Evaluating Hail Damage to Soybeans

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A hailstorm can cause yield losses in soybeans ranging from slight to destruction of the crop. Extensive research has been conducted to accurately predict the effects of hail damage on soybean yields. Results from these studies are used by hail insurance companies to assess yield losses and make adjustments to clients. The information in this Extension Circular should be valuable to producers facing replant decisions; it also may be useful in cases of insect damage.

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 divided into the following categories for assessing hail damage: stand reduction, leaf defoliation, stem damage, and pod damage. Also, any plant damage and loss will reduce the plant's ability to compete with weeds. Early damage and stand losses will cause the biggest losses from weeds.

Determining Soybean Growth Stages

Accurate determination of stage of growth is necessary to determine yield loss due to hail. Iowa State Publication *Soybean Growth and Development* (PM1945)* does an excellent job describing soybean growth stages. The growth stage information in *Table 1* is taken from this publication.

The system of soybean growth stages divides plant development into vegetative (V) and reproductive (R) stages. The vegetative stages are numbered according to how many fully developed trifoliate leaves are present. The reproductive (R) stages begin at flowering and include pod development, seed development, and plant maturation.

Determinate soybeans cease vegetative growth when flowering begins; indeterminate varieties continue to grow during reproductive stages. Most soybean varieties grown in Nebraska are indeterminate.

There will be a range of growth stages in the field at any one time. When determining the growth stage of your crop, consider a field to be in a particular growth stage when 50 percent or more of the plants are in or beyond that stage.

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*A copy of this 29-page, full-color publication can be ordered at the ***Iowa State University Extension Distribution Center*** website at *http://extension.agron.iastate.edu/soybean/production_growthstages.html* or by calling (515) 294-5247.

Table 1. The following descriptions and photos of soybean growth stages are from the Iowa State University Extension publication *Soybean Growth and Development* (PM 1945).

Note: *Click on the image to view a larger and fuller version.*

Vegetative Stages	
VE **Emergence** — Cotyledons have been pulled through the soil surface.	**VC** **Unrolled unifoliolate leaves** — Unfolding of the unifoliolate leaves.
V1 **First trifoliolate** — One set of unfolded trifoliolate leaves.	**V2** **Second trifoliolate** — Two sets of unfolded trifoliolate leaves.
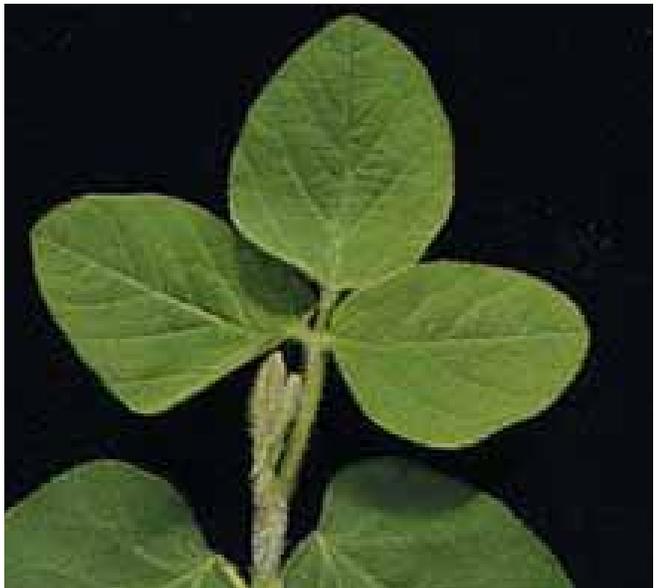
Table 1. continued

V4
Fourth trifoliolate — Four unfolded trifoliolate leaves.

V6
Sixth trifoliolate — Six unfolded trifoliolate leaves.

nth trifoliolate — V stages continue with the unfolding of trifoliolate leaves. The final number of trifoliolate leaves depends on the soybean variety and the environmental conditions.

Reproductive Stages

R1
Beginning flowering — Plants have at least one flower on any node.

R2
Full flowering — There is an open flower at one of the two uppermost nodes.

Table 1. continued

R3
Beginning pod — Pods are 3/16 inch (5 mm) at one of the four uppermost nodes.

R4
Full pod — Pods are 3/4 inch (2 cm) at one of the four uppermost nodes.

R5
Beginning seed — Seed is 1/8 inch long (3 mm) in the pod at one of the four uppermost nodes on the main stem.

R6
Full seed — Pod contains a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem.

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Table 1. continued

R7
Beginning maturity — One normal pod on the main stem has reached its mature pod color.

R8
Full maturity – Ninety-five percent of the pods have reached their full mature color.

Determining Yield Loss

Estimating yield reductions takes several steps, depending on the growth stage and the extent of damage. The following section explains the major loss categories and how to calculate them. The worksheet on page 8 includes an example showing how to determine an estimated yield reduction. These are just estimates and results will vary depending on many factors. They should be within 10 percent of the final yield reduction most of the time.

Stand Reduction

Stand reduction is a measure of the number of plants killed by the storm. The pre-storm plant population is compared to the remaining stand 7 to 10 days after the storm to determine the yield loss due to stand reduction. The hail charts have a maximum starting population of 125,000 because yield increase above this level is small for uniform plant spacing.

To determine the pre-storm population, count the original number of plants in 10 feet of row. Repeat this step several times throughout the field to get a representative sample. Now convert the average stand per 10 feet of row to plants per acre, using the following formula:

$$\frac{(\text{Avg. number of plants in 10 foot row})}{(\text{Row spacing in inches})} \times 52{,}250 = \frac{\text{Number of plants}}{\text{per acre}}$$

If the initial stand cannot be determined, go to a nearby field that was seeded with the same planter at the same population with the same seed and determine the population at that site. It is recommended that plant population be determined soon after emergence on all fields so you have this information if needed later to determine hail loss as well as make other crop management decisions.

Using the same procedure, determine the remaining live plant population.

Original and final plant populations are used to estimate yield loss due to stand reduction (*Table 2*). *Table 2* is valid through all vegetative growth stages, those before flowering begins. Stand loss during reproductive stages reduces yield proportionally, or 1 percent yield loss for each 1 percent stand loss.

If hail occurs late in the season and pods are injured, estimate the percent of damaged area on the pods. If the remaining stand is 120,000 or greater and is uniform, there usually is little field loss. Weeds may be a bigger problem with reduced competition.

Table 2. Percent field loss of soybean as affected by the amount of stand reduction (all stand figures in 1,000 plants/acre).

Original Stand	Remaining Stand											
	120	110	100	90	80	70	60	50	40	30	20	10
	-- Percent --											
125	1	3	6	10	14	18	24	30	36	44	54	65
120	0	1	5	9	13	17	23	29	35	43	53	64
110		0	3	7	11	15	21	27	33	41	51	62
100			0	3	7	11	17	23	29	37	45	59
90				0	3	7	13	19	25	33	43	55
80					0	4	10	16	22	30	40	52
70						0	6	12	18	25	35	48
60							0	7	13	20	30	45
50								0	8	16	25	41
40									0	11	23	39

Defoliation Loss

Defoliation is measured as a percentage of the leaf area destroyed by 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. Research has shown that leaf loss during vegetative stages has little effect on yield. Defoliation loss is measured only in the reproductive stages for indeterminate varieties.

To determine the amount of leaf area destroyed, examine each exposed leaf and estimate the leaf area that was present before the storm. (There is a tendency to overestimate defoliation percentage. Each leaf should be examined individually.) Evaluate 20 plants for growth stage and determine the percent leaf area destroyed. Average values are compared to *Table 3* (for indeterminate varieties) or *Table 4* (for determinates) to find the estimated percent yield reduction due to defoliation.

Table 3. Percent yield loss of indeterminant soybean varieties as affected by degree of defoliation.

Growth Stage	Defoliation (% leaf area destroyed)									
	10	20	30	40	50	60	70	80	90	100
R1-2	0	2	3	5	6	7	9	12	16	23
R3	2	3	4	6	8	11	14	18	24	33
R4	3	5	7	9	12	16	22	30	39	56
R5	4	7	10	13	17	23	31	43	58	75
R6	1	6	9	11	14	18	23	31	41	53

Table 4. Percent yield loss of determinant soybean varieties as affected by degree of defoliation.

Growth Stage)	Defoliation (% leaf area destroyed)									
	10	20	30	40	50	60	70	80	90	100
V9-V12	0	0	0	0	4	5	7	8	9	10
R1-R2	0	0	0	6	11	13	15	20	32	40
V13-V^n	0	0	0	3	8	9	11	14	19	25
R3	0	0	5	7	12	14	17	25	40	50
R4	0	5	7	9	12	16	19	30	43	76
R5	3	5	8	11	15	18	23	35	50	84
R6	2	4	6	8	11	13	17	25	36	62

Table 5. Percent yield reduction in soybeans as affected by nodes cut off (number of nodes cut off expressed as percent of total number of nodes).

Growth Stage	Percent Nodes Cut Off						
	5	15	25	35	45	55	65
V1-V^n	0	1	3	5	7	11	18
R1-R2	1	4	7	9	12	16	23
R2.5	2	6	10	14	18	24	32
R3	3	9	14	19	25	32	41
R3.5	4	12	19	27	35	43	53

Table 6. Percent yield reduction of soybeans as affected by nodes broken over (number of nodes broken over expressed as percent of total number of nodes).

Growth Stage	Percent Nodes Cut Off						
	5	15	25	35	45	55	65
V1-V^n	0	0	1	2	3	5	8
R1-R2	0	1	2	4	6	10	14
R2.5	1	3	6	9	11	16	20
R3	2	6	10	14	17	21	25
R3.5	2	8	13	18	23	28	33

Stem Damage

Stem damage is further divided into stem cutoff (stems completely cut off and removed from the plant) and stems bent or broken over. To determine the amount of stem damage, count the number of nodes above the cotyledonary node present at the date of loss. Estimate the number of nodes that have been cut off from the plant. Count the number of nodes above the break or broken over part of the stems. Separate the number of nodes cut off from the number of those on a broken over portion of the stem. Plants that are bruised but still standing are not counted. Sample 20 plants, then compare the averages with *Table 5* (for nodes cut off) and *Table 6* (for nodes broken over). These tables provide an estimate of percent yield loss due to stem damage. Percent yield losses due to stem cutoff, broken over stems, and defoliation are added together to determine the percent plant damage.

Calculating Actual Loss Due to Hail

Direct damage is the sum of the yield losses from stand reduction and pod damage (when appropriate). The plant damage — the sum of losses due to stem cutoff, broken over stems, and defoliation — is multiplied by the remaining percent stand to find the plant damage loss. Actual hail loss is the sum of direct damage and plant damage loss. Bruising is difficult to estimate early in the season but may cause problems later. It usually is wise to defer adjustments so accuracy of the loss can be improved.

The worksheet can be used to estimate soybean percent yield loss. It includes an example and a column where you can fill in your numbers. The example assumes a soybean field in the R1 stage was hail damaged. The stand was reduced from 57 plants to 40 plants per 10 feet of row. Defoliation and stem damage numbers are shown. There was no pod damage.

Soybean Yield Loss Worksheet

	Date of Storm _____	Example	Your Figures
1.	Growth Stage (Table 1)	R1	
2.	Stand Reduction		
	a) Original plants in 10 feet of row	57	
	b) Row spacing in inches	30	
	c) Original stand (in plants/acre) — (57/30) × 52,250	100,000	
	d) Final number of plants in 10 feet of row	40	
	e) Final stand (in plants/acre) — (40/30) × 52,250	70,000	
	f) Percent stand remaining — (70,000/100,000) = 0.70	70%	
	g) Yield loss (from Table 2)	11%	
	h) Yield loss due to pod damage	0%	
	i) Total direct damage (Lines 2g + 2h)	11%	
3.	Defoliation (R-stages only)		
	a) Average percent leaf area destroyed	60%	
	b) Yield loss (Table 3 or Table 4) — (for an indeterminant variety)	7%	
4.	Stem Damage		
	a) Total nodes above cotyledons — before the storm on 20 plants	100	
	b) Number of nodes cut off completely — from 20 plants	25	
	c) Percent nodes cut off (35/100) × 100%	35%	
	d) Yield loss from Table 5.	9%	
	f) Number of nodes on broken over or bent portion of stem on 20 plants	55	
	g) Percent nodes broken over (55/100) × 100%	55%	
	h) Yield loss from Table 6.	10%	
5.	Plant damage loss [(3b + 4d + 4h) × 2f/100] or [(7% + 9% + 10%) × 0.70]	18.2%	
6.	Actual Yield Loss [Direct damage (Line 2i) + plant damage loss (Line 5)] (or 11% + 18.8%)	29.2%	

These instructions are intended as a general guideline for assessing soybean yield loss due to hail damage. Individual hail insurance companies may defer final yield loss determination until later in the season. Although early season defoliation appears quite devastating, research has shown that soybean plants can recover under favorable growing conditions. These instructions are continually being revised as further research becomes available. Specific predictions should be left to trained hail adjusters.

This publication has been peer reviewed.

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