Evaluation of Potential Farmers Benefits from Hail Suppression

Steven T. Sonka and Craig W. Potter

The Great Plains wheat farmer must accept many production and price risks. One of these production risks is the possibility that a severe hail storm will damage his growing crop. Being typically a localized event, a hail storm can be particularly damaging to the farmer's net income because a hail occurence can severely reduce one farmer's production but not visibly affect the price received for the remainder of his output. Another unpleasant aspect of the hail hazard is its variability of occurrence. Crop losses due to hail may be a minor hazard when expressed as an annual average over a number of years but an individual farming operation can suffer a severe setback if a large hail loss occurs in a particular year.

Historically, hail has been a particularly significant hazard for farmers in the wheat producing states of the Great Plains. Boone estimates that of the ten leading states for crop damage from hail, six (Texas, Nebraska, Kansas, North Dakota, South Dakota, and Colorado) are Plains states. He estimates that over 40 percent of the national crop loss from hail occurs in these six states.

Because of the negative impacts of hail loss, remedies have been sought to reduce the magnitude of damage from hail storms. One remedy proposed has been that of weather modification, or hail suppression [Changnon and Morgan]. This strategy involves cloud seeding, typically by airplane in this country, in an attempt to alter the damage producing characteristics of hail storms. Past modification efforts have often been local in nature although South Dakota has had experience with a 'statewide' program of hail suppression [South Dakota Division of Weather Modification]. But many people question the effectiveness of weather modification efforts and some fear that such efforts may have negative impacts. Therefore, efforts to initiate hail suppression programs are often subjects of controversy [Farhar].

Before initiating such controversial programs, information is needed as to the benefit to farmers of such programs relative to the other responses the farmer can take in regard to potential hail damage. It is this question which the study discussed in this paper addresses.

Steven T. Sonka is an assistant professor and Craig W. Potter is a research assistant in the Department of Agricultural Economics, University of Illinois, Urbana.

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The Study

This paper describes an attempt to quantify the potential benefits to farm operators if hail suppression programs, of varying degrees of success, were adopted in an agricultural region. Two areas, one in northwestern Kansas and one in southwestern North Dakota, in the Great Plains wheat belt were selected for analysis. These areas were selected because wheat, which is susceptible to hail damage, is an important crop in these regions and hail insurance records indicate that these areas suffer severe crop damage from hail.

The analysis basically consists of simulating yearly net income estimates for potential strategies the wheat farmer can select to reduce losses from hail. Although numerous specific strategies are tested in the analysis, three basic options can be described. They are:

1) No insurance, no hail suppression: For this option the farmer elects not to participate in a crop insurance program and a hail suppression program is not in operation in his area.

2) Crop insurance: Two types of crop insurance are considered.

a. Hail insurance, covering only crop losses from hail damage, is available from commercial insurance companies. Various specific policies are available under this option. They include insuring for the expected value of production, insuring for the expected cost of production, and deductible options of 30, 40, or 50 percent.

b. All-risk insurance is available from some commercial companies and from the Federal Crop Insurance Corporation. The FCIC program, which covers crop loss from a number of production hazards including hail, was adopted for this study.

3) Hail suppression: No estimate of the likely success of a hail suppression program is attempted here. Rather, estimates of net income are generated assuming specified levels of success are achieved. Three levels of reduction in crop damage due to hail are considered: 20, 50, and 80 percent. In addition, three levels of rainfall are associated with each level of crop damage reduction. These rainfall alternatives are -10 percent change, no change, and a +10 percent change in rainfall during the hail season.[1]

In addition to the three options just discussed, disaster payments as provided in the 1973 Agricultural and Consumer Protection Act were included for every strategy considered [Agricultural Stabilization and Conservation Service]. These payments are available with no direct cost to the farmer.

The study creates net income estimates for each strategy from the perspective of a farmer contemplating his next season production decisions. Each strategy has a specific net income equation associated with it. For each area, the most general of these income statements would be:

$$NI^t = (AP * Y_i^t * TS) + P_{hi}^t + P_{ar}^t + P_{dp}^t - PC - C_{hi} - C_{ar} - C_{hs}$$

where: t = year of the simulation series (t = 1 in 1926 through 49 in 1974); NI^t = net income to a crop-share tenant in the t-th year;[2] AP = 1972-74 average price for wheat: basis Minneapolis for North Dakota and Kansas City for Kansas [U.S. Department of Agriculture]; Y_i^t = estimated yield for the t-th year given 1973 technology and the ith strategy (Y_i^t varies by non-hail caused yield fluctuations and the level of hail suppression assumed);[3] TS = crop-share tenant's portion of the crop = 2/3's of the production of each area [Commodity Economics Division, USDA]; p_{hi}^t = payment from hail insurance given the t-th year hail loss [Fosse]; p_{ar}^t = payment from all-risk crop insurance given the t-th year yield [Sharp]; p_{dp}^t = tenant's share of the federal disaster payment given the t-th year yield [Agricultural Stabilization and Conservation Service, USDA]; PC = tenant's cost of production [Commodity Economics Division, USDA]; C_{hi} = premium for hail insurance [Fosse]; C_{ar} = premium for all-risk insurance [Sharp]; and C_{hs} = cost of hail suppression, specified equal to \$1/harvested acre [Henderson].

Estimation Results

For each of the several strategies considered, net income estimates are generated given a 1973 technology base and yearly yield fluctuations specific to the period from 1926 to 1974. These estimates are averaged for the period and, in addition, estimates of variability of income are determined. For purposes of presentation, the variability coefficients discussed will be the standard deviation of each net income series, the lowest annual income estimated for each strategy and the estimated number of years out of 100 the farmer could expect to break-even. Estimates for both areas are presented in

[1] Here weather modification is assumed to be designed to suppress hail with any rainfall changes as side effects. Therefore, changes in rainfall are restrained to occur in the months from April through August in Kansas and from May to August in North Dakota.

[2] Only returns to the crop share tenant are analyzed in this paper as a simplifying device eliminating the need to determine a proper charge for land. The effects of the various options on the landowner can be expected to follow the same pattern as exhibited by returns to the crop share tenant, however.

[3] Y_i^t is generated by regressing yields for 1926 to 1974 on simple trend variables representing technology. The percentage error between the predicted and actual yields are then combined with the yield estimate given 1973 technology to give the base series of yields assuming 1973 technology but accounting for yearly fluctuations. A detailed presentation of this process is given by Potter.

Table 1. Estimation results for the northwestern Kansas and southwestern North Dakota areas

Strategy		Kansas				North Dakota			
		Average income	Standard deviation of income	Lowest annual income in period	Years to break even[1]	Average income	Standard deviation of income	Lowest annual income in period	Years to break even[1]
		($/ac)	*($/ac)*	*($/ac)*	*number*	*($/ac)*	*($/ac)*	*($/ac)*	*number*
Hail Insurance									
A No hail insurance, no hail supression		25.58	29.92	-25.56	80	7.52	20.60	-26.42	64
B Value of production		25.25	26.75	-22.03	83	7.08	18.68	-26.20	65
C 40% deductible on value of production		25.91	27.15	-15.75	83	7.42	19.04	-21.88	65
D Cost of production		25.44	26.95	-18.48	83	7.18	18.46	-24.82	65
E 40% deductible on cost of production		25.78	28.01	-14.88	82	7.44	19.22	-21.47	65
F All-risk crop insurance		24.86	28.89	-15.68	81	7.13	19.21	-13.23	64
G All-risk and cost of production hail insurance combined		24.71	26.58	-20.82	82	6.69	18.09	-17.94	65
Hail Suppression Possibilities									
Change in rainfall[2]	Reduction in crop damage								
H 10% decrease		22.60	29.34	-24.70	78	7.41	19.66	-20.66	64
I no change	20%	25.74	29.54	-21.40	81	7.62	19.70	-21.03	65
J 10% increase		28.47	30.21	-19.31	83	7.83	19.74	-21.39	66
K 10% decrease		24.34	28.94	-17.67	80	9.18	18.85	-20.66	69
L no change	50%	27.35	29.29	-14.68	82	9.40	18.90	-21.03	69
M 10% increase		30.11	29.94	-12.74	84	9.62	18.97	-21.39	70
N 10% decrease		25.98	28.86	-17.67	82	11.34	19.08	-20.66	72
O no change	80%	29.12	29.06	-14.68	84	11.56	19.19	-21.03	73
P 10% increase		31.88	29.77	-12.74	86	11.69	19.41	-21.39	73

[1] Estimated number of years out of 100 that the farmer could expect to break even.

[2] The yield effects of changing rainfall in the growing season months were adapted from Potter. The original equations for these coefficients related yearly yields to a number of rainfall, temperature, and technology trend variables for each state.

table 1. For each area only the more attractive strategies for each type of option are presented.

The results presented in table 1 depict the economic benefits, both in terms of average income and variability of income, of potential hail suppression capabilities. Rainfall levels were also varied because of the possibility that hail suppression programs could alter rainfall [Changnon and Morgan]. For this analysis township hail-loss data were used to reduce as much as possible the averaging effect of aggregate data. The specific townships selected have historically high levels of crop damage from hail. From the years 1926 to 1974 crop damage to wheat averaged 12% in the Kansas township and 11% in the North Dakota township, with both townships suffering total losses from hail in one year [Fosse].[4] Therefore the data from these townships should make a strong case for hail suppression – if that case can be made at all.

The goal of participating in insurance is to substitute a known but smaller, loss (the premium) for an uncertain, but larger, income loss due to an adverse event. The insurance strategies presented here seem to accomplish that goal. The standard deviation of the income series for each insurance strategy is lower than for the no hail insurance, no hail suppression situation, Strategy A. Some of the

[4] These areas also suffer severe yield fluctuations because of factors other than hail. For the 1926-74 period, wheat yields in the North Dakota area averaged 14 bushels per acre with a standard deviation of 7 bushels while yields in the Kansas area averaged 17 bushels per acre with a standard deviation of 10 bushels [North Dakota Statistical Reporting Service, Kansas Crop and Livestock Reporting Service].

insurance strategies do involve a decrease in expected average income, however. But when both the mean and standard deviation are compared for each strategy (as done to compute the number of years out of 100 the farmer can expect to breakeven), the farmer generally can accept less risk by insuring. And the options involving all-risk insurance result in higher estimates of the lowest annual income occurring in the simulation period. This higher estimate means the farmer would either not have to deplete cash reserves, or borrow, as much in a bad year as he might with Strategy A.

But insurance is expensive. With non-insurance variable costs of production of about $40 per acre, hail insurance on the full value of production is more than $6 per acre in the North Dakota region and more than $8 per acre in the Kansas region. The all-risk option is estimated to have a cost of slightly less than $3 per acre. It should be noted that for purposes of this analysis, hail insurance was assumed to be purchased each year of the period. But after a dry winter, many farmers choose not to participate in hail insurance programs, fearing that crops will not be worth enough to insure. Inability to model this behavior probably means that the attractiveness of hail insurance policies is understated in this report.

The data of table 1 clearly show that the benefit of a hail-suppression program to the individual farmer is directly related to the effectiveness of that program. Ignoring rainfall effects, a 20% reduction in crop damage due to hail only slightly increases average income and does not improve certainty of income relative to options presently available. But the 50 and 80 percent effectiveness levels (Strategies L and O) result in higher average incomes and more certain incomes than do presently available options, especially for the North Dakota area.

Any change in rainfall is shown to very much alter the benefits from hail reduction. A 10 percent increase in rainfall makes the 20 percent crop damage reduction level superior to any of Strategies A through G. Decreasing rainfall 10 percent, however, can overcome the income benefit of the 20 percent crop damage reduction to make strategy H inferior to strategies A through G. And for the Kansas area, a 10 percent decrease in rainfall more than offsets the income gain of the 50 percent reduction in crop damage.

All of the 80 percent reduction in crop damage situations would have greater expected incomes and less variability of income (as measured by the years expected to breakeven figure) than Strategy A. However, the income and certainty gains are much more pronounced for the North Dakota area than for the Kansas area.

An interesting side aspect of the analysis deals with the magnitude of disaster payments. Using current provisions of the 1973 Act and yield fluctuations based on historic patterns, disaster payments to the tenant are estimated to average $1.69 per acre for the North Dakota area and $1.80 per acre for the Kansas area—for each year of the simulation period. This program reduces the value of any hail suppression effort to the producer because as the wheat yield is increased, the disaster payment will tend to be reduced. In addition to the average effects presence of this program acts to reduce variability of income. For example, if the provisions of this program would not have been included, the standard deviation of the income series for the no insurance, no hail suppression option, strategy A, would have risen to $22.73 per acre in the North Dakota area and to $32.50 per acre in the Kansas area. These are increases of 10 and 9 percent respectively. This analysis assumed the disaster program was in effect for all options; if, however, this program was not available the relative attractiveness of the insurance and suppression programs with respect to income variability would be enhanced.

Summary

The study discussed here investigates the possible benefits of specific hail suppression effectiveness levels (in terms of reduced crop damage from hail and altered rainfall) for wheat farmers in the Great Plains region. These benefits are compared to net income levels of options presently available to the farmer for reducing the risk aspects of the hail hazard.

The results of the analysis indicate that the farmer can reduce variability of income by participating in insurance programs. But at a cost of lowered average income. This relationship holds for a variety of hail insurance programs and for all-risk crop insurance.

The results reported in this paper stress the need for accurate estimates of the potential effects of a hail suppression program before the benefits to the farmer of that program can be ascertained.[5] For example, in either area studied an operational program which resulted in 20 percent decreases in crop damage due to hail would not be superior to presently available options–unless coupled with a 10 percent increase in growing season rainfall. But greater reductions in crop damage could involve relatively sizeable benefits, both for average income and certainty of income, especially in the southwestern North Dakota area.

[5]The most recent effort to quantify the potential effectiveness of hail suppression with current technology was done by Changnon and Morgan. They indicate that in the Great Plains region hail damage reductions of 25 to 35 percent along with 0 to 10 percent increases in hail season rainfall may currently be expected. These expectations are bracketed by Strategies I, J, and L in this paper. The potential value of improvements in hail suppression technology is depicted by the higher average income levels of those strategies with greater effectiveness levels than currently attainable.

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