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Uniform Combine Residue Distribution for Successful No-Till and Minimum Tillage Systems

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Non-uniform distribution of straw and chaff from the combine at harvest can create problems for the following crop, particularly under no-till and minimum tillage systems.

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### Tillage System Definitions

**No-Till:** Placement of seed and, in most cases, some or all of the crop's fertilizer requirement through the previous crop stubble without prior tillage. Soil disturbance is usually slight but varies with drill selection and operation.

**Minimum (or Reduced) Tillage:** A reduction in the number of tillage operations compared to conventional tillage, and/or the selection and use of tillage implements which leave 30 percent or more of the crop residue on the soil surface after seeding.

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### Acknowledgments

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**Uniform Combine Residue Distribution for Successful No-Till and Minimum Tillage Systems**

**Introduction**

Uniform distribution of straw and chaff from the combine at harvest is advantageous in any farming system. High concentrations of residue in combine straw and chaff rows can seriously interfere with tillage and planting operations and can create an adverse environment for plant growth (Fig. 1). The effects of heavy straw and chaff rows have been observed even where the moldboard plow is used. Uniform residue distribution is especially important for no-till or minimum tillage seeding of the following crop because more of the crop residue remains on or near the soil surface.

**Increasing Combine Residue Levels**

The potential for problems with combine residue distribution has increased over the past few decades. Two of the most significant reasons are wider combine headers and higher residue production with new wheat varieties.

Typical combine header widths have increased from about 12 feet in 1950 to 20 to 24 feet today. Combines with header widths of 30 feet or more are now available. Without special attachments or modifications, most stan-
standard combines with these header widths are not ade­quately equipped to spread the larger volumes of residue uniformly.

The introduction of new high-yielding semidwarf wheat varieties has increased the amount of straw and chaff to manage at harvest. STEEP researcher Paul Rasmussen, USDA-ARS soil scientist at Pendleton, Oregon, compared the grain and residue production data of a tall wheat variety in 1953 to a high yielding semidwarf variety 30 years later (Table 1). With the semidwarf variety, grain yield was increased 56 percent and total residue production was increased 19 percent. The largest component of the residue increase was chaff, which increased 698 pounds per acre. That is a 63 percent increase compared to 8 and 18 percent increases for stems and leaves, respectively. Wider combine header widths, together with this higher residue production of semidwarf wheats, has more than doubled residue amounts in combine straw and chaff rows since 1950.

To take advantage of the higher yield potential of new varieties, producers have increased the amounts of fertilizer applied. To take advantage of improved correlation between soil tests and crop response to fertilizer, producers have also increased their use of soil testing to optimize fertilizer rates. Technology on timing and placement of fertilizer has improved as well. All of these advances in fertilizer management have increased grain production potential and, typically, have also increased the volume of crop residue at harvest.

**Impacts of Combine Straw and Chaff Rows**

Many problems can be associated with high concentrations of straw and chaff behind the combine. Some of these problems include:

1. **Poor drill performance** — plugging; straw “tucking” in the seed row; uneven seeding depth.
2. **Uneven seedling emergence** — poor seed/soil contact; less access to solar energy.
3. **Slower growth** — shading, cooler and wetter soils.
4. **Lower nutrient availability** — immobilization of N, P and S and other nutrients in microbial decomposition of large amounts of residue.
5. **Favorable disease environment** — *Pythium* root rot and other diseases favored by the concentrated food source and cool, moist environment; increased disease inoculum carryover with slower residue decomposition.
6. **Reduced herbicide effectiveness** — delayed germination of weed and volunteer crop seeds; herbicide interception and absorption.
7. **Increased crop competition** — concentration of weeds and volunteer grain limit availability of nutrients, moisture and light to the crop.
8. **Increased rodent damage** — concentrated food source and cover; protection from predators.

Growers can prevent or minimize many of these potential problems by installing commercial chaff and straw spreaders, or modifying existing spreading systems. Research has shown that uniform combine residue distribution is a critical step in helping assure the success of a no-till or minimum tillage seeding of the following crop. Benefits are also found under conventional tillage systems.

**Evaluation of Combine Residue Distribution**

STEEP researchers at the Columbia Plateau Conservation Research Center near Pendleton have evaluated the effectiveness of residue distribution by different combines and residue spreading attachments. USDA-ARS Soil Scientists Clyde Douglas, Paul Rasmussen and Ray Allmaras measured the straw and chaff distribution from 26 farmer-operated combines in 1983 and 1984 during routine harvesting operations. These included both cylinder and rotary type combines, with and without straw and chaff spreaders.

Straw and chaff distribution was measured with a simple collection procedure. A 4-foot wide strip of standing grain was removed ahead of the combine. The strip was oriented parallel to the header and extended at least 6 feet beyond each end of the header. A 3-foot wide canvas was then laid on the ground in the cleared strip to catch the residue from the combine as it passed over (Fig. 2). Chaff (anything less than 2 inches long) and straw were collected and weighed separately from each 3-foot segment of the canvas across the header width.

### Table 1. Increase in grain and residue production in a common semi dwar r winter wheat variety in 1983 compared to a tall variety in 1953 at Pendleton, OR.

<table>
<thead>
<tr>
<th>Component</th>
<th>Tall — 1953 (pounds/acre)</th>
<th>Semidwarf — 1983 (pounds/acre)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>3,000</td>
<td>4,680</td>
<td>1,680</td>
</tr>
<tr>
<td>Total residue</td>
<td>6,600</td>
<td>7,862</td>
<td>1,262</td>
</tr>
<tr>
<td>Stems</td>
<td>4,290</td>
<td>4,639</td>
<td>349</td>
</tr>
<tr>
<td>Leaves</td>
<td>1,200</td>
<td>1,415</td>
<td>215</td>
</tr>
<tr>
<td>Chaff</td>
<td>1,110</td>
<td>1,808</td>
<td>698</td>
</tr>
</tbody>
</table>
Weight of the uncut stubble after combining was added to provide total residue levels.

Average total residue including harvested straw and chaff plus uncut stubble was 4.8 tons per acre — 2.7 tons of harvested straw and chaff and 2.1 tons per acre of uncut stubble.

Standard cylinder combines with no alteration (factory run) had very uneven residue distribution patterns (Fig. 3). Distribution of the residue, after combining, ranged from 2.1 tons per acre (only the uncut stubble) near the outer edges of the header to 9 tons per acre directly behind the combine. Chaff made up 65 percent of the 9 tons per acre residue in the straw and chaff rows behind the combine.

The one straw-chopper in the survey reduced straw length but did little to improve straw or chaff distribution. A cylinder combine with a commercial chaff spreader distributed straw and chaff much more uniformly. Chaff thrown beyond the header width caused some overlap, however, producing a peak in residue levels near the edge of the joining swaths (Fig. 3). This can be corrected by adjusting the speed of the chaff spreader.

Standard rotary combines with center exits and no residue spreading attachments had a distribution pattern (Fig. 4) similar to that produced by the standard cylinder combines without attachments (Fig. 3), only shifted slightly to the right. The residue concentration was as great as 9 tons per acre near the center of the header and decreased to 2.1 tons per acre, or just the uncut stubble, near the edge of the header (Fig. 4).

A prototype spreader distributed the residue more uniformly but again chaff and straw thrown beyond the header width overlapped with the adjoining swath and created a secondary peak in residue distribution. Residue concentrations from the prototype spreader ranged from 3.5 to 7 tons per acre. Shop modification of a rotary combine (flail system lowered, speed increased and more flail bats added) provided a uniform distribution of residue. The residue levels ranged from a low of 3.9 to a high of 5.7 tons per acre across the header width. Growers can either modify their own flail system or purchase relatively low-cost commercial modifications.

**Nutrient Tie-Up**

Reduced availability of nutrients, particularly nitrogen, is one of the many impacts of high concentrations of residue in combine straw and chaff rows. A carbon/nitrogen (C/N) ratio of about 50 or less is needed for complete decomposition of crop residue by soil microbes. Cereal residue contains only a small amount of nitrogen, commonly having a C/N ratio of 100 to 200. The additional nitrogen required for microbial decomposition must then come from the available soil nitrogen or from applied nitrogen fertilizer.
Table 2. Effect of rotary combine flail distribution system on residue amount across the header width and potential nitrogen shortage from microbial tie-up of nitrogen in residue decomposition.

<table>
<thead>
<tr>
<th>Component</th>
<th>Flail system</th>
<th>0-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residue</td>
<td>Standard</td>
<td>2.4</td>
<td>3.4</td>
<td>4.4</td>
<td>7.3</td>
<td>6.8</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Modified*</td>
<td>4.4</td>
<td>4.3</td>
<td>5.4</td>
<td>4.6</td>
<td>4.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Nitrogen shortage</td>
<td>Standard</td>
<td>17</td>
<td>24</td>
<td>31</td>
<td>51</td>
<td>48</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Modified*</td>
<td>31</td>
<td>30</td>
<td>38</td>
<td>32</td>
<td>30</td>
<td>31</td>
</tr>
</tbody>
</table>

*Flail cones lowered and speed increased with additional, larger flail bats added.

Microbial decomposition of high concentrations of residue in combine straw and chaff rows can tie up significant amounts of nitrogen, producing a shortage for the following crop. This results in uneven nitrogen fertility levels across the field and reduces yield potentials. Yellowish nitrogen-deficient strips in growing crops often distinctly outline combine straw and chaff rows from the preceding harvest.

Table 2 compares the effects of standard and modified flail systems of 24-foot rotary combines on residue levels and areas of potential nitrogen shortage. Average total residue from harvested straw and chaff plus uncut stubble was 4.8 tons per acre.

With the standard factory flail system, residue levels across the header swath ranged from a low of 2.4 tons per acre in the outer 4 feet to a high of 7.3 tons per acre in the middle 12- to 16-foot section. The corresponding nitrogen shortages from microbial decomposition were estimated to be three times as high in the 12- to 16-foot section as in the outer 4 feet — 51 pounds per acre compared to 17 pounds per acre.

With the shop-modified flail system (flail cones lowered, speed increased and flail bats added), the largest difference in residue levels was only 1.1 tons per acre and the difference in nitrogen shortage was only 8 pounds per acre.

Uniform combine residue distribution can help maintain more uniform and adequate soil nitrogen levels. Applying additional nitrogen fertilizer to correct nitrogen shortages in straw and chaff rows can result in excess fertilizer applications outside the rows. Even additional nitrogen will generally not solve the problem of combine straw and chaff rows, because of the interactions of increased plant disease, cooler soils, shading and other factors.

**Conclusion**

Successful no-till and minimum tillage systems begin with uniform distribution of straw and chaff from the combine at harvest. This is essential for achieving accurate seed placement and for maintaining both a favorable environment for crop growth and uniform soil fertility.

Commercial chaff spreaders or modified flail systems are now available to fit most combine models. Many growers have also made their own shop modifications for improving residue distribution. More information is available from combine dealers, County Agricultural Agents, SCS technicians or Conservation District supervisors. Good combine residue distribution systems are well worth the small time and financial investment.