Public Awareness of Plastic Mulch Film Residues in Agricultural Fields: a Survey Study

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Abstract: To investigate public awareness, attitudes, and recycling behaviors regarding plastic mulch film residues in agricultural fields, this study focuses on City X and employs a questionnaire survey. Descriptive statistics, chi-square tests, and correlation analysis are used to examine respondents' use of plastic mulch film, awareness of residual pollution, willingness to recycle, and factors influencing recycling behavior. The findings indicate that respondents generally recognize the agricultural functions of plastic mulch film; however, their understanding of residual pollution and related policies remains limited. Environmental awareness is significantly associated with willingness to recycle, while receipt of subsidies is significantly associated with actual recycling behavior. In response to these findings, this study proposes strengthening public education and awareness campaigns, improving recycling infrastructure, and establishing more effective incentive mechanisms. The results are intended to provide a reference for the prevention and control of residual plastic mulch film pollution in agricultural fields.

Keywords: Plastic Mulch Film in Agricultural Fields; Residual Pollution; Public Awareness; Recycling Behavior

1. Introduction

The use of plastic mulch film has helped conserve heat and soil moisture as well as suppressing weeds during agriculture. Inadequate collection or recycling of used films can result in their accumulation in agricultural soils which could pose risks to the ecological environment. To solve the problem of residual plastic mulch film pollution, it is necessary to improve recycling technology and system, while increasing attention to public environmental awareness, recycling intentions and actual participation. The understanding of public perception about environmental risk from plastic mulch film residues; current disposal practice; and practical barriers to recycling are crucial for enhancing the effectiveness of recovering agricultural plastic film. This study focuses on City X using a questionnaire survey to investigate public awareness and behavior regarding plastic mulch film residues in agricultural fields. We explore the relationship among environmental awareness, receiving subsidies, and recycling behavior and provide relevant recommendations that will help improve agricultural plastic pollution prevention and control.

2. Introduction to the Study

1.1. Research Background and Significance

The advantages of plastic mulch film include heat preservation, soil moisture conservation, and weed suppression; using plastic mulch film helps improve the growth condition for some crops [1]; however, if there are insufficient efforts at collecting after use, the remaining films could remain in agricultural soils over long durations that affect soil structure, water movement, and the agricultural ecological environment. Plastic mulch film residue management requires improvement of both materials and mechanized recovery technologies, while farmers' environmental awareness, their willingness to recycle, labor cost, and availability of recycling services play an important role too [2-3].

Studying the public's awareness and behavior about plastic mulch film residues will shed light on the gap between environmental knowledge and practice. It can be used by local authorities and agricultural service providers as a reference for creating public education programs, improving recycling networks, and proposing incentive measures. This study from a research perspective integrates awareness, attitudes, and behaviors within one analytical framework. From a practical perspective, we

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aim to find out the main barriers to recycling through respondent feedbacks and make targeted recommendations for improving residue management.

2.1 Overview and Brief Review of Domestic and International Research

Existing studies have primarily examined the agricultural effects of plastic mulch film, residual film pollution and its ecological impacts, recycling technologies and alternative materials, as well as farmers' environmental awareness and recycling behavior. International research has focused on agricultural plastics management, biodegradable materials, and environmental behavior, whereas research in China has paid considerable attention to the use and accumulation of plastic mulch film, recycling technologies, policy implementation, and farmer participation [4-5].Overall, residual plastic mulch film pollution is both a technical management challenge and a matter of public participation and service provision. Given regional differences in cropping patterns, film application practices, and recycling conditions, further region-specific investigations are needed to understand local circumstances and identify appropriate management strategies.

1.3. Research Content and Methodology

We investigate respondents' demographics, plastic mulch film usage, their awareness of its agricultural and environmental effects, their policy knowledge, their disposal practice, their willingness to recycle, and their perception of barriers in recycling.Research methods: Literature review; questionnaire survey; statistical analysis. We report frequencies and percentages for our sample characteristics and survey results. We apply cross-tabulations and Pearson's chi-square tests to analyze relationships among environmental awareness and willingness to recycle, and among receiving subsidies and actually recycling. Spearman's rank correlation analysis was applied to determine the relationship between education level and environmental awareness score.

3. Survey Design and Implementation

3.1 Survey Population and Sample Selection

The study is conducted in City X. Survey participants include agricultural producers, grassroots agricultural technicians, ordinary rural residents, and other individuals. A total of 110 questionnaires were distributed, of which 100 were valid and 10 were invalid, yielding a valid response rate of 90.9%.

3.2 Questionnaire Design and Survey Administration

This questionnaire includes different parts about basic demographics; plastic mulch film usage and awareness of their agricultural functions; awareness of residual pollution and relevant policies; disposal practices and willingness to recycle; and perceptions of barriers in recycling and suggestions for improvement of governance.In case of multiple responses, all options are coded individually. The environmental impact awareness score is determined by selecting the number of items out of four potential impacts (possible scores: 0-4). Prior to conducting this survey, we conduct a pilot test of the questionnaire with around 15-20 people to clarify and revise any ambiguous questions. We provide an "not applicable" option if there is no prior experience with plastic mulch film. In order to evaluate the linkages between subsidies and recycling behaviors, it would be necessary that our questionnaire contains a direct question about whether they had ever been given subsidies or other incentives regarding plastic mulch film recycling.

2.3. Data Processing and Analytical Methods

All 100 valid questionnaires were coded as valid records; all 10 invalid questionnaires were coded as invalid. Frequencies and percentages for descriptive statistics are presented. Pearson's chi-square test was performed on categorical variables whereas Spearman's rank correlation test was conducted to assess the relationship between educational attainment and environmental awareness scores with a significant level of 0.05. If the expected frequencies in the contingency table are too small to meet the assumptions of Pearson's chi-square test, it would be recommended that theoretically justified category consolidation or Fisher's exact test can be considered accordingly.

4. Analysis of Public Awareness and Behaviors Regarding Plastic Mulch Film Residues in Agricultural Fields

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4.1 Basic Characteristics of Respondents and Current Use of Plastic Mulch Film

Of all respondents, 60 are agricultural producers (60.0%), 27 are ordinary rural residents (27.0%), 8 are grassroots agricultural technicians (8.0%), while others account for 5%. Respondents between ages 36-50 accounted for the highest proportion at 32.0%, then 51-65 years old (26.0%) and finally 19-35 years old (24.0%). Junior secondary education was received by a total of 31 respondents (31.0%), whereas another 31 have senior secondary education or technical secondary school (31.0%). For plastic mulch film usage: 34 respondents said they use it often (34.0%), 21 occasionally (21.0%), 19 once but do not anymore (19.0%), and 26 never (26.0%). A total of 74 respondents previously experienced using plastic mulch film; this accounts for 74.0% of our sample.

Table 1. Basic Characteristics of the Sample and Use of Plastic Mulch Film

Indicator	Number	Percentage (%)
Agricultural producers	60	60
Ordinary rural residents	27	27
Grassroots agricultural technicians	8	8
Other occupations	5	5
Aged 36-50	32	32
Junior secondary education	31	31
Senior secondary/technical secondary education	31	31
Frequent use of plastic mulch film	34	34
Occasional use of plastic mulch film	21	21
Used in the past but not currently	19	19
Never used plastic mulch film	26	26

When analyzing actual recycling behavior, the denominator should be restricted to the 74 respondents with prior experience using plastic mulch film. Respondents who have never used the material should not be classified as non-recyclers.

4.2 Public Awareness of Residual Plastic Mulch Film Pollution

For self-assessment of awareness: There is no knowledge among 13 respondents regarding residual plastic mulch film pollution; limited knowledge among 30 respondents; and moderate knowledge among 27 respondents. Thirty (30.0%) respondents stated that they were relatively or very knowledgeable about this issue.The agricultural functions of plastic mulch film appear to be well known. Seventy-six respondents mentioned heat preservation and soil moisture conservation as the function of plastic mulch film; 72 said it has weed suppression effect; and 76 respondents noted its potential to promote crop growth or increase yields. However, only 25 respondents recognized its potential effects on soil structure and water movement, 31 recognized its possible effects on crop roots, 33 recognized the possibility of microplastic formation in soil, and 36 acknowledged potential long-term ecological impacts. Note these are multiple response questions so the percentages do not add up to 100%. Results indicate the level of awareness and perception by respondents instead of measuring actual environmental impact.Policy awareness: Twenty-four respondents have no knowledge of relevant policies; 54 respondents have heard of them but lack a detailed understanding; relative knowledge among 21 respondents and one respondent who was very knowledgeable. Only 22.0% reported being relatively or very knowledgeable about relevant policies. There is still room to convert general policy awareness with practical knowledge on how to participate in recycling programs. Education publics should include information on where recycling takes place, collection and delivery procedures, subsidy eligibility, and proper disposal methods.

Table 2. Awareness of Residual Pollution and Knowledge of Relevant Policies (N = 100)

Indicator	Number	Percentage (%)
Pollution awareness: No knowledge	13	13
Pollution awareness: Limited knowledge	30	30
Pollution awareness: Moderate knowledge	27	27
Pollution awareness: Relatively or very knowledgeable	30	30
Awareness of potential effects on soil structure and	25	25

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water movement		
Awareness of potential effects on crop roots	31	31
Awareness of the possibility of soil microplastic formation	33	33
Awareness of potential long-term ecological impacts	36	36
Policy awareness: No knowledge	24	24
Policy awareness: Heard of policies but lacks detailed knowledge	54	54
Policy awareness: Relatively or very knowledgeable	22	22

4.3 Disposal Practices and Willingness to Recycle Used Plastic Mulch Film

With regard to disposal, 21 respondents buried their used plastic mulch film; 21 took it to recycling collection points or recycling personnel; 18 left it in the field or discarded it indiscriminately; 11 sold it or disposed through other channels; 3 chose other methods. And there are 26 who select "not applicable" since they have never used plastic mulch film or lack related experiences.Of the 74 respondents with previous experience on use of plastic mulch film, only 32 actually recycled used film which is at a recycling rate of 43.2%, while 42 do not recycle it, accounting for 56.8%.As regards willingness to recycle, 19 were very willing, and 22 were relatively willing, totaling up to 41 respondents (41.0%), another 19 showed a neutral attitude, 31 were somewhat unwilling, and 9 were completely unwilling to recycle used plastic mulch film.

4.4 Major Factors Influencing Plastic Mulch Film Recycling and Differences Between Groups

The multiple response on barriers to recycling indicated that 47 respondents thought low recycling prices or lack of subsidies was a major barrier; another 45 said high labor cost and time needed for manual collection is an obstacle; 42 referred to lack of relevant knowledge/environmental awareness; 39 mentioned inconvenience of recycling channels; 26 stated that recycling points are too far away. This emphasizes the significance of economic costs, labor requirement and access to recycling services.In order to explore the association between environmental awareness and willingness to recycle, we divided respondents into two groups: one group (high-awareness) whose score was at least 3 points, other group (low-to-moderate-awareness) scored less than 3. There were 19 people in the high-awareness group out of which 16 were willing to recycle. Out of 81 in low-to-moderate-awareness group, 25 were willing to recycle. Proportions were 84.2% and 30.9%, respectively.

Table 3. Cross-Tabulation of Environmental Awareness and Willingness to Recycle

Awareness group	Willing to recycle	Neutral/ unwilling to recycle	Total
High awareness	16	3	19
Low-to-moderate awareness	25	56	81
Total	41	59	100

Table 4. Chi-Square Test of Environmental Awareness and Willingness to Recycle

Test	χ^2	df	p-value	Valid N
Pearson's chi-square	18.106	1	< 0.001	100

The Pearson chi-square test yielded (\chi^2(1) = 18.106), with ($p < 0.001$), indicating a statistically significant association between environmental awareness group and willingness to recycle. The direction of the association is consistent with Hypothesis H1.

The analysis of subsidies and actual recycling behavior included only the 74 respondents with prior experience using plastic mulch film. Among the 28 respondents who had received subsidies, 20 recycled used film and 8 did not. Among the 46 respondents who had not received subsidies, 12 recycled used film and 34 did not. The recycling rates in the two groups were 71.4% and 26.1%, respectively.

Table 5. Relationship between Subsidy Receipt and Actual Recycling Behavior (n = 74)

Subsidy status	Recycled	Did not recycle	Total
Received subsidies	20 (71.4%)	8 (28.6%)	28
Did not receive subsidies	12 (26.1%)	34 (73.9%)	46
Total	32 (43.2%)	42 (56.8%)	74

Table 6. Chi-Square Test of Subsidy Receipt and Actual Recycling Behavior

Test	χ^2	df	p-value	Valid N
Pearson's chi-square	14.579	1	< 0.001	74

The test yielded (\chi^2(1) = 14.579), with ($p < 0.001$), indicating a statistically significant association between subsidy receipt and actual

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recycling behavior. The direction of the association is consistent with Hypothesis H2. However, the analysis did not control for factors such as farm size, access to recycling services, or environmental awareness. Therefore, the results alone do not establish a causal effect of subsidies on recycling behavior.The Spearman correlation coefficient between educational attainment and environmental awareness scores was (\rho = 0.370), with ($p < 0.001$). The Kruskal-Wallis test comparing awareness scores across educational groups yielded ($H = 14.652$), with ($p = 0.005$). These findings suggest a positive association between educational attainment and environmental awareness scores, as well as differences in score distributions across educational groups. The results are consistent with Hypothesis H3. Nevertheless, educational attainment is not the sole factor influencing environmental awareness.

Table 7. Correlation and Group Differences between Educational Attainment and Environmental Awareness Scores

Test	Statistic	p-value	Interpretation
Spearman's rank correlation	(ρ = 0.370)	< 0.001	Educational attainment is positively correlated with environmental awareness scores
Kruskal-Wallis test	(H = 14.652)	0.005	Awareness score distributions differ across educational groups

Regarding preferred governance measures, 65 respondents supported establishing additional recycling collection points, 62 supported subsidies or measures to improve recycling convenience, 57 favored strengthening public education, 56 supported promoting thicker plastic mulch film and suitable alternative products, and 47 favored stricter management. In terms of communication channels, 70 respondents selected online platforms, while 53 preferred household visits and guidance from grassroots agricultural technicians.These findings indicate that effective governance should integrate infrastructure development, financial incentives, technological improvements, and public education rather than relying on a single intervention.

5. Problems Identified and Recommendations

5.1 Limitations in Public Environmental Awareness and Policy Knowledge

Survey results indicate that 30.0% of participants were relatively or very knowledgeable on residual plastic mulch film pollution; however, only 22.0% were relatively or very knowledgeable on related policies. Public knowledge regarding the agricultural function of plastic mulch film is relatively high but their understanding for its specific environmental impact as well as the policy implementation in practice are still lacking.Field demonstrations and agricultural extension guidance should be given to farmers; community outreach, short-form videos, and public information boards can be employed to increase awareness with ordinary residents. Education programs should inform people about accumulation of residual film, collection and recycling of used film, and potential environmental risks. It is important not to overstate or oversimplify any environmental effect or risk that requires additional research.

5.2 Practical Barriers to Plastic Mulch Film Recycling

Among all the barriers mentioned by the respondents are low recycling prices; high labor cost; lack of knowledge; and a shortage of recycling channels. Despite knowing that recycling is environmentally beneficial, the time involved, inconvenience of collection points as well as insufficient financial return can discourage people from acting upon their intention.Recycling collection points need to be positioned based on the spatial distribution of plastic mulch film use and seasonal agricultural activities. Collection schedule, contact information, and delivery requirement should be publicized. Encourage collaboration between village collectives, agricultural cooperatives, agricultural input suppliers, and recycling enterprises so as to decrease the cost incurred by farmers for finding recycling service and transportation of used film.

5.3 Strengthening Public Education, Improving Recycling Systems, and Establishing Effective Incentive Mechanisms

Firstly, we need to build up a regular public education mechanism: on-site demonstration and practical guidance at critical steps in applying and removing plastic mulch film;

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incorporating proper collection and delivery of residual film in agricultural extension training.

Secondly, improve the recycling network through exploration for centralized collection, coordinated transportation and standardization of disposal procedure. Choose appropriate recovery method based on local terrain, farm size and types of plastic mulch film used.

Thirdly, explore reasonable subsidy schemes, transparent disclosure of recycling price, incentives (e.g., reward points) etc.; set up transparent registration and settlement procedures; evaluate pilot programs with regard to cost and effectiveness.

Fourthly, promote use of thicker plastic mulch film, biodegradable mulch film or alternatives considering local crops, climatic condition, costs and actual product performance. We cannot apply one-size-fits-all solutions over all areas.

Finally, conduct regular assessment with respect to quantity of plastic mulch film recycled, percentage of participating farmers, coverage of recycling collection points, and public education campaign reach. This will form an iterative loop from identifying problems → implementing interventions → evaluating effectiveness → refining.

6. Conclusions and Future Prospects

6.1 Main Research Findings

The survey data yield the following illustrative findings.

First, 74.0% of respondents had experience using plastic mulch film. Awareness of its functions in heat preservation, soil moisture conservation, weed suppression, and promoting crop growth was relatively widespread. However, respondents demonstrated comparatively limited in-depth knowledge of environmental impacts and recycling policies.

Second, among respondents with prior experience using plastic mulch film, the actual recycling rate was 43.2%, while 41.0% of the entire sample expressed a willingness to recycle. These findings indicate that willingness to recycle and actual recycling behavior should be analyzed separately.

Third, low recycling prices, high labor costs, limited environmental awareness, and inconvenient recycling channels were among the major barriers identified by respondents.

Fourth, statistically significant associations were observed between environmental awareness and willingness to recycle, as well as between subsidy receipt and actual recycling behavior. Educational attainment was also positively and significantly correlated with environmental awareness scores. The directions of these statistical relationships were consistent with the three research hypotheses.

6.2 Research Limitations and Future Directions

This study is limited to City X and includes a sample of 100 valid questionnaires. Its geographical coverage is therefore restricted, which limits the generalizability of the findings. As the questionnaire relies primarily on respondents' self-reported information, recall bias cannot be entirely ruled out. Furthermore, the statistical analyses examine associations between variables without controlling for potential confounding factors, such as farm size and household income. Consequently, causal relationships cannot be directly inferred from the results.

In addition, the survey does not provide a detailed comparative analysis of plastic mulch film use and recycling across different crop types and field conditions. Future research could expand the geographical scope and sample size, incorporate additional explanatory variables into multivariable analyses, and combine survey findings with field-based monitoring data. Comparing subjective environmental awareness with actual levels of residual plastic mulch film pollution would also help clarify the mechanisms driving recycling behavior and provide a stronger evidence base for developing differentiated and context-specific governance policies.

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