Artificial Cloud Seeding: An Alternative to Get Rains

T Sankar and N Kowshika
Article ID: 48
Department of Plant Protection, Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Tiruchirappalli 620 027, Tamil Nadu
Corresponding Author: mawthammm1996@gmail.com

Introduction

Meteorological conditions influencing ground-based glaciogenic cloud seeding are cloud temperature, cloud liquid water, and ice crystals formation within, below or above the super-cooled cloud. Cloud temperature is a key parameter to activate the ice nuclei condensation and the rate of diffusional snow growth are highly temperature dependent. Clouds composed of liquid water droplets at temperatures below 0°C (super-cooled clouds) contain large numbers of tiny water droplets that are too small to precipitate. Hence, common practice of cloud seeding has positive impact on the amount of precipitation from clouds. When the water droplets inside clouds are too small or less, we can introduce the artificial ways to create ice crystals and thereby facilitate the formation of precipitation, weather phenomenon called as artificial rain making (Givati and Rosenfeld, 2005).

The Desert Research Institute found that 8 to 15 per cent increase in snowpack by cloud seeding. Evidence of cloud seeding study is that, seeding on super-cooled orographic clouds (clouds that develop over mountains) has seasonally increased the precipitation by about 10 per cent (Huggins, 2009). The California Department of Water Resources estimated that an average snowpack increases of 4 percent in their research on 2013. All these researches have given more interest to global scientists to further explore on the technology.

Approaches

The intention of rainfall enhancement techniques is to convert the super-cooled water droplets into precipitation sized ice particles that then fall to ground as either rain or snow. According to Cotton (1982), there are theoretical approaches to precipitation enhancement by the seeding of super-cooled clouds, namely,

1. Static seeding
2. Dynamic seeding
3. Hygroscopic seeding

Static seeding

The hypothesis of static cloud seeding is that the introduction of an "optimum" concentration of ice crystals may enhance the efficiency of precipitation by converting the reservoir of super-cooled water droplets into precipitation sized particles. Therefore, additions of ice nuclei materials into the clouds may result in precipitation. Static cloud seeding is the eldest one and still being practiced by many even today. It consists of spreading dry ice or silver iodide into the cloud to provide crystals which can condense surrounding moisture (Schaefer, 1946).

Dynamic seeding

Dynamic cloud seeding is practised based on the hypothesis of sudden release of the latent heat of fusion when a super-cooled cloud (ice + heat= water) is rapidly glaciated through seeding increases the buoyancy of the cloud and boost vertical air currents, this in turn generates deeper and more vigorous cloud that produces more rain. Several dynamic cloud seeding experiments have been conducted in the USA, the most notable of which was the Florida Area Cumulus Experiment, FACE. The results of these experiments were about 13-15% in Israeli and positive effects of 18% - 24% were found subareas of the experiment. (Bruintjes, 1999).

Hygroscopic seeding

Hygroscopic seeding method is introducing hygroscopic particles like salts through the flares or explosive in the lower portion of the cloud that readily takes water by vapour diffusion in super saturated clouds. This method is mostly suitable for tropical climate regions.

Chemicals used

The most common chemicals involved in cloud seeding are:

- Silver Iodide
- Potassium Iodide
- Dry Ice (Solid Carbon Dioxide)
- Liquid Propane
- Urea
- Salt - Sodium Chloride

Silver Iodide (Agl), solid inorganic compound is the "weapon of choice" for the cloud seeding industry. AgI nuclei is usually produced when combustion of an acetone solution from ground-based generators. Approximately 50,000 kg are used for cloud seeding annually, each seeding experiment consuming 10–50 grams. Liquid propane**,** which expands into a gas has also been used. This can produce ice crystals even at higher temperatures compared to silver iodide. After promising research, the use of hygroscopic materials such as table salt and talcum powder are becoming more popular (Hill and Ming, 2012).

Instruments

Ancient instrument used for cloud seeding are ground generators, plane, or rocket launchers. New technology instruments are aircrafts, drones and howitzers and depicted in Fig. 1a & 1b respectively.

Criteria of Cloud seeding

The main criteria of cloud-seeding are, when and how to apply the chemicals and on which clouds to be targeted. The criteria is including the account of their temperature, thickness and convective patterns, and the way that the winds flow into and out of them. The best cloud to shoot for seeding is orographic clouds, which are produced when air is forced upwards over mountain ranges. Such clouds are short-lived, relatively shallow and contain much water (French *et al.*, 2018).

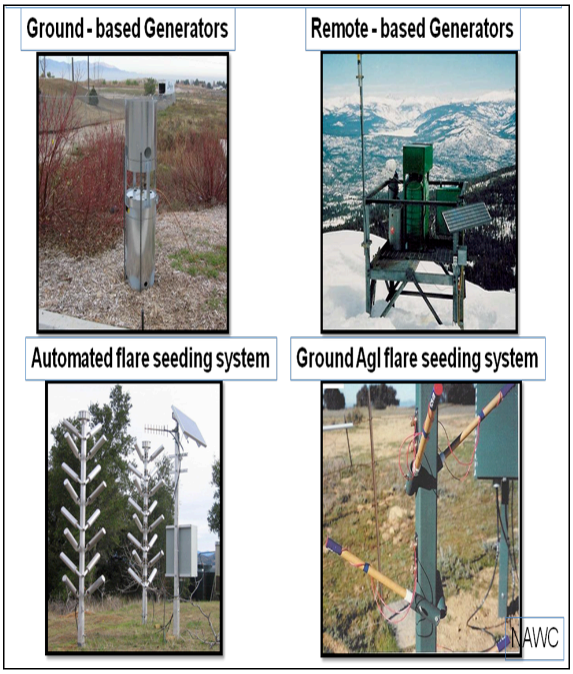

Fig. 1a: Ancient instrument Figure

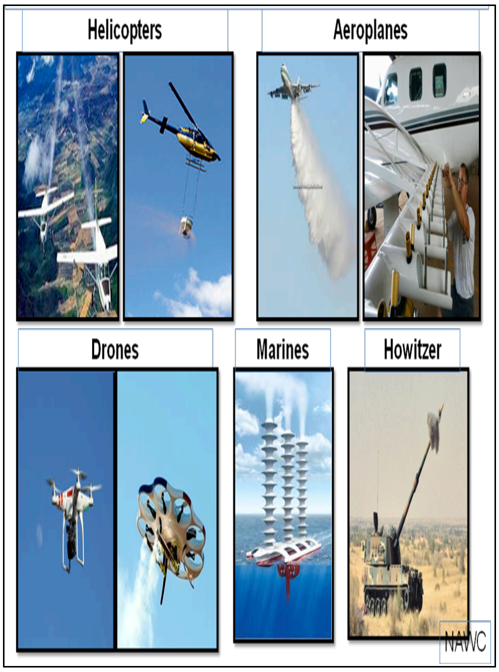

Fig. 1b: New technology instruments

For successful artificial rains, the following conditions are necessary:

- Cloud formation in super cooled condition
- Large spread of clouds
- Upward movement of clouds with wide spread
- Ideal conditions on earth's surface to accelerate the process of cloud formation.

Protocols of cloud seeding

- Maintaining of logbook, indicating the number of seedable clouds, seeded clouds and reasons there off for not seeding by the Meteorologists at Radar Station.
- Threshold value of Decibel (dbZ – Radar Reflectivity) is to be decided.
- Threshold value of Vertical Integral Limit (VIL) is to be decided.
- Necessity of filling the proforma by the pilot about the kind of clouds he has seen physically, the kind of clouds seeded and the reasons there off for not seeding if necessary.
- Meteorologists should decide the number of flares to be fired, or the pilot in the field of experiment.
- How much time is needed between now casting and actual flying for seeding?

Suitable Clouds

Ordinary cumulus clouds are most often found in the sky that are too small to produce any worthwhile rains by seeding. American meteorologist Chuck Doswell has explained that the rain at the ground through seeding typical should be target on a fairly large cloud which is 10 km tall and 10 km in diameter. Substantial work has also been conducted in the past regarding the dispersion and transport of seeding material in both convective and orographic clouds. Many of the potential rain-bearing clouds in tropical and semi-tropical countries are convective in nature and their tops often not exceeding the height of the freezing level (Doswell, 1985).

Conclusion

It may be concluded that cloud seeding operations are boon to the farmers especially where rainfed agriculture is followed and cloud seeding is an opportunity to fill the reservoirs paving way towards increasing the ground water levels at favourable conditions. Apart from rain making, we can save lot of crops by suppressing the hail storms well in advance during the pre-monsoon showers along with the advantage of dissipating the profuse rainfall during the floods. In the context of more droughts and floods due to climate change, cloud seeding techniques can be effectively to augment the adverse effects and will help the society in a multipurpose way.

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