

COMPARISON BETWEEN SEEDED AND UNSEEDED STORMS IN ALBACETE (SPAIN)

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Abstract. Since 1970 the Ministry of Agriculture has developed a broad program of study on hailstorms. In some cases, this study has included cloud seeding. In 1978 the application of AgI nuclei began in a part of the Spanish Levant. After five years, the results indicated reduction in crop damage caused by hail. The types of storms are described, an analysis on the behavior of seeded cloud masses is presented, and a comparison of seeded and unseeded storms is summarized.

1. INTRODUCTION

In the Spanish Levant there is a wide area which contains a variety of high quality crops. Unfortunately, every summer that area suffers many hailstorms which severely damage the crops.

At the beginning of the 1970's, the Ministry of Agriculture tried to develop a series of defense systems based on ground generators. This network was completed when a small meteorological radar was installed. After several years, some shortcomings were found in the storm prediction as well as the effectiveness of the generator network. Moreover, the hailstorms developed some distance away from the crops, the majority coming from Albacete (Figure 1).

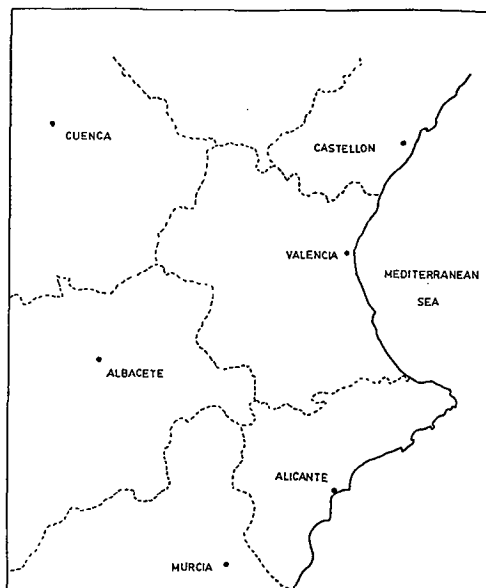


FIG. 1. GEOGRAPHY OF SPANISH LEVANTE

In 1978 the Ministry of Agriculture decided to develop a defense system for hail suppression based on the aerial application of AgI. The target area chosen to carry out this work covered 600,000 Ha within the interior of Albacete province. The aim was to form a containment barrier against hailstorms.

This program continued until 1983. At the end of this period a detailed study of the data on hail damage was carried out. A comparison was made between the period 1975 to 1977 without aerial protection, and the period 1978 to 1983 when the aerial protection was active. The damages in the outer area were 33% greater in the second period than in the first and those in the protected area were 48% less. In the area immediately adjacent, the damages were reduced by 72% to which Romero and Balasch (1985) give a significant factor of 99%. In view of these results, the study of detected cloud masses, their possible characterization, and the comparison between the groups formed by "natural clouds" and those which were "seeded" began to develop.

Here we offer some indication of corresponding changes in the behavior of seeded clouds.

2. EXPERIMENTAL DESCRIPTION

During the years when the project was active, a 250 Kw, 5.5 cm meteorological radar was available. Horizontal (PPI) and vertical (RHI) sweeps were included in the operations. The radar data were entered into a computer. This provided accurate information on a series of variables such as the reflectivity (measured in dBZ), contours, dimensions, etc.

To apply the AgI nuclei inside the cloud masses, we used two turbocharged aircraft (Piper Aztec) equipped with AgI ejectable pyrotechnic cartridges. The flight paths were followed with the help of an IFF system from the Operations Centre. Data provided by the European Meteorological Network was added to the local sounding. By using a numerical model, the probability of the formation of cloud masses and their characteristics were determined.

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3. SEEDING OPERATION

Once cloud masses were detected in the study area, and the information from the radar computer system showed reflectivity values above 30 dBZ with cloud development greater than 6,000 meters, then one of the aircraft was launched to patrol the storm and give supplementary information to the Operations Centre (liquid water content, updraft speed, etc. When radar reflectivities of 45 dBZ were found at or near 6.5 Km, the IFF directed seeding aircraft flying at -12°C ejected pyrotechnics in sufficient number to yield 100 nuclei per liter effective at -15°C . When seeding had taken place on the new storm development, the cloud masses were analyzed to see if there was a decrease in reflectivity and/or height.

4. CHARACTERISTICS OF THE STORMS IN ALBACETE (SPAIN)

Before analyzing the results of seeding operations, we shall describe some of the storm characteristics in Albacete using data provided by the meteorological radar.

To obtain a better radar data sample, horizontal slices (PPI) were made, normally at 3 with intervals of 15 minutes. At points of maximum reflectivity a corresponding RHI measurement was made at similar time intervals necessary for corresponding analysis of the storm's evolution. From the data analysis we have been able to determine:

- the average lifetime of storms, based on the criterion of Foote and Mohr (1979) which defines lifetime as the period during which reflectivity is measured greater than 45 dBZ.
- the average maximum reflectivity in order to obtain information about the maximum precipitation zone.
- the average height of the maximum reflectivity.
- Maximum height of the 10 dBZ contour or the active limit ceiling of the cloud mass.

The results obtained from analyzing storms unmodified by seeding but which developed close

to the protection area during the summers of the years 1980 and 1983 are presented in Table 1.

From Table 1 it appears:

- the average maximum reflectivity can be considered rather low as it only rises to a value of 51.4 dBZ.
- the heights at which maximum reflectivity occurs corresponds to the 0°C isotherm, which tallies with the "fusion zone" quoted by other observers (Rogers, 1977).
- the cell tops averaged 10.7 Km where the average temperature is -42°C .
- The average cell lifetime duration of reflectivities greater than 45 dBZ (Foote and Mohr, 1979) of 75 minutes is somewhat longer than in many other areas, but shorter than in Alberta, Nelspruit and Colorado.

5. COMPARISON BETWEEN SEEDED AND UNSEEDED STORMS

It is important to emphasize that the resultant data on the years during which AgI was used showed a lessening of damage due to hailstorms. nevertheless, to verify the modifications caused by the insertion of AgI nuclei, it is advisable to more accurately characterize the seeded and unseeded cloud masses.

To do this, we have used the following method:

- We tabulated all the storms with a lifetime greater than 10 minutes (according to the established criterion) which developed in the zone adjacent to the protected area (in some cases, within the protected area when storms could not be seeded for some reason).
- We tabulated all the storms that were modified by the seeding action.

Cloud modification induced by the seeding was measured by Goyer's (1975) "growth factor", the ratio of the time-integrated cloud top height excess above 7.6 Km during the 20 minutes before time t_0 (defined at a later time) to the similar time-integrated height excess during the entire time from $t_0 - 20$ until the top descended

● No. OF CELLS	43
● MAXIMUM AVERAGE REFLECTIVITY	51.4 dBZ
● AVERAGE HEIGHT OF MAXIMUM REFLECTIVITY	3.6 Km
● AVERAGE HEIGHT OF TOPS	10.7 Km
● AVERAGE DURATION OF CELLS	75 min

TABLE 1. General characteristics of cells

to 7.6 Km. From the 29 seeded storms, t_0 was the time of first seeding, and for the 43 unseeded storms it was the time at which cloud top first reached 10 Km.

Regressions of this factor on storm duration were computed and separated for unseeded and seeded cells. These plots are shown in Figure 2.

6. CONCLUSIONS

Seeded storms grew much more slowly than unseeded ones, indicating that seeding had the desired effect of reducing storm intensity, hence the hail size. But seeded storms lasted, on the average, only 6 minutes less (72 minutes) than seeded ones (78 minutes), indicating no significant decrease in storm lifetime, despite the apparent intensity decrease.

7. REFERENCES

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(*Editor's note: For unexplained reasons, only 30 points represent the 43 unseeded storms and only 24 points represent the 29 seeded ones).

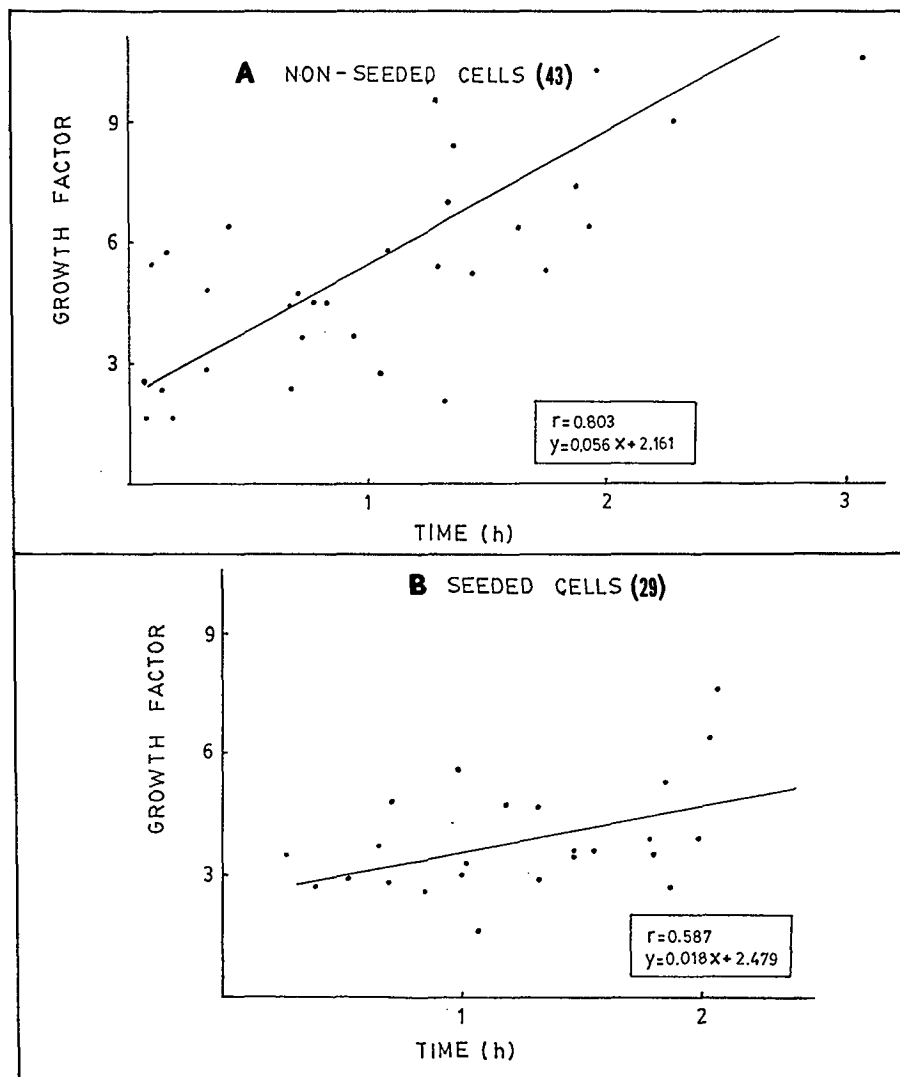


Figure 2. Regressions of Growth Factor on storm duration for (a) nonseeded and (b) seeded cells.