Stem Breakage

SIMULATING HAIL DAMAGE

To Spring Wheat

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About 60 percent of the total crop hail insurance written in North Dakota is on wheat. In the 22-year period from 1948 to 1969, $2,300,000 was paid annually to North Dakota farmers for wheat damage by hail. An equitable and more accurate financial adjustment of hail damage is beneficial to both farmers and hail insurance companies by keeping rates at a reasonable level and by paying only actual losses.

Simulated hail treatments applied to both spring and winter wheat have been conducted by other researchers previous to this study. The location of the break on the stem of wheat has considerable effect on the resulting yield loss (1, 3). Stem breakage either near the spike (head) or near the soil surface caused the greatest yield loss (1, 2, 3). The stage of growth of the wheat when damage occurs as well as the environmental conditions which follow the damage are of considerable importance in determining the severity of yield loss (1, 2, 3, 4, 5). Results of yield loss from studies conducted under different environments may not be applicable to the conditions encountered in the spring wheat area, hence this study was initiated.

This study was conducted to determine the effect of various degrees of simulated hail damage at different stem heights and at specific stages of growth at three locations in North Dakota: Fargo, Carrington and Dickinson.

Methods

Hail damage was simulated by grasping the wheat plant stem between the fingers and bending it until the spike (head of wheat) hung toward the ground. Only rarely did this treatment break the spike completely from the stem.

Stem breakage treatments were applied at five stages of growth: boot, bloom, milk, soft dough and hard dough, when half of the plants treated

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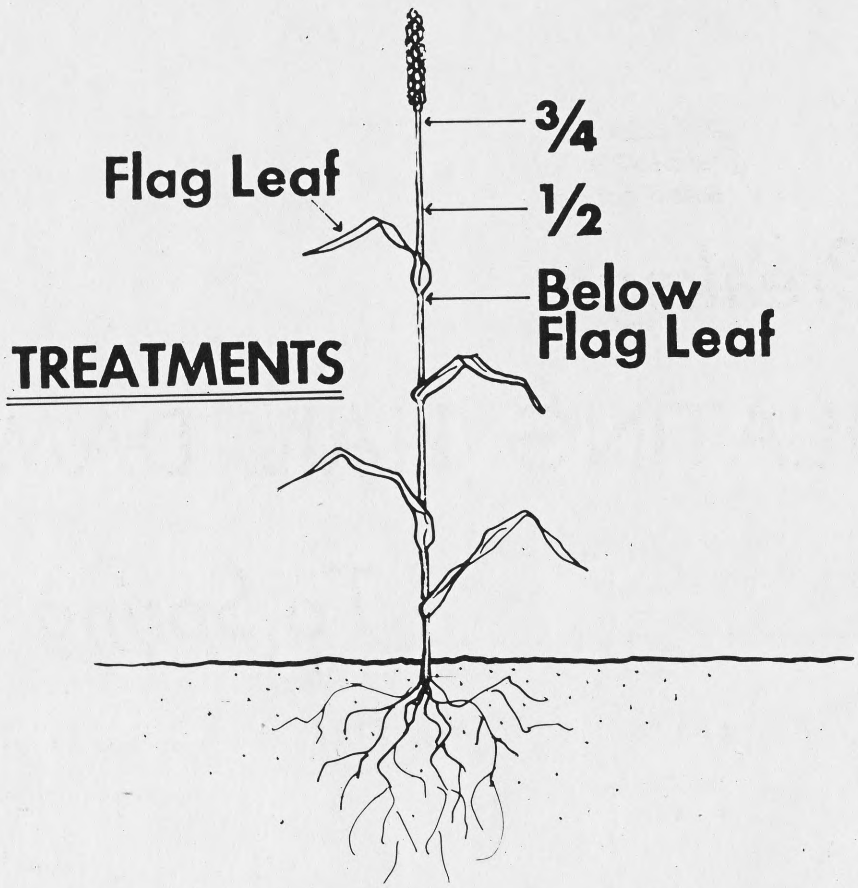

Figure 1. Illustration of the approximate breakage heights on the stem of spring wheat applied in the simulated hail study conducted at Fargo, Carrington and Dickinson, N. Dak., 1968-71.

had reached or exceeded each stage of development. Four treatments were applied at each stage of growth as follows: (1) untreated check, (2) break 1/3 of the stems below the flag leaf, (3) break 2/3 of the stems below the flag leaf, and (4) break all of the stems below the flag leaf.

An additional six treatments were applied at all stages of growth from bloom to hard dough: (5) break 1/3 of the stems 1/2 of the distance from the flag leaf to the spike, (6) break 1/3 of the stems 1/2 of the distance from the flag leaf to the spike, (7) break 2/3 of the stems 1/2 of the distance from the flag leaf to the spike, (8) break 2/3 of the stems 3/4 of the distance from the flag leaf to the spike, (9) break all of the stems 1/2 of the distance from the flag leaf to the spike, and (10) break all of the stems 3/4 of the distance from the flag leaf to the spike (Figure 1).

Each experiment was replicated four times, and each plot consisted of four eight-foot rows. All four rows of the plot received the same treatment, but only the center two rows were harvested for yield. A four-inch stubble was left.

Two years (1969 and 1970) of data were collected from Fargo and Carrington, while four years (1968 through 1971) of data were collected at Dickinson. Carrington had two experiments grown each year, one with breakage treatments only and one with 1/2-inch of water sprinkled on forcefully with a hose after breakage treatments to simulate rainfall which usually accompanies natural hail. The Fargo and Carrington sites were not usable for this research in 1968 due to severe lodging and hail, respectively. The experiment was grown for an extra year (1971) at Dickinson because the yield losses varied widely during different years. The variety, Chris, was used in 1968, but it lodged severely, so Waldron was substituted from 1969 through 1971.

Data were collected on test weight, 1000 kernel weight, and per cent protein (Udy technique) of grain from the harvested portion of the plot used to determine yield. Kernels per spike were determined from the border row of the plot. Ten spikes were collected from each plot in proportion to the treatment applied. For example, if a 2/3 treatment

Figure 2. Wheat plants after a 2/3 intensity breakage treatment applied approximately 1/2 of the distance from flag leaf auricle to the spike (number 7 in materials and methods at the bloom stage of growth).

Figure 3. Wheat plants with the treatment which resulted in the most severe yield loss imposed at hard dough stage of growth (all stems were broken ¾ of the distance from the flag leaf auricle to the head.)

Figure 4. A 2/3 intensity treatment imposed on hard dough stage of growth just below the flag leaf auricle, simulating a lower stem break made by hail.

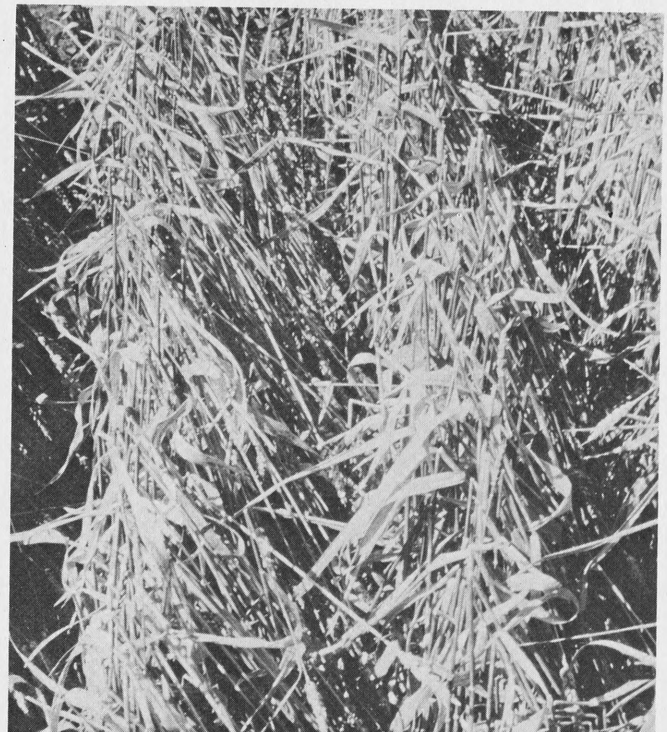

Figure 5. All the stems broken just below the flag leaf auricle. In general, the heads were at least two to three inches above the ground after treatment.

Table 1. Effect of stem breakage (100% intensity) applied at various stages of growth on grain yield.

Stage of growth	Per cent yield reduction[1] Fargo 1969-70	Carrington 1969-70	Dickinson 1968-1971	Stage of growth average
Boot	39	28	33	33
Bloom	33	40	51	42
Milk	51	57	51	53
Soft dough	32	47	39	39
Hard dough	21	33	36	30
Location average	35	41	42	
LSD .05[2]	8	8	7	

[1]Averaged across breakage heights.
[2]Least significant difference (LSD) indicates the amount of difference between two means to be confident that in 95 out of 100 times this value is not due to chance alone.

was applied, seven treated and three non-treated spikes were collected. The total number of kernels was counted and the average number of kernels per spike was calculated. Fallen spikes were determined by counting the number of spikes at bloom stage in a staked two-square-foot area before treatments were applied. The number of spikes remaining were determined by counting the same area just before harvest.

Table 2. Effect of the position of the break on the stem on per cent reduction of yield caused by 100% stem breakage averaged over years.

Treatment	Per cent yield reduction — Stage of growth: Boot	Bloom	Milk	Soft dough	Hard dough	Average
	Fargo 1969-70					
Below flag leaf[1]	39[2]	28	39	16	15	27
1/2 above flag leaf[1]		37	54	29	23	36
3/4 above flag leaf[1]		35	61	51	24	43
	Carrington 1969-70[3]					
Below flag leaf	28	39	42	37	25	34
1/2 above flag leaf		42	62	49	33	47
3/4 above flag leaf		40	68	55	41	51
	Dickinson 1968-1971					
Below flag leaf	33	42	34	32	34	35
1/2 above flag leaf		51	50	39	28	42
3/4 above flag leaf		60	69	45	47	55

[1]See Fig. 1 for clarification of breakage points on the stem.
[2]If per cent yield reduction at any other treatment intensity is desired, multiply the per cent yield reduction by the per cent broken stems. For example, to determine loss at 50% stem breakage for boot stage of growth at Fargo (39% loss) would be .5 x 39 equals 19.5% yield loss.
[3]Carrington data are an average of dryland and wetted experiments.

Discussion

Greatest yield reduction, from most to least, resulted when stems were broken respectively in the milk stage, followed by bloom, soft dough, boot, and hard dough stages (Table 1). Location differences were detected, since yield reduction was greatest at Dickinson, followed by Carrington and Fargo. Individual location stage of growth differences were found. For example, boot injury treatments at Fargo reduced the yield more than hard dough treatments, while the opposite was found at Carrington.

In general, the degree of yield reduction as a result of stem breakage depends upon the position of the break on the stem. The closer the stem was broken to the spike, the greater the loss in yield at all three locations and at all stages of growth (Table 2).

The higher breaks on the stem (1/2 and 3/4 of the height) caused the spikes to be poorly anchored, and with constant movement in the wind the spikes dropped from stem or straw to the ground. The stem breakages below the flag leaf (Figure 1) caused the spikes to fall within the protective canopy of leaves and helped to prevent the spikes from being blown from the stems (Table 3).

Table 3. Effect of different stem breakage positions at 100% intensity on the percentage of fallen spikes.

Treatment	Per cent fallen spikes[1] — Stages of growth: Bloom	Milk	Soft dough	Hard dough	Treatment average
	Fargo 1969-70				
Below flag leaf	14	9	22	15	14
1/2 above flag leaf	21	18	13	18	18
3/4 above flag leaf	21	34	31	27	27
	Carrington 1969-1970[2]				
Below flag leaf	14	10	10	10	11
1/2 above flag leaf	23	10	11	8	13
3/4 above flag leaf	23	32	16	35	26
	Dickinson 1968-1971[3]				
Below flag leaf	11	16	5	14	11
1/2 above flag leaf	33	5	12	11	15
3/4 above flag leaf	40	51	19	16	31

[1]Reported for the treatment where all the stems were broken.
[2]Carrington data are the average of dryland and wetted experiments.
[3]Dickinson 1970 data were not included because there were no significant differences.

Also, stem breakage below the flag leaf has more protection and support around the break because the stem is enclosed by the leaf sheath.

Environmental conditions following a breakage treatment had considerable effect on the number of spikes lost from the stems. The stages of growth had little effect on the per cent fallen spikes, except that those treated in bloom or milk stage were exposed to the possibility of wind for a longer time. This effect was most evident at Dickinson. Because of the less flexible stem and heavier spike at hard dough stage, compared to the other stages of growth, any wind which occurred after this treatment generally resulted in heavy yield loss due to fallen spikes. However, the time interval from stem breakage to harvest at the hard dough stage is relatively short compared to the other growth stages.

The data obtained from these studies indicate that the milk stage of growth is a very critical period in kernel development. Restriction of the translocation of nutrients to the spike at this stage of growth due to stem or straw breakage greatly reduces test weight, kernel weight and yield. Stem breakage at the bloom stage of growth more severely reduces the number of kernels per spike than any other stage of growth, but kernel weight and test weight are not as severely affected as at either milk or soft dough. Stem breakage at the hard dough stage generally reduces yield by the loss of harvestable heads rather than affecting weight or number of kernels per spike.

Since a straight-line relationship existed between loss in yield and increasing intensity of stem breakage, adjustment factors may be readily adapted for number of broken stems. These factors also must include the stage of growth when the damage occurred and leaf damage factors which were not evaluated in this study.

The position of the breakage on the stem in relation to the spike also is quite important. At each location and in every experiment, stem breakages near the spike (3/4 above flag leaf) reduced yield more than any other type of stem breakage. Recognition of the importance of these high stem breaks and their expected losses and of differences caused by the effects of the environments at different locations within the state should aid both the farmers and insurance adjustors to reach more equitable loss adjustment. Stem breakage near ground level was not evaluated, since previous work (1) had indicated complete loss of the spike if it was on the ground.

The stages of growth, when stem breakage treatments were applied, had a considerable effect on the number of kernels per spike, test weight, kernel weight, and per cent protein (Table 4). Treatments applied in bloom and to a lesser extent in milk stage of growth severely reduced the number of kernels per spike. Treatments applied in milk and to a lesser extent in soft dough stage reduced test weight and kernel weight the most. Per cent protein was increased from stem breakage inflicted during the milk stage. The increase in per cent protein possibly was caused by a reduction in the translocation of carbohydrates to the spike, which also reduced kernel weight and test weight.

Table 4. The average effect of stem breakage applied at various stages of growth[1] on kernels/spike, test weight, kernel weight, and per cent protein from Fargo and Carrington, 1969-70.

	Kernels/ spike	Test weight lbs/bu	1000 kernel weight(g)	Grain protein %
Bloom	23.4	59.1	34.2	16.5
Milk	25.5	55.8	30.8	17.7
Soft dough	28.1	57.3	31.8	16.6
Hard dough	28.6	58.9	33.2	15.8

[1]Characters were averaged over breakage positions and intensities.

Conclusions

This study was conducted to determine the effect of stem breakage on yield and other characteristics at three locations in North Dakota. The different breakage positions on the stem were of special concern. Each breakage position on the stem caused different yield reductions. At each breakage position the loss in yield was linearly proportional to an increasing intensity of stem breakage. Yield reduction factors for any per cent stem breakage are relatively easy to predict if weather conditions are normal. Because of the variation in weather which follows hail damage, the results may vary from year to year and certainly from location to location.

References

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