Harm of Hail to Crops and Countermeasures of Artificial Hail Suppression in Ulanqab City

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Abstract Hail is one of meteorological disasters affecting crop growth in Ulanqab City. It happens frequently from May to September, and this period is also the main growing season of crops. In this period, hail will cause damage to crops, make farmland soil harden, and bring varying degrees of harm to agricultural production. Artificial hail suppression is an important scientific and technological means for disaster prevention and mitigation. It is necessary to strengthen the monitoring, analysis and forecast of severe convection weather, intensify the release of early warning information of hail weather, provide accurate and reliable real-time information for the implementation of artificial hail suppression operations, strengthen the implementation of artificial weather modification, effectively carry out artificial hail suppression operations, and avoid and reduce the impact of hail disaster.

Key words Hail; Crops; Harm; Artificial hail suppression; Ulanqab City

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Hail is a kind of weather phenomenon caused by strong convection system. It has a small influence range, strong sudden occurrence and short process, and is accompanied by gale and heavy precipitation. China is a country with frequent hail disaster. Under the influence of large-scale cold air activities and terrain, there is an obvious difference between various regions in the distribution of hail in China. That is, it is more frequent in the north (mountainous areas, and inland areas) than the south (plains and coastal areas). Hail usually occurs in spring, summer and autumn, of which the number of hail days from April to July accounts for about 70% of the annual number. According to statistics, the annual economic losses caused by hail in China amount to hundreds of millions or even billions of yuan. Hail appears frequently during the annual spring ploughing and field crop growing season, so hail will damage seedlings, injure young fruits, and make crops fall, which has a huge impact on agriculture. It is the agricultural meteorological disaster second only to drought and flood hazards. Hail is one of the common agricultural meteorological disasters in Ulanqab City, and will cause different degrees of harm to local agriculture and animal husbandry production every year. In this paper, the characteristics of hail disaster in Ulanqab City were analyzed, and the harm caused by hail to crops was discussed. According to the adverse effects on agriculture, artificial measures for hail prevention were put forward.

1 Analysis of hail characteristics in Ulanqab City

Ulanqab is located in the center of Inner Mongolia Autonomous Region. The topography of the city is composed of Mongolia Plateau, Ulanqab hills, the Yinshan Mountains and loess hills from north to south. The topography and landform are complex. The branches of the Yinshan Mountains, Daqing Mountain and Huitengliang Mountain, traverse the center of the city to divide Ulanqab into front and back mountainous areas, and they have obvious differences in climate. It has a continental monsoon climate. The average annual temperature is 4.3 ℃, and the average annual precipitation is 150 - 450 mm. In a year, precipitation is concentrated from July to September, and there are often heavy rainfall weather processes. In summer, the air near the surface warms faster, and due to the special geographical location and the uplifting effect of mountain terrain, it is easy to form strong updraft and then cause hail weather in local areas.

In Ulanqab City, local hail weather occurs almost every year, and a wide range of hail disaster occurs once every two years on average, while serious hail occurs about once every three years[1]. Hail occurs from middle March to early November, and was mainly concentrated during May - September, during which the number of hail days accounts for about 93% of the total number of hail days in a year. July has the largest number of hail days, followed by June. This is caused by the seasonal fluctuation of subtropical high pressure and the characteristics of hail formation. The damage caused by hail in July and August is the most serious, that is, it directly causes crop reduction or even failure, and damages agricultural infrastructure.

The number of hail days in Ulanqab decreases from north to south in general[2]. The hail zone is located in the central and southern part of Daqingshan area and the tail split zone, showing a horizontal "T" shape, decreasing from south to north along the transverse axis of Zhuozi and Jining and from east to west along the vertical axis of Huade and Xinghe. Among them, Chahar Right Wing Middle Banner in the back mountainous area is the center with the frequent hail in Ulanqab, followed by the surrounding Chahar Right Wing Back Banner and Siziwang Banner, and Xinghe County in the east. The frequency of hail is the lowest in

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Liangcheng County and Fengzhen City in the front mountainous area.

2 Harm of hail to crops

Ulanqab has a unique climate, good ecological environment and natural advantages in developing green food. In recent years, Ulanqab City has vigorously developed characteristic planting, organic agriculture and efficient agriculture, mainly planting oats, naked oats, wheat, corn, potatoes and other food crops, of which naked oats is an important agricultural product in Ulanqab City. It is internationally recognized as the "global oats gold producing area", and naked oats has been approved as a geographical indication registration protection product. Besides, it is also one of the three major producing areas of potato in China, and the planting area and output of potato are in the forefront of the country. In addition, Ulanqab develops cold vegetable planting, and fine vegetables such as cabbage, Chinese cabbage, broccoli, carrot, onion, and celery are exported to more than 20 provinces, and form a certain scale of off-season vegetable planting.

In Ulanqab, hail often occurs in summer and autumn. During this period, crops in Ulanqab are growing vigorously. Hailstones fall rapidly from high altitude and exert great impact force. Hail is often accompanied by strong wind and rainstorm, and its destruction force is strong. It is more harmful to agricultural production, often damage a large area of fruits, vegetables and other crops, directly hitting corn, potatoes and other seedlings. Large hailstones can cause devastating damage to fruit trees, open vegetables and other crops in the flowering and fruit period. For example, on August 13, 2013, rare hail weather occurred in Siziwang Banner, with an average diameter of 20 – 30 mm, and it lasted for 20 min. The affected area of crops reached 2 600 hm^2, of which some crops were seriously damaged, and wheat and rape almost failed to harvest. From June 28 to 29, 2016, Ulanqaib City experienced regional strong convection weather accompanied by gale, hail, and heavy rainfall, and some areas of Xinghe County, Zhuozi County, Chahar Right Wing Front Banner, Chahar Right Wing Middle Banner, and Siziwang Banner were hit by hail. The maximum diameter of hailstones in Siziwang Banner reached 13 mm, and hailing lasted for about 10 min. As a results, the affected area of crops such as sunflower, corn, potatoes, melons, and beans was up to 10 751.6 hm^2, and the inundated area was 7 751 hm^2, while the area of crops without harvest was 3188 hm^2. The harm of hail to crops is mainly shown as follows.

2.1 Damage to crops If hail, gale and heavy rain occur at the same time, hail can directly damage crops, while gale and rain can lead to a large area of field crops lodging[3]. Hail in different seasons has different harm to crops. In spring, hail can directly damage and kill newly transplanted or unearthed seedlings, but they can be replanted in time after hailing, and the loss is relatively small. In summer when crops are growing vigorously, hail can damage their branches and leaves, fruits, and young ears, but it is difficult to remedy, so the loss is larger. In early autumn, most crops are mature and will be harvested, and hail can lead to the reduction of crop yield, so the damage caused by hail is irreversible. Meanwhile, some crops have strong stress resistance in the late growth period, and are less harmed by hail, so hail will not cause excessive losses.

2.2 Freezing of crops In the peak season of crop growth, temperature gradually rises and is the highest in a year. and the crops planted in this period like warmth and not tolerant of low temperature. Because the temperature of hail itself is below 0 ℃, it will accumulate on the ground after falling to the ground. When hail disaster is serious, the ground temperature will drop sharply, so that crops will be frozen or even have no harvest[4]. Compared with crop seedlings, crops in the flowering or mature stage are more seriously affected by freezing damage, and it can even cause devastating damage. Dicotyledonous crops such as beans are more seriously affected than gramineous crops. After fruit trees are damaged by hail, it will affect the growth in the current year and the growth and development in the further. After their branches and leaves are damaged by hail, it is easy to cause diseases and pests.

2.3 Soil compaction Hailing is accompanied by rainfall, and strong rainfall in a short period of time will inevitably cause the loss of surface soil in farmland. In addition, due to being hit by rain and hail, the surface layer of soil in the field will be hardened, affecting the respiration and growth of crop roots. Especially after hail and other strong convection weather in spring and summer, it is easy to have sunny and dry weather, so that the surface of hardened soil becomes drier, which is extremely unfavorable to the growth and development of crops in the seedling and vigorous growth periods.

3 Countermeasures of artificial hail suppression

Weather modification is an important scientific and technological means for rational development and utilization of air water resources, improvement of ecological environment, disaster prevention and reduction, and plays an important role in ensuring agricultural production and better serving people's production and life. At present, the weather department of Ulanqab City has significantly improved its ability of weather modification operation, and the operation efficiency has significantly increased. Presently, the method of hail suppression is anti-aircraft gun artificial hail suppression, and it provides a strong guarantee for the city's disaster prevention and reduction, and the increase of production and income of agriculture and animal husbandry.

3.1 Intensifying the monitoring, analysis and forecast of severe convection weather The refinement and accuracy of forecast of sudden and local hail and other severe convection weather should be continuously improved. Local meteorological departments should closely monitor the development and evolution of weather systems, and timely carry out consultation, research and judgment on severe convection weather and regional joint defense, and accurately predict the occurrence time, intensity and falling area of hail, provide accurate and reliable real-time information for artificial hail suppression operations, provide weather modification and hail suppression plans for operators in a timely manner.

3.2 Strengthening the release of warning information of severe convection weather After the forecast of severe weather,

(To page 70)

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(From page 63)

meteorological departments at all levels should pay attention to the release of warning information of sudden disastrous weather of government departments, relevant units and key regions, make full use of telephone, mobile phone short messages, wechat, Douyin and other channels to call relevant responsible persons, release the forecast and warning information to farmers and herdsmen, agricultural production bases, *etc.*, and ensure that those responsible for disaster prevention and mitigation receive early warning information in a timely manner. While making preparations for hail suppression in advance, they should work with departments of agriculture, emergency management, transportation and natural resources to study agricultural defense and response measures, and actively cooperate with weather modification and hail suppression.

3.3 Implementing weather modification responsibilities In the implementation of artificial hail suppression operations, it is necessary to make post responsibilities clear, and strengthen the duty system and sense of responsibilities. The main responsible comrades adhere to the front line of disaster prevention and mitigation work, ensure the safety and reliability of operation points and operating equipment according to crop seedlings and other agricultural production conditions, conduct real-time command based on weather changes, and seize the favorable opportunity to carry out hail suppression operations in a timely manner. Besides, it is needed to strengthen the collection and report of severe convection weather, timely report major disasters, and make a summary of artificial hail suppression operations.

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