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Adoption of Bio-pesticide among the Farmers through Internet Usage in Junagadh District of Gujarat

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ABSTRACT

This study was conducted during the month of January, 2024 to June, 2024 at Junagadh district of Gujarat. The pivotal measure for reducing pollution and facilitating green and sustainable agriculture lies in the application of biopesticides to replace chemical pesticides. The argument still rests on whether the use of the internet can assist farmers in selecting biopesticides or not. Junagadh district of Gujarat was selected for the study due to its prominent agricultural sector and the pressing need to improve biopesticide selection among local farmers. Total 160 farmers was selected for the study purpose. Probit model was applied in this article to probe the influencing factors regarding the use of the Internet on their selection of the biopesticides by farmers, and the TAM-PR model was also adopted to explore its intrinsic mechanisms. According to the research findings, the use of the Internet directly contributed to the application of biopesticides, which can affect farmers' decisions regarding biopesticides by means of perceived usefulness and perceived ease of use in an indirect manner. The result regarding perceived risk was not significant. It has a remarkable positive effect on farmers with high academic qualifications compared with those with low academic qualifications. Hence, it is of great significance to continuously facilitate the application of rural Internet usage, encourage environmentally friendly modes of production, and reduce agricultural pollution.

KEYWORDS: Internet use, biopesticides, TAM-PR model, farmer adoption behaviour

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Bio-pesticides are natural or biological agents used for controlling weeds, diseases, and pests. They come from living things including plants, animals, bacteria, fungus, viruses, and other living things (Arora and Mishra, 2016; Kumar et al., 2019; Mishra et al., 2020; Pithiya et al., 2024). The widespread application of pesticides in agriculture negatively impacts soil health by reducing beneficial bacteria, contributes to air pollution, and poses significant risks to human health. (Schreinemachers and Tipraqsa, 2012; McGinley et al., 2022; Praneetvatakul et al., 2024). To address these issues and support environmentally-friendly and sustainable agricultural practices, adopting biopesticides as an alternative to conventional pesticides is crucial. This shift helps advance green farming methods and ensures safer food for both producers and consumers (Balog et al., 2017; Arora et al., 2018; Tudi et al., 2021, Xu et al., 2021).

Farmers do not buy biopesticides, and even then, there are differences in consciousness and behaviour. Farmers often avoid using biopesticides due to limited awareness, challenges in altering their application practices, scepticism about their effectiveness, and the prevalence of chemical pesticide use in neighbouring areas (Nain et al., 2015; Huang et al., 2020; Amanjit et al., 2022; Kumar et al., 2024). Therefore, how to effectively match the demand for biopesticide information with the demand for agricultural production incomes, narrow the distance between farmers' opinions, and let biopesticides enter the homes of ordinary farmers has become an important topic in the promotion of biopesticide technology. The rapid development of the internet in rural areas helps address this issue effectively. The informational advantages of the internet are sufficient to meet farmers' needs for biopesticide information (Carr and Hayes, 2015; Zhao et al., 2021; Yang et al., 2023).

Changes in farmers' behavioural decision-making through internet use have attracted the attention of many scholars. The main reason why the internet can gradually change their decision-making behaviour is that farmers have internet thinking (Jagadeeswari et al., 2019; Joshi and Dhaliwal, 2019; Madhushekar et al., 2023). Using the internet, farmers expand their information needs in agricultural production, encourage other farmers to expand cultivated land, improve the allocation of labour resources, increase production decision-making and production efficiency, and increase peasant incomes (Ravikumar et al., 2015; Bentley et al., 2019; Panda et al., 2019; Sandeep et al., 2022). Researchers have found that the ease of access the Internet provides to knowledge and information influences farmers' adoption of green production technologies (Sheng et al., 2021; Shanmuka et al., 2022a). The use of the Internet significantly increased the adoption rate of straw return technology and enhanced the effectiveness of land conservation (Singh et al., 2021; Chen et al., 2022; Madhushekar et al., 2024). The internet has had a profound impact on farmers' adoption of green production technologies. However, some scholars believe that farmers need agricultural production information and are not interested in learning new technologies (Chowdhury et al., 2015; Singh et al., 2017; Shanmuka et al., 2022b). The aim of this article was to investigate whether internet usage could encourage farmers to adopt biopesticides and to understand how the internet impacts this adoption process. The study develops a theoretical framework connecting internet use with the adoption of biopesticides and examines their interrelationship. A TAM-PR model was created to analyse the underlying influence of internet use on farmers' adoption of biopesticides.

2. MATERIALS AND METHODS

2.1. Study sites

The present study was carried out during the month January, 2024 to June, 2024 at Junagadh district located on the Kathiawar peninsula in southwestern Gujarat with the city Junagadh, Gujarat, India as its administrative headquarters. It is located at 20° 47' N and 21° 45' N latitude and 70° 17' E and 70° 55' E longitudes.

2.2. Sampling technique

Multi-stage sampling was adopted as per the objective of study. In the first stage of sampling, the Junagadh district was selected. In the second stage two talukas was selected. At the third stage, four villages from each talukas was selected. From each villages 10 users and 10 non-users farmers was selected. In this way total 160 farmers were selected for the study purpose. Data were gathered through in-person interviews with farmers, typically conducted on their farms, using a structured questionnaire.

2.3. Statistical tools

Probit model was used to examine the use of the internet influences farmers adoption of bio-pesticides. A binary probit model with strong explanatory power for behavioural decision-making was selected to study the influencing factors of farmers use of bio-pesticides in the context of the internet.

The basic model is

$$P(Y_i=1/I_i)=\varphi(\alpha_i+\beta_i+\gamma_i X_i+\varepsilon_i) \quad \ldots\ldots(1)$$

Where,

Y_i=Farmers decision to adopt a bio-pesticide

I_i =Internet usage by respondents

X_i =Control variable

α_i, β_i, and γ_i=estimated coefficients of the regression model

ε_i=Random error

The following dependent variable and independent variables was used:

Dependent variable

Y=Bio-pesticides adoption (Yes / No)

Explanatory variable

X_1=Internet use (Yes / No)

Control variables

X_2=Gender (Male / Female)

X_3=Age

X_4=Education (Illiterate / Primary school/High school/ College)

X_5=Land size (ha)

X_6=Agricultural technology training (Yes / No)

X_7=Family labour

X_8=Farming annual income (Rs.)

X_9=Distance from village to township (km)

X_{10}=Health awareness (Yes / No)

X_{11}=Environmental awareness (Yes / No)

Mediators

X_{12}=Perceived usefulness (Disagree / Neutral / Agree)

• Bio-pesticides have an environmental protection effect.

• Bio-pesticides can let me get better profits.

• Bio-pesticides help me to reduce the use of chemical pesticides.

X_{13}=Perceived ease of use (Disagree / Neutral / Agree)

• Learning about bio-pesticide technology is very easy.

• Through simple training, bio-pesticide technology can be easily mastered.

• Through technical explanation, it is easy to understand the basic principles of bio-pesticide

X_{14}=Perceived risk (Disagree / Neutral / Agree)

• Worried that applying bio-pesticides will not effectively remove pests and diseases.

• Worried that bio-pesticides and chemical pesticides cannot be applied together.

• Worried about not skillfully mastering bio-pesticides, resulting in poor results.

3. RESULTS AND DISCUSSION

The analysis obtained from primary data collected with the structured questionnaire. A total number of 160 farmers were systematically and randomly selected and interviewed. Probit model was used in determining the factors influencing adoption of bio-pesticide.

3.1. Model 1. Only internet variable

As shown in Table 1, the chi-square value (71.46) was significant at 1%, indicating that the overall model 1 was highly significant. In this model the regression result adding only the internet application variable, and the results show that internet (p=0.001) was statistically positive significant at 1% level of significance. This indicates that internet use can significantly promote the adoption of bio-pesticides.

Table 1: Estimates of internet use on adoption of bio-pes ticide

Parameter	B	Std. Error	Sig.
(Intercept)	-0.88	0.17	0.007
Internet	1.71***	0.21	0.001

Chi-square: 71.46***; n=160; ***significant (p=0.01)

3.2. Model 2. Control variables

After adding control variables model 2 was estimated and result shown in table 2. As shown in Table 2, the chi-square value (73.61) was significant at 1%, indicating that the overall model 2 was highly significant. Among the variables, internet use (p=0.001) was statistically positive significant at 1% level of significance. Indicates that internet can increase the adoption of bio-pesticide. Education (p=0.028) and land size (0.034) pass the 5% significance level hence both have a significant positive effect on the adoption of bio-pesticide. It is confident to conclude that the higher the education level of the farmers and the larger the scales of planting, the more likely to adopt bio-pesticide. Health awareness (p=0.069) and environmental awareness (p=0.087) were statistically positive significant at 1% level of significance.

Table 2: Factors influencing adoption of bio-pesticide

Parameter	B	Std. Error	Sig.
(Intercept)	-2.99	1.63	0.067
Internet uses	1.79***	0.24	0.001
Age	-0.03	0.02	0.198
Education	0.75**	0.23	0.028
Land size	0.43**	0.12	0.034
Agricultural training	0.19	0.22	0.370
Family labour	0.16	0.17	0.334
Farming income	0.33	0.24	0.196
Distance	-0.12	0.14	0.920
Health awareness	0.87*	0.28	0.069
Environmental awareness	0.94*	0.42	0.087

Chi-square: 73.61***; n=160; ***significant (p=0.01), **significant (p=0.05) and *significant (p=0.001)

That indicates awareness of bio-pesticide can increase the adoption of bio-pesticide.

3.3. Model 3. Perceived usefulness

For the purpose of further analysing the transmission mechanism of bio-pesticides caused by internet use among farmers, the model 3 was constructed by adding three variables of perceived usefulness. As shown in Table 3, the chi-square value (70.24) was significant at 1%, indicating that the overall model 3 was highly significant. Internet uses (p=0.001) was statistically positive significant at 1% level of significance. That indicates the use of the internet can promote the perceived usefulness of bio-pesticide adoption among farmers. Other variables such as education, land size, health awareness and environmental awareness were all positively significant that encourage farmers to adopt bio-pesticides.

Table 3: Factors influencing adoption of bio-pesticide by perceived usefulness

Parameter	B	Std. error	Sig.
(Intercept)	-2.96	1.73	0.088
Internet uses	0.88***	0.25	0.001
Age	0.02	0.024	0.304
Education	0.73**	0.24	0.032
Land size	0.42**	0.12	0.047
Agricultural training	0.28	0.23	0.222
Family labour	0.14	0.17	0.403
Farming income	0.35	0.19	0.174
Distance	-0.16	0.20	0.734
Health awareness	0.83*	0.29	0.056
Environment awareness	0.96*	0.47	0.067
Bio-pesticides have an environmental protection effect	0.68*	0.23	0.072
Bio-pesticides can let me get better profits	0.83**	0.22	0.041
Bio-pesticides help me to reduce the use of chemical pesticides	0.09	0.18	0.622

Chi-square : 70.24***; n=160; ***significant (p=0.01), **significant (p=0.05) and *significant (p=0.001)

Bio-pesticides have an environmental protection effect (p=0.072) and bio-pesticides can let me get better profits (p=0.041) both were statistically positive significant at 10% level of significance. These two variables are perceived usefulness can significantly encourage farmers to adopt bio-pesticides.

3.4. Model 4. Perceived ease of use

Model 4 was developed by adding three variables related to perceived ease of use. As shown in Table 4, the chi-square value (71.32) was significant at 1%, indicating that the overall model 4 was highly significant. Internet uses (p=0.002) was statistically positive significant at 1% level of significance. That indicates the use of the internet can promote the perceived ease of use of bio-pesticide adoption among farmers. Other variables such as education, land size, health awareness and environmental awareness were all positively significant that encourage farmers to adopt bio-pesticides.

Learning about bio-pesticide technology is very easy (p=0.009), through simple training, bio-pesticide technology can be easily mastered (p=0.06) and through technical explanation, it is easy to understand the basic principles of bio-pesticide (p=0.010) were all statistically positive significant at 1% level of significance. These three variables are perceived ease of use can significantly encourage farmers to adopt bio-pesticides.

3.5. Model 5. Perceived risk

Model 5 was constructed by adding three variables of

Table 4: Factors influencing adoption of bio-pesticide by perceived ease of use

Parameter	B	Std. error	Sig.
(Intercept)	-2.08	1.76	0.038
Internet uses	1.74***	0.24	0.002
Age	0.02	0.02	0.256
Education	0.74**	0.23	0.045
Land size	0.46**	0.12	0.031
Agricultural training	0.17	0.23	0.455
Family labour	0.13	0.17	0.437
Farming income	0.40	0.20	0.147
Distance	0.17	0.21	0.682
Health awareness	0.93*	0.49	0.059
Environment awareness	0.98*	0.53	0.074
Learning about bio-pesticide technology is very easy	0.76***	0.13	0.009
Through simple training, bio-pesticide technology can be easily mastered	0.71***	0.14	0.006
Through technical explanation, it is easy to understand the basic principles of bio-pesticide	0.82***	0.15	0.010

Chi-square: 71.32***; n=160; ***significant (p=0.01), **significant (p=0.05) and *significant (p=0.001)

perceived risk. As shown in Table 5, the chi-square value (72.68) was significant at 1%, indicating that the overall model 5 was highly significant. Internet uses (p=0.001) was statistically positive significant at 1% level of significance. That indicates the use of the internet can promote the of bio-pesticide adoption among farmers. Other variables such as education, land size, health awareness and environmental awareness were all positively significant that encourage farmers to adopt bio-pesticides. Worried that applying bio-pesticides will not effectively remove pests and diseases, worried that bio-pesticides and chemical pesticides cannot be applied together and worried about not skilfully mastering bio-pesticides, resulting in poor results were not significant.

Table 5: Factors influencing adoption of bio-pesticide by perceived risk

Parameter	B	Std. Error	Sig.
(Intercept)	-2.56	1.87	0.170
Internet uses	1.77***	0.24	0.001
Age	0.03	0.02	0.206
Education	0.75**	0.23	0.036
Land size	0.43**	0.12	0.049
Agricultural training	0.18	0.23	0.421
Family labour	0.16	0.17	0.328
Farming income	0.33	0.24	0.195
Distance	-0.12	0.14	0.899
Health awareness	0.88*	0.48	0.068
Environment awareness	0.99*	0.43	0.053
Worried that applying bio-pesticides will not effectively remove pests and diseases	-0.02	0.17	0.884
Worried that bio-pesticides and chemical pesticides cannot be applied together	-0.06	0.15	0.686
Worried about not skilfully mastering bio-pesticides, resulting in poor results	-0.10	0.17	0.573

Chi-square : 72.68***; n=160; ***significant (p=0.01), **significant (p=0.05) and *significant (p=0.001)

4. CONCLUSION

The internet could effectively encourage farmers to adopt biopesticides by highlighting their benefits and ease of use. Internet access varies with farmers' education, awareness, and farm size, influenced biopesticide adoption. As digital agriculture advances, guiding farmers online was found essential for fostering eco-friendly practices and supporting sustainable agricultural development.

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