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A Questionnaire Case Study of Opinions of Chinese Agricultural Workers on the Coordinated Control of Emissions of Ammonia

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Abstract: So far, China's particulate pollution control is principally focused on primary particles and sulfur dioxide from coal combustion. The contribution of ammonia emissions to particulate matter with an aerodynamic equivalent diameter of less than or equal to 2.5 microns (PM2.5) has been increasingly emphasized. As a world-famous agricultural country with 523 million farmers (2017, National Bureau of Statistics of China), approximately 70.0–90.0% of China's ammonia emissions come from agriculture. With such a huge population, agriculture industrialization (socioeconomic policies and technology upgrades to reduce ammonia emissions from fertilizers and livestock) has a large potential but is more vulnerable to costs compared to other industries. We need a solution involving both economic benefits and environmental protection. For this purpose, we sent out an anonymous questionnaire consisting of 16 questions to 420 farmers and conducted a field visit survey in a rural area of Jiangsu Province. Through statistical analysis, we found that the use of nitrogen fertilizers in agriculture, which are an important source of ammonia through volatilization, is normal (200/420 × 100% = 47.62% of farmers use such fertilizers). Among the 420 farmers surveyed, 90.71% of them have knowledge of air pollution from agricultural activities and 92.15% of them have certain understanding of agricultural industrialization policies, indicating that coordinated control of ammonia emissions can be achieved together with policy propaganda. Through factor analysis and correlation analysis, we find that the early propaganda of policies can help farmers to be more willing to accept the policies. The correlation coefficient between awareness of pollution and policy approval is 0.94, and that between policy publicity and policy approval is 0.95. Generally speaking, the promotion of policies is worth carrying out during the implementation process.

Keywords: particulate pollution; ammonia; agriculture; industrialization; emission reduction; factor analysis; correlation

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1. Introduction

Due to rapid industrialization and urbanization, China has suffered from high concentrations of particulate matter with an aerodynamic equivalent diameter of less than or equal to 2.5 microns (PM2.5) in recent years (Cai et al., 2017 [1]; Li et al., 2018 [2]; Zhu et al., 2018 [3]). Exposure to these fine particulate matters detrimentally affects human health,

causing problems from respiratory illnesses to cardiovascular diseases and premature death (Lelieveld et al., 2015 [4]; Zhang et al., 2017 [5]). Major chemical components of PM2.5 in China include sulfate, nitrate, ammonium, black carbon, organic carbon, and mineral dust. With the implementation of stringent air pollution control policies in China from 2013 to 2018, annual mean PM2.5 concentration in the Beijing–Tianjin–Hebei (BTH) region decreased by 49.1% (from 108 $\mu G/m^{-3}$ in 2013 to 55 $\mu G/m^{-3}$) in 2018 (Zhai et al., 2019 [6]), in which nitrate concentration, however, only decreased only by 22% (Zhai et al., 2019 [6]). The secondary formation of nitrate is closely related to ammonia in the atmosphere, indicating the importance of control of ammonia (NH_3) emissions.

NH_3 in the atmosphere is an important precursor of nitrate and hence of PM2.5. Wang et al. (2013) [7] used the Goddard Earth Observing System chemical transport (GEOS-Chem) model to simulate nitrate concentrations over SiChuan Basin for the year 2006 and found that nitrate concentration could be reduced by 30% if NH_3 emission was reduced by 17%. Cheng et al. (2018) [8], by using the Weather Research and Forecasting Model (WRF), found that the reduction in NH_3 emission in BTH by 30% (from 1.8 to 1.2 Mt) would reduce the annual mean concentration of nitrate in BTH in 2014 by 7.4 $\mu G/m^{-3}$. Ye et al. (2019) [9], using the Community Multiscale Air Quality (CMAQ) model, also reported that a reduction in NH_3 emissions in BTH by 23.3% would reduce nitrate concentration in BTH in 2015 by 17.9%.

Most of the NH_3 emissions in China come from agricultural activities. From 1978 to 2017, total NH_3 emission in China increased by 102% (form 6.1 Tg to 12.3 Tg) (Ma, 2020 [10]). Averaged over 1978 to 2017, NH_3 emissions from the agriculture, residential, industry, biomass burning, and transportation sectors were, respectively, 7.7, 0.6, 0.5, 0.4, and 0.1 Tg. In the agriculture sector, 66.2% of NH_3 emissions were from Cropland and 31.4% were from livestock (cow and pig farming) (Ma, 2020 [10]). The provinces of Henan, Hebei, Shanxi, Shandong, and Jiangsu were the regions with the highest NH_3 emissions in China (Deng et al., 2018 [11]).

To reduce NH_3 emissions, a number of measures have been proposed. Tang et al. (2019) [12] proposed improving fertilizer by replacing the conventional nitrogen by polyaspartic acid chelating nitrogen fertilizer (PASP-N), which would reduce the use of nitrogen fertilizer from 219.1 to 185.3 kg hm^{-2} on the basis of experiments at a site of the Chinese Academy of Agricultural Sciences. Such change was shown to not influence the yield of corn. Jiang et al. (2019) [13] found that the volatilization of nitrogen fertilizers occurs mainly within two weeks after fertilization, and new fertilizer formulations can be used to reduce emissions. The experiment was carried out at the Scientific Research and Experimental Base of Shenyang Agricultural University from May 12, 2017 to September 29, 2017. The NH_3 volatilization of the basic group was 18.6 kg hm^{-2}, and that of the test group (blending controlled-release nitrogen fertilizer with urea) was 5.0 kg hm^{-2}. Cao et al. (2018) [14] summarized the methods of reducing NH_3 emissions in animal husbandry, including low protein feeding (with percentage reduction in NH_3 emissions of 30%), phrase feeding (20–30%), feces and urine separation (50%), frequent manure removal (10–70%), filtering exhaust air, and air scrubbing techniques (70–90%), and improvement of storage facility (20.0–100%).

To ensure a high efficiency of NH_3 reductions, agricultural industrialization, a modern mode of operation and industrial organization, is called for in the future. Its impact on agriculture includes socioeconomic policies and technological trends (Rotz and Fraser, 2015 [15]). Technological trends mainly refers to the use of new and more efficient methods in agricultural production. For example, crop production is a major source of ammonia emissions. With the upgrade of technology, farmers can apply fertilizers in deep soil at a large scale, effectively inhibiting the volatilization of ammonia. If the farmers can follow the advice from the government or experts with respect to advanced technology, such emission control measure is called coordinated control of ammonia.

The main concern of this article is whether farmers will be willing to accept such changes if technologies spread to agriculture on a large scale. Farmers' attitudes towards

agricultural policies will affect the implementation of policies to a certain extent. In the survey, we focused on the following information: (1) current status of agricultural production methods; (2) respondents' knowledge of agricultural pollution; (3) respondents' understanding of agricultural industrialization policies; (4) respondents' views on current production technology upgrades.

2. Materials and Methods

2.1. Questionnaire Design

In order to obtain the feedbacks from the farmers about the agricultural industrialization for the purpose of the control of NH_3 emissions, we designed a questionnaire with the questions shown in Table 1. The questions were classified into four categories. In the first category, the questions obtain information of the surveyed group, mainly about gender (Q1), age (Q2), education level (Q3), production cost (Q4), and annual income (Q5). This information can help us analyze the different attitudes of people with different attributes to policies. In the second, third, fourth, and fifth categories, we designed questions to learn information about the current status of agricultural activities (Q6, Q7, Q8), respondents' knowledge of air pollution from agricultural practice (Q9, Q10, Q11), respondents' understanding of agricultural industrialization policies (Q12, Q13, Q14), and respondents' views on current production technology upgrades (Q15, Q16).

Table 1. Summary of the questions designed in the questionnaire. The options corresponding to the questions will be given in the subsequent analysis.

Information of the Surveyed Group	
Q1	Could you please tell us your gender?
Q2	Could you please tell us your age?
Q3	Could you please tell us about your education level?
Q4	How much do you spend each year on feed and fertilizer?
Q5	What is your current annual income?
Current Status of Agricultural Production Methods	
Q6	Could you tell us for what reasons you believe to be that it's the right time for using fertilizers?
Q7	Do you think applying fertilizer has an obvious effect on the crop yield?
Q8	What kind of fertilizers do you use in agriculture?
Respondents' Knowledge of Agricultural Pollution	
Q9	Do you think agriculture causes air pollution?
Q10	Have you ever heard about any news report on air pollution from agriculture before?
Q11	Do you often pay attention to the news and the latest information about agricultural industrialization?
Respondents' Understanding of Agricultural Industrialization Policies	
Q12	How much do you know about industrialization?
Q13	Does the local government or media publicize the industrialization of agriculture?
Q14	Do you often pay attention to the news and the latest information about agriculture industrialization?
Respondents' Views on Current Production Technology Upgrades	
Q15	What should be improved about the current approaches?
Q16	What do you do in non-farm hours and do you have free time to learn new production techniques?

We carried out the survey in Shanqian Village (118° E, 34° N) in Xinyi, Jiangsu Province, one of the provinces with the highest NH_3 emissions. Jiangsu Province has a long history of agriculture, and it has a strong enough economic foundation to provide

new technologies. We conducted the survey during 23–28 July 2018. The questionnaire surveyed 420 people in total.

2.2. Statistical Methods

Before a policy is implemented, it is usually necessary to evaluate its feasibility. We evaluate the feasibility of agricultural industrialization using the 16 questions described above. From each question, we can obtain relationships between agricultural policy and farmers. Among the 16 questions, we found key questions that represent the relationship between policy and farmers by using factor analysis (Xue, 2019 [16]) and then carried out correlation analysis to determine how these key questions are related to each other. Through correlation analysis, for example, we can clarify whether farmers will be more supportive of policies (Q11) that can reduce emissions after they have a better understanding of pollution (Q9).

To carry out factor analysis, we converted the answers to each question into scores. For example, for Q9, there are the options "A. It doesn't. It is environment-friendly and it doesn't pollute.", "B. Not really. Agriculture is based on plants and animals. It is unlikely to produce pollution.", "C. Sometimes, agriculture as a mode of production may produce some pollution.", "D. It is possible to produce some pollution.", and "E. Sure, people have a clear knowledge in this respect." The five options correspond to score values of 1–5, respectively.

We surveyed 420 farmers with the 16 questions. By converting the options into scores, we built an 18×420 matrix to represent the statistical data of the questionnaire. Each X_i is a column vector with a dimension of 420, which contains the scores of question i from 420 farmers. For example, X_4 contains the responses to Q9. Therefore, we have the following matrix:

$$X = (X_1, X_2, \cdots, X_p) \tag{1}$$

Among the 16 questions in the questionnaire, we needed to find the key questions that affect the relationship between policy and farmers. Factor analysis uses maximum likelihood estimation to evaluate the synergy changes between each column in the matrix X (Chen et al., 2019 [17]). Factor analysis was carried out by using the SPSS26 software (https://www.ibm.com/cn-zh/analytics/spss-statistics-software?lnk=hmhmmpr_bua_cnzh) (accessed on 11 February 2021), which ranks the importance of each question by factor scores. The 16 questions have their own factor scores after factor analysis, and the total of these factor scores is 1.0. The more important questions score higher. We selected the questions with the sum of factor scores exceeding 0.85. As a result, the most important questions are Q10 (with a factor score of 0.28), Q11 (0.24), Q9 (0.21), and Q13 (0.19). We will discuss these key questions in Section 3.

We also carried out correlation analysis to determine how these key questions are related to each other. The correlation between X_a and X_b was calculated by Xue (2019 [16])

$$r(X_a, X_b) = \frac{Cov(X_a, X_b)}{\sqrt{Var[X_a]Var[X_b]}} \tag{2}$$

where *Cov* is the covariance to measure the overall error of two variables, and *Var* (variance) was used to measure the degree of dispersion of random variables or a set of data. By determining the relationship between the policy and farmers by this approach, we can know the feasibility of a specific policy before implementation.

2.3. Information of Surveyed Group

To acquire the basic information of the surveyed people, we designed five questions. Through this basic information, we can describe the group characteristics of the interviewees and pave the way for the analysis of their attitudes.

Q1 is "Could you please tell us your gender?", corresponding to the choices: "A. Male" and "B. Female". We received feedback from 354 men (Table 2, 84.29%) and 67 women

(Table 2, 15.71%). From Table 2, we can see a higher percentage of men, which is also in line with the current status of heavy manual farming. Generally, men are stronger than women in terms of strength and endurance, and most of the farming is physically demanding.

Table 2. The numbers of males and females that responded to the survey (result of Q1 "Could you please tell us your gender?").

Gender	Number of Farmers	Proportion (%)
Male	354	84.29%
Female	66	15.71%

Q2 is "Could you please tell us your age?". The options we provided are: "A. 30 and under", "B. 31 to 40 years old", "C. 41 to 50 years old", and "D. 51 and above". The numbers and percentages of people in these age groups are 85 (20.24%), 193 (45.95%), 78 (18.57%), and 64 (15.24%), respectively (Table 3), indicating that farmers who are 31 to 40 years old account for the largest fraction of surveyed people.

Table 3. The numbers and percentages of people in different age groups (result of Q2 "Could you please tell us your age?").

Age	Number of Farmers	Proportion (%)
Age 30 and under	85	20.24%
31 to 40 years old	193	45.95%
41 to 50 years old	78	18.57%
Age 51 and above	64	15.24%

Q3 is "Could you please tell us about your education level?". The options we have provided are: "A. No certificate received", "B. Elementary school", "C. Junior high school", "D. High school", and "E. College education or above". The numbers (fractions) of people that selected these options were 131 (31.19%), 181 (43.10%), 50 (11.90%), 46 (10.95%), and 12 (2.86%) (Table 4), respectively. Most people chose "B. Elementary school" and "A. No certificate received". These results show that the education levels of farmers are generally not high. The agricultural activities do not require high modern knowledge and knowledge of sowing and breeding is usually accumulated through experience. However, with gradual modernization of agriculture, there is also a proportion of people who have received higher educations. The fraction of people with education levels of high school and higher was 25.71% (Table 4).

Table 4. Education levels of the respondents' results of Q3 "Could you please provide your education level?".

Education Level	Number of Farmers	Proportion (%)
No certificate received	131	31.19%
Elementary school	181	43.10%
Junior high school	50	11.90%
High school	46	10.95%
University degree or above	12	2.86%

Q4 is "How much do you spend each year on feed and fertilizer?", which is a fill-in-the-blank question. We used frequency statistics to represent the answers from the surveyed people. The amount of money spent per farmer is between CNY 500 and CNY 1000, and the median value is CNY 775 (Table 5, half of the farmers spend less than CNY 775 per year). In Figure 1, the gray histogram shows the number of surveyed farmers in the corresponding interval, and the blue solid line represents the cumulative frequency. There is a small peak at the cost level of CNY 500. The frequency was the highest when the

cost reached about 800 (Table 5, 13.81% in the interval of CNY 750 to CNY 800). Overall, more than 91.19% of people spend no more than CNY 925 per year (Table 5 and Figure 1). Farmers are very concerned about to the cost spent in production.

Table 5. Results of Q4 "How much do you spend each year on feed and fertilizer?". The cost includes the annual purchase of fertilizer, feed, and all other materials for agricultural production.

Interval Center (¥)	Number of Farmers	Cumulative Sum (Number of Farmers)	Cumulative Percentage (%)
475	0	0	0
525	44	44	10.48
575	36	80	19.05
625	37	117	27.86
675	34	151	35.95
725	45	196	46.67
775	58	254	60.48
825	47	301	71.67
875	34	335	79.76
925	48	383	91.19
975	37	420	100.00
1025	0	420	100.00

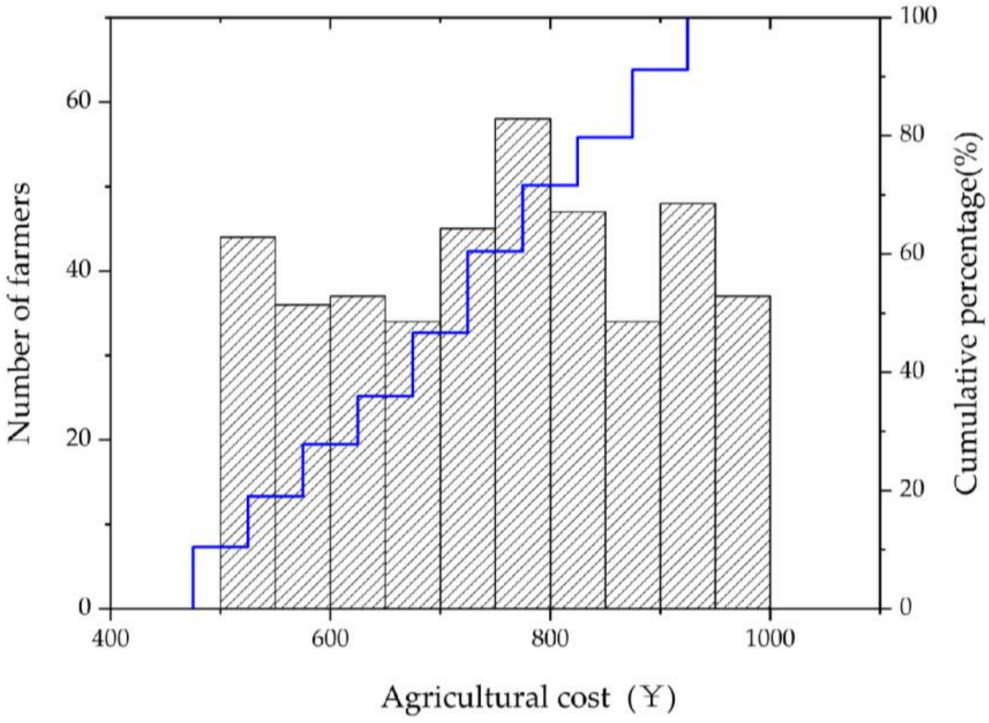

Figure 1. Histogram of surveyed data from Q4. The horizontal axis is the cost in the range of CNY 400–CNY 1000, the interval is CNY 50. The left vertical axis is the number of farmers in each cost interval, and the right vertical axis is the cumulative percentage of farmers. Values less than CNY 500 and greater than CNY 1000 also exist, but are very few. In our statistical analysis, records less than CNY 500 are regarded as CNY 500, and records greater than CNY 1000 are regarded as CNY 1000.

Q5 is "What is your current annual income?". The farmers' annual incomes are in the range of CNY 4000–CNY 26,000, with a peak around CNY 8000–CNY 14,000 (Table 6 and Figure 2). The highest percentage (32.62%) of farmers have annual incomes of CNY 10,000 to CNY 12,000 (Table 6 and Figure 2). On the whole, the frequency shows the characteristics of an approximately normal distribution.

Table 6. Results of Q5 "What is your current annual income?".

Interval Center (¥)	Number of Farmers	Cumulative Sum (Number of Farmers)	Cumulative Percentage (%)
5000	6	6	1.43
7000	17	23	5.48
9000	120	143	34.05
11,000	137	280	66.67
13,000	66	346	82.38
15,000	10	356	84.76
17,000	10	366	87.14
19,000	14	380	90.48
21,000	21	401	95.48
23,000	7	408	97.14
25,000	12	420	100.00

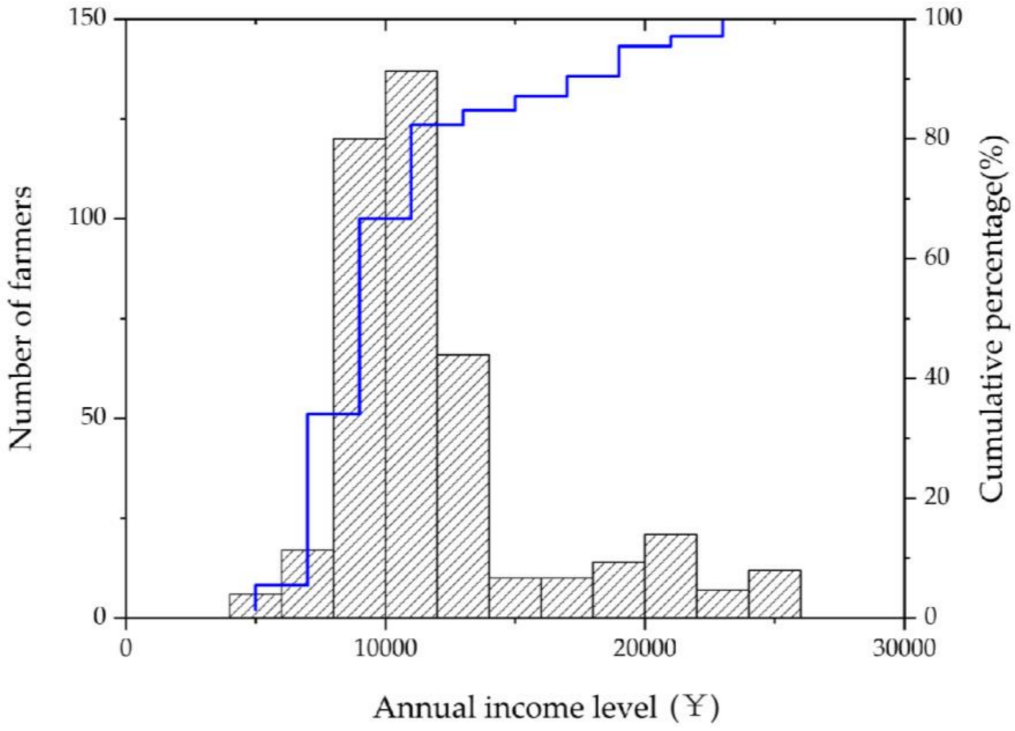

Figure 2. Histogram of surveyed data from Q5. The horizontal axis is the cost in the range of CNY 0–CNY 30,000, the interval is CNY 2000. The left vertical axis is the number of farmers in each income interval, and the right vertical axis is the cumulative percentage of farmers. Values less than CNY 4000 and greater than CNY 26,000 also exist, but are very few. In our statistical analysis, records less than CNY 4000 are regarded as CNY 4000, and records greater than CNY 26,000 are regarded as CNY 26,000.

3. Results

Public opinion determines whether a policy can be implemented smoothly. Our survey mainly includes four parts: (1) current status of agricultural production methods (Q6–Q8), (2) respondents' knowledge of agricultural pollution (Q9–Q11), (3) respondents' understanding of agricultural industrialization policies (Q12–Q14), and (4) respondents' views on current production technology upgrades (Q15 and Q16). The old agricultural production methods have put pressure on the environment, which has given the public a certain understanding of the pollution caused by agriculture. Under the long-term propaganda of the government, farmers would demand for upgrades of agricultural production methods. We also have a subsection (Section 3.5) to discuss the relationship between the characteristics

of samples of farmers and their policy attitudes. In Sections 3.5 and 3.6, we analyze the relationship between the polluting awareness, policy approval, and policy publicity.

3.1. Current Status of Agricultural Production Methods

The reasons for farmers to use chemical fertilizers and pesticides are not scientific enough, bringing double the amount of waste to the economy and environment. Q6 is "Could you tell us for what reasons you believe to be that it's the right time for using fertilizers?". The options we have provided are: "A. Weather factor, put on some fertilizer after the rain", "B. Personal planting experience, I feel like applying fertilizer when fertilizing", "C. Fixed time gap, without considering other factors", and "D. Crop growth factors, according to the law and crop growth needs". This is a question that can have multiple-choice answers. In total, 176 farmers ($176/420 \times 100\% = 41.90\%$) selected A (Table 7). The most selected options were B (63.33%) and C (62.38%). The selection rate of D was 50.95%. Judging from the results of this question, we find that the factors that determine the use of a specific production method by farmers are not clear.

Table 7. Results of Q6 "Could you tell us for what reasons you believe to be that it's the right time for using fertilizers?".

Options	Number of Farmers	Proportion (%)
A. Weather factor, put on some fertilizer after the rain.	176	41.90%
B. Personal planting experience, I feel like applying fertilizer when fertilizing.	266	63.33%
C. Fixed time gap, without considering other factors.	262	62.38%
D. Crop growth factors, according to the law and crop growth needs.	214	50.95%

Q7 is "Do you think applying fertilizer has an obvious effect on the crop yield?". We aim to determine the effect on the growth of crops after using fertilizer. The options we have provided are: "A. No direct feeling, everyone else is using it", "B. It feels like a little. It's better to use it than not", "C. Perhaps affects", and "D. There is a direct effect. Without fertilizer, the crop will fail". Among these options, C has the highest number of votes, 40.24%, (Table 8) and A has the lowest number of votes, 15.00%.

Table 8. Results of Q7 "Do you think applying fertilizer has an obvious effect on the crop yield?". It surveys the attitudes of farmers to the actual use of fertilizers.

Options	Number of Farmers	Proportion (%)
A. No direct feeling, everyone else is using it.	63	15.00%
B. It feels like a little. It's better to use it than not.	73	17.38%
C. Perhaps affects.	169	40.24%
D. There is a direct effect. Without fertilizer, the crop will fail.	115	27.38%

Q8 is "What kind of fertilizers do you use in agriculture?". The options we provided are: "A. Nitrogen fertilizer", "B. Phosphate fertilizer", "C. Potash fertilizer", "D. Compound fertilizer", "E. Organic fertilizer", and "F. Other". Among the six options, the percentage of farmers that selected C is the highest (64%, Figure 3). This is also a question that can have multiple-choice answers. Percentages of farmers that selected A, B, and D are 47.62%, 57.14%, and 51.43%, respectively, which are very close to each other (Figure 3). The fewest number of farmers selected E.

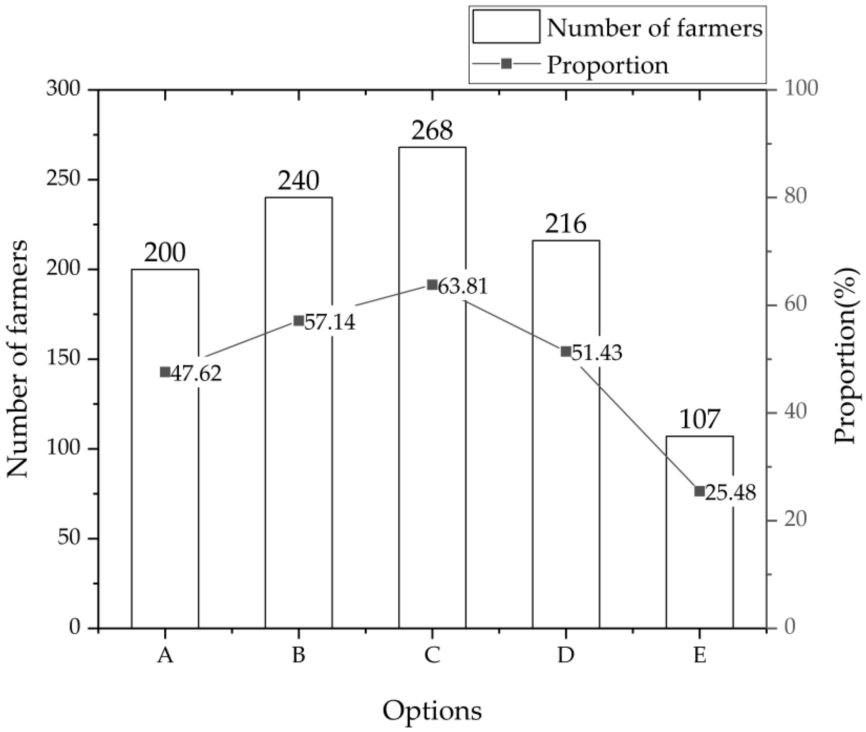

Figure 3. Histogram of surveyed data from Q8. It contains the types of fertilizers that farmers often choose when using fertilizers. The horizontal axis represents different options. The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentage of farmers that selected each option.

3.2. Respondents' Knowledge of Agricultural Pollution

Farmers having some understanding of air pollution caused by agriculture would have a certain degree of confidence in the suggestions from the government and experts in terms of long-term cooperation and coordination.

Q9 is "Do you think agriculture causes air pollution?". We try to understand farmers' views on pollution. The options we have provided are: "A. It doesn't. It is environmentally friendly and it doesn't pollute", "B. Not really. Agriculture is based on plants and animals. It is unlikely to produce pollution", "C. Sometimes, agriculture as a mode of production may produce some pollution", "D. It's possible to produce some pollution", and "E. Sure, people have clear knowledge in this aspect". The sentiment level of the options gradually increases from mild to severe. These options correspond to scores of 1–5 points, respectively. These scores will be used in a subsequent correlation analysis and factor analysis. The numbers (percentages) of farmers that selected these five options are 39 (9.29%), 67 (15.95%), 134 (31.90%), 126 (30.00%), and 54 (12.86%), respectively (Table 9). Options C and D have the largest number of votes, indicating that most farmers have a certain understanding of environmental pollution, which is helpful for us when implementing policies later.

Q10 is "Have you ever heard about any news report on air pollution from agriculture before?". We aim to determine the farmers' awareness of air pollution from news media. The options we have provided are: "A. No, I don't know anything about it", "B. Yes, but a few", "C. Yes, it is often mentioned", and "D. I have heard of it, and I took the initiative to learn about it". A large fraction of farmers ($209/420 \times 100\% = 49.76\%$) selected C (Figure 4). Which means the awareness of air pollution is relatively clear. We found that people involved in agricultural activities have a clear understanding of the problem of air pollution.

Table 9. Results of Q9 "Do you think agricultural activities cause air pollution?".

Options	Number of Farmers	Proportion (%)
A. It doesn't. It is environmentally friendly and it doesn't pollute.	39	9.29%
B. Not really. Agriculture is based on plants and animals. It is unlikely to produce pollution.	67	15.95%
C. Sometimes, agriculture as a mode of production may produce some pollution.	134	31.90%
D. It's possible to produce some pollution.	126	30.00%
E. Sure, people have clear knowledge in this aspect.	54	12.86%

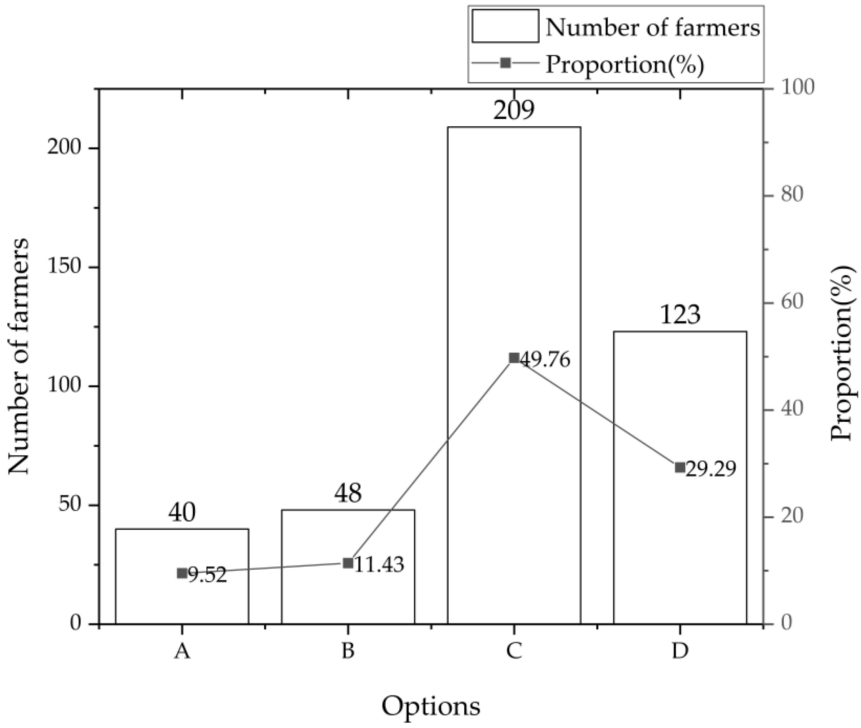

Figure 4. Histogram of surveyed data from Q10 "Have you ever heard about any news report on air pollution from agriculture before?". The horizontal axis represents different options. The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentages of farmers that selected each option.

Q11 is "To what extent would an expert play a part in your consideration of purchasing fertilizers?". We hope to learn about the interviewees' trust in government, experts, and media. The options we have provided are: "A. Not at all", "B. Will affect to some extent", "C. Large impact", and "D. Only rely on recommendations from authoritative sources". The largest proportion (168/420 = 40.00%) of farmers selected C (Figure 5), which shows the large degree of trust they have in the recommendations of experts and the government.

3.3. Respondents' Understanding of Agricultural Industrialization Policies

Q12 is "How much do you know about industrialization?". We want to determine the farmers' knowledge about agricultural industrialization. The options we have provided are: "A. Don't know", "B. Know little", "C. Know some of", "D. Know a lot of", and "E. Completely know". Among the five options, option C holds the largest proportion of 34.52% (Figure 6), followed by option D (30.73%). The proportion of option A (7.85%) is the smallest with only 33 people choosing it. Only 41 people (9.76%) chose E. These results indicate that farmers have some understanding of industrialization.

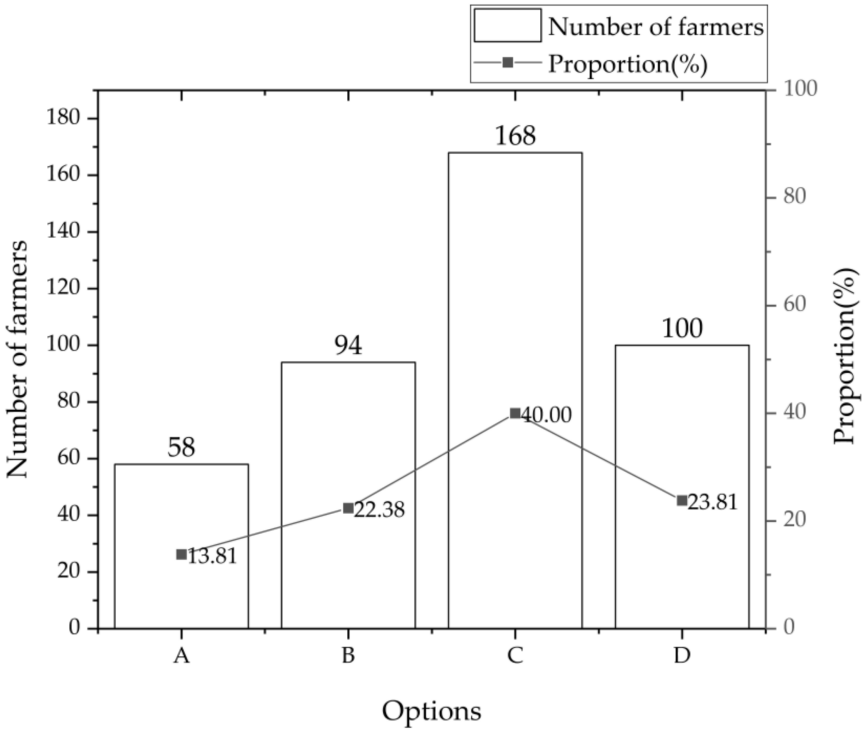

Figure 5. Histogram of surveyed data from Q11 "To what extent would an expert play a part in your consideration of purchasing fertilizers?". The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentages of farmers that selected each option.

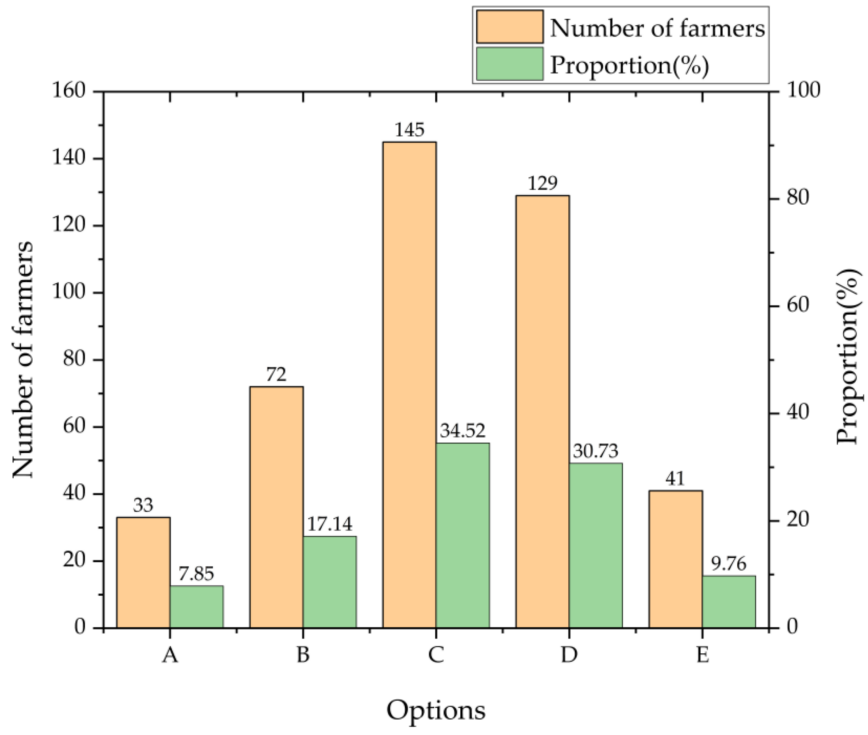

Figure 6. Histogram of surveyed data from Q12 "How much do you know about industrialization?". The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentage of farmers that selected each option.

Q13 is "Does the local government or media publicize the industrialization of agriculture?". We try to understand the efficiency of publicity of agricultural policies. The options we have provided are: "A. Never heard of it", "B. Heard very little", "C. Sometimes heard", "D. Often heard", and "E. Heard all the time". Among the five options, C (34.76%) and D (32.62%) received relatively high fractions of votes (Figure 7). The proportions of the remaining three options are very close, which are 9.29% for A, 12.86% for B, and 10.47% for E. Therefore, the government and enterprises have effectively promoted agricultural industrialization policies.

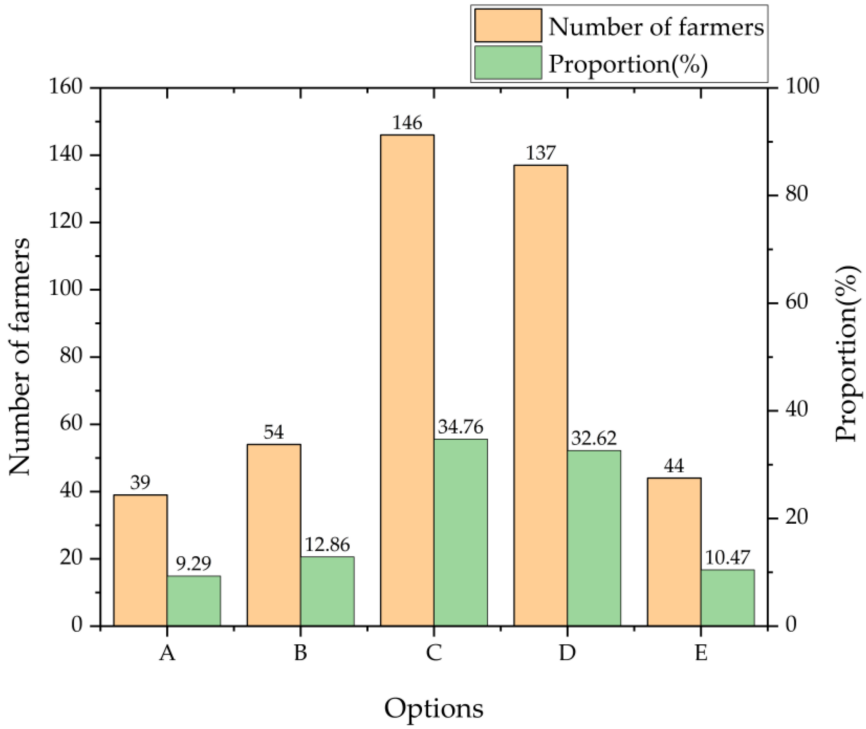

Figure 7. Histogram of surveyed data from Q13 "Does the local government or media publicize the industrialization of agriculture?". The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentage of farmers that selected each option.

Q14 is "Do you often pay attention to the news and the latest information about agricultural industrialization?". The options we have provided are: "A. Pay no attention to it", "B. Pay little attention to it", "C. Pay some attention to it", "D. Always pay attention to it", and "E. Is very concerned about it". Among these five options, more people chose C (31.90%) and D (31.67%) (Figure 8). Options A (11.19%) and E (9.29%) were rarely chosen. These results show that farmers are concerned with the industrialization of agriculture.

3.4. Respondents' Views on Current Production Technology Upgrades

Respondents also provided many suggestions for the methods or approaches of agricultural production, among which the advances in technology had the highest concern. Q15 is "What should be improved about the current approaches?". The options we have provided are: "A. It doesn't need to be improved anymore", "B. Need mechanized production to reduce work", "C. Need to know more about the weather to adjust planting plan", "D. Need more efficient fertilizers to increase the efficiency of planting", "E. Need guidance for planting different plants in the same place", "F. Need knowledge for planting different crops in different years", "G. Need more knowledge about sustainable farming", and "H. Other". The highest proportion is C (56.90%), and it is similar to D (55.48%) (Figure 9), which are related to the information about weather and the efficient use of fertilizers.

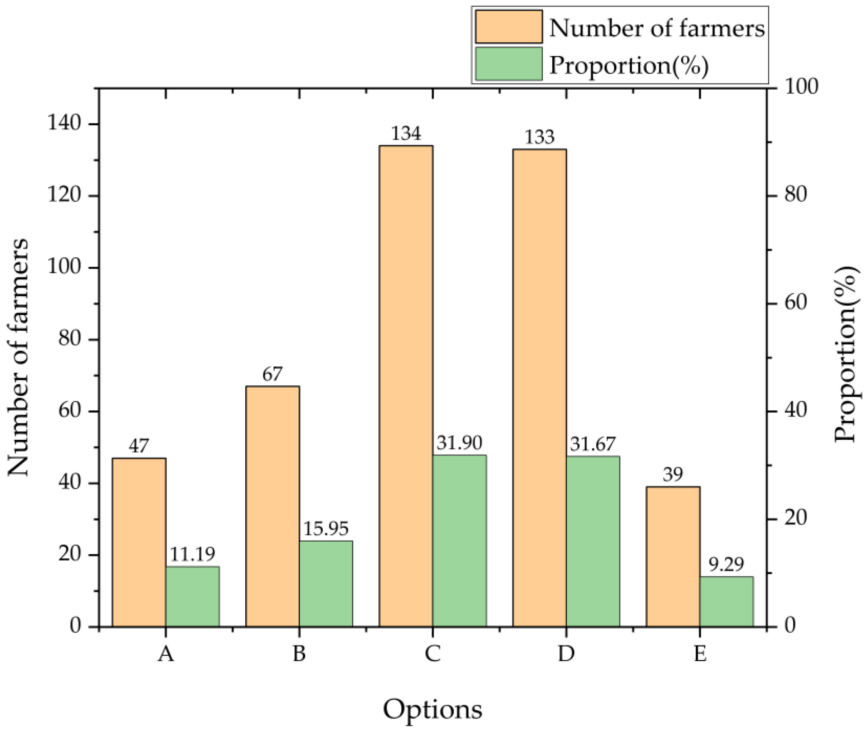

Figure 8. Histogram of surveyed data from Q14 "Do you often pay attention to the news and the latest information about agricultural industrialization?". The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentage of farmers that selected each option.

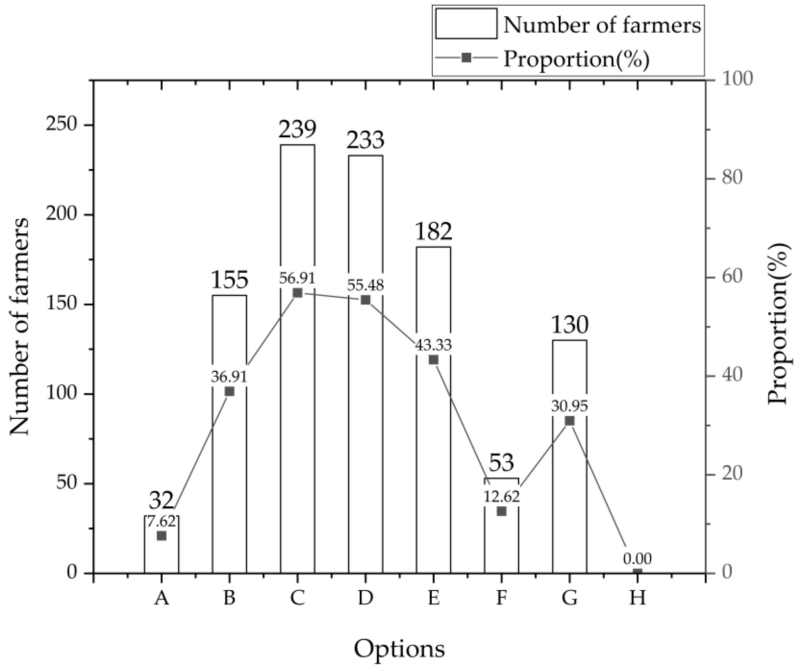

Figure 9. Histogram of surveyed data from Q15 "What should be improved about the current approaches?". The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentage of farmers that selected each option.

Q16 is "What do you do in non-farm hours and do you have free time to learn new production techniques?". The options we have provided are: "A. I have my own business", "B. Engage in other technical work", "C. Engage in other kinds of manual work", "D. No fixed plan of work, work casually in the local", "E. Find part-time job in other places within the province", "F. Find part-time job in other provinces", "G. Do housework at home", and "H. Other". C received the highest votes (60.00%) and F had the fewest votes (9.29%) (Figure 10). It can be seen that they are more inclined to carry out scattered work not far from their homes to obtain other income.

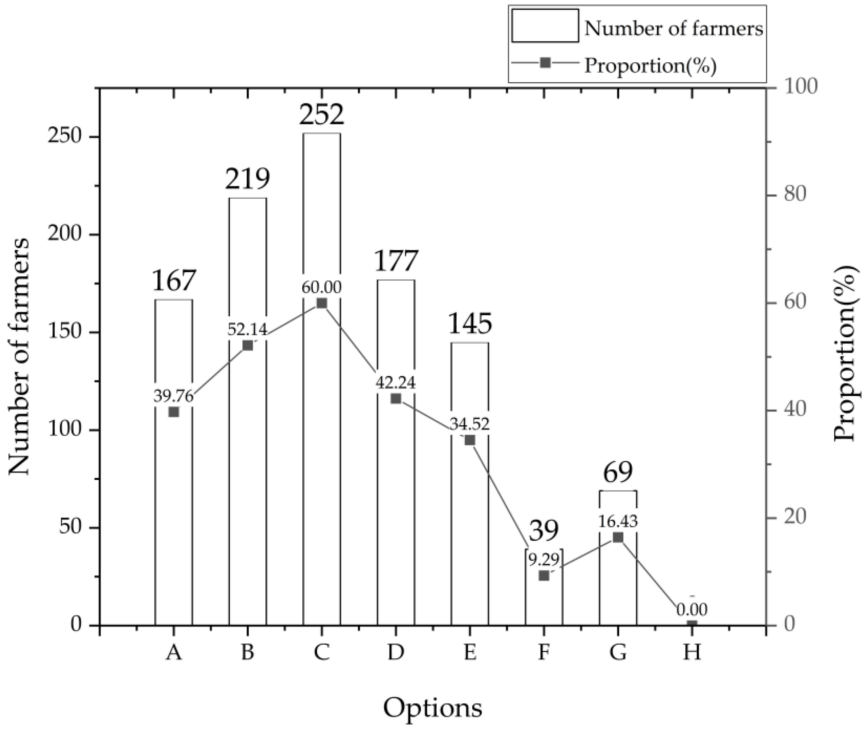

Figure 10. Histogram of surveyed data from Q16 "What do you do in non-farm hours and do you have free time to learn new production techniques?". The left vertical axis is the number of farmers that selected each option, and the right vertical axis is the percentage of farmers that selected each option.

3.5. The Relationship between Awareness of Pollution and Policy Approval

After analyzing the information obtained from each question, we used the factor analysis approach described in Section 2.2 to identify the key questions. By inputting the matrix X into SPSS26, the scores of the 16 questions were calculated. The sum of scores of all questions is 1. The more important the question is, the higher SPSS26 score the question has. Questions whose total score exceeded 0.85 were defined as key questions. On the basis of our analysis, the key questions are Q10 (with a factor score of 0.28), Q11 (0.24), Q9 (0.21), and Q13 (0.19). Among them, Q9 (Do you think agricultural activities cause air pollution?), Q10 (Have you ever heard about any news report on air pollution from agriculture before?), and Q11 (To what extent would an expert play a part in your consideration of purchasing fertilizers?) were designed to determine farmer's knowledge of agricultural pollution, which are shown below to have an important influence on farmers' attitudes towards agricultural policies.

The clearer the farmers' awareness of pollution, the stronger recognition of government's policies they will have. We want to figure out whether different levels of awareness of pollution will lead to different levels of policy awareness. The questions and options of Q9 and Q11 are listed in Tables 10 and 11, respectively. Table 12 shows how farmers that selected each option of Q9 would choose the options of Q11. For example, among

the 134 (26 + 29 + 47 + 32) farmers that selected option C, 26, 29, 47, and 32 of them selected options A, B, C, and D of Q11, respectively. People who chose Q9 (C) were more willing to choose Q11 (C), indicating that people who realize the impact of agriculture on environment are also more likely to agree with experts' recommendations with respect to purchasing fertilizer. We also found that when farmers were less aware of pollution, they were less welcoming to policies. For example, among those who chose Q9 (B) ("Not really. Agriculture is based on plants and animals. It is unlikely to produce pollution", 66 people in total), only 15.15% (10/66) expressed support of the policy. Compared with Q9 (E) ("Sure, people have clear knowledge in this aspect", 54 people in total), 29.63% (16/54) of the respondents supported the policy. The correlation coefficient between Q9 and Q11 (see Section 2.2) is 0.94, which is a high value (statistically significant at the 95% level by the Chi-square test).

Table 10. Question and corresponding options of Q9.

	Q9: Do You Think Agriculture Causes Air Pollution?
A	It doesn't. It is environmentally friendly and it doesn't pollute.
B	Not really. Agriculture is based on plants and animals. It is unlikely to produce pollution.
C	Sometimes, agriculture as a mode of production may produce some pollution.
D	It's possible to produce some pollution.
E	Sure, people have clear knowledge in this aspect.

Table 11. Question and corresponding options of Q11.

Q11: To What Extent Would an Expert Play a Part in Your Consideration of Purchasing Fertilizers?	
A	Not at all.
B	Will affect to some extent.
C	Large impact.
D	Only rely on recommendations from authoritative sources.

Table 12. Analysis of correlation between pollution awareness and policy approval. Each row corresponds to the options of Q9 (Do you think agricultural activities cause air pollution?) and each column corresponds to the options of Q11 (To what extent would an expert play a part in your consideration of purchasing fertilizers?).

Option		**Q11 (Number of Farmers)**			
		A	**B**	**C**	**D**
Q9	A	5	12	13	9
	B	8	12	36	10
	C	26	29	47	32
	D	13	24	57	33
	E	6	16	16	16

3.6. The Relationship between Policy Publicity and Policy Approval

The publicity of policy affects the public's recognition of the policy. In Q10 (Have you ever heard about any news report on air pollution from agriculture before?), we obtain different degrees of policy publicity(See Table 13 for details). The data acquisition method in Table 14 is the same as that in Table 12. People who heard more propaganda of policy have relatively higher recognition of the policy (87 farmers, Q10(C), Q11(C) and Table 14). The correlation coefficient between Q10 and Q11 (see Section 2.2) is 0.95, which is a high value (statistically significant at the 95% level by the Chi-square test). In Q11, our problem

setting does not refer to a specific policy but represents the way that the government implements the policy. The different options indicate the farmers' willingness to comply with the implementation of the policy. In other words, Q11 determines the possibility of policy approval by farmers.

Table 13. Question and corresponding options in Q10.

Q10: Have You Ever Heard about Any News Report on Air Pollution from Agriculture Before?	
A	No, I don't know anything about it.
B	Yes, but a few.
C	Yes, it is often mentioned.
D	I have heard of it, and I took the initiative to learn about it.

Table 14. Analysis of correlation between pollution publicity and policy approval. Each row corresponds to the options of Q10 (Have you ever heard about any news report on air pollution from agriculture before?) and each column corresponds to the options of Q11 (To what extent would an expert play a part in your consideration of purchasing fertilizers?).

Option		**Q11 (Number of Farmers)**			
		A	**B**	**C**	**D**
Q10	A	6	8	14	12
	B	5	11	21	11
	C	25	49	87	48
	D	22	25	47	29

4. Conclusions and Discussions

This survey mainly analyzes whether farmers are willing to accept the implementation of agricultural industrialization policies. We obtained 420 survey data through questionnaires, focusing on the current status of agricultural production methods, respondents' knowledge of agricultural pollution, respondents' understanding of agricultural industrialization policies, and respondents' views on current production technology upgrades. Data from the survey show that 47.62% (200/420 × 100% = 47.62%, Figure 3) of the surveyed farmers are using nitrogen fertilizers with strong ammonia emissions. When applying fertilizers, 63.33% (266/420 × 100% = 63.33%, Table 7) of the people utilize them based only on experience. A total of 90.71% ((67 + 134 + 126 + 54)/420 × 100% = 90.71%, Table 9) of the respondents believe that agriculture will bring negative impacts on air pollution, and some of them (54/420 × 100% = 12.86%) make it clear that pollution is present. A total of 92.15% ((72 + 145 + 129 + 41)/420 × 100% = 92.15%, Figure 6) of people have an understanding of agricultural industrialization. For industrialization with new technologies, farmers are looking forward to effective fertilizers (233/420 × 100% = 55.48%) and increasing their knowledge of the climate (239/420 × 100% = 56.91%) (Figure 9).

We used factor analysis to identify the key questions that affect farmers' attitudes. We acquired the following key questions: Q9 (Do you think agricultural activities cause air pollution?), which scored 0.21, Q10 (Have you ever heard about any news report on air pollution from agriculture before?), which scored 0.28, and Q11 (To what extent would an expert play a part in your consideration of purchasing fertilizers?), which scored 0.24. The correlation between awareness of pollution and policy approval is 0.94, and that between policy publicity and policy approval is 0.95, both of which are very high correlations. It can be judged that the publicity of a policy can have a positive impact on farmers' perceptions of the status of pollution and the associated policies, which provides a foundation for smooth deployment of subsequent policies.

Generally speaking, the current environmental reforms in agriculture already have led to some basic understanding of air pollution for the masses, and we are positive with regard to the advancement of agricultural industrialization. Based on the data in the survey and our analysis, we make some recommendations as follows:

- Policy publicity has a positive effect on awareness of pollution and policy approval. If we want to implement the policy smoothly, we can increase policy publicity.
- Farmers in different places have different demands for new technologies for industrialization. We can promote industrialization policies in different ways according to this characteristic.
- Farmers have a certain demand for accurate weather forecasts and we can consider this in policy for industrialization. The timing of harvest for some crops, such as wheat and rice, depends heavily on accurate short-term forecasts.
- The majority of ammonia emissions come from fertilizers and livestock. New technologies are needed to reduce ammonia emissions.

The conclusions from this work can be compared with previous studies on China's agricultural policy. Sun et al. (2018) [18] conducted a survey in mountainous areas in southern Ningxia and found that the implementation of agricultural industrialization policies would increase farmers' income. Wang et al. (2018) [19] reported that some agricultural policies would promote the agricultural productivity in Nanjing, Suzhou, Zhenjiang, Taizhou, Suqian, and Huai'an. However, the study of Zhang et al. (2018) [20] found that farmers' enthusiasm for participation is not high if the upgrade of agricultural technology is not accompanied with policy promotion. In our study, we found that publicity of policy before the promotion of agricultural policy is essential, which is important for the coordinated emission control of NH3 in the near future.

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