Hail Injury

(Duane R. Berglund)

Hail storms can and will cause different types of sunflower plant injury. Plant death, damage to the terminal bud, physical injury to the stalk and head, and defoliation are all types of injury that can influence yield. Variables such as hailstone size and degree of hardness, speed and density, storm duration and plant environmental status, such as whether the leaves are flaccid or turgid, influence the type and degree of crop injury. The stage of plant development is also an important factor. Figures 109 and 110 illustrate two distinct types of hail damage. As shown in Figure 109, almost all heads have been destroyed, while plants shown in Figure 108 have a high level of defoliation with the heads still attached.

One of the major factors causing differential growth and yield response is the stage at which the injury occurred. Data were obtained from a sunflower date-of-planting study at Carrington, N.D. Five sunflower hybrids sown at six planting dates between May 1 and June 20 were damaged by a hail storm on Aug. 6. Stages of plant development at the time of the storm were from R-1 to R-7. Data were taken approximately one week after the storm. Average percent defoliation from all planting dates was similar at about 26.4 percent. An average of 4.7 stalk and head stone bruises occurred per nondestroyed plant. The percent of plants destroyed and the percent of the remaining plants with heads broken off or bent over but attached decreased with plant maturity (Table 13).

Defoliation: Reduced yield as a result of defoliation depends on the amount of leaf loss and the stage at which it occurs. Stages R-1 through R-6 appear to be the most sensitive to defoliation since much of the photosynthate produced at this time is directed to head development. At early and late stages of plant development, high levels of defoliation may not have a major impact on seed yield. Approximate yield reductions due to varying degrees of random defoliation

Figure 109. Heads destroyed by hail stones.
(A.A. Schneiter)

Figure 110. Sunflowers defoliated by hail.
(A.A. Schneiter)

Table 13. Effect of hail injury on sunflower at several stages of plant development.

Date planted	Approx. development stage when injured	% Plants destroyed	Injury on nondestroyed plants		
			% Heads broken off	% Heads broken over but still attached	% Attached heads
May 1	R-7	19.2	7.6	14.3	78.0
May 9	R-6	24.1	6.3	17.1	76.6
May 21	R-5	23.9	17.1	17.8	65.2
May 30	R-3	29.6	16.1	17.0	66.9
June 10	R-2	55.7	36.4	23.7	39.9
June 20	R-1	60.7	39.9	22.6	37.6

at several stages of growth are presented in Table 14. These values are based on investigations conducted at Fargo and Carrington and are the best estimates available on the effect of defoliation for average growing conditions.

Stand Reduction: Plant death as a result of hail injury is a common occurrence, especially at early stages of development when plants are small. At early stages of plant development, before plants begin competing with each other, yield losses due to stand reduction caused by hail are not different than those that would occur due to reduced seeding rates. If the amount of stand reduction is significant and/or occurs when the plant has begun to develop and compete with neighboring plants, the remaining uninjured plants cannot compensate enough and yields will be reduced. Losses due to stand reduction increase as the plant matures since it decreases the time for remaining plants to compensate.

Approximate yield reductions from variable levels of random stand reduction at several stages of plant development are presented in Table 15. These values are based on studies conducted at Carrington and Fargo. These values represent direct stand reduction where the plants have been destroyed and no longer are competing with uninjured plants for light, water or nutrients.

Injured Plants: In addition to stand reduction and defoliation, injuries such as terminal bud removal or injury and stem breakage or bruising may occur as a result of hail. An example of a living but severely injured plant is the gooseneck shown in Figure 111.

Plants that are injured but living sometimes may reduce total crop yield more than if they had been completely destroyed since they continue to compete with uninjured plants for space, light and nutrients but do not produce an equal yield. Competition from injured plants may reduce the ability of noninjured plants to compensate for the hail-damaged plants.

The response of plants to a hail injury, such as terminal bud removal, varies depending on the stage

Figure 111. Goose-neck and stem bruising caused by hail injury. (A.A. Schneiter)

at which the injury occurs. When plants are injured in this manner at vegetative (V) stages, they usually develop branches that produce small seed-bearing heads. When injury to the terminal bud occurs during the early reproductive (R) stages, a greater percentage of the plants may die. When injury occurs near or after flowering, the plants usually remain green and continue to live but do not produce seed. A similar type of response can be evident when plants have been injured by the head-clipping weevil; however, the injury from the head-clipping weevil is a straight cut across the stalk.

The effect of bruising by hailstones is difficult to determine. If the amount of stalk bruising is such that the plant does not weaken or break during the remainder of its development prior to combine harvest, the effects on yield may be minimal. Stalk injury of such magnitude or at a specific location on the plant

Table 14. Approximate percent yield reduction from the indicated percent total leaf area destroyed at several stages of sunflower plant development.

	Percent Leaf Area Destroyed																			
Stage *	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
	- Approximate percent yield loss -																			
V-E to V-3 (6-26 days)	0	0	0	1	1	1	2	2	2	3	3	3	4	4	5	7	8	10	12	15
V-4 to V-5 (27-29 days)	0	0	0	1	2	2	2	2	3	4	4	4	5	5	7	9	12	14	17	21
V-6 to V-8 (30-34 days)	0	0	0	1	2	2	2	2	3	4	4	5	6	6	8	10	14	16	19	22
V-9 to V-11 (35-39 days)	0	0	1	2	3	3	4	4	4	5	5	5	5	7	9	11	14	17	21	24
V-12 to V-(N) (40-43 days)	0	1	2	3	4	4	5	5	5	6	7	7	9	12	15	18	22	26	31	35
R-1 (44-51 days)	0	2	3	4	5	6	6	6	7	7	8	9	13	16	20	24	29	34	40	47
R-2 (52-58 days)	0	2	3	4	6	8	9	10	11	12	13	14	16	18	23	30	37	45	55	65
R-3 (59-67 days)	0	2	5	8	10	15	17	19	21	24	28	32	38	44	51	59	68	78	88	99
R-4 (68-75 days)	0	2	4	5	7	10	12	12	15	18	22	27	34	39	45	53	61	72	85	99
R-5 (76-84 days)	0	1	2	3	5	7	8	10	13	16	20	25	32	37	43	49	55	67	78	90
R-6 (85-92 days)	0	0	1	1	3	3	4	8	11	15	19	24	29	35	41	46	53	63	72	80
R-7 (93-102 days)	0	0	1	1	1	3	5	7	8	10	11	13	14	16	17	18	19	20	21	22
R-8 (103-110 days)	0	0	1	1	1	2	2	3	4	5	6	7	7	8	9	9	10	10	10	11
R-9 (111-maturity)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Number of days after planting for development to a specific stage will vary significantly depending on environmental conditions and the hybrid. Interpolating percent of loss between stages may be necessary.

resulting in nonharvestable heads certainly would have an effect on yield. Physical injury by hailstones on the back of a sunflower head at or near anthesis can result in Rhizopus head rot, especially if wet or humid conditions are present. Physical injury can occur as a result of bird, insect or hailstone damage. Increased dead plant tissue resulting from a hail storm, especially on the back of a head, may increase the chance of white mold infection.

Table 15. Approximate percent yield reduction from the Indicated percent stand reduction at several stages of sunflower plant development.

	Percent Stand Reduction																			
Stage *	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
	- Approximate percent yield loss -																			
V-E to V-3 (6-26 days)	0	1	2	3	4	8	10	11	12	12	13	14	16	18	24	32	43	58	77	100
V-4 to V-5 (27-29 days)	0	1	2	3	4	8	10	11	12	12	13	14	16	18	24	32	43	58	77	100
V-6 to V-8 (30-34 days)	0	1	2	3	4	8	10	11	12	12	13	14	16	18	24	33	43	58	77	100
V-9 to V-11 (35-39 days)	0	1	2	3	4	8	10	11	12	12	13	14	16	19	25	33	44	59	77	100
V-12 to V-(N) (40-43 days)	0	1	2	3	4	8	10	12	12	13	14	15	17	21	27	35	46	60	78	100
R-1 (44-51 days)	1	2	5	9	12	14	15	16	17	18	19	21	25	29	35	43	53	66	81	100
R-2 (52-58 days)	2	3	7	9	13	17	19	21	23	24	26	28	31	35	40	47	57	68	83	100
R-3 (59-67 days)	4	7	11	13	15	17	21	24	27	29	31	34	37	41	46	53	61	72	84	100
R-4 (68-75 days)	5	10	14	18	20	22	25	27	29	32	35	38	42	47	53	60	68	77	88	100
R-5 (76-84 days)	5	10	14	19	20	24	28	31	35	39	42	45	49	54	60	66	73	81	90	100
R-6 (85-92 days)	5	10	15	19	22	26	31	35	39	44	48	52	56	62	68	73	79	85	93	100

*Number of days after planting for development to a specific stage will vary significantly depending on environmental conditions and hybrid. It may be necessary to interpolate percent of loss between stages.