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Agronomy Advice

http://corn.agronomy.wisc.edu

July 2009 Field Crops 28.492-69

Late-Season Hail Effects on Corn

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The hailstorm of July 24, 2009 in southwest Wisconsin happened at one of the worst times possible during the corn life cycle. Most of the crop in the affected area was in the middle of tasseling and sillking. The crop had great yield potential and was looking promising until the storm hit. The most important thing to remember after a hail storm is to wait. Go ahead and view the damage, but do not make any assessments until 7-10 days have passed. It will take that long for the corn plant to begin growing again if it can.

Assessing Corn Plant Health

Assessing plant health after a destructive event such as flooding, hail, frost or insect feeding is important for replant decisions. Often these events damage the exposed leaves, but will have little or no effect on the belowground growing point or final seed yield.
To assess plant health after a destructive event and for making a replanting decision:

1. Wait a minimum of 3 to 4 days. After a storm event we need to be patient and let plants respond.
2. Observe the growing point. If color is white to light yellow then plant is alive. If you suspect the plant is not healthy or questionable, count as ½ of a plant for population purposes.
3. Consult replanting chart. See “Corn Replant/Late-Plant Decisions in Wisconsin” (Lauer, 1997).

Flooding at any time when the growing point is below the water level can kill the corn plant in a few days, especially if temperatures are high. Growing point tissues are depleted of oxygen. Frost should not be a problem with corn until the growing point moves aboveground around V5 to V6.

Crop insurance damage charts are based upon the stage of crop development, so recording the date of the storm event and the correct stage of development is key to assessing damage. To assess whether the plant is healthy the growing point needs to be observed. Look for color other than a healthy cream or light yellow. The first signs of damage on a growing point are a change to a light red or brown within about 4-6 days. If the growing point changes color, then the plant will likely not yield well and may even die.

Hail

Those who will be advising growers faced with the likelihood of hail damage should get ready by consulting the National Corn Handbook NCH-1 "Assessing Hail Damage to Corn". This publication does a good job of describing factors to consider, and has charts used by the National Crop Insurance Association for assessing yield loss due to 1) stand reduction through tenth-leaf stage only, and 2) defoliation.

Hail affects yields primarily by reducing stands and defoliating the plant. Defoliation causes most of the loses. Knowing how to recognize hail damage and assess probable loss is important for decision making.

Because it is difficult to distinguish living from dead tissue immediately after a storm, the assessment should be delayed 7 to 10 days. By that time regrowth of living plants will have begun and discolored dead tissue will be apparent. The corn plant has the capacity to compensate for various stresses and it would take this long before the plant has recovered to its remaining potential. If farmers have hail insurance, wait until the adjustor has made their measurements and injury determinations before making any decisions.

Hail adjusters use standard tables to calculate compensation for yield loss associated with hail. Four assessments are made on corn when hail occurs after silking (Vorst, 1990) including:

1. Determining yield loss due to stand reduction,
2. Determining yield loss due to defoliation,
3. Determining direct ear damage, and
4. Bruising and stalk damage.

As the season progresses, hail injury and losses could become more significant. Some comments on concerns not covered by NCH-1:

1. **After** the tenth leaf stage, yield and stand reductions are on about a one-to-one ratio (eg. 80% stand = 80% potential) and are in addition to losses shown in the defoliation chart.
2. Plants with bruised, but not severed stalks or ears will usually produce a near normal, harvestable ear.
3. Growers should monitor stalk rot of severely defoliated plants which have a good-sized ear. Photosynthate will be mobilized towards the ear rather than the stalk. This could weaken the stalk and encourage stalk rot development. These fields may need to be harvested early to avoid standability problems.
4. Nitrate levels in corn may become elevated. Animal performance could be reduced. Growers with complete defoliation and high soil nitrogen levels (due to fertilizer, manure, or legume plowdown) should test nitrate levels and probably ensile the corn before feeding.
5. Late season leaf loss will allow more light to penetrate to the soil and late-season weed growth may flourish.

Determining yield loss due to **stand reduction** is made by comparing yield potential of the field at its original population with yield potential at its now-reduced population. Yield loss after silking is adjusted directly by determining the percentage of killed plants. Likewise **ear damage losses** are adjusted directly by determining the percentage of damaged kernels on ears.

In corn, most yield reduction due to hail damage is a result of **leaf loss**. To determine yield loss due to defoliation, both the growth stage of the field and the percent leaf area removed from the plant must be determined (Table 1). Significant yield damage due to defoliation occurs immediately after silking and decreases as the plant matures.

Damage due to **bruising** is determined at harvest by counting the number of lodged plants. Bruising may allow an avenue of infection for stalk rots and molds that cause mycotoxin problems. Weather conditions during the remainder of the season affect disease severity.

Table 1. Yield impact of plant leaf defoliation on corn yield at different stages of development.

Stage	Percent Leaf Area Destroyed																		
of Growth	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

* Source National Crop Insurance Service's "Corn Loss Instructions" (Rev 1984)

(Vorst, 1990)

Hail during kernel grain-fill is detrimental to grain yield. Depending on the stage of development and the amount of leaf loss, grain yield can be reduced from 0 to 41 percent after the soft-dough stage of development (Table 2). Any losses due to ear dropping would increase this yield loss estimate.

Table 2. Grain yield loss after plants killed or defoliated.

Corn Development Stage	Plants Killed	Plants Defoliated
	percent yield loss	
R4 (Soft dough)	55	35
R5 (Dent)	40	25
R5.5 (50% kernel milk)	12	5
R6 (Black layer)	0	0
derived from Afuakwa and Crookston (1984)		

Management options after Late-Season Hail and Lodging Events

The types of options available to farmers varies from farm-to-farm and field-to-field. On a farm basis, the decision hinges on availability of other corn handling systems involving drying capacity, silage storage facilities, high moisture corn handling equipment, snaplage equipment, etc. Using these later systems means that the harvested corn product will probably have to be fed on-farm to livestock.

On a field basis, things to consider are mold development, moisture levels for ensiling, and effects on maturation rate, yield and quality. If ears are damaged, easier entry of mold causing organisms into the ear can take place. If it is wet for the duration of the season, mold problems will probably increase. Drier weather may not promote growth of mold producing organisms. Safer storage of corn predisposed to mold causing organisms can be achieved by drying grain to 15.5% moisture, ensiling at the proper moisture for the silo type, or treating high moisture corn with propionic or acetic acid.

Hailed corn will usually achieve physiological maturity earlier, but take longer to dry-down than non-hailed corn. Yield and test weight will likely decrease when stressed by hail.

If ensiling, hail damaged corn should be stored separately from other silage already put up. Hail damaged corn may have lower quality, and by storing separately, the farmer will have the option of mixing poor and good silages to obtain a satisfactory ration, or feeding the damaged silage to animals that do not have high quality forage requirements. An estimate of silage yield and quality should be obtained to compare with the grain yield estimate.

Fields assessed as total losses after silking

Corn that was broken off at the ear will not continue to grow. What options remain for those planning on silage?

1. If the crop was insured, check with insurance adjuster to ensure that any action does not cause a greater loss in payment than the value of forage produced.
2. Consider the value of the nutrients if the crop is simply disked down.
3. Harvest the remaining forage for silage as the whole plant moisture dries down. Make sure the forage to be ensiled is at the proper moisture. The lower stalk and leaves will ferment if harvested at 60 to 70% (moisture depending on storage type) and produce a low quality silage adequate for heifers and dry cows.
4. A common question is: what can be planted to produce more tonnage yet this year? Frankly the options are few this late in the season.
    - **Absolutely do not plant sorghum-sudangrass or sudangrass.** This is a warm season annual that will grow only very little when the average daily temperature falls below 80^{o} F. Since little growth will occur in September, the result will be low yield.
    - Corn planted August 1 can be expected to yield about 0.7 to 2.8 t/a dry matter in Southern Wisconsin. These yields were achieved in 2006 and 2005 when a killing frost hit on October 12 and October 26.
    - Oats planted during the first two weeks of August can be expected to yield 1 to 2 t/a dry matter in Southern Wisconsin and less as one moves north.
    - Other small grains will yield less because they will not head this year.
    - Some acres may be prepared for winter wheat production.

An economic estimate should be made of the options (ie. corn grain, high-moisture corn, silage, snaplage, etc.) available in the grower's situation. Estimates of changes in yield and quality due to plant part loss should be taken into account. For corn grain yield, information from crop insurance hail adjusters tables would be a good source for making estimates. Little economic information on hail damage is available on other harvesting options such as silage, high-moisture corn, or snaplage. One approach would be to use yield and quality changes observed under normal development and conditions and adjust downward.

Impact of Defoliation on Corn Forage Quality

Forage yield decreases as leaf removal increased in severity, and as time of defoliation nears silking (Lauer et al., 2004; Roth and Lauer, 2008). As defoliation increased forage yield decreased at a greater rate (Figure 1). Averaged across all environments, forage yield decreased 16% when complete defoliation occurred at V7. Likewise 100% defoliation decreased forage yield 43%, 70%, and 40% at V10, R1 and R4 growth stages, respectively. Greater forage yield decreases are measured with early defoliation (V7 to V10) than predicted grain yield decreases currently used by hail adjusters. This likely occurs because both increased leaf removal and decreased grain yield combine to reduce forage yield. The response to defoliation from simulated hail damage is different between corn forage and corn grain.

Most quality responses resembled yield responses for each defoliation treatment across environments (Figure 2). Increasing defoliation either did not affect quality, especially at V7 and V10 stages, or lowered quality, especially at the R1 and R4 stages of development. The largest differences in NDF, ADF, and in vitro true digestibility occurred at R1 and R4 at the complete defoliation level. NDF increased from 44% in the control to 61 % with complete defoliation at R1 or 51 % at R4. In vitro true digestibility decreased from 81 % in the control to 73% or 79 % with complete defoliation at R1 or R4, respectively. Starch content was most affected with defoliation at R1. Across environments NDF digestibility was not significantly affected. These forage quality changes resulted in decreased Milk per Ton and Milk per Acre in most environments.

Wiersma (1993) looked at quality changes in corn silage at five stages of kernel maturity (Table 3). These values would be for corn silage under normal conditions. With hail damage, loss of leaves and poor kernel fill would affect quality by increasing fiber content and decreasing yield, crude protein, and digestibility. This data may be helpful in assisting the decision to harvest corn for silage or leave for grain.

Fig. 1. Relative corn forage yield after defoliation at V7, V10, R1, and R4 (Ritchie et al., 1993). Relative forage yield was determined by dividing the forage yield of each plot by the average of the highest forage yield defoliation treatment for each environment. Dashed lines and open symbols are corresponding predictive relationships between relative grain yield and defoliation derived from (National Crop Insurance Services, 1998) leaf loss charts.

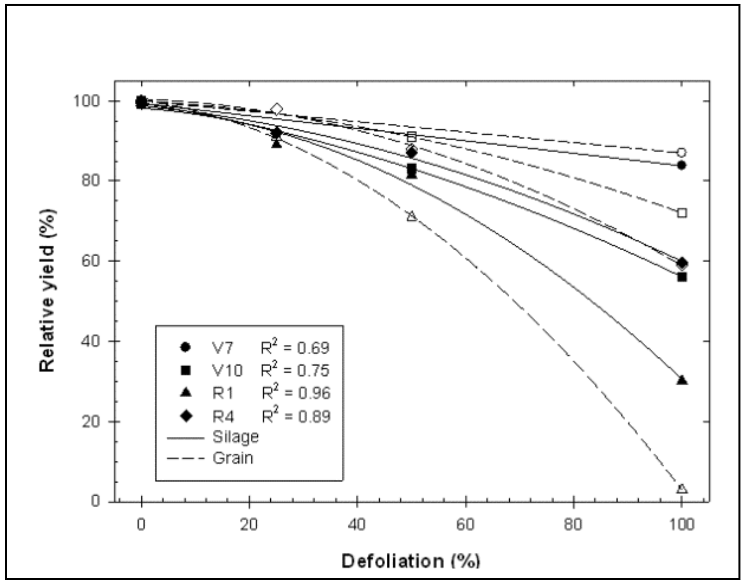
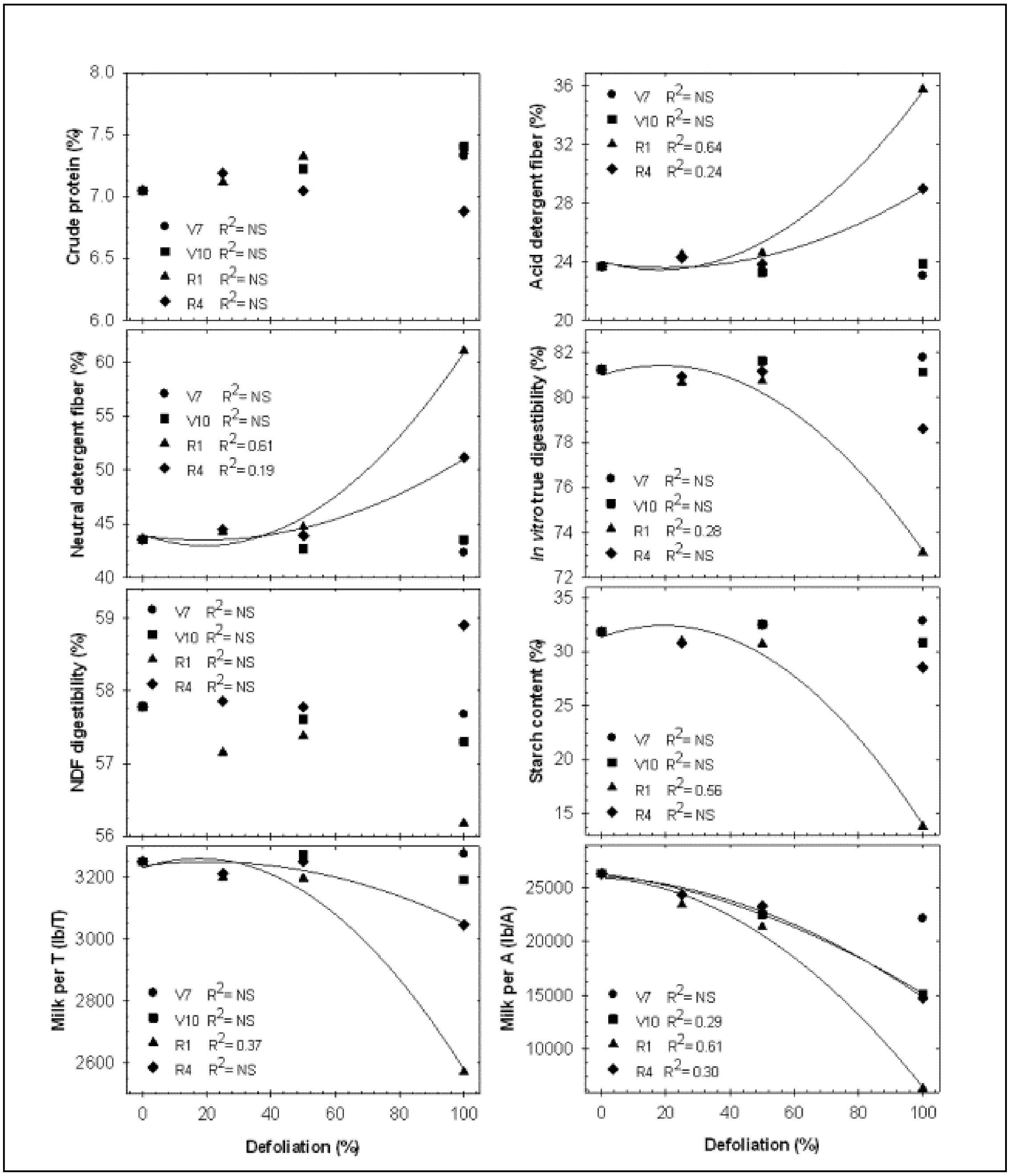


Table 3. Whole plant dry matter, crude protein, ADF, NDF, and digestibility for corn silage at five stages of kernel maturity.

Maturity stage	Dry matter	Yield	Crude protein	ADF	NDF	Digestibility (in vitro)
	%	ton/A	%	%	%	%
Soft dough	**24**	**5.4**	**10.3**	**27.2**	**52.7**	**77.1**
Early dent	**27**	**5.6**	**9.9**	**24.3**	**48.0**	**79.0**
1/2 milkline	**34**	**6.3**	**9.2**	**22.8**	**45.1**	**80.0**
3/4 milkline	**37**	**6.4**	**8.9**	**23.8**	**47.3**	**79.6**
No milkline	**40**	**6.3**	**8.4**	**24.0**	**47.3**	**78.6**

Fig. 2. Changes in corn forage quality changes with defoliation at V7, V10, R1, and R4 (Ritchie et al., 1996). Graph values are treatment means averaged across environments.



Using Foliar Fungicides

Disease risks associated with hail damage

Fungicide application cannot recover yield potential lost due to hail damage. Fungicides protect yield potential by reducing disease. There are some diseases of corn that are favored by wounding, e.g., Goss's wilt, common smut and stalk rot, but fungicides are not effective against the pathogens. The foliar diseases managed by fungicides (e.g., gray leaf spot, northern corn leaf blight, eye spot, and common rust on corn, and brown spot and frog eye on soybeans) are caused by pathogens that do not require wounds for infection.

A simulated hail-fungicide trial was conducted at Urbana in 2007, with corn plants being damaged with a string trimmer just before tasseling to simulate hail damage (Bradley, 2008). Some plots were left undamaged as well. The fungicides Headline, Quadris, and Quilt were applied to the plots and compared to an untreated check. When the data were statistically analyzed, fungicides did not significantly improve yield compared to the untreated check in the "hail-damaged" plots or the nondamaged plots (Table 4). The simulated hail damage alone did decrease yield by approximately 30 bu/A compared to the nondamaged plots, however.

Table 4. Effect of simulated hail damage and foliar fungicides applied at tassel emergence on gray leaf spot severity and yield of a susceptible corn hybrid near Champaign, Illinois, in 2007. (Bradley and Ames, 2008. Foliar Fungicides in Corn Production: A Look at Local and Regional Data. Proceedings of the 2008 Illinois Crop Protection Technology Conference.)

Simulated Hail[1]	Fungicide	Rate/Acre	GLS Severity[2]	Yield (bu/ac)
No Untreated			57	174
	Headline®	6 fl oz	33	179
	Quadris®	6 fl oz	42	170
	Quilt®	14 fl oz	40	155
Yes Untreated			62	141
	Headline ®	6 fl oz	48	144
	Quadris®	6 fl oz	47	142
	Quilt®	14 fl oz	35	140
		LSD [3] 12		11

[1] Hail was simulated by damaging corn plants with a weed-eater type string mower.

[2] Gray leaf spot severity (0-100% scale).

[3] Fisher's protected least significant difference (P = 0.05).

Using Gramoxone to dry down corn after a total loss (see Standard label)

In 2009 the Iowa Department of Agriculture and Land Stewardship (IDALS) secured a crisis exemption label for the use of Gramoxone Inteon herbicide as a harvest aid on hail damaged corn in northeast Iowa. Hail-damaged crop standing in the field are typically over 80 percent moisture and does not dry down much on its own at immature stages, even though it is heavily damaged by hail. The crop needs to be below 70 percent for proper ensiling. Gramoxone applied to standing hail-damaged corn will accelerate dry-down so that the crop can be harvested below 70 percent moisture. The Iowa Section 18 label stated 1 to 2 pints per acre and a 7-day harvest interval. **This section 18 label does not allow use in Wisconsin, so farmers cannot legally apply Gramoxone.**

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