



Drivers of IPM Adoption among Hybrid Tomato Farmers in Karnataka: Insights through Mlogit Model

Sudhanand Prasad Lal^{1*}, K. N. Sunil Kumar² and Gyan Shukla³

¹Assistant Professor cum Scientist, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur-848125, Bihar, India

²Territory Business Manager, Mahyco Seeds Private Limited, Mysore-563135, Karnataka, India

³Ph.D. Scholar, Department of Extension Education, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, U.P., India

*Corresponding author email id: sudhanand.lal@rpcau.ac.in

HIGHLIGHTS

- Cultural and chemical practices were found to be more prevalent in IPM practices than physical and biological practices regarding hybrid tomatoes.
- In the MLR model, Nagelkerke's R-square revealed that selected explanatory variables explained 60.90 per cent of variations in the adoption level of IPM practices.
- MLR model identified factors influencing the adoption of IPM were age ($p=0.021$), education ($p=0.022$), Extension contact ($p=0.013$), and cosmopolitaness ($p=0.029$).

ARTICLE INFO

Keywords: Adoption, Hybrid tomato, Integrated pest management, Multinomial logistic regression, Sustainable agriculture..

<https://doi.org/10.48165/IJEE.2025.61109>

Conflict of Interest: None

Research ethics statement(s):

Informed consent of the participants

ABSTRACT

The investigation was undertaken during 2020 to study the adoption level of IPM practices and the factors influencing adoption among hybrid tomato growers in Karnataka as such studies are scanty in India despite 60 per cent market share of hybrid tomato. Primary data were collected using a structured interview schedule by personally interviewing 120 respondents. Findings revealed that cultural practices like crop rotation, exhibited higher adoption rates, while biological methods were relatively less adopted. Overall, IPM adoption remained limited, with only a small proportion of growers fully embracing these practices. Multinomial logistic regression (MLR) had Nagelkerke's R-square or Pseudo R^2 value of 0.609, indicating 60.90 per cent of total variations in the adoption level of IPM practices, explained by selected explanatory variables. Further, MLR identified factors significantly influencing the adoption of IPM were age ($p=0.021$), education ($p=0.022$), Extension contact ($p=0.013$), and cosmopolitaness ($p=0.029$) (odds ratio [OR], 6.707; 95% CI of OR 1.211 to 37.158) found significant at 5% level ($p<0.05$); while social participation ($p=0.076$) was found significant at 10 per cent level ($p<0.10$). Targeted interventions and training programmes are needed to promote sustainable practices, particularly among hybrid tomato growers, addressing barriers and enhancing the adoption of IPM practices.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) ranks as the fourth most economically significant food crop globally and is cultivated across nearly all countries (Schreinemachers et al., 2018). India contributes 11 per cent of the world's total tomato production, making it the

second-largest producer after China (FAO, 2020). However, tomato plants are highly vulnerable to a wide range of insect pests and plant diseases, collectively referred to as "pests", posing a continuous challenge for farmers to safeguard their crops effectively. NIFA (2023) reported that pests cause extensive damage to other agricultural products across the globe accounts 20-40 per cent

annually, whereas about 30-35 per cent annual yield loss in India (The Hindu, Feb. 25; 2017). Due to poor knowledge, farmers often resort to using excessive and imbalanced amounts of chemical pesticides to safeguard their crops (Depenbusch et al., 2023). The farmers need information about IPM practices on the utmost prominence for sustainable and effective management of pests (Shukla et al., 2024a). Since the last three decades, pesticide use has increased almost a couple of fold worldwide. Globally, the application of pesticides per area of cropland is 1.8 kg ha⁻¹, and India is one of the top ten (Globally, 9th rank) pesticide consumer countries in the world (FAO, 2022). While chemical pesticides are widely recognised for their effectiveness, their indiscriminate use harms beneficial insects, non-target plants, soil, and the environment, as well as the presence of residues in food products, which pose risks to human health too (Mancini et al., 2005; Stehle & Schulz, 2015; Kariathi et al., 2016). So, the realisation has set that the use of solely synthetic pesticides is not economically and environmentally sound for controlling pests. Deleterious effects of chemical pesticides on human health and the ecosystem have forced agriculturists to look at IPM which is a harmonious integration of cultural practices, plant products-based formulations, and bio-agents (Kogan, 1998) for lessening the quantum of deadly pesticides. This method is considered to be economical, effective, practical, protective, and eco-friendly.

Narayanaswamy et al., (2013) reported that adoption of IPM practices among the Tomato farmers in Karnataka brought the benefit cost ratio increased from 1.7 to 2.3 as compared to non-adaptor of IPM practices. The yield was also obtained 18.2 tons acre⁻¹ by IPM adopter farmers as compared to 16.1 tons acre⁻¹ in non-IPM farmers. Despite its technical and economic advantages and its environmentally friendly approach compared to conventional chemical methods, IPM adoption remains limited to just about 2% of the area treated with plant protection inputs (Rao & Rao, 2010). So, the present study investigation was undertaken to study the adoption level of IPM practices among hybrid tomato growers as such studies are scanty in India despite 60 per cent of hybrid tomato market share.

METHODOLOGY

An ex-post facto study was conducted to measure the adoption level of IPM practices (Srivastava et al., 2024) and its socio-economic determinants among hybrid tomato growers in the Kolar district of Karnataka in 2020. The Kolar district was purposely selected as the district occupied first position both in area and production of tomatoes among the districts of Karnataka. Two blocks of the Kolar district namely Srinivasapura and Mulbagal; and three villages from each selected block were chosen through a simple random sampling method. Furthermore, from each selected village, 20 respondents were selected on a random basis. Thus, a total sample constituted 120 respondents (hybrid tomato growers) for the study purpose. Primary data were collected from respondents by personally interviewing the respondents with the help of a structured interview schedule.

The adoption of IPM practices by respondents was assessed using an interview schedule comprising 29 questions categorised into four groups: i) Cultural control, ii) Mechanical control, iii)

Chemical control, and iv) Biological control. Responses were quantified by assigning scores of “2” for full adoption, “1” for partial adoption, and “0” for non-adoption. The adoption score for each statement was determined using the following formula Chattopadhyay & Pareek (1967):

$$\text{Adoption scores} = \sum n_2 \times 2 + \sum n_1 \times 1 + \sum n_0 \times 0$$

Where, n_2 = number of items belonging to the full adoption category

n_1 = number of items belonging to the partial adoption category

n_0 = number of items belongs the non-adoption category

Based on obtained adoption score, respondents were categorised as fully adopted, partially adopted, and not adopted adoption categories using the arithmetic mean ($\bar{x}$) and standard deviation (σ). The overall adoption score was computed by obtaining the average adoption score of all four sub-categories. A multinomial logistic regression model was used for analysing the determinants of the adoption level of IPM practices among hybrid tomato growers. It is used when the responses of the dependent variable have more than two nominal categories (namely fully adopted, partially adopted, and not adopted). In the social science research, the major advantage of using multinomial logistic regression over multiple linear regression is, prior does not require continuous and numerically normal distribution of data (Petrucci, 2009; Kumari, et al., 2022; Kumar & Lahiri, 2023; Verma, et al., 2023).

RESULTS

Adoption level of cultural practices by hybrid tomato cultivators

Table 1(a) provides an overview of the adoption of various cultural practices among tomato growers, along with the total adoption score. Among the various IPM practices listed under the cultural practices category, summer ploughing garnered a mixed response, with 3.33 per cent of farmers fully adopting it, 75 per cent partially adopting it, and 21.67 per cent not adopting it. Timely removal and destruction of tomato stubbles and burning of residues saw higher partial adoption at 60 per cent, with 15.83 per cent fully adopting it. Non-stocking of diseased plants near the field received a relatively balanced response, with 25 per cent fully adopting it, 37.50 per cent partially adopting it, and the same percentage not adopting it. Notably, practices like the non-burning of LDPE mulch papers and the use of photodegradable and biodegradable plastic mulch showed lower adoption rates overall. Crop rotation with different crops and stacking immediately after flowering with support sticks had relatively higher levels of adoption, with 26.67 per cent and 28.33 per cent fully adopting them, respectively.

Adoption level of physical/mechanical practices by hybrid tomato cultivators

Table 1(b) outlines the adoption levels of various physical and mechanical practices employed by tomato growers along with the total adoption score. Rouging of plants affected by bacterial wilt exhibited relatively low adoption rates, with only 6.67 per cent of farmers fully adopting it, while 21.67 per cent partially adopted

Table 1. Practice-wise Adoption of IPM methods by hybrid Tomato cultivators

S.No.	Cultural Practices	Adoption			Total Adoption Score
		FA (%)	PA (%)	NA (%)	
1.a)					
1	Summer ploughing	3.33	75.00	21.67	98
2	Timely removal and destruction of tomato stubbles and burning of residues	15.83	60.00	24.17	110
3	Non-stocking of diseased plants near the field	25.00	37.50	37.50	105
4	Non-burning of LDPE mulch papers	3.33	20.83	75.84	33
5	Photodegradable and biodegradable plastic mulch	1.67	20.83	77.50	29
6	Different trap crops grown in hybrid tomato (Marigold, Maize, Cucumber, Cowpea)	3.33	25.00	71.67	38
7	Crop-rotation with different crops like (Beans, Field Bean, Capsicum, Chilli)	26.67	38.33	35.00	110
8	Different Intercrops grow in hybrid tomato crops (Okra, Onion, Radish)	7.50	46.67	45.83	74
9	Stacking immediately after flowering with the help of eucalyptus/bamboo sticks	28.33	38.33	33.34	114
1.b)	Physical/Mechanical Practices				
1	Rouging of plants affected by bacterial wilt	6.67	21.67	71.66	42
2	Use of yellow sticky traps to control white flies	15.00	26.67	58.33	68
3	Use of flower model traps to control thrips	2.50	7.50	90.00	15
4	Use of mulching with black low-density polyethylene (LDPE) sheet to control weed growth and conserve moisture	8.33	58.33	33.34	90
5	Use of biodegradable plastic mulch which increases fruit yield and quality	4.17	5.00	90.83	16
6	Use of light traps (2 units acre ⁻¹)	4.17	4.17	91.66	15
7	Use of green nylon net around hybrid tomato field to control white flies	20.83	25.00	54.17	80
8	Use of methyl eugenol pheromone trap to control fruit flies	12.50	35.00	52.50	72
1.c)	Chemical Practices				
1	Different Systemic fungicides (To control Late Blight)	40.83	39.17	20.00	145
2	Different systemic and contact fungicides	12.50	59.17	28.33	101
3	Different insecticides (To control chewing and sucking pests)	36.67	20.83	42.50	113
4	Different systemic and contact insecticides	14.17	51.67	34.17	96
5	Selective and non-selective herbicides (To control weeds)	15.00	8.33	76.67	46
6	ETL of pest control	2.50	12.50	85.00	21
1.d)	Biological Practices				
1	Use of larval parasite like (<i>Bracon spp</i> , <i>Ichneumon spp</i> , <i>Campoletis spp</i>)	0.83	0.83	1198.34	3
2	Use of egg parasitoids like (<i>Trichogramma spp</i> , <i>Tetrastichusspp</i> , <i>Telonomus spp</i>)	1.67	2.50	95.83	7
3	Use of predators like (Red ants, Dragonfly, Ladybird beetle)	0.83	0.83	98.34	3
4	Grow pulses or cow peas on the bunds to build natural enemy fauna	20.00	8.33	51.67	82
5	NPV (<i>Nuclear Polyhedrosis Virus</i>) 100 LE /acre	0.00	0.83	99.17	1
6	Seed treatment with <i>Trichoderma viride</i> / <i>Trichoderma harzianum</i> (2g/100gm seed)	2.50	3.33	94.17	10

FA=Full Adoption; PA=Partial Adoption; NA=Non-Adoption

it, and 71.66 per cent did not adopt it. Similarly, the use of yellow sticky traps for controlling white flies saw moderate adoption, with 15 per cent fully adopting it and 26.67 per cent partially adopting it. Conversely, practices like using flower model traps for thrips control and employing light traps showed limited adoption, with the majority of farmers not utilizing these methods. Mulching with black low-density polyethylene (LDPE) sheets for weed control and moisture conservation had moderate adoption, with 8.33 per cent fully adopting it and 58.33 per cent partially adopting it. Adoption rates were notably low for the use of biodegradable plastic mulch and light traps. However, the use of green nylon nets around hybrid tomato fields for white fly control and methyl eugenol pheromone had relatively higher adoption rates, with 20.83 per cent and 12.50 per cent of farmers fully adopting them, respectively.

Practice-wise adoption level of chemicals by hybrid tomato cultivators

Table 1(c) provides insights into the adoption rates of various chemical practices employed by tomato farmers, alongside the total adoption score. For controlling late blight, different systemic fungicides such as Dimethomorph, Tebuconazole, Metalaxyl, and Tricyclazole combined with Hexaconazole showed relatively high adoption rates, with 40.83 per cent fully adopting and 39.17 per cent partially adopting them. Conversely, practices involving systemic and contact fungicides saw moderate adoption, with Metalaxyl combined with Mancozeb and Tricyclazole combined with Mancozeb exhibiting 12.50 per cent full adoption and 59.17 per cent partial adoption. In terms of insecticide usage for chewing and sucking pest control, various options like Acephate, Fipronil,

Spinosad, Abamectin, Lambda-cyhalothrin, Thiamethoxam, and Imidacloprid were employed, with 36.67 per cent fully adopting and 20.83 per cent partially adopting them. Similarly, systemic and contact insecticides, including Beta cyfluthrin combined with Imidacloprid and Fipronil combined with Imidacloprid, demonstrated moderate adoption rates, with 14.17 per cent fully adopting and 51.67 per cent partially adopting them. Selective and non-selective herbicides for weed control, such as Metribuzin, Oxyfluorfen, Paraquat Dichloride, and Glyphosate, showed varying adoption rates, with 15 per cent fully adopting and 8.33 per cent partially adopting them. Additionally, the concept of Economic Threshold Level (ETL) for pest control exhibited low adoption rates, with only 2.50 per cent fully adopting it and 12.50 per cent partially adopting it.

Adoption level of biological practices by hybrid tomato cultivators

Table 1(d) outlines the adoption rates of various biological practices utilised by tomato farmers, alongside the total adoption score. Adoption of larval parasites like *Bracon spp.*, *Ichneumon spp.*, and *Camptoplex spp.* were minimal, with only 0.83 per cent fully adopting and 0.83 per cent partially adopting them, while the majority, accounting for 98.34%, did not adopt these practices. Similarly, the use of egg parasitoids such as *Trichogramma spp.*, *Tetrastichus spp.*, and *Telenomus spp.* showed limited adoption, with 1.67 per cent fully adopting, and 2.50 per cent partially adopting them, while 95.83 per cent did not adopt these methods. Predators like red ants, dragonflies, and ladybird beetles also saw minimal adoption, with only 0.83 per cent fully adopting and 0.83 per cent partially adopting them, while the vast majority, constituting 98.34 per cent, did not adopt these predator species. However, the practice of growing pulses or cowpeas on bunds to enhance natural enemy fauna displayed relatively higher adoption rates, with 20.00 per cent fully adopting and 28.33 per cent partially adopting them, although 51.67 per cent did not adopt this method. Adoption of NPV (Nuclear Polyhedrosis Virus) at a rate of 100 LE per acre was not fully adopted by any of the respondents and 0.83 per cent partially adopted it while 99.17 per cent did not adopt this approach. Seed treatment with *Trichoderma viride* or *Trichoderma harzianum* at a rate of 2g per 100g seed exhibited moderate adoption, with 2.50 per cent fully adopting and 3.33 per cent partially adopting it, while 94.17 per cent did not adopt this seed treatment method.

Overall adoption level IPM technology among hybrid tomato growers

Figure 1, provides an overview of the overall adoption levels of Integrated Pest Management (IPM) technology among hybrid tomato growers, categorized into fully adopted, partially adopted, and not adopted. Among the surveyed growers, 1.67 per cent fully adopted IPM technology, indicating a small but notable portion of growers who have fully integrated IPM practices into their tomato cultivation methods. Additionally, 20.00 per cent of growers partially adopted IPM technology, suggesting that a significant portion has incorporated some IPM practices but may not have fully implemented the entire range of strategies. Conversely, the

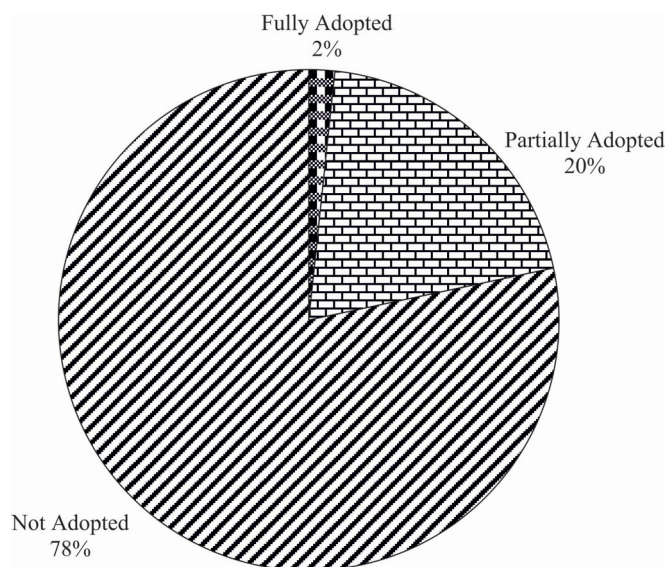


Figure 1. Over-all IPM Adoption Level vis-a-vis Hybrid Tomato

majority of hybrid tomato growers, comprising 78.33 per cent, have not adopted IPM technology at all. This indicates a substantial portion of growers who have yet to embrace or implement IPM practices in their tomato farming operations. Overall, while there is a small segment of growers who have fully embraced IPM, there remains a considerable opportunity for further education, outreach, and support to encourage broader adoption of IPM strategies among hybrid tomato growers.

Multinomial logistic regression between the adoption level of hybrid tomato cultivators and various factors affecting it

The multinomial (polytomous) logistic regression model is an extension of the binomial logistic regression model previously employed by Shukla et al., (2024b) to analyse the factors influencing farmers' information-seeking behaviour through mobile phones. It ought to be mentioned here at the outset that the multinomial logistic regression model was used for the entire 3 broad categories tested in below Table 2. The criterion level was set to declare a particular respondent in any of the 3 categories viz., Non-adoption, Partial adoption, and Full adoption (Shil et al., 2022). The result of multinomial logistic regression (mlogit model) on determinates of adoption is presented in the below table using 'Non-adoption' as the reference category.

Table 2 revealed that Nagelkerke's R-square or Pseudo R² was 0.609, indicating that 60.90 per cent of the variations in the dependent variable i.e., adoption of IPM practices, were explained by the selected explanatory variables. Table 3 depicted explanatory variables incorporated in the model: Age, year of schooling, family education status, tomato farming experience, social participation,

Table 2. Multinomial logistic regression between the Adoption level of hybrid tomato cultivators and various factors affecting it

	Pseudo R-Square
Cox and Snell	0.462
Nagelkerke	0.609
McFadden	0.435

Table 3. Parameter Estimates of Multinomial Logistic Regression Analysis

Adoption	B	Std. Error	Wald	df	Sig.	Exp(B)	95% CI of Exp(B)	
							Lower Bound	Upper Bound
Intercept	-3.177	6.402	0.246	1	.620			
Age (yr)	-0.202	0.088	5.314	1	.021**	0.817	0.688	0.970
Year of Schooling	0.042	0.157	0.073	1	.787	1.043	0.767	1.420
FES	-0.345	0.532	0.420	1	.517	0.708	0.250	2.009
Tomato farming Experience (yr)	0.063	0.107	0.341	1	.559	1.065	0.863	1.314
Social Participation	-0.116	0.158	0.539	1	.463	0.891	0.654	1.213
Occupation	1.577	0.992	2.527	1	.112	4.839	0.693	33.810
Annual Family Income (Rs)	0.145	0.155	0.872	1	.350	1.156	0.853	1.567
Landholding (ha)	0.527	0.848	0.386	1	.534	1.694	0.321	8.930
Extension Contact	0.604	0.308	3.850	1	.050	1.830	1.001	3.346
Mass media exposure	-0.086	0.159	0.292	1	.589	0.918	0.672	1.253
Cosmopolitiness	1.155	0.728	2.519	1	.112	3.174	0.762	13.217
Intercept	11.329	7.583	2.232	1	.135			
Age	-0.312	0.097	10.399	1	.001***	0.732	0.605	0.885
Year of Schooling	0.606	0.265	5.222	1	.022**	1.833	1.090	3.081
FES	-0.401	0.601	0.445	1	.505	0.670	0.206	2.176
Tomato farming Experience	0.139	0.118	1.391	1	.238	1.149	0.912	1.449
Social Participation	-0.333	0.188	3.150	1	.076*	0.716	0.496	1.035
Occupation	1.602	1.042	2.361	1	.124	4.962	0.643	38.280
Annual Family Income	0.136	0.159	0.736	1	.391	1.146	0.839	1.565
Landholding	-0.020	0.954	0.000	1	.984	0.980	0.151	6.359
Extension Contact	0.809	0.325	6.212	1	.013**	2.246	1.189	4.243
Mass media exposure	-0.049	0.190	0.067	1	.0796	0.952	0.656	1.381
Cosmopolitiness	1.903	0.874	4.747	1	.029**	6.707	1.211	37.158

The reference category is Non-adoption; Std. Error=SE; 99% CI= 99% Confidence Interval for Exp(B)/Odds ratio (OR); Exp (B)=Exponential of estimate; CI=Confidence Interval; McFadden(.435), Cox and Snell (.462), Nagelkerke .609) Pseudo R-Square values; *significant at 1% level ($P<0.01$); *** Indicates significant at 1% level of significance, in a two-tailed test, ** Indicates significant at 5% level of significance, in a two-tailed test, * Indicates significant at 10% level of significance, in a two-tailed test.

occupation, annual family income, land holding, extension contact, mass media exposure, and cosmopolitiness. Among the 11 variables taken to the model only 5 variables viz., Age, year of schooling, social participation, extension contact, and cosmopolitiness were found to be significant. Age was statistically significant at 5% level with $p=0.021$, with the fair Wald statistics value of 10.399 vis-à-vis to soar a non-adoption category to fall under partial adoption category and for the significant value decrease at $p<0.01$ ($p=.001$) to move from partial to full adoption category. Years of schooling was significant at 5% with $p=0.022$ to increase from the reference category to the full adoption category. With the fair wald statistics value of 3.150 vis-à-vis to soar from the non-adoption category to the full adoption category. Social participation was statistically positively significant at 10% with $p=0.076$, with the fair wald statistics value of 4.747 vis-à-vis to soar from the non-adoption category to the full adoption category. Social contact was statistically positively significant at 5% with $p=0.013$, with the fair wald statistics value of 6.212 vis-à-vis to soar from the non-adoption category to the full adoption category. Cosmopoliteness was positively significant at a 5% level with $p=0.029$, with the fair Wald statistics value of 4.747 vis-à-vis to soar from the non-adoption category to the full adoption category. The findings were contradictory to the findings of Lal (2017) whereas ‘Polychotomous Logistic Regression’ for the MH-20 scale divulged

that a unit increase in the ‘adoption’ variable can increase the odds of immediate attention (the reference category) farmers to become a mentally healthy farmer by 311.50% i.e. (odds ratio [OR], 4.115; 99% CI of OR 1.344 to 12.603) at 5% significance level with Nagelkerke Pseudo R-Square values of 0.744.

DISCUSSION

The results of the study on the adoption levels of IPM practices among hybrid tomato cultivators reveal diverse patterns of adoption influenced by socioeconomic factors and the perceived benefits of each practice. Cultural practices, such as crop rotation and stacking with support sticks, showed relatively higher adoption rates. However, other practices like summer ploughing and the non-burning of LDPE mulch paper were adopted less frequently. The high rate of partial adoption for summer ploughing suggests that while farmers recognize some benefits, there may be barriers to fully integrating these practices, such as labour intensity or insufficient understanding of long-term benefits. In the case of physical and mechanical practices, low adoption rates for critical methods like rouging and flower model traps point to a lack of awareness or accessibility. Conversely, practices like using green nylon nets for white fly control were more widely adopted, indicating that farmers are more likely to adopt visible, effective methods. This suggests the need for more targeted training and demonstrations to increase

the uptake of less familiar but beneficial practices. The adoption of chemical practices also varied, with the majority of farmers fully adopting systemic fungicides for late blight control, showing a preference for familiar chemical solutions. However, low adoption rates of Economic Threshold Levels (ETL) highlight a gap in understanding or trust in this integrated approach, likely due to limited education on its long-term advantages. Meanwhile, biological practices that had particularly low adoption rates among farmers are the use of larval parasites or egg parasitoids. The overwhelmingly high non-adoption rate for larval parasites underscores a significant lack of awareness about the efficacy of biological controls, suggesting an urgent need for educational outreach to promote sustainable, non-chemical pest management solutions.

The study also highlights the influence of socio-economic factors on the adoption of IPM practices. Age was found to be a significant determinant, with older farmers showing greater resistance to adopting new methods, possibly due to established routines or skepticism. On the other hand, higher levels of education were positively correlated with adoption, indicating that schooling plays a crucial role in fostering openness to innovative agricultural practices. Social participation and access to agricultural extension services also had a significant impact on adoption rates, emphasizing the importance of community engagement and extension services in promoting sustainable practices. The Nagelkerke R-square value suggests that these socioeconomic factors account for a substantial proportion of the variability in adoption levels, reinforcing the need for interventions tailored to these variables. These findings have important implications for policymakers and future research. There is a clear need for comprehensive education and outreach programs to promote the adoption of IPM practices among hybrid tomato growers. Policymakers should focus on initiatives that improve access to training on sustainable practices, particularly those with low adoption rates. Promoting community engagement through farmer cooperatives and support networks could also facilitate knowledge sharing and encourage the wider adoption of innovative practices. Future research should focus on developing practical, easy-to-implement guides for farmers and conducting long-term studies on the impacts of adopting IPM practices on crop yields and pest control.

CONCLUSION

The study explores the adoption of IPM practices among hybrid tomato growers in the Kolar district, Karnataka, and the socio-economic factors influencing the adoption. Results indicate varied adoption levels across different IPM categories, with practices like crop rotation showing higher adoption, while biological control methods are less common. Overall, full adoption of IPM is limited, with few growers implementing the practices up to the optimal level. The multinomial logistic regression analysis highlights the significance of certain socio-economic factors such as age, education, social participation, social contact, and cosmopolitanism in influencing adoption levels. These findings underscore the need for targeted interventions and educational programs to promote the adoption of sustainable agricultural practices, particularly among tomato growers. By addressing

barriers to adoption and enhancing awareness about the benefits of IPM, policymakers, and agricultural stakeholders can work towards fostering a more environmentally friendly and economically viable approach to pest management in tomato cultivation.

REFERENCES

- Bayaga, A. (2010). Multinomial Logistic Regression: Usage and Application in Risk Analysis. *Journal of Applied Quantitative Methods*, 5(2). <https://jaqm.ro/issues/volume-5,issue-2/pdfs/bayaga.pdf>
- Chattopadhyay, S. N., & Pareek, U. (1967). Prediction of multi-practice adoption behavior from some psychological variables. *Rural Sociology*, 32(3), 324–333.
- Depenbusch, L., Sequeros, T., Schreinemachers, P., Sharif, M., Mannamparambath, K., Uddin, N., & Hanson, P. (2023). Tomato pests and diseases in Bangladesh and India: farmers' management and potential economic gains from insect resistant varieties and integrated pest management. *International Journal of Pest Management*, 1-15. <https://www.tandfonline.com/doi/full/10.1080/09670874.2023.2252760>
- FAO. (2020). FAOSTAT Database on Production. Rome, Italy, <http://www.fao.org/faostat/>.
- FAO. (2022). Pesticides Use, Pesticides Trade and Pesticides Indicators—Global, Regional and Country Trends, 1990–2020. FAOSTAT Analytical Briefs, no. 46. <https://www.fao.org/3/cc0918en/cc0918en.pdf>
- Kariathi, V., Kassim, N., & Kimanya, M. (2016). Pesticide exposure from fresh tomatoes and its relationship with pesticide application practices in Meru district. *Cogent Food & Agriculture*, 2(1), 1196808. <https://www.tandfonline.com/doi/full/10.1080/23311932.2016.1196808>
- Kogan, M., Turnipseed, S. G., Shepard, M., De Oliveira, E. B., & Borgo, A. (1977). Pilot insect pest management program for soybean in southern Brazil. *Journal of Economic Entomology*, 70(5), 659–663.
- Kumari, S., Singh, A.K. & Lal, S. P. (2022). Rice varietal preference of farmers in rice bowl region of Bihar: A polychotomous logistic regression analysis. *Indian Journal of Extension Education*, 58(1), 48–53. <http://www.isee.org.in/uploadpaper/58,January%20-%20March,09.pdf>
- Lal, S. P. (2017). Critical appraisal of farmers' mental health vis-à-vis agricultural sustainability in green Revolution belt of India, PhD (Ag), Thesis, NDRI, Karnal. https://books.google.co.in/books/about/Critical_Appraisal_of_Farmers_Mental_Hea.html?id=fZUaxQEACAAJ&redir_esc=y
- Mancini, F., Van Bruggen, A. H., Jiggins, J. L., Ambatipudi, A. C., & Murphy, H. (2005). Acute pesticide poisoning among female and male cotton growers in India. *International journal of occupational and environmental health*, 11(3), 221–232. <https://www.tandfonline.com/doi/abs/10.1179/107735205800246064>
- Narayanaswamy, B., George, S., Hegde, M. R., & Doijode, S. D. (2013). Communication for enhancing adoption of IPM technologies among tomato farmers. *Interaction*, 31(2), 75–78. <https://www.indianjournals.com/ijor.aspx?target=ijor:jcs1&volume=31&issue=2&article=015&type=pdf>
- NIFA, (2023). Researchers helping protect crops from pests. national institute of food and agriculture, USDA. <https://www.nifa.usda.gov/about-nifa/blogs/researchers-helping-protect-crops-pests#:~:text=Between%2020%25%20to%2040%25%20of,is%20lost%20to%20pests%20annually.>

- Kumar Pavana, S. T. & Lahiri, B. (2023). Conditional selection of multifactor evidence for the levels of anaemia among women of reproductive age group. *Evaluation and Program Planning*, 100, 102344. <https://doi.org/10.1016/j.evalprogplan.2023.102344>
- Petrucci, C. J. (2009). A primer for social worker researchers on how to conduct a multinomial logistic regression. *Journal of Social Service Research*, 35(2), 193-205. <https://www.tandfonline.com/doi/epdf/10.1080/01488370802678983?needAccess=true>
- Rao, G. V. Ranga, & Rao, V. R. (2010). Status of IPM in Indian agriculture: a need for better adoption. *Indian Journal of Plant Protection*, 38(2), 115-121. https://oar.icrisat.org/5008/1/IndianJournalofPlantProtection_38_2_115-121_2010.pdf
- Schreinemachers, P., Simmons, E. B., & Wopereis, M. C. (2018). Tapping the economic and nutritional power of vegetables. *Global Food Security*, 16, 36-45.
- Shil, B., Lahiri, B., Pal, P., Ghosh, A., Biswas, P., & Singh, Y. J. (2022). Determinants of adoption behaviour of the fish farmers of Pabda fish culture (*Ompokbimaculatus* Bloch, 1794) in Tripura, Northeast India. *Aquaculture International*, 30(4), 2017-2041. <https://doi.org/10.1007/s10499-022-00885-9>
- Shukla, G., Ansari, M. N., & Lal, S. P. (2024a). Assessment of agricultural information needs of farmers: Triangulating reliability of standardized information need index. *Gujarat Journal of Extension Education*, 36(2), 26-29. <https://doi.org/10.56572/gjoe.2024.37.2.0005>
- Shukla, G., Ansari, M. N., Lal, S. P., Bandhavya, M. & Singh, P. (2024b). Role of mobile phones in enhancing farmers' information seeking behaviour: a binary logistic regression approach. *Indian Research Journal of Extension Education*, 24(4), 145-148.
- Srivastava, D., Lal, S. P., & Shukla, G. (2024). Visualizing the shift: Word cloud analysis of Pradhan Mantri Jan Aushadhi Suvidha Sanitary napkin. *Indian Journal of Extension Education*, 60(3), 18-22. <https://doi.org/10.48165/IJEE.2024.60304>
- Stehle, S., & Schulz, R. (2015). Agricultural insecticides threaten surface waters at the global scale. *Proceedings of the National Academy of Sciences*, 112(18), 5750-5755. <https://www.pnas.org/doi/abs/10.1073/pnas.1500232112>
- Stern, V., Smith, R., van den Bosch, R., & Hagen, K. (1959). The integration of chemical and biological control of the spotted alfalfa aphid: The integrated control concept. *Hilgardia*, 29(2), 81-101. <https://hilgardia.ucanr.edu/Abstract/?a=hilg.v29n02p081>
- The Hindu (2017). Pests eat away 35% of total crop yield, says ICAR scientist. *The Hindu*, February 25, 2017. <https://www.thehindu.com/news/national/pests-eat-away-35-of-total-crop-yield-says-icar-scientist/article17368426.ece>
- Verma, A. P., Meena, H. R., Lal, S. P., Kumar, V., Gupta, B. K., Mishra, D., Ojha, P. K., & Mishra, B. P. (2023). Perception and analysis of existing practices associated with risk of brucellosis among dairy farmers. *Indian Journal of Extension Education*, 59(4), 62-66.