

Analysis of Influencing Factors on Grain Output in Hebei Province Based on Multiple Linear Regression Analysis

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Abstract: Food problem is one of the major problems facing the world today. Only with food can people feel at ease. In this paper, the influence of multiple linear regression analysis on grain output was carried out according to the six indicators of total power of agricultural machinery, effective irrigation area, conversion amount of agricultural fertilizer application, pesticide use, sown area of grain crops and affected area in Hebei Province from 2000 to 2021. Through a series of fitting tests, it was found that the total power of agricultural machinery, the effective irrigated area, the sown area of grain crops and the affected area would all have a significant impact on the grain output of Hebei Province, and the test results were conducive to further guiding the general direction of grain yield increase in Hebei.

Keywords: grain yield, Multiple linear regression analysis, Influencing factors

1. Introduction

"The people depend on food", food is a strategic material for national development, a necessity for people's life, and the basis for the production of all consumer goods. China has about 1.4 billion people. If there is a problem with food, no one can save us. Only by holding the rice bowl tightly in our own hands can we maintain overall social stability. In recent years, the state has repeatedly stressed the issue of food security and promulgated a number of policies on food and agricultural development. In the first year of the 14th Five-Year Plan, the CPC Central Committee issued the 14th Five-Year Plan for National Economic and Social Development and the Outline of the Long-term Goals for the year 2035, which further explicitly calls for enhancing China's capacity for food security and development. The important plans and long-term goals for the implementation of the food security strategy fully reflect the coherence and consistency of China's food security policy. To solve the problem of food production and increase grain output is the primary concern of ensuring food security.

In order to ensure national food security, the Hebei provincial government actively responded to the call of the state and made contributions to solving the problem of food security. At present, the available arable land of Hebei Province is 97.807 million mu, accounting for only 34.54% of the total area of Hebei Province, which is 188,800 square kilometers. The available arable land is relatively small. Therefore, this paper takes Hebei Province as the research object, collects relevant agricultural data from 2002 to 2021, comprehensively analyzes the influence of various factors on grain production, and puts forward targeted construction plans in order to improve grain production.

2. Research status at home and abroad

In recent years, many scholars have analyzed the factors affecting national or provincial grain production through different research methods and research scales.

In the application of principal component analysis, Wu Dan et al. [1] selected 11 indicators in Shaanxi province to analyze the impact of grain output, and the results pointed out that the total power of agricultural machinery, the amount of agricultural diesel, the number of rural employees, the total agricultural output value, the amount of agricultural plastic film, the amount of fertilizer applied and the amount of pesticide used were the main driving factors affecting the grain production in Shaanxi Province. Wang Guomin et al. [2] selected 11 indicators and used factor analysis to make an empirical analysis of China's grain output and its influencing factors from 1993 to 2013. Wang Shuangjin et al. [3] used factor analysis method and time series trend chart to analyze the influencing factors of grain output.

Some scholars adopted BP neural network model, Lu Siheng and Yin Hong [4] incorporated 8 indicators (total power of agricultural machinery, amount of agricultural diesel oil used, effective irrigation area, conversion amount of agricultural fertilizer applied, amount of pesticide used, rural electricity consumption, sown area of grain crops and affected area) to establish a grain production prediction model of Yunnan Province, and the results showed that the model had a good forecasting effect. The error range is small. Li B et al. [5] proposed a grey BP neural network model prediction model (GR-BPNN) to forecast grain output in Henan Province, combining long short-term memory neural network (LSTM), convolutional neural network (CNN), traditional BP neural network (BP), GM(1, N) model and stepwise regression (SR) are also implemented as the benchmark model, and the results show that GR-BPNN has better forecasting effect.

Compared with other methods, the multiple linear regression analysis model has been chosen by a large number of scholars. Deng Xiaoxiao et al. [6] used the effective irrigation area, fertilizer application amount, total power of agricultural machinery, grain sown area and disaster area of Gansu Province from 2003 to 2016 to analyze the multiple linear regression of grain production in Gansu Province. Effective irrigation has a significant positive correlation with grain output in Gansu Province, while disaster area has a significant negative correlation with grain output in Gansu Province, and no significant correlation exists among other factors. Zhao Junwei et al. [7] selected five indicators, including grain sown area and total power of agricultural machinery, according to the relevant data on the website of the Bureau of Statistics from 1994 to 2011, and conducted a regression analysis on the factors affecting grain output in Jiangxi Province. The conclusion was obtained that the main factors affecting the grain output in Jiangxi Province were the grain sown area and the total power of agricultural machinery.

Based on the above analysis, considering the availability of data and the feasibility of operation, this paper adopts multiple linear regression to analyze the grain output of Hebei Province from 2002 to 2021.

3. Research methods

3.1. Summary of the research area

The research area is North China -- Hebei Province, including 11 prefecture-level cities, 49 municipal districts, 21 county-level cities, 91 counties and 6 autonomous counties. By the end of 2022, the permanent population of Hebei will be 74.2 million. It has 90.168 million mu of cultivated land. Among them, paddy fields were 1.4431 million mu, accounting for 1.60 percent; Irrigated land was 57.846,500 mu, accounting for 64.15 percent; And dry land was 30.8785 million mu, accounting for 34.25 percent. Its grain output has exceeded 70 billion jin for nine consecutive years. In the last ten

years, Jizhu granaries have continuously delivered satisfactory "report cards", making "China Bowl" loaded with more "Hebei grain" a reality step by step.

3.2. Data sources

The research data in this paper are all from the Hebei Statistical Yearbook of Hebei Provincial Bureau of Statistics and the China Statistical Yearbook of National Bureau of Statistics. The key factors affecting grain production in Hebei Province are selected based on the data analysis for a total of 20 years from 2002 to 2021. A total of 6 variables that may affect grain output (10,000 tons) were selected for analysis, which are as follows: x1 (total power of agricultural machinery (thousands of kilowatts)), x2 (effective irrigation area (thousands of hectares)), x3 (conversion amount of agricultural fertilizer application (thousands of tons)), x4 (pesticide use (thousands of tons), x5 (sown area of food crops (thousands of hectares)), x6 (affected area (thousands of hectares)).

3.3. Analytical methods

This paper selects multiple linear regression to analyze the factors affecting the grain output in Yunnan Province, and analyzes how the 6 independent variables (x1 ~ x6) directly affect the grain output and the relationship between them. Grain output is generally affected by many factors, if only one factor to study its impact, it will be too one-sided, and can not fully and accurately recognize the impact of each factor on grain output. Therefore, multiple linear regression is used in this paper to estimate which factors significantly affect grain output. Relevant data from 2002 to 2021 are collected by consulting Hebei Statistical Yearbook, and the two multiple linear regression equations are shown in spss26.0 software.

In general, it is assumed that the dependent variable Y has N independent variables: x1, x2, x3,... xn; If there is a collinear relationship between Y and N independent variables, then the multiple linear regression model is:

$$Y=b_0+\sum b_ix_i \quad (1)$$

Where b0, b1,... bn is N+1 with estimated parameters.

4. Results and analysis of multiple linear regression

4.1. Fitting results of 6 variables to grain output

SPSS26.0 was used for analysis to obtain the fitting table, as shown in Table 1. R-squared in the table is 0.921, indicating that the fitting degree is good and the grain output of Hebei Province can be explained by the 6 selected variables.

Table 1: Fitting table among the variables

Models	R	R square	R square after adjustment	Errors in standard estimates
1	.960 ^a	.921	.885	173.66747

SPSS26.0 was used for analysis and ANOVA table was obtained, as shown in Table 2. The F value in the table was 25.346, and the P value was 0.000 < 0.05. The combination of variables had a significant impact on the dependent variable. The total power of agricultural machinery, the effective irrigation area, the amount of agricultural fertilizer applied, the amount of pesticide applied, the sown area of grain crops and the affected area have significant effects on the grain output of Hebei Province.

Table 2: Table of variance analysis

ANOVA ^a						
Models		Sum of Squares	Degrees of Freedom	Mean square	F	Salience
1	Regression	4586685.336	6	764447.556	25.346	.000b
	Residual	392085.072	13	30160.390		
	In total	4978770.408	19			

4.2. Testing of regression model

Although the independent variable has a significant impact on the dependent variable, there may be a correlation between the independent variables, that is, multicollinearity, which will affect the evaluation of the contribution rate of the self-variable star; Therefore, it is necessary to carry out collinearity diagnosis for the independent variables in the regression equation. The variance inflation factor (VIF) is the ratio of the variance when there is multicollinearity between the independent variables to the variance when there is no multicollinearity, and the value is the reciprocal of the tolerance. The higher the VIF value, the more serious the collinearity problem. When VIF is greater than 10, a strong collinearity relationship exists. As can be seen from Table 3, VIF values of all variables in the model are less than 10, indicating that there is no multicollinearity relationship in the multiple regression equation of grain yield. Therefore, the model in this paper does not need to be optimized, and the "optimal" equation can be directly obtained as follows:

$$Y = -4116.531 + 0.95x_1 - 0.272x_2 + 17.555x_3 - 0.036x_4 + 0.816x_5 - 0.100x_6 \quad (2)$$

Table 3: Regression results of grain production in Hebei Province

model		Coefficient			t	Salience	Collinearity statistics	
		Unstandardized coefficients		Standardized coefficient				
		B	Standard error	Beta			Tolerances	VIF
1	(Constant)	-4116.531	2746.573		-1.499	.158		
	x1	.095	.058	.242	1.621	.129	.273	3.664
	x2	-.272	.416	-.052	-.653	.525	.941	1.062
	x3	17.555	6.047	.669	2.903	.012	.114	8.763
	x4	-.036	.010	-.780	-3.694	.003	.136	7.360
	x5	.816	.344	.320	2.372	.034	.333	3.007
	x6	-.100	.083	-.162	-1.200	.252	.332	3.013

4.3. Forecast of grain output in Hebei Province

After many tests and screenings, the "optimal" equation is obtained:

$$Y = -4116.531 + 0.95x_1 - 0.272x_2 + 17.555x_3 - 0.036x_4 + 0.816x_5 - 0.100x_6 \quad (3)$$

According to the equation, x1(total power of agricultural machinery), x2(effective irrigation area), x5(sown area of grain crops) are positively correlated with grain output in Hebei Province;

X6(disaster area) was negatively correlated with grain output in Hebei Province. There was no significant correlation with other factors. If other conditions remain unchanged, the increase of any of the three factors x1(the total power of agricultural machinery), x3(the amount of agricultural fertilizer folded) and x5(the sown area of grain crops) will increase the grain yield. If other factors remain unchanged, x2(effective irrigated area), x4 (pesticide use), x6 (affected area) increase, then the grain yield will decrease.

5. Conclusion

(1) Now is the era of agricultural mechanization, when the fitting results were tested, the total power of agricultural machinery showed a significant positive correlation with food output, indicating that mechanization can improve productivity, reduce human labor, reduce unnecessary time, so that crops can be planted at the most appropriate time, so as not to delay crop growth. Hebei Province should continue to improve the use of mechanization, innovate agricultural machinery technology, increase the publicity of agricultural machinery, and improve the comprehensive quality of farmers.

(2) The effective irrigated area is still the main factor that significantly affects the grain yield. When crops are growing, they have the right environment to ensure their growth, such as adequate water, sunlight, air and other external conditions. So effectively irrigated area can promote a series of processes such as crop growth, flowering, fruit and so on. Therefore, reasonable and effective irrigation should be carried out. Excessive irrigation will lead to the phenomenon that the larger the irrigated area, the lower the grain yield.

(3) There is a significant positive correlation between fertilizer use and grain yield in Hebei. Proper use of chemical fertilizer will not aggravate the pollution of agricultural resources and the decline of soil quality, which is conducive to grain yield increase. Hebei Province should continue to control the amount of chemical fertilizer reasonably, encourage the use of organic fertilizers such as treated farm fertilizers, and improve the quality of chemical fertilizers.

(4) There was a significant negative correlation between pesticide use and grain output in Hebei Province. Appropriate use of pesticides will kill some pests and help the healthy growth of crops, but the analysis results show that pesticides will not increase crop production. Moreover, long-term use of pesticides has a negative impact on crops, such as irrational use of pesticides, resulting in the flow of pesticides into the surrounding ecological environment, and crop growth environment will be harmed by pesticides. Therefore, changing the application structure of fertilizers and pesticides is conducive to the gradual increase of grain output in Hebei Province.

(5) There was a significant positive correlation between the disaster area and grain output in Hebei Province. Natural disasters occur frequently in China's agriculture, especially drought and flood. It can be imagined that the size of the affected area impresses the grain output. However, natural disasters, such as heavy rain, heavy snow, flood, drought and other uncontrollable factors, can not be avoided, we should do a good job in advance to protect the crop countermeasures, in the disaster comes to try to reduce the loss to the minimum. Although the disaster is inevitable, if the disaster can be timely and accurate forecast, the loss can be reduced to the minimum when the disaster comes. It is also necessary for government departments to attach great importance to natural disasters, and to warn farmers of disasters in advance and prevent disasters.

(6) Effective irrigated area is still the main factor that significantly affects grain yield. When crops are growing, they have the right environment to ensure their growth, such as adequate water, sunlight, air and other external conditions. So effectively irrigated area can promote a series of processes such as crop growth, flowering, fruit and so on. Water scarcity will be a major enemy of food production, and it is closely related to human survival.

The sown area of grain crops also has a significant positive correlation with grain output in Hebei. On the whole, the grain production in Hebei increased steadily and the grain sown area also expanded

to a certain extent. In order to maintain the sustainable growth of grain production, Hebei Province should strengthen land trustement and land transfer, reuse idle and abandoned farmland, strengthen the integration of land resources, smooth land and ridge, and expand the effective cultivated land area. However, the area of cultivated land should not be blindly expanded. The quality of cultivated land should be guaranteed, the soil structure should be improved and the soil fertility should be increased.

6. Suggestions

(1)Protect the cultivated land area and improve the utilization rate of cultivated land

We will intensify land trusteeship and land transfer. On the whole, grain production in Hebei increased steadily and the grain sown area also expanded to a certain extent. In order to maintain the sustained growth of grain output, Hebei Province should strengthen land trustement and land transfer, reuse idle and abandoned farmland, strengthen the integration of land resources, smooth land and ridges, and expand the area of effective farmland. However, the area of cultivated land should not be blindly expanded. The quality of cultivated land should be guaranteed, the soil structure should be improved and the soil fertility should be increased.

(2)Keep grain prices stable and promote scientific planting.

We will keep grain prices stable and introduce policies to support agriculture, so as to maintain farmers' incomes and attract more people back to their hometowns to find jobs and start businesses. While encouraging rural residents to return to their hometowns to find jobs or start businesses, we should also teach farmers scientific planting methods to increase grain output.

(3)Strengthening climate monitoring and timely disaster warning.

In recent years, due to the existence of unstable factors such as typhoons, natural disasters occur frequently. Accelerating the improvement of natural disaster early warning and forecasting system and improving the early warning accuracy can reduce the impact of natural disasters on agriculture to a certain extent and reduce agricultural economic losses. Maintain water conservancy facilities and resist the negative impact of flood or drought.

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