# Clustering Analysis on the Climatic Conditions in Hundreds of Kilometers of Celery Belts in Hulu River Valley

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**Abstract** By using climate data in national stations in Xiji County, Ningxia during 1981 and 2020, a regression analysis was carried out on weather data in crop growth season in three automatic weather stations in Hulu River Valley. The results showed that celery belts of Hulu River Valley was divided into two groups: early-maturing region of south Xinglong - Xiaohe where is warm and rainy, serotinous region of north Jiqiang - Xinying where is warm and cold and rainless. Four subregions: Xinlong, Xiaohe, Jiqiang, Xinying. Each sub-region was divided into five regions according to climate layer and observation in growth season: temperature accumulating planting period, low temperature seedling period, suitable temperature for external leaf growth stage, high-temperature for celery mulching-sanded plantation in different sowing periods, water and fertilizer, insect prevention, time to market sales.

**Key words** Celery agricultural belts, Climatic Conditions, Cluster analysis, Hulu River Basin

Xiji County in Ningxia is a notoriously poor county in China. In recent years, through industrial adjustment, potato and celery have become two primary industries in the development of modern agriculture and economy in Xiji County. The Hulu River Basin, originates from Moon Mountain in Xiji County, goes through Xinying, Jiqiang, Xiaohe, Jiangtai, and Xinglong, *etc*. The entire river runs 97 km, and covers 1 358.5 $km^2$. Celery is the new species that are introduced from Europe and America. People in Hulu River Valley make ambitious exploration under the guidance of professional agriculture scientific and technical personnel and initiate the new technology and promote plantation successfully. Since 2008, the plantation area, distribution towns, total production and production value increase dramatically (Table 1). As the celery in Xiji tastes good, has little fiber, tender text and no pollution, celery won favor from each vegetable market. Meanwhile, the time to market of celery in Xiji happen to be the time when celery in other parts of China gets off the market, which fills up the marketing time of celery market. In order to excavate the climate resource in Xiji and to build the optimal celery production base in Northwest China, Ningxia Meteorological Bureau have started the program to study climate conditions in celery industry belt of hundreds of kilometers in Hulu River Valley and meteorological services since 2010. Through mutual hard work of meteorological and agricultural departments in recent two years, the suitable sowing time, output and market of celery were explored. According to the climate and market change to determine suitable growing period, we can avoid the unnecessary lose in employees' salary, time, pest, and market price, and determine the construction of agricultural service indicators and business system.

**Table 1 Table 1 Retail of celery in Hulu River Valley**

| Year | Plantation area//$km^2$ | Towns | Total output t | Output value $10^5$ Yuan | Retail price Yuan/kg | Famers' income per capita// Yuan |
|---|---|---|---|---|---|---|
| 2008 | 413.3 | Jiqiang, Xinying, Xingnong | 36 000 | 31 | 0.086 | 65 |
| 2009 | 1 013.3 | Jiqiang, Xinying, Xingnong, Malian, Jiangtai | 92 000 | 1 036 | 1.126 | 215 |
| 2010 | 1 786.7 | Jiqiang, Xinying, Xingnong, Malian, Jiangtai Xiaohe, Shizi, Xingping | 210 000 | 2 100 | 1.000 | 438 |
| 2011 | 3 466.7 | Jiqiang, Xinying, Xingnong, Malian, Jiangtai Xiaohe, Shizi, Xingping | 300 000 | 3 000 | 1.000 | 625 |

## 1 Materials and methods

**1.1 Regression calculation of data in regional automatic station** Statistics are given about the average temperature, average highest temperature, average lowest temperature, extremely highest temperature, extremely lowest temperature, and average precipitation from 1981 to 2010. The accumulated daily temperature ≥0 ℃, ≥5 ℃, ≥10 ℃, ≥15 ℃, ≥20 ℃ was discussed. The corresponding data of temperature from 2010 to 2011 in Xinying, Xiaohe, Xinglong automatic meteorological station are collected. The precipitation data is given with relevant analysis and regression calculation.

**1.2 Prediction of celery during growth period** According to the field experiment and investigation, the early sowed celery in

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Xinying, Jiqiang, Xiaohe and Xinglong has been observed.

**1.3 Hierarchical clustering algorithm of SPSS** In order to make objective judgment of celery industry[1], Hierarchical clustering algorithm of SPSS was applied. By dint of Between – group link-age method, the standardization of digital transformation uses Maximum magnitude of 1, the statistics method use Agglomeration schedule, graphic output uses Dendrogram to classify the climate in Xinying, Jiqiang, Xiaohe and Xinglong. The same method is applied to conduct clustering analysis of climate in four towns.

## 2 Results and analyses

**2.1 Simulated calculation of meteorological conditions in three stations in Hulu River Valley** The observed data about the meteorology in national basic station in Xiji indicated that the average temperature of crops during the growing period from the late March to the first ten days of October was 13.1 ℃. The average highest temperature was 19.9 ℃ and the average lowest temperature was 7.4 ℃. The extreme highest temperature was 32.8 ℃ in the late July in 2000 and the extreme lowest temperature is −14.4 ℃ in the late March in 1998 when the precipitation was 356.6 mm. Therefore, the weather in the crops' growing period was cold, dry and with large temperature difference. Moreover, the thermal condition in Xiji County was weak and the accumulated temperature was little. The accumulated temperature of activity ≥0 ℃, ≥10 ℃, and ≥20 ℃ was 2 633.5 ℃·day, 2 370.9 ℃·day and 242.5 ℃·day. The annual meteorological elements' value in national basic station and the relevance of meteorological data in three stations during 1981 and 2010 were extremely significant, and only the precipitation in Xinying station was significant (Table 2). Regression equation was simulated to calculate the meteorological element value to represent the climate in certain area. As shown in Table 3, the temperature and accumulated temperature increased with the reduction of altitude from north to south.

In recent years, the field experiment in Jiqiang Town indicates that the temperature from April to May was low and the soil temperature from 0 to 20 cm during the daytime improved by 2.1 and 4.4 ℃ and the temperature at sunny day enhanced by 5.9 and 8.2 ℃. From the late May to the mid August, the soil temperature rose by 2.3 and 5.4 ℃ than soil temperature, and the temperature at sunny days improved by 7.8 and 9.6 ℃. The membrane made the accumulated temperature increased by 220 and 310 ℃·d, which shortened by 20 and 30 d during the growth period, and replenished the disadvantage of accumulated temperature. After using membrane, the moisture in the soil enhanced by 2.2% and 5.3%, which was about 1 450 and 2 110 $m^3/hm^2$.

**Table 2 Simulation equation and relevant coefficient of meteorological elements in three stations along Hulu River Valley**

| Meteorological elements | Xinying | | Xiaohe | | Xinglong | |
|---|---|---|---|---|---|---|
| | Simulated equation | Relevant coefficient | Simulated equation | Relevant coefficient | Simulated equation | Relevant coefficient |
| Average temperature | $y = -1.29 + 1.06x$ | 0.979** | $y = 0.20 + 1.04x$ | 0.98** | $y = 1.10 + 1.05x$ | 0.983** |
| The highest temperature | $y = -3.53 + 1.17x$ | 0.968** | $y = -0.34 + 1.09x$ | 0.961** | $y = -0.39 + 1.12x$ | 0.963** |
| The lowest temperature | $y = -0.95 + 1.07x$ | 0.952** | $y = -0.07 + 1.11x$ | 0.970** | $y = 1.58 + 1.04x$ | 0.959** |
| Extremely high | $y = -15.03 + 1.45x$ | 0.954** | $y = -11.24 + 1.38x$ | 0.959** | $y = -11.45 + 1.38x$ | 0.942** |
| Extremely low | $y = 1.20 + 0.99x$ | 0.954** | $y = 3.89 + 0.95x$ | 0.946** | $y = 4.47 + 0.92x$ | 0.927** |
| Precipitation | $y = -1.83 + 1.05x$ | 0.570* | $y = -4.18 + 1.29x$ | 0.655** | $y = -1.45 + 1.12x$ | 0.661** |
| Accumulated temperature | $y = -0.74 + 1.02x$ | 0.983** | $y = 3.62 + 1.03x$ | 0.984** | $y = 5.99 + 1.08x$ | 0.981** |
| ≥5 ℃ accumulated temperature | $y = -9.56 + 1.02x$ | 0.975** | $y = 8.24 + 1.00x$ | 0.986** | $y = -4.29 + 1.24x$ | 0.857** |
| ≥10 ℃ accumulated temperature | $y = 4.68 + 0.97x$ | 0.808** | $y = 21.04 + 0.92x$ | 0.970** | $y = 42.33 + 0.87x$ | 0.972** |
| ≥15 ℃ accumulated temperature | $y = 7.06 + 0.90x$ | 0.912** | $y = 31.62 + 0.92x$ | 0.928** | $y = 37.43 + 1.17x$ | 0.834** |
| ≥20 ℃accumulated temperature | $y = -1.12 + 0.76x$ | 0.663* | $y = 2.78 + 1.57x$ | 0.825** | $y = 31.38 + 1.69x$ | 0.756** |

**Table 3 Calculation result of climate in three stations in Hulu River Valley**

| Stations | Average temperature ℃ | Highest temperature ℃ | Lowest temperature ℃ | Extreme high temperature ℃ | Extreme low temperature ℃ | Activity temperature ℃ | ≥5 ℃ ℃·d | ≥10 ℃ ℃·d | ≥15 ℃ ℃·d | ≥20 ℃ ℃·d | Precipitation mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Xinying | 12.6 | 19.8 | 7 | 32.4 | −14.6 | 2 593.0 | 2 503.2 | 2 365.7 | 1 511.4 | 170.2 | 336.2 |
| Xiaohe | 13.8 | 21.3 | 8.1 | 34.0 | −9.8 | 2 826.1 | 2 797.4 | 2 555.1 | 1 905.3 | 368.7 | 370.0 |
| Xinglong | 14.9 | 21.5 | 8.9 | 33.8 | −8.8 | 3 016.1 | 3 166.4 | 2 803.9 | 2 381.3 | 786.8 | 370.8 |

**2.2 Clustering analysis of climate resources in celery belt in Hulu River Valley** According to the clustering analysis of climate data in Xinying, Jiqiang, Xiaohe and Xinglong in Hulu River Valley (Fig. 1), the result in Xinglong and Xiaohe belongs to one category and that in Jiqiang and Xingying belongs to another category. Based on many years' observation of climate and investigation, the terrain in Xiaohe is relatively flat and is the dividend line where winter wheat being grown in north part of Xiaohe while spring wheat being grown in south part of Xiaohe. The climate over many years indicated that the climate was distinct within two

plantation zones and the two areas were divided into four smaller sections, namely rainy in zone Xingnong, warm and rainy zone in Xiaohe, cold and dry zone in Jiqiang, cold and dry late production zone in Xinying.

a

| Number of clusters | Case 4: Xinglong | | 3: Xiaohe | | 2: Jiqiang | | 1: Xinying |
|---|---|---|---|---|---|---|---|
| 1 | × | × | × | × | × | × | × |
| 2 | × | × | × | | × | × | × |
| 3 | × | | × | | × | × | × |

b

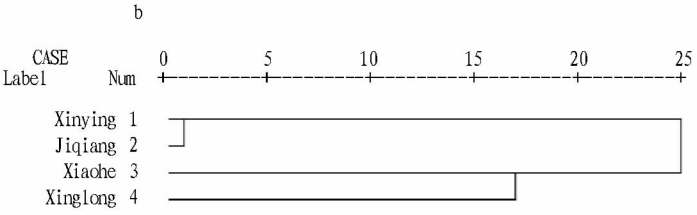
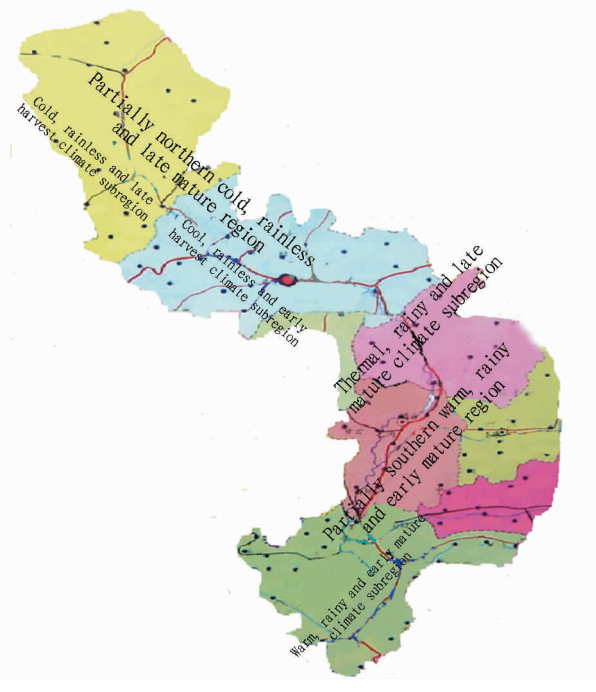



**Fig. 1 Column (a) and diagram (b) of climate clustering in celery belt in Hulu River Valley**

**2.3 Clustering analysis of celery in Hulu River Valley** According to the climate characteristics of low temperature, large temperature difference and late defrosting of soil in Xiji, the production of celery is divided into four periods, sowing period, seedling period, growing period and harvest period. The growth of celery in each town was recorded (Table 4). Based on the advice of agricultural technicians, the celery is planted on April 1 each year in Xinglong, and on April 15 in Jiqiang. In terms of the clustering analysis of weather during the celery growth period, taking Jiqiang as an example, the celery was sown in the first ten days of April and the average temperature at sowing period was 5.3 ℃ and the ≥0 ℃ was 90.0 ℃·d. The ≥5 ℃ accumulated temperature was 58.9 ℃·d. Since Mid May, the seed went into seedling period when the average temperature at day time was 16.2 ℃ and the average temperature at night was 8.4 ℃. The≥ 0 ℃ accumulated temperature was 490.2 ℃·d. The ≥5℃ accumulated temperature was 445.9 ℃·d, and the ≥10 ℃ accumulated temperature was 271.8 ℃·d. The ≥15 ℃ accumulated temperature was 54.8 ℃·d. Such temperature can guarantee the normal growth of celery at later stage[2]. The seeds went into growing period from the first ten days of June when average temperature was 15.2℃ and the highest temperature was 22.0 ℃ while the lowest temperature was 8.6 ℃. The inner leaves grew from the last ten days of June to the mid July when the average temperature was between 17.4 and 18.5 ℃, the highest temperature 24.2 – 24.8 ℃ and the lowest temperature 11.0 – 13.0 ℃. The celery can be sold on market in the last ten days of July. During the growth period, the ≥0 ℃ accumulated temperature was 1 692.9 ℃·d and the ≥5 ℃ accumulated temperature was 1 648.5 ℃·d, the ≥10 ℃ accumulated temperature was 1 465.5 ℃·d, the ≥15 ℃ accumulated temperature was 1 017.1 ℃·d, the ≥20 ℃ accumulated temperature was 155.1 ℃·d.

According to the above discussion, the influences of meteorological conditions on the growth of celery were concluded as follow. The weather in the sowing period ensured the normal plantation of membrane celery and the weather in the seedling period made the seedling suffering from less than 5 ℃. The temperature reflected the growth of celery and the leaf indicated that the thermal resources during the growth period. Timely harvest period suggested the price advantage of celery in Xiji. In reference to the further clustering analysis of membrane celery at different sowing periods in Hulu River Valley (Table 5), the appropriate time to plant celery, the fertilizer plan, field management and time to market was concluded.




Note: a. Cold and dry weather in Jiqiang; b. Cold and dry weather in Xinying; c. Warm and rainy weather in Xinglong; d. Warm and rainy weather in Xiaohe.

**Fig. 2 Diagram of climate in each area being planted with celery**

**Table 4 Growth of celery in Hulu River Valley**

| Section | Planting period | Seedling period | Leaf growing period | Leaf growing period | Harvest period |
|---|---|---|---|---|---|
| Xinying | The late April | The early June | The earlyJuly | The late July | The late August |
| Jiqiang | The mid April | The late May | The mid June | The mid July | The mid August |
| Xiaohe | The earlyApril | The mid May | The earlyJune | The late June | The late July |
| Xinglong | The late March | The earlyMay | The late May | The mid June | The mid July |

**Table 5 Clustering analysis of membrane celery at different sowing periods in Hulu River Valley**

| Section | Sowing period | | | Seedling period | | | Growing period | | |
|---|---|---|---|---|---|---|---|---|---|
| | Early period | Middle period | Later period | Early period | Middle period | Later period | Early period | Middle period | Later period |
| Xinying | Mid April | Early April | EarlyMay | Late May | E arlyJune | Mid June | Late June | EarlyJuly | Mid July |
| Jiqiang | EarlyApril | Mid April | Late April | Mid May | Late May | Late May | EarlyJune | Mid June | Late June |
| Xiaohe | EarlyApril | Mid April | Late April | EarlyMay | Mid May | Late May | EarlyMay | EarlyJune | Mid June |
| Xinglong | Late March | EarlyApril | Mid April | EarlyMay | Mid May | Mid May | Mid May | Late May | Late May |

| Section | Leaf growing period | | | Harvest period | | |
|---|---|---|---|---|---|---|
| | Early period | Middle period | Later period | Early period | Middle period | Later period |
| Jiqiang | Mid July | Late July | Early August | Late July | Mid August | Late August |
| Xiaohe | Late June | Early July | Mid July | Late July | EarlyAugust | Mid August |
| Xinglong | Mid June | Late June | Early July | Mid July | Late July | EarlyAugust |

## 3 Discussion and conclusions

Firstly, according to the general climate and extreme value, clustering analysis was applied to divide the celery industry climate in Hulu River Valley in Xiji County in Ningxia into two sections. One is the Xinglong – Xiaohe warm section. The average temperature was between 13.8 and 14.9 ℃. The precipitation was no less than 370.0 mm. The accumulated temperature was between 2 826.1 and 3 016.1 ℃·d. The other is Jiqiang – Xinying section. The average temperature was between 12.6 and 13.1 ℃. The precipitation was between 336.2 and 356.6 mm. The accumulated temperature was between 2 593.0 and 2679.1 ℃·d. These two general areas can be further divided into four sections, which have certain reference value to the celery industry and introduction of refined species. With the accumulation data in automatic meteorological data, this work needs further study.

Secondly, based on the climate characteristics in Xiji, the growth period of celery is divided into plantation period, seedling period, leaf growth period and inner leaf growth period, and harvest period. The appropriate time to plant celery, the fertilizer plan, field management and time to market was concluded. Because of short observation period of celery, there are many ways to divide the climate category and the conclusion needs further prove.

Thirdly, the weather was quite dry in Xiji and in summer the hail occured now and then. The underground water in Hulu River Valley had decreased in recent years and the water resource was limited. The celery needed to be watered for eight or nine times. After being put on the market, lots of water was consumed to clean the celery. During the development of irrigation, it was necessary to think of cloud resources and to improve the technology of artificial precipitation.

Fourthly, the weather in Xiji in spring was quite cold. Meteorological department had made accurate prediction of temperature before the plantation of celery each year and feasible suggestions to adjust the plantation period are given.

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the intangible cultural heritage of traditional craftsmanship, and the geographical indication name "Chu chrysanthemum" is the intangible heritage of agricultural brand. Therefore, we should implement double protection on intangible cultural heritage and geographical indication of the traditional chrysanthemum.

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