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Forecast of Grain Supply and Demand in Jiangsu Province and Analysis of Its Influencing Factors--based on Spatial Panel Model and ARIMA-GM Joint Model

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Abstract: *To analyze the influencing factors of grain yield change at present stage and predict the possible grain problems in Jiangsu province is not only beneficial to explore the development trend of grain problems in Jiangsu Province, but also can provide theoretical basis for the government's grain production decision-making. This article selected cities in Jiangsu province in 2001-2020 food production and its related influencing factors of data, the first structure, spatial panel data model to analyze the indexes which influence the production of food, and then through the ARIMA - GM joint model changes of grain production in Jiangsu province in the next five years to forecast, and comparing the future population forecast data of Jiangsu province, To study the change of grain supply and demand and potential problems in Jiangsu province in the next five years. The results show that agricultural technical efficiency, land scale management and effective labor input are the important factors restricting grain yield at present. At the same time, through the prediction of grain output, combined with the forecast results of population in Jiangsu Province, and compared with the growth rate, it can be seen that the growth rate of grain output in the highly developed areas of Jiangsu province, such as Nanjing, Suzhou, Wuxi and other cities, is far less than the growth rate of population. It can be seen that in some areas of Jiangsu Province in the next few years, the problem of grain supply and demand may gradually become prominent, become the "heart trouble" restricting economic development. Finally, some feasible suggestions are put forward for the possible grain production problems in Jiangsu Province.*

Keywords: *Spatial panel model; Advanced technology progress; ARIMA-GM*

1. Introduction

Food security and production has always been the most concerned issue in China. Since 2004, the No.1 Document of the Central Government has focused on the food issue for many times, proposing to "stabilize food production and ensure effective supply", requiring all parts of the country not to ignore the food issue while developing the economy. In 2016, General Secretary Xi jinping proposed in the 13th Five-Year Plan that grain should be stored in technology and grain should be stored in land to stabilize and increase grain output in various aspects. In 2020, The State Council further raised the issue of "preventing farmland from becoming non-grain", focusing on food security and supply problems caused by the rapidly growing population. The 14th Five-Year Plan and the Outline of the Vision for 2035 set grain production capacity as an important indicator of economic and social development, pointing out that both the current grain production capacity and the projected grain production capacity reflect the extreme importance the central government attaches to grain issues.

Since the concept of moderate scale operation first appeared in the 1980s, the CPC Central Committee and The State Council have repeatedly mentioned "encouraging and developing moderate scale operation" in the No. 1 central document. However, based on thousands of years of small-scale peasant economic tradition of "intensive farming", with the deepening of modernization process, China has appeared a trend of blindly imitating the "large-scale farm production" of the United States and Australia. Since the beginning of the 21st century, the state has issued 18 documents on the work related to agriculture, rural areas and farmers, which not only include appropriate scale operation, but also emphasize the importance of agricultural science and technology.

China's population has exceeded 1. 443 billion, up 5. 38% from the sixth census, with an average annual growth rate of 0. 53%, according to data from the seventh census. The aging trend of population

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is gradually increasing, the social burden is becoming heavier, the emergence of negative population growth and other problems is the experience summarized by all countries in the world for many years. Jiangsu Province is the concentration of floating population, the net inflow of population ranks the fourth in China, but the number of agricultural workers is still decreasing year by year. Combined with existing studies, it is not difficult to see that with the current trend of population change, agriculture is the most basic problem we are facing, and food is the root of agricultural problems. Therefore, "who will plant the land", "how to plant the land", "how much land" become the main issues at present.

This paper studies the influencing factors of grain yield change in Jiangsu province and the problems of grain supply and demand in the next five years. Firstly, based on the C-D production function, a spatial panel model was constructed, which combined the technological indicators such as technical efficiency and cutting-edge technological progress with the land scale management indicators, supplemented by control variables such as the total power of agricultural machinery and the amount of fertilizer application, to fit the grain yield of each city in Jiangsu Province, and analyzed the meaning behind the regression results. Secondly, the ARIMA-GM joint model is used[1], forecast the grain output of each city in Jiangsu province in 2021-2025, combined with the existing forecast results of population change in Jiangsu Province[2], defined the ratio of the growth rate of grain output to the growth rate of population as the index of the change of grain supply and demand; Finally, based on the regression results of input variables, the relationship between the change of grain supply and demand in each region in the future and input variables was analyzed, and feasible policy suggestions were put forward.

2. Data sources and indicators

This paper selects the data of 13 cities in Jiangsu province from 2001 to 2020 from China Urban Statistical Yearbook, Jiangsu Statistical Yearbook, China Rural Statistical Yearbook and Jiangsu Statistical database. Based on existing studies, this paper interprets the output variables together with technical efficiency and cutting-edge technological progress on the basis of C-D production function, taking land scale operation and effective labor input as the core input variables. Output variable is the total output of grain in each city over the years. The basic control variables are per capita net income of farmers, total power of agricultural machinery, rural electricity consumption, agricultural fertilizer usage, innovation index and urbanization rate. [3]

3. Model selection and construction

3.1. Model Construction

Based on c-D production function, spatial effect and spatial correlation of grain yield were considered, and spatial autocorrelation model and spatial error model were established to regression grain yield and its influencing factors.

3.1.1. Spatial autocorrelation model

Spatial autocorrelation model represents the spatial correlation between regions reflected in dependent variables in the form of [4]:

$$Y_{it} = \delta\sum_{j=1}^{N} w_{ij}Y_{jt} + \beta_1 T_{it} + \beta_2 E_{it} + \beta_3 L_{it} + \beta_4 K_{it} + XT_{it}^{'} + \alpha_i + \varepsilon_{it}, \tag{1}$$

3.1.2. Spatial error model

Spatial error model reflects the relationship between cities through the covariance matrix of spatial error terms. When the interaction between cities is different due to different distances, the spatial error model is used to study it [5].

$$Y_{it} = \beta_1 T_{it} + \beta_2 E_{it} + \beta_3 L_{it} + \beta_4 K_{it} + XT_{it}^{'} + \alpha_i + \theta_{it}, \quad \theta_{it} = \rho\sum_{j=1}^{N} w_{ij}\theta_{jt} + \varepsilon_i, \tag{2}$$

3.2. Model judgment and selection

In order to better reflect the characteristics of Jiangsu agricultural panel data and the influence of explanatory variables on the explained variables, the model with the optimal estimation result was found to reduce the error caused by the loss of data information in the model construction stage. In this paper,

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F test, LM test and Hausman test were used to select mixed OLS model, fixed effect model and random effect model. Among them, the essence of F test detects whether there is disturbance term of individual heterogeneity in the model, and whether the disturbance term only changes with individual change. If there is, random effect model is selected. Otherwise, mixed OLS model is selected. Secondly, the essence of LM test is to test whether there are random effects in the model, that is, whether there are differences in the distribution of different samples in the same population. If there are, the random effects model should be selected. Otherwise, mixed OLS should be selected. Finally, the essence of Hausman test is to test whether the random disturbance term in the model is correlated with explanatory variables. If so, the fixed-effect model is selected; if not, the random effect model is selected.

3.3. ARIMA-GM joint model

In order to study the future grain supply and demand in Jiangsu Province, this paper needs to establish a grain yield prediction model based on the existing population prediction results of Jiangsu province by experts. The ARIMA-GM joint prediction model was constructed to predict grain yield by combining the commonly used prediction models of agriculture, industry and population.

Based on the fitting errors of ARIMA and GM (1,1), ARIMA and GM (1,1) are weighted to obtain the final prediction results. Specific operations are as follows:

Weight allocation for ARIMA model and GM (1,1) model:

$$w_i = 1 - \frac{\varepsilon_i}{\sum_{i=1}^{2} \varepsilon_i}, i = 1, 2, \tag{3}$$

Where, represents the average relative error of the predicted value between ARIMA model and GM (1,1) model. ε_i The influence of the model with large error can be effectively reduced by cross weighting.

Calculate the prediction result of the combined model: where represents the predicted value of ARIMA model or GM (1,1) model.

4. Case analysis

Based on the data of factors related to grain production in Jiangsu province from 2001 to 2020, and combined with the existing research data of population prediction in Jiangsu province, this paper conducts an in-depth study on the influencing factors of grain yield change in various cities in Jiangsu province and whether there are problems in the relationship between grain supply and demand with the change of population growth trend.

4.1. Model test results

As can be seen from the model test results in Table 1, the F value of F test is 42. 99, and the P-value of LM test and Hausman test are both lower than the minimum significance level, that is, the three tests are significant at 1% level. Therefore, the null hypothesis is rejected, and the fixed-effect model is considered as the optimal choice, and the model only has individual influence on the cross section. There is no structural change, the structural parameters of explanatory variables are the same in different cross sections, the only difference is the intercept term.

Table 1: Model test results

Inspection methods	The results of	Model selection
F test	$F = 42.499$	The fixed effect model is superior to the mixed OLS model
LM test	$P - value < 2.2e - 16$	Random effect model is better than mixed OLS model
Hausman test	$P - value < 2.2e - 16$	Fixed effect model is better than random effect model

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4.2. Estimation of the impact of agricultural production factors on food production

Based on the test results, this paper finally chooses the fixed effect spatial autocorrelation model and spatial error model to study the influencing factors of grain yield. Meanwhile, in order to obtain more robust regression results, the spatial weight matrix in the model adopts the spatial weight matrix of Queen geographic standard and economic distance to fit the model. The results of the two models under different spatial weight matrices are compared and their estimates are shown in Table 2.

Table 2: Estimation results of spatial panel model

variable	Model 1		Model 2	
	Near	Economic	Near	Economic
Technical efficiency	2. 929 e-01 * * *	1. 390 e-01 * *	2. 883 e-01 * * *	2. 039 e-01 * * *
Advanced technology progress	1. 024 e-03 *	2. 918 e-03 *	9. 358 e-04 *	2. 291 e-04 *
Grain sown area per household	1. 389 e-01 * * *	9. 605 e-02 * * *	1. 348 e-01 * * *	1. 129 e-01 * * *
Effective labor input	2. 549 e-03 * * *	2. 431 e-03 * * *	2. 587 e-03 * * *	2. 747 e-03 * * *
Engel coefficient of rural residents	2. 228 e-03	2. 531 e-03	2. 277 e-03	1. 855 e-03
Total power of agricultural machinery	2. 854 e-04 * * *	3. 50 e-04 * * *	2. 916 e-04 * * *	3. 228 e-04 * * *
Rural electricity consumption	8. 849 e-05	1. 427 e-04	9. 990 e-04	1. 281 e-04
The amount of agricultural fertilizer used	1. 238 e-03	1. 363 e-03	1. 2145 e-03	1. 654 e-03
Innovation index	2. 864 e-04 * * *	2. 289 e-04 * * *	2. 717 e-04 * * *	2. 030 e-04 * * *
Urbanization rate	4. 996 e-06 * * *	3. 719 e-06 * * *	5. 803 e-06 * * *	4. 961 e-06 * * *

Data source: Jiangsu Statistical Yearbook, China Urban Statistical Yearbook, 2001-2021
Note: Model 1 is the spatial autocorrelation model; Model 2 is the spatial error model; Near corresponds to the spatial panel model under geographical distance; Economic corresponds to the spatial panel model under Economic distance. ***, ** and * are significant at the significance level of 1%, 5% and 10% respectively.

By comparing the spatial autocorrelation model and spatial error model based on different spatial weight matrices in Table 3, it can be seen that the regression results of control variables under different models are basically the same, which shows that the model fitting results are good.

Visible analysis control variable coefficient estimation results, technical efficiency, worth of land area, the effective labor input, agricultural machinery total power, innovation index as well as the urbanization rate at 1% level of increase in grain output has a significant role in promoting, conform to the theoretical analysis for the results of forecast, and the effects of technical efficiency on food production of elasticity is the largest, It fully conforms to the statement that "science and technology is the primary productive force". Only continuous innovation of science and technology can maximize the upper limit of grain yield.

The elasticity coefficient of per household land area is second only to technical efficiency, which also has a significant positive impact on grain yield, indicating that land resources are still the most basic dependence of grain production when science and technology develop to a certain extent. As the area of arable land increases, grain yield per unit area can be further increased through advanced agricultural techniques and planting concepts.

Effective labor input is significantly positive in the 1% confidence interval. According to the calculation process of effective labor input, it is not difficult to see that with the increase of education years of food production employees in Jiangsu Province, the grain output increases significantly. This means that learning advanced agricultural management methods and concepts or indirectly influencing the development of agricultural science and technology through learning science and technology is the core of promoting the positive development of grain yield. Based on the situation of land distribution and utilization, it can be concluded that under the condition of scarce land resources, continuously improving the education level of relevant practitioners is conducive to promoting the structural adjustment of agricultural labor force and increasing grain output in many aspects.

Machinery total power and innovation index significantly influence for food production is very easy to understand: grain production mechanization helps to improve the land area of worth of online, can increase the productivity of the workers, the continuous improvement of innovation index will help the industry to raise the level of science and technology innovation of agricultural science and technology level also can increase accordingly. The estimated coefficient of urbanization on grain yield is significantly positive, indicating that the advancement of urbanization is beneficial to grain production.

By comparing the influences of technology-related variables such as technical efficiency and innovation index on grain yield, it is found that the cutting-edge technological progress only has a significant effect on grain yield at the level of 10%, which is different from the above analysis. The main possibility is as follows: frontier technology represents a forward-looking, pioneering and exploratory major technology in a field, while in the agricultural field, frontier technology develops slowly and breakthrough process declines. Although technological development has a significant impact on grain yield, from the perspective of time series, the average impact of frontier technological progress on grain yield is low, which may be an important factor leading to the poor regression effect of frontier technological progress on grain yield change.

The effect of Engel's coefficient on grain yield increase was not obvious, but it still had a positive effect on grain yield increase, which was in line with expectations. However, it can be seen from the regression results that rural electricity consumption and fertilizer application amount do not significantly inhibit grain yield, which is contrary to the research results of Yang Yiwu et al. , and the possible reasons are as follows: With the improvement of mechanization level, the education level of grain production employees does not match the development of science and technology, leading to the excessive use of power resources, energy, fertilizer and other inputs, resulting in a certain degree of pollution, land fertility decline, soil plate and other phenomena, and ultimately to the grain output has a restraining effect. However, by observing the magnitude of its coefficient, we can see that its inhibition effect is limited and insignificant. Although unexpected, it is also reasonable.

4.3. Forecast food production in 2021-2025

Based on the data from 2001 to 2015, the ARIMA model and GM (1,1) model were trained to predict the grain output of Jiangsu province from 2016 to 2020, and the prediction results of the ARIMA-GM joint model were measured and compared with the real data to calculate the average error rate of the three models. The results are shown in table 3.

Table 3: Average error of prediction models for each city

city	Mean error of prediction model		
	ARIMA	GM (1, 1)	ARIMA-GM
nanjing	13. 69%	9. 32%	10. 57%
wuxi	2. 64%	15. 00%	2. 44%
xuzhou	1. 98%	5. 87%	1. 91%
changzhou	3. 37%	2. 08%	2. 45%
suzhou	22. 14%	7. 41%	10. 29%
nantong	2. 28%	1. 90%	1. 84%
lianyungang	0. 54%	5. 99%	0. 85%
huaian	2. 77%	5. 06%	2. 25%
yancheng	2. 24%	5. 80%	2. 75%
yangzhou	9. 21%	9. 42%	9. 21%
zhenjiang	28. 16%	17. 94%	15. 93%
taizhou	9. 21%	9. 10%	8. 42%
suqian	2. 20%	5. 07%	2. 09%
The average error	7. 73%	7. 69%	5. 46%

The results in Table 4 show that the prediction accuracy of the ARIMA-GM combined model is higher than that of the two single prediction models, so the combined model is selected for the prediction of grain yield. Figure 1 respectively show the change of grain supply and demand and the average change of each city in 2021-2025.

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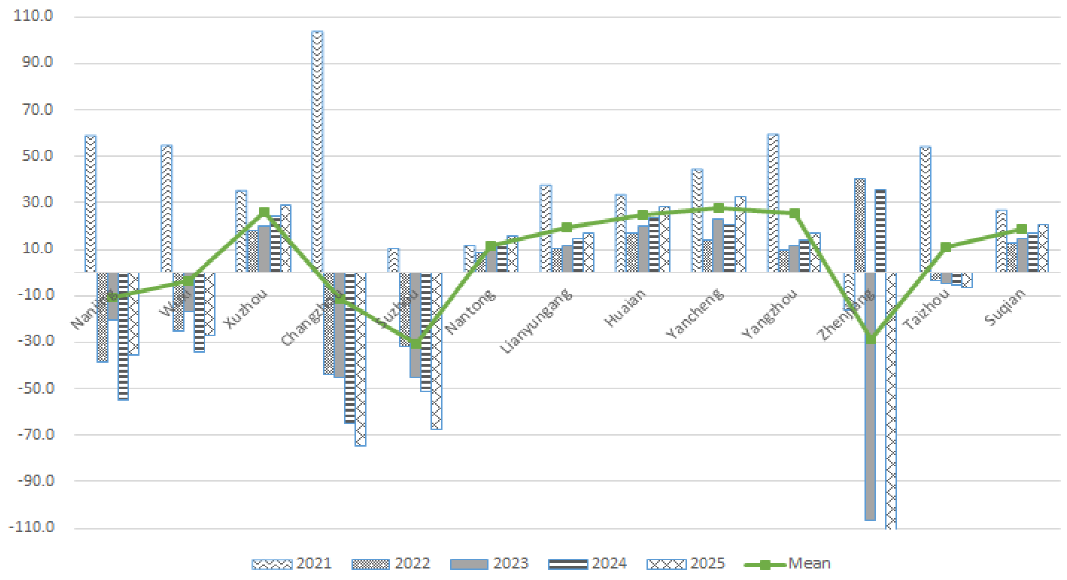

Figure 1: Change of grain supply and demand in Jiangsu province

Figure 1 clearly shows the change of grain supply and demand in Jiangsu Province in the next five years. It can be seen that the change of grain output in some areas of Jiangsu Province will not reach the balance of supply and demand in the next five years, presenting a state of "living beyond one's means", which is particularly obvious in the highly developed areas such as southern Jiangsu. Combined with the analysis results of the impact of input variables on grain output, it is not difficult to see the reasons. Firstly, the scientific and technological development in developed areas gradually deviates from the scope of agriculture, resulting in the "low" speed of cutting-edge technological progress. With the increasing trend of migrant population, the regional population burden increases rapidly. Secondly, the urbanization rate of highly developed areas is high, and the cultivated land base is small. Meanwhile, in order to achieve further economic development, the commercial land gradually erodes the grain land, and the cultivated land area decreases year by year. Finally, the lack of agricultural education and the poor investment of the new generation of agriculture-related students in corresponding industries lead to the structural deficiency of employees. All the above factors are potential inducements for the imbalance of grain supply and demand in some areas of Jiangsu Province in the future.

5. Conclusions and recommendations

In this paper, based on panel data from 2001-2020 cities in Jiangsu province agriculture, by expanding the c-d production function, constructing spatial panel data model, and through the test to select the optimal estimation model, influence the grain yield of each input variable for fitting, output efficiency, frontier technology progress, land moderate scale operation parameters such as regression coefficient, Analysis of the connection between the regression results with the reality, and the cities of Jiangsu province grain production forecast, calculation of Jiangsu province in 2021-2025 food production growth rate, compared to the existing corresponding year population growth forecast data of Jiangsu province, explore in different cities in the next five years food production growth and population growth rate change trend the cause and the possible problems.

The results show that: 1) the progress of science and technology is an important guarantee of grain yield;2) Moderate scale operation is the "catalyst" to further improve scale efficiency and maximize grain yield after the development of science and technology to a certain extent;3) Education is a long-term, chronic investment, but it is also indispensable. Education is an important way to absorb advanced management and management ideas and methods, the cornerstone of scientific and technological development and progress, and the fundamental method to train agricultural talents. 4) organic inputs such as fertilizer for food production present inhibition, can not only reflect the grain planting workers, education level, the lack of new generation employees is more likely to see because of land quality, as a result of organic inputs, groundwater declines in the quality problems have been around a long time, need to take related measures to control investment and improve the quality of the land. To sum up, this paper proposes the following suggestions based on the reality of Jiangsu province:

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(1) We should pay more attention to the updating speed of agricultural science and technology

The impact of technological efficiency on grain yield has always been the highest, influencing the change of grain yield on the whole. However, the impact of cutting-edge technological progress on grain yield at the present stage ranks fourth among all factors, and is only significant at the level of 10%. Technical progress of slow growth while lead to the influence degree of the frontier science and technology on grain yield increase, but also can lead to a series of problems, one of the most prominent is the paper points out "food production increase slowly in the population growth rate", leading to imbalance between supply and demand of grain, and even limit the economic and social development to a certain degree.Therefore, the evaluation index of agricultural science and technology development should not be limited to whether frontier science and technology has been produced, but should focus on the "speed" of frontier science and technology progress. The government should coordinate the appropriation of funds, strictly control the qualification of non-science and technology projects in agriculture and food, and invest the surplus funds in science-related projects. Agricultural universities, research institutes and other scientific research institutions should encourage the proposal of new ideas and new ideas, and provide new ideas for front-line researchers through the "open source" method to promote the rapid development of agricultural science and technology.

(2) Encourage agricultural discipline teaching, improve the enthusiasm of relevant industries

The calculation of effective labor input is based on the average number of years of education in rural areas of Jiangsu Province. Effective labor input is significant at the level of 1%. Although its impact on grain yield is weaker than that of cutting-edge technological progress, it is intrinsically related to scientific and technological progress and the development of large-scale land management, and has long-term and sustainable effect. In view of this result, to the country's fundamental subjects such as agriculture should not be with the development of commodity economy is becoming the "dismal science" of students mouth should through online and offline method, called on the new generation students into the related industries, it involves the national one hundred plan and in the rush to "plan" in one hundred the second goal in the process of national stability problem, Increase financial and policy support for related industries, and even encourage and support employment in agriculture-related industries to a certain extent, so as to promote the rapid and healthy development of the whole industry chain.

(3) We will encourage land transfer and promote the development of appropriately scaled operations

Due to the regional characteristics of Jiangsu Province, effective land for grain production is insufficient, agricultural land is relatively scattered, and the problem of land fragmentation is prominent. The model fitting results show that the impact of average household land area on grain yield is second only to technical efficiency, and it is significant at 1% level, proving that appropriate planting scale has a significant promoting effect on grain yield change. Combined with the above two points, the government should innovate the way of land transfer, formulate new land transfer policies in view of problems, improve land transfer information services, reduce land transfer costs, promote the further development of moderate scale land operation in the province, and drive the comprehensive and sustainable development of the industry.

(4) Improve the rational allocation of resources

Jiangsu province, as a typical province with "more people and less land" in China, has scarce land resources, and the cultivated land area is decreasing year by year. Therefore, it is urgent to make rational use of cultivated land resources, strictly observe the red line of cultivated land, prohibit non-agricultural and non-cultivated industries from occupying agricultural land, and ensure the cultivated land area. According to the analysis results, the amount of fertilizer application has a restraining effect on grain output, indicating that to some extent, the consequences caused by the long-term abuse of fertilizer and other organic inputs have gradually emerged, and the problems of land hardening and plate formation need to be solved urgently.At the same time, under the background of slow update of cutting-edge technology, the overall sown area of grain crops in Jiangsu province is decreasing year by year, while the power of agricultural mechanization is increasing year by year. This phenomenon shows that: At present, the waste of mechanical power is a serious problem in Jiangsu Province.When strengthening the moderate scale operation, we should pay attention to the reasonable distribution of production factors, and make full and coordinated use of labor, capital, science and technology, so as to improve the grain output.In addition, cities in Jiangsu province not only need to absorb advanced management experience from each other, but also need to achieve reasonable allocation of resources within the region, implement inter-regional operations of labor, machinery and equipment, establish an efficient and orderly resource allocation system, reduce resource waste and improve resource utilization rate.

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(5) Learn from and compete with each other

Municipal governments at all levels in Jiangsu should strengthen the absorption of technology and innovative ideas from within and outside the province, can not simply imitate, combinative oneself is actual, it quickly and effectively into the real benefits of the "visible and handled", strengthen the link in the province at the same time, encourage healthy competition, so that the food production industry full of vitality.

To increase grain yield per unit area in order to cope with the imbalance between grain supply and demand and the restriction of economic development caused by the "explosive" population growth in Jiangsu province in the future, the key lies in science and technology, development in rational management and education. To attract more and more people into the study of food issues and even agricultural industry is a top priority and a long-term solution. On this basis, exerting the important role of effective labor input in modern agriculture, we should not only improve the quantity of labor force, but also improve the quality of employed labor force, so as to make up for the structural shortage of labor force and ensure the "successor" of grain production in Jiangsu Province.

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