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NebGuide

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Soybean 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 soybeans.

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A hailstorm can cause yield losses in soybeans ranging from slight to total 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 consequent adjustment made to clients. The information in this NebGuide should be valuable to producers facing replant decisions, and may also 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 classified as leaf defoliation, stand reduction, stem damage, and pod damage.

Determining Soybean Growth Stages

Accurate determination of stage of growth is necessary to determine yield loss due to hail. W. R. Fehr and C. E. Caviness developed one of the most widely accepted systems for describing soybean growth stages (*Table I*). Vegetative growth stages (or V-stages) are identified by the number of nodes above the cotyledons. A node is counted when the attached leaf is completely unfurled. Reproductive stages (R-stages) occur after the plant begins to flower and are defined by the development of the flowers, pods, and seeds. Determinate soybeans cease vegetative growth when flowering begins; indeterminate varieties continue to grow during reproductive stages. Most soybean varieties grown in Nebraska are indeterminate.

Table I. Description of soybean growth stages.

Stage	Description[1]

VE Emergence (10 days to V1).[2]

VC Cotyledons (seed leaves) exposed, but no true leaves exposed.

V1 Two nodes on the main stem with fully developed leaves, beginning with the unifoliate leaf node (5 days).

V2 Three nodes on main stem with fully developed leaves (5 days).

V3 Four nodes on main stem with fully developed leaves (5 days)...(pattern continues: 5 days for V4-V5; 3 days for each following V5).

V8 Nine nodes on the main stem with fully developed leaves, beginning with the unifoliate leaf node.

R1 One flower appearing at any node (10 days to R3).

R2 Open flower at one of the two uppermost nodes on the main stem with a fully developed node (full bloom stage).

R3 Pod 0.5 cm (1/4 inch) long at one of four uppermost nodes with a fully developed leaf (9 days).

R4 Pod 2 cm (3/4 inch) long at one of the four uppermost nodes on the main stem with a fully developed leaf (full pod, 9 days).

R5 Beans beginning to develop at one of the four uppermost nodes on the main stem with a fully developed leaf. A bean is beginning to develop when it can be felt if the pod is squeezed (beginning seed stage).

[1]These descriptions were taken from Fehr, W.R. and C.E. Caviness. 1977. *Stages of soybean development*. Coop. Ext. Serv., Iowa State Univ., Spec. Rep. No. 53 (revised).
[2]Typical number of days to the next growth stage under Nebraska conditions.

Determining Losses

1. **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.

   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:

   $$\frac{\text{(ave. \# plants in 10' row)}}{\text{(row spacing in inches)}} \times 52{,}250 = \text{\# plants per acre}$$

   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 II*). *Table II* is valid through all vegetative growth stages (i.e., before flowering begins). Stand loss during reproductive stages reduces yield proportionately, or 1 percent yield loss for each 1 percent stand loss.

Table II. 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

2. **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 III* (for indeterminate varieties) or *Table IV* (for determinates) to find the estimated percent yield reduction due to defoliation.

Table III. 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 IV. 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
V13-V^n	0	0	0	3	8	9	11	14	19	25
R1-R2	0	0	0	6	11	13	15	20	32	40

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

3. **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. Keep separate the number of nodes cut off from 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 V* (for nodes cut off) and *Table VI* (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.

Table V. 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	----------Percent Nodes Cut Off----------						
Stage	**5**	**15**	**25**	**35**	**45**	**55**	**65**
V1-V^n	0	1	3	5	7	11	18
R1-R2	1	4		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 VI. 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	----------Percent Nodes Cut Off----------						
Stage	**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

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, 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.

Figure 1 is a worksheet for estimating percent yield loss showing an example calculation. This example assumes a soybean field in the R1 stage was hail damaged. The stand was reduced from 57 plants to 40 plants per 10' of row. Defoliation and stem damage figures are shown. There was no pod damage.

Figure 1. Soybean yield loss worksheet

DATE OF STORM: _____	EXAMPLE	YOUR FIGURES
1. Growth Stage (*Table I*)	R1	_____
2. Stand Reduction:		
6.a) original plants in 10' of row	57	_____
6.b) row spacing in inches	30	_____
6.c) original stand (in plants/acre) --(57/30) × 52,250	100,000	_____
6.d) final # plants in 10' row	40	_____
6.e) final stand (in plants/acre) --(40/30) × 52,250	70,000	_____
6.f) percent stand remaining --(70,000/100,000) = 0.70	70%	_____
6.g) Yield loss (from *Table II*)	11%	_____
6.h) Yield loss due to pod damage	0%	_____
6.i) Total direct damage (2g. + 2h.)	11%	_____
3. Defoliation (R-stages only):		
6.a) Ave. % leaf area destroyed	60%	_____
6.b) Yield loss (*Table III* or *Table IV*) --(for an indeterminant variety)	7%	_____
4. Stem damage:		
6.a) Total nodes above cotyledons --before the storm on 20 plants	100	_____
6.b) Number of nodes cut off completely --from 20 plants	25	_____
6.c) Percent nodes cut off (25/100) × 100%	25%	_____
6.d) Yield loss from *Table V*.	7%	_____
6.f) Number of nodes on broken over or bent --portion of stem on 20 plants	55	_____
6.g) Percent nodes broken over --(55/100) × 100%	55%	_____
6.h) Yield loss from *Table VI*.	10%	_____
5. Plant damage loss c) --[(3b. + 4d. + 4h.) × 2f/100.] or	16.8%	_____

c) --[(7% + 7% + 10%) × 0.70

6. Actual Yield Loss
   c) --[direct damage (line 2i) + plant damage loss (line 5)]
   c) --(or 11% + 16.8%) 27.8% _____

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 NebGuide is based on the system developed by the National Crop Insurance Association (Publication No. 6302, *SOYBEAN LOSS INSTRUCTION* Rev. 1985).

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