chisel (for soybeans) - zero (for corn) system and no. 11, the fall chisel (for soybeans) - spring field cultivate (for corn) system. No significant differences were found among the no. 2, 3, 4 and 5 systems. This would indicate that a minimum amount of tillage is necessary for corn following soybeans when moldboard plowing of corn residues is part of the system. Equally high yields were obtained with the minimum tillage continuous systems: fall chisel (no. 7), spring chisel (no. 9) and spring disk (no. 10). Yields were correlated significantly to early plant growth ($r = +.403^*$).
Table 2. Influence of tillage methods following soybeans on corn production at Waseca in 1974.

<table>
<thead>
<tr>
<th>No.</th>
<th>Primary</th>
<th>Secondary</th>
<th>Emergence date</th>
<th>Early plant growth</th>
<th>Tassel date</th>
<th>Final popl'n X1000</th>
<th>Lodging %</th>
<th>Moisture at harvest %</th>
<th>Yield bu/A</th>
</tr>
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<tr>
<td>1</td>
<td>NONE</td>
<td>NONE</td>
<td>25</td>
<td>4.6</td>
<td>26</td>
<td>19.8</td>
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<td>19.1</td>
<td>94.8</td>
</tr>
<tr>
<td>2</td>
<td>Fall plow</td>
<td>f. cult.</td>
<td>&quot;</td>
<td>5.3</td>
<td>27</td>
<td>20.0</td>
<td>13.1</td>
<td>18.6</td>
<td>107.8</td>
</tr>
<tr>
<td>3</td>
<td>Fall chisel</td>
<td>&quot; &quot;</td>
<td>&quot;</td>
<td>6.1</td>
<td>26</td>
<td>21.2</td>
<td>7.2</td>
<td>20.1</td>
<td>106.2</td>
</tr>
<tr>
<td>4</td>
<td>Spr.</td>
<td>&quot;</td>
<td>&quot;</td>
<td>6.1</td>
<td>26</td>
<td>20.5</td>
<td>9.5</td>
<td>18.1</td>
<td>111.6</td>
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<tr>
<td>5</td>
<td>Zero</td>
<td>Zero</td>
<td>&quot;</td>
<td>5.7</td>
<td>26</td>
<td>20.3</td>
<td>4.0</td>
<td>16.7</td>
<td>108.4</td>
</tr>
<tr>
<td>6</td>
<td>Spr. plow</td>
<td>f. cult.</td>
<td>&quot;</td>
<td>4.7</td>
<td>27</td>
<td>19.5</td>
<td>1.7</td>
<td>19.9</td>
<td>96.2</td>
</tr>
<tr>
<td>7</td>
<td>Fall chisel</td>
<td>&quot; &quot;</td>
<td>&quot;</td>
<td>5.5</td>
<td>26</td>
<td>20.5</td>
<td>10.7</td>
<td>17.8</td>
<td>107.2</td>
</tr>
<tr>
<td>8</td>
<td>Zero</td>
<td>Zero</td>
<td>&quot;</td>
<td>5.6</td>
<td>26</td>
<td>19.2</td>
<td>4.5</td>
<td>17.8</td>
<td>99.7</td>
</tr>
<tr>
<td>9</td>
<td>Spr. chisel</td>
<td>Disk</td>
<td>&quot;</td>
<td>5.3</td>
<td>26</td>
<td>19.5</td>
<td>11.8</td>
<td>17.8</td>
<td>108.0</td>
</tr>
<tr>
<td>10</td>
<td>Spr. disk</td>
<td>&quot;</td>
<td>&quot;</td>
<td>5.6</td>
<td>26</td>
<td>20.7</td>
<td>4.8</td>
<td>18.5</td>
<td>110.8</td>
</tr>
<tr>
<td>11</td>
<td>Spr. f. cult.</td>
<td>f. cult.</td>
<td>&quot;</td>
<td>5.2</td>
<td>27</td>
<td>20.2</td>
<td>3.3</td>
<td>17.8</td>
<td>99.0</td>
</tr>
<tr>
<td>12</td>
<td>Fall plow</td>
<td>&quot;</td>
<td>&quot;</td>
<td>5.1</td>
<td>26</td>
<td>20.7</td>
<td>1.6</td>
<td>19.4</td>
<td>105.5</td>
</tr>
</tbody>
</table>

Signif: 1/
BLSD (.10): ns + + +
CV (%): 19.4 6.2 76. 6.6 6.7

1/ + = significant at the 90% level; ns = not significant at the 90% level.
Leaf K, Ca & Mg concentrations were affected by the tillage systems (Table 3). The continuous fall plow system, no. 2 and the fall plow (for soybeans) - fall chisel (for corn) system, no. 3 resulted in highest leaf K and because of the competitive ion effect lowest Ca & Mg. Lowest leaf K, bordering on K deficiency levels, was associated with the zero tillage treatments combined with fall plow (for soybeans), no. 5 or fall chisel (for soybeans), no. 8. These results compare favorably to those found in the continuous corn tillage study. In both studies, moldboard plowing apparently distributed soil K more evenly throughout the profile and, therefore, did result in greater K uptake. These differences may have been accentuated by the dry conditions in July previous to leaf sampling.

Table 3. Influence of selected tillage methods following soybeans on nutrient concentrations in the corn earleaf at Waseca in 1974.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nutrient</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Cu</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Primary</td>
<td>Secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>NONE</td>
<td>NONE</td>
<td>.31</td>
<td>1.75</td>
<td>.74</td>
<td>.56</td>
<td>302</td>
<td>51</td>
<td>38</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>F. plow</td>
<td>f. cult.</td>
<td>.30</td>
<td>1.96</td>
<td>.68</td>
<td>.52</td>
<td>314</td>
<td>48</td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>F. chisel</td>
<td></td>
<td>.31</td>
<td>1.96</td>
<td>.67</td>
<td>.50</td>
<td>298</td>
<td>45</td>
<td>32</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Zero</td>
<td>Zero</td>
<td>.32</td>
<td>1.51</td>
<td>.84</td>
<td>.72</td>
<td>321</td>
<td>63</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>F. chisel</td>
<td>f. cult.</td>
<td>.31</td>
<td>1.73</td>
<td>.73</td>
<td>.66</td>
<td>316</td>
<td>50</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>Zero</td>
<td>Zero</td>
<td>.33</td>
<td>1.58</td>
<td>.79</td>
<td>.65</td>
<td>326</td>
<td>54</td>
<td>35</td>
<td>13</td>
</tr>
</tbody>
</table>

Signif: ns * ** ** ns ns ns ns ns
BLSD (.05): .37 .10 .12
CV (%): 4.0 12.4 8.1 12.8 7.7 17.8 9.0 10.0 11.2

Average 4-inch soil temperatures were obtained via thermocouples from three continuous tillage systems: fall plow, fall chisel and no tillage. Temperatures were read daily over a six-week period for corn and a five-week period for soybeans (Table 4).
Table 4. Average soil temperature at 4 inches and surface residue accumulation as influenced by three continuous tillage methods for a corn-soybean rotation at Waseca in 1974.

<table>
<thead>
<tr>
<th>Period</th>
<th>CORN following Soybeans</th>
<th>SOYBEANS following Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall plow</td>
<td>Fall chisel</td>
</tr>
<tr>
<td>5/22-25</td>
<td>56.9</td>
<td>57.0</td>
</tr>
<tr>
<td>5/28-30</td>
<td>65.0</td>
<td>64.6</td>
</tr>
<tr>
<td>6/3-8</td>
<td>66.6</td>
<td>66.1</td>
</tr>
<tr>
<td>6/10-14</td>
<td>65.8</td>
<td>65.7</td>
</tr>
<tr>
<td>6/17-20</td>
<td>67.5</td>
<td>67.1</td>
</tr>
<tr>
<td>6/24-28</td>
<td>74.0</td>
<td>73.4</td>
</tr>
<tr>
<td>6 weeks</td>
<td>66.1</td>
<td>65.8</td>
</tr>
<tr>
<td>5 weeks</td>
<td>68.0</td>
<td>67.6</td>
</tr>
<tr>
<td></td>
<td>Trace</td>
<td>Trace</td>
</tr>
</tbody>
</table>

Soil temperature differences among tillage treatments for corn were very small. Moldboard plowing averaged only 0.7° warmer than no tillage with chiseling being intermediate. This small difference would be expected with only trace amounts of soybean residue on the surface.

For soybeans, the soil temperature differences among the treatments were significantly larger. Temperature of the chiseled and no tillage areas averaged 0.5 and 1.3°F cooler, respectively, over the five-week period than with moldboard plowing. This would be expected due to the build-up of corn residues on the soil surface. These residues averaged trace, 2.22 and 3.23 tons DM/A for the plow, chisel and no tillage treatments, respectively. Even though these residue accumulations were significant and soil temperatures were cooler, early soybean plant growth differences were not visually noticed among the treatments.

RESULTS: SOYBEANS

Final soybean population and yield were affected by the tillage treatments (Table 5). The continuous no tillage system resulted in both significantly lower population and yield than all other treatments. Yields from this treatment were lower primarily because of poor weed control rather than the depressed population. The preemergence herbicides were apparently deactivated by the high surface residue accumulations so that grass control was minimal. Cultivation was also prohibited by the residues. Yields
and populations among the other treatments were not significantly different.

Volunteer corn population, due to harvest losses caused by severely wind-lodged corn in 1973, was somewhat greater with the minimum tillage treatments than with the fall moldboard or no tillage treatments. Emergence date was not affected.

Table 5. Influence of tillage methods following corn on soybean production at Waseca in 1974.

<table>
<thead>
<tr>
<th>No.</th>
<th>Primary</th>
<th>Secondary</th>
<th>Emergence date</th>
<th>Volunteer Corn Popl'n</th>
<th>Volunteer Corn Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>June beans/ft</td>
<td>plant/A</td>
<td>bu/A</td>
</tr>
<tr>
<td>1</td>
<td>NONE</td>
<td>NONE</td>
<td>4</td>
<td>4.8</td>
<td>330</td>
</tr>
<tr>
<td>2</td>
<td>Fall plow</td>
<td>f. cult.</td>
<td>3</td>
<td>5.8</td>
<td>390</td>
</tr>
<tr>
<td>3</td>
<td>fi</td>
<td>fi</td>
<td>3</td>
<td>6.0</td>
<td>225</td>
</tr>
<tr>
<td>4</td>
<td>fi</td>
<td>fi</td>
<td>3</td>
<td>5.7</td>
<td>445</td>
</tr>
<tr>
<td>5</td>
<td>fi</td>
<td>fi</td>
<td>3</td>
<td>6.0</td>
<td>110</td>
</tr>
<tr>
<td>6</td>
<td>Spr. plow</td>
<td>f. cult. &amp; disk</td>
<td>3</td>
<td>5.6</td>
<td>560</td>
</tr>
<tr>
<td>7</td>
<td>Fall chisel</td>
<td>disk</td>
<td>3</td>
<td>5.6</td>
<td>1340</td>
</tr>
<tr>
<td>8</td>
<td>fi</td>
<td>fi</td>
<td>3</td>
<td>5.4</td>
<td>335</td>
</tr>
<tr>
<td>9</td>
<td>Spr. chisel</td>
<td>fi</td>
<td>4</td>
<td>5.8</td>
<td>1005</td>
</tr>
<tr>
<td>10</td>
<td>Spr. disk</td>
<td>fi</td>
<td>3</td>
<td>5.6</td>
<td>500</td>
</tr>
<tr>
<td>11</td>
<td>Fall chisel</td>
<td>f. cult.</td>
<td>4</td>
<td>5.5</td>
<td>670</td>
</tr>
<tr>
<td>12</td>
<td>Fall disk</td>
<td>disk</td>
<td>3</td>
<td>5.9</td>
<td>445</td>
</tr>
</tbody>
</table>

Signif: ** * **
BLSD (.05): 0.5 710 3.1
CV (%): 5.9 79. 6.8

Nutrient concentrations in the uppermost, mature, trifoliolate leaf samples taken at mid-bloom (July 26) generally showed no effect of the tillage treatments (Table 6). This was in contrast to the tillage effects on the nutrient concentrations within the corn leaves.
Table 6. Influence of selected tillage methods following corn on the nutrient concentrations in the soybean leaf at mid-bloom stage at Waseca in 1974.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
</tr>
<tr>
<td>----------</td>
<td>%</td>
</tr>
<tr>
<td>NONE</td>
<td>.43</td>
</tr>
<tr>
<td>F. plow f. cult.</td>
<td>.41</td>
</tr>
<tr>
<td>F. chisel disk</td>
<td>.42</td>
</tr>
<tr>
<td>Fall disk</td>
<td>.43</td>
</tr>
</tbody>
</table>

Signif: ns ns ns + ns ns ns ns ns
BLSD (.10): .07
CV (%): 4.6 10.0 6.3 7.5 5.4 11.1 5.7 10.7 4.2

Nitrogen fixation data were obtained on selected treatments by acetylene reduction techniques performed by Dr. Ham and co-workers on August 7. Specific activity, a measure of N fixation, was affected significantly by primary tillage (Table 7). Highest activity resulted from fall plowing with spring plowing, fall disk and no tillage being significantly lower. The chisel treatments were intermediate. Nodule weight, nodule number and total activity were not affected this year. Sincere appreciation is extended to Dr. Ham for providing the labor and technology in obtaining these data.

Table 7. Nitrogen fixation by soybean as influenced by tillage methods at Waseca in 1974.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nodule Wt. /plant</th>
<th>Nodule No. /plant</th>
<th>Total¹/ Activity /µl/ethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Secondary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero</td>
<td>None</td>
<td>.797</td>
<td>63</td>
</tr>
<tr>
<td>Fall plow</td>
<td>Field cult.</td>
<td>.575</td>
<td>63</td>
</tr>
<tr>
<td>Spr. plow</td>
<td>&quot;</td>
<td>.769</td>
<td>63</td>
</tr>
<tr>
<td>Fall chisel Disk</td>
<td>&quot;</td>
<td>.697</td>
<td>64</td>
</tr>
<tr>
<td>Spr. &quot;</td>
<td>&quot;</td>
<td>.553</td>
<td>59</td>
</tr>
<tr>
<td>Fall disk</td>
<td>&quot;</td>
<td>.805</td>
<td>65</td>
</tr>
</tbody>
</table>

Signif: ns ns ns +
BLSD (.10): .07
CV (%): 28.5 33.2 30.3 32.8

¹/ Ethylene produced per plant.
²/ Ethylene produced per gram of nodule tissue.
LIME PLOTS, WASECA, 1974

John Grava, C.J. Overdahl, G.W. Randall, R.P. Schoper

A field experiment was established at the Southern Experiment Station in the spring of 1971 to study the effects of liming on yield and chemical composition of corn, and chemical properties of soil. The investigation was continued in 1972, 1973, and 1974.

Two other experiments were established on this field, one with soybeans and another with alfalfa on April 26, 1972. The dolomitic limestone used in these two experiments had the following quality characteristics:

- Passing 8-mesh sieve: 96.3%
- Passing 60-mesh sieve: 38.7%
- Calcium Carbonate Equivalent: 96.4%

Five lime rates (0, 2.5, 5.0, 7.5, 10.0 tons/acre) arranged in a randomized complete block design were replicated six times. Individual plots were 20 feet wide and 30 feet long.

Corn

All corn plots received the following in 1974:
(a) 194 + 35 + 45 lbs/A of plant nutrients, expressed as N, P₂O₅, K₂O;
(b) herbicide: broadcast 2.5 lbs. Lasso + 2.5 lbs. Atrazine per acre;
and (c) insecticide: Furadan 1 lb/A. Pioneer 3780 was planted on May 1 at 26,000 plant/A.

The yield of corn and chemical composition of the sixth leaf at tasseling are given in Tables 1 and 2. Lime treatments showed no significant effect on corn yields in 1974. Lime rates significantly increased the Mg content of corn leaves and significantly reduced the Zn and Mn concentrations.

---

Table 1. Yield of corn, Waseca lime plots, 1974.

<table>
<thead>
<tr>
<th>Rate of Lime (Tons/A)</th>
<th>Yield (bu/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
</tr>
<tr>
<td>2.5</td>
<td>119</td>
</tr>
<tr>
<td>5.0</td>
<td>114</td>
</tr>
<tr>
<td>7.5</td>
<td>122</td>
</tr>
<tr>
<td>10.0</td>
<td>119</td>
</tr>
</tbody>
</table>

Significance: NS

CV, %: 6.3
Table 2. Chemical composition of sixth corn leaf at tasseling, Waseca lime plots, 1974.

<table>
<thead>
<tr>
<th>Rate of Lime</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Al</th>
<th>Fe</th>
<th>Zn</th>
<th>Cu</th>
<th>Mn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons/A</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>0</td>
<td>0.31</td>
<td>2.41</td>
<td>0.80</td>
<td>0.31a*</td>
<td>108</td>
<td>217</td>
<td>48.4b</td>
<td>9.4</td>
<td>127.0b</td>
<td>10.4</td>
</tr>
<tr>
<td>2.5</td>
<td>0.31</td>
<td>2.40</td>
<td>0.78</td>
<td>0.34ab</td>
<td>106</td>
<td>203</td>
<td>42.6ab</td>
<td>8.0</td>
<td>85.0a</td>
<td>9.4</td>
</tr>
<tr>
<td>5.0</td>
<td>0.32</td>
<td>2.42</td>
<td>0.81</td>
<td>0.36b</td>
<td>107</td>
<td>214</td>
<td>41.6ab</td>
<td>7.8</td>
<td>83.1a</td>
<td>10.7</td>
</tr>
<tr>
<td>7.5</td>
<td>0.31</td>
<td>2.31</td>
<td>0.81</td>
<td>0.35ab</td>
<td>103</td>
<td>209</td>
<td>42.7ab</td>
<td>7.5</td>
<td>74.9a</td>
<td>11.0</td>
</tr>
<tr>
<td>10.0</td>
<td>0.32</td>
<td>2.35</td>
<td>0.78</td>
<td>0.38b</td>
<td>101</td>
<td>209</td>
<td>35.2a</td>
<td>7.1</td>
<td>67.4a</td>
<td>10.5</td>
</tr>
</tbody>
</table>

Significance: NS NS NS * NS NS * NS ** NS

CV, % 3.3 7.4 7.4 8.6 7.0 3.7 15.6 18.7 17.6 13.5

* Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.
**Soybeans**

Average soil pH's for depths from 0 to 24 inches as affected by various lime rates are given in Table 3. The surface soil pH was increased from an initial level of 5.4 to 5.7-6.0 with from 2.5 to 10 tons of lime/A.

Table 3. The effect of various lime rates on soil pH, two years after application at Waseca, (soybean plot).

<table>
<thead>
<tr>
<th>Lime treatments</th>
<th>Soil Depth</th>
<th>Soil pH</th>
<th>SMP buffer index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons/A</td>
<td>Inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0-6</td>
<td>5.4</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>6-12</td>
<td>5.6</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>5.8</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>18-24</td>
<td>6.0</td>
<td>6.3</td>
</tr>
<tr>
<td>2.5</td>
<td>0-6</td>
<td>5.7</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>6-12</td>
<td>5.8</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>5.9</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>18-24</td>
<td>6.2</td>
<td>6.5</td>
</tr>
<tr>
<td>5.0</td>
<td>0-6</td>
<td>5.7</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>6-12</td>
<td>5.7</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>5.9</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>18-24</td>
<td>6.1</td>
<td>6.4</td>
</tr>
<tr>
<td>7.5</td>
<td>0-6</td>
<td>5.9</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>6-12</td>
<td>5.9</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>6.1</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>18-24</td>
<td>6.2</td>
<td>6.5</td>
</tr>
<tr>
<td>10.0</td>
<td>0-6</td>
<td>6.0</td>
<td>6.3</td>
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<td></td>
<td>6-12</td>
<td>5.9</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>6.0</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>18-24</td>
<td>6.3</td>
<td>6.3</td>
</tr>
</tbody>
</table>
Wells soybeans were planted on May 24 in 30 inch rows. All plots received 1 qt/A Treflan + 5 qt/A Amiben.

The yields and chemical composition of the upper-most mature trifoliate leaf are reported in Tables 4 and 5. The various lime treatments showed no effect on soybean yields in 1974. A significant reduction in the Cu, Mn and B content of the soybean leaf tissue were noted with increasing lime rates.

Table 4. Yield of soybeans, Waseca lime plots, 1974.

<table>
<thead>
<tr>
<th>Rate of Lime (Tons/A)</th>
<th>Yield (bu/A)</th>
<th>Significance</th>
<th>CV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>27</td>
<td>NS</td>
<td>6.2</td>
</tr>
<tr>
<td>2.5</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td>28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. Chemical composition of soybean trifoliate leaves, Waseca lime plots, 1974.

<table>
<thead>
<tr>
<th>Rate of Lime</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Al</th>
<th>Fe</th>
<th>Zn</th>
<th>Cu</th>
<th>Mn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons/A</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
<td>ppm</td>
<td></td>
<td>ppm</td>
<td></td>
<td>ppm</td>
</tr>
<tr>
<td>0</td>
<td>0.39</td>
<td>1.85</td>
<td>1.42</td>
<td>0.53</td>
<td>70</td>
<td>172</td>
<td>61.5</td>
<td>6.4b*</td>
<td>76.1b</td>
<td>58.2b</td>
</tr>
<tr>
<td>2.5</td>
<td>0.40</td>
<td>1.81</td>
<td>1.38</td>
<td>0.53</td>
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<td>8.6</td>
<td>13.5</td>
<td>4.5</td>
<td>8.6</td>
<td>6.9</td>
<td>10.8</td>
<td>19.8</td>
<td>3.4</td>
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</table>

* Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.
Alfalfa

Average soil pH's for depths from 0-24 inches as affected by various lime rates are given in Table 6. The surface soil pH was increased from an initial level of 5.4 to 6.1-6.5 with from 2.5 to 10 tons of lime/A.

Table 6. The effect of various lime rates on soil pH, two years after application at Waseca (Alfalfa plot).

<table>
<thead>
<tr>
<th>Lime treatments</th>
<th>Soil Depth</th>
<th>Soil pH</th>
<th>SMP buffer index</th>
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<td>6.3</td>
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</tr>
</tbody>
</table>
Vernal alfalfa was seeded in May of 1972. All plots received a broadcast application of 0 + 30 + 60 in the fall of 1973. Alfalfa yields as reported in Table 7 were not significantly increased through the use of lime. Plant tissue analysis from each cutting are reported in Table 8.

Table 7. Yield of alfalfa, Waseca lime plots, 1974.

<table>
<thead>
<tr>
<th>Rate of Lime (Tons/A)</th>
<th>First Cutting</th>
<th>Second Cutting</th>
<th>Third Cutting</th>
<th>Total</th>
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<td>2.5</td>
<td>1.8</td>
<td>1.4</td>
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<td>NS</td>
<td>NS</td>
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<td>CV, %</td>
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<td>7.8</td>
<td>4.2</td>
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