# The study of the relationship between climate factors and growth period of spring wheat based on APSIM model

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**Abstract.** To explore the influence of climate factors on wheat growth period, the sequence, based on the test of APSIM model, research of the relationship between wheat and climate factors using the APSIM model and correlation analysis. The results show that the APSIM model can be used to simulate the wheat growth period, the sequence; wheat seeding emergence date related to the temperature and soil temperature; wheat maturity date related to the temperature, soil temperature and potential evapotranspiration.

## Introduction of APSIM model

APSIM model has started to develop since 1991, is a model of agricultural production systems by the Australian Agricultural Production Systems Research Group (APSUR) development. The model has a strong sensitivity to forecast the yield and economic risk analysis under extreme environmental conditions. Although the model is similar to other models in yield and economic evaluation, the model is better than that of crop rotation system, which can simulate the dynamic of different tillage measures [1]. Predict the relationship between yield and temperature, rainfall and soil moisture. It can realize the dynamic decision-making and the climate strain management of different years, but also can provide reference for the new varieties of strain management.

## Materials and methods

### The experimental method

Test data from the Inner Mongolia Tumotezuoqi test station, which is located in Inner Mongolia Autonomous Region, between Hohhot and Baotou. The data were divided into two groups. The model parameters were tested with 1998-2002, and the model was verified by 2003-2013 data. By simulating the data of 1961-1997 after verification, then analyze their correlation.

### Model parameters

According to the data of climate and soil properties in the study area, a basic database is established. Then based on the original APSIM-Wheat module, combining experiment in the study area, the module parameters can be modified and revised to create crop parameter module, and "seamless" connected to the platform for simulation [2].

### Climate parameters

As the basis of APSIM model, climate model is the key to establish a reasonable and accurate model for the application of the model. APSIM model is driven by daily meteorological elements, the process of crop physiology and ecology, soil water and nutrient dynamics and soil erosion

 

amount of numerical simulation. Model is required to run the basic meteorological elements include: the amount of daily solar radiation, the daily maximum temperature, the daily minimum temperature, the daily rainfall, the local latitude, mean monthly temperature and monthly average temperature change parameters. This study meteorological data comes from Tumotezuoqi climatological observation station.

**Soil data**

Soil is the decisive factor that affects the growth of crops under certain climate conditions. Different from other crop models, the core of the APSIM simulation system is the soil rather than vegetation. Therefore, it is very important to establish a reasonable and accurate model of soil properties [3]. According to the parameters of soil properties, the soil attribute module was set up. In this study, soil parameters in Table 1:

Tab.1 Soil properties of the experiment site used for specifying APSIM simulation

| Model | Item | Soil layer (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 60 | 90 | 120 | 150 | 180 | 210 |
| Soil water | Bulk density (g. $cm^{-3}$) | 1.02 | 1.03 | 1.02 | 1.02 | 1.06 | 1.11 | 1.12 | 1.15 |
| | Wilting coefficient (mm. $mm^{-1}$) | 0.29 | 0.29 | 0.29 | 0.29 | 0.30 | 0.31 | 0.32 | 0.33 |
| | Drainage upper limit (mm. $mm^{-1}$) | 0.54 | 0.53 | 0.54 | 0.54 | 0.52 | 0.50 | 0.50 | 0.48 |
| | Saturated moisture (mm. $mm^{-1}$) | 0.59 | 0.58 | 0.59 | 0.58 | 0.57 | 0.55 | 0.55 | 0.53 |
| | Coefficient of air-dry (mm. $mm^{-1}$) | 0.15 | 0.26 | 0.29 | 0.29 | 0.30 | 0.31 | 0.32 | 0.33 |

**Crop attribute parameter**

APSIM model uses generic crop growth models to simulate the growth of various crops, but each crop has a different model parameter values. By collecting crop attribute information of the Experimental Station, established attribute parameter of wheat. Wheat property module includes parameters Wheat Genetic parameters of the study area, wheat growth and development, yield formation. The wheat attribute module mainly includes the parameters of the genetic parameters, the growth and development process, the yield formation of Wheat Varieties in the study area. In this study, the parameters of wheat in Table 2:

Tab.2 Parameters of model calibration

| Parameter | Value |
|---|---|
| Startgf_to_mat (˚C) | 580 |
| Vern_sens | 1.6 |
| Photop_sens | 3.2 |
| Potential_grain_filling (mg.$grain^{-1}$.$d^{-1}$) | 0.0025 |

**Model checking method**

The model calibration mainly uses the standard statistical parameters as the calibration index, including correlation coefficient ($R^2$), root mean square error (*RMSE*), relative, Formula is as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (Y_{obs} - Y_{sim})^2}{N}} \quad \text{(a)}$$

$$NRMSE = 100 \frac{\sqrt{\frac{1}{n} \sum_{i=1}^{n} (Y_{obs} - Y_{sim})^2}}{Y_{mean}} \quad \text{(b)}$$

$$Me = 1 - \frac{\sum (Y_{obs} - Y_{sim})^2}{\sum (Y_{obs} - Y_{mean})^2} \quad \text{(c)}$$

In (b) and (c) formulas, *NRMSE* and *Me* are the validity of normalized root mean square error and the model, $Y_{obs}$ is the measured value, $Y_{sim}$ is the simulation value, $Y_{mean}$ is the average value of the measured value. In (a) formula, the smaller the *RMSE* value, the smaller the deviation between the simulated and the actual observation, and the *NRMSE* control in 10%. *Me* is the model's validity index, and the simulation result of the model is better when *Me*>0.5 [4]. $R^2$ can reflect the simulated values in agreement with the experimental data, the value is closer to 1 indicates that the simulation effect is better.

## The Results and Analysis

### APSIM model checking

The validity of the model is tested according to the simulated data and the measured data of the 2003-2013.All validation metrics are shown in table 3.

Table.3 Evaluation indices for spring wheat

| Growth period | Parameter | Value |
|---|---|---|
| Emergence dates | $R^2$ | 0.7211 |
| | RMSE | 2.296 |
| | NRMSE (%) | 2.107 |
| | Me | 0.603 |
| Maturity dates | $R^2$ | 0.6996 |
| | RMSE | 1.732 |
| | NRMSE (%) | 0.868 |
| | Me | 0.672 |

From table 3, the wheat seedling stage and mature stage of the absolute error are 2.296 and 1.732 days respectively, the normalized root mean square error of 2.107% and 0.868% respectively, the model parameters effectively ME was 0.603 and 0.603, respectively, were greater than 0.5, the simulation effect is better, show that model to simulate the wheat growth period sequence had a higher accuracy [5].

### Correlation analysis of wheat growth period

The growth period of wheat was influenced by soil type, crop variety, and environmental factors, but the soil types and crop varieties were the same, so the simulation stage was influenced by the fluctuation of climate factors. Based on the observed meteorological data of 1961-1997, the emergence and maturity of 37 years of wheat are simulated, and the correlation between the daily order and climatic factors is analyzed. As in Table 4,

Table.4 Growth period correlation analysis

| | | emergence | maturity | Temp | sunhour | rain | humidity | soiltemp | radn | ETO |
|---|---|---|---|---|---|---|---|---|---|---|
| Emergence | correlation | 1 | .533** | -.413* | .047 | -.048 | .016 | -.348* | .010 | -.148 |
| | significance | | .001 | .011 | .782 | .777 | .923 | .035 | .954 | .383 |
| | N | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |
| Maturity | correlation | .533** | 1 | -.670** | -.125 | -.017 | .234 | -.620** | -.168 | -.418* |
| | significance | .001 | | .000 | .459 | .923 | .164 | .000 | .322 | .010 |
| | N | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |

From table 4, it is known that the emergence date is significantly related to temperature and soil temperature, and is significantly correlated with the maturity date, and has no correlation with sunhour, rainfall, humidity, solar radiation and potential evapotranspiration. The maturity date of the growth period was significantly correlated with the potential evapotranspiration, and was significantly correlated with the soil temperature, temperature and the emergence date, and was not related to the sun hour, rainfall, humidity and solar radiation.

## Conclusion and Discussion

In order to analyze the influence of climatic factors on the growth period, the APSIM model was used to verify the validity of the data in the study area. The results show that the normalized root mean square error and the model's validity parameters are satisfied with the model test, and the APSIM can be used to simulate the growth period of wheat. The model is used to simulate the 1961-1997 years. Through the analysis, the wheat seedling emergence date is related to temperature and soil temperature, and the maturity date of wheat is related to temperature, soil temperature and potential evapotranspiration.

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