Study on the character of climate warming and northward movement of winter rapeseed in dried and cold areas in Northwest China

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Abstract

The study on living through the winter of Winter Rapeseed in different area was conducted for many years. Using the data including mean monthly temperature, highest temperature, lowest temperature, accumulated temperature of more than 0°C,10°C,and negative accumulated temperature for less than 0°C from 1961 to 2005 in Northwest, China were collected to analyze response of climate warming on heat resource and northward movement of Winter Rapeseed, and the the relationship between survival rate and meteorologic factors. The results showed that mean monthly temperature, highest temperature, lowest temperature, accumulated temperature more than 0°C, 10°C from 1987 to 2005 were significantly higher than that from 1961 to 1986, especially the increment of the lowest temperature in winter, and the lowest temperature rising played a main role in climate warming over Northwest China. The negative accumulated temperature less than 0°C reduced obviously. As the trends of climate change appeared warming since the late 1980s in Northwest China, thermal resource increased, planting areas of Winter Rapeseed were expanded to northward about 1000 km, altitude from 1000 m to 1500, even to 2300 m, and was extend from 35°30´to 39°46´.The study showed that it was possible for practicing winter rapeseeds production in dried and cold areas in Northwest China and would play an important role in the improvement of ecotype environment and the construction of adjusting agriculture environment system.

Key words: Northwest, China, Climate Warming, Winter Rapeseed, Northward movement

Introduction

Global climate warming are the most prominent problems of global system climate change in the post hundreds years. It leads to the change of ecology and environment, frequent meteorologic disaster, and even largely impact on crop distribution and planting structure of crops. Negative effect on sustainable agriculture production is appeared gradually. The studies on response of crops to global climate change, a fundamental of global changed ecosystem, can reveal response mechanism of biology to global climate change. Global temperature was risen about 0.6-0.2 centigrade from the report from the third assessment of IPCC. Northwest is one of the most sensitive areas in China. The increment of winter temperature was greater than that of other seasons. The strong changes of climate, especially abnormal temperature rising in winter, not only decrease the threaten of freezing to crops, but also affect the regulation of agriculture structure widely which makes plant crops expansion northward and raising in altitude. Winter Rapeseed, distributed mainly in the East of river, is one of the oil plants in Gansu province and its planting area occupies 14.9 percents of oil plant planting area, and 13.3 percents in production. We studied the adaptability and feasibility of the expansion northward of Winter Rapeseed in middle part and Hexi region of Gansu from 2002 to 2006. In this paper, we used the 43 years' data from 171 weather stations distributed in Northwest to lucubrate the traits of climate warming in Northwest and the effects of the expansion northward of Winter Rapeseed. The results will provide gist to the regulation of local agriculture structure responding the global climate change.

Material and Methods

The data for daily mean temperature of 171 weather stations in five provinces of Northwest from 1961 to 2005 was collected and active accumulated temperatures for more than 0°C and less than 0°C per year were calculated, respectively. The change extent of active accumulated temperature can be expressed by the variance between the mean of active accumulated temperature from 1987 to 2005 and that from 1961 to 1986. The changes of the mean temperature, the lowest temperature and ≥0°Cactive accumulated temperature were contrasted and analyzed. In addition, an attempt to analyses the changes of expansion to northward of Winter Rapeseed's planting area was done by using isoline of the mean temperature, -10°C, in the coldest month.

Results

Temperature chance in Northwest China

We contrasted and analyzed the mean annual temperature of 171 weather stations in Northwest and found the mean month temperature from 1987 to 2005 was higher 0.7°C than that from 1961 to 1986 and the weather station where the temperature increments was changed from 0.6 to 2.4°C occupied 74 percents of all stations(Table 1-a). Clearly, the increment of temperature in the Northwest was higher 0.35°C than that in the country in 20 century later. The spatial distribution of

temperature increment was different because of the far-flung area and complex terrain in Northwest. The region where temperature increment was the most marked was North Xingjiang, Jungger basin, Tulufan basin and the east of Chaidamu basin where the increment of the mean annual temperature was 1.0-1.3 centigrade. The second was the east of the Northwest and the other places of Qinghai-Tibetan Plateau, which increment was 0.6-1.0°C. The least was 0.2-0.6°C in Talimu basin and west of Tian mountain. In temporal, the highest increment of temperature was in winter. The mean increment in January, February and December was 1.0, 1.7 and 1.4°C, respectively. However, the increment in different province was 0.7-1.3, 1.3-2.2 and 1.2-1.8°C, respectively in which the highest was in February. The lowest temperature in the Northwest was increased for 0.8°C (Table 1-b), which was higher 0.7°C than the mean month temperature. The mean increment in most station (80% station) was between 0.5°Cand 2.4°C, and that in other places was between 0.1°C and 0.4°C. The highest increment for the lowest temperature in different place was in January, February and December, the increments were 1.1°C, 1.9°Cand 1.5°C, respectively. The increment from March to November was between 0.4°C and 0.9°C, which was higher than that in the same period. This implied that the increment of the mean temperature was due to the increment of the lowest temperature.

Table 1 The mean value of monthly temperature (a) and the lowest monthly temperature (b) difference between 1987-2005 and 1961-1986 over the Northwest China (°C)

Monthly	1	2	3	4	5	6	7	8	9	10	11	12	average
Northwest China	1.0	1.7	0.4	0.4	0.2	0.5	0.5	0.2	0.9	0.3	1.0	1.4	0.7
Xingjiang	1.3	2.0	0.3	0.2	0.1	0.4	0.3	0.2	0.7	0.3	0.9	1.7	0.7
Qinhai	0.7	1.3	0.6	0.3	0.2	0.9	0.7	0.3	0.8	0.4	1.0	1.2	0.7
Gansu	1.0	1.7	0.5	0.5	0.2	0.6	0.8	0.2	1.0	0.3	0.9	1.3	0.7
Ningxia	1.3	2.2	1.0	0.7	0.3	0.6	0.7	0.3	1.2	0.4	1.1	1.8	0.9
Shanxi	0.8	1.6	0.3	0.6	0.2	0.1	0.4	-0.2	1.0	0.3	0.5	1.1	0.5

Monthly	1	2	3	4	5	6	7	8	9	10	11	12	average
Northwest China	1.1	1.9	0.8	0.6	0.4	0.9	0.7	0.4	0.8	0.5	0.9	1.5	0.8
Xingjiang	1.5	2.3	0.7	0.5	0.5	0.7	0.7	0.5	0.8	0.7	1.1	2.1	1.0
Qinhai	0.8	1.4	1.0	0.7	0.3	1.1	0.7	0.4	0.7	0.6	1.3	1.3	0.9
Gansu	1.0	1.8	0.7	0.5	0.2	0.9	0.7	0.2	0.7	0.3	0.6	1.2	0.7
Ningxia	1.5	2.6	1.4	1.0	0.7	1.2	0.9	0.3	1.0	0.6	1.0	1.9	1.1
Shanxi	0.9	1.6	0.4	0.4	0.4	0.6	0.6	0.1	0.8	0.2	0.2	1.0	0.6

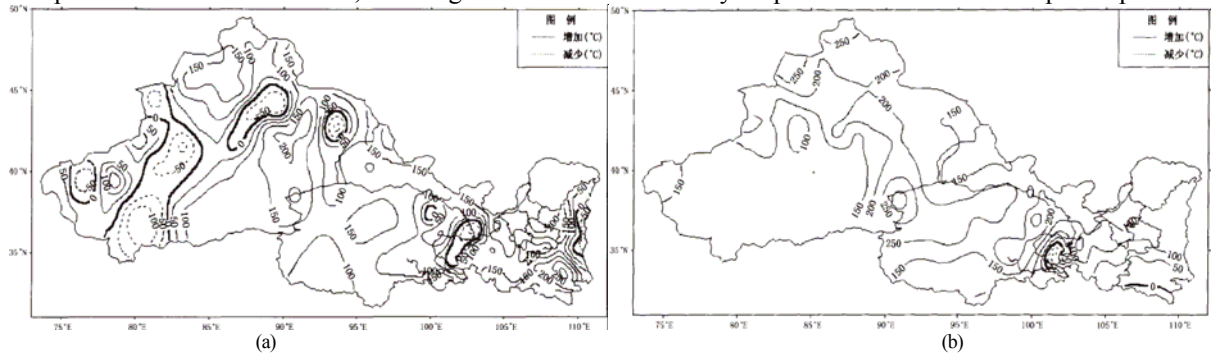
Chance of accumulated temperature in Northwest China

The active accumulated temperature for daily mean temperature ≥0°C from 1987 to 2005 was higher112°C than that from 1961 to 1986 in Northwest. Clearly, thermal resource of the majority of areas in Northwest was increased and the increments in 81% and 60% stations were 50-720°C and 100-720°C, respectively. However, there was a decrease in only small parts of stations (13% of stations). The increments of thermal resource in the majority of areas in Xinjiang were 100-250°C, however, that in small partswas decreased for 50-100°C, and the increments in Qinghai were 100-150°C, 100-200°C in Gansu, Ningxia and the north of Shanxi, 150-500°C in the middle-south of Shanxi where the increment of thermal resource was the maximal (Fig. 1-a).The active accumulated temperature for daily mean temperature ≥10°C from 1987 to 2005 was increased for 107°C than that from 1961 to 1986 in Northwest China and the increments in 74% and 64% stations were 50-710°C and 100-710°C, respectively, the decrease in 15% stations was 70-780°C. The increments of active accumulated temperature in the majority of Xinjiang was increased for 70-150°C. However, the decrease in a small part of areas in Tian mountain and Sorth Xingjiang was 70-150°C. The active accumulated temperature in the east of the Northwest China was increased for 70-180°C, however, that in a small part area of the southeast of Shanxi and the east of Qinghai was decreased for 70-180°C, respectively. The negative accumulated temperature in the period of the daily mean temperature ⩽0°C was the integrated temperature index to assess the condition of crops' live through the winter. The absolute value of mean negative accumulated temperature from 1987 to 2003 was decreased for 137°C contrasted to that from 1961 to 1986 in Northwest because of the climate warming. The absolute value of negative accumulated temperature in 89% and 79% stations was decreased for 50-340°C and 100-340°C, respectively. However, there was a decrease in Longnan of Gansu and the south of Shanxi for 50°C (Fig.1-b). In addition, the absolute value of negative accumulated temperature ⩽0°C was occurred as a trend of durative decrease. The decrease in 1960s, 1970s, 1980s and 1990s were -874°C, -823°C, -776°C and -723°C, respectively. By comparing the absolute value, the mean decrease of each decade was 50°C and the decrease from 1960s to 1990s was 151°C.

The influence of global warming on the winter rapeseed movement northwards

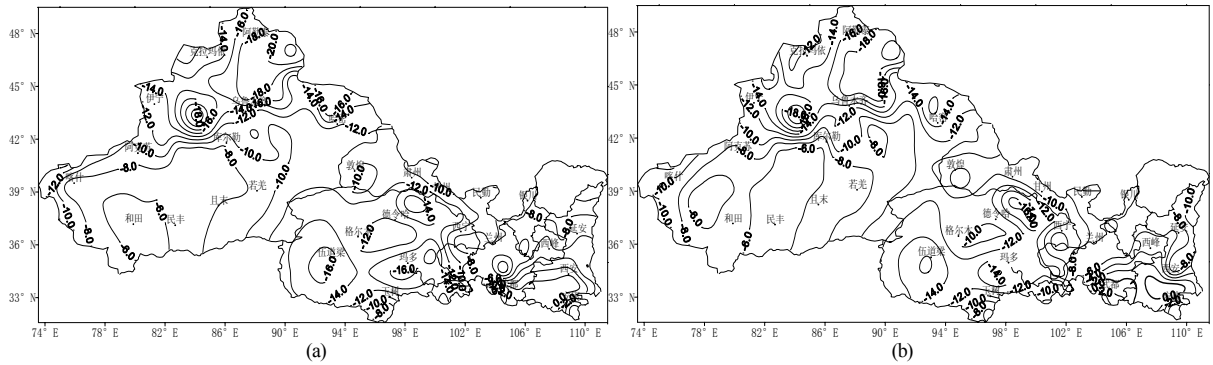
The most essential question that winter rapeseed moves northward is whether it can survive safely in the winter, During 1997-2005, 20 winter rapeseed cultivars were bred in Gansu Hexi. The result indicated that,, survival rate of three cultivars, MXW-1. DQW-1 and WYW-1, in winter in the Gansu Jiuquan area reached 94.60~100.00%, which are strong cold resistant varieties. The output of these three varieties reached 4400.30 kg/hm^2. The winter rapeseed living through winter is related with the climatic conditions, the variety characteristic, the cultivation measure and many other factors. Whether the winter rapeseed can survive the winter depends on the lowest temperature in winter. Using the average temperature of January (the coldest month) as the target of the winter rapeseed over the winter, the actual situation of the field test indicated that the survival rate of the winter was directly related to the average temperature in January (R=0.9547). Analysis shows that when the average temperature in January was more than -9.7 °C, the survival rate of the winter rapeseed would be more than 80%. So January average temperature -10 °C was defined as the target of the plant temperature of winter rapeseed for living safely through the

winter (Fig. 2). It can be seen that the contour line of January average temperature of -10°C was along Mingqing-Yunchang-Wuwai-Gulang before 1986. The location was more northerly than the actual location. The main reasons were attributed to the lack in super cold resistance cultivars before and the increase of average temperature in January. The contour line of January average temperature of -10 °C during 1987-2005 was along Jingta-Jiuquan-Yumeng. It expanded more than 1,000 meters to north compared to 1986. The sea level was heightened from 1000 m to 1500-2300 m. The latitudes was expanded from 35°30′ to 39°46′, so the region has been certificated by the promotion test for winter rapeseed production.



(a) (b)

Fig 1 The accumulated temperature difference for mean daily temperature ≥0°C (a) and ⩽0°C (b) between 1987-2005 and 1961-1986 in Northwest China (°C)



(a) (b)

Fig 2 The temperature isoline of mean month temperature between 1987-2005 (b) and 1961-1986 (a) in Northwest China (°C)

4 Discussion

The month average temperature, the highest temperature, the minimum temperature in Northwest were obviously increased in 1987-2005 compared with 1961-1986, the increasing degree of the minimum temperature was the most significant, and the increasing degree was greater in winter than in summer. So the climate warming was the result of minimum temperature increase. The coldest month average temperature in winter, the increasing degree of the minimum temperature and the reduction of the absolute value of accumulated temperature in winter and heat resources increase are helpful for the winter crop's north boundary line expanded to northwards. Studies have suggested that climate warming has make the rapeseed culture's north boundary line extend towards the westward and northward more than 1000 Km. The sea level was heightened from 1000 m to 1500-2300 m. The latitude was expanded from 35°30′ to 39°46′. The successful culture of the rapeseed in this area in winter will offer an important basis for the repartition of the rapeseed production zone, and provide one kind cover crops in spring and winter for the cold district in North. It also will take important roles to promote the rapeseed over winter in cold district of North, and the sustainable development of agriculture and the constructions of ecological environment.

References

Shi Y.F, Shen Y.P,Hu R.J.(2002)Preliminary study on signal impact and foreground of climatic shift from warm dry to warm humid in Nrothwest China.Journal of Glaciology and Geocryology,.24(3):219-226.

Li D.L,Wei L,Cai Y.et al.(2003).The present facts and the future tendency of the climate chang in Northwest China Journal of Glaciology and Geocryology,25(2):135-142.

Houghton J.T, Ding Y.H, Griggs D.G. (2001).Climate Change: Contribution of Working Group Ito the Third Assessment Report of the Intergovernmental Panel on Climate Change.CambridgeUniversityPress,UK,583-638.

Chen X.Q, Zheng G.G. (2002).Climatological Problem in Sustainable Development.Beijing:China Meteorological Press, 89-98 (in Chinese)

Chen K.Z, Chen X.W. (2003).The new stages,features, developments and discussion of China's developing vegetable industries by utilizing climatic resources. *Chin Agric Sci Bull*, 19(3):135-138(in Chinese with English abstract)

Deng Z.Y, Qiu H.M, Li H.D.(2000)Development of Climate and Agriculture in the East of Gansu. Beijing: China Meteorology Press. 56-69(in Chinese)

Fu Y, Zhang G.S, Yan L.D. (2004).Impact of climate change on cropping systems and adaptive strategies in Qinghai Province. *Chin J Agrometeorol*, 25(3):11-14(in Chinese with English abstract)

Gao S.H, Guo J.P. (1999).An examination of the countermeasures for increasing climatic resources utilization rate in the Three North of China. *Resour Sci,* 21(4):1-54(in Chinese with English abstract)

Lin E.D, Yang X.(2003).The Countermeasures for Impact of Climatic Changing on Agriculture. Beijing: China Meteorology Press. 72-77 (in Chinese)
Liu D.X,Dong A.X,Deng Z.Y.(2005).Impact of climate warming on agriculture in Northwest China. *J Nat Resour*,20(1):119-125 (in Chinese with English abstract)
Qin D.H, Wang F.T, Zhao Z.C, Wang S.L.(2003). Impact of Climatic Changing on Ecological Agriculture. Beijing: China Meteorology Press.pp 88-98 (in Chinese)
Song Y.L, Zhang Q, Dong W.J. (2004).Impact of climate change on cotton production in Xingjiang autonomous region. *Chin J Agrometeorol*, 25(3):15-20 (in Chinese with English abstract)
Sun S. (2005). Some thoughts of global change and earth system science studies in China. *Adv Earth Sci*, 20(1) : 6-10(in Chinese with English abstract)
Wang R.Y, Zhang Q, Wang Y.L.(2004).Response of corn to climate warming in arid areas in Northwest China. *Acta Bot Sin*,46(12):1387-1392
Yang X.L,Yin D.(2001).Climatic change and influence on agriculture in Pingliang district during the recent decades. *Meteorolog*, 27(5):16-18(in Chinese with English abstract)
Wen M,Zhang R.H,Yang Z.B.(2004).Rational development and utilization of climate resource. *Adv Earth Sci*, 19(6):896-902(in Chinese with English abstract)
Pu J.Y,Deng Z.Y,Yao X.Y. (2005).A study on ecoclimatic of winter wheat and its suitable planting regions in Gansu. *Agric Res Arid Areas*.23(1):179-186(in Chinese with English abstract)