Climatic Changes and Grain Production in China

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Abstract

Based on provincial level information on grain production in China for nearly 40 years, an analysis was performed on the dynamics of the temporal and spatial changes in grain production in China. Model analysis was also performed on the basis of information on air temperature and rainfall and climatic production collected at 340 meteorological stations for nearly 40 years. Results reveal that grain production has tended to increase in the past 40 years in China, while its increase was significant in the northern part of China and slow in the southern part of China. It was also observed that there was a strong positive correlation between grain production and rainfall/air temperature, which implies that future climatic changes of the globe will help the northern part of China to develop into a major grain production area.

Introduction

During the past 40 years, China achieved remarkable records in grain production. Its grain production gradually increased from 100 m tons in the early years of the New Republic, to the present 450 m tons, *i.e.* 3.5 times in a 40-year period, with an average annual growth rate of 3.5% (Zhang, 1995). China has successfully supported its population, comprising 22% of the total population of the world, with its arable land, which accounts for only 7% of the total arable land of the world. Especially since the implementation of the reform and opening policy, grain production has entered a new phase. China has basically solved the subsistence problems of its urban and rural population, and now aims at increasing the living standards. Grain production is not only the basis of agricultural production, but also the basis of social subsistence and development of humanity, especially in China that has a population of 1.2 billion. In 1995, Mr. Brown published his article entitled "Who will feed China?" (World Watch Institute), indicating that the grain problem in China is very important to the world. A large number of agronomists, systematists, geographers, and biologists have applied a series of methods and models of system analysis, such as linear planning, simulated planning, dynamic planning, input and yield, gray systems, fuzzy mathematics, layer analysis, and system dynamics, in the study on grain system problems. It has involved the use of agricultural resources, the prediction of agricultural development, the formulation of agricultural policies, the analysis of agricultural potential, agricultural management and promotion, and many other topics. They carried out a variety of studies on the grain production system at all levels, on a world to country basis, in terms of regions, farms, biological populations, and individual growth, and endeavored to reveal the rules of substance flow, energy exchange, and information dissemination in the grain production system, in order to effectively regulate the grain production system and meet the increasing demand of people for maximum supply. However, China, as a developing country, has only a weak agricultural foundation, and its grain production is, to a large extent, dependent upon climatic conditions. Therefore, it is especially important for China to carry out studies on the relations between climatic changes and grain problems.

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Dynamics of temporal and spatial changes in grain production in China in the past 40 years

The grain production system is formed and develops within a certain temporal dimension and spatial dimension, and the structure, function and characteristics of this system all show temporal and spatial differences. Therefore, only the analysis of temporal orders and spatial changes may enable to understand the inherent dynamics of the grain production system.

1 Analysis of temporal changes in grain production in China during the past 40 years

When the dynamics of temporal changes in grain production are studied, many scholars are used to dividing this study into several stages and periods, in order to analyze the dynamics of changes and discuss the mechanism of development. To summarize the results of these studies, theories such as "5 periods" (Liu, 1995), "8 stages"(Wang, 1993), and "3 periods"(PRC State Council News Media Office, 1996), have been formulated concerning grain production in China in the past 40 years. Among them, the most authoritative one is the "3 periods" theory developed by the State Council News Media Office. It divides the grain production process of China in the past 40 years into 3 periods, *i.e.* 1949-1978, 1979-1984, and 1985-1995. Of these periods, the first one (1949-1978) represents the period of stable development of grain production, in which, grain production increased from 113.20 to 304.75 m tons, *i.e.* an annual increase of 3.47% during the 29-year period. Both arable land area and grain-sown area expanded during this period, and progress was made in the agricultural infrastructure, agricultural material preparedness, and input to agricultural sciences and technology. It not only guaranteed the increase of grain production in this period, but also laid a firm foundation for the sustainable development of grain production. The second one (1979-1984) is the period of fast development of grain production. In 1984, China attained a total grain production of 407.30 m tons, *i.e.* an average annual increase of 17.0917 m tons or 4.95% each year during the 6-year period. It is the period of fastest growth of grain production since the establishment of the New Republic. The third one (1985-1995) saw a slow growth of grain production. In 1995, China attained a total grain production of 466.62 m tons, *i.e.* an average annual increase of 1.24% during the 11-year period. Fig. 1 shows the overall tendency in the development of grain production in China in the past 40 years.

2 Analysis of spatial changes in grain production in China in the past 40 years

Space is a basic attribute of grain production. Since natural and social environment factors relevant to grain production display regional differences, grain production in turn shows very strong regional features of space. Furthermore, with the passage of time, the regional features of space relevant to grain production will also change correspondingly. Many experts carried out multi-directional studies on this aspect. Zhang *et al.* (1997) started their research from a study on the grain production structure in typical years in the 3 major regions, *i.e.* "the eastern, central, and western parts of China", and performed a comparative analysis of the importance of grain production in these regions in terms of national total grain production and its changes in 1949, 1979, 1984, and 1994. They concluded that since 1984, regional grain production has slightly decreased in the eastern region, slightly increased in the central region, and has remained stable in the western region, while the importance of the southern part of China in grain production has abruptly declined, and that of the northern part has tended to increase.

Dang *et al.* (1998) carried out an analysis of the spatial changes in grain production in China through the use of GIS technology. They concluded that the northern part of China will become an important area in the development of grain production, while a larger decrease in grain production may occur in the southern part. In this paper, the author uses the information concerning the grain-sown area, unit grain production, and total grain production in China at the provincial level collected in 1984 and 1997, in the analysis of the trend of spatial

changes in grain production in China (Figs. 2, 3, and 4).

Fig. 2 shows that the grain-sown area in most of the provinces and cities in the eastern part of China declined to a different extent, and slightly increased only in Fujian, Shandong, and Hebei Provinces. This occurred mainly because the regional economy had been developing quickly in the eastern part of China since 1984 and more farmland was occupied by township enterprises, transportation facilities, and city construction projects. The grain- sown area increased in all the provinces in the western part of China, with the only exception of Xinjiang and Qinghai. Unit grain production per area increased to a different extent in most of the provinces and cities of China (Fig. 3). Total grain production in most of the provinces and cities of China has tended to increase, while in the northern part of China it has tended to increase significantly. Hence, the northern part of China is expected to become the major grain production area in China, while the total grain production in the southern part has tended to show a comparatively slow increase (Fig. 4).

Analysis of grain production and climatic changes in China

1 Extraction of trend of grain production in China in the past 40 years

Many factors may affect grain production, including natural environment factors like meteorological factors, and soil factors, as well as social and economic factors like improvement of crop varieties, agricultural policies, and input to science and technology. However, the analysis of the structure of total grain production is mainly dependent upon 2 factors, *i.e.* unit grain production and grain-sown area. The results (Zhang *et al.*, 1997) show that the first direct impetus to the development of total grain production in China for the past 40 years has been the unit grain production, followed by the grain-sown area. Therefore, analysis of the main factors influencing the changes of unit grain production may enable to further examine the changes in total grain production. The main factors influencing unit grain production may be placed into 2 categories. One category involves grain crop varieties, agricultural policies, and regional natural conditions (like soil conditions). These factors affect grain production in a very complicated pattern while showing a relative stability and regularity in a certain region, and forming the main body of grain production which is referred to as tendency production. The other category consists of production fluctuations which are referred to as climatic production derived from climatic change factors. It is added to the tendency production. Therefore, the extraction of the tendency production is the first step in the analysis of grain production and climatic changes. The practical steps are listed as follows:

(1) Select grain production in China between 1949 and 1997 as the target of the analysis;

(2) Use the linear regression approach to simulate the tendency of grain production changes for the 46-year period, and the results are as follows:

$$y = 785.055x - 1520481$$

Wherein, y = simulated grain production; and x = year

Correlation coefficient R = 0.971

Since there is a high correlation between the simulated production and the actual production, we consider this simulated production as the grain tendency production in China (Fig. 1).

2 Analysis of relations between grain production and climatic changes

Air temperature and rainfall constitute the most important climatic factors which affect grain production in China. In this paper, the major climatic factors affecting grain production are selected including the average annual air temperature, annual rainfall, annual accumulated temperature above 0℃, and annual accumulated temperature above 10℃. All these parameters were collected at 340 important meteorological stations between 1949 and 1996. First, we identified the spatial mean to calculate the order of temporal changes in the meteorological factors, which were then combined with the grain climatic production in China (*i.e.* actual grain

production minus grain tendency production) into a temporal order array. We used the multiple regression analysis approach in the analysis of the correlation between grain production and each meteorological factor, and the results were as follows:

$$y = 1707.62T_a + 33.14R - 0.18T_0 - 1.49T_{10}$$

Where: y = grain climatic production; R = annual rainfall; T_a = annual average air temperature; T_0 = annual accumulated temperature above 0℃; and T_{10} = annual accumulated temperature above 10℃.

The above equation shows that there was a positive correlation between the grain climatic production and the annual average air temperature/annual rainfall in China during the past 40 years. This indicates that abundant rainfall and higher average air temperature will result in higher grain production. According to the results of global change prediction, after the CO_2 content doubles, the air temperature and rainfall in the northern part of China will increase to some extent, suggesting that in the future, grain production in the northern part of China will increase to some extent. As reported by many scholars, the northern part of China will become the major grain production area in China.

Conclusion and problems

1 Grain production has tended to increase in China during the past 40 years, especially between 1979 and 1984;
2 As shown by the trend of spatial changes, the grain-sown area decreased in the eastern part of China while it increased in the western part; grain production increased significantly in the northern part while it increased slowly in the southern part;
3 There has been a strong positive correlation between the grain climatic production and the annual rainfall/annual average air temperature in China, *i.e.* grain production increased with rainfall and temperature, suggesting that future global warming may help the northern part of China to develop into a major grain production area;
4 Since there is a certain correlation between grain production and the climate in temporal and spatial dimensions, further efforts have to be made in studies on the mechanism of correlation in spatial dimension.

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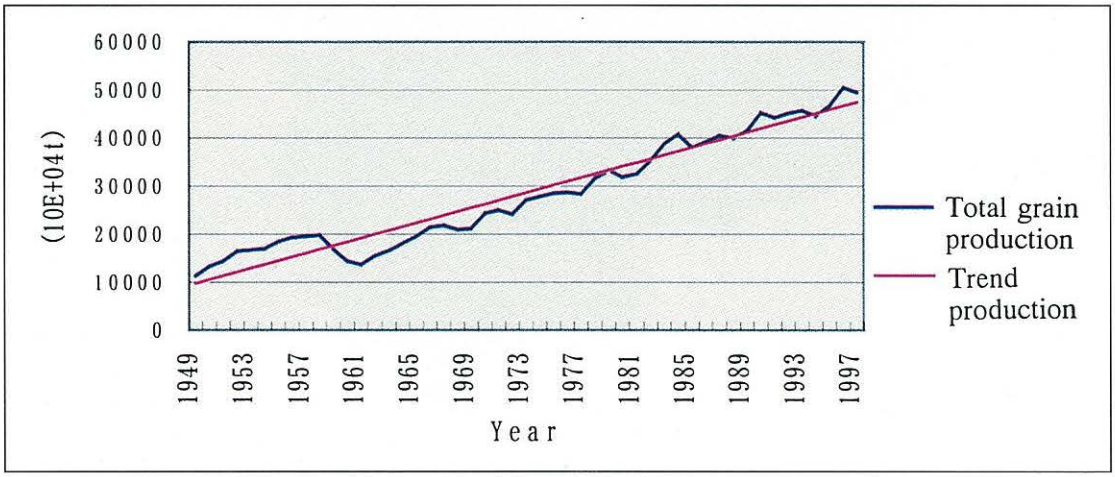

Fig. 1 Changes in grain production in China during the past 40 years (Statistical data of the planting industry of China (1949-1991), the National Statistics Bureau)

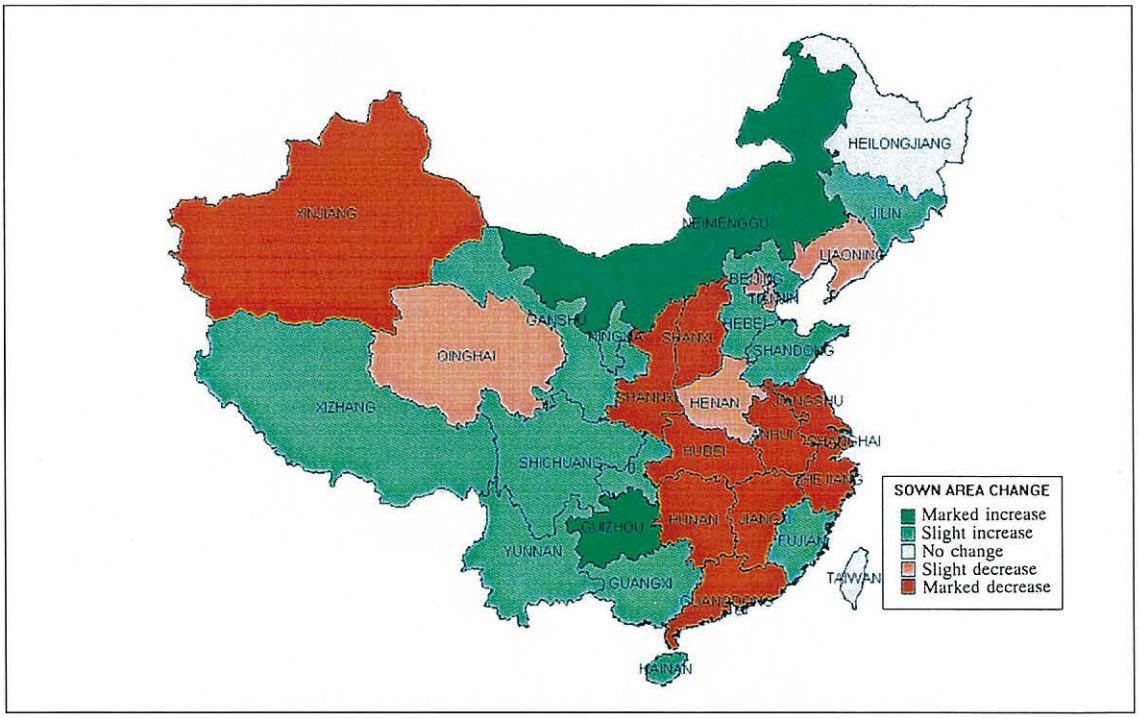

Fig. 2 Changes in grain-sown area in China (1984-1997)

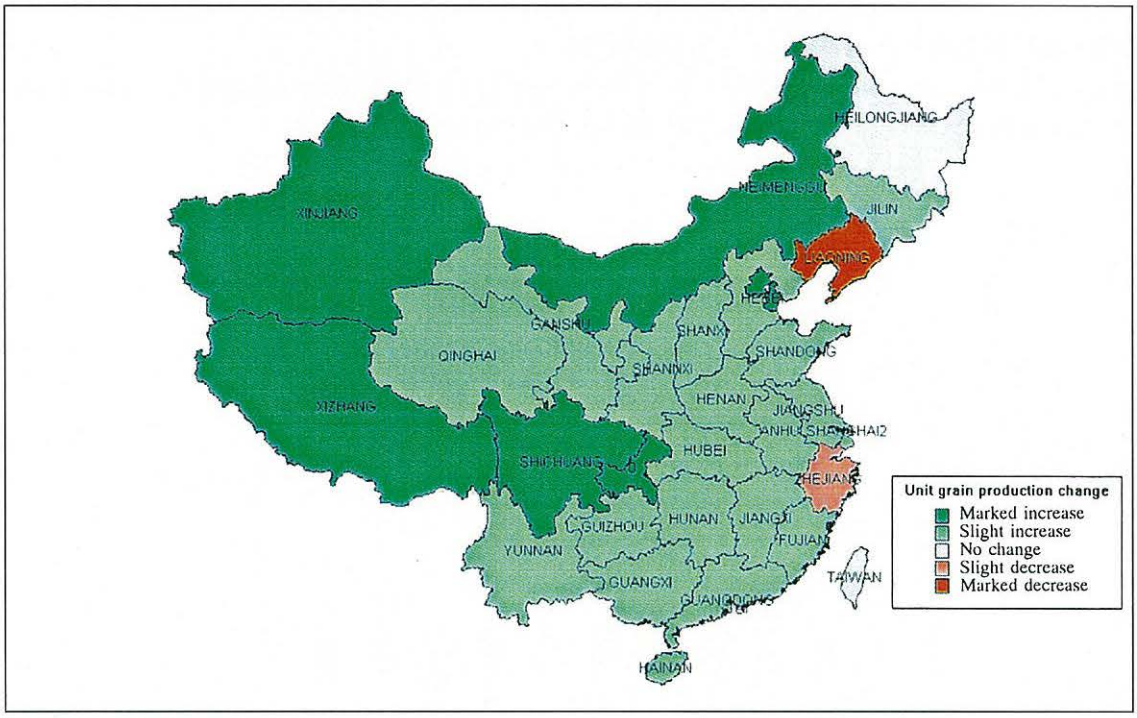

Fig. 3 Changes in unit grain production in China (1984-1997)

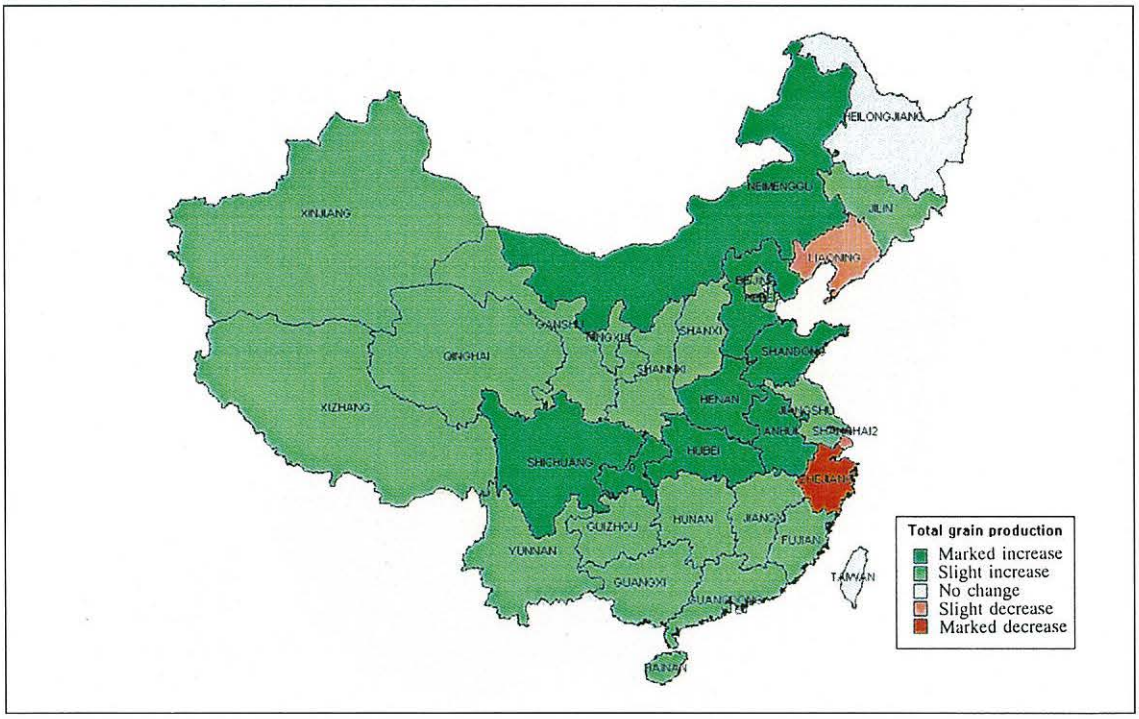

Fig. 4 Changes in total grain production in China (1984-1997)