NATIONAL CORN HANDBOOK

Climate & Weather **NCH 1**

Assessing Hail Damage to Corn

James V. Vorst, Purdue University

Reviewers

George Bender, National Crop Insurance Adjusters
Dale Hicks, University of Minnesota
Gerry Posler, Kansas State University
Jim Rink, Farm Bureau Crop Insurance

In the U.S., approximately half of all hailstorms occur between March and May. These early storms are responsible for only minor corn yield losses, however, because the corn either has not yet been planted or is too small to be damaged significantly. Even when fields are severely damaged early in the growing season, they can often be replanted.

On the other hand, about a third of all hailstorms occur between June and September. These have resulted in yield losses to corn estimated at $52 million annually.

Hail affects yields primarily by reducing stands and defoliating the plant. Defoliation causes most of the losses. Thus, knowing how to recognize hail damage and assess probable loss is a very valuable decision–making aid.

For instance, proper assessment of yield loss after an early–season storm can help you determine whether or not to replant or understand how an insurance adjuster determines yield loss. An accurate estimate of loss from a late storm is important for making correct harvesting and marketing decisions.
In this publication, we will examine how hail damages the corn plant, how the degree of damage can be determined and how the extent of yield loss is estimated.

When Corn Is Most Susceptible to Hail Damage

Prior to, and for some time after emergence, the corn plant is affected very little by hail damage. At emergence, the plant's growing point is below the soil surface and remains there for about 3 weeks (until five to seven leaves have fully emerged). Because the growing point is below the soil surface and in the leaf whorl, plant damage due to hail at these early stages rarely results in any significant stand or yield loss.

Approximately 3 weeks after emergence, all nodes and internodes have developed, and the growing point is elevated above the soil surface due to internode elongation. For the next 4–5 weeks, the plant grows rapidly and becomes increasingly vulnerable to hail damage up through the tasseling stage, which is the most critical period. Once past tasseling, hail would cause progressively less yield loss as the plant approaches maturity.

Determining Yield Loss Due to Stand Reduction

When a hailstorm occurs early in the growing season, an accurate stand reduction assessment is important if replanting is still a management option. Because it is difficult to distinguish living from dead tissue immediately after a storm, the assessment should be delayed for a week to 10 days. By that time, regrowth of living plants will have begun and discolored dead tissue will be apparent. (Another reason for assessment delay is that some plants initially surviving a storm may soon die because of disease infection entering at the sites of plant damage.)

To get an accurate estimate of the extent of damage, observe and sample plants from at least three parts of affected fields, totaling about 1/100 acre. Use Table 1 to determine how many feet of row are required to make 1/100 acre at various row spacings. Then divide that figure by the number of sampling locations to determine how many feet to sample at each location.

IOWA STATE UNIVERSITY
University Extension

NCH 1 Reprinted May 2002

Table 1. Total Feet of Row Required to Make 1/100 Acre at Various Row Spacings.

Row Spacing	Row Length	Row Spacing	Row Length
20 in.	261 ft.	32 in.	163 ft.
22 in.	238 ft.	34 in.	154 ft.
24 in.	218 ft.	36 in.	145 ft.
26 in.	201 ft.	38 in.	138 ft.
28 in.	187 ft.	40 in.	131 ft.
30 in.	174 ft.		

To sample pre–tasseled corn, split the stems of several obviously damaged plants with a knife to observe the growing point. If it is whitish–yellow in color, the plant is alive and should survive; if discolored and soft, the plant is dead or dying.

Some plants may be "tied" or "crippled"; i.e., the leaves fail to expand in a normal manner from the whorl. Since it cannot be determined until much later whether or not these crippled plants will develop normally, they should be classified as non–living if replanting is being considered.

Percent yield loss due to stand reduction is estimated by comparing yield potential of the field at its original plant population with yield potential at its now–reduced population. Table 2 has made these estimates for 25 different original and remaining population levels in 1/100 acre. When determining the advisability of replanting, be sure to consider availability and cost of adapted hybrid seed, replanting costs, calendar date, and the possible need for additional weed control. (For more information on replant decisions, see NCH–30, "Guidelines for Making Corn Replanting Decisions.")

Determining Yield Loss Due to Defoliation

Most yield reduction in corn due to hail damage is a result of the loss of photosynthetically active leaf area. How severe that reduction is likely to be depends on not only the amount of leaf area removed, but also the corn's growth stage when hail occurs (Table 3). When leaf area is removed, the plant loses some of its capability to produce dry matter, resulting in reduced grain yields. However, grain yield reductions are not directly proportional to leaf area reductions, because of increased dry matter production in the remaining leaf area and movement of dry matter from other plant parts into the developing ear.

1. The first step in assessing yield loss due to defoliation is to establish the stage of plant growth at the time of the storm.

Growth stages BEFORE tasseling are defined in terms of the number of leaves exposed, e.g., 7–leaf stage, 13–leaf stage, etc. Counting of leaves starts with the lowermost leaf, which has a rounded tip (Leaf 1 in Figure 1), and continues up to the "indicator leaf," which is the uppermost leaf that is 40–50 percent exposed from the whorl and whose tip points below a horizontal line (Leaf 5 in Figure 1).

Table 2. Estimated Percent Corn Yield Loss Due to Stand Reduction Occurring through the Tenth-Leaf Stage of Growth (1/100 Acre Area).*

Original Stand	READ TOP LINE FOR REMAINING PLANTS																									Original Stand
	320	310	300	290	280	270	260	250	240	230	220	210	200	190	180	170	160	150	140	130	120	110	100	90	80	
320	0	1	2	3	4	5	6	7	8	9	11	13	16	18	21	23	26	29	32	35	38	41	45	49	53	320
310		0	1	2	3	4	5	6	7	8	10	12	14	16	19	21	24	27	30	33	36	39	43	47	52	310
300			0	1	2	3	4	5	6	7	9	11	12	14	17	20	23	25	28	31	34	37	41	45	50	300
290				0	1	2	3	4	5	6	8	10	11	13	15	18	21	23	26	29	32	35	39	43	48	290
280					0	1	2	3	5	6	7	9	10	12	14	16	19	21	24	27	30	34	37	41	46	280
270						0	1	3	4	5	6	7	9	10	12	14	16	18	21	24	28	31	35	40	45	270
260							0	1	3	4	5	6	7	9	10	12	14	16	19	22	25	29	33	38	43	260
250								0	1	2	3	4	6	7	8	10	12	14	17	20	23	27	31	36	41	250
240									0	1	2	3	4	5	6	9	10	12	15	18	22	26	29	34	40	240
230										0	1	2	3	4	5	8	9	11	14	17	21	25	29	33	39	230
220											0	1	2	3	4	7	8	10	13	16	20	24	28	33	38	220
210												0	1	2	4	6	7	9	12	16	20	24	27	32	37	210
200													0	1	3	5	6	8	11	15	19	23	27	31	36	200
190														0	2	4	5	7	10	14	17	21	25	30	35	190
180															0	2	4	6	9	12	15	19	23	28	33	180
170																0	2	4	7	10	13	17	21	26	31	170
160																	0	2	5	8	11	15	19	24	29	160
150																		0	3	5	8	12	16	21	26	150
140																			0	3	6	10	14	18	23	140
130																				0	3	6	10	15	20	130
120																					0	3	7	12	17	120
110																						0	3	8	12	110
100																							0	4	8	100
90																								0	4	90
80																									0	80

*Reprinted by permission from the National Crop Insurance Service's "Corn Loss Instructions" (Rev. 1984)

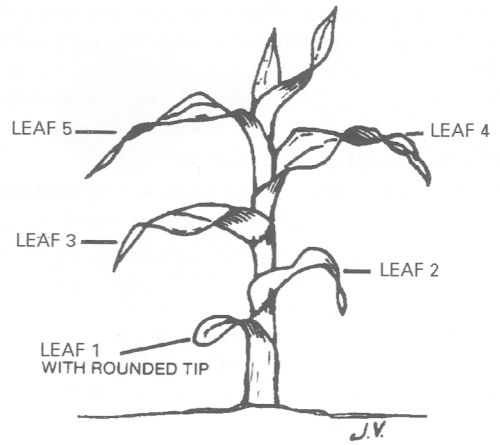

Figure 1. Corn plant in the 5-leaf growth stage. (Tip of Leaf 5 no longer points upward, so it is the "indicator leaf.")

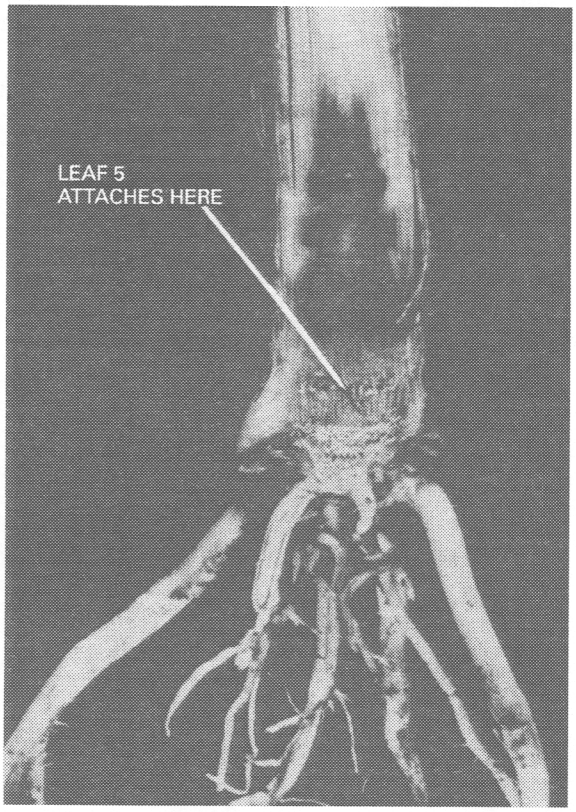

Figure 2. Longitudinal section through base of corn plant, showing fifth leaf attachment (at top of first noticeable elongated internode).

In some situations (particularly as the plant nears tasseling), Leaf 1 may have been removed, in which case the lowermost leaf will not have a rounded tip. By splitting the stalk, you can positively identify leaf location, since Leaf 5 is attached to the top of the first noticeably elongated internode (Figure 2). Growth stage can then be determined by counting upward from the fifth leaf to the indicator leaf. If, for example, this indicator leaf is the eleventh above Leaf 5 (the leaf attached to the top of the first elongated internode), the corn is considered to be in the 16–leaf stage of growth (i.e., 11 + 5).

Growth stages AFTER tasseling are identified according to development of the ear shoot and kernels as follows:

- Silked stage: silks have emerged and tassel is shedding pollen.
- Silks brown stage: 75 percent of silks on ear shoot show purple to brown color but are not dry to the touch.
- Pre–blister stage: silks all brown but not dry; no fluid in kernels, which look like pimples.
- Blister stage: kemels look like white, water blisters; fluid is colorless.
- Milk stage: roasting ear stage with cob at its maximum length and kernels yellow in color and containing only milky fluid (no solid substance).
- Late milk stage: milky fluid thickening and solids forming in base of kernels.
- Soft dough stage: kernels contain semi–solid substance, but still produce thick milky material when squeezed; kernels near butt end of ear beginning to dent.
- Early dent stage: all kernels beginning to dent and containing thick gummy substance; but many still squirt "milk" when mashed.
- Dent stage: kernels denting or dented and can be cut easily with fingernail.
- Nearly mature stage: kernel hull on opposite side of embryo has shiny appearance halfway to cob.
- Mature stage: black layer formed at base of kernels; kernel moisture 35–40 percent.

2. The next step in assessing yield loss due to defoliation is to estimate percent of leaf area destroyed per plant. In making this estimate, consider both leaf area removed and leaf area still attached to the plant but no longer green. Live green tissue remaining on the plant, even though mutilated, should not be considered as leaf area destroyed. Examine plants in each of at least three areas of a damaged field to be assured of an accurate estimate.

3. With the corn growth stage established and amount of leaf area loss estimated, use Table 3 to determine likely yield reduction from defoliation.

Determining Direct Ear Damage

Ear damage due to hail may result from hailstorms occurring late in the season. To determine the extent of crop loss due to ear damage, select ears from 10 consecutive plants and count the number of damaged kernels on all of the ears. Next, determine the total number of kernels on all 10 ears, and calculate the percent of total kernels damaged. This figure is the percent of loss due to direct ear damage. If direct ear damage occurs in association with stand reduction, the percent ear damage is adjusted to account for plants lost. This is done by multiplying the percent ear damage times the percent of plants remaining.

Bruising and Stalk Damage

After the corn has reached the 10–leaf stage, stem bruising may occur. To calculate the damage due to bruising, determine the number of totally destroyed plants out of 100 consecutive plants. Bruised plants that do not actually go down should not be counted. Bruising may allow an avenue of infection for stalk rots, which may increase lodging later in the season. Since weather conditions during the remainder of the growing season affect disease severity, it may not be possible to evaluate fields with severe bruising until the end of the season.

Estimating Total Yield Loss

Total corn yield loss from hail damage is estimated by adding the expected yield loss caused by stand reduction, the expected loss caused by defoliation, and the expected loss caused by direct ear damage. Remember, however, that this is only an estimate of the percent yield loss. As with undamaged corn, extremely favorable weather during the rest of the growing season can cause actual yields to be higher than expected. Similarly, unfavorable weather can cause greater–than–anticipated reductions.

Table 3. Estimated Percent Corn Yield Loss Due to Defoliation Occurring at Various Stages of Growth.

Stage of Growth	—Percent Leaf Area Destroyed —																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
7 Leaf	0	0	0	0	0	0	1	1	2	3	4	4	5	5	6	7	8	9	9
8 Leaf	0	0	0	0	0	1	1	2	3	4	5	5	6	6	7	8	9	10	11
9 Leaf	0	0	0	1	1	2	2	3	4	5	6	6	7	7	9	10	11	12	13
10 Leaf	0	0	0	1	2	3	4	5	6	7	8	8	9	9	11	13	14	15	16
11 Leaf	0	0	1	1	2	3	5	6	7	8	9	10	11	12	14	16	18	20	22
12 Leaf	0	0	1	2	3	4	5	7	9	10	11	13	15	16	18	20	23	26	28
13 Leaf	0	1	1	2	3	4	6	8	10	11	13	15	17	19	22	25	28	31	34
14 Leaf	0	1	2	3	4	6	8	10	13	15	17	20	22	25	28	32	36	40	44
15 Leaf	1	1	2	3	5	7	9	12	15	17	20	23	26	30	34	38	42	46	51
16 Leaf	1	2	3	4	6	8	11	14	18	20	23	27	31	36	40	44	49	55	61
17 Leaf	2	3	4	5	7	9	13	17	21	24	28	32	37	43	48	53	59	65	72
18 Leaf	2	3	5	7	9	11	15	19	24	28	33	38	44	50	56	62	69	76	84
19–21 Leaf	3	4	6	8	11	14	18	22	27	32	38	43	51	57	64	71	79	87	96
Tassel	3	5	7	9	13	17	21	26	31	36	42	48	55	62	68	75	83	91	100
Silked	3	5	7	9	12	16	20	24	29	34	39	45	51	58	65	72	80	88	97
Silks Brown	2	4	6	8	11	15	18	22	27	31	36	41	47	54	60	66	74	81	90
Pre-Blister	2	3	5	7	10	13	16	20	24	28	32	37	43	49	54	60	66	73	81
Blister	2	3	5	7	10	13	16	19	22	26	30	34	39	45	50	55	60	66	73
Early Milk	2	3	4	6	8	11	14	17	20	24	28	32	36	41	45	50	55	60	66
Milk	1	2	3	5	7	9	12	15	18	21	24	28	32	37	41	45	49	54	59
Late Milk	1	2	3	4	6	8	10	12	15	18	21	24	28	32	35	38	42	46	50
Soft Dough	1	1	2	2	4	6	8	10	12	14	17	20	23	26	29	32	35	38	41
Early Dent	0	0	1	1	2	3	5	7	9	11	13	15	18	21	23	25	27	29	32
Dent	0	0	0	1	2	3	4	6	7	8	10	12	14	15	17	19	20	21	23
Late Dent	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Nearly Mature	0	0	0	0	0	0	0	0	1	2	3	4	5	5	6	6	7	7	8
Mature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reprinted by permission from the National Crop Insurance Service's "Corn Loss Instructions" (Rev.1984)

File: Agronomy 2-2

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Stanley R. Johnson, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.