Impact of Defoliation on Grain and Stalk Quality in Corn

P. R. Thompson* and A. B. Geyer
The Ohio State University
Department of Horticulture and Crop Science
2021 Coffey Rd, Columbus, OH 43210

INTRODUCTION

Effects of defoliation on the grain yield of corn have been well documented in numerous research studies (7,14,17,18). Results of this research have served as the basis for charts used by crop-hail insurance adjustors in determining grain yield losses due to leaf blade removal by hail (11), as well as wind and frosts. The charts have also been used to estimate effects on yield from other types of mechanical injury such as the destruction of viable leaf tissue by insect feeding, diseases, and/or chemicals. Reduction in corn yield has been shown to be directly proportional to the percentage leaf area destroyed (7). The degree of yield loss caused by defoliation is also dependent on the growth stage when defoliation occurs with yield losses greatest during the late vegetative and reproductive stages (7, 14,17).

Although defoliation may affect the “source-sink balance” and kernel weight of corn (7,18), the impact of defoliation on stalk and grain quality has received relatively little attention. Defoliation may cause economic damage and incur production costs exceeding those associated with grain yield loss. With more corn planted for specific end users, farmers need to know the effects of defoliation on the grain composition of corn to assess the economic impact of leaf destruction. Similarly with drying costs increasing and likelihood of more field drying, farmers need to understand the greater risk of stalk lodging associated with defoliation injury.

OBJECTIVE

The objective of this paper is to review and compare past research concerning effects of defoliation on the stalk and grain quality of corn.

MATERIALS & METHODS

The literature contains numerous studies on corn defoliation which we examined to assess effects of defoliation on stalk and grain quality. In addition, we evaluated results of recent Ohio studies that address this topic. Most of this research has been conducted by removing varying numbers of leaves from corn plants at different stages of plant development.

RESULTS & DISCUSSION

Tables 1 and 2 provide an overview of past research on stalk and grain quality losses associated with leaf blade removal or destruction by mechanical or chemical injury, insect feeding, and/or foliar diseases. As with grain yield, defoliation effects on these other agronomic characteristics are influenced by the level of defoliation and the growth stage when defoliation occurred (Figures 1 and 2).

Table 1. Defoliation effects on stalk total non-structural carbohydrates (TNC), stalk rot and stalk lodging of corn at different stages of development.

<table>
<thead>
<tr>
<th>Growth stage when defoliated</th>
<th>V5/6</th>
<th>VT/R1</th>
<th>V12/13</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stalk TNC</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Stalk rot</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Stalk lodging</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
</tbody>
</table>

† Decreased; nc - no change; na - not available

Table 2. Defoliation effects on grain oil, protein and starch composition, kernel weight, test weight, shelling percentage, maturity, grain moisture and seed vigor of corn at different stages of development.

<table>
<thead>
<tr>
<th>Growth stage when defoliated</th>
<th>V5/6</th>
<th>VT/R1</th>
<th>V12/13</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil content</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Protein</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Kernel weight</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Test weight</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Shelling percentage</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Maturity</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Grain moisture</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
<tr>
<td>Seed vigor</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
<td>nc</td>
</tr>
</tbody>
</table>

† Decreased; nc - no change; na - not available

Stalk Rot, Total Non-Structural Carbohydrates, and Stalk Lodging

Defoliation at tasseling and during grain fill increased stalk rot (16). Post silking defoliation reduced stalk total non-structural carbohydrates (TNC) levels and accelerated utilization of stalk TNC for grain fill (2,5,9,18,19), which predisposes stalks and roots to stalk rot (3). Hail storms during grain fill (R3-5) that caused extensive leaf shredding resulted in severe stalk lodging (4). In a recent Ohio study (16) that evaluated effects of defoliation above and below the ear during grain fill, stalk rot was increased by leaf removal above the ear, especially 100% defoliation above the ear (Figure 1). At R1, stalk rot ranged from 56% for 100% leaf removal above the ear to 18% for 50% leaf removal below the ear. Effects of lower canopy leaf removal on stalk rot were generally negligible. At R1 and R3 significant differences among defoliation treatments for stalk lodging were present, with the 100% leaf removal treatment above the ear showing greater stalk lodging (16).

Figure 1. How differential leaf removal above and below the ear during grain fill affects stalk rot.

Stalk Rot, Total Non-Structural Carbohydrates, and Stalk Lodging

Defoliation at tasseling and during grain fill increased stalk rot (16). Post silking defoliation reduced stalk total non-structural carbohydrates (TNC) levels and accelerated utilization of stalk TNC for grain fill (2,5,9,18,19), which predisposes stalks and roots to stalk rot (3). Hail storms during grain fill (R3-5) that caused extensive leaf shredding resulted in severe stalk lodging (4). In a recent Ohio study (16) that evaluated effects of defoliation above and below the ear during grain fill, stalk rot was increased by leaf removal above the ear, especially 100% defoliation above the ear (Figure 1). At R1, stalk rot ranged from 56% for 100% leaf removal above the ear to 18% for 50% leaf removal below the ear. Effects of lower canopy leaf removal on stalk rot were generally negligible. At R1 and R3 significant differences among defoliation treatments for stalk lodging were present, with the 100% leaf removal treatment above the ear showing greater stalk lodging (16).

Figure 1. How differential leaf removal above and below the ear during grain fill effects stalk rot. Stalk rot percentages are averages from studies with two corn hybrids conducted at three Ohio sites in 2001 and 2002.

Figure 1. How differential leaf removal above and below the ear during grain fill affects stalk rot.
Defoliation at tasseling and during grain fill, especially in hybrid corn, resulted in greater grain protein (9, 12, 14, 17). See Grain Oil Content below for relationship between protein and oil in response to defoliation.

Grain Oil Content
Complete defoliation of corn at the five-leaf stage (8) reduced grain protein whereas pre-anthesis defoliation increased grain protein (9, 12, 14, 17). See Grain Oil Content below for relationship between protein and oil in response to defoliation.

Grain Oil Content

Leaf removal treatments at R3 and R5, especially 100% leaf removal, increased grain lysine content (Thomison, unpublished data).

Fatty Acid Profiles
Leaf removal treatments during grain fill especially complete defoliation at R3 increased levels of linoleic and linolenic acid and decreased levels of stearic and oleic acid; linolenic and arachidic acid levels in grain were not affected by defoliation (Thomison, unpublished data).

Seed Germination and Vigor
Reduction in germination in response to complete leaf removal was associated with reductions in kernel size (19). Leaf defoliation did not affect warm germination and only rarely affected vigor as measured by cold germination. Irrbids that produced the fewest total leaves were especially sensitive to defoliation. Warm and cold germination were not affected by leaf removal during the detasseling operations performed in hybrid corn seed production (20).

Summary
The impact of defoliation on grain yield has received considerable attention in corn. However, defoliation also influences other economically important agronomic characteristics including stalk rot and lodging, maturity, and various grain quality attributes. Defoliation during grain fill increases stalk rot that can lead to greater stalk lodging. Leaf defoliation at or before the V4/V5 stages has been associated with delays in crop maturity and higher grain moisture harvest. Defoliation at tasseling and during grain fill, especially during the early kernel development stages, can accelerate crop maturity and result in lower test weight. Severe leaf loss during grain fill affects the nutritional value of corn by changing the chemical composition of the kernels. Growers need to recognize the economic implications associated with these defoliation effects in order to adjust their management practices accordingly.