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GENERAL ASPECTS OF THE EXTREME METEOROLOGICAL PHENOMENON: HAIL

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Abstract: Choosing functional and structural characteristics of the equipment on the technological flow of any milling unit is influenced primarily by the physical properties of intermediate products of grist. The paper presents results of experimental research on the physical properties of grist (coefficient of static friction - on three types of surfaces, the angle of natural slope, density, surface area, porosity) in the plane sifter compartment of the second grinding mill for a unit of 4.2 t/h in Romania.
Keywords: hail, hail grains, cloud-seeding, anti-hail equipment

1. INTRODUCTION

Climate and agriculture influence each other. This impact is more than obvious nowadays because climate changes and variability are global.

Climate change is a huge challenge for agriculture, having a direct impact on the productivity of the agricultural sector. The negative effects on agricultural production are influenced by extreme meteorological events. Productivity and quality of fruit and vegetables are affected by periods of increased relative humidity, frost and hail. The major cause of variation in crop productivity and quality, from year to year, is the variability of rainfall.

Agricultural crops are vulnerable to exposure to limiting vegetation conditions caused by climatic extremes, are sensitive to their fluctuation and variability and depend on their adaptability to periods of thermal and water stress. [2]

2. MATERIAL AND METHOD

The hail is always accompanied by strong showers, winds and lightning and is an extreme weather phenomenon that presents a significant climate risk and which, although it occurs quite rarely, can cause material damage of local or regional proportions in a short time depending on the route followed by the clouds that generated it. [3]

This phenomenon occurs between March and October, with the highest production frequency in the summer season and especially during the short-term rainfall specific to this period of the year.

Hail formation

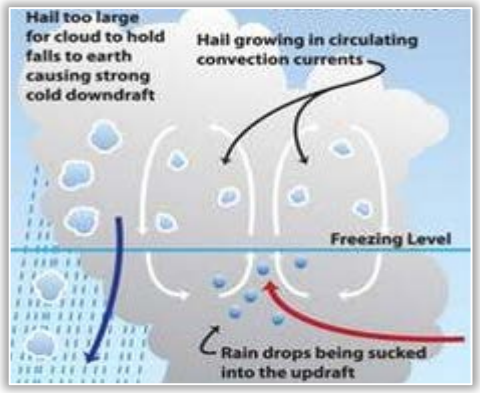
Hail is a solid precipitation. The occurrence of hail is related to the presence of Cumulonimbus clouds, large vertical clouds, inside of which upward and downward currents appear.

a)[1] b) [4] c) [4]

Figure 1 - Thunderstorms clouds (Cumulonimbus)

The primary form of the hail is represented by a soft sleet drops formed at the top of the cloud by condensation of the water vapour in the cloud and rain drops freezing. From this moment, downward and upward currents carry this fragment both to the base of the cloud (downward currents) and to the upper part of the cloud (upward currents). Thus, in its journey, the sleet drop is covered with transparent ice layers (when brought by downward currents towards the median area) and opaque ice (in the upper part of the cloud where the temperature is lower). As soon as it gains a weight that conquers the upward current force, the hailstone falls to the ground.

The hailstone size depends on the intensity of the genetic processes of the phenomenon. Thus, the thermal contrast between hot and cold air, the intensity of heat convection upward currents, the intensity of the cold front movement speed and the dynamic convection it generates, the altitude up to which the warm air can be exalted, the vertical sharp development of the hail cloud are important growth factors in hailstone size. [3]



a) [6]

b) [1]

Figure 2 - Hail formation

Figure 3 – Hailstones

Hail storms start suddenly, and the duration of the phenomenon is inversely proportional to the size of the hailstones. The shorter the duration of the falls, the larger the size of the hailstones as well as the mechanical influence they exert. [7]
Hailstone dimensions are highlighted by the size of the hailstone diameter. Hailstones are spherical, conical or irregular in appearance and are made up of a nucleus around which several layers of ice appear.
Researches carried out by specialists showed that diameters are smaller (below 5 mm) in the first part of spring and autumn compared to the second half of spring and summer when they can reach exceptional sizes, ranging between 20-30 mm. Such dimensions determine the extent of the risk caused by falling hailstones.

Figure 4 – Hailstones [8]

Figure 5 – Section of a "monster hailstone" [9]

Effects and reduction of hail damage

Hail, torrential rains and wind intensifications have adverse consequences on cereal crops, vegetables, vines and fruit trees that have been caught at various stages of development, affecting or stopping their vegetative cycle by seriously injuring

foliage, shoots and fruits. When a medium-sized hailstone moving in the air drops to the ground, it reaches a speed of about 180 km/h, while a raindrop hardly overcomes 30 km/h.

Figure 6 – Hail damage [10]

Depending on the intensity of the phenomenon and the moment of occurrence - in a critical phase of plant development or at the end of the vegetation phase - hail damage can be disastrous ranging from 5 to 100%. Apart from partially or totally destroying the crop of the current year, hail also affects the crop of the next year as a result of the large-scale injury to the vegetative apparatus of the respective crop and their impoverishment in reserve substances. The negative effects of late hail, in the case of vines, last for two years.

On the plant organs affected by hail, a series of parasitic fungi (manna, mould, etc.) get attached very easily, so immediate action is required to save plants that are not yet completely destroyed.

Figure 7 – Plants affected by hail [11, 4]

In the case of fruit trees, fruit-bearing shrubs and vines, it is recommended to apply fungicide treatments, especially if their bark was destroyed. These prevent the development of certain diseases caused by open wounds in the bark. These treatments are important to be performed within a period of 21-24 hours after the occurrence of the phenomenon.

In the case of the garden, remove the damaged or destroyed elements of the crop in question. Vegetables affected by hail, such as green lettuce, radish or spinach, are picked because they can grow again if the weather improves. Among the most sensitive plants in the garden are tomatoes, peppers and eggplants. Therefore, these vegetables need more attention with the end of the phenomenon. So, pick up the ice pieces that lie among the plants and keep the leaves of the vegetables even if they are ragged. If the plants were laid to the ground and the roots were brought to the ground surface, they are replanted. For vegetables to have a good chance of getting better if weather improves, tomatoes, peppers and eggplants must be supported by poles.

Also, other post-hail gardening activities are recommended: loosening between the rows in the case of corn and plant ridging, applying nitrogen fertilizers, applying a low nitrogen fertilizer to perennial plants and using plants that can no longer be saved in compost.

The only positive effect of hail is the rainfall intake on the active surface, which often interrupts drought periods of high intensity. [3]

3. RESULTS

Given the destructive effect of hailstorms, mankind has, over time, been preoccupied continuously to combat this phenomenon. People tried to combat this phenomenon with empirical or religious means (our Geto-Dacians ancestors were shooting the bow in the clouds to frighten the demons/clouds); they used - in rural communities - church bells and prayers to defend themselves from this phenomenon.

With the technological evolution, as the knowledge about clouds developed, the technology of sounding and determining the general parameters first and later the ones specific to hail-forming clouds, the fundamental research programs were initiated and subsequently the development of systems for combating hailstorms.

Methods of fighting hail:

Cloud-seeding is a type of weather change that aims to change the amount or type of precipitation falling from the clouds by dispersing substances into the air that serve as condensation of clouds or ice nuclei, which modifies microphysical processes within the cloud. The usual intention is to increase precipitation (rain or snow), but also to reduce or even suppress hail and fog, also widely practiced in areas and airports where harsh weather conditions occur.

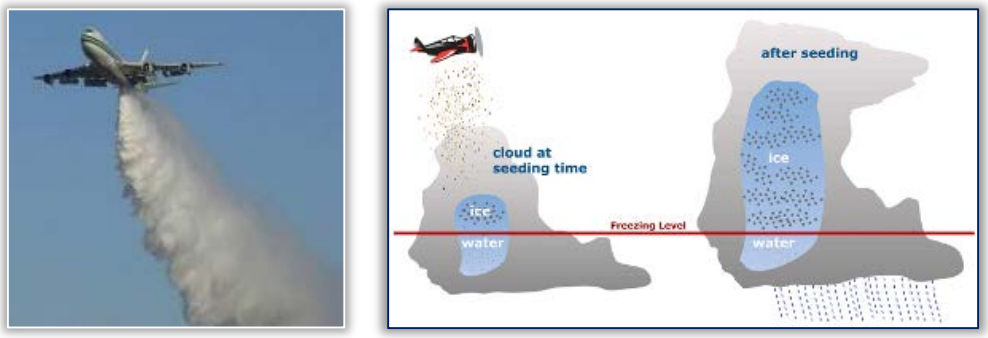


Figure 8 - The science of cloud-seeding [12, 13]

Rocket-based seeding

Anti-hail rockets are built to fly up to 10,000 meters. Once they get there, they release a chemical compound based on silver iodide that aims to transform ice crystals (hail) into water. Then, the rocket self-destructs and just a few small pieces of cardboard get on the ground.

From a technical point of view, it is the most appropriate method for protecting complex relief areas, with large wine and fruit growing areas. This method allows chemical seeding into the potential cloud cell, and the reaction time is much shorter. The disadvantage is the need to achieve a proper density of launch points in the protected area and the need to ensure air traffic security during the intervention.

The system developed in Moldova, Ukraine, Central Asia, Argentina recorded an efficiency of 75-96%.

Figure 9 – Anti-hail rocket RAG-96 and rocket launcher [10,14]

Figure 10 - Cessna 441 Conquest II used to conduct cloud-seeding flights in the Australian state of Tasmania [15]

Aircraft seeding

If the use of hail control rockets is impossible (absence of rocket infrastructure, ban on rocket launch), this second method can be used as seeding efficiency, which launches the anti-hail equipment from an aircraft. There are three types of such equipment (Figure11):

- pyrotechnic generators on board the aircraft, which produce an aerosol, during the flight, near dangerous clouds;
- cartridges, which could be shot from the aircraft, which produce aerosols during their fall through the cloud;
- jet cartridges that could be shot from the aircraft with the possibility of directly attacking a dangerous hail cell.

It is an expensive method and requires specific aviation logistics. It poses a danger to the crew that is involved in the intervention activity because it has to act in the storm, below or above the clouds.

It is suitable for the protection against hailstones of large, flat surfaces and in developed aviation countries. This technique has been used mainly in the US, Argentina, China and Germany (Figure 12). Economic efficiency for this aviation-based technology is up to 40%.

Figure 11 - Aircraft anti-hail technologies [16]

Figure 12 - Pyrotechnic means used to combat hail by air [17]

Ground-based generator seeding

The use of the ground-based generator is done under the coordination and monitoring of the Authority for the Administration of the National Anti-Hail and Rain Simulation System (AASNACP), through operators licensed by AASNACP. Thus, the ground-based generator begins to work if a potentially hazardous hail condition occurs based on the weather alert a few hours before the potential start of the process.

A propane flame is used to vaporize the seeding solution, which is composed of silver iodine mixed with acetone. Emitted silver iodine particles follow the natural trajectories of atmospheric dynamics and are absorbed by hail clouds through convective air movement in areas of atmospheric instability. These particles are condensation nuclei. In addition, their presence in the clouds causes the droplet size to decrease inside the clouds and thus the likelihood of the formation of large hail nuclei decreases.

The operating mechanism is used in several European countries (Croatia, France, Hungary, Spain, Italy, Switzerland) and even outside the continent (Canada).

Figure 13 – Ground-based generator (propane burner) [18,19]

Because the operating principle is based on the upward currents that carry the particles in the required areas, the system can be used locally, and the precision of seeding is influenced by the evolution of air currents. It has satisfactory efficiency and low logistics (Figure13). It is an inexpensive means in terms of investment and exploitation. The location of these units is recommended to be done in the border areas where it is not possible to act with rockets to provide the required anti-hail protection in other locations too, as a complementary protection system.

— Hail cannon

This device emits sound waves towards the clouds in which hail is formed in order to stop the formation of ice particles (Figure 14).

An explosive mixture of acetylene and air is pushed into the lower chamber of the machine. Some systems also use oxygen under pressure to increase the explosive effect. By suddenly passing this mixture through the strangled part of the machine to the cone, a shock wave is generated, which can be perceived as a strong whistling. The wave propagates, at the sound speed up to 15,000 m, in the clouds above, causing a disruption of the hail particles growth phase.

The system is activated at short intervals of 4 to 7 seconds for the entire period since the storm approaches the cannon's location until it will have passed the protected area. As a result, rainfall that would have fallen as hail falls in the form of rain or sleet. It is essential that the machine is activated during the storm's approach, as shock waves can prevent hail formation but cannot alter the form of hail particles that are already formed.

These systems work with solar panels, with manufacturers claiming that this allows for better protection taking into account the lighting that often accompanies storms that produce hail.

The surface protected by such an isolated system is a circle with a radius of approximately 500 m, the effectiveness of the protection decreasing as the distance from the installation location increases.

To protect neighbouring areas from noise, the installations are surrounded by straw bales. The noise of cannon operation does not disturb the closest buildings, which are at a distance of 400 m.

There are systems controlled by radar systems that replace manual operation, which is of particular importance for areas where hail falls occur at night.

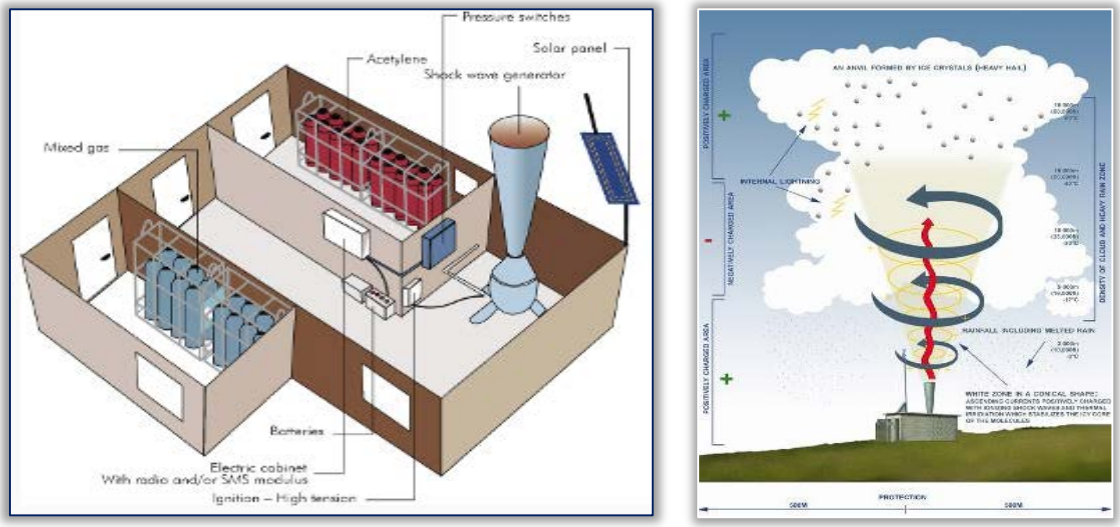


Figure 14 – Hail cannon technical and operational scheme [20]

Figure 15 - Placement of hail cannon in the field [21]

— Hail protection nets

Hail is one of the greatest enemies of the garden, as it causes major damage both among the layers of vegetables, as well as in the orchard and vineyard.

The effects of falling hail may be smaller or bigger, depending on the duration of the phenomenon and the amount of precipitation, and many times, as a result of hail, all vegetable crops are compromised or damaged in large proportion.
In areas with high risk of hail, special hail protection nets can be installed, but after flowering, because installed before, they prevent the bees' flight.
The nets are made of materials that prevent hailstones from reaching the crops or even reaching the ground. They can withstand rather heavy loads and have a tilted position for a better discharge of the hail. These are mainly located in the vegetable garden, in the orchard with fruit trees, but also in the area where there are vineyards.
Hail protection nets do not prevent plant growth, so they can become a useful solution in the summer season when the hail frequency is high. [1] This system is a safe means of protection against hail, but the installation and handling costs are very high for large areas.

Figure 16 - Ways of installing hail protection nets

— Agricultural crop insurance policy

Beyond the technical protection measures, another form of protection that farmers can adopt against the phenomena that can compromise their crops is the conclusion of a policy of agricultural crop insurance. This policy provides financial protection in case of damage caused by fire or natural phenomena, including hail risk.
It is important to know that crop insurance policies cannot be concluded at any time in the course of a year, but only according to the type of the crop insured. Thus, the orchards are assured for the risk of hail after their full blossoming, the vineyard is insured after the beginning of the budding, the multiannual plantations - after the 15th of April, and the plantations of other field crops - after their emergence.

4. CONCLUSIONS

Hail can cause major damage when it occurs in the full vegetation season, when hailstone size exceeds 10 mm in diameter, when the duration and density of the hailstones' fall is high, when a persistent ice layer is deposited, when it occurs after dry periods and has as a result of soil erosion.
Hail can affect dwellings, cars, trees can lose their crown, gardens and hundreds of hectares of agricultural land can be destroyed and even human victims can be recorded.
Among the methods listed, rocket seeding is the most operative and efficient, however, due to several specific reasons (the presence of a rocket infrastructure, accommodation of start stations, obtaining a rocket firing authorization, etc.) it is not always possible. The use of ground-based generators is the least efficient. However, it is quite widely used in places where the application of cloud seeding by air is encountering difficulties.
Due to climate change and air pollution, the risk of hail damage is increasing, which requires continuous knowledge and analysis of the peculiarities of this phenomenon and a continuous development of the means of combating the effects produced in the fall region.

Note:
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