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Comparative Study of Impacting Factors of Grain Production of Inner Mongolia Region in Different Periods

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Abstract On the basis of grey correlation analysis, 8 factors impacting grain production prominently as follows are selected to establish indices system: yield per unit (X_1), grain planting area (X_2), agricultural labor forces (X_3), the total power of agricultural machinery (X_4), using amount of fertilizer (X_5), the damaged area of crops (X_6), effective irrigation area (X_7), and agricultural fixed assets investment (X_8). According to the relevant data of *Inner Mongolia Statistical Yearbook* from 1988 to 2008, we use the method of grey correlation analysis to analyze the factors impacting grain production in Inner Mongolia, quantify the correlation degree of the total grain output and all factors, and finally conclude the impacting capacity of all factors on grain production in the light of correlation degree value. The results show that yield per unit still is the principal factor impacting the total output of grain in Inner Mongolia; the area of grain planting and the area of affected crops are the two most important factors responsible for the decrease of grain output; effective irrigation area the total power of agricultural machinery are the two primary factors impacting the increase of grain output; the using amount of fertilizer shows dwindling impact on grain production; agricultural fixed assets investment still hovers at the minuscule impact degree on grain production.

Key words Grain production, Grey correlation analysis, Inner Mongolia, China

Grain is prerequisite of national development and social stability. The safe production of grain has affinity with social harmony. There are manifold factors impacting the total output of grain, like the planting area, water conservancy, fertilizer, seed, soil, climate, cultivating technology, policy environment and so on. In order to realize the low-input and high-output, and obtain good economic benefit, social benefit and ecological benefit, it is necessary to conduct systematic analysis to explore the principal factors impacting grain production. By using the relevant data of Inner Mongolia, and the analytical method of grey correlation, I conduct the correlation analysis on many factors impacting the grain production in Inner Mongolia, quantify the correlation degree between the total output of grain and all factors, and conclude the impact ability of all factors on grain output according to correlation degree value. This will be significant in reality for food security of Inner Mongolia.

1 Indices selection, data sources and research methods

1.1 The overview of study area Inner Mongolia Autonomous Region, located in the north of China, $97^{\circ}12' - 126^{\circ}04' E$, $37^{\circ}24' - 53^{\circ}23' N$, traverses three great natural economic areas: Northeast China, North China and Northwest. Its total area of land reaches 1.1546 million km^2 . It has 12 Mongol

leagues, and 101 counties, cities and districts. The total population was 24.137 million, and non-agricultural population reached 12.483 million in whole regions in 2008. The urbanization rate of the region is 53.4 percent. The average temperature in whole year is $-1 - 10^{\circ}C$, and the precipitation annually is 50–450 mm. The GDP in 2008 is 776.18 billion yuan, and the output value of the primary industry is 90.698 billion yuan, accounting for 11.68% of total output value; the output value of the secondary industry is 427.103 billion yuan, accounting for 55.02% of total output value; the output value of the tertiary industry is 258.379 billion yuan, accounting for 33.28% of total output value. Since recent years, the animal husbandry and agriculture are developing steadily. Along with a series of direct, powerful and effective important agriculture-support policy formulated by the central government, especially the important policies and measures of increasing output of grain and farmers' income-increase, the agricultural production, especially the grain production has a turn for the better. According to data, the planting area of agricultural crops in whole area in 2008 was 6.8608 million hm^2 , increasing by 0.1 million hm^2 on the previous year; the grain output in whole year reaches 21.313 million t, increasing by 15.6% on the previous year. The agricultural area of Inner Mongolia and semi-agricultural semi-pasturing area are mainly located in the east and south of Greater Khingan Mountains and Yinshan mountain range. The plain of Hetao, Tumochuan, west bank of Nen River, and vast mountainous areas are the important granary of autonomous region and even the north of China, because there are black soil, black calcium soil, chestnut calcium soil and other diverse soil conducive to the growing of agricultural crops, and usable overground and

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underground resources.

1.2 Indices selection The grain production is influenced by some factors of planting area, water conservancy, input, soil, climate, cultivation technology and policy. According to the practical situation of grain production in Inner Mongolia, coupled with the former relevant researches^[1-4], I select 8 prominent factors impacting grain production: yield per unit (X_1), grain planting area (X_2), agricultural labor forces (X_3), the total power of agricultural machinery (X_4), using amount of fertilizer (X_5), the damaged area of crops (X_6), effective irrigation area (X_7), and agricultural fixed assets investment (X_8).

1.3 Data source The data source is from *The Statistical Yearbook of Inner Mongolia* from 1988 to 2008^[5].

1.4 Research method On the basis of analyzing the status quo of grain output of Inner Mongolia, this research adopts grey correlation analytical method. The grey correlation degree analysis provides quantified measure to developmental change tendency of a system, so it is suitable for dynamic process analysis. In addition, this method has low requirement on data and small calculation amount, so it is easy to be applied extensively. The aim of this analytical method is to disclose the intensity of factor relations, and the objective of operation is the time sequence of factors. So, by using grey system theory, this research conducts grey correlation analysis on factors of impacting grain output in Baotou City. The basic steps are as follows^[6]:

First, calculate the initial value image or mean value image of all sequences,

$$X'_i = \frac{X_i}{x'_i(1)} = (x'_i(1), x'_i(2), \dots, x'_i(n)), i=0,1,2,\dots,m$$

Second, calculate the difference sequence,

$$\Delta_i(k) = |x'_0(k) - x'_i(k)| \text{ in this formula, } \Delta_i = (\Delta_i(1), \Delta_i(2), \dots, \Delta_i(n)), i=1,2,\dots,m.$$

Third, calculate the maximum difference and minimum difference,

$$M = \max_i \max_k \Delta_i(k), m = \min_i \max_k \Delta_i(k)$$

Fourth, calculate the correlation coefficient,

$$\gamma_{oi}(k) = \frac{m + \xi M}{\Delta_i(k) + \xi M}, \text{ in this formula, } \xi \in (0,1), k=1,2,\dots, n; i=1,2,\dots,m$$

Fifth, calculate the correlation degree, and sort the order and select the factors impacting grain production of Baotou City after calculating the correlation degree,

$$\gamma_{oi} = \frac{1}{N} \sum_{k=1}^n \gamma_{oi}(k), i=1,2,\dots,m$$

In the formula, X'_0 and X'_i are the initial value images of sequences of X_0 and X_i ; X_0 and X_i are the sequences of grain output and impacting factors; $x_0(k)$ and $x_i(k)$ are the kth element in the sequences of X_0 and X_i , is sequence number and is the observed element number in sequence; $x'_0(k)$ and $x'_i(k)$ are the initial images of the kth element in sequences of X_0 and X_i , and $\gamma_{oi}(k)$ is the correlation coefficient of the kth element in sequences of X_0 and X_i ; ξ is the coefficient of discrimination, and the research selects ξ as 0.5; n is the total number of the observed elements in sequences.

2 The analysis of results

2.1 Variation trend of grain yield in Inner Mongolia from 1989 to 2008 The Fig. 1 shows that the grain output of Inner Mongolia fluctuates greatly, but it tends to increase on the whole. In terms of variation of quantity, we can divide the whole period into three independent periods: first, during the years 1988–1998 when the grain output was increasing steadily, the grain output increased from 7.83 million t to 15.754 million t, with annual increase rate of 10.31% on average, increasing by 113.38%; second, during the years 1999–2001 when the grain output was decreasing continuously, the grain output decreased from 14.285 million t to 12.391 million t, with annual decrease rate of 4.42%, decreasing by 10%; third, during the years 2002–2008 when the grain output increase was restored, the grain output increased from 14.061 million t to 21.313 million t in 2008, with annual increase rate of 6.44%, increasing by 51.58%, reaching an all-time high.

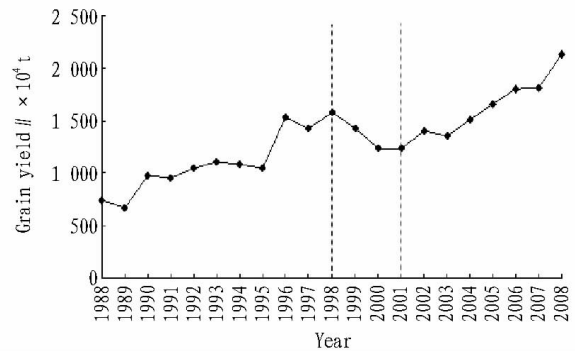


Fig. 1 Variation trend of grain yield in Inner Mongolia from 1989 to 2008

2.2 The comparison of grey correlation degree of impacting factors of grain output in Inner Mongolia from 1988 to 2008

2.2.1 The calculation of grey correlation degree. According to the relevant data of *Inner Mongolia Statistical Yearbook* from 1988 to 2008, and the application software of grey theory system devised by Professor Liu Sifeng in Nanjing University of Aeronautics and Astronautics, the table of grey correlation degree of the factors impacting grain output in Inner Mongolia in different periods is obtained (Table 1). From the analysis of Table 1, we can get the following results: first, during the years 1988–1998 when the grain output was increasing steadily, the sequencing result of the correlation degree of all impacting factors and grain output: effective irrigation area > the unit yield of grain > the using amount of fertilizer > the total power of agricultural machinery > the planting area of grain > the agricultural labor forces > the damaged area of agricultural crops > the agricultural fixed assets investment. Second, during the years 1999–2001 when the grain output was decreasing continuously, the sequencing result of the correlation degree of all impacting factors and grain output: the planting area of grain > the damaged area of agricultural crops > the unit yield of grain > the agricultural labor forces > the using amount of fertilizer > the agricultural fixed assets investment > effective irrigation area > the

total power of agricultural machinery.

Third, during the years 2002–2008 when the grain output increase was restored, the sequencing result of the correlation degree of all impacting factors and grain output: the unit yield of

grain > the total power of agricultural machinery > the planting area of grain > effective irrigation area > the agricultural labor forces > the using amount of fertilizer > the agricultural fixed assets investment > the damaged area of agricultural crops.

Table 1 Grey correlation degree of the factors impacting grain output in Inner Mongolia in different periods

Influencing factors	1988–1998		1999–2001		2002–2008	
	The grey correlation degree	Sequencing	The grey correlation degree	Sequencing	The grey correlation degree	Sequencing
Yield per unit (X_1)	0.866 024	2	0.726 729	3	0.981 471	1
Grain planting area (X_2)	0.772 082	5	0.916 06	1	0.975 873	3
Agricultural labor forces (X_3)	0.757 971	6	0.721 295	4	0.958 385	5
The total power of agricultural machinery (X_4)	0.798 468	4	0.588 943	8	0.976 295	2
Using amount of fertilizer (X_5)	0.838 702	3	0.680 595	5	0.958 043	6
The damaged area of crops (X_6)	0.694 555	7	0.787 883	2	0.885 774	8
Effective irrigation area (X_7)	0.867 474	1	0.617 229	7	0.974 252	4
Agricultural fixed assets investment (X_8)	0.657 518	8	0.635 929	6	0.892 119	7

2.2.2 The analysis of the grey correlation results. According to the principle of correlation degree analysis, if the correlation degree value of sequence of number is big, it is close with the reference sequence of number, and *vice versa*.

2.2.2.1 The unit yield of grain is still the main factor impacting the total output of grain. From Table 1, we know that the correlation degree of unit area output of grain from 1988 to 2008 is in the top three; the correlation with grain output from 2002 to 2008 ranked 2nd; the correlation with grain output from 1999 to 2001 ranked 3rd; the correlation with grain output from 2002 to 2008 ranked 1st. It indicates that the unit yield of grain is still the main factor impacting the total output of grain. The variation tendency of total output of grain meshes with the variation tendency of unit yield of grain, namely the total output of grain increases along with the increase of unit area yield of grain (Fig. 2). The unit yield of grain fluctuates prominently in the year of good harvest or the bad year. Since the recent years, the autonomous region achieves good results in terms of strengthening capacity for resisting natural disasters by promoting the infrastructure construction of farmland, implementing seeds project, adjusting and optimizing varieties structure, improving the operating technology in fields, transforming medium-and-low output of farmland and developing irrigable land. The unit yield increased continuously, from 3 237 kg/hm² in 2002 to 3 800 kg/hm² in 2005, and then to 4 056 kg/hm² in 2008, which makes the great contribution to ensuring national food security.

2.2.2.2 The area of grain planting and the area of affected crops are the two most important factors responsible for the decrease of grain output. During the years 1999–2001 when the grain output was decreasing continuously, the area of grain planting and the area of affected crops are the two most important factors responsible for the decrease of grain output, and their correlation degree are 0.92 and 0.79 respectively. The planting area of grain is the basic guarantee of grain production. The decrease of grain planting area can cause the decrease of total output of grain. From 1988 to 1998, the grain planting area of Inner Mongolia had the tendency of increase, increasing from 3.721 million hm² to 5.031 million hm². In

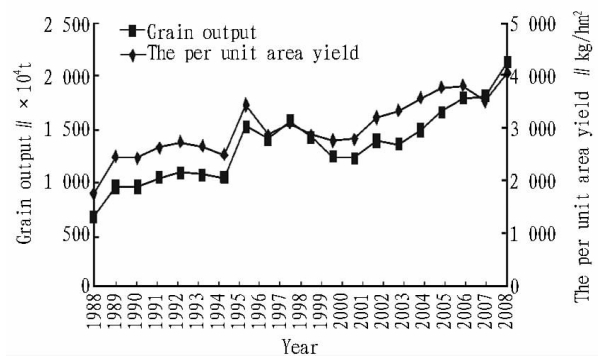


Fig. 2 Total grain output and per unit area yield in Inner Mongolia from 1989 to 2008

1999, in order to protect environment, Inner Mongolia began to return farmland to forests and grass with detailed planning, so the planting area of grain began to decrease. The grain planting area was decreased to 4.381 million hm² in 2001, and the total output of grain decreased from 14.285 million t in 1999 to 12.391 million t in 2001. The decrease of grain output is also impacted by natural disasters. The types of agricultural crops damaged by natural disaster include drought, flood, hail, freeze and the pest damage, of which the drought is the main type. The drought area is 4.127 9 million hm² in 1999; the flood-stricken area is 0.139 3 million hm²; the hail-stricken area is 0.286 5 million hm²; the freeze-stricken area is 0.401 4 million hm² (Table 2).

2.2.2.3 Effective irrigation area and the total power of agricultural machinery are the two primary factors impacting the increase of grain output. Effective irrigation area and the total power of agricultural machinery are the two primary factors impacting the increase of grain output. During the years 1988–1998 when the grain output was increasing steadily, the primary factor of impacting the grain output is effective irrigation area, and the correlation degree value of it and grain output is 0.87, ranking 1st. According to the statistical data, the effective irrigation area in 1990 was 1.251 5 million hm²; in 1992 was 1.695 9 million hm²; in 1994 was 1.754 9 million hm²; in 1996 was 1.851 2 million hm²; in 1998 was 1.829 7 million hm². During

the years 2002 – 2008 when the grain output increase was restored, the total power of agricultural machinery was the primary factor impacting the increase of grain output, and the correlation degree value of it and grain output is 0.98, ranking 2nd. The farmland area by using machinery accounted for 59.82% of total area of farmland in 2002; the farmland area by using machinery accounted for 81.4% of total area of farmland in 2008; the planting area of farmland by using machinery accounted for 55.36% of total planting area of farmland in 2002, and the

planting area of farmland by using machinery accounted for 69% of total planting area of farmland in 2008; the harvest area by using machinery accounted for 13.5% of total planting area of agricultural crops in 2002, and the harvest area by using machinery accounted for 30% of total planting area of agricultural crops in 2008. Along with the economic development, the degree of effective irrigation area and mechanization in this region increases year by year.

Table 2 Total grain output and farming areas stricken by natural disasters from 1999 to 2001

Year	Total grain yield ×10 ⁴ t	Drought affected area ×10 ⁴ hm ²	Flood affected area ×10 ⁴ hm ²	Wind and hail affected area ×10 ⁴ hm ²	Low-temperature and freezing affected area ×10 ⁴ hm ²	Disease and pest affected area ×10 ⁴ hm ²
1999	1 428.5	412.79	13.93	28.65	11.43	40.14
2000	1 241.9	377.30	13.20	31.20	15.80	40.70
2001	1 239.1	312.45	11.50	31.81	30.33	19.46

2.2.2.4 The using amount of fertilizer shows dwindling impact on grain production. The correlation degree of using amount of fertilizer and grain output decreased from top 3 from 1985 to 1998 to top 5 from 1999 to 2001, then to top 6 from 2002 to 2008. The impact of using amount of fertilizer on grain output tends to dwindle. The research shows that the using amount of fertilizer, same with using amount of agricultural pesticide, the using amount of which has upper limit in unit farmland. The excessive use will result in output decrease and waste. So, we should input the limited human resources, capital and goods into the field where the increase of grain output is prominent and the cost is low in order to increase grain output.

2.2.2.5 Agricultural fixed assets investment still hovers at the minuscule impact degree on grain production. The agricultural fixed assets investment correlates with grain output positively, but it plays the minuscule role of impacting the grain output in Inner Mongolia, and it is just general correlation degree. The correlation degree of agricultural fixed assets investment and grain output ranked 8th from 1988 to 1998; ranked 6th from 1999 to 2001; ranked 7th from 2002 to 2008. It indicates that the agricultural fixed assets investment still hovers at the minuscule impact degree on grain production.

3 Conclusion

The analysis of grey correlation is a statistical analytical method on many factors, and it can make up for the demerits caused by using the statistical technique. It can be applied to any sample, disregarding the quantity of samples and whether there is law. In addition, it has small amount of calculation and it is very convenient, so there is no contradiction of quantified results and the stationary analytical results. According to the analysis, the yield per unit still is the principal factor impacting the total output of grain in Inner Mongolia; the area of grain planting and the area of affected crops are the two most important factors responsible for the decrease of grain output; effective irrigation area the total power of agricultural machinery are the two primary factors impacting the increase of grain output; the using amount of fertilizer shows dwindling impact on grain production; agricultural fixed assets investment still hovers at

the minuscule impact degree on grain production. The analysis of this thesis is significant to food security of Inner Mongolia.

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