

An Empirical Analysis of the Impact of Pesticide and Fertilizer Pollution on Household Income

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Abstract: In agricultural production, agricultural non-point source pollution threatens the safety of water supply and food safety, restricts the sustainable development of the agricultural economy and rural ecological environment, and is the bottleneck of agricultural development in China. To explore the impact of this situation on the real income of rural households, the paper is based on the data from China Family Panel Studies (CFPS) from 2014 to 2018. With the pollution status in agricultural production as the explanatory variable and the total value of household agricultural and sideline products as an explanatory variable, a fixed effect model was established to estimate the influence of fertilizer and pesticide application on labor income level. The results show that the income brought by pesticide and fertilizer input is low efficiency, and some farmers have achieved high yields with low input. In addition, the education level of the agricultural population and the size of the family had no significant effect on this. Considering the output problem, the application of pesticides and fertilizers is necessary, but the cognition that pesticides and fertilizers can increase crop yield and income makes the application of pesticides continue to increase, which is not conducive to the increase of agricultural output value. It is necessary to attach importance to new methods of increasing agricultural production based on the application of small amounts of fertilizers and pesticides and use technological reform and professional agricultural education to promote the rational use of pesticides and fertilizers and achieve rapid development of agriculture.

Keywords: agricultural non-point source pollution, household income, fixed effect model, rural revitalization.

1. Introduction

In agricultural production, pesticide application is a key agricultural technical activity, which directly affects crop growth, yield, and quality, and then has a significant impact on farmers' economic income. From the perspective of cost-effectiveness, the relationship between fertilizer and pesticide input and farmer income is not a simple positive correlation. The scientific use of chemical fertilizers and pesticides can effectively prevent and control the spread of pests and diseases, improve crop yield and quality, control production costs, and maximize farmers' economic benefits. However, excessive or improper use of pesticides not only increases production costs, but also may cause negative effects such as drug damage, pest resistance enhancement and environmental risks, and environmental pollution and residues of agricultural products will greatly reduce the market competitiveness of

products, and ultimately reduce the actual income of farmers. Pollution from non-point agricultural sources has overtaken industrial and urban areas to become the main source of water pollution, according to the Rural Agriculture Bureau.

Through literature review, the Chinese government has strengthened the formulation and implementation of pesticide management policies in the past decade, such as banning high-toxicity and high-residue pesticides and advocating the use of green, low-risk and appropriate pesticides and fertilizers to promote the increase and value-added of agricultural and secondary industries. However, the specific amount of investment and application time are different, and the income increase effect is also different, and whether the household income is really increased needs to be studied. Therefore, there is a complex interaction between the application of chemical fertilizer and pesticide and the economic income of farmers. This study aims to deeply analyze the specific impact mechanism of pesticide application on the income of farmers, and use household data and model construction to better explore how to improve the economic benefits of agricultural production by optimizing the strategy of pesticide use, so as to achieve the goal of sustainable agricultural development.

2. Literature Review

Li Shouyue et al. believed that farmers' cognition of agricultural pollution had a positive impact on agricultural input behavior [1]. Guo Zhaohui and others have shown that subsidies for agricultural pollution control will lead to the increase of agricultural output and the decrease of non-agricultural output, which is not conducive to the increase of economic welfare [2]. Phamov et al.'s research shows that intensive production and food safety hazards also lead to environmental and health problems [3]. Zhang Yi et al. believe that labor force is prone to reduce labor participation after experiencing pollution health impact [4]. Gong Jianwei's research shows that green agriculture and farmers' income are coordinated development, but also need to consider production reduction and cost issues [5]. Satrovic et al. proposed that the environmental Kuznets curve of agricultural development also affects the level of social income distribution [6]. Delgado's focus on farmers diversifying trade and importing and exporting is also constrained by high costs [7].

In the studies on environmental economy and labor economy, there are few literatures that use the input of fertilizers and pesticides as research indicators. Meanwhile, in previous studies, income surveys were mostly concentrated at the provincial level, with per capita GDP and per capita agricultural output value as research objects, and few people actually tracked the micro level of specific household income. And fully consider the family background and other conditions that affect the increase of income of each farmer. Therefore, the selection of a certain number of households engaged in agricultural production data, analysis of the specific relationship will be a new angle. At present, the traditional cognition of high investment and high return is not in line with the requirements of The Times. Farmers' income generation should also be shifted to a more modern perspective. Appropriate and effective input of pesticides and fertilizers can promote the healthy development of agricultural economy, which will also give some inspiration to the agricultural pollution problem that is still being solved.

3. Model Construction and Data Source

Core explanatory variable (pollute): Agricultural non-point source pollution refers to the pollution of water, soil, air and agricultural products caused by pollutants produced in the process of agricultural production in rural areas without proper disposal, mainly including chemical fertilizer pollution, pesticide pollution and livestock and poultry manure pollution, and the sources are mainly pesticides and fertilizers lost due to irrational use in agricultural production. Therefore, the amount of household fertilizer and pesticide input is used to measure.

Explained variable (output): Taking into account the income directly brought by agricultural production activities, the total value of household farm and sideline products is used to measure.

In this paper, the model is constructed as a fixed effect model and an extended two-way fixed effect model, in order to observe the influence of multiple explanatory variables control factors and time factors. Based on CFPS household economic survey questionnaires in 2014, 2016 and 2018, a total of 2048 household data were screened and sorted out, and the model was established as follows. Where $output_{it}$ is the farmer's income and $pollute_{it}$ is the level of agricultural pollution. $labor_{it}$ is also selected, that is, the number of people in a household at home all year round. Labor force quality $educ_{it}$, the level of family culture and education; Together with the government support intensity gov_{it} , that is, the amount of government subsidies, these three factors serve as control variables. The time variable is year, a_i represents the fixed effect of pesticides and fertilizers on agricultural output value, and u_{it} is the random error term.

$$output_{it} = \beta_0 + \beta_1 pollute_{it} + \beta_2 gov_{it} + \beta_3 labor_{it} + \beta_4 educ_{it} + u_{it} + a_i \quad (1)$$

Through this model, we can intuitively see the impact of chemical fertilizer and pesticide pollution on agricultural output value, and control other effective factors affecting agricultural production. The statistical results of the data are shown in Table 1, and it can be seen that the input cost of pesticides and fertilizers is an important part of the agricultural household income.

Table 1: Summary Statistics

VarName	Obs	Mean	SD	Min	Median	Max
O	6144	11800.764	20960.796	-1.000	5000.000	3.70e+05
P	6144	4391.465	8135.898	-1.000	2400.000	2.00e+05
G	6144	1604.511	3719.690	-1.000	800.000	97500.000
L	6144	3.590	1.670	1.000	3.000	14.000
E	6144	28.898	578.787	-1.000	0.000	42830.000

4. Empirical Result Analysis

The regression results can confirm that fertilizers and pesticides have an impact on agricultural output value, but in fact, due to the differences in regional natural and geographical environment, economic development level and traditional farming methods, it is very likely that there are individual effects. First of all, the stationarity test is done. Through the image observation, it can be found that the expected value of the output value in different years is roughly the same, the variance is also constant, and the data is stable. The next study performed a robust Hausman test on the panel data, and the results showed that a P-value of 0.0003 could reject the null hypothesis of random effects. The results of LSDV method are exactly the same as those of intra-group estimators, so it is considered that the model has individual fixed effect. Therefore, the fixed effect model is used for analysis.

On this basis, a bidirectional fixed effect model with time trend is established, and the regression results are shown in Table 2, P value is 0.000, rejecting the null hypothesis. Therefore, the variable $pollute$ has a significant impact on output. From an economic point of view, product categories, market information docking and sales may have a more important impact on agricultural income. The regression results of pesticide input intensity of chemical 4 fertilizer were significant. When every 100 yuan of pesticide and fertilizer is invested, the output value of agricultural products is increased by about 44.9 yuan, which is not enough to make ends meet. This may be due to the unscientific amount of pesticide input and fertilization, as well as the damage to the land and roots caused by years of pesticide and fertilizer residues, resulting in ecological damage and unsatisfactory output. It also shows that farmers' traditional cognition leads to the increasing use of pesticides. But it is difficult

to get the corresponding economic return. The wrong traditional concept will also make the original land, water, air and other natural resources in rural areas affected by negative externalities, weakening the output capacity of natural resources.

However, the influence of other variables in the model is not obvious, which may be due to the nature of contemporary agricultural production itself. In terms of the popularization of mechanization, the improvement of agricultural planting knowledge and the accumulation of labor experience of several generations of farmers, the number of labor force and the level of cultural education are no longer as important to agricultural output value as traditional agriculture. The factor utilization and intensity of labor force have also improved. At the same time, government support has an economic role in promoting agricultural development, but China's population development has passed the Lewis turning point, and then how to cross the middle-income trap and achieve innovative development is still a difficult problem. China can not adopt a one-size-fits-all approach to the implementation of agricultural development policies, except providing infrastructure construction funds and other material guarantees. More attention should be paid to the combination of technological innovation and the requirements of The Times.

In the model regression with the addition of time dummy variable, the model is made to have the characteristics of time series. The results show that the coefficient of the dummy variable year in 2018 is significantly non-zero, and the time factor is taken into account, indicating that the influence caused by the accumulation of pesticides and fertilizers in recent years has become prominent. The results also show that the effect of pesticide and fertilizer input on agricultural output value is basically unchanged, which proves that the problem of agricultural production efficiency and loss has been difficult to make greater breakthroughs.

Table 2: Results of model regression

	(1)	(2)
	O	O
P	0.449***	0.449***
	(13.64)	(13.71)
G	0.0476	0.104
	(0.71)	(1.55)
L	335.3	277.7
	(1.52)	(1.26)
E	-0.109	-0.109
	(-0.29)	(-0.30)
2014.year		0
		(.)
2016.year		-475.4
		(-1.11)
2018.year		-2390.9***
		(-5.55)
cons	8553.7***	9623.0***
	(10.33)	(11.15)
N	6144	6144

In addition, by observing the scatter plot of the relationship between pesticide and fertilizer input and the total value of agricultural products, there are outliers on both sides of the regression line. At the beginning of agricultural production, an appropriate amount of pesticides and fertilizers can achieve high yield and value-added crops. When the amount of pesticides and fertilizers increases to a certain extent, the driving force for increasing production and value-added is gradually insufficient. The relationship between fertilizer input intensity and per capita disposable income of rural residents shows an inverted U-shaped curve, which is an internal logic [8]. Some farmers with low pesticide input have higher income but get higher income than most farmers with similar pesticide input. On the contrary, there are fewer farmers with high pesticide input, and it is more difficult to obtain high income than families with low pesticide input. In the data used in this paper, most of the household pesticide and fertilizer input is moderate, some of the family samples with little fertilizer and pesticide input get high output value due to scientific farming and other factors, and many individual samples invest a lot of fertilizer and pesticide, but the output value is very low.

The above analysis proves that the appropriate amount of effective and reasonable pesticide and fertilizer input can promote the healthy development of agricultural economy, and the green and efficient economic development model will have a longer term future. On the basis of the macroscopical conclusion, the differences of the implementation management methods in different regions and different types of crops were discussed. Based on the macro conclusion, the psychological game analysis of farmers' use of chemical fertilizers and pesticides, the analysis of public opinions and market evaluation on social media, etc., all play an important role in the innovation and development of agriculture in the new era.

5. Policy Recommendation

First of all, we need to recognize the traditional concept of increasing production, because according to the empirical results, we do not completely deny the role of pesticides and fertilizers, but to increase the use of reasonable amounts according to the needs of different crops and production areas, and cannot implement a blanket reduction or increase policy. But more important is to consider special cases, analyze why their output has ultra-high efficiency, and want to obtain higher efficiency, to pay attention to a small amount of fertilizer and pesticide application based on new agricultural production methods, that is, technical input. Hence the following policy recommendations.

The accumulation of human capital is the basis of technological progress [9]. For farmers themselves, planting science popularization and environmental protection education for farmers should be strengthened through mass media and experts' visits to villages, so as to strengthen professional training of agricultural production and enhance investment in human capital. At the same time, the reasonable establishment of agricultural technology extension institutions to provide scientific and technological support and training to help farmers master the correct pesticide application technology is also to improve the efficiency of pesticide use, which is an important measure to ensure and increase farmers' income. Strive to cultivate "modern agricultural makers" and new professional farmers, and promote the development of "Internet + agriculture" in the new era. We will give subsidies to young people who enter the agricultural industry.

In terms of agricultural technology, the traditional inefficient agricultural technology should be eliminated, mature application technology should be developed and promoted, and fertilization methods should be improved according to local conditions to improve the efficiency of pesticide and fertilizer utilization. Organic fertilizers and green pesticides are encouraged to replace inorganic fertilizers and highly toxic pesticides, and comprehensive pest control strategies are advocated [10]. Promote e-farming, especially the use of mobile phones to control, analyze and monitor household crop income. Developing climate-smart agriculture to help smallholder farmers cope with extreme weather [11].

Controlling the prices of pesticides and fertilizers within a reasonable range is conducive to maintaining farmers' production enthusiasm and grain planting income, and ensuring national food security [12]. In the autumn fertilizer preparation stage of the market, domestic demand increases and dealers' purchase volume keeps increasing, ensuring the stable supply of fertilizer manufacturers. Appropriately raise the prices of some fertilizers and pesticides to reduce farmers' dependence on pesticides and fertilizers in production. We will strengthen market price supervision of pesticides and fertilizers to avoid market turmoil caused by information confusion.

6. Conclusion

China's agricultural production has been inseparable from pesticides and other chemical substances, fertilizer contribution rate to grain production increase is high, fertilizer and pesticide have a positive effect on the output value of crops in the early stage. The use of agricultural chemicals brings economic benefits, but also produces obvious negative externalities: large use of pesticides and fertilizers and unreasonable application methods lead to low efficiency. Pesticide residues also contribute to the widespread problem of food contamination and can also lead to direct economic losses. Only by maintaining the balance between economic benefits and natural benefits can agricultural economy achieve sustainable development.

In summary, as China's economic construction enters a new era, the demand for industrial structure upgrading and high-quality development, while attaching importance to the innovation of the tertiary industry and high-tech industry, it is more important to ensure the high-quality and efficient development of the primary industry, leaving more space for emerging industries. It is necessary to continue to promote the protection of resources and the environment, adhere to the rational use of natural resources and the renovation of the living environment, pay attention to the development of modern rural industries, but also pay attention to the protection of rural ecology, realize the effective use of resources, and build an ecologically livable countryside.

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