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Assessment of Knowledge, Attitude, and Practices on Pesticide use among Cucumber and Watermelon Farmers in selected Districts of the Coast Region, Tanzania

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Pesticides are indispensable for enhancing agricultural productivity and widely used by farmers to control pests and diseases, with increasing application documented in various studies worldwide. However, mismanagement and misuse pose serious health and environmental risks. This study aimed to assess the knowledge, attitude, and practices (KAP) of cucumber and watermelon farmers in selected districts of the Coast Region, Tanzania. Pwani is a key supplier to major marketplaces in the Dar es Salaam region and to foreign markets, particularly Kenya. A descriptive cross-sectional survey was conducted among 169 cucurbits

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farmers from seven Wards across three administrative Districts of the Pwani Region. Participants were recruited using a snowball sampling technique. Data were collected through face-to-face interviews using a structured questionnaire administered in Kiswahili. Both SPSS and STATA computer software were used for data analysis and visualisation. Descriptive statistics were used to summarise farmers' socio-demographic characteristics, knowledge on pesticide use, pests and diseases, safety practices, and attitudes toward pesticide-related health and environmental impacts. The respondents comprised of 89.3% male farmers who farmed cucurbits. The mean age of respondents was 40 years, indicating that the majority fall within the economically active, productive working-age population, as defined by the Organisation for Economic Co-operation and Development (OECD). The education level was generally low, with two-thirds (68.6%) having completed only primary education. Low education was found to be a major factor that affected farmers' ability to read pesticide labels, understand safety instructions, and apply pesticides correctly, which can contribute to unsafe use and exposure. Only 53.9% of farmers followed label instructions, yet 78.1% read them. Most disposed of empty pesticide containers unsafely by throwing them away (94.7%), while 4.7% used them for fetching drinking water. Pesticide use was high, with 52.7% of farmers spraying weekly and 31.9% twice per week throughout the growth period. It was established that 39.6% harvested between 0-7 days and 57.9% within 8-15 days after spraying. Use of personal protective equipment (PPE) was inadequate, indicating a high risk of occupational exposure. The attitude towards pesticide use among farmers was reasonably positive (56.21%). Pesticide use among cucurbit farmers was both extensive and frequent. Safety measures, label compliance, container disposal, pre-harvest intervals, and PPE use still need improvement. Safer and more sustainable pesticide management requires better extension support, regulatory oversight, and farmer training.

Keywords: Pesticide; pesticide exposure; knowledge; attitude; practice; Tanzania.

1. Introduction

The United States Environmental Protection Agency (EPA) defines pesticides as chemical substances that control and inhibit pest populations. They are also used to control other organisms, such as nematodes and arthropods, including insects, as well as vertebrates that compromise food supplies and cause various health complications (EPA, 2021). However, pesticides are known to be toxic and hazardous substances (Yadav & Devi, 2017). Studies on the knowledge and application of pesticides in various developing nations have demonstrated that farmers' practices frequently pose health risks (Ali, 2023; Terziev & Petkova-Georgieva, 2019; Yadav & Devi, 2017) and hazards related to the environment (Ali, 2023; Kaur et al., 2019; Rajmohan et al., 2020). Inappropriate use of pesticides still occurs in many areas, thereby causing various problems. Human exposure to pesticides mainly occurs through food residues, occupational exposure, unsafe use of pesticides on domestic animals, and outdoor and indoor exposure. Systemic pesticides, often containing imidacloprid, thiamethoxam, acetamiprid, carbendazim, tebuconazole, metalaxyl, difenoconazole, hexaconazole, glyphosate, atrazine, metribuzin, and nicosulfuron, can cause various environmental effects, including poisoning of freshwater, reduction of ecosystem diversity, diminishing predatory organisms, interference with insect pollination, and endangering the production of food (Omelchun et al., 2025). They also cause health problems in humans and animals (Ahmad et al., 2024; Hashimi et al., 2020).

Agriculture is a primary occupation for the majority of the rural populations and forms the backbone of the economies of many countries worldwide (Losch, 2016). Agricultural practices and crop production systems have evolved in response to technological advances, environmental concerns, and market demand (Giller et al., 2021). Tanzania has 44 million hectares of arable land, 10.8 million of which are utilised for crops (URT, 2025). The United Republic of Tanzania (2024) reported that in the 2022 population and housing census, 66% of Tanzanians resided in rural areas and worked in agriculture. Most crops can thrive in different soil, environment, and temperature conditions (Mkonda, 2021). Despite smaller, scattered plots among farmers, the heavy reliance on pesticides has dramatically increased production among small-scale cucumber and watermelon farmers. The average smallholder farm is 1-5 hectares, and few farmers hold more than 20 hectares, especially in low-potential, poorly inhabited areas (URT, 2025). Tanzania's Ministry of Agriculture (2025) reports that smallholder farmers utilise 80% of the cultivated land. The National Horticulture Development Strategy and Action Plan (2021-2031) also list horticulture as a fast-growing agricultural sub-sector, rising 9-21% annually compared to 4% for the total agriculture industry. Small-scale farmers dominate horticulture, with a few large growers. It employs 4.5 million people, 65-70% of them are women and youth, and generates over USD 779 million yearly (TanzaniaInvest, 2024). Agriculture has a significant influence on the national economic growth, nutrition and food security (Msafiri & Mwombela, 2021).

Addressing these risks requires an understanding of the human and behavioural factors that influence pesticide use. The Knowledge, Attitude, and Practices (KAP) framework provides a systematic method for assessing farmers' perceptions, understanding, and pesticide use (Sharafi et al., 2018). Knowledge includes awareness of risks, safety protocols, and labelling information; attitude encompasses perceptions of risk, chemical effectiveness, and alternative methods; and practices concern actual behaviours regarding mixing, application frequency, use of personal protective equipment (PPE), storage, and disposal (Aluko et al., 2016). Inconsistencies across these three domains, such as insufficient information coupled with hazardous practices, frequently reveal barriers to safer behaviour, including financial constraints, cultural norms, or limited access to training and allied resources.

In addition, despite the documented prevalence of pesticide application in Tanzanian horticultural farming (Kapeleka et al., 2024; Mrema et al., 2017; Ngowi et al., 2007), a considerable knowledge gap remains regarding the KAP of cucumber and watermelon farmers in the Coast Region. Recently, research has mainly focused on staple crops (Mahugija et al., 2017), leading to an inadequate examination of strategies for horticultural products. This gap prevents the formulation of specific, evidence-based strategies that might mitigate occupational and environmental impacts while preserving agricultural output. Therefore, the present study aimed to assess the knowledge, attitude, and practices regarding pesticide use among cucumber and watermelon farmers in selected districts of the Coast Region, Tanzania.

2. Materials and Methods

2.1 Study Area

This study was conducted in the Coast Region of mainland Eastern Tanzania (Fig. 1). The decision to select this location was based on the high production of fruits and vegetables, particularly cucumber and watermelon, and the extensive use of pesticides.

2.2 Study Design

A descriptive cross-sectional survey design was employed to assess farmers' knowledge, attitude, and practices regarding pesticide application in cucumber and watermelon production.

2.3 Sampling Method

Purposive sampling was used to select the region and districts for this study. These sampling techniques allow the target sample with the required knowledge and information on the subject matter to be reached quickly (Nyimbili & Nyimbili, 2024). Then, Wards with intensive cucumber and watermelon production were also deliberately selected. A total of seven wards from three districts with about 300 farmers who produce cucumber and watermelon, while 169 of these were involved in this survey. Further, a snowball sampling technique was used to recruit participants for this study.

2.4 Sample Size

The sample size was calculated using equation (1) to determine the minimum sample size (Kothari, 2004).

$$no = z^{2\frac{(p\,x\,q)}{d^2}} \tag{1}$$

Where: no = sample size, z = standard deviation at a given confidence level, for this study, a 95% confidence level = 1.96, q is (1-p), the maximum probability was chosen to be 0.5, and d is the margin of error (0.05%). This yields n_o = 384.

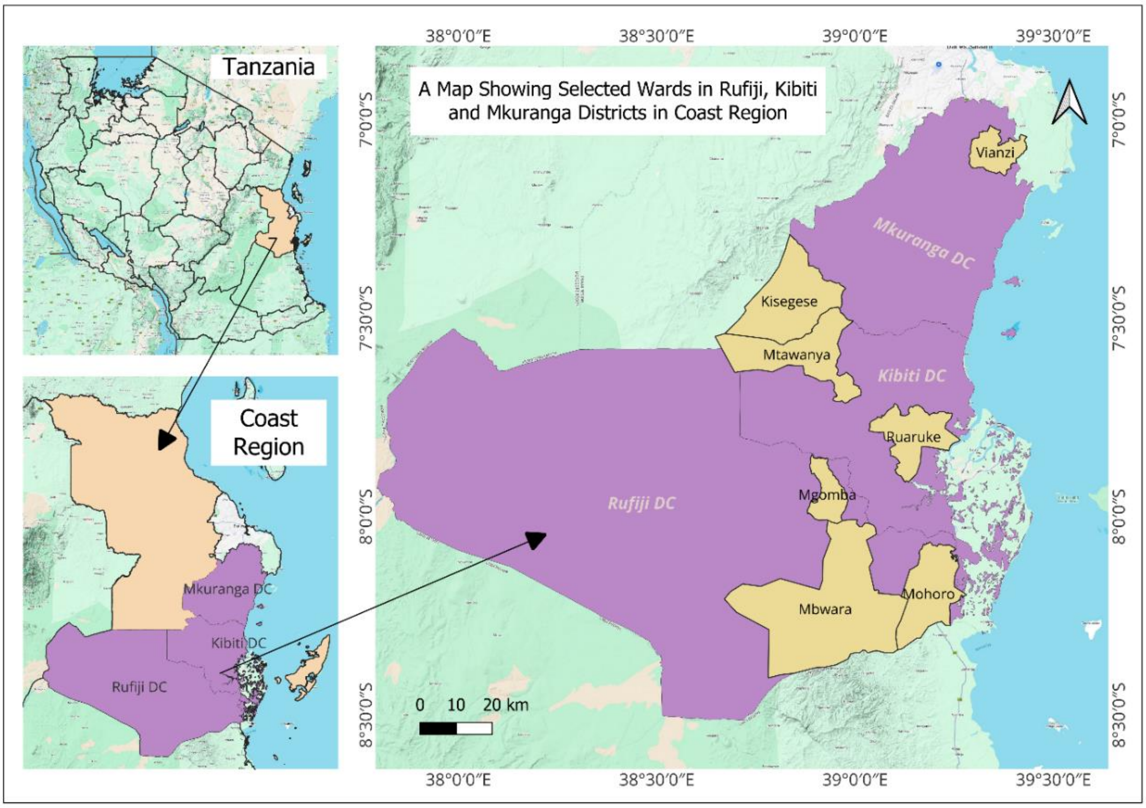

Fig. 1. Map of a study area

The adjusted sample size was calculated using the formula for cross-sectional studies (Cvetkovic-Vega et al., 2021). Initially, a sample size of 384 respondents was determined, assuming a 95% confidence level, a 5% margin of error, and a 50% response distribution. However, given the finite population of cucumber and watermelon farmers in selected districts of the Coast Region (N=300), a finite population correction was applied using equation (2) below. In addition, the total number of farmers who produce cucumber and watermelon in the 3 districts and 7 wards where this study was conducted is approximately 300. This information was obtained from district agricultural officers for each district. Therefore, the final sample size was adjusted using the finite population formula. This gives out n = 168.8 ≈ 169.

$$n = {}^{no}\!/_{1 + (\frac{no-1}{N})} \quad (2)$$

Where n = adjusted sample size for the finite population, and N = total population size.

2.5 Data Collection Procedures

A structured questionnaire comprising both closed and open-ended questions was administered to participants during this survey. The questionnaire was adapted from that used in a previous study by Kapeleka (2024), with some modifications tailored to fit the objective of this study. The revised questionnaire was pretested in the study area to assess clarity, relevance, and flow.

2.6 Data Analysis

Data were analysed using SPSS 20.0 version computer software. Descriptive statistics, including percentage and frequency tables for categorical data and mean, median, standard deviation, and range for continuous data, were used to summarise the data. Quantitative data were presented as means ± standard deviations (SD). Also, STATA computer software version 15 was used for the visualisation of results. For the overall attitude assessment, individual scores were summed to obtain the total attitude score, which ranged from 20 to 33. The mean attitude score (25), calculated from the total scores, was used to classify attitude as positive (>=25) or negative (<25).

3. Results and Discussion

3.1 Demographic and Socio-economic Characteristics

The general characteristics of the sampled population (N=169) are presented in Table 1. Respondents were drawn from seven wards across three districts in the Coast Region. Males were 89.3%, compared to 10.7% female. This disparity suggests that production is mainly male-dominated, potentially reflecting gender differences in land ownership, access to agricultural inputs, and decision-making roles within farming households. This pattern is similar to evidence from horticultural systems in various areas, where pesticide-intensive fruit and vegetable production and pesticide spraying operations are commonly undertaken by men, due to labour demands, control over land and capital, and gendered task allocation (Mrema et al., 2017; Zaller, 2020).

Table 1. Demographic and socio-economic characteristics (N=169)

Variable	Categories	Frequencies	Percentage	Mean ± SD
Region	Pwani	169	100	NA
District	Kibiti	45	26.6	
	Mkuranga	49	29	NA
	Rufiji	75	44.4	
Wards	Mtawanya	17	10.1	
	Ruaruke	28	16.6	
	Mgomba	33	19.5	
	Mbwara	23	13.6	NA
	Mohoro	19	11.2	
	Kisegese	31	18.3	
	Vianzi	18	10.7	
Sex	Male	151	89.3	
	Female	18	10.7	
Age	15-24	6	3.6	40.70 ± 10.76
	25-34	49	29	
	35-44	59	34.9	
	45-54	34	20.1	
	55-64	12	7.1	
	Above 65	9	5.3	
Education level	Not gone to school	22	13	NA
	Primary level	116	68.6	
	Secondary level	21	12.4	
	College/University	10	5.9	
Occupation	Agriculture	123	72.8	NA
	Agriculture and commerce	30	17.8	
	Agriculture and livestock	12	7.1	
	Agriculture and a public servant	4	2.3	
Farming experience	0-4	69	40.8	
	5-9	61	36.1	
	10-14	29	17.2	
	15-19	4	2.4	
	Above 20	6	3.6	

Source: Authors' construct from fieldwork, 2026

The majority of respondents were between 25 and 44 years old, while fewer were in the youngest and oldest age groups. It ranged from 21 to 67 years, with a mean age of 40.70 ± 10.76 years. This suggests that the majority of respondents were in the economically active and working-age group (OECD, 2021). Similar age profiles have been reported in several studies across different regions on fruit and vegetable production (Agmas & Adugna, 2020; Dewi et al., 2022; Kapeleka, 2024; Sharafi et al., 2018).

The majority of respondents had a low level of education, with 68.6% having attended only primary school, 13% having not attended school at all, 12.4% having attended secondary school, and 5.9% having attended college or university. Education among farmers can play a key role in responsible pesticide management, as it enhances understanding of safe handling practices and helps in reducing excessive pesticide application (Dewi et al., 2022; Mubushar et al., 2019; Oshingbade et al., 2025). This matters for pesticide risk because limited education can reduce the ability to read and correctly interpret label instructions, calculate doses, understand pre-harvest intervals, and consistently apply PPE guidance, which is linked to unsafe handling and misuse in farming contexts (Bagheri et al., 2021; Dugger-Webster & LePrevost, 2018; Malisa, 2019).

Also, all 169 respondents are involved in the cultivation of cucumber and/or watermelon, with 72.8% engaged only in agricultural activities, 24.9% engaged in agriculture alongside other self-employment activities such as commerce and livestock keeping, and only 2.3% were public servants. This aligns with studies on commercial horticulture, where intensive production of high-value crops such as watermelon can require focused attention and generate sufficient income to discourage off-farm activities (Mango et al., 2018). On the other hand, the 24.9% practicing diversification reflects a rational risk-management strategy. Recent studies on smallholder systems highlight that households diversify their livelihoods through activities to mitigate risks associated with climate change, price changes, and crop failures (De la O Campos et al., 2023; Mohammed et al., 2021). This finding is consistent with evidence indicating that livelihood diversification is notably limited in Ghana's Guinea and Sudan Savannah areas, with just 15% and 20% of rural families having broadened their income sources beyond agriculture (Dumenu & Obeng, 2016). Furthermore, activities such as commerce and livestock keeping provide an important financial resilience, a finding consistent with the mixed livelihood model prevalent across sub-Saharan Africa (Musumba et al., 2022; Srivastava et al., 2025). On top of that, a minimal percentage (2.3%) are public servants, indicating that farming serves as a secondary source of income.

As for farming experience, the majority of farmers have been working for 0 to 9 years (76.9%), about 16.9% have 10 to 19 years, and only 3.6% have more than 25 years. The median farming experience was 5 years, and the interquartile range was from 3 years (25th percentile) to 9 years (75th percentile). The minimum and maximum years of experience were 0.5 and 30, respectively. This distribution of agricultural experience significantly indicates the sub-sector dynamics. A large number of new startups indicates that a subsector is experiencing rapid expansion and change. Also, the limited number of farmers with over 25 years of experience (3.6%) significantly hampers the dissemination of informal, localised knowledge, such as insect cycle management or climate change adaptation, typically retained by seasoned farmers and shared through informal networks (Kansiime et al., 2021). These findings are inconsistent with a study by Ntow et al. (2006) in Ghana, which indicated that the majority of farmers engaged in fruit farming had 30.8 years of experience, and those engaged in vegetable cultivation had 15.3 years of experience. Furthermore, although new farmers may be open to adopting modern technologies in horticulture farming, as indicated by Kondylis et al. (2017). In Emeana et al. (2019), the limited presence of a highly experienced farmer may weaken the community's use of agro-ecological knowledge, thereby constraining adaptive capacity and highlighting the need for targeted extension services to strengthen foundational skills.

3.2 Pesticide Usage Patterns

Table 2 shows farmers' pesticide use, which is characterised by dependence on moderately to extremely hazardous pesticides, the use of pesticides not approved for major crops, and a significant gap between registered uses and farm operations. In Tanzania, TPHPA, established by Act No. 04 of 2020, registers, monitors, and controls all pesticides. Farmers identified various pesticides as the most commonly used in the study area, referring to them primarily by local or trade names. These include Dudu-acelamectin, Agri-grow, Poly-booster, Mautu, Aktic 72 WP, Amakan, Supazeb-FU/0321, Fungo force 72 WP, and Bestacron 720 EC (Fig. 2).

Insecticides (51.5%), fungicides (35.5%), and herbicides (13.0%) were most often used. Dudu Killer 100 SC (N=37, 21.9%) used abamectin + imidacloprid, the most prevalent combination of active ingredients. This composition fights pest resistance and broadens control. This method raises concerns about pesticide stacking, which can increase resistance and impose a hazardous burden on ecosystems and farmers. Damalas and Koutroubas (2018) proposed that farmers frequently prefer the immediate effectiveness of pest management over long-term health and environmental risks, particularly when facing significant crop-loss threats. In addition, many of the pesticides used in the study area fall under WHO class Ia (extremely hazardous) and class Ib (highly hazardous). Linkdivos 500 EC and Multimida Plus 344 EC contain active ingredients that are known to be acutely toxic to humans and non-target organisms. Further, the frequent use of such hazardous compounds, especially given that most farmers rarely wear PPE when handling pesticides, poses a substantial occupational health risk. A significant regulatory and safety inconsistency was observed.

Fig. 2. To show locally available pesticide products reported as most commonly used by farmers
(Source: Field work, 2026)

Furthermore, most farmers use Dudu Killer 100 SC (N=47, 21.9%) and Agri-Flex 185 SC (N=5, 3%) for tomatoes, onions, and peppers, but not for cucumbers or watermelons. This shows either a widespread inability to read the label in pesticide use on crops not included on the label. Also, the application of pesticides without following target-crop guidelines occurs because of communication among farmers, who think that using pesticides on non-target crops does not pose significant risks to consumers and will have the same effects as on the target crop. These results are consistent with those of previous studies by Donkor et al. (2016), Jodeh et al. (2016), Mansy (2024), Malhat et al. (2025), Peshin et al. (2020), Salem (2020), and Tang et al. (2025).

Table 2. Pesticides used by farmers and the WHO toxicological class (N=169)

Pesticide	Frequency (%)	Trade name	Active ingredient(s)	Chemical class	WHO class	Registered by TPHPA for use on
Insecticide	4 (2.4)	Byter Ninja 15% SC	Lambda cyhalothrin 5% + imidacloprid 10%	Pyrethroid insecticide + Neonicotinoid insecticide	**II**	For Control of Aphids Thrips and Jassids in Wheat and Cotton
Insecticide	37 (21.9)	Dudu Killer 100 SC	Imidacloprid80g/l +Abamectin 20g/l	Neonicotinoid insecticide + Avermectin (macrocyclic lactone) insecticide	**II + Ib**	Control of Thrips and Spider Mites on Onions and Tomatoes
Insecticide	3 (1.8)	TutaForce 50%WP	Thiocyclam Hydrogen Oxalate 50%	Nereistoxin analogue insecticide	**U**	Control of Leaf Miner, Thrips and Aphids on Tomatoes and Vegetable Crops
Insecticide	4 (2.4)	Snowbecco Plus 220 ZC	Lambdacyhalothrin94g/l + Thiamethoxam 126g/l	Pyrethroid insecticide + Neonicotinoid insecticide	**II**	Control of Fall Army Worm in Maize and Aphids in Tomatoes
Insecticide	13 (7.7)	Multimida Plus 344EC	Cypermethrin 144g/L + Imidacloprid 200 g/	Pyrethroid insecticide + Neonicotinoid insecticide	**II + Ia**	Control of various pests on Cotton and horticultural crops
Insecticide	5 (3.0)	Agri-Flex 185 SC	Thiamethoxam 152g/l + Abamectin 33g/l	Neonicotinoid insecticide + Avermectin (macrocyclic lactone) insecticide	**II + Ib**	Insecticides to control leaf miners, mites, thrips, aphids and whiteflies on tomatoes, pepper, cucumber and onion.

Pesticide	Frequency (%)	Trade name	Active ingredient(s)	Chemical class	WHO class	Registered by TPHPA for use on
Insecticide	4 (2.4)	Faw 112EC	Acetamiprid 64g/L + Emamectin Benzoate 48g/L	Neonicotinoid insecticide + Avermectin (macrocyclic lactone) insecticide	**II**	Control of Aphids Moth (plutellaxylostella) on Tomato, Sweet Pepper, Hot Pepper, Beans, Potatoes, Eggplant, Watermelon, Carrot, Cabbage, Cauliflower, Onions, Cucumber, Apple, Grapes, Avocado, Mangoes, Citrus, Pomes, Guavas, Pawpaws, Passion and Citrus
Insecticide	5 (3.0)	Rochlor 550 EC	Chlorpyriphos 500 g/l + Cypermethrin 50 g/l	Organophosphate insecticide + Pyrethroid insecticide	**II**	For Control of Bollworm and Other Chewing Pests in Cotton
Insecticide	12 (7.1)	Linkdivos 500 EC	Dichlorvos 500 g/L	Organophosphate insecticide	**Ia**	Control of Corn Bores, Moth and Spiders on Tomatoes, Potatoes and Cabbage
Fungicide	15 (8.9)	Superzole 325SC	Difenoconazole 125g/L +Azoxystrobin 200g/L	Triazole fungicide + Strobilurin fungicide	**II + U**	Control of Powdery Mildew, Early Blight, Leaf Spot on Tomatoes and Potatoes; Anthracnose on Watermelons, Sheath Blight on Rice
Fungicide	2 (1.2)	MOVIL 5 EC	Hexaconazole 50g/l	Triazole fungicide	**III**	Control of fungal diseases in horticultural crops and powdery mildew in cashew
Fungicide	7 (4.1)	Link Super 76WP	Propineb 70%+Cymoxanil 6%	Dithiocarbamate fungicide + Cyanoacetamide-oxime fungicide	**U + II**	Control of Blight, Anthracnose, Scab Diseases Downy Mildew and Rust on Tomatoes, Potatoes, Chill, Cucumber and Cabbage

Pesticide	Frequency (%)	Trade name	Active ingredient(s)	Chemical class	WHO class	Registered by TPHPA for use on
Fungicide	14 (8.3)	Kutuzeb Super 760 WP	Mancozeb 64% + Cymoxanil 12%	Benzothiadiazole herbicide + Acetanilide herbicide	**U + II**	For the Control of late Bright Diseases on Tomatoes
Fungicide	5 (3.0)	Power - Guard 250 SC	Carbendazim 125g/L + Tebuconazole 125g/L SC		**U + II**	Control of late blight on tomatoes, Powdery Mildew, Leaf and Nut bright disease on Cashew, and various insects on Horticultural crops
Fungicide	2 (1.2)	Force 5 EC	Hexaconazole 50g/L		**III**	Control of Fungal diseases on Horticultural Crops and Powdery Mildew (Oidium Anacardii Noack) on Cashew
Fungicide	1 (0.6)	Byter King 72 WP	Mancozeb 640g/kg + Metalaxyl80g/kg		**U+ II**	For The Control of Downy Mildew Grapes and Early and Late Blight Disease in Tomatoes, Potatoes
Fungicide	9 (5.4)	Superkinga 72WP	Mancozeb 640 g/kg + Cymoxanil 80 g/Kg		**U + II**	Control of Powdery Mildew on Okra, Early and Late Blight on Tomato and Downy Mildew on Cucumber
Fungicide	2 (1.2)	Farmerbin 60WG	Pyraclostrobin 5% + Metiram55%WG		**U**	Control of Early/Late Blight, Leaf Spot on Tomatoes and Potatoes, Downy Mildew on Cucumbers, Anthracnose, Scab Diseases on Oranges and Fungal diseases on Avocado

Pesticide	Frequency (%)	Trade name	Active ingredient(s)	Chemical class	WHO class	Registered by TPHPA for use on
Fungicide	2 (1.2)	Conquer 480 SC	Azoxystrobin 80 g/L + Chlorothalonil 400 g/L		**U**	Control of downy mildew cucumber, Late blight on Tomatoes, Brown patch on Turfgrass, Anthrax on Watermelon, Leafspot on Banana and Stem rust on Vegetables
Fungicide	1(0.6)	Superzole 325SC	Difenoconazole 125g/L +Azoxystrobin 200g/L		**II + U**	Control of Powdery Mildew, Early Blight, Leaf Spot on Tomatoes and Potatoes; Anthracnose on Watermelons, Sheath Blight on Rice
Herbicide	12 (7.1)	GuardForce Gold	Atrazine 20% + Mesotrione 7% + Nicosulfuron 3%		**III + U**	Pre Emergence Herbicides for Control of Broad and Narrow Leaf Weeds on Maize
Herbicide	1(0.6)	Byter - Soldier 480SL	Glyphosate 480g/l		**III**	Control of Weeds on Maize
Herbicide	3 (1.8)	Veggie Force 70% WP	Metribuzin 70% WP		**II**	Control of grasses, broad leaf weeds on Tomatoes and Carrot
Herbicide	6 (3.6)	Basagran PL2	Bentazone 160g/litre Propanil 340g/litre		**II**	Control of Broad-leaved weeds, sedges and grasses on Rice, beans, maize.

(Source: Authors' construct from fieldwork, 2026; WHO, 2020)
Classification of pesticide active ingredients. Ia = Extremely hazardous; Ib = Highly hazardous; II = Moderately hazardous; III = Slightly hazardous; U = Unlikely to present acute hazard

3.3 Farm Characteristics, Markets, Pest/Disease Pressure and Access to Extension Services

The findings show a profile of commercial, small-scale horticultural farming, characterised by several marketing channels and inconsistent access to expert advice, particularly from extension officers (Table 3). The variations in farmers' access to pest-control extension advice across the three districts are shown in Fig. 3. A larger number of farmers in Kibiti and Mkuranga reported not receiving guidance from agricultural experts. On the other hand, Rufiji recorded a greater number of farmers who had received extension advice. The findings suggest that access to agricultural advisory services was comparatively superior in Rufiji than in Kibiti and Mkuranga. Further, the results indicated significant variability in farmers' responses across the seven surveyed wards (Fig. 4). Mohoro and Mbwara recorded the highest positive responses (n=18 and n=19, respectively), indicating that individuals in these areas received extension services. Also, Mgomba recorded the fewest positive responses, with only 6 farmers reporting they had received extension services, while 27 had not. This suggests insufficient participation in this ward. Moreover, Mtawanya, Ruaruke, and Kisegese exhibited several adverse responses, indicating a potential deficiency in extension services and agricultural knowledge among farmers in these areas. Interestingly, Vianzi ward had an equal distribution of positive and negative responses, indicating that the farmers are currently deliberating their course of action. The results indicated that interventions should target wards with minimal positive responses. Conversely, effective strategies observed in high-adoption wards such as Mohoro and Mbwara may serve as models for broader implementation throughout the study area.

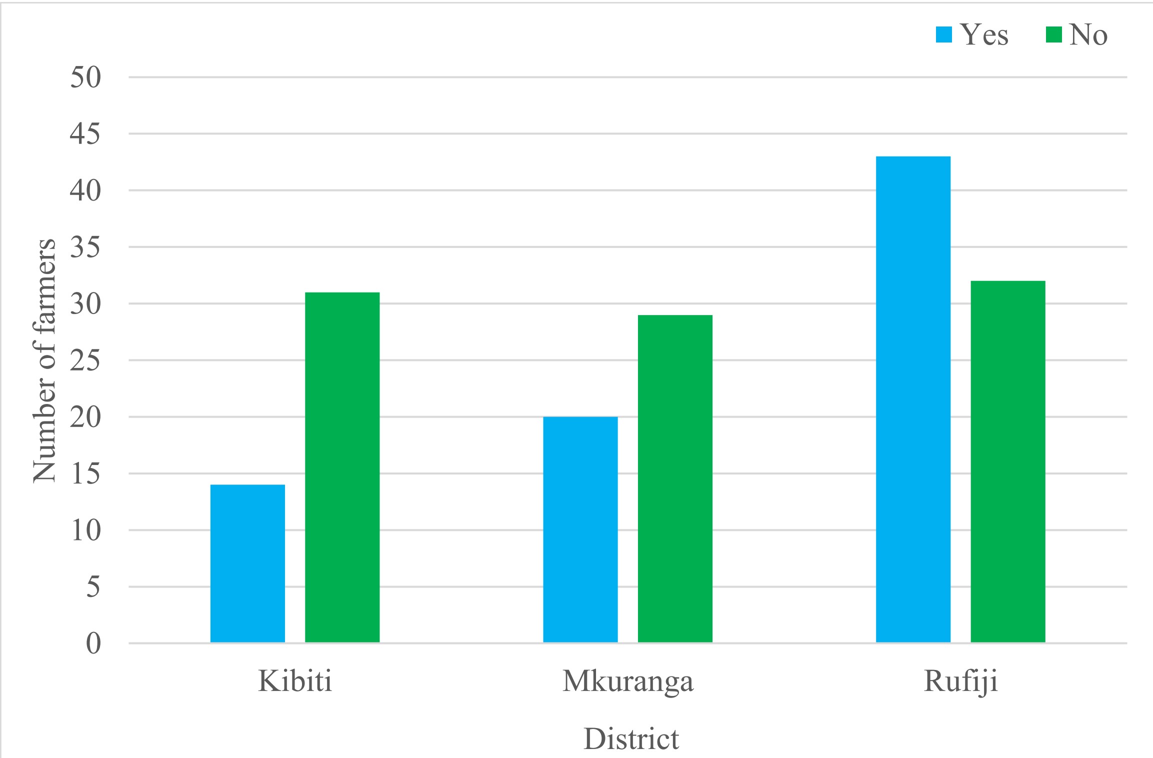

Fig. 3. Farmers' access to extension service advice on crop pest control by district

This sub-sector is mainly characterised by watermelon cultivation (84.6%) and cucumber (15.4%) (Table 3). A distinct commercial need drives this field of expertise: 87% of farmers engage only in business production, while 12.4% integrate both business and home consumption. Also, the agricultural settings are predominantly small-scale, with 85.2% cultivating on 0-5 acres. According to the Ministry of Agriculture of the United Republic of Tanzania report (2025), the average farm size for smallholder farmers ranges from 1 to 5 hectares. However, a very small number of farmers possess land over 20 hectares, especially in low-potential regions that are comparatively less inhabited. This also corresponds with the prevalent smallholder model in Sub-Saharan Africa, wherein intensive labour and management on limited land are employed to produce cash income (Moyo, 2016). The distribution of plot sizes shows that only a small proportion of farmers operate larger farms (2.4% at 18-23 acres; 0.6% above 30 acres), indicating emerging differences in landholding size within the community.

Table 3. Farm characteristics, pest/diseases pressure and access to extension services (N=169)

Variable	Categories	Frequencies	Percentage
Which crop do you grow?	Cucumber	26	15.4
	Watermelon	143	84.6
Size of farm in acres	0-5	144	85.2
	6-11	20	11.8
	12-17	0	0
	18-23	4	2.4
	24-29	0	0
	Above 30	1	0.6
Major purpose of agriculture production	Home consumption	1	0.6
	Home consumption and business	21	12.4
	Business only	147	87
Challenges to farming activities	Insect pests	15	8.9
	Fungal diseases	3	1.8
	Insect pests and Fungal disease	57	33.7
	Insect pests, fungal diseases, birds, mouse and other rodent	53	31.4
	Insect pests, wildlife, fungal diseases, mouse and other rodents	22	13
	Plant diseases	19	11.2
Pests/diseases that appear in the field each season	Mildew	48	28.4
	Fungus	12	7.1
	Mildew and fungus	47	27.8
	Wilting	19	11.2
	Flies and wilting	6	3.6
	Stem borer and flies	16	9.5
	Red spider mites	14	8.3
	Rotting before harvesting	7	4.1
Have you ever met agricultural experts for advice on how to control pests/diseases?	Yes	77	45.6
	No	92	54.4
Where do you sell cucumber/watermelon	Dar es Salaam	135	79.9
	Dar es Salaam and Kenya	11	6.5
	Rufiji	16	9.5
	Brockers	6	3.5
	Did not get enough to sell	1	0.6

Source: Authors' construct from fieldwork, 2026

On top of that, the majority of farmers (78.1%) reported various challenges they face in farming, including birds and rodents. However, 33.7% report problems with both insects and fungi, and 31.4% report problems with birds and rodents. Also, mildew (28.4%) and the combination of mildew and fungus (27.8%) are the most commonly observed seasonal problems (Fig. 5), suggesting frequent use of fungicides such as Mancozeb-based mixtures. On the other hand, the mention of stem borers, flies, and red spider mites, approximately 21%, aligns with the heavy use of insecticides. These findings are consistent with the studies by Bardin and Gullino (2020), Kituta et al. (2025), Pretty and Pervez Bharucha (2015), Sharma et al. (2016), and Wang et al. (2025).

A critical finding is that more than half (54.4%) of farmers in the study areas have never sought advice from an agricultural expert on pest/disease control during cucumber and watermelon farming. The majority of farmers rely on communication among themselves, agro-dealer recommendations, and previous experience, which are regarded as sources that may not prioritise integrated pest management. The limited interaction with agricultural experts highlights a structural gap in extension and technical support services, restricting farmers' access to knowledge, training, and advisory services and, in turn, limiting the adoption of sustainable agricultural practices (Junior, 2022).

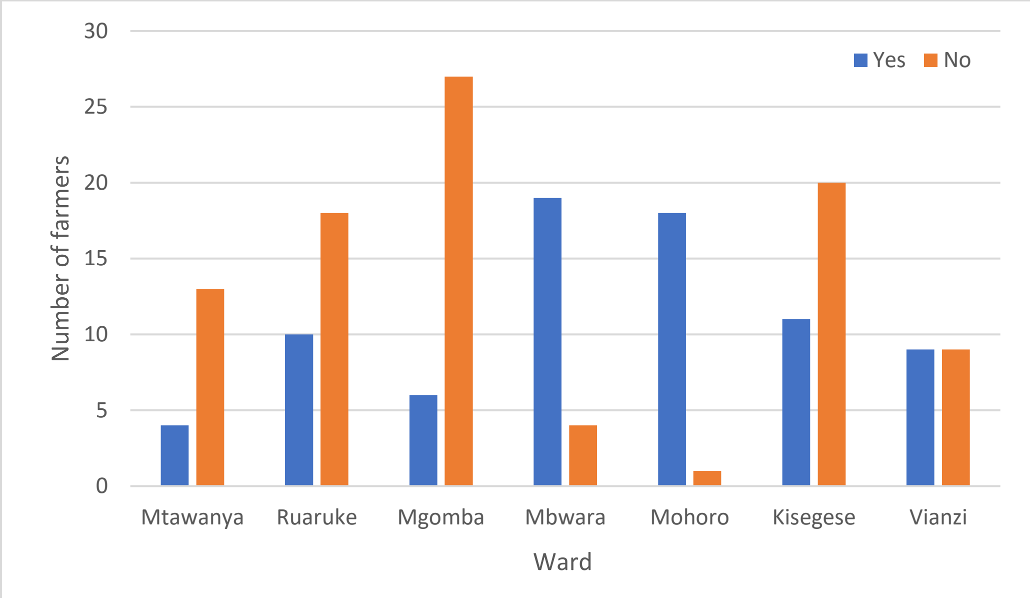

Fig. 4. Farmers' access to extension service advice on crop pest control by ward

The major market is highly concentrated, with Dar es Salaam serving as a primary market for 79.9% of farmers, who bring their products to market through brokers. Again, 3.5% of farmers sell to brokers who visit their farms directly, while local markets such as Rufiji, Ikwiriri, and Kibiti (9.5%) offer limited diversification. Mayala and Bamanyisa (2018) proposed that most fruit and vegetable producers sell their products in Dar es Salaam markets. Interestingly, based on information from farmers, about 6.5% of farmers sell their products to customers from neighbouring Kenya who cross the border to purchase mainly watermelons. This trend aligns with the National Horticulture Development Strategy and Action Plan (2021-2031), which suggests that approximately 70% of fruit and vegetable exports are produced by smallholder farmers.

3.4 Attitudes Toward Pesticide Use, Health, and Environmental Impacts

Farmers' attitudes toward pesticide use, environmental impacts, and health impacts are presented in Table 4. Attitude was assessed using a set of Likert-scale questions, and a composite attitude score was calculated for each respondent. A classification of attitudes was adopted from Mazlan and How (2017). Among 169 respondents, 56.21% had a positive attitude towards the use of pesticides regarding health and environmental impacts. In contrast, 43.79% had a negative attitude (Fig. 6). Individually, farmers show very strong agreement that the pesticides they use remain effective and satisfy their needs (5.00 ± 0.000 on a five-point Likert scale), indicating unanimous agreement among respondents. This result suggests a significant reliance on pesticides as the principal method for crop protection. Similarly, farmers highly acknowledged that pesticides negatively affect human health (4.80 ± 0.44). Comparable results have been documented among vegetable cultivators in Ghana, where Miyittah et al. (2020) observed that pesticides were regarded as important for mitigating production losses. Similar dependence has also been documented in Iran, where Abadi (2018) reported that farmers maintained positive attitudes towards pesticide efficacy despite being aware of potential risks. Further, studies by Kapeleka et al. (2024) and Wongwichit et al. (2012) found that farmers frequently associate pesticide usage with acute health symptoms such as skin irritation and headache. Nevertheless, respondents show moderate awareness of the effects of pesticides on the environment (3.07 ± 0.51), and comparatively low agreement on specific pathways such as toxic waste generation, contamination of soil and water bodies, and impacts on plant diversity, with a mean of 2.10 ± 0.713, 2.43 ± 0.792, respectively. Similarly, a neutral attitude towards environmental effects was observed among smallholder farmers in Ethiopia (Gesesew et al., 2016).

Fig. 5. To show common diseases commonly affect cucumber and watermelon
(Source: Field work, 2026)

Generally, the overall individual attitude score (3.53 ± 0.25) reflects a moderately risk-aware profile, characterised by strong perceived benefits alongside incomplete appreciation of environmental consequences. This trend indicates that while farmers acknowledge certain concerns linked to pesticide use, these views may not reliably translate into safer handling, application, and disposal practices in the absence of appropriate extension support and practical training. The results from this survey showed a mean composite attitude score of 3.53 out of 5 on the Likert-scale attitude assessment, corresponding to approximately 70.6% of the maximum attainable score. This suggests that farmers had a neutral-to-moderately positive attitude toward pesticide use and its associated health and environmental impacts. Studies by Miyittah et al. (2020) in Ghana and Abadi (2018) in Iran also indicated similar results.

3.5 Farmers' Knowledge of Pesticide Use and Safety

Table 5 highlights farmers' knowledge of pesticide use and safety measures. Over half of the respondents (55%) reported receiving guidance or training on pesticide use for pest and disease management, whereas 45% had not received any training. While extension officers were a significant source (13.6% independently and 23.6% together with pesticide sellers), a sizable number of farmers (30.8%) relied on experience and interpersonal communication, indicating that informal peer networks primarily influence pesticide decision-making. Also, it was revealed that 45% of farmers who had not received any training rely on their experience when practising farming, suggesting they gain this experience by learning from one another.

Table 4. Descriptive statistics of attitudes toward pesticide use, health and environment impacts

Variable	Minimum	Maximum	Mean ± SD
How do you perceive the current effectiveness of pesticides compared to the last two years?	5	5	5.00 ± 0.000
Do the pesticides used satisfy your needs?	5	5	5.00 ± 0.000
Pesticide has negative effects on human health?	3	5	4.80 ± 0.440
Pesticides have negative consequences on the environment	2	5	3.07 ± 0.507
Pesticides produce toxic waste products	1	4	2.10 ± 0.713
Pesticides contaminate soil and major water bodies	1	5	2.43 ± 0.792
Pesticides can affect plant diversity	1	5	2.31 ± 0.852
Overall attitude	**3**	**5**	**3.53 ± 0.245**

Source: Authors' construct from fieldwork, 2026

Table 5. Knowledge of pesticide use and safety (N=169)

Variable	Categories	Frequencies	Percentage
Have you ever received advice/training on the effective use of pesticides in controlling pests/diseases?	Yes	93	55
	No	76	45
If yes, where did you get the advice/training?	Extension officer	23	13.6
	Pesticide company/sellers	17	10.0
	Experience and communication among farmers	52	30.8
	Extension officers, researchers, and non-government organizations	1	0.6
Do you know about banned pesticides?	Yes	9	5.3
	No	160	94.7
Do you check the weather before applying the pesticide?	Yes	163	96.4
	No	6	3.6
Do you identify parasites before applying pesticides?	Yes	169	100
	No	0	0
Do you choose the right time for pesticide application?	Yes	168	99.4
	No	1	0.6
Do you follow the recommended dose of pesticide?	Yes	126	74.6
	No	41	24.2
	Maybe	2	1.2
If, no, why?	To increase efficacy	30	17.7
	A habit	9	5.3
	Soil factors	3	1.8
	Extent of a pest/disease	1	0.6
Routes of pesticide exposure	Ingestion, inhalation, and skin	32	18.9
	Inhalation and skin	137	81.1
Most dangerous route of exposure	Skin	104	61.5
	Inhalation	52	30.8
	Ingestion	13	7.7

Variable	Categories	Frequencies	Percentage
Problems related to exposure on human health	Skin rash	105	62.2
	Asthma	49	28.9
	Death	15	8.9
Symptoms associated with pesticide exposure	Skin rash and irritation	104	61.5
	Nausea, vomiting, and fever	16	9.5
	Coughing and headache	25	14.8
	Coughing, headache, and loss of consciousness	24	14.2

Source: Authors' construct from fieldwork, 2026

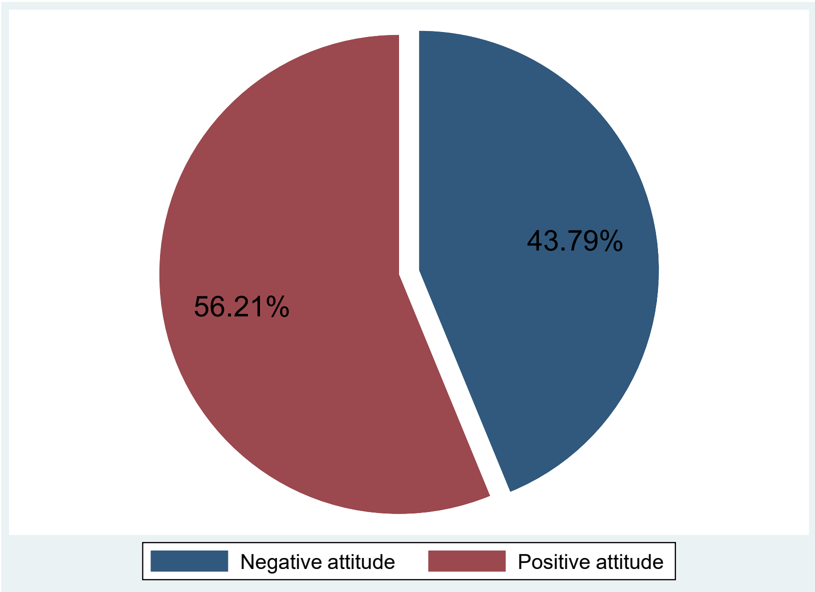

Fig. 6. To show the attitude of farmers in the study area towards pesticide use, health, and environmental impacts

On top of that, only 5.3% reported being aware of banned pesticides, while 94.7% reported not knowing about this issue. This indicates limited awareness of regulatory controls and potential use of non-recommended pesticides. In contrast, 96.4%, 100%, and 99.4% reported checking the weather, identifying pests/parasites, and choosing the right time for application, respectively. This trend suggests that farmers possess significant operational knowledge regarding appropriate spraying times; however, they have limitations in regulatory and operational knowledge. Studies by Abadi (2018) and Poonia et al. (2024) observed a similar trend.

Improved knowledge of pesticide application might eventually prevent human and environmental exposure by r educing usage and substituting highly toxic pesticides with those of lower toxicity (Tudi et al., 2021). In addition to exposure risk perception, 81.1% of farmers identified skin and inhalation as major routes of exposure, with skin perceived as the most dangerous (61.5%). The most commonly reported symptoms were skin-related effects, specifically skin rash/irritation (61.5%). The findings point to the importance of using personal protective equipment, following correct mixing practices, and implementing post-spray hygiene interventions, such as showering. This mirrors findings from studies conducted in Tanzania by Mrema et al. (2017) and Ngowi et al. (2007), in which farmers reported various health symptoms, such as feeling sick and skin problems, following pesticide exposure.

Furthermore, these findings align with FAO (2019), which suggested that exposure mostly occurs through the skin channel during spray preparation and through both dermal and inhalation pathways during application. Ingestion may occur through contaminated food ingested during or after application, or through oral contact with contaminated hands. Contaminated clothing is a major source of exposure. Bystanders may be subjected to direct skin exposure and inhalation of the sprayed insecticides. Stocks of outdated pesticides continue to pose a risk in several countries, especially when storage or disposal methods are inadequate (FAO, 2019).

Fig. 7. Field evidence of fungal disease on watermelon fruit
(Source: Field work, 2026)

Regarding application doses, 74.6% of respondents reported following the label-recommended doses, while 24.2% reported not doing so. Among those not following the recommended doses, 17.7% reported not following them to increase pesticide efficacy or effectiveness, and 5.3% reported it as a habit without a specific technical justification. This is a key misuse-risk pathway, as excessive dosing can increase occupational exposure and raise the likelihood of residues on produce. These findings contrast with several studies that proposed that mixes exhibiting neurotoxic effects predominantly consisted of insecticides, whereas the majority of fungicide mixes were linked to impacts on endocrine regulation and/or reproduction (Hernández et al., 2017; Rehman et al., 2024; Richardson et al., 2019).

3.6 Farmers' Practices on Application, Storage and Disposal of Pesticides

Pesticide use, practices, and disposal of pesticide containers by farmers are shown in Table 6. Nearly all farmers purchased pesticides from retail stores (97.6%), indicating that agro-input outlets are the primary source for pesticide products. A total of 78.1% of respondents reported reading pesticide label instructions; however, only

53.9% adhered to them, highlighting a significant gap between awareness and actual compliance. In situations involving primarily harmful disposal practices, 94.7% indicated discarding pesticide containers around the farm area (Fig. 9), whereas 4.7% claimed reusing them for other purposes, such as collecting drinking water in the field. Pesticide application occurred regularly, with 52.7% of individuals spraying once weekly, 31.9% twice weekly, 2.9% three times weekly, 2.4% once every two weeks, and 0.6% once a month. Interestingly, the remaining 9.5% are applied at random, depending on the presence of pests and diseases, without considering other factors. Pre-harvest intervals (PHIs) were generally short, with 39.6% of harvests occurring between 0-7 days and 57.9% within 8-15 days post-application, thus increasing the risk of residues at harvest, particularly for systemic and persistent pesticides.

Table 6. Farmers' practices on application, storage and disposal of pesticides

Variable	Categories	Frequencies (%)
Where do you get pesticides?	Pesticide retail shop	165 (97.6)
	Retail and wholesale pesticide shop	3 (1.8)
	Open/auction market	1 (0.6)
Where do you store pesticides?	Pesticide store	24 (14.2)
	Kitchen	3 (1.8)
	General store	109 (64.5)
	Others	33 (19.5)
Do you read the instructions on the pesticide container?	Yes	132 (78.1)
	No	37 (21.9)
If yes, do you follow the instructions given?	Yes	91 (53.9)
	No	70 (41.4)
	Maybe	8 (4.7)
What do you do with an empty pesticide container?	Throw away	160 (94.7)
	Burned	1 (0.6)
	Fetching drinking water	8 (4.7)
On average, how often do you spray pesticides in the field?	Once a week	89 (52.7)
	Twice a week	54 (31.9)
	Three times a week	5 (2.9)
	Once every two weeks	4 (2.4)
	Once a month	1 (0.6)
	Other	16 (9.5)
What is the pre-harvesting period after spraying (in days)	0-7	67 (39.6)
	8-15	98 (57.9)
	Above 15	4 (2.4)

Source: Field survey, 2026

In practice, the majority of the respondents stored pesticides in general stores (64.5%), with a minimal number storing them in the kitchen (1.8%), indicating possible exposure hazards at the household level (Fig. 8). Only a few individuals (14.2%) stored their pesticide packages appropriately in the correct place or designated location. This trend is inconsistent with findings from a study conducted in Kuwait, where 59.0% stored their pesticides in a store designated exclusively for pesticides (Jallow et al., 2017).

The findings on significant reliance on retail outlets correspond with several studies indicating that pesticide choices are frequently influenced by input vendors and informal advising networks, which may encourage non-standardised use/practices in the absence of extension contact (Devi et al., 2017; Mengistie et al., 2017; Staudacher et al., 2021). The significant percentage of individuals storing pesticides in non-designated sites aligns with previous findings of another study indicating that improper storage persists and may elevate family exposure risk (Mzara, 2018). The read-to-follow gap is also reported in other studies (Abou Ibrahim et al., 2023; Akter et al., 2018; Bagheri et al. 2021).

Fig. 8. A photograph to show unsafe pesticide storage practices observed during the survey, where pesticide was stored near food items in a household setting

Fig. 9. Farmers poor disposing pesticide packages and mixing cups after spraying
(Source: Field survey, 2026)

Table 7. Safety precautions and the use of personal protective equipment (N=169)

Variable		Categories	Frequencies	Percentage
Do you use expired date pesticides?		Yes	0	169
		No	100	0
Do you consider toxicity signs on the pesticide container?		Yes	0	0
		No	169	100
Do you use appropriate pesticides that kill the target pest?		Yes	145	85.5
		No	24	14.2
Do you change clothes and take a shower after applying pesticides in the field?		Yes	168	99.4
		Maybe	1	0.6
Describe the things you do while dealing with pesticides	Eating	Yes	0	0
		No	169	100
	Drinking	Yes	7	4.1
		No	162	95.9
	Smoking	Yes	1	0.6
		No	168	99.4
Specify the PPE you wear when dealing with pesticides		Use and in good condition	28	16.6
	Gloves	No	141	83.4
	Boots	Use and in good condition	105	62.1
		No	61	36.1
		Have but don't use	1	0.6
		Use but worn out	2	1.2
	Respirator	Use and in good condition	1	0.6
		No	168	99.4
	Mask	Use and in good condition	59	34.9
		No	109	64.5
		Have but don't use	1	0.6
	Goggles	Use and in good condition	11	6.5
		No	158	93.5
	Overall coat	Use and in good condition	29	17.2
		No	140	82.8
	Head cover	Use and in good condition	5	3
		No	164	97

Source: Authors' construct from fieldwork, 2026

Further, this study observed poor disposal of pesticide containers; the results are similar to those of other studies by (Bondori et al., 2019; Gesesew et al., 2016; Mohafrash & Mossa, 2024; Sharafi et al., 2018). This might pose environmental risks (Rajmohan et al., 2020). Frequent pesticide applications in fruit and vegetable farming to manage high pest pressure and meet market demands can increase cumulative exposure. The findings are similar to those of Mwanja et al. (2017), Quijano et al. (2016), and Tang et al. (2025). For PHIs, results are consistent with various studies that provide evidence of non-compliance as a key pathway to detectable pesticide residues in fruits and vegetables (Fosu et al., 2017; Malhat et al., 20205; Popescu et al., 2025).

3.7 Safety Precautions and the Use of Personal Protective Equipment (PPE)

Table 7 presents information on safety precautions and PPE use. Hygiene behaviour reported was very high, with 99.4% argues that they change clothes and take a shower after pesticide application. The majority of farmers (85.5%) reported using pesticides that target the pest of interest. Risk behaviours during handling were uncommon among farmers: eating (0%) and smoking (0.6%); however, 4.1% reported drinking while handling pesticides. This is inconsistent with a study by Evaristo et al. (2022), which observed farmers eating, drinking, and smoking while applying pesticides on their farms. Similar findings were reported in Ethiopia, where Gesesew et al. (2016) found that 12.6% of farmers (N=796) reused empty pesticide containers for food storage. The use of PPE was reported by farmers, with boots as the most commonly used item in good condition (62.1%) and masks (34.9%). In comparison, the use of gloves (16.6%), overall coats (17.2%), safety goggles (6.5%), head covers (3.0%), and respirators (0.6%) was very low while handling the pesticide. Respondents also reported that they did not use expired pesticides (100%). However, all farmers (100%) indicated they did not consider toxicity signs on the containers, which implies poor pesticide management within the product selection range.

Low use of PPE when handling pesticides, particularly respirators, goggles, gloves, and head covers, was due to several factors, including cost, low education levels, lack of training, and discomfort in hot climates (Moreira & da Silva, 2023). This finding is consistent with many studies from developing countries (Kapeleka, 2024; Miyittah et al., 2020; Ojo et al., 2025). However, nearly all farmers take a shower and change clothes after spraying, which is more encouraging than in other studies, where post-spray hygiene is inconsistent. A study by Khanal et al. (2025) in Nepal reported that 40% of farmers did not shower after spraying.

4. Conclusion

The present study assessed knowledge, attitude, and practices related to pesticide use among cucumber and watermelon farmers in selected Districts of the Coastal Region, with particular attention to human health and environmental implications. The findings reveal significant reliance on pesticide use in cucurbit farming, with farmers demonstrating moderate awareness of health risks and practical knowledge of application practices. Education level emerged as a key factor that strongly influences knowledge, time, pesticide dosage, practices, and attitude. Also, farmers showed moderate awareness of health risks and practical knowledge of pesticide application. Major gaps persist in regulatory knowledge, safe handling practices, container disposal, compliance with pre-harvest intervals, and consistent use of personal protective equipment. These findings highlight the need for strengthened extension services, targeted farmer training, and improved regulatory oversight to promote safer pesticide management and reduce health and environmental risks. Enhancing farmer training programs through extension services is essential to improve safe pesticide handling, correct dosing, proper container disposal, adherence to pre-harvest intervals, and consistent use of personal protective equipment. In addition, stronger regulatory oversight and promotion of Integrated Pest Management strategies are needed to reduce excessive reliance on hazardous pesticides and protect human health and the environment.

Consent and Ethical Approval

This research was granted permission and conducted in compliance with the regulations and guidelines of Sokoine University of Agriculture. Permission to conduct this study was granted by the Prime Minister’s Office, Regional Administration and Local Government, with permit number JC. 156/254/01. Farmers participated voluntarily and were recruited after giving consent.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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