Forecast of Grain Production of China during the Twelfth Five-Year Plan Period

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Abstract According to the latest revised agricultural economic statistical data in *China Statistical Yearbook*-2010, by selecting and establishing the square root-treated grey model, the empirical analysis and forecast research on the grain output of China from 2011 to 2015 are conducted. The results show that the grain output of China in 2011 will reach 557.739 million tons, and it will break through 600 million tons at 605.617 million tons in 2015. The persistent and stable grain output will ensure that the national economy develops in normal during the twelfth five-year plan period and remit the world grain crisis efficiently; meanwhile, the problem of exorbitant grain prices should be remitted in some level.

Key words China grain production, Square root-treated grey model, Forecast, China

As a saying goes " people relies on food and grain goes prior to food". Food security is a major strategic problem in the world. China is a granary country with the largest population in the world, so its food should be supplied by itself. Laying solid foundation on the fundamental position of agriculture is not only the successful experience drawn from the past 30 years' development, but the actual needs of Chinese future development. By 2010, the total yield of Chinese grain production had achieved 546.41 million t, 2.9% more than that in the previous year, which realized the yield increase in consecutive seven years in the half century. The sown acreage of grain had achieved 0.11 billion hm^2, which realized the growth of sown acreage in consecutive 7 years. The yield per hectare has come to 4 972.5 kg, 103.5 kg more than that in the previous year, which has created a new historical high[1-2].

In recent ten years, the self-sufficient degree of Chinese grain has maintained above 95%. The national grain consumption system is perfect. At present, China owns nearly 0.2 billion t of grain reserves, far higher than the warning line of food security. However, it doesn't mean that China is free from food security. At present, the anti-disasters capability of Chinese agriculture is still very weak, the middle and low farmland accounts for 60% of the total farmland. If the central government can not collect land resource rapidly, besides the aging labors and continuously worsen water shortage, the grain production in future China will be affected seriously.

Chinese government pays much attention to food security. Since 2004, the central government has issued the " No.1 Document" for " three agriculture" for consecutive seven years. The central rural work conference closed currently clarifies that the stable development of grain production is the primary task in 2011, ensures the sown acreage of food and endeavors to improve the production per unit. The prediction on the grain production is the prerequisite for implementing safety strategy and agricultural sustainable development. Through selecting, the grey prediction model can be improved. By selecting the improved model, the evidence for Chinese food security and management is supplied.

1 Data source and research method

1.1 Data source According to updated statistics of *China Statistical Yearbook* – 2010 and *Statistical Communique of the People's Republic of China on the* 2010 *National Economy and Social Development*[1,3], the statistical data of China grain production from 2001 to 2010 is obtained (Table 1).

Table 1 National total grain production from 2001 to 2010 $\times 10^4$ t

Year	Yield	Year	Yield
2001	45 263.7	2006	49 804.2
2002	45 705.8	2007	50 160.3
2003	43 069.5	2008	52 870.9
2004	46 946.9	2009	53 082.1
2005	48 402.2	2010	54 641.0

1.2 Research method Grey system theory focuses on the study of such unascertained system that is known with small sample, less data or poor information. Through forming and developing the known information, the grey system theory can realize the exact description and recognition of real world[4]. Grey prediction is one of the contents of grey system theory. Grey prediction is the prediction on the basis of GM(1,1) model. The basic thought pattern of grey prediction is to handle the dispersed and random original data to get the accumulated generating sequence with strong rule. Through establishing model, the prediction value is reverted by inverse accumulating operation. The grey prediction has the following features: establishing model needs few data, four data or above are enough; the distribution feature of the data should not be known and it is

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flexible to establish the model; the accuracy of prediction is high and can well reflect the actual situation of system; strong practicability of the model can be adopted in the field of social science and natural science. Grain production is the mutual results by the mutual restriction and coordinated development of complex factors. The model is suitable to adapt to research and explore the inner rule. On the basis of Ref. [5], a more accurate and stable new grey prediction model can be established[5,6]. Supposing the time series of the original grain production $P^{(0)} = [p^{(0)}(1), p^{(0)}(2), \cdots, p^{(0)}(n)]$. The model establishes prediction model do not use the original data, but pre-handle the original square root by the original sequence, that is

$$x^{(0)}(k) = sqrt(p^{(0)}(k)), \quad (1)$$

Through conducting the one order accumulation formation of sequence $x^{(0)}$, the sequence generator is $x^{(1)}$, that is

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) \quad (k=1, 2, \cdots, n) \quad (2)$$

According to grey theory, the grey differential equation $x^{(0)}(k) + az^{(1)}(k) = b$ is established. In the equation, a, b are the undetermined coefficient, and then the background value is:

$$z^{(1)}(k) = \frac{x^{(1)}(k-1) + x^{(1)}(k)}{2}, \ k=2, 3, \cdots, n \quad (3)$$

By using the least square method, the parameter list is:

$$\hat{a} = (a, b)^T = (B^T B)^{-1} B^T Y \quad (4)$$

In the formula, $B = \begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{pmatrix}$;

$Y = (x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n))^T$

Supposing $\hat{x}^{(0)} = x^{(0)}(n)$, the white responsive equation:

$$\hat{x}^{(0)}(k) = x^{(0)}(n) \cdot e^{-a(k-n)} \quad (k=1, 2, \cdots, n) \quad (5)$$

In the end, through $p^{(0)}(k) = [x^{(0)}(k)]^2$ it is returned to the aggregated volume. The prediction model is square root grey model (SRGM) in the paper.

According to the actual data in Table 1, the following four Chinese grain yield prediction models are established—Common GM(1,1) model, dispersed grey incremental model, logarithm new development coefficient optimized model (LNDCGM) and square root general model(SRGM), to predict the Chinese grain yield in 2010. Through calculating various grey prediction value, the value is listed on Table 2. Through comparison, SRGM model is not only simple, but also has high prediction degree. It can ensure the closeness of the primary value and actual value. Therefore, the SRGM model is adopted to predict the total yield of Chinese grain production from 2011 to 2015.

2 Results and analysis

2.1 Selection of the dimensions of SRGM model of prediction on aggregate production of Chinese grain The different dimensions of grey model are different from the accuracy of prediction, so in order to improve the prediction accuracy, from 5 to 9 dimensions of the data of aggregate production of grain according to the actual situation of Chinese grain production. By using MATLAB software programming operation[7], the SRGM model with different dimensions is established, and the calculation results can be seen on Table 3. It can be seen from Table 3 that the prediction accuracy of eight dimensions model is 99.1%, and the results is satisfactory.

Table 2 Comparison of China grain production tested and forecasted by each model in 2010

Model	Actual value $\times 10^4$ t	Forecast value $\times 10^4$ t	Absolute error $\times 10^4$ t	Relative error // %
Common GM (1, 1) model	54 641.0	55 735.9	1 094.9	2.00
Discrete grey incremental model	54 641.0	53 320.7	1 320.3	2.42
Optimization model of new development coefficient of logarithm	54 641.0	54 049.5	591.5	1.08
SRGM model	54 641.0	54 146.2	494.8	0.91

Table 3 Comparison of the forecast of SRGM model with different dimensions

Dimensions of model	Actual value $\times 10^4$ t	Forecast value $\times 10^4$ t	Absolute error $\times 10^4$ t	Relative error // %
5 dimensions	54 641.0	53 832.5	808.5	1.48
6 dimensions	54 641.0	53 835.2	805.8	1.47
7 dimensions	54 641.0	53 867.8	773.2	1.41
8 dimensions	54 641.0	54 146.2	494.8	0.91
9 dimensions	54 641.0	53 919.5	721.5	1.32

2.2 Prediction on Chinese grain production from 2011 to 2015 According to the above comparison and analysis, the eight dimensions of SRGM model of Chinese aggregate grain production from 2003 to 2010 is established:

$$\hat{x}^{(0)}(k) = 233.538\,0e^{0.010\,311\,3(k-8)} \quad (6)$$

Through testing, the proportion of the mean square difference of model parameter $C = 0.028\,1$, the small error probability $p = 1$, the mean fitting accuracy $\bar{q} = 98.83\%$, the model has passed the test and the accuracy degree is excellent. By using the model (5), the prediction value of national grain production from 2011 to 2015 will be 55 773.9 $\times 10^4$, 56 931.9, 58 122.4 $\times 10^4$, 59 319.6 $\times 10^4$ and 60 561.7 $\times 10^4$ t respectively.

3 Conclusions and discussions

Selecting and establishing the square root general model on the basis of researching the general model GM(1,1) has greatly weakened the disturbing factors and revealed the rule of operation system and stabilized the model, so it has high accuracy degree. The empirical analysis shows that the new grey model is not restricted by samples, so it is easy to establish the model and the calculation workload is light and easy to be controlled. The results of the new grey model are better than the general grey model as for the time series with rapid growth in short term. Besides, it is a ideal tool for economic prediction and research.

In November, 2008, the central government issued the *Middle and Long Term Plan of National Food Security from* 2008 *to* 2020. In the plan, by 2010, the area of national maintain farmland would be no less than 0.12 billion hm^2, among which the area of grain sown acreage should be stabilized at

0.084 billion hm^2 or above and the grain comprehensive production capability should be stabilized at 0.54 billion t or above. The prediction results of the research shows that, in 2011, the total yield of national grain production will achieve 55 773.9 × 10^4 t, and the yield will maintain stable increase in the Twelfth Five-Year Plan period, the annual average growth rate is about 2.09%. Although the annual average income dropped slightly comparing with the in the 2.43% in the Eleventh Five-Year Plan, in general it will increase annually. in the last year of the Twelfth Five-Year Plan, the yield of national grain will welcome monumental breakthrough and it will break 0.6 billion t and go to 0.605 617 billion t. It is exciting news. That is to say, in the period between the Eleventh Five-Year Plan and the Twelfth Five-Year Plan, the outline plan may be materialized.

However, Chinese food safety is not free from worries, for three are many hidden problems. In the first place, the Chinese agricultural environment is rather fragile, the drought, flood, pesticides, low temperature, cold rain, thunderstorm and hail happen frequently. The statistics show that every year, China has 0.02 billion hm^2 of agricultural products to be destroyed by natural disasters and 0.2 billion rural people have to suffer the disaster. As a result of the disaster, every year, China will loss 20 billion kg of grain and the direct economic losses will lose about 20 billion yuan, and it is the fundamental situation of China[8]. In the second place, water and farmland shortage always affect the Chinese grain safety. Chinese population accounts for 21% of total world population, but the area of farmland takes only 8.5% of the total farmland and the water reserve accounts for only 6.5% of the world water reserve. From 1996 to 2008, the national farmland area reduced from 0.130 07 to 0.121 73, 0.008 33 billion yuan in 12 years . In the same period, the area of per capita farmland reduced from 0.102 7 to 0.091 3 hm^2, lower than the 40% of the total world average level[9]. China has dense population but limited land, which pushes some agricultural area to farm with high intensify, thus leads to the decrease of forest area. At the same tine, modern agricultural technology demands intensive land, but the dispersed agricultural can not supply it. In the third place, there is huge gap between the social services enjoyed by rural residents and urban residents. The income of farming is far lower than working out may abate farmers' enthusiasm on farming. After considering the Chinese agricultural policies of future ten years, the problems can not be ignored. In the fourth place, since 2010, the natural disasters hit the world frequently; many countries suffer from thunderstorm, flood and drought. The grain production in many countries is affected, which leads to the price rise of food worldwide. Since the last winter, Yunnan Province, Guizhou Province and Hunan Province of China have been suffering from the continuous cold rain. But the Shandong Province, Henan Province and Hebei Province and six other north provinces have been suffering the drought for more than three months. The serious drought may lead to the reduction of summer grain production. A report issued by the Food and Agriculture Organization of the United Nations in January, 3 reported that in January , 2011, the global food price index has kept seven months' increase, surpassed the peak value in 2008 grain crisis and come to the highest point since 1990. The FAO has issued the warning concerning the grain price might be affected by Chinese drought. The officers from the United Nation appeal to each country to take actions to handle the possible grain shortage. At present, Chinese grain price is increasingly close to the international grain price. Generally speaking, Chinese grain price stays in a relatively safe place, but it can not completely isolate from the external crashes. Confronting with the increase of international grain price, China can not be free from its impacts. The rise of grain is easy to cause the structural grain price rise, so adjusting grain price is the key work for the Party and Chinese government. The government should intensify the support on supporting farmers, prospering grain and enriching farmers to enhance farmers' enthusiasm on cultivation. The grain increase of Chinese grain for seven years is not so easy. At the same time, in order to handle inflation and stabilize the social development, the government should adopt intensified policies on control price.

Water conservancy is the determinant of agriculture. At present, the biggest restriction on food safety is water and the weakest section is water conservancy. In recent years, the frequently happened drought has fully displayed that the backward water conservancy construction is still the biggest problem in stabilizing agricultural development and national food security. In the developmental plan of the Twelfth Five-Year Plan, the nation emphasizes that the key to intensifying the agricultural construction is to intensify the construction on water conservancy and try to improve the disaster-resistance capability of Chinese agriculture. On January 29, 2011, the central government issued the No.1 Document of Decision on Accelerating the Reform of Water Conservancy. It is the first time that the central government pays attention to the water conservancy construction since 60 years. Combining the research, it can be known that under the global grain crisis, the food security problem of China can be solved effectively and Chinese grain production will have a new future.

4 Summary

In summary, each government and cadre should adhere to the spirit of central government; get to know the position and function of agriculture, especially grain, in the development of social economy. The process of promoting industrialization and urbanization can not be based on the interests of agriculture. The government should insist on the warning line of 0.12 billion hm^2 farmland and try to realize the continues increase of grain and farmers' income in the Twelfth Five-Year Plan period and make new contribution to arrest inflation and alleviate world grain crisis.

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3.2 Suggestions

3.2.1 Increasing machinery subsidy on crop residues recycling and abating the burden of masters of agricultural machine. The government should intensify the subsidies on crop residues recycling; improve the proportion of machinery subsidy; enhance the efficiency of subsidy; promote competition; lower the price of mechanized crop residues recycling and promote the application of mechanized crop residues recycling. Besides, through subsidizing oil price of agricultural machine, the burden of masters of agricultural machine will be alleviated. Under the permissive condition, the government should subsidize the rural households which return crop residues to land.

3.2.2 Intensifying the technical training on owners of agricultural machine and education on farmers. In order to ensure the circular use of mechanized crop residues, the government should provide technical training and vocational education to owners of agricultural machine and to ensure the fully display of the effects of mechanized crop residues recycling. In the meantime, the government should increase the promotion on the working mechanism, interests of increasing grain yield and increasing soil fertility of mechanized crop residues recycling to let farmers know the importance of mechanized crop residues recycling, so as to promote the long -term and effective use of mechanized crop residues recycling.

3.2.3 Promoting rural security system and decreasing the risks bought by rural labors transfer to rural areas. The government should guarantee the punctuate income of farmers to help farmers afford the costs of mechanized crop residues recycling. Besides, the government should perfect rural security mechanism to reduce the risks bought by the labor transfer to rural areas so as to ensure the factor of rural labor transfer on improving the fertility of rural soil.

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