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Meteorological Factors Analysis of the Influence on the Rice Yield in Yanbian Prefecture

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Abstract

The data of meteorological and the rice yield In Yanbian region from 1980 to 2011 was used in this paper, in order to analyze the regulation of the meteorological factors of accumulated temperature, rainfall and Sunshine hours and its influence on the meteorological yield of rice. By correlation analysis and partial correlation analysis, we found the meteorological of rice had a significant positive correlation with the rainfall and sunshine hours ,had not correlation with accumulated temperature, and the regression equation of the meteorological yield and accumulated temperature, rainfall and sunshine was got by the Multiple linear regression analysis. And the average accumulated temperature and sunshine hours were increased 6.7℃ and 3.8h annually, while rainfall was decreased 4mm per year. With the intensity of the phenomena of climate warming and rainfall reduction in Yanbian prefecture, the impact on drought and Rice yield will become heavy.

Keywords: Rice; Meteorological Yield; Regression Analysis

1 INTRODUCTION

China's rice cultivation is mainly concentrated in these three regions: the Yangtze River, the southeast coast and the Northeast Plain, and they accounted for the national rice planting area of 48%, 17.36% and 15.87%[1]. The total output of rice accounts for 45% of China's food crops, so the rice production is related to China's food security issues[2]. Rice planting regional characteristics are obvious, and the difference of variety and yield of different regions is large. Yanbian is located in the eastern part of Jilin Province, so its unique geographical and climatic conditions make rice of high quality. However, due to less arable land and a lower level of production, how to improve the yield of rice becomes extremely important. In addition to the improvement of production technology, a major factor contributing to inter-annual fluctuations in rice yields is meteorological factors. Among them, accumulated temperature, rainfall and sunshine hours are the most important factors. Zheng Zhuo and other researchers' research results show that, according to the rice varieties and regional temperatures, the fertilization time can be calculated [3]. Shi Chunlin and other researchers construct a mechanism model of spikelet abortion induced by high temperature, according to the daily variation of temperature, the distribution of spikelet flowering and the influencing factors of spikelet vigor[4],Wei Jinlian and others' study show that there was a significant difference in the effect of night temperature rise on the yield of rice at different growth stages[5]; Wang Ping and other researchers' study the effect of climate warming on rice yield in Heilongjiang Province, indicating that temperature is the main factor affecting the yield of rice in this region[6]; Zhu Yongning and others study the effects of temperature and accumulated temperature on the meteorological yield of rice in Liaoning Province[7]. Due to climate change and differences and regional changes and differences in rice production, the conclusions of these studies are not the same, so it is important to study the impact of climate change on rice yield in different regions.

In general, crop yields can be broken down into trend yields and meteorological production, where meteorological production is the part which is affected by meteorological factors[8]. Yanjing 28, Jijing (81, 511, 88, 512), Tongyu

313, Baijing 1, Songjing 9 and other rice varieties planted in Yanbian area have a greater degree of impact affected by the weather, and especially in the fertilization period, meteorological factors have a greater impact on rice yield. This paper attempts to analyze the relationship between meteorological yield of rice and accumulated temperature, rainfall and sunshine hours in Yanbian, and to study the significance of these factors in rice production. This paper analyzes the relationship between meteorological factors and its relationship with meteorological yield, explains the influence of meteorological factors on meteorological yield, and obtains the regression equation of multivariate regression model fitting.

2 DATA SOURCES AND ANALYTICAL METHODS

2.1 Data Sources

The meteorological data of this paper are based on the meteorological data from 1980 to 2011 of China Meteorological Science Data Sharing Service website; Rice production data uses the *China Statistical Yearbook* from 1980 to 2011 Yanbian state of rice production.

The growth process of rice in Yanbian area is from mid to late April, and then it is harvested by mid-October, therefore, in the weather data collection process, we selected the 1980 ~ 2011 April to October part. Among them, for the accumulated temperature data, we selected from 1980 to 2011 in April to October each year the average daily temperature greater than or equal to 10℃ part. Rice production can be broken down into trend yields and meteorological production as well as production from random factors. The introduction of meteorological production is to exclude the different historical periods of production technology and policy differences, resulting in changes due to meteorological factors that part of the output, expressed in formula form as: $Y=Y_t+Y_m+e$. Y is the yield per unit area(kg/hm^2); Y_t is the trend yield(kg/hm^2); Y_m is the meteorological output((kg/hm^2)); e is a random error, generally not considered in the actual operation.

2.2 Calculation of Meteorological Output

The weather production is derived by the moving average method. Moving average method is based on the time series data item by item, followed by the calculation of the number of items with the order of the average number to reflect the long-term trend of the method. When the value of the time series fluctuates greatly due to the influence of the periodic and irregular changes, and it is difficult to show the development trend, we can use the moving average method to eliminate the influence of these factors, analyze and forecast the long-term trend of the sequence.

Let the time series be:Y_1，Y_2，……Y_t…… ; simple moving average method formula

$$M_t = \frac{Y_t + Y_{t-1} + Y_{t-2} \cdots\cdots Y_{t-n+1}}{n} (t \geq n)$$

M_t is the moving average of the period t; n is the number of items moving average.

Since moving averages can smooth the data, eliminating the effects of periodic and irregular changes, long-term trends are displayed and can therefore be used for forecasting, the forecast formula is: $Y_{t1} = M_t$, that is, the t-th moving average is the predicted value of t + 1, which is the trend yield.

Among them, the choice of n value is essential, where the use of mean square error minimization principle, that MSE minimum.

$$MSE = \frac{1}{n}\sum (y - \hat{y})^2$$

where n is the number of new sequences. In this paper, n is the value of 3,4,5,6,7,8, calculated that when n = 7, the mean square error is minimal.

TAB.1 THE ACTUAL YIELD, TRENDS YIELD AND METEOROLOGICAL YIELD OF RICE FROM 1980 TO 2011 IN YANBIAN((KG/HM2)

Year	AY	TY	MY	Year	AY	TY	MY
1980	3073.5			1996	5264.8	4393.5	1231.3
1981	4075.3			1997	5817.8	4569.4	1248.4
1982	4483.2			1998	1853.0	4627.6	-2775.0
1983	4180.1			1999	6389.1	4108.4	2280.7
1984	5663.4			2000	5871.9	4291.0	1580.9
1985	5714.3			2001	6036.4	4987.4	1049.0
1986	2536.7			2002	3466.6	5041.4	-1575.0
1987	5202.3	4246.6	955.7	2003	1786.7	5008.5	-3222.0
1988	2273.8	4550.8	-2277.0	2004	6054.4	4460.2	1594.0
1989	4393.2	4293.4	99.8	2005	5965.2	4494.0	1471.2
1990	5410.3	4280.6	1129.7	2006	5952.5	5081.5	871.0
1991	5487.9	4456.3	1031.6	2007	5957.7	5019.1	938.6
1992	5111.0	4431.2	679.7	2008	6678.5	5031.4	1647.1
1993	996.6	4345.0	-3348.0	2009	3759.2	5123.1	-1364.0
1994	5658.3	4125.0	1533.3	2010	5049.7	5164.9	-115.2
1995	3697.1	4190.1	- 493.0	2011	5312.5	5631.0	-318.5

NOTE:AY=ACTUAL YIELD,TY=TREND YIELD,MY=METEOROLOGICAL YIELD

3 RESULTS AND ANALYSIS

3.1 Variation of Accumulated Temperature, Rainfall and Sunshine Hours in Rice Growth Period in Yanbian State

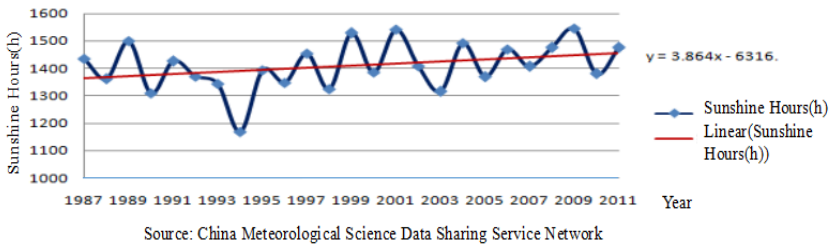


FIG. 1 THE CHANGES OF ACCUMULATED TEMPERATURE IN THE GROWING PERIOD OF RICE FROM 1987 TO 2011 IN YANBIAN

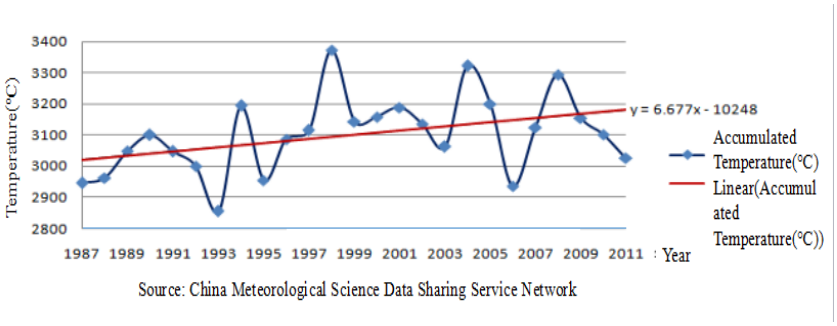
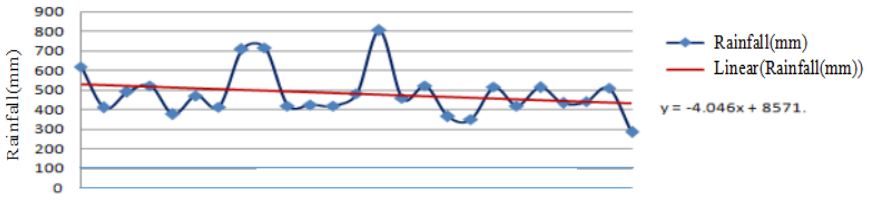


FIG. 2 THE CHANGES OF SUNSHING HOURS IN THE GROWING PERIOD OF RICE FROM 1987 TO 2011 IN YANBIAN



Source: China Meteorological Science Data Sharing Service Network

FIG. 3 THE CHANGES OF RAINFALL IN THE GROWING PERIOD OF RICE FROM 1987 TO 2011 IN YANBIAN

As shown in Figure 1, from the accumulated temperature point of view, from 1987 to 2011, Yanbian rice accumulation period of accumulated temperature fluctuations are relatively large, and the overall trend of increasing，the linear trend equation is:

$$Y = 6.677X - 10248$$

From the sunshine hours[Figure 2], the overall volatility is not great, and there is a slow upward trend,the linear trend equation is:

$$Y = 3.864X - 6316$$

From the point of view of rainfall[as shown in [Figure 3], except 1994, 1995 and 2000, the rainfall has increased abnormally, and the overall trend is decreasing,the linear trend equation is:

$$Y = -4.046X + 8571$$

3.2 Analysis on the Relationship between Meteorological Yield, Accumulated Temperature, Rainfall and Sunshine Hours in Rice

The data of accumulated temperature, rainfall and sunshine hours during the rice growing period in Yanbian area from 1980 to 2011 are summarized as follows:

TAB.2 THE ACCUMULATED TEMPERATURE，RAINFALL AND SUNSHINE HOURS IN THE GROWING PERIOD OF RICE IN YANBIAN

Year	AT(℃)	Rainfall(mm)	SH(h)	Year	AT(℃)	Rainfall(mm)	SH(h)
1980	2919.3	412.9	1301.5	1996	3087.4	417.2	1348.2
1981	2920.9	451.9	1398.3	1997	3115.1	425.0	1454.5
1982	3209.4	525.4	1605.3	1998	3372.0	417.9	1323.9
1983	3014.5	476.3	1366.3	1999	3143.1	478.7	1527.6
1984	2902.0	478.9	1370.0	2000	3159.0	804.5	1384.5
1985	3058.1	357.5	1395.0	2001	3187.7	456.6	1540.4
1986	2763.9	694.7	1323.9	2002	3135.7	520.4	1408.2
1987	2945.4	616.0	1434.9	2003	3061.8	363.6	1315.3
1988	2961.4	408.3	1360.0	2004	3321.4	349.4	1491.2
1989	3047.9	489.1	1498.9	2005	3199.8	513.8	1367.6
1990	3098.8	522.1	1309.2	2006	2935.9	418.7	1469.3
1991	3047.1	375.1	1425.8	2007	3123.7	512.2	1405.7
1992	2999.9	469.8	1371.1	2008	3292.8	432.8	1474.9
1993	2854.5	412.0	1344.3	2009	3154.4	439.2	1545.4
1994	3193.1	706.6	1168.1	2010	3100.9	510.5	1379.2
1995	2954.9	714.7	1393.3	2011	3024.8	282.6	1474.4

NOTE:AT=ACCUMULATED TEMPERATURE,SH=SUNSHINE HOURS

The meteorological yield, accumulated temperature, rainfall and sunshine hours of rice in Yanbian area were

analyzed. The results are shown in Table 3. It can be seen from Table 3 that the correlation coefficient between meteorological and rainfall is 0.285, the significant level is 0.168; The correlation coefficient between meteorological and accumulated temperature is 0.267, and the significant level is 0.197. The correlation coefficient between meteorological output and sunshine hours is 0.232, the significant level is 0.264, and the three are all significant levels. Due to the close relationship between rainfall, accumulated temperature and sunshine hours, we consider partial correlation analysis. As shown in Table 4, when the control variable is rainfall, the correlation coefficient between meteorological and sunshine hours is 0.363, the significant level is 0.081, which is significant at the 0.1 level. When the control variable is sunshine hours, the correlation coefficient between meteorological output and rainfall is 0.396, the significant level is 0.056, and there is some obvious significance, and there is no obvious significance between meteorological output and accumulated temperature. It can be seen that rainfall and sunshine hours have a positive correlation with the meteorological yield of rice.

TAB.3THE ANALYSIS OF CORRELATION AMONG THE METEOROLOGICAL YIELD, ACCUMULATED TEMPERATURE, RAINFALL AND SUNSHINE HOURS

	Rainfall	**AT**	**SH**	**WP**	**SL**
Rainfall	1	-.018	-.336	.285	.168
AT	-.018	1	.051	.267	.197
SH	-.336	.051	1	.232	.264

TAB.4 THE ANALYSIS OF PARTIALCORRELATION AMONG THE METEOROLOGICAL YIELD, ACCUMULATED TEMPERATURE, RAINFALL AND SUNSHINE HOURS

	Rainfall	**AT**	**SH**	**WP**	**SL**
Rainfall	1	-.001	-.396	.056	
SH	-.048	1	.363	.081	

NOTE:AT=ACCUMULATED TEMPERATURE,SH=SUNSHINE HOURS,WP=WEATHER PRODUCTION,SL=SIGNIFICANT LEVEL

3.3 Regression Analysis of Meteorological Yield, Accumulated Temperature, Rainfall and Sunshine Hours in Rice

Taking the rice meteorological yield as the dependent variable, the cumulative temperature, rainfall and sunshine hours were used as independent variables to establish multiple linear regression model[9]: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$. Among them,β_0, β_1, β_2, β_3 are unknown parameters that need to be solved by the model. Where ε is a random error, it is necessary to make the following assumptions:ε is the normal distribution with the mean 0 and the variance σ^2, and the results are as follows:

TAB.5THE SIGNIFICANCE TEST OF THE REGRESSION EQUATION

R	***R²***	***Adj-R²***	***F***	***P***
.517	.268	.163	2.558	.082

TAB.6 THE SIGNIFICANCE TEST OF THE REGRESSION COEFFICIENT

	EV	***t* value**	***Sig* value**
Constant	-22733.843	-2.387	.026
AT	3.408	1.371	.185
Rainfall	5.631	2.063	.052
SH	6.820	1.796	.087

NOTE:EV=ESTIMATED VALUE,AT=ACCUMULATED TEMPERATURE,SH=SUNSHINE HOURS

From Table 5 we can see that the complex correlation coefficient R=0.517 , the decision coefficient R^2=0.268

indicating that the equation can only be explained by 26.7% of the part; F=2.558,P=0.082，indicating that the equation only achieves general significance. As can be seen from Table 6, the estimated value of the constant is -22733.843, the *t* value is -2.387, the *Sig* value is 0.026, indicating that the constant is significant; The regression coefficient of the accumulated temperature is estimated to be 3.408, the *t* test value is 1.371 and the *Sig* value is 0.185, indicating that the linear effect of the accumulated temperature on the meteorological yield is not significant; The regression coefficient of precipitation is estimated to be 5.631, the *t* test value is 2.063 and the *Sig* value is 0.052, indicating that the linear effect of rainfall on meteorological yield is generally significant; The regression coefficient of sunshine hours is estimated to be 6.820, the *t* test value is 1.796, and the *Sig* value is 0.087, indicating that the linear effect of sunshine hours on meteorological output is generally significant. The equation for the overall regression is:

$Y = -22733.843 + 3.408X_1 + 5.631X_2 + 6.820X_3$ (Where Y is the meteorological yield of rice, X_1 is the accumulated temperature, X_2 is the rainfall, and X_3 is the sunshine hours).

4 DISCUSSIONS AND CONCLUSION

4.1 Analysis of Meteorological Yield

Meteorological production is generally obtained by using the time series method to obtain the trend yield, and then the actual output minus the trend yield is obtained, and for the same group of actual production, the use of different methods may come to different weather production, Zhang Li and other researchers study the use of 3-year, 5-year moving average method and growth curve simulation method to calculate the trend yield and get three kinds of weather production. In this paper, a trend-averaged method is used to derive the trend yield of rice in Yanbian area from 1987 to 2011, and the meteorological yield is calculated, and the principle of minimization of mean square error is used to eliminate the periodic and irregular changes influences. Compared with the curve design and the complex parameter setting and the segmentation equation, the application of the moving average method is more extensive and simple.

4.2 Effects of Meteorological Factors on Rice Yield

Meteorological factors affect the actual yield of rice in different years by affecting the meteorological yield of rice. Therefore, it is of great significance to study the influence of meteorological factors on rice meteorological yield. In this paper, the correlation analysis and partial correlation analysis of meteorological yield, accumulated temperature, rainfall and sunshine hours of rice were carried out. It was found that the rainfall and sunshine duration had a positive correlation with the meteorological yield of rice to a certain extent. There is no significant linear effect on the meteorological yield of rice. The linear regression of the meteorological yield of rice was simulated by accumulated temperature, rainfall and sunshine hours, the regression equation is obtained: $Y=-22733.843+3.408X_1+5.631X_2+6.820X_3$, and the equation is generally significant. The accumulated temperature and sunshine hours of Yanbian state rice increased by 6.7℃ and 3.8h respectively, and the average rainfall was 4mm per year. The rainfall is the most important meteorological factor affecting rice yield. With the increase of climate warming and rainfall reduction in Yanbian area, the frequency of drought in Yanbian area will increase and the impact on rice yield will be more and more. Therefore, we should strengthen the research and application of drought-related technologies, take measures such as soil water storage and soil moisture, and develop irrigation to reduce the loss of rice production caused by meteorological factors.

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