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Determinants of Biological Control Agent Adoption Among OPAG-Assisted Rice Farmers in South Cotabato

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ABSTRACT

This study analyzed the determinants influencing the adoption of biological control agents (BCAs) among OPAG-assisted rice farmers in South Cotabato. Specifically, it described farmers' socioeconomic profiles, determined adoption levels, examined the relationship between farmer characteristics and adoption, identified key determinants, determined constraints, and developed policy recommendations. A quantitative cross-sectional research design was employed involving 244 randomly selected farmers from major rice-producing municipalities. Data were collected through structured interviews and analyzed using descriptive statistics, chi-square tests, regression analysis, exploratory factor analysis, and Garrett ranking. Results showed that 60.7% of farmers adopted BCAs, indicating a transition toward early majority adoption, although use remained partial and selective. Chi-square and regression analyses showed that awareness, training, irrigation access, and institutional support significantly influenced adoption, while most demographic and farm characteristics were not significant predictors. Exploratory factor analysis identified five determinants: institutional support and extension services, perceived effectiveness and environmental benefits, social influence, economic factors, and market and technical access. Among these, institutional support and perceived effectiveness emerged as strong drivers, whereas limited market and technical access remained a critical constraint. Garrett ranking confirmed that lack of knowledge and limited market availability were the leading barriers. The study concludes that BCA adoption is knowledge-driven and institutionally mediated rather than primarily determined by demographic characteristics. Strengthened extension services, expanded farmer training, improved irrigation access, and reliable BCA supply systems are recommended to promote sustainable pest management in rice production.

Keywords: *adoption, biological control agents, integrated pest management, rice farmers, South Cotabato, sustainable agriculture*

INTRODUCTION

Rice is a staple food for nearly half of the world population, making sustainable pest management an essential requirement for food security, environmental protection, and rural livelihood resilience (Ali et al., 2019; FAO, 2023). Integrated Pest Management (IPM) offers a science-based alternative to chemical-intensive agriculture by combining biological, cultural, ecological, and judicious chemical control strategies. Within this framework, biological control agents (BCAs), including parasitoids, predators, and microbial pesticides, suppress pest populations while conserving beneficial organisms and reducing environmental harm.

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In South Cotabato, the Office of the Provincial Agriculturist and local government units have promoted BCA use through extension services, farmer field schools, and institutional support programs. These initiatives are intended to increase farmer access to biological inputs and encourage environmentally sustainable rice production. However, despite the availability and promotion of BCAs, many rice farmers continue to rely on chemical pesticides because these products are perceived to produce faster and more predictable results.

This awareness-practice gap suggests that adoption is shaped not only by exposure to technology but also by knowledge, confidence, technical access, social influence, production stability, and institutional support. Agricultural technology adoption studies indicate that farmer decisions are affected by perceived benefits, risk perception, access to resources, training, and extension mechanisms (Feder et al., 1984; Mariano et al., 2012; Rogers, 2003). Localized evidence is therefore needed to identify the specific determinants of BCA adoption among OPAG-assisted rice farmers in South Cotabato. This study addressed this need by analyzing farmer profiles, adoption levels, significant relationships, key determinants, constraints, and program implications for sustainable pest management.

Literature Review

Biological Control Agents and Integrated Pest Management

Integrated Pest Management has gained increasing attention as a practical and ecologically sound approach to rice pest control. BCAs function within IPM by regulating pest populations through natural enemy activity, microbial suppression, or ecological interactions that reduce the need for synthetic pesticides. Studies on rice systems show that ecological pest management can sustain productivity while minimizing environmental and health risks (Ali et al., 2019; Pretty & Bharucha, 2015).

Socioeconomic and Institutional Determinants of Adoption

Socioeconomic factors such as education, farm size, tenure, and income may influence adoption by shaping farmers' ability to process information and invest in new practices. However, adoption often depends more strongly on enabling conditions, including training, extension services, irrigation, and organizational membership. Farmer Field Schools and participatory extension have been shown to increase ecological knowledge, reduce uncertainty, and improve the practical application of IPM technologies (Hasan, 2015; Kondo et al., 2025; Waddington et al., 2014).

Social Influence, Knowledge, and Market Accessibility

Farmers make technology decisions within social networks. Peer learning, cooperatives, community demonstrations, and farmer organizations can accelerate diffusion by allowing farmers to observe the performance of new practices under local conditions (Bandiera & Rasul, 2006; Horgan et al., 2024). Knowledge gaps, weak ecological literacy, limited technical guidance, and unavailable inputs can hinder adoption even when farmers recognize the benefits of BCAs (Mkenda et al., 2020; Ratto et al., 2022). Thus, adoption should be understood as a multidimensional process involving farmer cognition, institutional support, technical access, economic feasibility, and social validation.

METHODS

Research Design

The study employed a quantitative cross-sectional research design to examine the determinants influencing the adoption of BCAs among rice farmers in South Cotabato. The design allowed the researcher to capture farmer profiles, adoption status, perceived determinants, and constraints at a single point in time.

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Research Locale

The study was conducted in selected OPAG-assisted rice-producing areas of South Cotabato, namely Brgy. Dajay in Surallah, Brgy. San Jose in Norala, Brgy. Teresita in Sto. Niño, Brgy. Cabudian in Banga, Brgy. Takunel in Lake Sebu, and Brgy. Lumakil in Polomolok. These sites were selected because of their contribution to provincial rice production and their exposure to government-supported rice production, mechanization, and IPM-related programs.

Participants and Sampling Technique

A multi-stage sampling procedure was used. Barangays with high rice production intensity were purposively selected based on OPAG records, and individual respondents were randomly drawn from the master list of beneficiaries under the Consolidated Rice Production and Mechanization Program. Using Slovin's formula with a population of 625 farmers and a 5% margin of error, the computed sample size was 244 respondents.

Table 1. Distribution of Respondents by Municipality

Municipality	Population (N)	Proportion (%)	Sample Size
Surallah	212	33.94	83
Sto. Niño	142	22.77	56
Norala	107	17.08	42
Banga	68	10.95	27
Lake Sebu	41	6.57	16
Polomolok	55	8.76	20
Total	625	100.00	244

Research Instrument and Data Collection

Data were collected through face-to-face interviews using a structured questionnaire. The questionnaire covered socioeconomic characteristics, farm characteristics, institutional and social factors, awareness and adoption of BCAs, perceived determinants measured using a five-point Likert scale, and constraints ranked using the Garrett ranking technique. Enumerators were oriented before fieldwork to ensure consistency, informed consent, and ethical data collection procedures (Dillman et al., 2014).

Data Analysis

Descriptive statistics summarized respondent characteristics and adoption levels. Chi-square tests examined associations between socioeconomic variables and adoption status. Regression analysis estimated the net effect of predictors on adoption. Exploratory factor analysis identified latent determinants of adoption using principal axis factoring with Varimax rotation, while Garrett ranking prioritized constraints based on farmer perceptions. Analyses were organized to align with the study objectives.

Ethical Consideration

Participation was voluntary, and informed consent was obtained from all respondents. Confidentiality and anonymity were observed, and data were used solely for academic purposes. Respect for local farming practices and cultural sensitivity was maintained throughout data collection.

RESULTS AND DISCUSSION

Profile of the Respondents

The respondents were mostly older rice farmers, with 62.3% aged 50 years and above, while only 6.1% were below 25 years old. The age pattern indicates an aging farming population, which may influence

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adoption because older farmers often rely on experiential knowledge while younger farmers may be more receptive to innovations. Gender distribution was relatively balanced, with males comprising 54.9% and females 45.1%. Educational attainment was generally moderate to high, with 46.3% reaching college level and 42.2% completing secondary education.

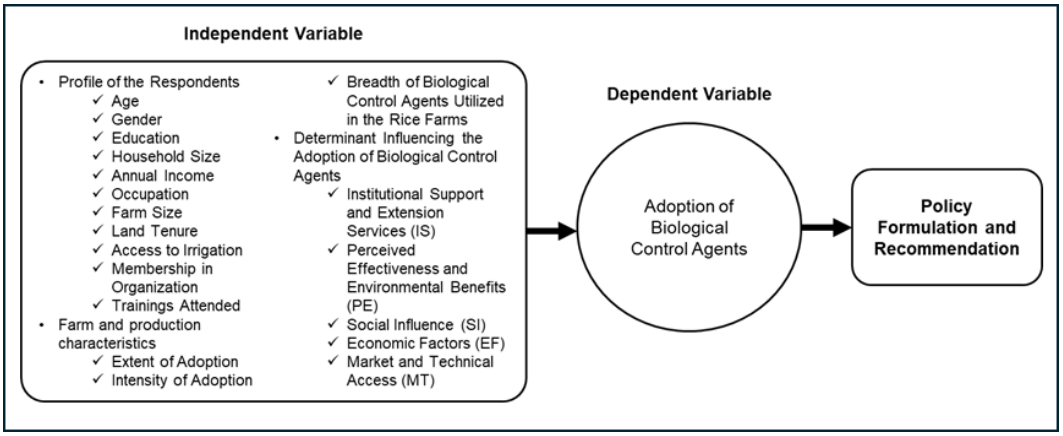

Figure 1. Conceptual paradigm of the study

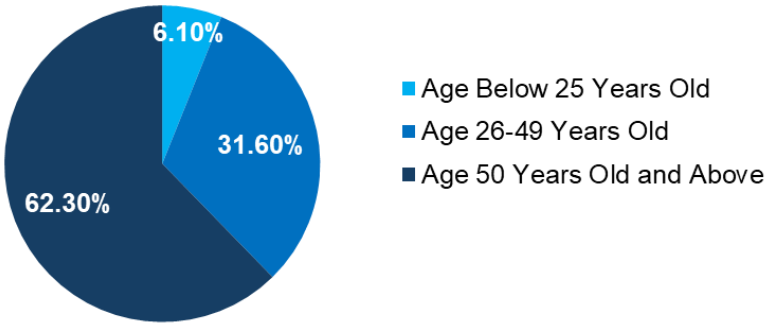

Figure 2. *Age distribution of rice farmer-respondents*

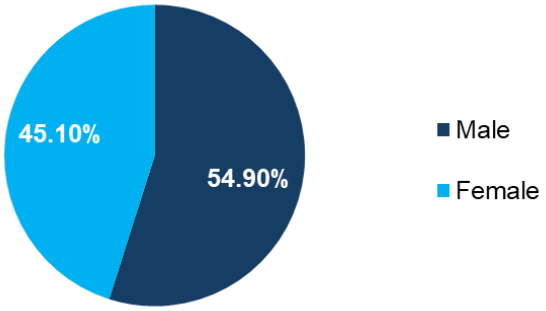

Figure 3. *Gender distribution of rice farmer-respondents*

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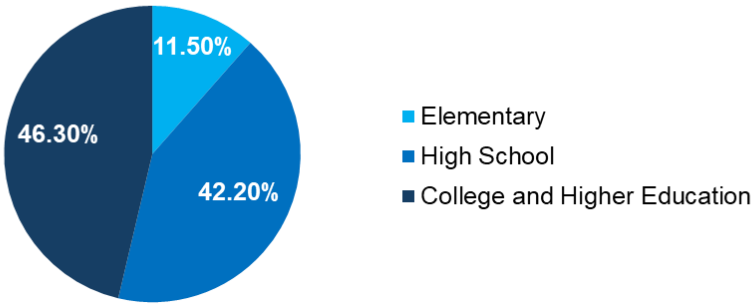

Figure 4. *Educational attainment of rice farmer-respondents*

Most households had 3-5 members (67.2%), suggesting a moderate family labor base. In terms of income, 66.4% reported annual income within the ₱10,001-50,000 bracket, reflecting limited financial capacity. Most respondents primarily worked in agriculture (83.6%), operated small to medium farms, and 63.9% owned their land. Access to irrigation was high at 88.9%, organizational membership reached 93.9%, and 59.4% had received IPM-related training. These results show that farmers had strong institutional linkages but uneven training exposure.

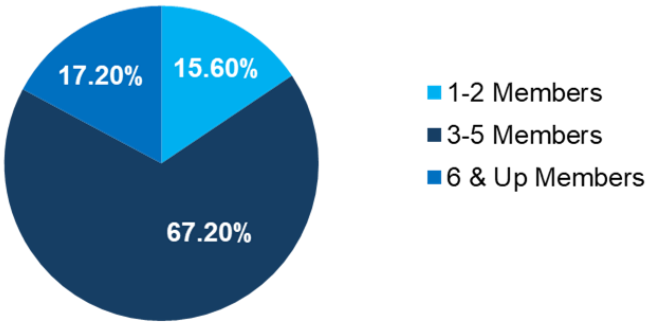

Figure 5. *Household size distribution of respondents*

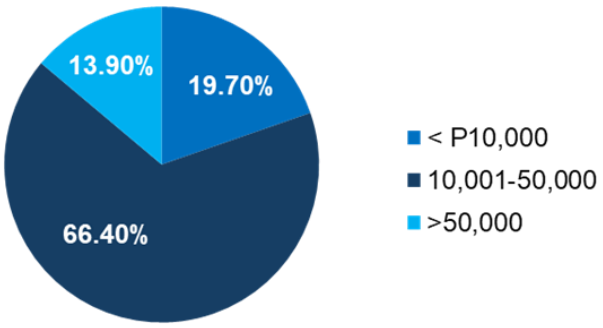

Figure 6. *Annual income distribution of respondents*

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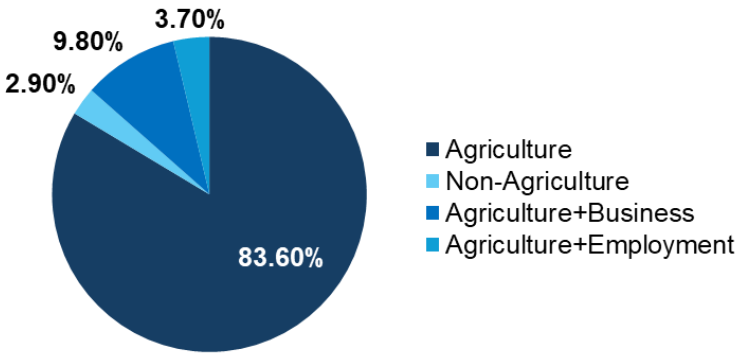

Figure 7. *Occupation profile of respondents*

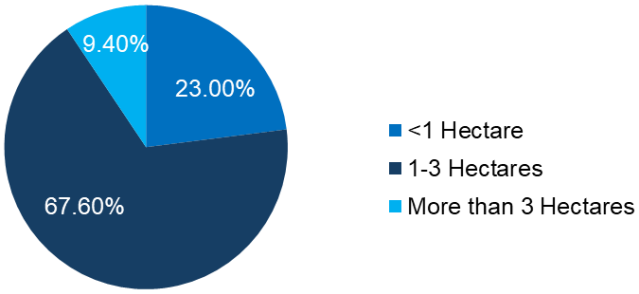

Figure 8. *Farm size distribution of respondents*

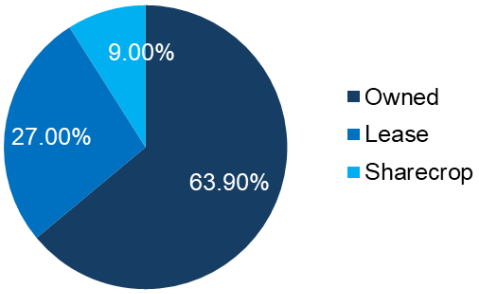

Figure 9. *Land tenure status of respondents*

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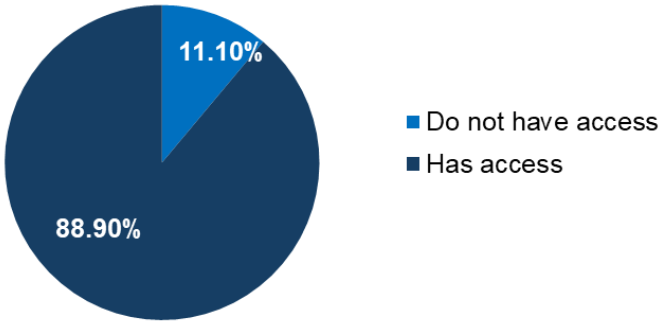

Figure 10. *Access to irrigation among respondents*

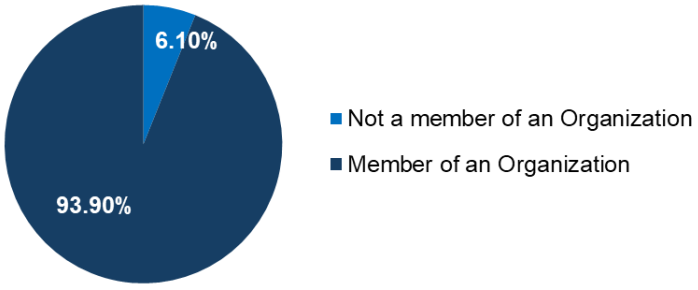

Figure 11. *Membership in farmer organizations*

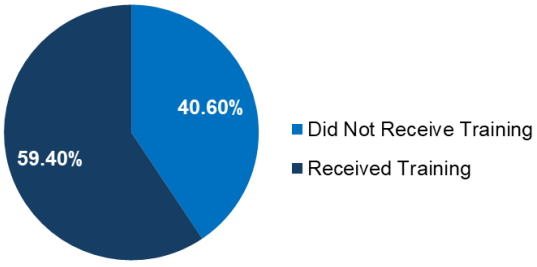

Figure 12. *Training participation of respondents*

Extent, Intensity, and Breadth of BCA Adoption

The study found that 60.7% of OPAG-assisted rice farmers had adopted BCAs, while 39.3% had not. This indicates that BCA technology has moved beyond early introduction and is approaching the early majority phase of diffusion. However, adoption remained incomplete, suggesting that some farmers still

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require additional knowledge, field validation, and confidence before shifting from chemical-based pest management.

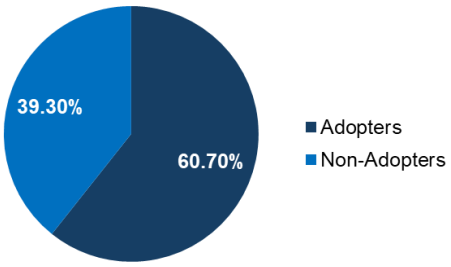

Figure 13. Extent of Adoption of the Rice Farmers on theBiological Control Agents by Number of Adopters and Non-Adopters (Adoption Status)

Figure 13. *Extent of BCA adoption among OPAG-assisted rice farmers*

Table 2. Distribution of Respondents by Duration of BCA Use

Duration of BCA Use	Frequency	Percent (%)
Less than 1 year	96	39.3
1-3 years	75	30.7
4-6 years	51	20.9
More than 6 years	22	9.0
Total	244	100.0

The duration of use shows that adoption is still developing: 39.3% had used BCAs for less than one year and 30.7% for one to three years. This pattern suggests that many adopters remain in the implementation and confirmation stages, where farmers continuously evaluate technology performance and build confidence through repeated use (Rogers, 2003).

Table 3. Utilization of Specific Biological Control Agents Among Adopters

Biological Control Agent	Applied (n)	% of Adopters	Did Not Apply (n)	% of Adopters
Trichogramma japonicum	104	70.30	44	29.70
Metarhizium anisopliae	39	26.40	109	73.60
Trichoderma harzianum	53	35.80	95	64.20

The breadth of adoption was selective. Farmers mostly used Trichogramma japonicum (70.3% of adopters), while Metarhizium anisopliae and Trichoderma harzianum were less used. This suggests that farmers favor BCAs that are more familiar, accessible, and easier to observe in terms of effect. Less familiar microbial agents may require more technical guidance, demonstration, and supply-chain support.

Relationship Between Farmer Characteristics and BCA Adoption

Chi-square results showed that most demographic and farm characteristics, including age, gender, education, household size, income, occupation, farm size, and tenure, were not significantly associated with adoption. In contrast, access to irrigation, organizational membership, training, and awareness showed significant associations. This suggests that adoption depends less on fixed farmer characteristics and more on enabling conditions that improve knowledge, confidence, and production stability.

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Table 4. *Summary of Chi-Square Test of Association Between Selected Variables and BCA Adoption*

Variable	Chi-square (p-value)	Interpretation
Age	2.812 (0.245)	Not significant
Gender	0.113 (0.736)	Not significant
Education	0.859 (0.651)	Not significant
Household size	0.643 (0.725)	Not significant
Income level	5.445 (0.066)	Not significant
Farm size	1.935 (0.380)	Not significant
Land tenure	2.263 (0.323)	Not significant
Access to irrigation	15.344 (0.000)	Significant
Membership in organization	7.737 (0.005)	Significant
Training received	92.560 (0.000)	Highly significant
Awareness of BCA technology	106.812 (0.000)	Highly significant

Regression analysis confirmed that awareness, training, irrigation access, and years of use significantly predicted adoption. Training increased the likelihood of adoption because farmers gained technical knowledge and practical skills. Awareness served as the entry point of the innovation-decision process, while irrigation created production stability that made BCA use more feasible. Income showed a negative effect, implying that higher-income farmers may continue to prefer chemical pesticides because of their immediate and predictable results.

Table 5. *Regression Summary of Significant Predictors of BCA Adoption*

Variable	t-value	p-value	Interpretation
Income	-2.959	0.003	Significant negative effect
Irrigation access	3.623	0.000	Significant positive effect
Training received	4.136	0.000	Significant positive effect
Awareness	6.358	0.000	Significant positive effect
Years of use	15.331	0.000	Highly significant indicator

Key Determinants of BCA Adoption

Exploratory factor analysis was used to identify the latent dimensions that shaped BCA adoption. The Kaiser-Meyer-Olkin value of 0.918 indicated strong sampling adequacy, and Bartlett's test of sphericity was significant ($\chi^2 = 3361.286$, $p < 0.001$), confirming that the variables were suitable for factor analysis. Five determinants were extracted: institutional support and extension services, perceived effectiveness and environmental benefits, social influence, economic factors, and market and technical access.

Table 6. *Key Determinants Identified Through Exploratory Factor Analysis*

Determinant	Key Variables	Factor Loading Range
Institutional support and extension services	IS1-IS5	0.522-0.733
Perceived effectiveness and environmental benefits	PE1-PE5	0.622-0.762
Social influence	SI1-SI5	0.485-0.749
Economic factors	EF1-EF5	0.419-0.850
Market and technical access	MT1-MT5	0.412-0.709

Institutional support emerged as a major determinant because farmers relied on extension workers, training programs, technical recommendations, and government assistance to understand and apply BCAs.

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Perceived effectiveness and environmental benefits also strongly influenced adoption, consistent with the concept of relative advantage in diffusion theory. Social influence showed that farmer organizations and peer experiences shape decisions through trust and observation. Economic factors mattered, but they were not the sole driver. Market and technical access remained a weak area, indicating that supply and advisory systems require strengthening.

Constraints Affecting BCA Adoption

Garrett ranking showed that lack of knowledge and limited market availability were the top constraints, both with a mean score of 56.56. Lack of technical guidance ranked second, followed by lack of credit or financial support, preference for chemical pesticides, and high product cost. These results confirm that the main barriers are informational, technical, and structural rather than purely demographic.

Table 7. *Garrett Ranking of Constraints Affecting BCA Adoption*

Constraint	Mean Score	Rank
Lack of knowledge about BCAs	56.56	1
Limited availability in the market	56.56	1
Lack of technical guidance	54.51	2
Lack of credit / financial support	45.29	3
Preference for chemical pesticides	42.21	4
High cost of products	41.60	5

The findings indicate that wider adoption requires more than technology promotion. Farmers need reliable access to BCAs, field-based demonstrations, continuous technical advisory services, and institutionalized support within local rice programs. A systems-based approach, including BCA integration into the Consolidated Rice Production and Mechanization Program, can help align pest management with mechanization, synchronized planting, and integrated crop management.

CONCLUSION

The study concludes that BCA adoption among OPAG-assisted rice farmers in South Cotabato is moderate, with 60.7% of farmers adopting at least one biological control agent. Adoption has reached the early majority stage but remains partial and selective, with Trichogramma japonicum used more widely than Metarhizium anisopliae and Trichoderma harzianum. Most adopters are still relatively new users, indicating that sustained field support is needed to deepen and stabilize adoption.

Adoption is not primarily determined by age, gender, education, farm size, tenure, or other socioeconomic characteristics. Rather, it is significantly influenced by awareness, training, irrigation access, organizational membership, and institutional support. The strongest determinants are institutional support, perceived effectiveness, social influence, economic considerations, and market and technical access. The major constraints are lack of knowledge, limited market availability, and insufficient technical guidance. Overall, BCA adoption in South Cotabato is knowledge-driven, institutionally mediated, and dependent on reliable access to inputs and support systems.

Recommendation

Based on the findings, local agricultural offices and program implementers should strengthen targeted extension programs that prioritize untrained and low-income farmers. Training should use field demonstrations, Farmer Field School approaches, and practical ecological pest management activities so farmers can observe BCA performance under local conditions. Awareness campaigns should be sustained to move farmers from initial knowledge to actual and continued use.

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The Provincial Government and LGUs should improve BCA availability through localized production, distribution partnerships, and technical advisory systems. BCAs should be formally integrated into the Consolidated Rice Production and Mechanization Program as part of the technological package and operations manual. This integration should include clear protocols on selection, timing, storage, compatibility, and application. Financial assistance, input support, and continuous monitoring should also be provided to reduce risk and encourage wider adoption. Future studies may examine adoption intensity, long-term field performance, cost-benefit outcomes, and behavioral factors such as risk perception and trust in ecological pest management.

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