Yield Loss of Corn to Incremental Defoliation During the Reproductive Stages of Development

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Abstract

The importance of leaf area to corn for grain production beginning at silking has been documented in past years. However, being able to predict yield loss to defoliators such as foliar plant diseases and insects that progressively increase in severity over time has been difficult to quantify. A leaf removal study was conducted at the Dean Lee Research and Extension Center located near Alexandria, Louisiana. Leaves were removed at one or more of the following corn growth stages: R1 (silking), R2 (blister), R3 (milk), and R5 (dent). All of the lower leaves (leaves below the ear leaf) were removed at the four different reproductive growth stages with the exception of the untreated check. Other treatments included continued removal of the upper leaf area at subsequent growth stages resulting in defoliation ranging from 50 and 79%. Two hybrids, differing in relative maturity were evaluated in this study. Both hybrids responded similarly to yield loss from the defoliation treatments. Lower leaves are important to yield at the silking, blister, and milk stages of reproductive development. Yields were reduced even more when the upper leaves were incrementally removed beginning at these stages. Even at the dent stage, yields were reduced by over 5% when lower leaves were removed and 16.2% when the first upper leaf was removed. The objective of this study was to determine the effect of leaf loss at different reproductive stages of development on yield.

Introduction

Corn is a very important crop that has multiple uses. As a food for humans it is a source of protein, carbohydrates, fiber, and oil. It is also a primary source of animal feed (Alvanagh et al., 2009). Therefore, the loss of yield in corn crops can have major impacts on both commodities and food sources. One major cause of yield loss in corn crops is defoliation due to diseases. Southern corn rust, caused by the agent *Puccinia polysora* Underwood, is a major disease of corn. This disease is known to cause significant losses in crop yields. Epidemics have occurred throughout the tropics over the years. An epidemic also occurred in the 1970s across the southern United States. Another series of infections by the pathogen occurred in 2010 when spores entered the United States from Latin America (Brewbaker et al., 2011). Diseases such as this reduce yield by reducing leaf area via progressive defoliation which occurs as the disease progresses (Adee et al., 2005). Defoliation and loss of photosynthetic tissue reduces yield in one of two ways. First, yield can be reduced by the reduction in the number of kernels produced in each ear of corn. Second, yield can be reduced due to the decreased weight and size of the kernels of corn produced. The loss of leaves can also reduce photosynthate from being channeled into the roots and stalks which may result in lodging (Ward et al., 1999).

Objectives

1. Determine the effect of leaf loss at different reproductive stages of development on yield.
2. Determine if yield losses from defoliation are consistent among hybrids differing in relative maturity.
3. Determine if leaves below the ear leaf are important to yield.

Materials and Methods

This study was conducted at the Dean Lee Research and Extension Center located near Alexandria, Louisiana. Defoliation treatments involved the removal of the leaf area at one or more of the following corn growth stages: R1 (silking), R2 (blister), R3 (milk), and R5 (dent). All of the lower leaves (leaves below the ear leaf) were removed at the four different reproductive growth stages with the exception of the untreated check (Table 1). The reason for removing the lower leaves was to help determine the contribution of the lower leaves to yield, and reduce the variability of lower leaves that may or may not be healthy and contributing to yields of the differing hybrids. Other treatments included continued removal of the upper leaf area at subsequent growth stages resulting in defoliation ranging from 50 and 79%. At each defoliation, one leaf was removed to achieve 7% leaf area removal. Defoliation was achieved by cutting perpendicularly across the leaf blade at the leaf collar, leaving the leaf sheath intact. Upper leaf removal began at the ear leaf and proceeded up the plant to simulate the progression of foliar diseases through the corn canopy. Defoliation was timed to the growth stage of each hybrid and varied as much as seven days between hybrids. Defoliated plants were located in the center of the two middle rows of each subplot. Ten plants from each of the two middle two rows were selected. Prior to leaf removal, the total number of leaves were counted for each plant that was selected for treatment. The border rows and plants on each end of the middle two rows were not defoliated in order to reduce the influence of neighboring plots, such as increased light infiltration.

The experimental design was a randomized complete block using four replicates in a split-plot design, with defoliation treatments as the main plot and corn hybrids as the subplots. The subplot size was four rows wide by forty-five feet in length. Row spacing was thirty-eight inches. Two corn hybrids (Terral Rev1884AM and Rev28HR20) differing in relative maturity (108 and 118 days) were planted on March 14, 2017 at 34,000 plants per acre. Soil type was a Coushatta silt loam. Previous crop was soybeans. Adequate amounts of precipitation was received throughout the growing season (Table 2). Harvest date was on August 9 and 10, 2017. Hand harvested ears were shelled and total weight in grams was recorded for each plot. Test weight, harvest moisture, and seed weight were recorded. Seed weight was determined by recording the weight of three hundred seed after being dried in the oven to 5% moisture. Analysis of variance was performed on grain yield using ARM 2017 (Gylling Data Management, Inc.).

Hybrids Response to Defoliation

Both hybrids responded similarly to the defoliation treatments; there was no interaction (P = 0.64) between defoliation and hybrid for yield loss (data not shown). Averaged over all treatments, 28HR20 yielded more than 18BHR84. Yield differences of these hybrids are simply due to differences in their yield potential.

Timing of Defoliation

The hybrids lost 26.8%, 24.8%, 25.9, and 5.59% in yield when the leaves below the ear leaf were removed at silking, blister, milk, and dent stages, respectively when compared to the untreated check. The lower leaves represented fifty percent of the total leaves on the plants.

At fifty-seven percent defoliation, yield losses were 36.6%, 35.3%, 32.6%, and 16.2% at the silking, blister, milk, and dent stages, respectively when compared to the untreated check.

When sixty-four percent defoliation was achieved by incrementally removing leaves beginning at the silking, blister, and milk stages, yield losses were 51.7%, 47.0%, and 38%, respectively when compared to the untreated check.

Yield losses of 63.1% and 49.3% were found when seventy-one percent of the leaves were incrementally removed beginning at the silking and blister stages, respectively when compared to the untreated check.

Hybrids lost 63.3% in yield when seventy-nine percent of the leaves were incrementally removed beginning at silking (Table 3).

Conclusions

Lower leaves are important to yield at the silking, blister, and milk stages of reproductive development. Yields were reduced even more when the upper leaves were incrementally removed beginning at these stages. Even at the dent stage, yields were reduced by over 5% when lower leaves were removed and 16.2% when the first upper leaf was removed.

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Table 1. Description of timing and severity of corn defoliation treatments

Defoliation Treatment	Crop growth stage when leaves were removed					Total % defoliation
	Lower leaves[1]	R1 (silk)[2]	R2 (blister)[3]	R3 (milk)[4]	R5 (dent)[5]	
Silk						0
Silk	X					50
Silk	X	X				57
Silk-Blister	X	X	X			64
Silk-Blister-Milk	X	X	X	X		71
Silk-Blister-Milk-Dent	X	X	X	X	X	79
Blister						0
Blister	X					50
Blister	X		X			57
Blister-Milk	X		X	X		64
Blister-Milk-Dent	X		X	X	X	71
Milk						0
Milk	X					50
Milk	X			X		57
Milk-Dent	X			X	X	64
Dent						0
Dent	X					50
Dent	X				X	57

[1]All lower leaves were removed.
[2,3,4,5]Upper most leaf was removed each time

Table 2. Growing season precipitation (inches) by month.

Month	Rainfall (inches)
March	2.48
April	12.91
May	6.49
June	7.66
July	4.09
Total	33.63

Table 3. Yield of corn in response to progressive defoliation initiated at different growth stages.

Treatment[1,2]	Grams/20 ears[3]	% Defoliation
Silk-UTC	3085 ab	0
Silk	2278 de	50
Silk-UL	1974 f	57
Silk-UL, Blister-UL	1503 g	64
Silk-UL, Blister-UL, Milk-UL	1148 h	71
Silk-UL, Blister-UL, Milk-UL, Dent-UL	1141 h	79
Blister-UTC	2977 b	0
Blister	2341 d	50
Blister-UL	2015 f	57
Blister-UL, Milk-UL	1649 g	64
Blister-UL, Milk-UL, Dent-UL	1578 g	71
Milk-UTC	3168 ab	0
Milk	2308 de	50
Milk-UL	2097 ef	57
Milk-UL, Dent-UL	1929 f	64
Dent-UTC	3220 a	0
Dent	2939 b	50
Dent-UL	2608 c	57
LSD (P=0.05)	235	

[1]All lower leaves were removed with the exception of the untreated checks.
[2]Upper most leaf was removed each time.
[3]Adjusted to 15.5% moisture.