

A  
review  
of  
research  
on . . .



*Colorado experiences crop and property damage every year from hailstorms. This thunderstorm produced severe hail damage northeast of Fort Morgan on 27 June 1959.*

- ◀ Can anything be done to prevent hail?
- ◀ Does cloud-seeding for hail suppression really do any good?
- ◀ If hail is reduced by cloud seeding, doesn't it mean that precipitation is also reduced?
- ◀ If we have a cloud-seeding program, are we getting our money's worth?

BY DR. RICHARD A. SCHLEUSENER\*

**T**HESE questions are of direct economic importance, particularly in northeastern Colorado, where hail losses are higher than in any other location in the United States. These questions provide the background for research which has been conducted at Colorado State University on the hail problem. The research be-

gan with an attempt to evaluate a cloud-seeding program in northeastern Colorado in 1959. Research is continuing in order to learn more about the characteristics and formation of hail. It is hoped that a better understanding of the characteristics and formation of hail might lead eventually to effective techniques of weather modification

to reduce hail damage and to increase precipitation.

#### **Hail Suppression—Is It Effective?**

In 1959 a large-scale attempt was made to reduce hail damage in northeastern Colorado. In an area of about 3400 square miles, potential hail producing clouds were seeded with silver iodide crystals

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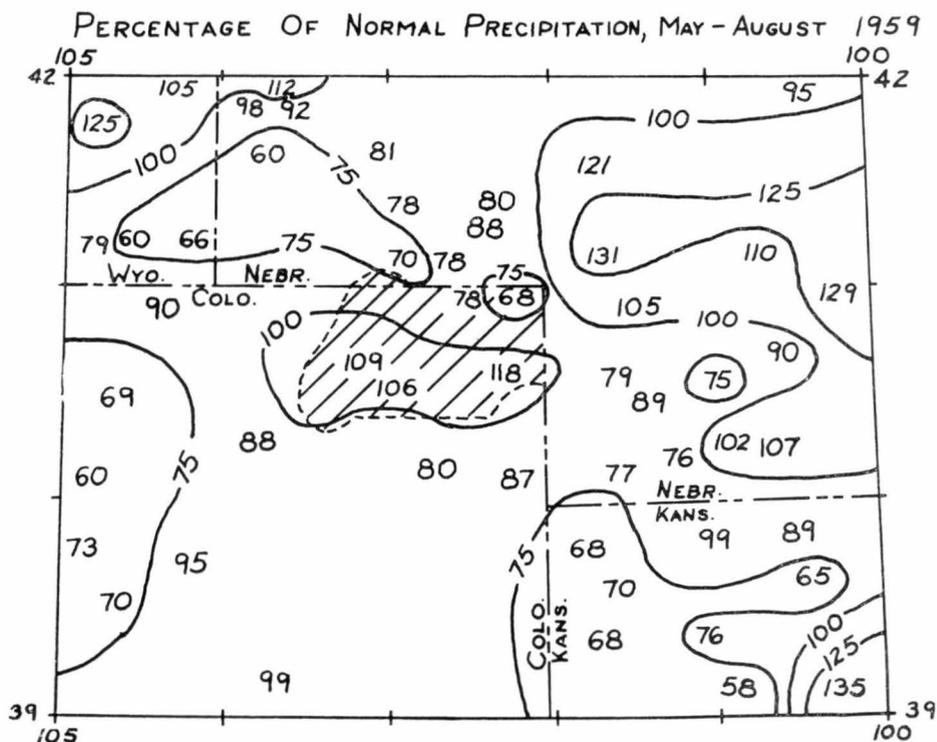
by a commercial weather modification firm in order to attempt to reduce hail damage. Five aircraft and about 125 ground generators were used. Colorado State University was asked to make an independent evaluation of this operation. Financial support for the study was provided by a grant from the National Science Foundation.

Information for the evaluation was obtained from a number of sources. Individual farmers were requested to give reports by mail on hail and rain. About 250 "hail indicators" consisting of aluminum and styrofoam were located in the study area and examined regularly in order to get objective measurements of hail damage. The weather modification firm cooperated fully by giving information on locations and times of generator operations. Additional information was available from historical records of crop damage from Great Western Sugar Company and from records of the U. S. Weather Bureau. Conventional methods of photography, and "time-lapse" motion pictures were used to study the appearance of the clouds.

Using the information thus obtained, comparisons were made between hail events that were considered to have been seeded and those considered not to have been seeded.



Time-lapse photography is used as a tool to study cloud formations that produce hail.



Percent of normal precipitation for the area included in the cloud-seeding program in 1959 (shown by cross-hatching) and adjacent areas for the period May—August, 1959.

#### Results of the Evaluation Study

Analysis of these data does not provide a clear-cut "yes or no" answer on the effectiveness of hail suppression, but does provide some preliminary results. The chart shows a comparison of hail impact energy values for seeded and non-seeded hail events. "Impact energy" gives a measure of how hard a given

area is "hit" by hail. The hail impact energy values were estimated from measurements of the number, size, and shape of dents on the hail indicators. (This method also considers the damaging effect of wind-driven hail, since elongated dents are produced on the indicators by wind-driven stones.) It has been observed in the field that crop damage to wheat, corn, or sugar beets becomes noticeable when the hail impact energy exceeds about 20 ft.-lbs. per sq. ft., and becomes severe or complete when greater than about 100 ft.-lbs. per sq. ft. The chart shows that the seeded cases show slightly smaller energy values than the non-seeded cases for the 1959 season. This can be interpreted as indicating less crop damage for the seeded cases. However, the differences are small, so the results should be considered as tentative only.

#### What About Precipitation?

A shortage of precipitation was a serious problem in eastern Colorado in the summer of 1959. The map based on official Weather Bureau Records, shows that the southern part of the area included in the

cloud-seeding program received more than the average amount of precipitation, and more than surrounding areas.

Further studies were made of the effect of the cloud-seeding program on precipitation amounts by comparing the amounts of rainfall received inside the seeded area ("target" stations) with the rainfall received at stations outside the seeded area ("control" stations). The amounts received in 1959 at these "target" and "control" stations were then compared with what has occurred in previous years when no cloud seeding was taking place. This method of comparison shows that the amounts of precipitation received in 1959 at the "target" stations were higher than would have been expected for eight out of eleven periods in 1959 when comparisons could be made.

These comparisons give an indication of an increase in precipitation associated with the cloud seeding program in 1959.

#### Meaning in Dollars and Cents

While it is not possible to make any estimate of the magnitude of the effects of cloud seeding on hail and precipitation, it is evident that even a small effect has great economic importance. Based on historical records of hail damage from the Great Western Sugar Company, crop-hail insurance rates, and records of crop production, it is estimated that a 10 percent reduction in hail damage to winter wheat alone in Logan, Sedgwick and Phillips counties would reduce average annual losses from hail by about \$260,000. A similar analysis indicates that a 10 percent increase in precipitation over the area included in the cloud seeding program in 1959 (using a value of \$5.00 per acre foot) would be worth about \$900,000 annually.

#### Research Now Under Way

Research is continuing on the hail problem.

Funds have been made available from the National Science Foundation for a two-year study of the characteristics and formation of

hail in the western high plains. During this period primary emphasis will be placed on getting detailed information at the ground surface on hail occurrence and precipitation. The observations will include the location, amount, and intensity of hail. Hail structure and density will be studied, and other chemical and physical tests will be made.

#### Plans for Future Research

Later studies will include cloud observations to relate the hail observed at the ground to the weather processes that produce the hail. After a better understanding of the hail formation process has been gained, an experimental program of cloud seeding is planned to study, on a scientific basis, the effects of weather modification activity on hail and precipitation. It will take several years to get adequate data to complete such a program.

At the completion of such a systematic study, better information will be available on the dual problem of direct concern to residents of the high plains: frequent damaging hailstorms and recurrent precipitation shortages.

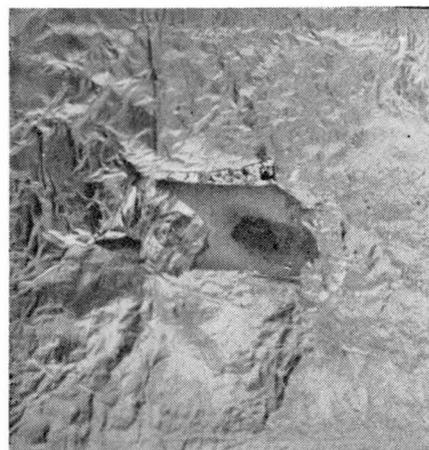
#### SUMMARY

Research by Colorado State University in northeastern Colorado in 1959 in connection with a weather

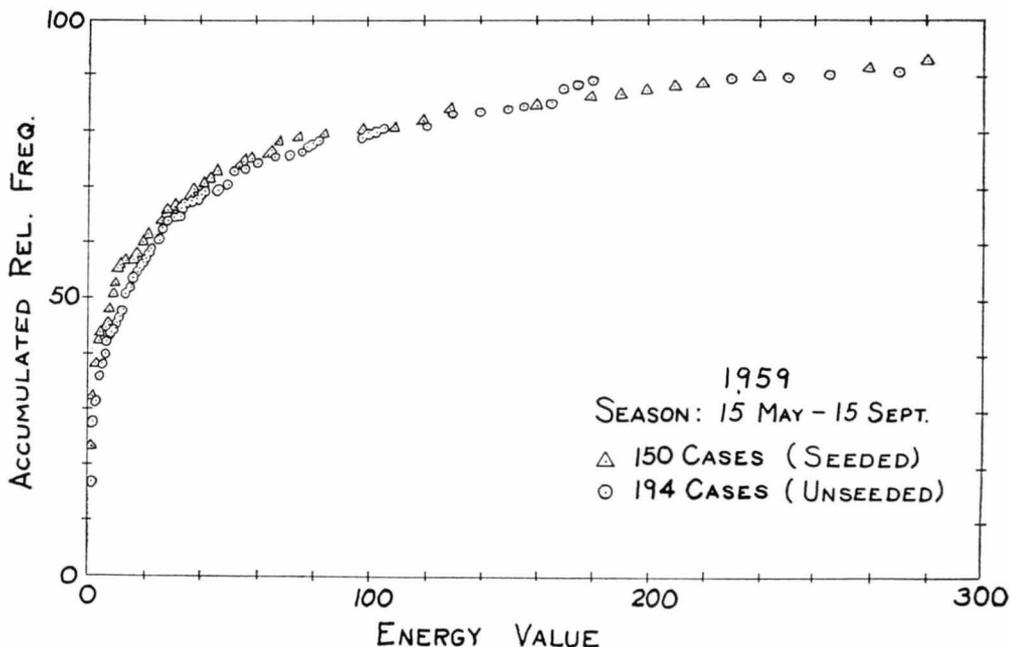
modification program does not provide conclusive evidence on the effect of cloud seeding on hail and precipitation. The research gives some indication, however, of a decrease in hail and an increase in precipitation associated with the cloud-seeding program.

Further research is now being conducted in an effort to gain a better understanding of the characteristics and formation of hail.

The author wishes to express sincere thanks to all the individuals who cooperated in the study by reporting on hail occurrences.



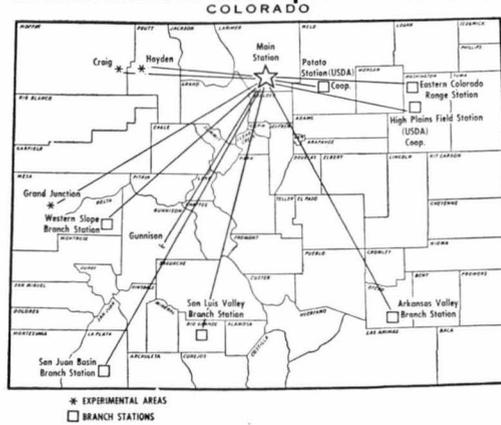
Hail indicators are used to measure the intensity of hail. This indicator had been struck by a hard stone that fell during a high wind.



Comparison of hail impact energy values ( $E$ , foot-pounds per square foot) for seeded and non-seeded cases.

Agricultural research in your area  
... on your problems

### Branch Stations and Experimental Areas



NEWS LETTER TO COOPERATORS

on

Colorado State University Hail Research Project

No. 1 - June 1960

This letter is being sent to you to keep you informed of the status of research studies on hail in northeastern Colorado being conducted by Colorado State University.

The enclosed reprint from Colorado Research gives a review of the studies conducted in 1959 and outlines the plans for research for 1960 and later years.

We now have a good start on our studies for 1960. We have 100 hail indicators installed on a two-mile spacing along the roads from Raymer to Sterling to Haxtun to Sedgwick to Fort Morgan to Raymer. Additional indicators have been located with individuals in the same region. Several samples of hailstones have been obtained for laboratory studies. The reports received by mail from cooperative observers have been very helpful in the study.

Please continue to send us reports of hail occurrences as you have in the past. The reports generally have been excellent. Following are items which would help us in interpreting your reports:

1. Be sure to give the date of the storm.
2. Give the time and duration of the hail as accurately as possible.
3. Please sign the report.
4. Any remarks you can give us on the storm will be helpful, such as:
  - Direction of storm movement.
  - Shape of stones.

We are interested in obtaining samples of large hailstones for detailed laboratory analysis. If you should collect any hailstones golf-ball size or larger (bigger than about 1-1/2" diameter), please wrap about a dozen individually in waxed paper or aluminum foil and store them in your freezer. Send us a "Hail Report" indicating that you have these stones stored, and we will try to pick them up from you within two weeks.

Thank you for your cooperation.

*Richard A. Schleusener*

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Fort Collins, Colorado  
1 July 1960



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