Agrochemical Input Behavior and Cleaner Production Adoption Willingness of Farmers in Beijing–Tianjin–Hebei, China

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Abstract: Beijing–Tianjin–Hebei is an important agricultural production area in China, and farmers’ agrochemical input behavior directly affects the risk of agricultural non-point source pollution and the effect of green agricultural development. Based on a questionnaire survey and field interview data, this study investigated the agrochemical input behavior of farmers in Beijing–Tianjin–Hebei, and analyzed its influencing factors. Using the Probit model, we carried out an empirical study on farmers’ willingness to invest in cleaner production of agrochemicals from four aspects: farmers’ characteristics, agricultural input, environmental awareness and technical cognition. The results showed that the kinds of fertilizer were mainly compound fertilizer, urea and organic fertilizer, and the fertilization method was mainly surface spreading, accounting for 50.6% of the total surveys; the number of agrochemicals was determined chiefly by agricultural sellers, accounting for 55.5%. The proportion of the guidance from technical departments in Beijing was higher than that of Tianjin and Hebei. The first influencing factor for farmers’ behavior towards agrochemical input was the pursuit of high yield and high profit, accounting for 24.9%, 22.6% and 26.0%, respectively. The guidance of relevant technical departments still did not fully cover the use of agrochemicals. The study also found that factors such as the price of farming materials, the price of agricultural products, family income, farmland facilities, government propaganda, technical training and subsidies all impacted the agrochemical input behavior. Pre-production technical guidance and farmers’ awareness significantly affected the willingness to adopt cleaner production. Technical training was helpful to improve farmers’ willingness to participate actively, and enhancing the pertinence of training played an important role in the adoption of cleaner production technology. In conclusion, the influencing factors of farmers’ agrochemical input in Beijing, Tianjin and Hebei were complex, and the scientific application level still needs to be improved. This paper finally discusses and puts forward some countermeasures and suggestions for agrochemical reduction and efficiency improvement.

Keywords: fertilizers; pesticides; agricultural film; cleaner production; adoption willingness

1. Introduction

Beijing–Tianjin–Hebei is an important agricultural production area in China, with a high multiple cropping index and output intensity. In the pursuit of yield, farmers generally have blind or excessive behavior in agricultural chemical input, which leads to high agricultural chemical input [1,2]. Data showed that the sown area of crops in Beijing, Tianjin and Hebei reached 8.65 million ha in 2021 [3], while the total amount of chemical fertilizer input was 2.99 million tons, so the amount of chemical fertilizer applied per unit area was 345.4 kg/ha, which was higher than the national average of 307.7 kg/ha. In 2020, the pesticide input in Beijing, Tianjin and Hebei was as high as 58,435,000 tons; the amount of agricultural film used was about 119,000 tons, accounting for 4.9% of the total
agrarian film used in China. Especially in Beijing, the intensity of pesticide and plastic film use showed a particular upward trend. A large amount of agricultural chemical input makes the environmental load heavy, poses a severe threat to soil [4,5], water [6–8] and the atmospheric environment [9] and further affects the quality of agricultural products and even human health [10,11].

As one of the central bodies of agricultural production and management, farmers are the direct implementers of agricultural chemical input. Farmers’ chemical input behavior mainly includes the category selection of agricultural chemicals, application methods, input amount, input cost and the technology adopted. Finding out farmers’ agrochemical input behavior is an essential prerequisite for adopting scientific fertilization management measures to improve use efficiency and protect the ecological environment [12].

At present, some studies have been carried out on the input preference, adoption willingness and influencing factors of adopting green production technology in foreign countries [13,14]. In China, Yin [15] and Chen [16] respectively studied the influencing factors of farmers’ fertilizer application intensity and fertilization behavior in Henan province and the city of Xuzhou, Jiangsu Province based on field survey data and farmers’ behavior theory. Based on the data of fixed observation points in rural areas from 1995 to 2016, Gao et al. [17,18] studied the relationship between the high consumption of agrochemicals and the individual characteristics of smallholders in China. Some studies used models to analyze the influencing factors of input behavior and willingness. Qi et al. [19] and Liu et al. [20] used a logistic model to analyze the influencing factors of safe pesticide application behavior and the adoption of new technologies in Zhejiang and Heilongjiang Provinces. Relying on the theory of cost–benefit and production factors, Cui and Yu [21] analyzed the willingness and influencing factors of vegetable farmers to reduce the application of agrochemicals based on questionnaire data in Shandong Province. He and Qi [22] used the bi-variable Probit model to analyze the influencing factors of risk perception of excessive fertilization and adoption of environment-friendly technology for citrus growers; Zhao [23] took the farmers’ behavior of fertilizer and pesticide application as an alternative variable and studied the impact of incentive policies for ecological protection of farmland on farmers’ behavior; Luo et al. [24] empirically analyzed the influence of green cognition and the realistic situation on farmers’ willingness to apply biopesticides and behavior in Shaanxi Province. Qin and Lv [25] analyzed the influencing factors of farmers’ adoption of green prevention and control technologies using the Heckman two-stage model based on household survey data and empirically analyzed the economic and environmental effects of farmers’ adoption of green prevention and control technologies.

According to the current research progress, relevant scholars have carried out research on the application behavior of chemical fertilizers and pesticides in many provinces based on field investigation, adopted suitable models to study the related factors affecting farmers’ behavior and obtained valuable research results. However, farmers’ agrochemical input behavior in different regions is greatly influenced by local agricultural production habits, technical level and policy orientation. Beijing–Tianjin–Hebei is an important functional area of agricultural production in China, and farmers’ agrochemical input behavior directly affects the risk of agricultural non-point source pollution and the efficiency of chemical fertilizers, pesticides and agricultural films. However, there is still a lack of in-depth exploration of farmers’ agrochemical input behavior, influencing factors and cleaner production adoption willingness in this area. Therefore, taking Beijing–Tianjin–Hebei as the research area, we studied the characteristics of farmers’ agrochemical input behavior and analyzed the influencing factors of input behavior; then, the Probit model was used to analyze farmers’ willingness to adopt agrochemicals in cleaner production from four aspects: farmers’ characteristics, agrochemical input, environmental awareness and technical cognition, to provide a theoretical basis and decision support for the scientific management of agrochemical input. The research is of great significance in promoting the reduction and improving the efficiency of agrochemicals and enhancing the green development of agriculture.
2. Materials and Methods

2.1. Study Area

Beijing–Tianjin–Hebei is located in the North China Plain, 113°27′~119°50′ E, 36°05′~42°40′ N, which is an important grain-producing and intensive vegetable-planting area in China. The regional land area is 216,000 km², accounting for 2.3% of the whole country; the population is 110 million; Haihe River and Luanhe River are the main water sources for residents and agricultural production. The main soil types in the region are brown soil, cinnamon soil, fluvo-aquic soil and chestnut soil, and the cultivated land area is 65,000 km², accounting for about 30% of the total area of this region.

The Beijing–Tianjin–Hebei region includes Beijing and Tianjin municipalities and 11 prefecture-level cities in Hebei Province, which are Baoding, Langfang, Tangshan, Qinhuangdao, Shijiazhuang, Zhangjiakou, Chengde, Cangzhou, Handan, Xingtai and Hengshui. The Beijing–Tianjin–Hebei region shows an important strategic position in China’s social and economic development.

2.2. Data Sources

The agrochemical input data were retrieved from the China Agricultural Statistical Yearbook 2011–2022.

The questionnaire survey of farmers in the Beijing–Tianjin–Hebei region was carried out from October 2019 to June 2020 to deeply clarify the agrochemical application methods and influencing factors. The content of the questionnaire mainly included the essential characteristics of farmers (gender, age, education, planting years, etc.), family resources (income, economic sources, acres of planting, types of crops, etc.), input behavior (use types, determination methods for dosage, application methods, technical guidance, etc.), farmers’ environmental cognitive characteristics, influencing factors of input behavior, etc.

In order to ensure the pertinence of the questionnaire design and the practicality of the survey results, a pre-survey was carried out to check whether there were problems in the questionnaire design and whether the survey’s purpose could be achieved, in order to enhance the scientific nature of the questionnaire and the effectiveness of the survey results. According to the problems found in the pre-investigation, the questionnaire was revised and supplemented before the formal investigation. In the field investigation, the dominant producing areas with relatively concentrated planting industries were selected for analysis. If the input behavior in agricultural production in a region was fairly consistent, 1~2 households were selected as representative households; if there was a big difference, the number of questionnaire samples was increased reasonably. The field survey area covered cereal, vegetable and fruit crops. A total of 500 questionnaires were distributed, and 477 questionnaires were recovered, with a recovery rate of 95.4%. Among them, 157, 145 and 175 questionnaires were collected in Beijing, Tianjin and Hebei, respectively.

2.3. Research Methodology

2.3.1. Probit Model Introduction

This study is based on the theory of rational small-scale farmers’ behavior [26], which is the basis of studying farmers’ adoption of cleaner agricultural production technology. It is considered that farmers aim to maximize their benefits and adopt certain technologies rationally. That is, under the given resource constraints, rational farmers pursue maximizing their profits, and the decision making of cleaner production behavior mainly depends on their dynamic comparison of the cost–benefit of this behavior. This study investigated farmers’ adoption behavior of cleaner production technology and provided a basis for green agricultural production in the Beijing–Tianjin–Hebei region.

Based on the above setting, the decision-making behavior of farmers’ cleaner production technology was analyzed. A simultaneous bi-variable Probit model was established, which satisfied the following assumptions: first, there was a correlation between the random disturbance terms of the equations, so it was necessary to estimate the equations in
Second, there were two result variables in the model. The model was set as follows:

\begin{equation}
\begin{aligned}
y_1^* &= b_1 + \beta_1 X_1 + \epsilon_1 \\
y_2^* &= b_2 + \beta_2 X_2 + \epsilon_2 \\
E(\epsilon_1) &= E(\epsilon_2) = 0 \\
var(\epsilon_1) &= var(\epsilon_2) = 1 \\
cov(\epsilon_1, \epsilon_2) &= \rho 
\end{aligned}
\end{equation}

where \(y_1^*\) and \(y_2^*\) are unobservable latent variables, which are expressed as whether one is willing to rationally adjust the use of chemical fertilizer, pesticide and agricultural film and whether one is eager to participate in the activities of reducing the amount and increasing the efficiency of agrochemicals; \(X_1\) and \(X_2\) represent the factors that affect the willingness of farmers to make these two decisions; \(b_1, b_2, \beta_1, \beta_2\) are the corresponding estimation coefficients; perturbation terms \(\epsilon_1\) and \(\epsilon_2\) obey the two-dimensional joint normal distribution, the expected values of the two equations \(E(\epsilon_1)\) and \(E(\epsilon_2)\) are both 0, the variance values of the two equations \(var(\epsilon_1)\) and \(var(\epsilon_2)\) are 1 and the correlation coefficient is \(\rho\).

\[\begin{pmatrix} \epsilon_1 \\ \epsilon_2 \end{pmatrix} \sim N\left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right) \]

\(\rho\) is the correlation coefficient of \(\epsilon_1\) and \(\epsilon_2\). If \(\rho\) is significant, and \(\rho = 0\), \(\epsilon_1\) and \(\epsilon_2\) are uncorrelated, that is, the two equations in the model can be estimated separately, and the results of separate estimation and simultaneous estimation are entirely consistent. If \(\rho \neq 0\), then the two equations in the model need to be estimated at the same time, where \(\rho > 0\), \(y_1^*\) and \(y_2^*\) show complementary effect and \(\rho < 0\), \(y_1^*\) and \(y_2^*\) present a substitution effect.

\(y_1^*\) and \(y_2^*\) are the result variables of the model. If \(y_1^* > 0\), it shows that farmers are willing to rationally adjust the number of agrochemicals, that is, \(y_1 = 1\); otherwise, \(y_1 = 0\). If \(y_2^* > 0\), it shows that farmers are willing to participate in reducing the amount and increasing the efficiency of agrochemicals, that is, \(y_2 = 1\); otherwise, \(y_2 = 0\). This is determined by the following equation:

\[y_1 = \begin{cases} 
1 & \text{if } y_1^* > 0 \\
0 & \text{if } y_1^* \leq 0 
\end{cases}\]

\[y_2 = \begin{cases} 
1 & \text{if } y_2^* > 0 \\
0 & \text{if } y_2^* \leq 0 
\end{cases}\]

The explanatory variable of this model is farmers’ willingness to participate in cleaner production. The explanatory variable is divided into four categories: farmers’ characteristic variables, production input variables, environmental cognitive variables and technical cognitive variables.

2.3.2. Variable Description

The influencing factors and research variables of cleaner production behavior are summarized as follows: farmers’ characteristics (gender, age, family income, etc.), agrochemical inputs (fertilizer input, pesticide input, agricultural film input), environmental awareness (environmental impact cognition, risk preference) and technical cognition (technical training, policy understanding, etc.). Table 1 shows variable settings and assignments.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you willing to rationally adjust the use of chemical fertilizers,</td>
<td>Unwilling = 0, willing = 1</td>
</tr>
<tr>
<td>pesticides and agricultural films?</td>
<td></td>
</tr>
<tr>
<td>Are you willing to participate in the activities of reducing the amount</td>
<td>Unwilling = 0, willing = 1</td>
</tr>
<tr>
<td>and increasing efficiency?</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>30 years old and below = 1, 31–40 years old = 2, 41–50 years old = 3, 51–60 years old = 4, 61 years old and above = 5</td>
</tr>
<tr>
<td>Education level</td>
<td>Junior middle school and below = 1, senior middle school = 2, associate or bachelor’s degree = 3, master’s degree and above = 4</td>
</tr>
<tr>
<td>Planting years</td>
<td>5 years and below = 1, 6–10 years = 2, 11–20 years = 3, 21–30 years = 4, 31 years and above = 5</td>
</tr>
<tr>
<td>Identity category</td>
<td>Small-holder farmers = 1, large planting households = 2, agricultural cooperatives = 3</td>
</tr>
<tr>
<td>Types of work</td>
<td>Full-time agriculture = 1, part-time agriculture = 2, non-agricultural work = 3</td>
</tr>
<tr>
<td>Household income</td>
<td>CNY 50,000 and below = 1, CNY 50,000–100,000 = 2, CNY 100,000–150,000 = 3, CNY 150,001 and above = 4</td>
</tr>
<tr>
<td>Cultivated land area</td>
<td>0.2 ha and below = 1, 0.2–0.3 ha = 2, 0.3–0.6 ha = 3, 0.6–1.0 ha = 4, 1.0 ha and above = 5</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>CNY 500 and below = 1, CNY 501–1000 = 2, CNY 1001–2000 = 3, CNY 2001–3000 = 4, CNY 3001–4000 = 5, CNY 4000 and above = 6</td>
</tr>
<tr>
<td>Pesticide cost</td>
<td>CNY 200 and below = 1, CNY 201–400 = 2, CNY 401–600 = 3, CNY 601–800 = 4, CNY 801–1000 = 5, CNY 1001 and above = 6</td>
</tr>
<tr>
<td>Agricultural film cost</td>
<td>CNY 0 = 1, CNY 1–1000 = 2, CNY 1001–2000 = 3, CNY 2001–3000 = 4, CNY 3001 and above = 5</td>
</tr>
<tr>
<td>Is the amount of fertilizer used clear?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Is there overuse?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Do you pay attention to agricultural film pollution?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>What is the severity of pollution?</td>
<td>Not serious = 1, average = 2, serious = 3, very serious = 4</td>
</tr>
<tr>
<td>Do you think saving is necessary?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Are you aware of the urgency?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Is there guidance before production?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Have you participated in training?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Do you receive subsidies?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Do you understand the zero growth action?</td>
<td>No = 0, yes = 1</td>
</tr>
<tr>
<td>Do you know the agricultural film recycling plan?</td>
<td>No = 0, yes = 1</td>
</tr>
</tbody>
</table>

1 CNY 100 = USD 14.33.

2.3.3. Model Building

Given that the bi-variable Probit model allows correlation between error terms of different equations, it was used to explore whether farmers are willing to adopt cleaner production technology and whether they are eager to participate in cleaner production behavior. The specific form is as follows.

\[ Y^* = P(Y_i = 1/X) = \Phi(BX_i) \]

In the formula, \( Y^* \) is the explained variable, \( X \) indicates the behavior decision of farmers’ cleaner production and \( X_i \) is an explanatory variable, indicating the influencing factors of farmers’ cleaner production behavior, including farmers’ characteristics, environmental cognition and other variables. \( P (Y_i = 1/X) \) is the probability that farmers adopt cleaner production behavior under given conditions; \( \Phi, B, X_i \) are the cumulative distribution function.
of standard state distribution, the parameter vector to be estimated and the ith observation sample, respectively.

2.3.4. Model Running

To ensure the validity of the regression results, the multicollinearity of the independent variables is tested first. The results showed that the variance expansion factor (VIF) is less than 10 and the tolerance is more significant than 0.1, indicating no multicollinearity of the independent variables. Using the Stata statistical software, the bi-variable Probit model was used to estimate the influencing factors of farmers’ willingness to adopt cleaner production behavior.

3. Results

3.1. Agrochemical Input

3.1.1. Total Quantity of Agrochemical Input

The application rate of chemical fertilizers (net nutrient, N, P₂O₅, K₂O and compound fertilizer) showed an increasing trend year by year before 2014 and then decreased after 2015 in Beijing, Tianjin and Hebei (Figure 1). The statistical data showed that the total rate of chemical fertilizer use in the year of 2014 was 3.71 million tons, and it decreased to 2.99 million tons in the year 2021, reduced by 7200 tons (19.3%).

Figure 1. Fertilizer application in Beijing–Tianjin–Hebei from 2010–2021.

The pesticide usage in Beijing and Tianjin was basically the same, maintained at 1997–3972 tons, and showing a certain downward trend from 2010–2020. The pesticide usage in Hebei Province was 84,615 tons in 2010, with a slight upward trend from 2011 to 2013, reaching 86,720 tons. Afterwards, it slowly decreased to 54,289 tons in 2020. The total change in pesticide use in Beijing, Tianjin and Hebei gradually decreased from 92,308 tons in 2010 to 58,435 tons in 2020.

The use of agricultural film in Beijing has decreased year by year from 13,539 tons in 2010 to 7562 tons in 2020, a decrease of 5977 tons (44.2%). The use of agricultural film in Tianjin gradually decreased from 12,009 tons in 2010 to 7521 tons in 2020, with a decrease of 37.4%. The use of agricultural film in Hebei Province showed a trend of increasing year by year before 2016, from 118,619 tons in 2010 to 138,434 tons in 2016, and then it decreased to 103,742 tons in 2020. The trend of total usage of agricultural film in Beijing–Tianjin–Hebei showed an initial increase followed by a decrease. The total usage increased from 144,167 tons in 2010 to 161,263 tons in 2013 and then showed a downward trend, reaching 118,825 tons in 2020.

The above results showed that the agrochemical input in Beijing–Tianjin–Hebei was high and may cause accumulation of pollution in the environment. It is necessary to reduce the applied amount reasonably.
3.1.2. Application Intensity of Agrochemical Input

The fertilizer application intensity (amount of application per unit area) in Beijing and Tianjin was significantly higher than the national average (323.4 kg/ha) from 2010–2021, while the fertilization intensity in Hebei Province was close to the national average before 2017 and later higher than the national average (Figure 2). Since 2010, the average fertilizer application intensity in Beijing–Tianjin–Hebei has ranged from 339.7 to 370.2 kg/ha, with an average of 350.9 kg/ha, indicating a higher application intensity.

![Fertilizer application intensity in Beijing–Tianjin–Hebei and China.](image)

Since 2010, the intensity of pesticide use in Beijing has been increasing year by year, from 10.4 kg/ha in 2010 to 18.2 kg/ha in 2020, an increase of 7.9 kg/ha (75.5%). The intensity of pesticide use in Tianjin was relatively low, ranging from 4.6 to 7.6 kg/ha, showing a decreasing trend year by year. The intensity of pesticide use in Hebei Province remained between 6.7 and 8.8 kg/ha. The average pesticide use intensity in Beijing–Tianjin–Hebei was basically equivalent to that in Hebei Province. The intensity of pesticide use in China has shown a decreasing trend year by year, from a peak of 10.3 kg/ha in 2012 to 7.8 kg/ha in 2020. Compared with the national pesticide use intensity, the pesticide use intensity in Beijing was far higher than the national average, and the difference between the two increased. The intensity of pesticide use in Hebei Province and Tianjin was below the national average level.

From 2010 to 2012, the annual use of agricultural plastic film per unit area in Beijing decreased from 204.7 kg/ha to 170.4 kg/ha, a decrease of 16.8%. The downward trend was obvious, followed by a fluctuating upward trend. By 2018, the use of plastic film per unit area reached 204.7 kg/ha, which was the same as in 2010. From 2019 to 2020, the agricultural plastic film per unit area showed a decreasing trend and dropped to 182.1 kg/ha in 2020. The intensity of plastic film use in Beijing was much higher than that in Tianjin and Hebei and higher than the national average. The intensity of plastic film use in Tianjin and Hebei was below the national average level.

The above results showed that the application intensity of agrochemical input in Beijing–Tianjin–Hebei was high, and it is necessary to conduct agrochemical investigations to make the farmers' behavior clear and scientifically applicable.

3.2. Farmers' Behavior of Agrochemical Input

3.2.1. Different Kinds of Fertilizer Input

The main fertilizer types selected by farmers were compound fertilizer (Figure 3), accounting for 72.0% of the total investigated, followed by urea, accounting for 61.7% of the total survey. Nearly half of farmers applied organic fertilizer, accounting for 49.7% of the
total investigated. The fourth was water-soluble fertilizer, accounting for 25.7% of the total investigated. Phosphate fertilizer, potassium fertilizer and medium and trace elements were also used, accounting for 16.1%, 23.4% and 10.7%, respectively. Most farmers applied more than two kinds of fertilizers.

![Figure 3. Distribution of kinds of fertilizer applied by surveyed farmers.](image)

Specifically, the proportion of surveyed farmers in Hebei Province applying compound fertilizers (28.8%) was higher than that in Tianjin (23.1%) and Beijing (20.1%), accounting for nearly one-third of the total surveyed farmers. The proportions of surveyed farmers in Tianjin and Hebei Province using urea were higher than that in Beijing, while the proportion of farmers in Beijing applying organic fertilizer was higher than in Tianjin and Hebei Province. It was noted that farmers in Tianjin usually applied water-soluble fertilizer, with a higher proportion than Beijing and Hebei Province.

3.2.2. Fertilizer Application Method

The fertilization method of the surveyed farmers was mainly surface spraying, accounting for 50.6% of the total surveys (Figure 4); the second was deep construction with soil covering and water-soluble post-pouring, accounting for 45.0% and 42.5% of the total investigated, respectively. Ditch application and hole application accounted for 26.6% and 19.0%, respectively. It is worth noting that farmers have adopted water and fertilizer integration measures, accounting for 18.8% of the total survey. The study also found that farmers’ fertilizer application methods were gradually diversified, and more than half of the surveyed farmers chose two or more methods of fertilizer application.

In detail, the main fertilizer application method in Hebei Province was surface spreading, which has a higher proportion than deep construction with soil covering and water-soluble post-pouring. Meanwhile, in Tianjin, the most common fertilizer application method was water-soluble post-pouring, accounting for 21.4% of the surveyed farmers. The main fertilizer application methods in Beijing were deep construction with soil covering, surface spreading and water-soluble post-pouring, with a relatively low proportion.
3.2.2. Fertilizer Application Method

The fertilization methods used by farmers showed significant differences among the three regions. In Hebei Province, the most common method was surface spreading, which accounted for 45.0% of the total surveyed farmers. Deep construction with soil covering and water-soluble post-pouring were also popular, with proportions of 42.5% and 41.4%, respectively. In Tianjin, surface spreading was the most widely used method, with a proportion of 49.2%. Ditch application and hole application were less common, with proportions of 8.8% and 7.3%, respectively. In Beijing, the most common method was surface spreading, followed by deep construction with soil covering and water-soluble post-pouring, with proportions of 13.2%, 16.6%, and 21.4%, respectively.

3.2.3. Agrochemical Use Determination

As for the basis of determination for chemical fertilizer, pesticide and agricultural film application, it was found that the applied amount of agrochemicals by farmers mostly came from agrarian sellers, accounting for 55.5% (Figure 5). Secondly, it came entirely from experience, accounting for 50.3%. The third was mutual consultation between relatives and friends, accounting for 37.4%. The proportion of guidance from technical departments was 29.8%, which was less than 1/3 of the total number of investigations. Only 14.3% of farmers used agrochemicals according to the policies of administrative departments. The rest obtained information from radio, television or through other channels. It was found that farmers adopted various ways to communicate and determine the appropriate input amount before applying, which indicated that farmers’ concept of rational fertilization had gradually improved.

The amount of agrochemicals applied by farmers in Hebei Province mostly came from agrarian sellers, followed by completely based on experience and relatives and friends, which was similar to Tianjin. Meanwhile, in Beijing, the applied amount of agrochemicals by farmers mainly came from experience, followed by the guidance from technical departments, of which the proportion was higher than that of Tianjin and Hebei.
Of the investigated farmers, 51.7% said they had not received guidance from relevant technical departments, indicating the coverage of technical advice needs to be further expanded; 79.2% of the farmers were worried that the production would decline with a reduction in agrochemicals, indicating that the surveyed farmers still have significant concerns about the yield and income.

### 3.2.4. Treatment of Pesticide Packaging Waste

As for how to deal with the pesticide packaging materials, the survey results showed that 49.2% of the farmers threw them in special garbage dumps or recycling points, 32.9% of the farmers piled up the pesticide packaging materials and other garbage together and nearly one-third of the farmers threw them directly on the edge of the field or water (Figure 6). It was also found that 24.8% of farmers chose more than two treatment methods.

![Figure 6. Treatment of pesticide packaging waste of surveyed farmers.](image)

Specifically, the surveyed farmers in Hebei Province discarded the pesticide packaging waste mainly at the edge of fields or water, while in Beijing and Tianjin, they mainly threw them in special garbage dumps or recycling points.

### 3.2.5. Disposal of the Agricultural Film

According to the survey, 50.6% of the farmers sold the used agricultural film as waste products, followed by discarding it directly on farmland (accounting for 1/3 of the total surveyed farmers) (Figure 7); 19.9% of farmers reused it, 7.8% of farmers burned it and 23.0% of farmers used it for other purposes. Further investigation showed that less than one-third of farmers confirmed that agricultural film was recycled by a specially assigned person after use, and 66.4% of farmers indicated that there was no specially assigned person to recycle it.
pesticides and agricultural films, the statistical results showed that 73.6% of the farmers
protection policies, farmers' awareness of agricultural environmental protection has been
production caused severe or very serious pollution. Up to 85.7% of farmers were aware of
plastic film. In addition, 67.3% of farmers said they were not sure about the mechanized
farmers were concerned about the pollution caused by agricultural film, and pointed
fertilizers, pesticides or agricultural films, indicating that more than half of farmers
environmental pollution, while 11.0% of farmers were not aware of this issue.

3.2.5. Disposal of the Agricultural Film
According to the questionnaires collected, 62.6% of farmers reported excessive use of
film on the farmland, followed by selling it as waste. Meanwhile, in Beijing and Tianjin,
surveyed farmers usually mainly sold it as waste.

3.2.6. Application of Cleaner Agricultural Production Technology
Of the farmers, 58.6% indicated they had used biological pest control technologies,
such as bacteria, natural enemies, yellow boards, insecticidal lamps and other prevention
and control materials and equipment; 49.0% of surveyed farmers said they were not aware
of degradable plastic film, and 92.6% of surveyed farmers said they did not use degradable
plastic film. In addition, 67.3% of farmers said they were not sure about the mechanized
recycling of plastic film.

3.3. Farmers' Environmental Cognition
From the questionnaires collected, 62.6% of farmers reported excessive use of fertilizers,
pesticides or agricultural films, indicating that more than half of farmers have realized
that agricultural chemicals exceed reasonable quantities; 72.9% of farmers were concerned
about the pollution caused by agricultural film, and pointed out that in recent years, due
to the increasing use of black plastic films, “black pollution” has become more and more
serious. Among the surveyed farmers, 75.6% of farmers reported that pesticides could cause
environmental pollution, 64.9% stated that agricultural films could cause environmental
pollution and 60.2% thought that chemical fertilizers could cause environmental pollution.
In addition, 5.6% of farmers thought that chemical fertilizers, pesticides and agricultural
films would not cause environmental pollution, while 11.0% of farmers were not aware of
this issue.

The results also showed that 64.2% of farmers believed that the pollution caused by
the extensive use of chemical fertilizers, pesticides and agricultural films in agricultural
production caused severe or very serious pollution. Up to 85.7% of farmers were aware of
the urgency of rational use of agrochemicals. The above results showed that with the popularization of knowledge, technology and the promotion of agricultural and environmental
protection policies, farmers' awareness of agricultural environmental protection has been
gradually enhanced, and their awareness of the rational use of agricultural chemicals is
becoming getting higher and higher.

3.4. Influencing Factors of Farmers' Behavior toward Agrochemical Input
As for the reasons why farmers use more agrochemicals such as chemical fertilizers,
pesticides and agricultural films, the statistical results showed that 73.6% of the farmers
interviewed hope to obtain higher profits, 54.8% of the farmers only focused on the yield and neglected the environmental protection, 53.5% of the farmers lacked professional technical guidance, relying solely on experience, and 22.4% of the farmers indicated that the government did not pay enough attention to environmental issues (Figure 8). Of the farmers, 63.5% gave at least two factors that made them willing to apply a large number of agrochemicals.

![Figure 8. Reasons for farmers to use agrochemicals in large quantities.](image)

Specifically, the first influencing factor for farmers’ behavior towards agrochemical input in Beijing, Tianjin and Hebei Province was the pursuit of high yield and high profit, accounting for 24.9%, 22.6% and 26.0%, respectively. The second influencing factor in Hebei Province was the lack of professional technical guidance and application based solely on experience, accounting for 22.3%. Meanwhile, in Beijing and Tianjin, the second influencing factor was that farmers only focused on the yield and neglected environmental protection, followed by application based on experience.

Of the surveyed farmers, 30.6% stated that if the prices of agricultural products such as corn, wheat and vegetables rose, they would increase the use of chemical fertilizers, pesticides and agricultural films, while 40.9% of the surveyed farmers declared that there was variability between them. On the contrary, 42.3% of farmers said that if the prices of agricultural materials such as chemical fertilizers, pesticides and agricultural films rose, they would not increase the input of agrochemicals. However, 16.6% of farmers stated that they would still increase the input of agrochemicals despite the rising price of agricultural materials.

Regarding whether household income affects agricultural input, 62.2% of the farmers interviewed stated that there was no close relationship between household income and agricultural input, while 23.0% of the farmers said that the higher the household income, the more agrarian input; 14.8% of the farmers stated that the higher the household income, the less attention they paid to agricultural production. Due to the relatively low farmland income, the investment in agricultural chemicals would be expected to decrease.

As for the impact of farmland irrigation facilities on the agrochemical input, 44.3% of farmers believed that good farmland irrigation facilities would reduce the agrochemical input, while 16.6% of farmers declared that it would increase the agrochemical input and 39.1% of farmers stated that they had no impact.

As for whether the propaganda of government management departments on agricultural pollution and environmental protection could have an impact on the use of agrochemicals, 71.6% of farmers said it was effective and 77.0% of farmers stated that the guidance from agricultural technology departments would affect the application of agrochemicals. The above results indicated that the propaganda of government management departments
and the guidance from agricultural technology departments would have a significant positive effect on farmers’ agrochemical input.

Regarding whether they have participated in technical training on crop fertilization, pesticide application and agricultural film use, the same proportion of interviewed farmers answered “yes” and “no” and 87.9% of the farmers indicated that they have technical need for the rational use of chemical fertilizers, pesticides and agricultural films. Due to the limited access to agricultural production information, 59.5% of farmers said that they had not received any publicity on the recyclability of agricultural film, and 68.9% and 78.1% of farmers stated that they were not fully aware of the “Zero Growth Action of Chemical Fertilizer and Pesticide” and “Agricultural Film Recycling Action”.

As for the influence of government subsidies on agrochemical input, 93.1% of farmers thought that if the government provided a certain amount of cash or in-kind subsidies, they would be willing to reduce the number of agrochemicals applied and keep them at a reasonable level.

Farmers stated that the methods for rational application of agrochemicals mainly included strengthening farmers’ training, field guidance, technical departments recommending specific dosages, publicizing rational use and other ways, accounting for 76.3%, 71.4%, 62.0%, 60.0% and 7.6% of the interviewed farmers, respectively.

3.5. Influencing Factors of Farmers’ Willingness to Adopt Cleaner Production

The bi-variable Probit model was used to estimate the influencing factors of farmers’ willingness to rationally adjust the use of chemical fertilizers, pesticides and agricultural films, as well as their willingness to participate in the activities of reducing their amount and increasing their efficiency. The results were as follows (Table 2).

Table 2. Estimation results of Probit model on farmers’ cleaner production willingness.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Are You Willing to Rationally Adjust the Use of Chemical Fertilizers, Pesticides and Agricultural Films</th>
<th>Are You Willing to Participate in the Activities of Reducing Amount and Increasing Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>−0.546 ** 1</td>
<td>−1.013 *** 2</td>
</tr>
<tr>
<td>Education level</td>
<td>−0.162</td>
<td>0.434</td>
</tr>
<tr>
<td>Planting years</td>
<td>−0.455 * 3</td>
<td>−0.418 *</td>
</tr>
<tr>
<td>Identity category</td>
<td>0.636</td>
<td>−0.44</td>
</tr>
<tr>
<td>Types of work</td>
<td>−1.172 ***</td>
<td>−0.362</td>
</tr>
<tr>
<td>Household income</td>
<td>−0.326</td>
<td>−0.158</td>
</tr>
<tr>
<td>Cultivated land area</td>
<td>0.057</td>
<td>0.076</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>−0.268</td>
<td>−0.137</td>
</tr>
<tr>
<td>Pesticide cost</td>
<td>−0.041</td>
<td>0.132</td>
</tr>
<tr>
<td>Agricultural film cost</td>
<td>−0.215</td>
<td>−0.301</td>
</tr>
<tr>
<td>Is the amount of fertilizer used clear?</td>
<td>0.014</td>
<td>0.206</td>
</tr>
<tr>
<td>Is there an overuse problem?</td>
<td>1.272 **</td>
<td>0.858 **</td>
</tr>
<tr>
<td>Are you concerned about white pollution?</td>
<td>0.315</td>
<td>0.344</td>
</tr>
<tr>
<td>What is the severity of pollution?</td>
<td>0.739 **</td>
<td>0.419 *</td>
</tr>
<tr>
<td>Do you think saving is necessary?</td>
<td>0.759</td>
<td>1.260 **</td>
</tr>
<tr>
<td>Are you aware of the urgency?</td>
<td>1.615 ***</td>
<td>0.363</td>
</tr>
<tr>
<td>Is there guidance before production?</td>
<td>1.602 **</td>
<td>1.498 **</td>
</tr>
<tr>
<td>Have you participated in training?</td>
<td>−0.079</td>
<td>1.196 **</td>
</tr>
<tr>
<td>Do you receive subsidies?</td>
<td>−0.270</td>
<td>−0.389</td>
</tr>
<tr>
<td>Do you understand the zero growth action?</td>
<td>0.028</td>
<td>−0.354</td>
</tr>
<tr>
<td>Do you know the agricultural film recycling plan?</td>
<td>0.264</td>
<td>0.915</td>
</tr>
<tr>
<td>Constant</td>
<td>4.101 **</td>
<td>0.038</td>
</tr>
<tr>
<td>Number</td>
<td>413</td>
<td>413</td>
</tr>
<tr>
<td>Prob &gt; Chi 2</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>−68.251</td>
<td>−73.951</td>
</tr>
</tbody>
</table>

1 ** indicates significance at the 5% level. 2 *** indicates significance at the 1% level. 3 * indicates significance at the 10% level.
3.5.1. Age

It can be seen from Table 2 that age had a significant negative impact on farmers’ decisions to adopt cleaner production technologies. The older farmers are, the less likely they are to adopt cleaner production technologies. The main reason may be that these environment-friendly measures, such as soil testing and formula fertilization, biological control, etc., have high technical content. Young farmers have a strong learning ability and can master new technologies quickly, while older farmers have a low ability to accept new things. They prefer to adopt the traditional agricultural production methods with high input and high output.

3.5.2. Years of Planting

Planting years significantly negatively affected farmers’ decision making on cleaner production technology adoption. That is, the longer farmers plant, the less willing they are to adopt cleaner production technology. The main reason may be related to age. The longer the planting period, the older the farmers are. The production habits make farmers unwilling to make changes and their acceptance of new technologies was also low.

3.5.3. Types of Work

The types of work significantly negatively affected farmers’ willingness to reduce fertilizer, pesticide and agricultural film input, but had no significant impact on whether they were willing to participate in activities to reduce application and increase efficiency. That is, full-time farmers engaged in agricultural production were more inclined to reasonably reduce the use of chemical fertilizers, pesticides and agricultural films when ensuring crop yield. This is mainly because farmers who were engaged in agricultural production paid more attention to reducing production costs, while farmers who were engaged in non-agricultural production had higher income and paid less attention to agricultural production costs.

3.5.4. Viewpoint of Excessive Use of Agrochemicals

This variable had a significant positive impact on farmers’ decisions to adopt cleaner production technologies. It was believed that farmers who overused chemical fertilizers, pesticides and agricultural film were more willing to adopt cleaner production technologies and participate in reducing application and improving efficiency.

3.5.5. Cognition of the Pollution Degree

Cognition of the pollution degree significantly positively affected farmers’ decision making on cleaner production technology adoption. That is, the more serious the pollution caused by the extensive use of agrochemicals, the more willing they are to participate in reducing application and increasing efficiency. The higher farmers’ awareness of excessive use of agrochemicals, the more inclined they are to adopt cleaner production technology.

3.5.6. Urgency of Saving and Rational Use of Agrochemicals

This variable showed a significant positive impact on farmers’ decision-making to adopt cleaner production technology, but had no significant effect on their willingness to participate in activities of reducing application and increasing efficiency. That is, farmers believed that the more urgent the situation of saving and rational use of agrochemicals, the more inclined they are to adopt cleaner agricultural production technology.

3.5.7. Pre-Production Technical Guidance

Pre-production technical guidance had a significant positive impact on farmers’ decision making on cleaner production behavior. The reason may be that pre-production technical guidance is beneficial for enhancing farmers’ awareness of environmental protection and guiding farmers to adopt environment-friendly technology.
3.5.8. Technical Training

Technical training had a significant positive impact on farmers’ willingness to participate in activities of reducing application and increasing efficiency but had no significant effect on the decision to adopt cleaner production technologies. It was to some extent indicated that farmers who participated in technical training have improved their awareness of environmental protection and were willing to participate in activities to reduce application and improve efficiency, while the pertinence of specialized training needs to be further enhanced to make farmers really willing to adopt cleaner production technologies.

4. Discussion

4.1. Positive Effects Resulting from Reducing Agrochemical Inputs

The results in this study indicated that the applied amount of agrochemical input was high in Beijing–Tianjin–Hebei, which was serious and may be a risk to the environment. It is necessary to reasonably reduce the number of applications. Reducing agrochemical inputs not only has a positive effect on environmental protection and green agricultural development, but also reduces the cost of inputs and promotes the maximization of agricultural production benefits. Geng et al. [27] put forward that reducing chemical fertilization in agroecosystems without influencing the vegetable yield was a proficient method for sustainable agriculture and environmental safety. A six-year experiment was conducted in Ningxia, China, to assess the effects of reduced fertilization on yield, nitrogen use efficiency (NUE), N leaching and the economic benefits. The results showed that reducing chemical fertilizer significantly improved the NUE, reduced N leaching (23.7%) and improved the N economic benefit (NEB, 41.8%) as compared to the conventional fertilizer. Guo et al. [28] found that when pesticides are reduced by 35–65%, it had no adverse effect on crop yields and thus had the potential to reduce the costs of pest control and produce the greatest economic benefit. Lechenet et al. [29] stated that the reduction of pesticide use was one of the critical drivers to preserve the environment and human health. Pesticide use could be reduced through the adoption of new production strategies. They analyzed the potential conflicts between pesticide use and productivity or profitability with data from 946 non-organic arable commercial farms and estimated that total pesticide use could be reduced by 42% without any negative effects on productivity or profitability in 59% of farms from a national network. This corresponded to an average reduction of 37%, 47% and 60% of herbicide, fungicide and insecticide use, respectively. It was demonstrated that pesticide reduction was already accessible to farmers in most production situations.

4.2. Strategies for Agrochemical Reduction and Efficiency Improvement

4.2.1. Improve the Scientific Level and Promote the Reduction and Efficiency

The results of this study showed that farmers mainly applied fertilizer by surface spreading. The amount of agrochemical input primarily came from agricultural sellers or entirely depended on experience. The proportion of recommendations from government publicity and guidance from agricultural technicians was relatively small, indicating that the scientific advice on agrochemical input needs to be further improved, which was consistent with the results of Cui et al. [21]. Scientific and reasonable application will promote the efficient use of resources, thereby reducing the environmental risks caused by excessive consumption, ensuring the quality and safety of agricultural products and further promoting the sustainable development of agriculture. In our investigation, farmers in Hebei Province in particular usually applied the fertilizer by surface spreading, with a higher proportion than other application methods. The amount of agrochemical application by farmers in Hebei Province mostly came from agrarian sellers, followed by application fully based on experience and relatives and friends. The intensity of pesticide use in Beijing has been increasing year by year, from 10.39 kg/ha in 2010 to 18.24 kg/ha in 2020. So, it is urgent to improve the scientific application level of agrochemicals. The following technologies and measures could be taken to elevate the level of scientific input. First, according to the basic parameters such as soil nutrients, crop demand, fertilizer use
efficiency, etc., fertilization schemes and scientific fertilization methods should be scientifically formulated and publicly published for different regions, different soil types and different crops, so as to save fertilizer, improve efficiency and promote precision fertilization technology [30]. Second, timely monitoring and early warning of pests and diseases should be used, and green prevention and control technology should be strengthened. Third, the quality supervision of standard agricultural film should be strengthened, plastic film mulching technology should be improved, agricultural film should be used reasonably and appropriately and degradable agricultural film should be popularized. It was suggested that farmers should be guided to use agrochemicals scientifically from various aspects.

4.2.2. Improve Farmers’ Willingness to Participate in and Promote Emission Reduction

The results of this study showed that more than half of farmers were aware of the excessive agrochemicals, and the environmental pollution caused by overuse was taken seriously. They realized the seriousness of pollution and the urgency of saving reasonable investment. Consciousness determines action, and raising awareness will help prompt farmers to actively participate in the activity of reducing the quantity and increasing the efficiency. Farmers are the main body of agricultural production and the direct implementers of agrochemical input. The most important thing to reduce agrochemicals is the cooperation of farmers. Farmers play an essential role in agricultural production [31]. Therefore, prompting farmers to reduce chemical fertilizers, pesticides and agricultural films in agricultural production will have a positive impact on the agrochemical reduction. When guiding farmers to reduce the application of agrochemicals, farmers’ income should be ensured. Considering the improvement of agricultural products’ quality and agricultural ecological environment brought by the reduction of input, appropriate economic compensation or rewards can be given to farmers. It is suggested to provide preferential policies such as cash incentives, government interest subsidies, tax relief and project support to increase farmers’ willingness to participate in reducing the quantity and increasing the efficiency. Farmers should be encouraged to reasonably reduce agrochemical input and actively carry out cleaner agricultural production.

4.2.3. Strengthen the Publicity and Training of Agricultural Technology Departments

The results of this study showed that farmers were concerned about the yield production when reducing the agrochemical input. The usage of agrochemicals mostly came from agrarian sellers or was entirely based on experience. The proportion of agricultural chemicals used by farmers in Beijing under the guidance of technical departments was higher than that in Tianjin and Hebei, but the overall amount and intensity of fertilizer input were still relatively high. Moreover, the guidance from relevant technical departments still did not fully cover the use of agrochemicals. Pre-production technical consultation had a significant positive impact on farmers’ willingness to adopt cleaner production. Specialized technical training was helpful to improve farmers’ willingness to participate actively, and improving the pertinence of training played an important role in adopting cleaner production technology. Therefore, the propaganda and training should be strengthened to narrow the “one-kilometer gap” in agricultural technology knowledge. Agricultural technology management and extension departments should strengthen the training of farmers, popularize scientific fertilization knowledge, guide farmers to apply fertilizer reasonably, implement formula package fertilization and strengthen the management of precision fertilization according to the actual technical needs of farmers. In terms of pesticide use management, the plant protection policy of “prevention first, comprehensive prevention and control” should be implemented, farmers’ awareness of pesticide use should be improved through training and farmers should be helped to learn to use pesticides correctly. At the same time, it is necessary to strengthen the prediction of the occurrence of major pests, as well as the research, development and application of green prevention and control technologies, to ensure that agricultural producers and operators can prescribe the right pesticide timely and accurately. In the use of agricultural film, it is necessary to guide
and train on proper use, uncover the film in a timely manner, strengthen the application demonstration and widespread science propaganda of degradable agricultural film and improve the acceptance of degradable agricultural film.

In addition, the management and training of agricultural distributors should be strengthened. It seems that there is a conflict of interest between distributors and farmers’ benefits. Agrochemical distributors tend to increase the recommended amount to ensure profitability, leading to farmers overusing agrochemicals. However, some studies in recent years showed that agricultural distributors are the most direct service providers and technical instructors when farmers purchase agricultural chemicals and play a specific guiding role [32]. The sources of fertilizer application technology information for distributors mainly include three aspects: fertilizer production enterprises, their own experience and knowledge or product descriptions. Fertilizer production enterprises mainly transmit fertilizer technology information to retailers through training, product promotion meetings and other channels. Participating in agricultural technology training can help reduce distributors’ recommended fertilizer application rates for farmers. Agricultural technology training can transmit new technologies, knowledge and concepts to distributors, enhance their environmental awareness and help distributors correctly play their role in transmitting information, making them recommend fertilizer application rates for farmers more scientifically. The government should strengthen training for distributors, including fertilizer application technology, new varieties of fertilizers, relevant policies and regulations, etc., to enhance the environmental awareness of agricultural material distributors, improve the overall quality of fertilizer distributors, fully leverage their information transmission role and more accurately and scientifically transmit fertilizer information to farmers. Another study also claimed that as the main target audience for fertilizer service product transactions, distributors occupy a core position in the social network of rural fertilizer purchases and are the source of most farmers’ access to fertilizer knowledge and technical support [33]. As an effective communicator in the fertilizer service market, agricultural material distributors can provide ideas for reducing fertilizer use. Agrochemical distributors with agricultural technology qualification certificates and providing technical services can significantly reduce the amount of fertilizer used by farmers. Agricultural distributors are primarily self-employed, with varying levels of professional agricultural knowledge. Most employees have insufficient understanding of agricultural production and do not provide scientific guidance to farmers on the use of chemical fertilizers, pesticides and films. Therefore, it is urgent to strengthen the management and technical training for such agricultural distributors, improve the quality of agricultural operators and promote green development of agriculture. It is also necessary to give full play to the guidance, publicity and popularization functions of industry associations and farmers’ unions, rapidly improve the overall level of the industry, strengthen the guidance and demonstration functions and gradually reduce the unscientific use of chemical fertilizers, pesticides and agricultural films.

5. Conclusions

(1) The fertilizer input by farmers in production mainly included compound fertilizer, urea and organic fertilizer, and the fertilization method was mainly surface spreading, accounting for 50.6% of the total surveys. The determination of the number of agrochemicals chiefly came from agricultural sellers, accounting for 55.5%. The proportion of farmers receiving guidance from technical departments in Beijing was 14.7%, higher than that of Tianjin and Hebei. The guidance from relevant technical departments still did not fully cover the use of agricultural chemicals.

(2) Increasing yield and profit and a lack of professional technical guidance were the main reasons for farmers’ unreasonable agrochemical investment. Specifically, the proportions of the first influencing factor in Beijing, Tianjin and Hebei Province to pursue high yield and high profit were 24.9%, 22.6% and 26.0%, respectively.
(3) Regarding pre-production technical guidance, farmers’ awareness significantly positively affected farmers’ willingness to adopt cleaner production. Technical training was helpful to improve farmers’ willingness to participate actively, and enhancing the pertinence of training played an important role in the adoption of cleaner production technology.

**Author Contributions:** Conceptualization, L.C., J.Z. (Jiang Zhao) and A.W.; methodology, L.C. and J.Z. (Jiang Zhao); validation, L.C., N.S. and J.Z. (Jingjuan Zhao); formal analysis, L.C. and J.Z. (Jiang Zhao); investigation, L.C. and H.Z.; data curation, L.C. and J.Z. (Jiang Zhao); writing—original draft preparation, L.C.; writing—review and editing, N.S. and A.W.; supervision, N.S. and J.Z. (Jingjuan Zhao); project administration, L.C. and J.Z. (Jingjuan Zhao). All authors have read and agreed to the published version of the manuscript.

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