ENVIRONMENTAL KUZNETS CURVE DERIVED EMPIRICAL EVIDENCE FROM THE MAIN GRAIN-PRODUCING REGION IN HEILONGJIANG PROVINCE OF NORTHEASTERN CHINA FROM 2005 TO 2017

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Abstract. In Heilongjiang of China, the income of farmers affects the consumption of chemical agricultural products. This study simulated the relationships between chemical fertilizers, pesticides, agricultural film, and farmers' income growth for Heilongjiang (2005–2017) using Environmental Kuznets Curve (EKC) models. The results show that the total agricultural output value and the per capita income of farmers showed a decreasing trend, respectively. However, influenced by economic and policy factors, both chemical fertilizers and pesticides showed an N-shaped curve. The total agricultural output value and farmers' income growth in Heilongjiang had been at the "fast-growing" stage, with low environmental pollution according to the agricultural pollution level. Thus, the control of agricultural non-point source pollution has been quite effective, and as a result the agricultural environment improved significantly. The EKC models provided scientific evidence for estimating agricultural non-point source pollution load as well as their changeable trends for Heilongjiang from an economic perspective.
Keywords: *agricultural non-point pollution, chemical fertilizers, pesticides, per capita income of farmers, Heilongjiang*

Introduction

For a long time, China's grain output has increased greatly mainly as a result of the use of chemicals, such as fertilizers, pesticides and agricultural film. The input of chemical agricultural means has increased annually, and the scale has been expanding (*Fig. 1*). The low utilization rate of agricultural chemical means has led to the increasingly prominent problem of agricultural non-point source pollution, which has become a hot issue of social and public concern (Ongley et al., 2010; Huang et al., 2013; Li et al., 2014; Wang et al., 2019).

Grossman and Krueger (1995) introduced the EKC hypothesis, suggesting the existence of an inverse U-shaped relationship between pollutants and economy growth/income. It is reflected in the Environmental Kuznets Curve hypothesis which argues that as per capital income increases, environmental damages also rise to the maximum point at the beginning stage of economic development and eventually declines

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with the increase in income level (Barbier et al., 1996). The hypothesis is represented by an inverted U-shaped diagram that depicts the relationship between the level of environmental degradation and the economic growth (Grossman and Kruger, 1995).

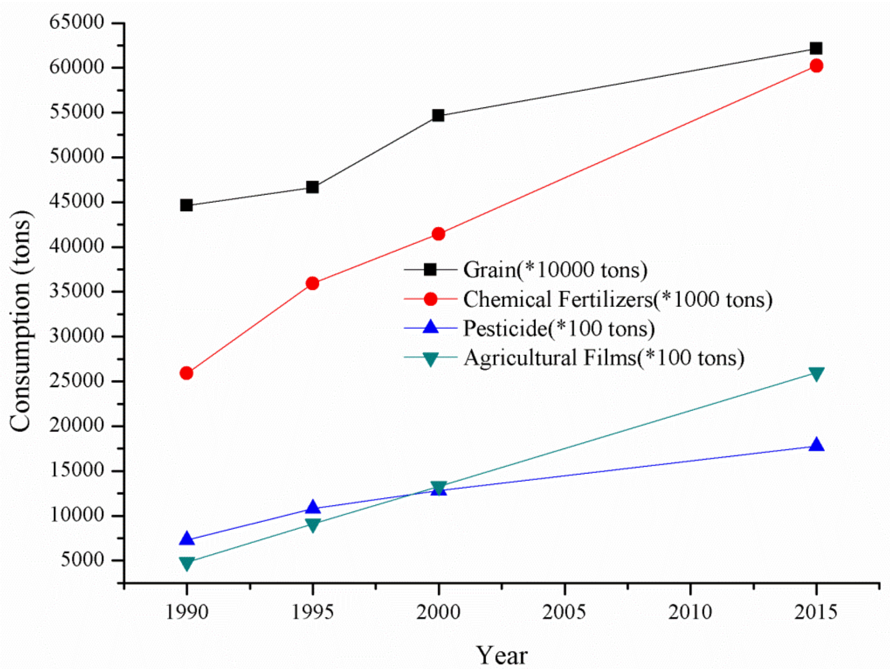

Figure 1. *The relation between grain growth and consumption of chemical agricultural production material in China. (Source: Department of Rural Socio-Economic Survey, National Bureau of Statistics)*

Empirical evidence on environmental risks in the US agricultural sector since 1970 supports the existence of increasing returns. Managi (2006) estimated the productivity of pesticide pollution abatement using refined empirical productivity measurement methods and explicitly control the level of technology. Their study showed the importance of including an environmental productivity variable in the EKC frame work. Jin et al. (2016) used time series data from 2000 to 2013 to verify the Environmental Kuznets Curve of pesticide use and economic growth in China, and to analyze the reasons for the increase of pesticide use in order to provide basis for the realization of pesticide reduction and sustainable agricultural development. Their results revealed that there is a significant inverted U-shaped curve relationship between pesticide use and per capita GDP and per capita gross agricultural output growth. That is, with economic growth, pesticide use increased first and then decreased. At present, China is still in the left half of the EKC curve, indicating that the use of pesticides is still in the rising stage (Zhang et al., 2019; Tzeremes, 2019). In order to achieve zero or even negative growth of pesticide use in China, it is necessary to formulate relevant policies for pesticide reduction and increase the promotion of advanced technology. Zhou et al. (2017) studied the provincial level data of 31 provinces (cities and districts) in China from 1993 to 2013, quantitatively analyzed the relationship between pesticide use and economic growth, and qualitatively explored the driving factors. The results show that there is a significant inverted U-shaped relationship between pesticide use and economic growth in China and other 24 provinces (cities and districts), except 7

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provinces (cities and districts). Among them, the use of pesticides in seven provinces (cities and districts) is still in the rising stage, and has not reached the peak; the use of pesticides in eight provinces (cities and districts) has reached the peak and showed a downward trend; the EKC curve of nine provinces (cities and districts) is in the "N" shape, and the use of pesticides is still in the rising stage.

The emission of non-point source pollutants from fertilizers in China shows an increasing trend (Shi et al., 2019). Mao et al. (2013) estimated the loss of phosphorus and nitrogen fertilizer in Ningxia irrigation area, and tested the relationship between agricultural non-point source pollution and farmers' per capita income. The results also supported the EKC hypothesis. Based on the provincial panel data from 1988 to 2016, Jie et al. (2018) examined the relationship between agricultural growth and non-point source pollution of fertilizers in China. On this basis, he used LMDI method to further investigate the internal causes of EKC formation. The results show that there is a significant "inverted U" EKC relationship between non-point source pollution of fertilizer and agricultural growth in China. The addition of space-time factors does not change the shape of EKC curve, but changes the time of inflection point. Wei et al. (2017) studied the effects of fertilizer input on water resources of Nanpanjiang River basin in Guizhou Province, taking fertilizer input and per capita income of rural residents in Guizhou Province from 2006 to 2015 as samples. Their results show that there is an Environmental Kuznets Curve between fertilizer input and environment, and the government and relevant departments should control the non-point source pollution caused by fertilizer input.

Shang et al. (2017) selected agricultural pollutants such as the intensity of agricultural film application as the evaluation index of agricultural non-point source pollution in Heilongjiang Province to verify the relationship between per capita agricultural output value and Environmental Kuznets Curve of agricultural non-point source pollution. Through research and analysis, the following conclusions are drawn: There is an EKC relationship between agricultural film and per capita agricultural output value in agricultural non-point source pollution sources in Heilongjiang Province, and the Environmental Kuznets Curve is inverted "N" type. On this basis, countermeasures and suggestions for non-point source pollution control in Heilongjiang Province are put forward. Combined with the first national census data of China, Dai et al. (2019) calculated agricultural non-point source pollution indexes based on the basic data of statistical yearbook. The results show that the overall trend of agricultural non-point source pollution is increasing yearly. From the EKC fitting curve test of agricultural non-point source pollution and per capita agricultural output value, it can be seen that the density of agricultural film use and per capita agricultural output value have a significant inverted u-shaped relationship. Combined with the results of empirical analysis, the paper puts forward some suggestions and measures to improve the situation of non-point source pollution in agriculture, increase agricultural economic growth and promote coordinated green development of agricultural environmental protection.

Materials and methods

Study area

Heilongjiang province (121°11′-135°05′E, 43°26′-53°33′N), located in the northeast of China, adjacent to Russia, is the world's famous major grain producing area (*Fig. 2*).

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It consists of thirteen municipalities and sixty-seven counties. The province covers a total area of 4.73×10^5 km^2, which accounts for 4.9% of China. Heilongjiang Province has been the main grain-producing area in China. In 2016, the cultivated land area was 1.24×10^7 ha, accounting for 7.5% of the whole country and 56.1% of the three northeastern provinces (Department of Rural Socio-economic Survey, National Bureau of Statistics, 2017). From the initial stage of the founding of the People's Republic of China, the annual output of grain has been increasing steadily reaching a breakthrough of 5×10^{10} kg in 2010. In 2018, the Province's total grain output reached 7.5×10^{10} kg, achieving a "15-years of bumper harvest "and ranking first in the country for eight consecutive years. In 2017, Heilongjiang's grain output accounted for 9.7% of the total national grain output and 51% of the three northeastern provinces (Department of Rural Socio-economic Survey, National Bureau of Statistics, 2018). Therefore, After the Sino-US Trade Dispute in 2018, the issue of agricultural resources and environmental security in Heilongjiang Province is of great significance in China.

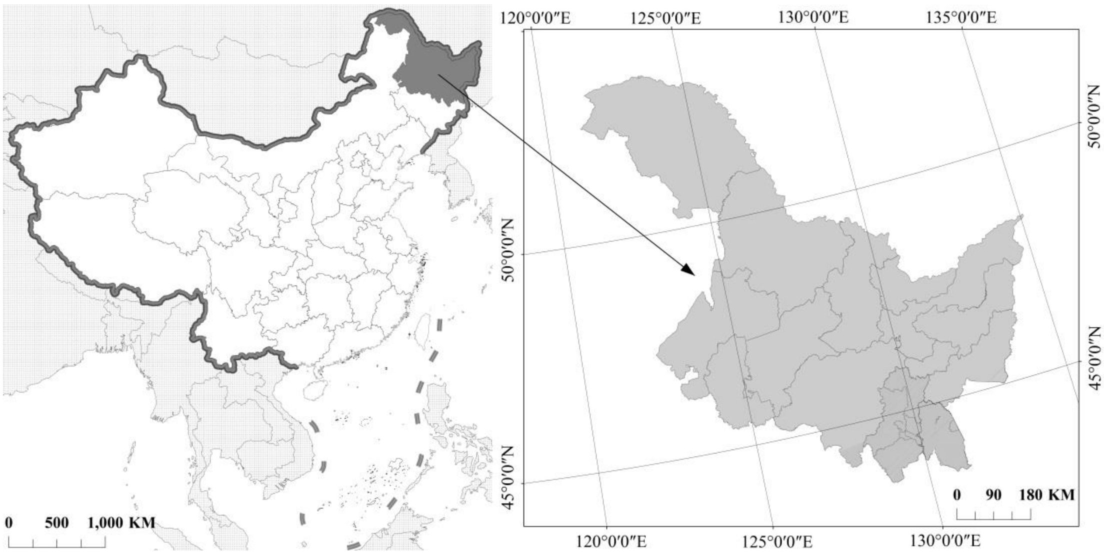

Figure 2. *Location sketch map of Heilongjiang Province*

Data and model

Data sources and processing

In order to analyze the relationship between farmers' income growth and agricultural non-point pollution in Heilongjiang, China, our empirical research used time series of consumption of chemical fertilizers, pesticides and agricultural films for the period 2005-2017 (*Table 1*). Data of farmers' income, consumption of chemical fertilizers, pesticides and agricultural films were obtained from the Heilongjiang Statistical Yearbook. The Data were processed using Excel 2016 and SPSS 20.

Model

On the basis of Environmental Kuznets Curve theory, the theoretical equation of the EKC between agricultural non-point pollution and farmers' income is

$$y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3 + \varepsilon$$

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where y is the environmental indicators, x is the per capita annual Net Income of farmers, β_0 is a constant, β_1,β_2 and β_3 is the estimated coefficient, ε is the error term.

Table 1. *Empirical research data in 2005-2017*

Year	Consumption of chemical fertilizers (10000 tons)	Consumption of pesticide (10000 tons)	Consumption of agricultural films (10000 tons)	Per capita annual net income of farmers (yuan)
2005	121.6	2.9	5.3	3221
2006	150.9	4.8	5.7	3552
2007	175.2	6	6.4	4132
2008	180.7	6.2	6.6	4856
2009	198.9	6.7	6.5	5207
2010	214.9	7.4	6.9	6211
2011	228.4	7.8	7.6	7591
2012	240.3	8.1	8.5	8604
2013	245	8.4	8.5	9634
2014	251.9	8.7	8.4	10453
2015	255.3	8.3	8.3	11095
2016	252.8	8.3	8.3	11832
2017	251.2	8.3	7.9	12665

The relationship between economic development and environment quality can be very complicated. From the above formula, we can draw seven relationships between environmental pollution and economic growth in the model.

1. If $\beta_1 > 0$, $\beta_2 = 0$, $\beta_3 = 0$, it shows that the relationship between economic growth and environmental pollution is a simple incremental one, which satisfies the first-order function relationship. The bigger the first-term coefficient is, the more serious the pollution will be with economic growth, as shown in the straight line *a* of *Figure 3*.

2. If $\beta_1 < 0$, $\beta_2 = 0$,$\beta_3 = 0$, it shows that the relationship between economic growth and environmental pollution is simple and decreasing, which satisfies the first-order function relationship, and the smaller the first-term coefficient, the better the environmental quality will be with the rapid economic growth, as shown in the straight line *b* below.

3. If $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 = 0$, it shows that the relationship between environmental quality and economic growth is a normal U-shaped relationship, which first improves and then deteriorates. Unlike the traditional inverted U-shaped Environmental Kuznets Curve (EKC), the environmental condition first improves and then deteriorates, as shown in *Figure 3c*.

4. If $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 = 0$, it shows that the relationship between environmental quality and economic growth is an inverted U-shaped relationship that deteriorates first and then improves. This is also a typical shape in international experience. The deterioration of environmental quality has a turning point, which is the highest or extreme point of environmental pollution, as shown in *Figure 3d*.

5. If $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$, it shows that the relationship between environmental pollution and economic growth is an N-type relationship, which first deteriorates, then

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improves, and finally deteriorates. The Environmental Kuznets Curve is shown in *Figure 3e*.

6. If $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 < 0$, it shows that the relationship between environmental pollution and economic growth is an inverted N-type relationship, which first improves, then deteriorates, and then improves. The Environmental Kuznets Curve is shown in *Figure 3f*.

7. If $\beta_1 = 0$, $\beta_2 = 0$, $\beta_3 = 0$, it shows that there is no linear relationship between environmental pollution and economic growth, and there is no Environmental Kuznets Curve.

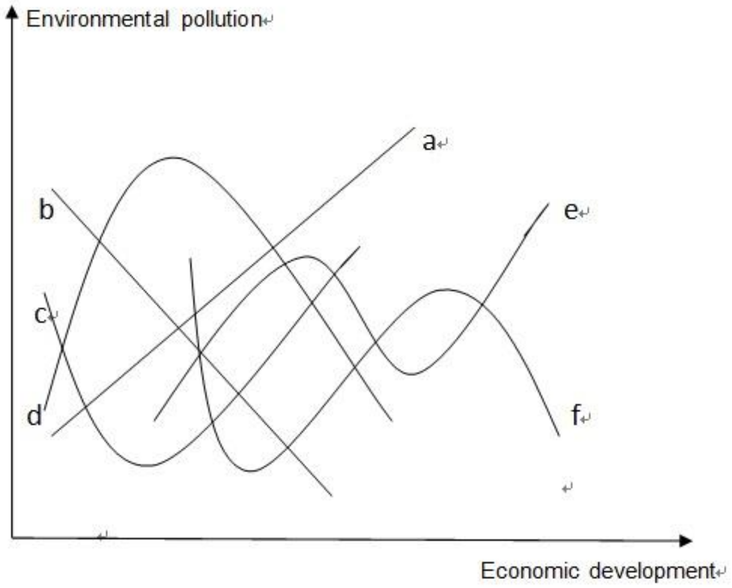

Figure 3. *Shape diagram of Environmental Kuznets Curve*

In this study, the per capita annual income of farmers was selected as the indicator which reflected the agricultural economic growth of Heilongjiang. Heilongjiang is a major agricultural province, agriculture is an important economic base. Therefore, the consumption of chemical fertilizers, pesticides and agricultural films was selected as the indicator which responded to pollution level of Heilongjiang.

With the help of SPSS software, income of farmers (as the horizontal axis) and agricultural production means (as the vertical axis) were fitted by linear, quadratic and cubic models. The results indicate that the cubic model can better reflect the relationship between consumption of chemical fertilizers, pesticides and income of farmers. The quadratic model can better reflect the fitting relationship between consumption of agricultural films and per capita income of farmers. For this reason, the relationship between income of farmers and agricultural environmental quality were fitted by the quadratic and cubic regression curve model (*Table 2*).

From the regression model of farmers' income of Heilongjiang with consumption of agricultural production means, it can be seen that the regression coefficient (R^2) of income with consumption of chemical fertilizer, pesticides and agricultural films was over 0.7. The fitting effect of per capita annual income of farmers and agricultural pollution index was ideal.

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Table 2. *The analysis results of regression model*

Agricultural pollution index (Y)	Model summary					Regression equation
	R^2	F	df1	df2	Sig.	
Chemical fertilizers consumption	0.962	76.278	3	9	0.026	$Y = (1.728e-10)X^3 + (-5.360e\text{-}06)X^2 + 0.0545X - 9.889$
Pesticides consumption	0.891	24.643	3	9	0.036	$Y = (1.245e-11)X^3 + (-3.630e\text{-}07)X^2 + 0.003X - 4.357$
Agricultural films consumption	0.792	19.023	2	10	0.003	$Y = (-2.956e-08)X^2 + 0.001X + 3.250$

Results and analysis

Agricultural development of Heilongjiang

From 2005 to 2017, the economy of Heilongjiang has grown rapidly. The Gross Domestic Product (GDP) increased from 554.28 billion yuan to 1590.27 billion yuan, an increase of approximately threefold, with an average annual growth rate of 15.58%. In addition, the per capita GDP increased from 14516 yuan to 41916 yuan, a 2.89-fold increase, with an average annual growth rate of 15.73%, and the per capita income of farmers increased from 3221 yuan to 12665 yuan, increased by 3.93 times, with an average annual growth rate of 24.43%, which exceeded the growth rate of GDP and per capita GDP (*Fig. 4*).

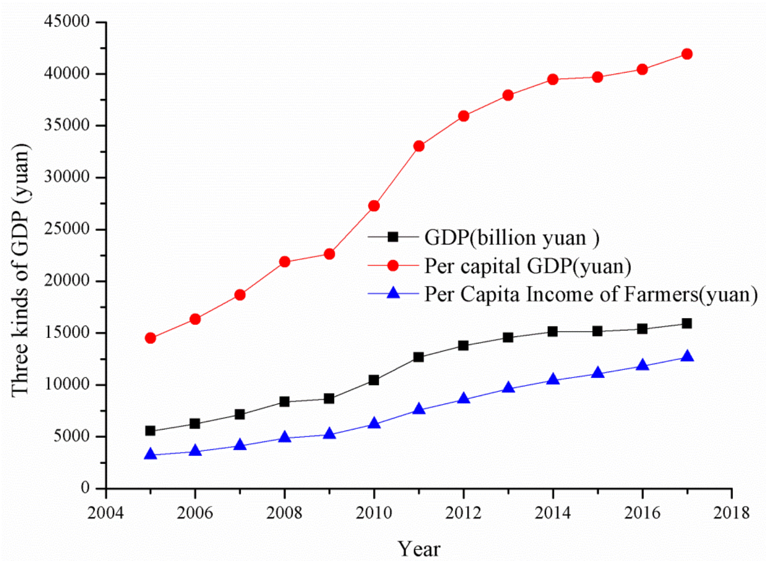

Figure 4. *The growth trend of GDP, per capita GDP and farmers' income in Heilongjiang during 2005~2017*

From 2005 to 2017, the growth rate of Heilongjiang's total agricultural output value is ahead of the whole country. China's agricultural output value increased 2.77 times, Heilongjiang's agricultural output value increased 4.32 times, and the growth rate exceeded China's agricultural output value by 1.56 times (*Fig. 5*). The average annual growth rate of China's total agricultural output value is 14.76%, while that of Heilongjiang Province is 27.63%, which is 1.87 times higher than the growth rate of China's total agricultural output value.

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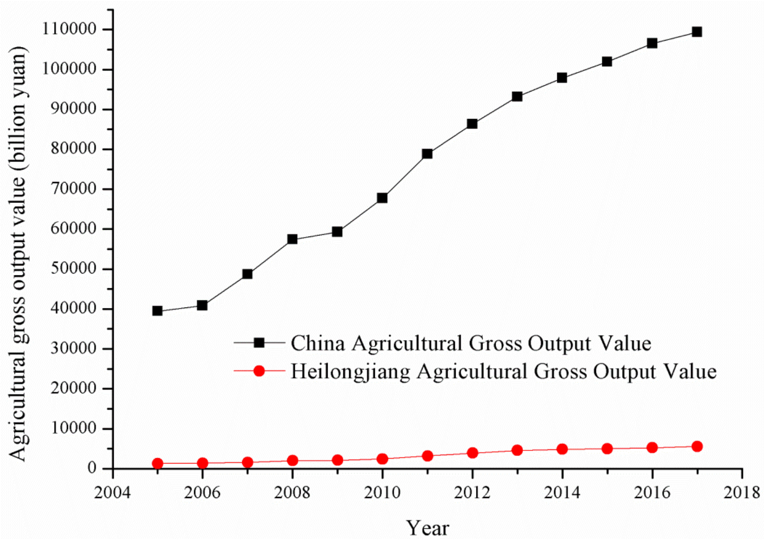

Figure 5. *The agricultural gross output value of China and Heilongjiang 2005~2017*

In the 13 years period (from 2005 to 2017), China's grain output has increased by 1.37 times, while Heilongjiang's grain output has increased by 2.06 times, and the grain growth rate is 1.5 times that of the whole country (*Fig. 6*). The average annual grain growth in China is 3.1%, compared with 8.8% in Heilongjiang, which is 2.84 times higher than that of the whole country. Heilongjiang accounted for 7.4% of the country's grain output in 2005, and increased to 11.2% in 2017.

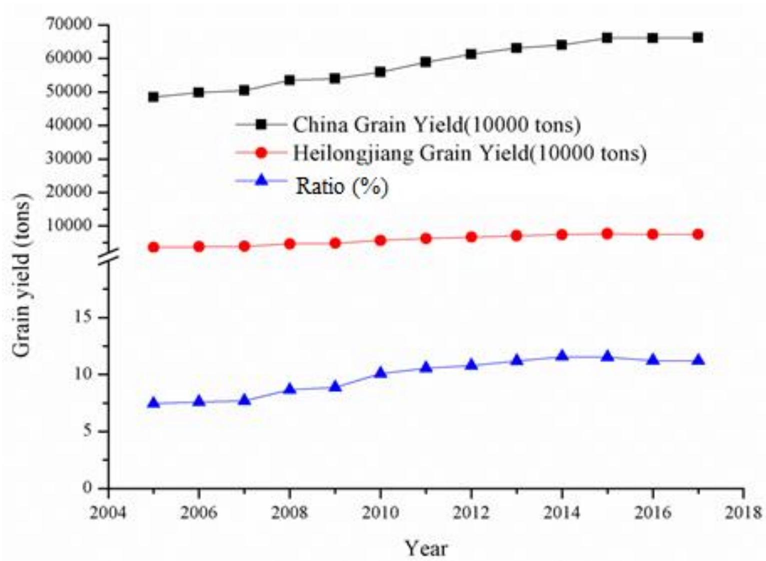

Figure 6. *The grain yield of China and Heilongjiang during 2005~2017*

In summary, the annual income growth rate of farmers exceeded the regional GDP and per capita GDP growth in Heilongjiang. The growth rate of Heilongjiang's total agricultural output value is obviously faster than that of the whole country. Heilongjiang is the most important major grain producing area in China, which is of great significance for ensuring national food security (Qi and Wu, 2017).

Agro-eco-environmental changes from 2005 to 2017 in Heilongjiang

With the growing demand of grain in China, the use of chemical fertilizers has also increased yearly. Until 2017, the intensity of fertilizer application in Heilongjiang Province was 170.10 kg/hm^2, which was 1.58 times higher than that in 2005, but still less than the world's recognized safety limit of 225 kg/hm^2 (Shi et al., 2016). The cubic model can better reflect the relationship between consumption of chemical fertilizers and income of farmers.

$$Y = (1.728e - 10)X^3 + (-5.360e - 06)X^2 + 0.0545X - 9.889 \qquad \text{(Eq.1)}$$

As we can see, from the result of curve fitting, it is roughly "N" type, and the per capita income of farmers at inflection point was 9634 yuan (*Fig. 7*). Before the inflection point, the intensity of fertilizer application increased with the increase of income. When the inflection point approached, the growth rate decreased significantly. After the inflection point exceeded 12665 yuan, the intensity of fertilizer application increased significantly. The result was similar to that of Hebei, Jilin, Jiangsu, Jiangxi, Guangdong, Hainan, Sichuan, Yunnan, Shanxi, Gansu and other 10 provinces (Liu et al., 2009). The relationship of fertilizer consumption and agricultural economic growth matched the N-shape EKC in Heilongjiang province (Shang et al., 2017). Without control, the input of fertilizer will continue to increase. Generally speaking, there is an EKC relationship between fertilizer application intensity and per capita income of farmers, and it is on the left side of the EKC curve. It can be understood that agricultural economic growth brings farmers' income. On the other hand, the rising demand for grain in China promotes the development of grain production, and the application of fertilizer also increases. This is consistent with the conclusion of some scholars (Bruyn and Opschoor, 1997; Opschoor, 1997) that the N-shaped curve is caused by economic factors.

The cubic model can better reflect the relationship between consumption of chemical pesticides and income of farmers.

$$Y = (1.245e - 11)X^3 + (-3.630e - 07)X^2 + 0.003X - 4.357 \qquad \text{(Eq.2)}$$

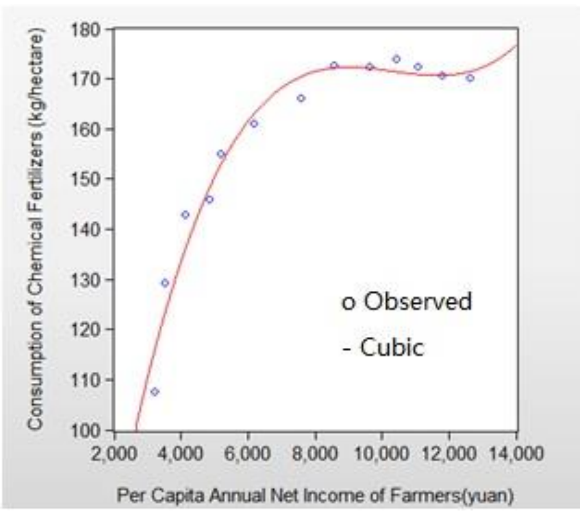

Figure 7. *The fitting curve of fertilizer consumption and per capita income of farmers in Heilongjiang during 2005~2017*

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From the fitting income curve results of pesticides and farmers, it presented N-type EKC curve (*Fig. 8*), and the turning point was 7591 yuan per capita income of farmers. Before the turning point, the intensity of pesticide application increased with the increase of agricultural economy, and the growth rate of pesticide use decreased significantly near the turning point, while the intensity of pesticide application increased significantly after exceeding 11832 yuan. The intensity of pesticide application in Heilongjiang Province decreased with the increase of per capita agricultural income from 2014, because the overall planting structure of Heilongjiang Province has changed in recent years. There has been witnessed reduction of planting area of some cash crops and increase of planting area of Maize with lower pesticide consumption. This therefore has attributed reduction in the use of chemical herbicides. On the other hand, the production technology of pesticides has improved. Farmers are opting for the use of foliar spray hence the utilization rate of pesticides has been more efficiently Appeal causes led to the development of the right side of the EKC curve. Friedl and Getzner (2003) believed that the N-shaped curve is caused by policy factors. The application of pesticides in Heilongjiang validates this conclusion. There are about 232 million pesticide waste packages (bottles, bags and barrels) in Heilongjiang Province each year. The total weight of these packages is about 7,000 tons, and the residual pesticides in the packages are about 180 tons (Lin, 2017). The main causes of pesticide pollution in Heilongjiang Province is attributed to the weak awareness of environmental protection of farmers and safe use of pesticides; the lack of effective recovery methods and harmless treatment technology in the field of pesticides; and the lack of effective supervision mechanism for the use of pesticides.

The quadratic model can better reflect the fitting relationship between consumption of agricultural films and per capita income of farmers.

$$Y = (-2.956e-08)X^2 + 0.001X + 3.250 \qquad \text{(Eq.3)}$$

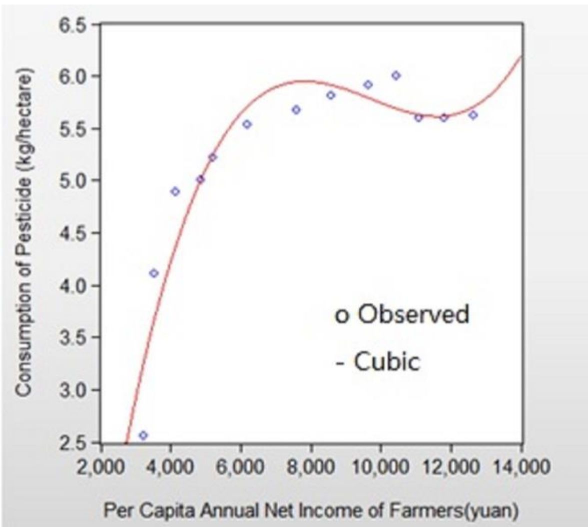

Figure 8. *The fitting curve of pesticide consumption and per capita income of farmers in Heilongjiang during 2005~2017*

According to the fitting curve results of agricultural film and income of farmers, it was a typical inverted U-shaped curve. The turning point of EKC occurred at 9634 yuan

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of per capita income of farmers. Before the turning point, the intensity of agricultural film application increased with agricultural economic growth, and then increased slowly when approaching the turning point. After exceeding 9634 yuan, the intensity of agricultural film application decreased sharply. As we can see from *Figure 9*, the agricultural film consumption showed a fluctuation from 2005 to 2017. The year 2012 was a turning point. Before 2012, the agricultural film consumption showed an increasing tendency, an increase of about 1.3 times, with an average annual growth rate of 20.29%. After 2012, the agricultural film consumption started to decrease gradually, with a decline of 12.23% in 2017 compared with 2012, which has confirmed the results of the EKC of agricultural film consumption and per capita income of farmers.

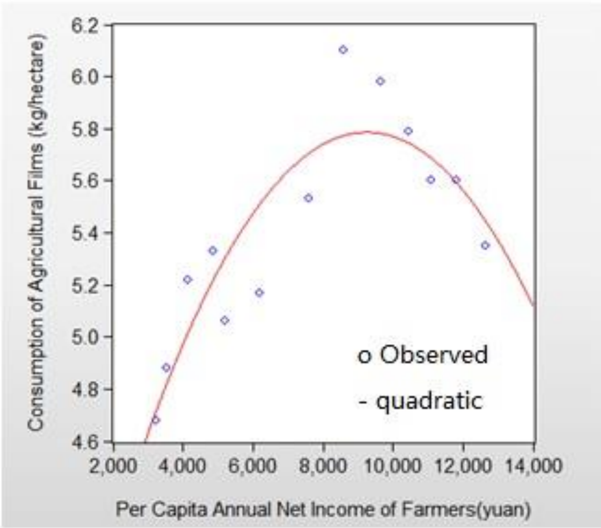

Figure 9. *The fitting curve of agricultural film consumption and per capita income of farmers in Heilongjiang during 2005~2017*

Control of agricultural non-point source pollution

A case study in north China showed that the amount of rural pollution source control reduced significantly, so as to protect and improve the environmental quality (Meng et al., 2014). In order to develop modern ecological agriculture, promote the transformation of China's grain base into a green granary and ensure food safety, Heilongjiang Province has implemented the "Three Reductions" of chemical fertilizers, chemical pesticides and chemical herbicides, and issued the "Opinions on the Implementation of the 'Three Reductions' of Agriculture in-depth". The opinions put forward that by 2020, the average application amount of chemical fertilizer per hectare should be reduced by more than 10%, the utilization rate of chemical fertilizer should be increased by 6.7%, the utilization rate of pesticides should be increased by 9%, and the use of herbicides should be reduced by more than 14,000 tons, or by 20%.

In controlling agricultural non-point source pollution, Heilongjiang Province has taken seven key measures.

Firstly, precise fertilization can be achieved by popularizing the technology of soil testing and formula fertilization and adjusting the structure of chemical fertilizer use.

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Secondly, adhere to the combination of agriculture and animal husbandry, support large-scale aquaculture enterprises and large-scale farms, build fecal treatment facilities, encourage social capital to invest in the construction of organic fertilizer treatment plants, and promote harmless fermentation technology of livestock and poultry manure.

The third is to promote the technology of deep mechanical fertilization, water and fertilizer integration, foliar spraying and other effective fertilization techniques to reduce chemical fertilizer and improve fertilizer utilization rate.

The fourth is to demonstrate and popularize bio-pharmaceuticals and environmental protection agents, replacing low-activity pesticides and chemical additives with high-activity pesticides and environmental protection additives.

Fifth, to develop and improve the information management and prediction system of on-line monitoring of pests and diseases, establish a regional early warning and network management platform system above county level, and comprehensively enhance the ability of monitoring and early warning of major pests and diseases.

Sixth, through the national public welfare investment, the construction of centralized dispensing service stations, the precise allocation of pesticides, packaging and residual liquid recovery and treatment.

Lastly is to continue to implement subsidy policies for subsidy of subsistence land consolidation, so that all suitable cultivated land will be subsided once every three years to improve land output capacity.

In 2018, the provincial high standard demonstration area of “Three Reductions” in agriculture reached 2.7 million ha. Tieli City carried out the “three-reduction” agricultural action, reducing the application of chemical fertilizer by more than 30 kg/ha, pesticide by 5% and herbicide by 5%. Nenjiang County completed the “three-reduction” agricultural demonstration area of 300,000 ha in 2018, with the application of organic fertilizer and farm manure reaching 648,000 tons, with an average reduction of 18% in the three indicators.

Agricultural non-point source pollution control in Heilongjiang has achieved results. From *Figure 10*, it can be seen that the application intensity of fertilizer and pesticide in Heilongjiang reached the highest value in 2014 from 2005 to 2017, which was 173.75 kg/ha and 6.0 kg/ha respectively, and showed a decreasing trend yearly. The application intensity of agricultural film reached the highest value of 6.10 kg/ha in 2012, and then decreased afterwards.

Conclusion and suggestions

In summary, the relationship between agricultural environment and agricultural economic growth was harmonious in Heilongjiang. While maintaining 24.43% annual growth of farmers’ income during the period from 2005 to 2017, Heilognjiang has managed to significantly reduce agricultural non-point source pollution. Analysis of a quadratic polynomial fit to the Environmental Kuznets Curve demonstrates that the environmental turning points for agricultural film consumption have occurred. This finding indicates that Heilongjiang has been at the stage of fast agricultural economic growth with low environmental pollution. Heilongjiang has established a green-oriented system forming a pattern of agricultural development that matches the carrying capacity of resources and environment and coordinates with the production of living ecology. Non-point source pollution in agriculture has been effectively controlled to achieve sustainable agricultural development.

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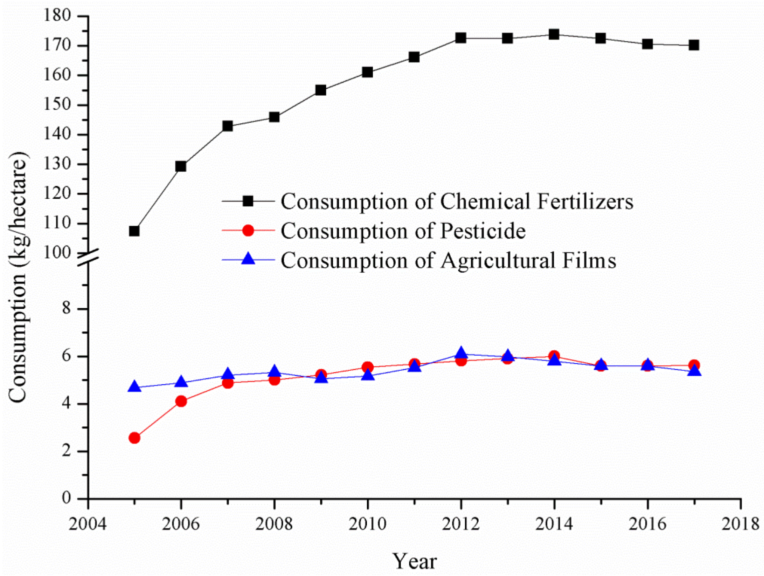

Figure 10. *Growth trend of agricultural non-point source pollution indicators in Heilongjiang during 2005~2017*

Although the quality of agricultural environment in Heilongjiang Province has been greatly improved, there are still many researches to be done in controlling agricultural comprehensive pollution and realizing ecological agriculture. In the future, the research work of increasing agricultural output value and controlling agricultural pollution will focus on three aspects.

First, give full play to regional comparative advantages and optimize the distribution structure of planting industry, in order to reduce the use of chemical fertilizers, pesticides and agricultural film. We should combine market demand orientation with farmers' traditional agriculture habits and accelerate the construction of a ternary planting structure featuring coordinated development of grain, economy and fodder. We will create an advantage zone for special agricultural products, and vigorously develop high value and high efficiency cash crops such as vegetables, fresh corn, edible fungi and potatoes with obvious supply advantages. As well as the special agricultural products such as selenium-rich ones, high green and organic food, and customized agricultural products. The corn industrial belt is mainly distributed in the cities of the first, second and third accumulative temperate zone in Songnen plain. The rice industrial belt is mainly distributed in the cities along the Nenjiang river, the Songhua river and the Sanjiang plain, as well as farms under the bureau of agricultural reclamation. The soybean industrial belt is mainly distributed in low limit of three accumulative temperate zones along the foothills of great and less Khingan mountains area and in the cities and farms under the bureau of agricultural reclamation in the fourth and fifth accumulative temperate zones. The belt is mainly distributed in arid and semi-arid areas such as Daqing, Qiqihar and Heihe. Potato industry belt is mainly distributed in Qiqihar, Harbin, Suihua, Heihe and other regions.

Secondly, to accelerate the open sharing and comprehensive utilization of large agricultural and rural data, in order to design and develop provincial-level agricultural Internet of Things (IoT) systems and related standards, and promote the application of Internet of Things technology. Through IoT, data sharing in the main business areas such as agricultural planting and production, agricultural machinery management, green food, soil testing and fertilization, plant protection, and agricultural products safety is realized, which effectively solves the problem of agricultural comprehensive pollution and continuously increases the income of farmers.

Lastly, we should coordinate the development of urban and rural integration, improve laws, regulations and policies related to non-point source pollution prevention and control in rural areas, such as straw burning and utilization, pollution prevention and control of agricultural film, pollution prevention and control of poultry and livestock breeding, and soil pollution prevention and control.

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