Investigation and Analysis of Agricultural Meteorological Disasters in Potato Fields in Ulanqab City

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Abstract The occurrence characteristics and impacts of agricultural meteorological disasters during the main growth period of potatoes in Ulanqab City were analyzed. According to the development needs of modern potato industry, some countermeasures for meteorological services in the disaster prevention and mitigation of potatoes were proposed, such as strengthening intelligent and digital meteorological services, and building a full-chain meteorological service for the entire growth period of potatoes. The aim is to reduce the impact of disasters and increase the yield and quality of potatoes through intelligent and digital meteorological services.

Key words Potato; Agricultural meteorological disasters; Meteorological service

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Ulanqab City is located in the central part of Inner Mongolia Autonomous Region, and has a typical semi-arid continental monsoon climate in the middle temperate zone, with distinct four seasons, abundant sunlight, and a large temperature difference between day and night, as well as fertile soil, which provides a unique growth environment for potato cultivation[1]. Potato is one of the main crops in Ulanqab City. Its planting area and output account for about half of those of Inner Mongolia Autonomous Region and about 6% of the annual average planting area and output of potatoes in China. The potatoes produced in this area have smooth skins, large and uniform pieces, high starch content and excellent taste. They are a geographical indication product of China. Ulanqab City, which is known as the "potato capital of China", is an important national production base for seed potatoes, commercial potatoes and specialized potatoes for processing. Potato industry has become a pillar industry for farmers and herdsmen in Ulanqab City to increase their income.

Ulanqab City is located on the Inner Mongolia Plateau. The terrain is complex, and there are diverse landform types from north to south, including plateaus, hills, mountains and hilly plateaus. Under its influence, the altitude difference is relatively large, and due to the blocking effect of the Yinshan Mountains, a significant climate difference is formed in front of and behind the mountainous area. The winter is long and cold; the spring is dry and windy; the summer is short, damp and hot with concentrated precipitation; the autumn temperature drops rapidly, and frost appears early. Meteorological disasters such as drought, strong wind, hail, flood and frost occur frequently and cause serious damage. Every year, they have varying degrees of impact on potato production. With the rapid development of modern meteorological science and technology, the prediction and forecast level of meteorological disasters has been continuously improved, and the prevention and mitigation service level of meteorological disasters has also been greatly enhanced.

Through the research and analysis on meteorological disasters, disaster response measures can be formulated in a timely and effective manner to minimize the adverse effects brought by meteorological disasters, improve the planting benefits of potatoes, and realize increased agricultural production and efficiency as well as an increase in farmers' income.

1 Main agricultural meteorological disasters during the growth period of potatoes in Ulanqab City

Potatoes prefer a cool climate and have a high demand for water. Their entire growth period is 60 - 120 d. According to their maturity, potatoes can be classified into very early maturing, early maturing, medium maturing and late maturing varieties. Their growth and development are influenced by various factors, such as climate, soil and planting techniques, among which climate is one of the most crucial factors. Most of the potatoes in Ulanqab City are medium maturing varieties. They are usually sown from late April to early May, and harvested from late September to early October. The main growth period is from May to September. During the growth period of potato in a field, common meteorological disasters in Ulanqab City include drought, rainstorm and flood, low temperature and frost, hail, *etc.*

1.1 Drought Potatoes require a considerable amount of water during their growth period, and precipitation should be 500 - 750 mm[2]. The expanding period of potato tubers is a critical growth

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stage. During this period, they are extremely sensitive to water, and adequate water supply is a necessary condition for yield formation. If there is a drought, it can lead to a significant drop in yield, and it is difficult to make up for it later. Every year, Ulanqab City experiences droughts of varying degrees, and these droughts are characterized by high frequency of occurrence, wide area of occurrence, long duration and high disaster rate[3]. Among them, the frequency of mild, moderate and severe drought is as high as 85%, 65%, and 33%, respectively. Among the four seasons, spring drought occurs most frequently, followed by summer drought, and it usually lasts for 2 – 3 months. In a typical drought year, the number of days without precipitation from April to May can reach more than 30 d. In a severe drought year, the drought can last for 2 – 3 seasons, and the number of days without precipitation reaches over 90 d. In some years, there may be years of continuous drought. The drought in Ulanqab City often affects the entire city, causing huge losses.

Spring drought is not conducive to potato planting, such as inhibiting the growth rate of potato stems and leaves, reducing photosynthesis, and affecting synthesis of nutrients. From June to August, potatoes in the fields grow vigorously. During the period of tuber expansion, drought will restrict the expansion of tubers, so they are small in volume and number. Moreover, potatoes are prone to being attacked by fungi and viruses, leading to their growth stagnation and a decrease in yield. In late August 2014, the average precipitation in Ulanqab City was only 19.9 mm, 28.4% less than the average of previous years, and 67% less in some areas. The relative moisture of soil was low, and soil moisture condition was poor. The trend of drought was severe. The drought in Chahar Right Back Banner lasted for more than 50 d, so that the number of dryland potato tubers is small, with a reduction of more than 70% in yield.

1.2 Rainstorm and flood Although potatoes have a relatively high demand for water during their growth and development, rainstorm and other extreme heavy rainfall is highly likely to cause floods, which is not conducive to their growth. Especially in summer, when potatoes are in the period of bud formation and flowering, heavy rainfall causes excessive soil moisture in low-lying fields, resulting in waterlogging. This can lead to oxygen deficiency in the root system, which prevents it from breathing normally. Moreover, high temperature and humidity weather facilitate the spread of late blight in potatoes, and it can erode their stems, leaves and tubers, causing tuber rot and directly affecting the yield and quality of potatoes. The precipitation in Ulanqab City is concentrated from June to August. The number of days with moderate rain or above heavy rainfall is the largest in July, averaging 10.0 d, and the average in August is 5.0 d. The number of days with moderate rain or above heavy rainfall from July to August accounts for approximately 72.2% of the total number of days with moderate rain or above heavy rainfall during the main growth period of potatoes. The precipitation is relatively abundant and concentrated. As the mountainous and hilly area of Ulanqab City accounts for more than two-thirds of the total area, heavy rainfall is very likely to cause flood disasters. The frequency of flood disasters from June to August accounts for more than 98% of the annual frequency, which leads to the frequent occurrence of late blight in potatoes. For example, in July 2013, Ulanqab City had excessive precipitation and high soil and air humidity, resulting in the occurrence of moderate late blight on 1 000 hm^2 of potatoes, and the incidence rate of diseased plants reached 5% – 30%. In early August 2024, a large-scale rainfall happened in Ulanqab City. A total of 280 hm^2 of potatoes suffered late blight in four counties and banners, and the area of prevention and control was up to 64 000 hm^2.

1.3 Low-temperature frost The annual average frost-free period in Ulanqab City is short. The annual average frost-free period in the front mountain area is 110 – 140 d, and that in the back mountain area is 81 – 108 d. Among them, the annual average frost-free period in Chahar Right Middle Banner is the shortest, only 81 d. Frost in Ulanqab City mostly occurs in spring and autumn. Among them, the probability of autumn and spring frost is 25% and about 17.6%. Frost appears frequently from April to May and from September to October. The first frost occurs in middle and late September in the front mountain area and in early and middle September in the back mountain area. The first frost appears the earliest in Chahar Right Middle Banner, occurring in early September. The late frost ends in middle and late May in the front mountain area and late May in the back mountain area. The average end date of late frost in Chahar Right Middle Banner is June 10, and it ends the latest.

Potatoes have poor cold resistance. Frost can cause varying degrees of damage to potato seedlings, mature plants and tubers. If late frost occurs during the seedling emergence period, it will inhibit the growth of axillary buds or the eyes of seed potatoes in the underground part of the main stem, delay the emergence of seedlings, and result in uneven and weak seedlings. During the formation period of potato tubers, frost can have a significant impact on their yield and quality. In the small hours of August 27, 2022, the temperature in Huade County, Shangdu County, Chahar Right Middle Banner, the northern part of Chahar Right Back Banner and Siziwang Banner of Ulanqab City dropped below 0 ℃. This frost caused a particularly severe reduction in the yield of potatoes in potato production areas that were currently under the influence of continuous drought. The proportion of regions affected by the frost in the potato production area of Shangdu County and Xinghe County almost reached 100%. The proportion of regions affected by the frost in the potato production area of Chahar Right Back Banner was up to 70% – 80%. The potatoes in Chahar Right Middle Banner were severely affected by the frost, while the frost damage in Huade County and Siziwang Banner was relatively slight.

1.4 Hail Hail is also one of the meteorological disasters that affect the growth of potatoes in Ulanqab City. Hail happens frequently in this city. The hailing center is located in the hilly and

mountainous areas near the Yinshan Mountains. The main hailing route is Chahar Right Middle Banner – Zhuozhi County – Jining District – Chahar Right Front Banner – Xinghe County. Moreover, the number of hail days gradually decreases from south to north. Among them, the annual average number of hail days in Zhuozhi County, Chahar Right Middle Banner, Jining District, Chahar Right Front Banner, and Xinghe County is 5 – 6 d, while in other areas it is less than 4 d. In Ulanqab City, hail appears the earliest in late March and the latest in early November. It is mainly concentrated from May to September, and the number of hail days accounts for about 99% of the total number of hailstone days in a year. The number of hail days in July is the largest, accounting for as high as 51%. Hail often occurs from 14:00 and 19:00 during the day, with an incidence rate of over 80%. At other times, the incidence rate is only about 20%.

Hail can generate a huge impact force during its falling process, directly damaging the plants and tubers, leaves, and tubers of potatoes. At the same time, the strong wind and heavy rainfall that accompany it can cause the plants to fall over, seriously affecting the normal growth and development of potatoes and then reducing their yield and quality. From June 28 to 29, 2016, local severe convective weather occurred in Ulanqab City, and Xinghe County, Zhuozhi County, Chahar Right Middle Banner, and parts of Siziwang Banner were hit by hail and floods. Among them, hailstones with the largest diameter of 13 mm appeared in Siziwang Banner, lasting for 10 min. As a result, a large area of crops such as potatoes, corn and sunflowers were damaged.

2 Countermeasures for meteorological services in the disaster prevention and mitigation of potatoes

2.1 Strengthening intelligent and digital meteorological services By using information technology means such as artificial intelligence and big data, an integrated and intelligent potato meteorological service business platform covering "agriculture + meteorology" should be developed and continuously optimized and upgraded to promote the development of potato meteorological services towards refinement and convenience, including five subsystems: monitoring, forecasting, early warning, assessment, and feedback, with a total of 16 functional modules. For instance, real-scene surveillance cameras are installed in the potato smart agriculture meteorological service demonstration base of Ulanqab Modern Agricultural Park, so as to monitor weather changes in real time and promptly obtain data of meteorological elements during the growth period of potatoes. During the key farming periods of potato growth and development such as spring sowing, irrigation, disease prevention and harvest, it can provide scientific meteorological service plans, release special service materials, and provide professional services for new types of agricultural business entities.

2.2 Building a full-chain meteorological service for the entire growth period of potatoes Meteorological departments and agricultural technicians should delve into potato fields to track the growth of potatoes, soil moisture conditions, and yield formation on the spot, and provide forecast service products for the suitable period of spring sowing and autumn harvest of potatoes based on the occurrence characteristics and impacts of agricultural meteorological disasters during the growth period of potatoes in Ulanqab City. During this period, through refined weather forecasts, they can help farmers to scientifically formulate planting plans, promptly adjust the timing of irrigation and pest control, actively respond to extreme weather, seize favorable opportunities to carry out artificial rain enhancement and hail prevention operations, and reduce the impact of disastrous weather during the growth period. In response to the risk of late blight in potatoes, it is necessary to continuously launch a series of specialized service products, strengthen the prediction in the bud formation and flowering period of potatoes, track the growth and development progress and the occurrence and spread of late blight, and release meteorological risk warnings for late blight and the meteorological suitability forecast for pesticide application in a timely manner, so as to increase the yield and quality of potatoes.

3 Conclusions

Ulanqab City has a cool climate, abundant sunshine and concurrent rainfall and heat, which is very suitable for potato growth. It is recognized as the golden belt of potato industry in China. Meanwhile, climate fluctuations and extreme weather such as drought, flood, low-temperature frost and hail are also factors affecting the yield and quality of potatoes. In response to the development demands of modern potato industry, the meteorological departments of Ulanqab City should work around all aspects of potato production, continuously improve the full-chain guarantee measures for potato industry, strengthen professional meteorological services during the growth period of potatoes, conduct special forecasts and early warnings of disastrous weather, and provide support for meteorological agricultural services to promote the rapid development of potato industry.

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