The Pharma Innovation Journal 2022; 11(12): 5750-5753

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 5750-5753

www.thepharmajournal.com
Received: 05-10-2022
Accepted: 13-11-2022

Abhijit Jagtap
Department of Extension Education, College of Agriculture, Dapoli, Ratnagiri, Maharashtra, India

Dr. SS Deshmukh
Subject Matter Specialist, Agriculture Extension, KVK Ratnagiri, Maharashtra, India

Dr. SC Warwadekar
Associate Professor, Department of Extension Education, College of Agriculture, Dapoli, Ratnagiri, Maharashtra, India

Dr. PJ Kshirsagar
Associate Professor, Department of Agricultural Economics, College of Agriculture, Dapoli, Ratnagiri, Maharashtra, India

Nikita Kadaskar
Department of Extension Education, College of Agriculture, Dapoli, Ratnagiri, Maharashtra, India

Corresponding Author:
Abhijit Jagtap
Department of Extension Education, College of Agriculture, Dapoli, Ratnagiri, Maharashtra, India

Modelling farmers intention regarding pesticides application in mango: An empirical analysis with extended theory of planned behaviour (TPB)

Abhijit Jagtap, Dr. SS Deshmukh, Dr. SC Warwadekar, Dr. PJ Kshirsagar and Nikita Kadaskar

Abstract
The present study was conducted in the South Konkan Coastal zone consisting of two districts Ratnagiri and Sindhudurg. The ex-post facto design of social research was used for the present study. A total of 120 respondents were selected by adopting random sampling method. Data was collected with the help of interview schedule and subjected to appropriate statistical analysis. The Partial Least Square-Structural Equation Modelling was done by using SMART-PLS 4.0 to identify the determinants of the Farmers intention regarding the pesticide's application in mango.

The results of PLS-SEM lead to revealed that the construct pesticide knowledge (PK) showed relatively lower values than expected. Considering the PK in predicting behavioural intention it is necessary to increase Farmers skill in production of healthy products and use of eco-friendly technology such as IPM to reduce pesticide use. Considering the significant role of moral norms on Farmers behavioural intention, they should be informed on the effects of the pesticides on human health, the environment, and future generations. (Such awareness can achieved through focused group discussion and learning by examples in extension training courses mass media as well as health recommendation of the health experts.) Considering the significant role of SN on Farmers intention it is necessary to provide comprehensive information about the harmful effects of the pesticides and the proper utilization methods of these chemicals to those who are reference group of farmers and their information resources so that the information is passed to farmers through these people. Promoting knowledge about pesticides is a fundamental step for regulating pesticide usage among farmers, probably by stabilizing and rendering farmers' attitudes resistant to change. Moral norms and subjective norms can play a role mainly by affecting perceived behavioural control and attitudes towards pesticides. Therefore, combination of educational interventions for upgrading general knowledge about pesticides, with training courses, disincentives, and public awareness campaigns relating to pesticides may improve our ability to affect farmers' behaviour.

Keywords: Structural equation modelling, intention, pesticide knowledge, Pls-partial least square

Introduction
Global pesticide use in agriculture has almost doubled since the early 1990s, reaching 4.2 million tonnes, or 0.6 kg per person, in 2019 (FAO-Food and Agriculture Organization of the United Nations, 2021). To put it simply, South America is the continent that uses the most pesticides on average (5.42 kg/ha), followed by Asia (3.67 kg/ha), North America (2.51 kg/ha), Oceania (2.09 kg/ha), Europe, and Africa (0.29 kg/ha) (FAO, 2020). Globally, pesticide sales have soared since the 1970s and are projected to reach USD 309 billion by 2025 (UNEP-United Nations Environment Programme, 2021).

According to the 2011 Indian Census, 20.0 per cent of the nation's GDP comes from agriculture, which provides a living for about 58.0 per cent of the people (Economic Survey, 2020-21). 70% of the rural population depends primarily on agriculture for their income (Indian Census, 2011). The primary sector sustaining India's agricultural economy is horticulture. 30% of the value of agricultural output is attributed to horticulture. Mango, banana, lime, lemon, papaya, and fenugreek are just a few of the many fruits that India is the world's top producer of (Horticulture Statistics, 2018). Even though the mango is typically associated with tropical regions, it can be successfully produced there. Mangoes (Mangifera indica L.), which are part of the Anacardiaceous family, are the most important fruit crop farmed for commercial purposes in India. Mangos are native to the Indo Burma region of South East Asia, which is located in the foothills of the Himalayas.

Mango being referred to as "The National Fruit of India" and is labeled the "King of Fruits." Mango is consumed worldwide because it has excellent nutritional and medicinal properties.

The Alphonso mango is thought to be superior than all other varieties. Geographical indicators (GI) in Ratnagiri and Sindhudurg enable Alphonso Mango to claim exclusivity rights to a product. Alphonso, on the other hand, has become extremely vulnerable to the impacts of climate change. Mango was consequently heavily infested by pests and insects. Regular use of insecticide and the adoption of cutting-edge technology can enable mango growers in increasing production. However, farmers have frequently been observed using insecticides indiscriminately on mango plants.

Plant pests are known to cause substantial losses in crop production on a global scale. (Damalas, 2016). Numerous management techniques have been developed to combat pests, including host plant resistance, physical barriers, botanical pesticides, biological control, biotechnological approaches, and synthetic pesticides. The strategy that is most usually applied in actual field situations, nevertheless, is chemically based management. Synthetic pesticides are primarily used against pests in the field to ensure high crop yields because of their capacity and high reliability to protect crops. Pesticides are already a significant factor of crop production in modern farming systems, but they are also connected to grave consequences like the emergence of pest resistance, the extinction of natural enemies, environmental contamination, adverse impacts on non-target organisms, and health hazards for humans (Damalas, 2009; Fan *et al*., 2015; Jallow *et al*., 2017; Bagheri *et al*., 2018; Bondori *et al*., 2018) [10, 12, 4, 7, 8].

However, the extended TPB model has not yet been used to assess the intentions of Indian mango producers to apply ample quantity of pesticides. This study aims to investigate the various factors that influence mango growers' intentions to use pesticides in the Konkan region. The identification of these factors will help extension services support farmers in creating a framework for prudent pesticide usage or in exploring alternative policy options for cleaner agriculture production and protect the environment.

Methodology

This study was carried out in Ratnagiri and Sindhudurg districts. Ratnagiri and Rajapur tehsils were selected from Ratnagiri district and Devgad and Malwan tehsils were selected from Sindhudurg district. Total of four tehsils were selected and out of these four tehsils twelve villages were selected randomly and from these twelve villages 10 respondents from each village were selected randomly for the study. Total 120 respondents were selected for the study. The data were collected by conducting personal interview through pre- Structured Interview Schedule.

Result and Discussion

Table 1: Frequency and percentage of statement of the model construct.

Sl. No.	Statement	Response N=120				
		SA	A	UD	D	SD
1	**Construct: Intention**					
i	I have in mind to store the pesticide in separate barn	17 (14.16)	36 (30)	23 (19.16)	25 (20.83)	19 (15.83)
ii	I plan to use pesticides in my mango orchard in the near future *	16 (13.33)	20 (16.66)	25 (20.83)	34 (28.33)	25 (20.83)
iii	I intend to spray pesticides based on experts' instructions	29 (24.16)	33 (27.5)	22 (18.33)	22 (18.33)	14 (11.66)
iv	I plan to reduce pesticide applications in my mango orchard	18 (15)	25 (20.83)	27 (22.5)	24 (20)	26 (21.66)
2	**Construct: Attitude**					
i	Pesticides overuse in mango is harmful for human health	23 (19.16)	33 (27.5)	27 (22.5)	20 (16.66)	17 (14.16)
ii	Pesticides use in mango orchards can be harmful to ecosystems and wildlife	22 (18.33)	29 (29.16)	30 (25)	21 (17.5)	18 (15)
iii	Judicious use of pesticides in mango is necessary for achieving production potential	10 (8.33)	32 (26.66)	30 (25)	29 (24.16)	19 (15.83)
iv	Successful farmer is one who produces the healthy mangoes without pesticides	11 (9.16)	30 (25)	30 (25)	26 (21.66)	23 (19.16)
3	**Construct: SN**					
i	Successful farmer is one who produces the healthy mangoes without pesticides	23 (19.16)	25 (20.83)	22 (18.33)	30 (25)	20 (16.66)
ii	My family discourages me from increasing pesticide use	20 (16.66)	26 (21.66)	25 (20.83)	25 (20.83)	24 (20)
iii	Agriculture experts criticize the over use of pesticides in mango orchard	21 (17.5)	26 (21.66)	23 (19.16)	22 (18.33)	28 (23.33)
iv	Input dealers motivate the use of pesticides for pest management	21 (17.5)	23 (19.16)	24 (20)	26 (21.66)	26 (21.66)
4	**Construct: PBC**					
i	Pesticide stores are in the vicinity and pesticides are easily available to me	19 (15.83)	26 (21.66)	27 (22.5)	20 (16.66)	28 (23.33)
ii	The method of using chemical pesticides is easy for me	15 (12.5)	36 (30)	26 (21.66)	24 (20)	19 (15.83)
iii	I can easily achieve current productivity with less pesticide use	19 (15.83)	20 (16.66)	27 (22.5)	30 (25)	24 (20)

iv	If I want to, I can easily put aside pesticide use.	12 (10)	31 (25.83)	24 (20)	27 (22.5)	26 (21.66)
5	**Construct: MN**					
i	Not spraying pesticides gives me the feeling that I am a better person	12 (10)	30 (25)	30 (25)	29 (24.16)	19 (15.83)
ii	I feel bad when I do not use pesticides*	22 (18.33)	26 (21.66)	30 (25)	30 (25)	12 (10)
iii	I feel guilty when I use pesticides	18 (15)	20 (16.66)	26 (21.66)	31 (25.83)	25 (20.83)
iv	I don't use pesticide if it is not label claimed for mango	21 (17.5)	26 (21.66)	24 (20)	21 (17.5)	28 (23.33)
v	Spraying more than the prescribed amount is not acceptable both legally and morally	25 (20.83)	21 (17.5)	25 (20.83)	26 (21.66)	28 (23.33)
6	**Construct: RP**					
i	Mango production is more profitable with the use of pesticides than without	10 (8.33)	32 (26.66)	31 (25.83)	28 (23.33)	19 (15.83)
ii	Pesticides harm the health of the farmer because they do not protect themselves	17 (14.16)	35 (29.16)	25 (20.83)	24 (20)	19 (15.83)
iii	Pesticides are not harmful when they are applied correctly	14 (11.66)	22 (18.33)	23 (19.16)	32 (26.66)	29 (24.16)
7	**Construct: PK**					
i	Spraying in windy conditions reduces pest control	11 (9.16)	48 (40)	55 (45.83)	06 (05)	0 (00.00)
ii	Choosing the right time to spray reduces pesticides requirement	09 (7.5)	46 (38.33)	58 (48.33)	07 (5.83)	0 (00.00)
iii	Frequent spraying eliminates pests and increases productivity*	08 (6.66)	40 (33.33)	61 (50.83)	10 (8.33)	01 (0.83)
iv	I am aware that spraying can contaminate water sources	07 (5.83)	39 (32.5)	62 (51.66)	12 (10)	0 (00.00)

*Figure in parentheses indicates percentage.
SA- strongly agree, A- agree, UD- Undecided, D -disagree, SD- strongly disagree. *=reverse score.

Table 1 reveals that among the four statements of the intention construct majority 30 per cent of the respondents were agree to the statement "I have in mind to store the pesticide in separate barn". majority 28.33 per cent of the respondents agreed with the statement "I plan to use pesticides in my mango orchard in the near future". 27.5 percent of the respondents agreed with the statement "I intend to spray pesticides based on experts' instructions". Majority 22.5 per cent of the people were undecided about the statement "I plan to reduce pesticide applications in my mango orchard."

Among the four statements of the attitude constructs majority 29.6 per cent of the respondent agree with the statement "Pesticides use in mango orchards can be harmful to ecosystems and wildlife". Followed by 27.5 per cent, 26.5 per cent and 25 per cent were agree with the statement "Pesticides overuse in mango is harmful for human health". "Judicious use of pesticides in mango is necessary for achieving production potential". "Successful farmer is one who produces the healthy mangoes without pesticides" respectively.

A majority of 25% of respondents disagree with the proposition that "Successful farmers are those who produce the healthy mangoes without pesticides" in the subjective norms construct for four statements. The majority of (23.33%) and (21.66%) respondents were strongly disagreed with the statements "Agriculture professionals condemn the over use of pesticides in mango orchard" and "Input dealers stimulate the use of pesticides for pest control"

The majority of (30 and 25.83%) respondents agreed with the statements "If I want to, I can easily put aside pesticide use" and "The method of using chemical pesticides is easy for me" among the four statements of the perceived behavioural control. 25% of the respondents were disagree about the statement "I can easily achieve current productivity with less pesticide use" and 23.33% respondent are strongly disagreed with the statement "Pesticide stores are in the vicinity and pesticides are easily available to me".

Among the five statements made in the moral norm's constructions, the majority of respondents (25.83%) disagreed with the claim that "I feel guilty when I use pesticides." 25% of the respondents agreed with the statement, "Not spraying pesticides gives me feeling that I am a better person. 25% of the respondents agree with the statement "I feel bad when I do not use pesticides". Also 23.33% of the respondents were strongly disagree with the statements "I don't use pesticide if it is not label claimed for mango" and "Spraying more than the prescribed amount is not acceptable both legally and morally".

Among the three statements of the risk perception majority 29.16 per cent of the respondents agreed with the statement "Pesticides harm the health of the farmer because they do not protect themselves". Also 26.66 per cent of the respondents were agreed and disagreed with the statements "Mango production is more profitable with the use of pesticides than without" and "Pesticides are not harmful when they are applied correctly" respectively.

For the four statements of the pesticide knowledge majority 51.66, 50.83, 48.33 and 45.83 per cent of the respondents were undecided about the statements "I am aware that spraying can contaminate water sources", "Frequent spraying eliminates pests and increases productivity", "Choosing the right time to spray reduces pesticides requirement" and "Spraying in windy conditions reduces pest control" respectively.

Conclusion

This study adds a novel contribution to the existing scientific

literature by analyzing both socio-economic and psychological factors influencing farmers' intentions towards pesticides application based on an extended TPB model. These findings indicate that while the farmers' characteristics and constructs of TPB can explain their behavioural intentions to apply pesticides in mango, adding three more constructs (Knowledge, Moral norms and risk perception) into the TPB framework can increase the predictive power and accuracy of the theory.

Attitude, moral norms and risk perception had significant effect on subjective norms possessed by the mango orchardists. Moral norms established a positive relationship between perceived behavioural control. Farmers with high moral standards naturally have control over the application of pesticides. They are unable to violate their own personal moral standards. Additionally, this study found that the attitude had the greatest direct impact on the intention towards the pesticide application.

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