Survey on fungicide usage patterns and farmer's willingness to adopt disease management practices in cucurbits

Abstract

The rising use of fungicides in cucurbits are significant issue, there are insufficient data to support the various factors influencing fungicide usage pattern. In this survey, a structured questionnaire and sequential exploratory mixed design was used to gather information about marginal scale (<5 acre) cucurbits farmers along with their perception on fungicide and their knowledge towards adopting integrated disease management. Cucurbits downy mildew and powdery mildew poses major diseases and shows severe yield loss upto 42% and 34%, respectively. The results revealed that most of the farmers heavily relied on fungicide (55.71%) for management, although they were aware of the negative impacts of fungicides on human health and the environment (67.14%). In this Dimethomorp (18.57%) and Metalaxyl + Mancozeb (17.14%) was mostly used. During a cropping season, farmers (38.57%) was used fungicide frequently for 8-9 times and also adhered to less pre-harvest intervals. In this study, a data on farmers following indiscriminate and frequent use of chemical fungicide which led to disease resurgence, resistance, also encouraged to follow integrated disease management strategy and adoption to preventive measures based on forewarning advisory.

Keywords: Cucurbits, survey, farmers, fungicide use patterns, integrated disease management, sustainable agriculture, awareness.

INTRODUCTION

Cucurbits belongs to cucurbitaceae family, are highly economically valued vegetables which includes pumpkin, cucumber, ash gourd, ridge gourd, bitter gourd, bottle gourd, snake gourd, water melon (Seshadri,2001).In response to the growing demand for food security due to a rising population, there has been a concerted effort to increase cucurbit cultivation in India. As a significant contributor to the global production of cucurbits, India produces around 5.1 million tons annually, accounting for approximately 28 million tonnes of the total global output (FAO, 2021). Cucurbitaceous vegetables, including cucurbits, are vital to India's agricultural sector, representing nearly 18% of the country's total vegetable production. These efforts to promote and encourage cucurbit cultivation aim to enhance overall vegetable productivity in the country (Rai *et al.,* 2008).

Cucurbits are extremely susceptible to various diseases due to their mushy and succulent nature. This susceptibility can reduce the growth rate of cultivated varieties. Plant pathogens cause nearly 20-40% of economic yield loss, among them 30% of crop diseases caused by fungi (Anderson *et al*., 2004). Pesticides are crucial components of the trendy agricultural technology that has been widely accepted throughout the world (Ali *et al.,* 2020). The vast majority of the farmers believed that fungicides are essential for high yields and excellent quality of the crop. Therefore farmers use a variety of fungicides applied more frequently to protect vegetables (Sutharsan *et al*., 2014). The practice of using indiscriminate amounts of fungicides can have a variety of negative impacts on users' health and has been known to almost all farmers (Damalas *et al*., 2006). Even while fungicides are a necessary part of commercial agriculture production, their indiscriminate usage by vegetable producers is a serious concern. In recent decades, synthetic pesticides have dominated the global market. However, there is a growing interest in sustainable agriculture practises worldwide as a result of growing awareness about the harmful effects of crop protection agents on health (Indiscriminately used fungicides are harming the biota while being employed to boost agricultural productivity. The environmental transmission of fungicide causes harm to non-target organisms. There is a chance that some fungicides harm the environment and human health. According to estimates, only about 0.1 percent of pesticides reach their target species, with the remainder polluting the ecosystem and harming the environment (Gill and Garg, 2014).

It is feasible to decrease the fungicide usage by carefully integrating various control strategies that prevent infestation. Fungicide usage and other interventions should be limited to levels that are economically viable, secure for the environment, and safe for human health (FAO, 1994). The conventional integrated disease management strategy focused a strong emphasis on ecological aspects of disease management.

The aim of this study was to examine cucurbits vegetable growers in Tamil Nadu with regard to their knowledge, attitudes, and practises regarding the usage of fungicides. The study investigated the level of fungicide use and looked at existing management techniques in vegetable production. In order to understand local farmers' opinion on fungicide poisoning and adverse environmental effects, a survey was conducted to assess their knowledge and perception of integrated disease management. These techniques make use of wide range of methods that work together to minimize the fungicide usage. Among that disease prediction model have a potential to decrease the frequency and amount of fungicide application.

2. MATERIAL AND METHODS

2.1 Selection of survey site and collection of data

The detailed Survey study was conducted on major cucurbits cultivating districts namely Coimbatore, Krishnagiri, Dindigul in Tamil Nadu (Figure.1, Table 1).

Table 1.Details of study location of Cucurbits growing areas in Tamil Nadu

Study district	Block	Location	No of farmers contacted	Max and Min temp./ Annual rainfall
Krishnagiri	Denkanikottai	12.5270° N, 77.7899° E	1	Mean annual temperature ranges from 37°C to 17°C and annual rainfall 830 mm
	Hosur	12.7409° N, 77.8253° E	31	
Coimbatore	Anaimalai	10.5821° N, 76.9343° E	15	Mean annual temperature ranges from 35°C to 18°C and

	Pollachi	10.6609° N, 77.0048° E	17	annual rainfall 677mm
Dindigul	Odanchatram	10.4897° N, 77.7544° E	3	Mean annual temperature ranges from 37.5 °C to 19.7°C and annual rainfall 836 mm
	Reddiyarchatram	10.4304° N, 77.8673° E	3	

2.2 Farmers selection and their farming pattern

Cucurbits were selected as the study crops due to frequent use of fungicide by farmers to maintain aesthetics against diseases, with agricultural instructors serving as the most reliable information source. Totally 70 farmers were selected based on the population of farming community involved in cucurbits cultivation during the study season through random sampling method, and it's important to note that these respondents might have grown different crops at various times during the cropping season.

2.3 Data collection

A descriptive survey method was employed to collect primary data from farmers regarding their knowledge, attitudes, and practices related to fungicide selection, application patterns, frequency, disease management awareness, and perceptions of integrated disease management; this method utilized standardized questionnaires and revealed farmers' perspectives on these topics, often yielding "YES" or "NO" responses to focused questions due to the variability in farming practices and the absence of fixed variables, following the identification of possible cucurbit cultivated areas from secondary data and literature prior to field visits..

2.4 Data analysis

The collected questionnaire data were input into an Excel spreadsheet and analyzed using statistical software including SPSS and R Studio. Descriptive statistics such as mean,frequencies, and percentages were computed. Categorical data were assessed using chi-square tests to determine significant associations between socioeconomic variables (e.g., age, farmer experience, education level) and various behaviors related to Integrated Disease Management (IDM), including willingness to practice IDM, attitudes toward the efficacy of chemical fungicides, safe fungicide use, and methods for disposing of empty containers. The strength and significance of these associations were evaluated using Cramer's V values and confidence levels. Non-parametric tests like the Kruskal-Wallis test were employed to analyze relationships between farmers' responses to specific questions, and the significance of these associations was confirmed using the exact Fisher test.

3. RESULTS AND DISCUSSION

3.1 Socio economic characteristics of the respondents

In present survey data reveals that majority of the farmers (48.57%) falls under 40-49 middle age groups and followed by (27.14%) 30-39 young age groups and old age group (22.86%) and very few of them (1.43%) comes under very old age groups. The survey found that, 100% gourds growers were men. This outcome was consistent with (Berni *et al.,* 2021) who stated that 402 farmers surveyed, 90.3% were men and 9.7% were women. These results show that the majority of the male are interested in farming practices and disease management. In terms of education, the majority of respondents (38.57%) pursued ordinary and advance levels of education followed by 15.72% respondents are degree holders.

Most of people are directly or indirectly depends on agriculture for their livelihood. According to survey data, majority of the farmers 40% cultivate cucurbits consistently followed by 34.29 %. Farming is the main source of income for 55.71% respondents (Table 2). Similar findings were reported by Bhutto and Bazmi (2007), who found that most farmers live in rural area subsistence on small land for agriculture.

Table 2.Socio economic characters of cucurbits cultivated respondents (farmers)

S.No	Particulars	Frequency (N=70)	Percentage
1.	**Age**		
	I. 30-39	19	27.14
	II. 40-49	34	48.57
	III. 50-59	16	22.86
	IV. 60-69	1	1.43
2.	**Gender**		
	I. Male	70	100
	II. Female	0	0
3.	**Education background**		
	I. Below ordinary level (<5th Grade)	5	7.14
	II. Ordinary level (5th -10th)	27	38.57
	III. Advance level (10th – 12th)	27	38.57
	IV. Above advance level (Degree)	11	15.72
4.	**Total period (years) of time engaged in cucurbits cultivation**		
	I. 1-2	8	11.43
	II. 3-4	28	40.00
	III. 5-6	24	34.29
	IV. 7-8	10	14.29
5.	**Major sources of income**		
	I. Farming	39	55.71
	II. Other	31	44.29

3.2 Fungicide choice and application pattern

Majority of the farmers (44.29%) perceived efficiency of fungicides to control the diseases. According to the survey data majority of farmers (42.86 %) contacted Agrochemical dealers/sellers followed by 40 % respondents learned by communicating with fellow farmers; and also 7.14% farmers consult agricultural officials, 10% of farmers got information from other sources. This outcome was consistent with Zhang and Lu (2007). survey found that among the respondents, approximately 34.5% had obtained fungicide information from fungicide distributors. Furthermore, about 54.43% acquired such information from their co-workers, 41.09% based on their own personal experiences, and 25.79%, 16.67%, and 7.36% relied on TV, newspapers, and the Internet, respectively.

Only around 44.29% respondents actually sprayed pesticides at the recommended amount while others 55.71% respondents used excessive amount and dosage. Reddy *et al*., (2011) reported that increasing trend fungicides was observed in 42.21% of farmers and they used the mixed fungicide pattern. This was suggested by different sources like Agrochemical dealers and Agricultural officers. About 64.29% of respondents had used the mixed pesticides for their crop (Table 3.) Similar findings were reported by Jamali *et al.,* (2014) that about 90% of surveyed farmers had used mixed fungicide spray.

Table 3. Choice of fungicides and patterns of application followed by the respondents(N=70)

S.No	Variables	Percentage of respondents
1.	**factors considering the choice of fungicide**	
	I. Cost of the product	17.14
	II. Efficiency of fungicide	44.29
	III. Ease of use	2.86
	IV. Ease of availability	27.14
	V. Previous practice /experience	35.71
2.	**Trend of fungicide use**	
	I. Increasing	42.21
	II. Decreasing	20.85
	III. Constant	34.89
3.	**Source of information on selection of fungicide**	
	I. Agrochemical dealers/sellers	42.86
	II. Agricultural officers	7.14
	III. Fellow farmers	40.00
	IV. Other source	10
4.	**Mostly Preferred formulation types**	
	I. Wettable powders	44.29
	II. Emulsified concentration	55.71
5.	**Amount of fungicide used for cultivation**	
	I. Excessive	55.71
	II. Not excessive	44.29
6.	**Regular monitoring of disease**	
	I. Yes	65.71
	II. No	34.29

3.3 Occurrence of main diseases and their identification and management

Regular disease monitoring practices was followed by 65.71per cent respondents from all study area and rest of 34.2per cent of the farmers did not follow any monitoring practices (Table 3). The survey depicted that downy mildew caused severe damage (42%) followed by powdery mildew (34%), leaf curl (14%), leaf spot (10%). The disease identification was done by farmers with their own experience (40%) followed by help of fellow farmers (28.57). (Figure 1, 2)

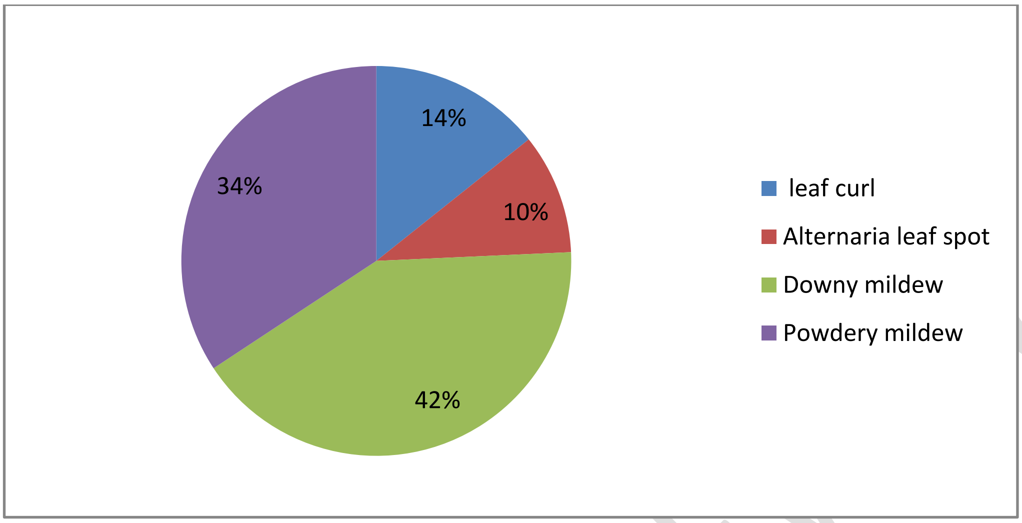

Figure 1. Common diseases experienced by farmers in their field (N=70)

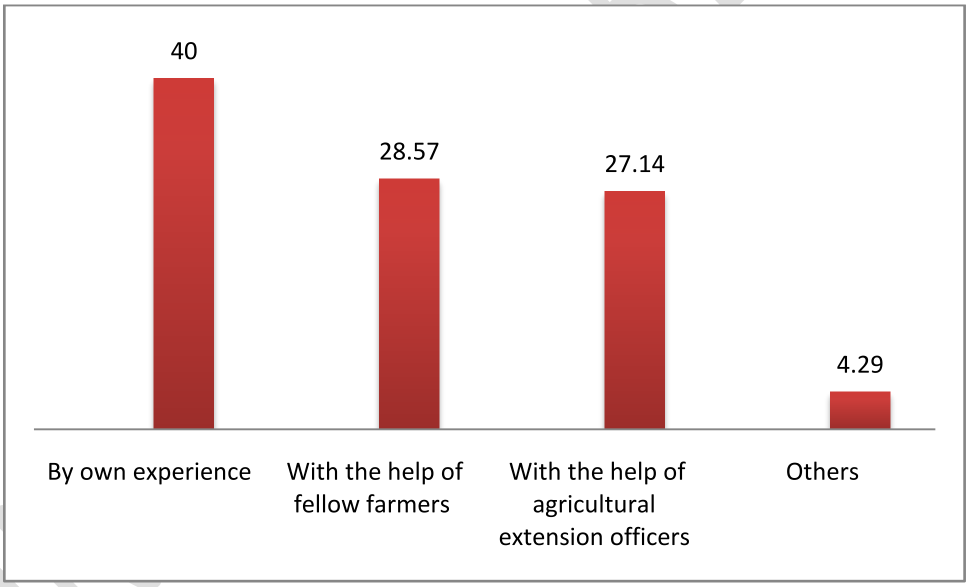

Figure 2. Mode of Disease identification by farmers in selected study area (N= 70)

3.4. Choice of fungicide product by farmers(N= 70)

Across the study sites, there were notable differences in farmer's preference for fungicide products. Dimethomorp (18.57%), Tebuconozole+Trifloxyxstrobin (7.14%), Propiconazole+Difenocozole (4.29%) was used to control powdery mildew. Similar findings were reported by Wahul et al., (2018). Metalaxyl+Mancozeb (17.14%) Azoxystrobin+Propiconazole (15.51%), Matalaxyl (11.43%) for downy mildew (Figure 3). Pandit et al., (2020) found that Metalaxyl+Mancozeb fungicide better for downy mildew control. Among them only few of farmers was used Zineb + Hexaconazole (11.43%), Mancozeb (10%), Tebuconazole (4.29%), Tebuconozole+Trifloxyxstrobin (7.14%), for controlling *alternaria* leaf spot.

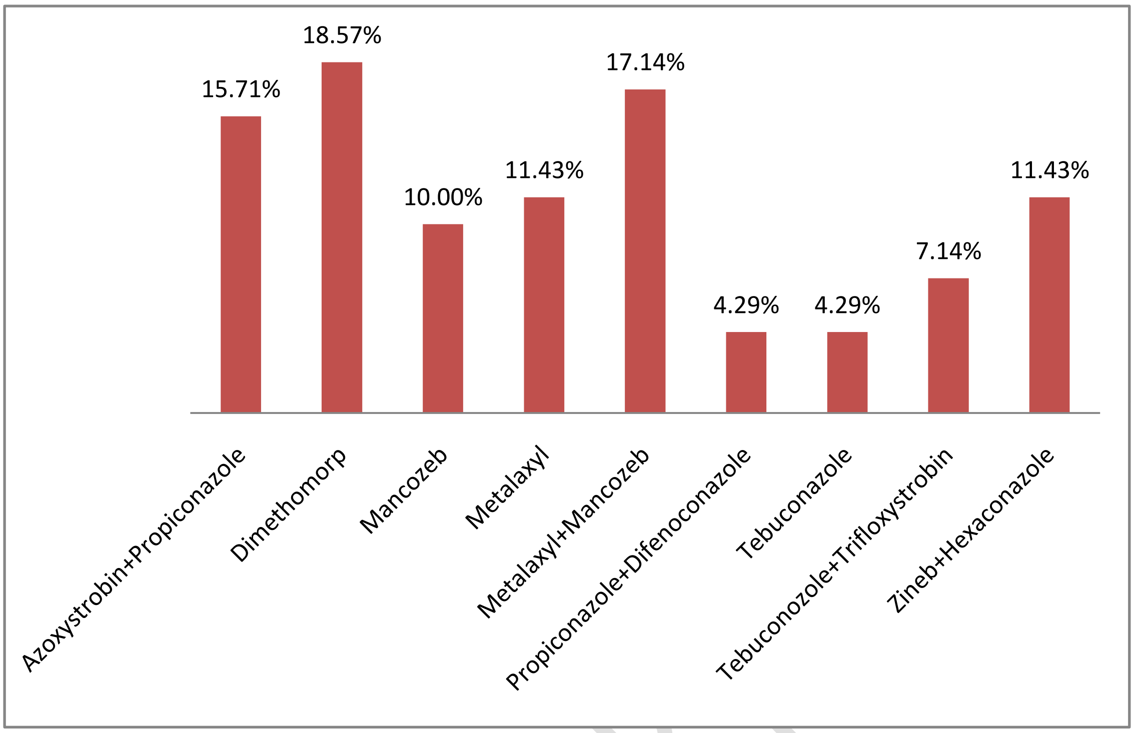

Figure 3. Fungicides practiced during cucurbits cultivation

3.5. Spraying practices followed by farmers(N= 70)

Fungicides were sprayed between 2 to 11 times by farmers during the cultivation season. The majority of farmers (38.57%) sprayed fungicide 8-9 times followed by (24.29%) 10 -11times and (21.43%) 6-7times during a single growing season to manage crop disease (Table 4, Figure 4). Most of the farmers (32.85%) followed the waiting period of 5-7 days. Few among them (1.43 %) did not follow any waiting period. The farmers were unable to wait until the safe harvest season because perishable nature of cucurbits which would lower the market price. According to this Majority of the farmers (40%) revealed that they applied fungicide on after emergence of disease while 32.86% and 27.14% of respondents applied depends on situation and before emergence of pest respectively. Significant proportion of the farmers (52.86%) sprayed fungicide on late evening while remaining (47 .14%) are sprayed on early morning. The use of fungicide in the morning had a negative impact on birds and other species that fed in morning.

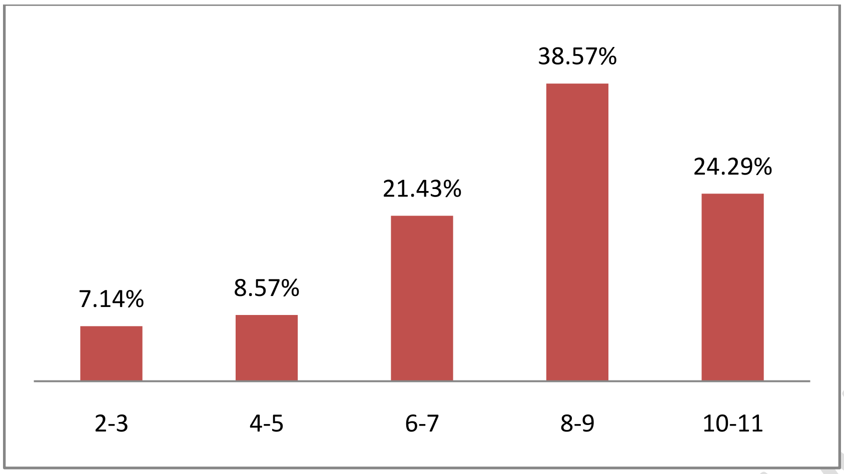

Figure 4.Frequency of fungicide applied by famers in their field

Table 4. General practices followed during application Fungicide (N=70)

S.No	Particulars	Frequency	Percentage of respondents
1.	**Time interval between last spraying and harvesting** I. No waiting period II. 1-2 III. 3-4 IV. 5-7	 1 30 16 23	 1.43 42.86 22.86 32.85
2.	**Time of fungicide application** I. Early morning II. Afternoon III. Late evening	 33 0 37	 47.14 0 52.86
3.	**Method of application** I. Mixed application II. Separate application of fungicide	 45 25	 64.29 35.71
4.	**Concern regarding to fungicide drift during application** I. Yes II. No	 33 37	 47.14 52.86
5.	**Awareness on the negative impact of fungicide on environment** I. Yes **II.** No	 44 26	 62.86 37.14
6.	**Awareness on the negative impact of fungicide on human health** I. Yes II. No	 47 23	 67.14 32.86
7.	**Take bath immediately after application** I. Yes II. No	 62 8	 88.57 11.43

3.6 Practices related to safe use of fungicides (N= 70)

From the survey, we observed that the majority of the farmers (58.57%) did not wear any protective clothes while applying fungicides expect mouth and nose covering clothes. It was noted that partial safety precaution measures including long sleeved shirts along with mouth and nose covering cloths were adopted by 14.29% of respondents. Only 7% of them reported to take all necessary precaution such as donning protective cloths, hand gloves, nasal masks etc. The application of pesticides is largely carried out manually by farmers without the use of any safer alternatives, such as motorized spraying machine (Table 5). Devi (2009) was noted that approximately 80% of Indian farmers chose to cover their faces and heads with cloth while opting to remain barefoot.

It was noted that 88.57% respondents were take a bath immediately after application of fungicide. The findings of Weng and Black (2015) align with the results mentioned above, indicating that approximately 81.8% of farm workers in Taiwan follow the practice of taking a shower right after applying pesticides and subsequently changing their contaminated clothes. While the respondent farmers employed a variety of disposal techniques for empty containers, burying (57.33 %) was the predominantly adopted by most of the farmers. About 67.14% of respondents were aware on the negative impact of fungicide on environment. Majority of the farmers 52.86% were unaware about fungicide drift effect. According to the findings of Mohanty *et al*., (2013), evident that the farmers demonstrated awareness regarding the toxic nature of pesticides, recognizing their potential harm to both the environment and the human body. The survey revealed that 60% of the respondents preferred to store the fungicide in separate room under locked condition, 38.57% in the field and remaining 1.43% in house (Table 5). Konradsen *et al*. (2007) found the similar findings, indicating that the majority of participants in Sri Lanka (82%) stored pesticides securely at home, with 46% opting to store them on their farms (Table 5).

Table 5.Safety awareness on disposal of fungicide container and risk of fungicide use

S.no	Variables	Frequency (N=70)	Percentage of respondent
1.	**Use of Protective cloths** I. Poor II. Moderate III. Highly satisfied	41 10 19	58.57 14.29 27.14
2.	**Take both immediately after application** I. Yes II. No	62 8	88.57 11.43
3.	**Method of disposal of empty fungicide bottles** I. Burial II. Burning	31 39	44.33 57.33
4.	**Method of storing fungicide** I. In a separate room under locked condition II. In a place within the house	42 1	60.00 1.43

	III. In a place located in the field	27	38.57

3.7 Health issues associated with fungicide application (N= 70)

The adverse health effects of fungicides on public health, and in particular the health of farm workers, have increased as a result of improperly regulated and potentially hazardous fungicide usage and inadequate knowledge. The majority of the interviewed farmers reported that they had suffered from multiple short term health effects such as Itching (28.57%), Headache (24.29%), Breathing difficult (14.29%), Skin irritation (12.86%), Allergy (8.57%), Muscle twitches (5.71%), Excessive salivation (5.71%) (Figure 5). In Nagendra *et al*., (2009) reported that 51.67% of individuals experienced skin irritation, while eye irritation and headache symptoms were reported by 44.17% and 35.83% of the participants, respectively.

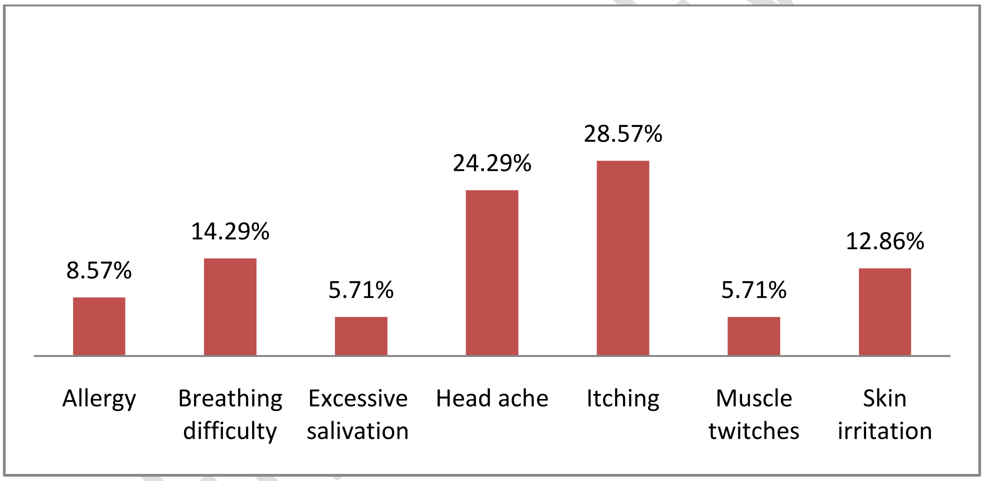

Figure 5.Health issues associated with fungicides spray

3.8 Farmers' opinion on fungicide use, integrated disease management and safe fungicide use are correlated with various demographic factors

Statistically significant associations ($P < 0.05$) were observed among certain demographic factors, fungicide usage practices, and perceptions of integrated disease management within specific groups of farmers (Table 6). The statistical analysis reveals a strong association between fungicide frequency and after application health issues, supported by a substantial Cramer's V value of 0.454616, while farmers' preference for Integrated Disease Management (IDM) exhibits a significant correlation with their choice of disease management methods, as indicated by a p-value of 0.000176 and a moderate Cramer's V value of 0.402862. Additionally, p-value of 1.2173E-9 and a meaningful Cramer's V value of 0.273112 emphasize the robust statistical significance of education background in influencing the adoption of protective clothing.

Table 6. Results of statistical significance of the variation among different response

S.no	variables	*P* value	Cramer v value
1	Farmers like to practise Integrated disease management instead of totally chemical based method	**0.000176**	**0.402862**
2	Fungicide frequency and health issues after fungicide application	**0.002504**	**0.454616**
3	Education background and use of protective cloth	**1.2173E-9**	**0.273112**

3.9 Effect of selected parameters on farmers' perceptions of fungicide effectiveness

Frequent and mixed chemical method of fungicide application are significantly correlated with farmers' perceptions of fungicide effectiveness. On the other hand, Factors like age group, total period of time engaged in cucurbits cultivation, income source, and separate application do not significantly impact these perception (Table 7). Furthermore, the farmers' opinion on fungicide effectiveness is influenced by certain practices. Farmers who hold a positive view on fungicide effectiveness tend to apply fungicide more frequently and mixed during the cropping cycle, have lesser intervals between consecutive fungicide applications, and allow a less pre harvest interval. Farmers with greater age, lower income, and more experience tend to hold less favourable views regarding the effectiveness of fungicides in disease control.

Table 7.Results of Kruskal-Wallis test to evaluate the statistical significance of the differences observed among farmers in their responses to effectiveness of fungicide.

Variables	*P* values
I. Socio economic characteristics	
▪ Age group	0.392408
▪ Total period of time engaged in cucurbits cultivation	0.115966
▪ Income source	0.772986
II. Frequency of application	6.3051E-16
III. Current number of fungicide application per crop cycle	0.256703
IV. Preharvest interval	0.029511
V. Method of application	
▪ Mixed chemical	6.4311E-14
▪ separate application	0.000102

3.10 Effect of selected factors on willingness to adopt IDM

The results indicate that factors such as age group, educational background, awareness of the negative impact of fungicides, and current fungicide usage are highly significant in influencing farmers' willingness to adopt IDM. However, income source shows weaker influence on farmers' willingness to adopt IDM. Farmers' readiness to adopt Integrated Disease Management (IDM) is influenced by demographic factors, with younger and more educated farmers showing greater willingness, although this willingness decreases with more years in farming. Those whose main income source is farming are also more inclined to embrace IDM. Interestingly, farmers who currently depend on chemical-based crop protection practices and are aware of the negative impact of fungicides are more inclined to adopt Integrated Disease Management (IDM).(Table 8).

Table 8. Results of Kruskal-Wallis test to evaluate the statistical significance of the differences observed among various groups of farmers in their willingness to adopt IDM.

Variables	***P* values**
I. Socio economic characteristics	
▪ Age group	6.4311E-14
▪ Educational background	6.3051E-16
▪ Total period of time engaged in cucurbits cultivation	0.772986
▪ Income source	0.055402
II. Awareness on negative impact of fungicide on the environment and human	3.0697E-13
III. Current fungicide usage	2.3783E-12

3.11 Effect of selected farmers on willingness to adopt forewarning model

Statistically significant associations ($P < 0.05$) were observed among some demographic factors. (Table 9). Educational background, the time interval for fungicide application, and current fungicide usage are factors significantly associated with farmers' willingness to adopt the forewarning model, while the total period of time engaged in cucurbits cultivation does not show a significant relationship with this willingness. Interestingly, none of the farmers were aware of the forewarning method, and only 30% expressed willingness to adopt it; results reveals that farmers with higher education levels, frequent fungicide usage, and higher application rates are more inclined to adopt the forewarning model, while those engaged in cucurbits cultivation for longer periods were less likely to adopt it due to lack of awareness.

Table 9.Chi-square test results showed statistically significant relationships with the farmer's willingness of forewarning model

Association Test	***P* Value**
I. Socio economic characteristics	
▪ Educational background	0.001914
▪ Total period of time engaged in cucurbits cultivation	0.282603

II.	Time interval for fungicide application	0.021303
III.	Current fungicide usage	0.002504

Conclusion

Research findings provide that cucurbits hindered by various diseases like powdery mildew, downy mildew, leaf spots, leaf curl. Among that powdery mildew, downy mildew threatens the food supply, exhibiting varying dispersal patterns, prevalence, and severity. The consequences of these diseases on sustainable crop yields in the future remain uncertain. It is possible to detect this airborne spore by using spore traps. The prediction model-based technology resents fresh opportunities for integrating disease monitoring predictive models, necessitating a robust analytical framework. Integrated model-based forecasting frameworks offer the potential to enhance the timeliness, effectiveness, and foresight in controlling crop diseases, while minimizing economic costs, environmental impacts, and yield losses. A monitoring system to ensure early detection of outbreaks should be in place, so that control measures can be planned, and applied at the most appropriate time. Farmer's shows less willingness for adopt this early prediction model because of lack of knowledge. Diversified extension activities include training to local farmers and engage in choosing and actively participating in educational programs. These activities enable farmers to learn, apply and adopt improved technology.

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