Study on Spring Wheat Yield Change of Inner Mongolia in Time and Space Based on APSIM Model

Yidan Yanyang[1, a], Jingwen Xu[1, b*], Junfang Zhao[2], Ning Li[1] and Yue He[1]

[1] College of Resources, Sichuan Agricultural University, Chengdu 611130, P.R. China

[2] Chinese Academy of Meteorological Sciences, CMA, Beijing 100081, P.R. China

[b] Corresponding author: x.j.w@163.com

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Abstract. The yield system of spring wheat in Inner Mongolia was investigated in this study. Based on the meteorological data, crop data and soil data between 1961 and 2010. And analyze the influence to the yield of spring wheat caused by climate change with the APSIM-Wheat model and mathematical Statistics mode. Then use the ArcGIS spatial interpolation analysis the spring wheat yield change in Inner Mongolia in time and space to give the scientific advice for the product change and plantation management.

Introduction

Overall, in the past 50 years, the trend of Inner Mongolia spring wheat yield increased first and then decreased, the average yield was 3560.84kg/ha, the highest yields was 3681.33kg/ha in the 1990s, and the lowest yield was 3432.82kg/ha in the early 20^{th} century. Temperature is the main driving factor for most of the plants' growth because warming accelerates the growth process of the plants. The study of Zhao Hong and Huang Feng in 2008 shows climate warming led the decline of spring wheat yield in the Loess Plateau. And booting stage production is very sensitive to temperature change. As the average temperature increased 1˚C,the spring wheat yield reduced 15-18g/m^2.And in sensitive period the decline takes about 40-50d. On the one hand, the increase of temperature can accelerate the yield by adding the effective accumulated temperature and active accumulated temperature. On the other hand, it can speed up the metabolism of the crop and accelerate the process of crop growth and development. Meanwhile, it can shorten the growth period which is bad for the material accumulation and grain yield.

Recent years, with the development of the computer technology, researchers have paid more and more attention to the crop growth model. Crop growth model has many advantages, such as powerful function and easy to use. And it can also develop the agriculture management. Crop growth model can be used widely since it is possible to improve the level of agricultural production, risk assessment and sustainable management, etc. Study based on statistical analysis to the effect of climate change on crop growth and development has a deeper understanding. But study based on crop growth model and the crop yield response to climate change, has not yet fully known.

APSIM model

The APSIM (the Agricultural Production Systems Simulator) developed by researchers in Australia is a successful upland crop system model. Allowing a number of other similar models connected to its system to simulate the different cropping systems.

The most basic(at least)factors to run the APSIM model includes daily solar radiation ($MJ \cdot m^{-2}$), daily maximum temperature(˚C), daily minimum temperature(˚C), daily precipitation(mm), local latitude, average temperature per month, and average temperature change per month etc. All the data in this study comes from the 12 meteorological stations in the northeast and northwest part of Inner Mongolia (meteorological stations are in form 1). Soil data of different northern dryland areas come from the Chinese soil database and Chinese scientific soil database which includes soil-class, subclass, soil types, levels of thickness, texture, bulk density, and other nutrients, and PH etc. And part of the saturated water content, field capacity, wilting coefficient come from the existing research result, part of them come from the relevant soil feature papers. APSIM model uses the GM crop growth model to stimulate the growth of annual and perennial crops. The differences between them are different model parameter values which includes clock and manager.

Model validation

Evaluate the model by comparing simulation results and the measured results of the graphical and other evaluation indexes. The model calibration mainly uses the standard statistical parameters as the calibration index, including correlation coefficient (R^2), root mean square error (*RMSE*), relative root mean square error (*NRMSE*), error consistency index-*D*, *MAE* and *ME*.

NRMSE shorts for normalized root mean squared error. And ME shorts for mean error. Smaller RMSE indicates lower deviation between stimulate result and real testing result. And this model has a high accuracy if NRMSE is under 10%. ME stands for the mean error index of this model and model has a better stimulate result if ME>0.5. R2 and D can show the consistency between the real testing result and stimulate result. The more they are closer to 1, better the stimulate result is. RMSE and NRMSE are more sensitive about the system stimulate error than R2 and D. RMSE and NRMSE stands for the absolute error and relative error between the real testing result and stimulate result. Smaller number means smaller error.

The Results and Analysis

The result of Model validation is shown in Table 1.

Table.1 Verify Evaluations

stations	RMSE	NRMSE (%)	D	MAE
Chifeng	177.75	5.78	0.49	344.55
Kailu	170.70	3.79	0.92	326.4
Naiman	50.4	1.52	0.85	119.4
Wengniuteqi	208.35	3.70	0.58	410.85
Tumotezuoqi	65.40	1.83	0.80	90.15
Chayouzhongqi	92.4	6.40	0.95	153.9
Guyang	106.95	11.1	0.85	41.1
Taipusiqi	28.95	2.02	0.56	51.3
Linhe	166.05	3.81	0.51	225
Wulateqianqi	45.6	0.96	0.85	108.45

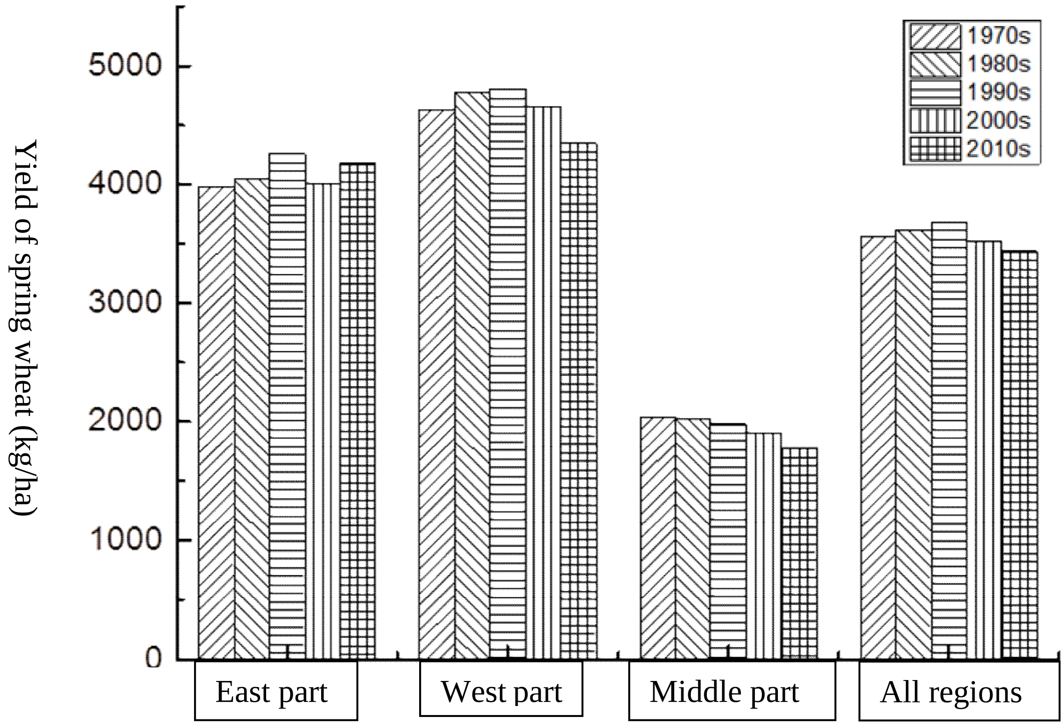

Fig.1 Time Change in Wheat Yield of Inner Mongolia's each part

From Fig.1, overall, in the past 50 years, the trend of Inner Mongolia spring wheat yield increased first and then decreased. The average yield was 3560.84kg/ha, with the highest yield was 3681.33kg/ha in the 1990s, and the lowest yield was 3432.82 kg/ha in the early 20^{th} century.

The yield regional distribution of Inner Mongolia's spring wheat has the trend of gradually increase from the middle to both sides. Yield of the whole region varied from 1732.87Kg/ha to 4360.75Kg/ha. The highest yield comes from Wengniuteqi which lies in the east part, and the lowest comes from Guyang which lies in the middle.

The west part of Inner Mongolia's spring wheat yield tends to increase first and decline later. The highest yield was in the 1990s, and the lowest yield was in the early 20^{th} century. And the middle part of the wheat region tends to decline. It got its highest number in the 1970s and lowest in the 2000s. And the east part of the wheat region tends to be varied. It has the highest number in the 1990s and lowest in the 1970s.

Conclusions

The APSIM model was verified to be suitable for the spring wheat growing areas in Inner Mongolia. In 1961-2010, the yield of spring wheat in Inner Mongolia increased at first and then decreased, and the yield distribution increased gradually from the middle to the West and East.

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