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Sorghum Yield Loss Due to Hail Damage*

This NebGuide discusses the methods used by the hail insurance industry to assess yield loss due to hail damage in grain sorghum.

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A hailstorm can cause yield losses in sorghum ranging from slight to total. Research has been conducted to accurately predict the effects of hail damage on sorghum yields. Results from these studies are used by hail insurance companies to assess yield losses and determine adjustments paid to clients. Information in this NebGuide will acquaint producers with procedures used to assess sorghum hail damage. These procedures may also be useful in estimating crop yields wherever stand loss or defoliation occurs.

Yield loss predictions are based on two factors: a) stage of growth at the time of damage, and b) the degree of plant damage. Plant damage is classified as either direct damage or defoliation. Direct damage is divided into three categories: stand reduction, stalk damage and head damage. Defoliation is the loss of leaf area which may lead to later yield losses. Each step of the adjustment process will be discussed. A worksheet (*Figure 4*) is provided to illustrate these adjustment procedures.

Determining Sorghum Growth Stages

Accurate determination of growth stage is necessary to determine yield loss due to hail. *Table I* lists and describes sorghum growth stages and indicates the number of days until the next growth stage for a typical 120-day grain sorghum hybrid. Vegetative growth stages are called leaf stages and are identified by the number of exposed leaves.

Table I. Description of sorghum growth stages.*	
Stage	**Description**
Vegetative Stages	
Emergence to 11-Leaf Stage	Time intervals is 32 days.
11-Leaf Stage	One-half of the 11th actual leaf is exposed. The collar of the ninth and the tip of the 13th leaf are visible. Time interval is four days.
12-Leaf Stage	One-half of the 12th leaf exposed, 10th leaf collars, tip of the 14th leaf visible, (four days).
13-Leaf to 20-Leaf Stage	Add one leaf to 12-leaf stage for leaf exposed, leaf collar and leaf visible. Interval between each stage is three days from 13-leaf stage to the 17-leaf stage and for the 20-leaf stage. 18- and 19-leaf stage interval is two days.
Reproductive Stages	
Early Boot	Boot has started to swell, head is extended to just below the flag leaf (three days).
Boot	Head almost full size and starting to emerge from the sheath of the flag leaf (two days).
Just Headed	More than 50 percent of the heads have emerged from the boot--no blossoms showing (two days).
Bloom	All heads have emerged from the boot and more than 50 percent of the heads show yellow pollen tubes over more than 50 percent of each head (five days).
Blister	Grain is in a watery form and only partially formed--no color to liquid (four days).
Early Milk	Grain is fully formed. Substance is a clear to slightly white, milky liquid. Removal of fluid from grain would leave only the hull (six days).
Milk	Substance is thick milky liquid, no solids (seven days).
Late Milk	Grain has reached a semi-solid form (seven days).
Soft Dough	When grain is crushed, a white substance emerges in a semi-solid form (six days).
Dough	When grain is crushed, a white substance emerges in an almost solid form (six days).
Hard Dough	Grain is firm and nothing emerges when crushed (six days).
Mature	Physiological maturity has been reached. Less than 40 percent moisture content. A thin black layer has developed on bottom tip of grain.
*All stages are based on 50 percent of the plants at or beyond a given stage of development.	

rior to the boot stage, **a stage indicator leaf** is used to determine the growth stage. This leaf is found on the top of the

plant, and is the leaf which is about one-half exposed. After the first few leaves have been sloughed off, the **node identification system** is used to determine leaf stage. *Figure 1* shows a longitudinal view of a split stalk. The seventh leaf is attached to the top of the first elongated internode. After determining the seventh leaf, count upward until the indicator leaf is identified.

To use the accompanying tables and loss procedures properly, the total number of leaves produced by the plant must be determined. This can be accomplished by unrolling the unemerged leaves from the whorl. If this cannot be done, wait until later in the season to determine ultimate leaf number. Typical ultimate leaf numbers for Nebraska range from 15 in the high plains of western Nebraska to 19 in the southeast.

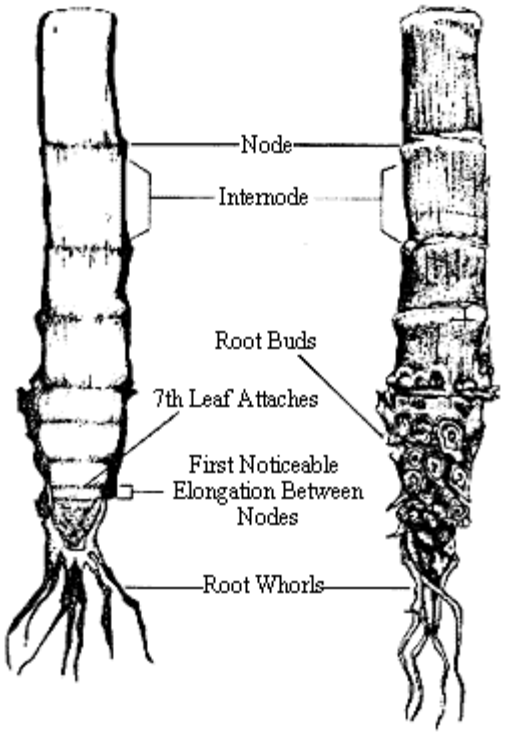

Figure 1. Enlarged view of lower stalk.

Determining Losses

1. **Stand Reduction** is a measure of the number of plants killed by the storm. In order to determine the yield loss due to stand reduction, the pre-storm plant population is compared to the remaining stand 7-10 days after the storm.

   Pre-storm population is determined by counting the original number of plants in 100 feet of row. (We suggest four rows 25 feet long.) Count the number of destroyed plants (growing point killed) by hail in the 100 feet of row. Do this in several representative locations in each field. Divide the average number of destroyed plants by the average number of original plants. The result is the gross percent stand reduction.

$$\frac{\text{Avg no. plants destroyed (in 100 ft of row)}}{\text{Avg no. original plants (in 100 ft of row)}} = \text{gross percent}$$

Use the stand reduction curve (*Figure 2*) to determine stand loss from the tenth leaf stage until the flag leaf (ultimate leaf formed) is fully exposed. Due to the nature of the sorghum plant, hail rarely reduces stand before the tenth leaf stage. To determine percent yield loss, find the gross percent stand reduction damage along the bottom axis then read percent yield loss on the vertical axis. For reproductive growth stages (after the flag leaf is exposed), yield loss is directly proportional to stand loss. For example, a 30 percent stand loss at the boot stage equals a 30 percent yield loss.

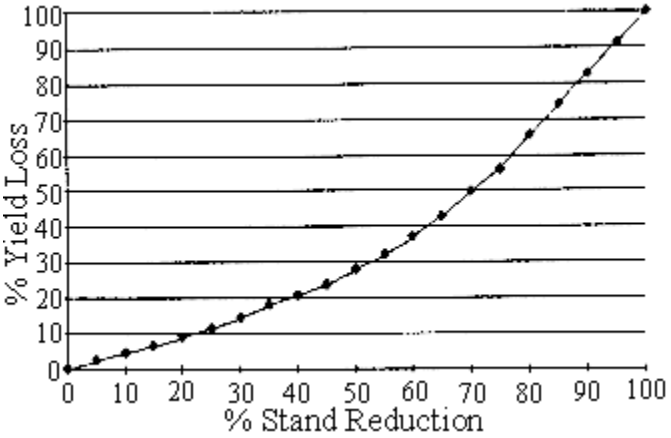

Figure 2. Percent yield loss of sorghum due to stand reduction. Use between 10-leaf stage and reproductive stages.

2. **Stalk damage** is difficult to accurately assess immediately following a hailstorm. Bruising is minor if it does not penetrate into the stalk, as evidenced by discoloration in the stalk interior. If the bruises do penetrate into the stalk or there is potential lodging, it is recommended that final adjustment be deferred until later in the season. Heavy defoliation between bloom and soft dough stages may induce lodging. When evaluated later in the season, damaged plants which do not produce harvestable heads will be considered "totally destroyed" and contribute to stand reduction losses.

3. **Head loss** is a measure of destruction of kernels in the head by hail. In order to determine the gross percent head damage, the number of kernels destroyed by hail is divided by the total number of kernels per head. Count the number of spikelets on an average sorghum head (*Figure 3*). Take three spikelets from a typical head--one from the top, middle, and bottom--and count the number of kernels on each spikelet. Average the three spikelet counts to get an average number of kernels per spikelet. Determine the number of kernels per head:

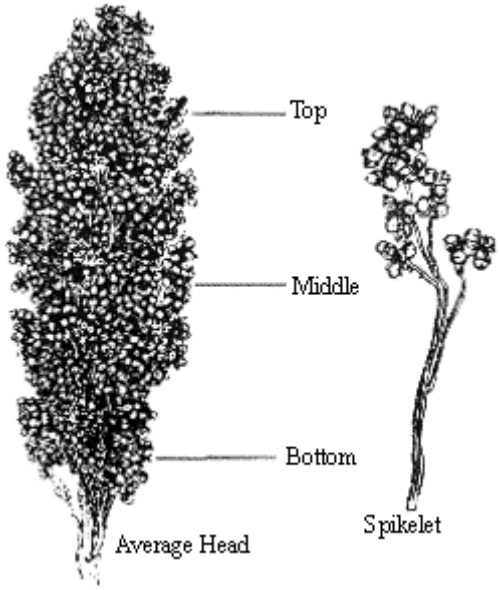

Figure 3. Sorghum head structure.

$$\frac{\text{No. of spikelets}}{\text{per head}} \times \frac{\text{No. of kernels}}{\text{per spikelet}} = \frac{\text{kernels}}{\text{per head}}$$

The number of kernels destroyed can be estimated by the number of missing and partially destroyed spikelets. Determine the number of kernels destroyed in 10 heads at several representative locations and calculate the average kernels lost per head. Gross percent head damage is determined by dividing the kernels destroyed by kernels per head:

$$\frac{\text{Avg no. of kernels lost per head}}{\text{No. of kernels per head}} = \text{Gross percent head loss}$$

4. **Defoliation** is measured as a percent of exposed leaf area destroyed during the storm. Percent defoliation is more accurate if evaluation is done 7-10 days after the storm. Leaf tissue that is green and still attached to the plant will continue to produce photosynthate, and is not considered leaf area destroyed.

   To determine the amount of leaf area destroyed, examine each exposed leaf and estimate leaf area present before the storm. Then for each leaf, estimate percent defoliation. (There is a tendency to overestimate defoliation percentage. Each leaf should be examined individually.) Evaluate a number of plants from several representative places in each field. Follow these steps:

   1. Determine growth stage and ultimate leaf number if still in a vegetative stage.
   2. Determine percent defoliation by summing percent defoliation for each leaf and dividing by number of leaves on the plant.
   3. Use *Table II* to determine gross percent yield loss due to defoliation.

Table II. Grain sorghum defoliation loss charts.

Vegetative Stages

For 15 Ultimate Leaves:

	Percent Defoliation									
Leaf Stage	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
9	0	0	0	1	1	1	2	3	3	4
10	0	1	1	2	3	4	5	6	7	8
11	1	2	3	5	7	9	11	14	17	20
12	1	3	6	10	12	17	21	27	31	37
13	1	3	8	14	17	23	30	36	43	50
14	2	4	10	16	20	26	34	41	49	57
15	2	7	13	18	22	30	38	47	56	65

For 17 Ultimate Leaves:

	Percent Defoliation									
Leaf Stage	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	1	1	1	2	2	3	3
11	0	1	1	1	2	2	3	4	4	5
12	0	1	1	2	3	4	5	6	7	8
13	0	1	3	5	6	9	11	14	17	20
14	1	3	6	10	12	17	21	27	31	37
15	1	3	8	14	17	23	30	36	43	50
16	2	4	10	16	20	26	34	41	49	57
17	2	7	13	18	22	30	38	47	56	65

For 19 Ultimate Leaves:

	Percent Defoliation									
Leaf Stage	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	1	1	1	2	2	3	3
11	0	0	1	1	1	1	2	3	3	4
12	0	0	1	1	2	2	3	4	4	5
13	0	1	1	2	3	4	5	6	7	8
14	0	1	3	5	6	9	11	14	17	20
15	0	2	5	9	11	15	19	28	28	33
16	1	3	7	11	14	19	24	30	35	41
17	1	3	8	14	17	23	30	36	43	50
18	2	4	10	16	20	26	34	41	49	57

19	2	7	13	18	22	30	38	47	56	65
Reproductive Stages										
	Percent Defoliation									
Stages	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Early boot	3	8	15	21	26	36	45	55	66	77
Boot	4	10	18	25	31	42	53	65	78	90
Just headed	4	12	20	27	34	45	58	71	85	98
Bloom	4	1	19	26	33	44	57	69	83	96
Blister	3	9	17	23	30	40	51	62	74	86
Early milk	3	8	15	21	26	36	45	55	66	77
Milk	2	7	13	17	22	30	38	46	55	64
Late Milk	2	5	10	14	17	23	30	36	43	50
Soft dough	1	3	7	10	12	16	21	25	30	35
Dough	1	2	5	6	8	11	14	17	20	23
Hard dough	0	1	2	3	4	6	7	9	10	12
Phy. mature	0	0	0	0	0	0	0	0	0	0
Note: For ultimate leaf numbers 16 and 18 estimate figures between the charts shown.										

Calculating Actual Loss Due to Hail

Figure 4 is a worksheet for estimating percent yield loss due to hail damage. Two examples are shown; the first is for a hailstorm occurring at a vegetative stage and the second for a hailstorm occurring at a reproductive stage. The procedure first determines the amount of direct damage to the crop (stand reduction and head loss). Secondly, yield loss due to defoliation is determined based on the percent crop remaining (100% - direct damage). The actual yield loss due to hail is the sum of the direct and defoliation yield loss.

These instructions are intended as a general guideline for assessing sorghum yield loss due to hail damage. Occasionally, it is difficult to determine actual loss on the first inspection. Therefore, insurance companies may defer final yield loss determination until later in the season. Although early season defoliation appears quite devastating, research and experience has shown that sorghum plants can recover under favorable growing conditions. Since regrowth is typical in sorghum plants, use these charts with caution when deciding whether to replant. Precise yield loss estimates should be left to trained hail adjusters.

Figure 4. Sorghum Yield Loss Worksheet

	Examples		*Your*
A. Background Information:	*#1*	*#2*	*Figures*
C. a. Date of Loss (storm)	7/15	8/28	
C. b. Inspection Date	7/21	9/7	

B. Growth Stage (GS)			
C. **a.** Stage at Inspection	15	Late Milk	
C. **b.** Stage at Loss	13	Milk	
C. **c.** Ultimate # of Leaves	17	--	
C. Determining Losses			
C. **1.** Stands Reduction (SR)			
C. 6. **a.** Destroyed plants in 100 ft of row	100	30	
C. 6. **b.** Original Plants in 100 ft of row	150	120	
C. 6. **c.** Percent SR (1a/1b)	67%	25%	
C. 6. **d.** SR Yield Loss			
C. 6. d. **i.** If GS less than 10, no loss	--	--	
C. 6. d. **ii.** If GS between 11 and full leaf development, C. 6. d. ii. use Percent Gross Damage (1c) and *Figure 2.*	45%	--	
C. 6. d. **iii.** If GS is reproductive use Percent Gross Damage (1c)	--	25%	
C. **2.** Stalk Damage C. 6. b. Usually deferred; if totally damaged add like stand reduction	0	0	
C. **3.** Head Loss			
C. 6. **a.** Avg # of spikelets per head	--	45	
C. 6. **b.** Avg # of kernels per spikelet	--	30	
C. 6. **c.** Avg # kernels per head (3a × 3b)	--	1350	
C. 6. **d.** Avg kernels destroyed per head	--	351	
C. 6. **e.** Avg gross Percent Head Loss (3d/3c)	--	26%	
C. **4.** Defoliation			
C. 6. **a.** Percent defoliation	50%	25%	
C. 6. **b.** Use *Table II* to determine percent yield loss	6%	10%	
C. **5.** Calculating Actual Yield Loss Due to Hail			
C. 6. **a.** Reduced stand (1d + 2)	45%	25%	
C. 6. **b.** Percent remaining crop (100% - 5a)	55%	75%	
C. 6. **c.** Head damage yield loss (5b/100 × 3e)	0	19.5%	
C. 6. **d.** Total direct loss (5a + 5c)	45%	44.5%	
C. 6. **e.** Percent remaining (100 - 5d)	55%	55.5%	
C. 6. **f.** Defoliation Yield Loss (4b/100 × 5e)	3.3%	5.6%	
C. **6.** Actual Loss (5d + 5f)	48.3%	50.1%	

*This NebGuide is based on the system developed by the National Crop Insurance Association (NCIA) (Publication No. 6851, *Grain Sorghum Loss Instructions*, Rev. 1980). Tables and illustrations reprinted with permission from NCIA.

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