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Knowledge, attitudes and practices as determinants of compliance with pesticide-use guidelines among horticultural farmers in Babati district, Tanzania

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ABSTRACT

The use of pesticides is still prevalent in vegetable farming in Tanzania. This cross-sectional study examined associations between farmers' knowledge, attitudes and reported practices and compliance with pesticide-use guidelines among 185 horticultural farmers in three wards of Babati District. The data from a structured 5-point Likert question was analyzed by frequency count, Pearson correlation and standardized multiple regression (n = 185). The majority of farmers were male (71.0%) and aged more than 45 years (49.7%), while the majority also had primary education (94.8%). There was high agreement on purchasing pesticides in original containers (99.5%) and health-risk awareness (84.3%), but low agreement on reading pesticide labels (15.7%), understanding pesticide hazard symbols (5.4%), being aware of official pesticide guidelines (3.2%), use of personal protective equipment (PPE) (37.9%), record-keeping (5.4%), and sprayer calibration (1.6%). Knowledge ($r = 0.544$), practices ($r = 0.431$) and attitudes ($r = 0.321$) correlated positively with compliance ($p < 0.01$). The regression model was significant, $F(3, 181) = 29.64$, $p < 0.001$, adjusted $R^2 = 0.318$. Knowledge ($\beta = 0.451$, $p < 0.001$) and practices ($\beta = 0.233$, $p = 0.005$) independently predicted compliance; attitudes did not ($\beta = -0.052$, $p = 0.524$). Extra emphasis should be put on a literacy-sensitive extension, and practical training and low-cost protective equipment.

Key words: Pesticide use, Horticultural farmers, Knowledge-attitude-practice, Compliance, Tanzania

INTRODUCTION

Horticulture contributes significantly to rural employment, livelihoods, and high-value food production in Tanzania, and smallholders (those less than 2 acres) produce a significant amount of fruit and vegetable production (Kapeleka, 2024). Pesticides are important in reducing pest and disease losses that would otherwise result in losses in intensive tomato (*Solanum lycopersicum* L.), onion (*Allium cepa* L.), cabbage (*Brassica oleracea* L.) and pepper (*Capsicum* spp.) production. Recent surveys of farms, however, reveal that this dependence is not well-regulated.

Of the 385 vegetable farmers in Iringa, Arusha and Kilimanjaro, 47.9% used the products incorrectly, 88.9% of farmers were not aware of safety practices and doses of fungicides and insecticides applied were far higher than world averages (Kapeleka, 2024). Likewise, about 1/4 of the Tanzanian cotton growers knew the correct pesticide mixing, health and environmental risks (Charles, 2025), and about 1/4 of women horticultural workers had poor pesticide knowledge (Olirk *et al.*, 2026), while 93.1% understood little about handling pesticides during pregnancy (Mwakalasya *et al.*, 2024). Mwezi *et al.* (2026) found that 58.3% of small-scale farmers across five regions in Tanzania had poor pesticide-safety knowledge and 21.9% formally trained in risk-reduction strategies. Deficient handling is an occupational and environmental issue throughout Africa. A 2024 meta-analysis revealed very low pooled use of masks, gloves, boots and overalls when working with pesticides, frequent storage of pesticides in household storage areas and re-use of empty containers among pesticide applicators (Mengistu *et al.*, 2024).

Farmers using pesticides without personal protective equipment (PPE) was 88.4% and reusing empty pesticide containers was 59% in the north-west of Ethiopia (Wondie *et al.*, 2026); near Lake Tana, of the farmers using pesticides, 39.4% complied with safety precautions; agrochemical knowledge was good for 42.3% but safe use was 22.4%. (Zeleke *et al.*, 2026). Of the farm workers, 40.6% in Awi Zone practiced safe handling (Temesgen *et al.*, 2025). Based on the recommendations of FAO and WHO (2020), PPE, locked storage and correct dose and safe disposal are dependent constructs, which are the parts of the study discussed in the present study.

Farmers' knowledge, attitudes and practices (KAP) are well defined as the rationale behind the adoption or rejection of farm safety measures. Theory of Planned Behaviour (TPB) theories behavior as being a function of attitude, social norms and perceived control—such as skills and equipment availability (Ajzen, 1991). Evidence from Tanzania has consistently demonstrated low farm level knowledge and injuries and information from retailers (Lekei *et al.*, 2014; Matowo *et al.*, 2020). Recent studies indicate that the unavailability of labels and lack of safety information significantly contributes to excessive pesticide usage (Kapeleka, 2024), training substantially improves knowledge and adoption of integrated pest management (IPM) (Charles, 2025), and trained farmers are more likely to use safer practices (Mwezi *et al.*, 2026), while untrained farmers have higher odds of unintentional pesticide poisoning (Kapeleka *et al.*, 2025). Northern Tanzania horticulture is also gendered, with women sometimes not being trained to use PPE even though they know the risks to their health (Olirk *et al.*, 2025; Olirk *et al.*, 2026). In horticultural areas of Tanzania, maternal spraying during pregnancy has been shown to be linked to lower social–emotional and executive-function scores in children aged 4–6 years (Mwakalasya *et al.*, 2025). In Iringa and Njombe, farmers know what practices are safer but have, due to cost of inputs, been tempted to mix unsafely and store poorly, as well as by cheaply available counterfeit products, and weak regulation (Chilipweli *et al.*, 2025). The level of knowledge and awareness among Kenyan tomato farmers correlates with their adherence to it, while the cost of PPE and lack of training are structural barriers (Ndirangu *et al.*, 2025).

Similarly, non-adherence is blamed in Fogera and Mecha, Ethiopia, not only for lack of interest, but also for PPE cost, lack of storage and lack of disposal systems (Chekol, 2025). Babati District of Manyara Region has year-round horticulture and pesticide use is high throughout the year.

The previous KAP research has been done in Arusha, Kilimanjaro, Iringa, and large horticultural estates; but not in Ayalagaya, Arri and Kiru in smallholder vegetable production. The study thus sought to investigate if knowledge, attitude and practices influence compliance with the pesticide-use guidelines among horticultural farmers in these wards.

MATERIALS AND METHODS

Study design and area

A quantitative cross-sectional survey was conducted in Babati District, Manyara Region, northern Tanzania (approximately 3°–5° S, 35°–37° E). Three wards Ayalagaya, Arri and Kiru were selected purposively because of intensive irrigated horticulture and frequent pesticide use (District Agricultural Office, unpublished data). GPS locations of the study wards are shown in Fig. 1. Knowledge, attitudes and practices were treated as hypothesized determinants of compliance (Fig. 2).

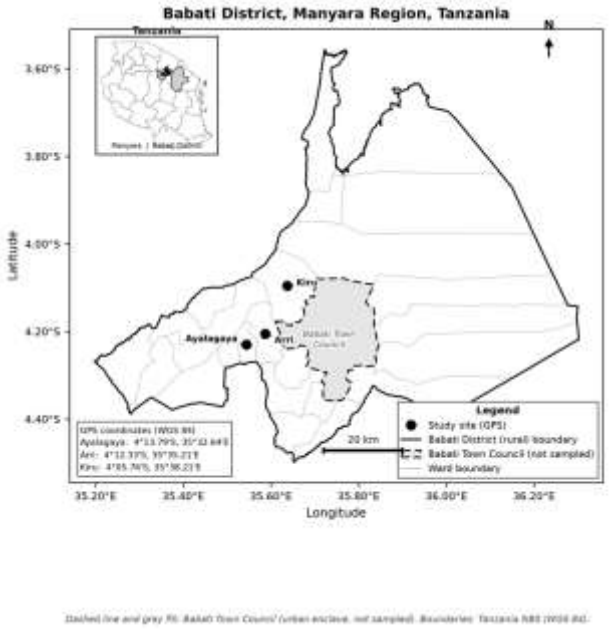


Fig. 1. Location map of the study sites in Babati District, Manyara region, Tanzania

Filled circles are GPS positions of Ayalagaya (4°13.79'S, 35°32.64'E), Arri (4°12.33'S, 35°35.21'E) and Kiru (4°05.76'S, 35°38.21'E) (WGS 84). Grey fill and dashed outline mark Babati Town Council, an urban enclave that was not sampled. Administrative boundaries: Tanzania National Bureau of Statistics (ward shapefile).

Population and sampling

The target population was small-scale horticultural farmers who regularly apply pesticides to tomatoes, onions, cabbage and related vegetables. Large-scale commercial farms, agro-dealers and policymakers were excluded. Local agricultural offices listed 576 horticultural farmers in the three wards. The sample size was determined with Yamane's formula (Yamane, 1967). The analysed sample comprised 185 farmers, allocated as 48 (Ayalagaya), 41 (Arri) and 96 (Kiru) (Table 1). Wards were selected purposively. Respondents were drawn from the horticultural-farmer lists supplied by the ward agricultural offices.

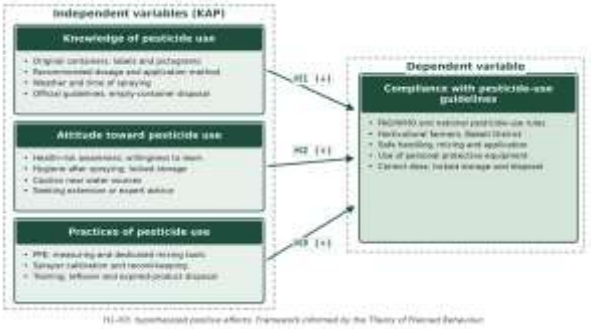


Fig. 2. Conceptual framework of hypothesized KAP determinants of compliance with pesticide-use guidelines among horticultural farmers in Babati District

Knowledge, attitudes and practices are hypothesized to exert positive effects (H1–H3) on compliance. The framework is informed by the Theory of Planned Behaviour (Ajzen, 1991) and by the study objectives.

Table 1. Sampling frame and achieved sample by ward

Ward	Population (N)	Sample (n)
Ayalagaya	186	48
Arri	164	41
Kiru	226	96
Total	576	185

Data collection

A structured questionnaire was developed from the study objectives and the pesticide KAP literature, following standard survey procedures (Kothari, 2004). The instrument was programmed in KoboToolbox and administered to horticultural farmers in the three wards between 10 and 20 June 2024. It captured background characteristics and Likert items (1 = strongly disagree to 5 = strongly agree) on knowledge, attitudes, practices and compliance.

Strongly agree and agree were combined as agreement. Item means were also compared with a study-defined cut-off of 2.64. Completed records were downloaded from KoboToolbox and imported into IBM SPSS Statistics version 27 for coding and analysis.

Statistical analysis

Data were analysed in IBM SPSS Statistics version 27. Frequencies, percentages, means and standard deviations described items. Pearson correlations described associations among the four constructs. Multiple linear regression then tested whether knowledge, attitudes and practices jointly determine compliance. Standardized coefficients (β) were estimated from the Pearson correlation matrix of the four constructs (n = 185). That solution is algebraically identical to ordinary least squares on z-scored variables given those correlations. Model fit is reported as R^2, adjusted R^2 and $F(3, 181)$. Multicollinearity was assessed with variance inflation factors. Significance was set at $\alpha = 0.05$. Kolmogorov–Smirnov tests (n = 185) rejected normality for the study variables; parametric methods were retained on the basis of sample size.

Validity, reliability and ethics

Content validity was supported by a review of pesticide KAP literature and by supervisor examination of the instrument. Factor loadings were reported above 0.50. The Kaiser–Meyer–Olkin measure was 0.734 and Bartlett's test was significant ($\chi^2 = 256.321$, df = 120, $p < 0.001$) (Table 2). Cronbach's alpha exceeded 0.70 for all four scales (Table 3). Research clearance was issued by the Vice Chancellor of the Open University of Tanzania (Ref. OUT/PG202100213, 5 June 2024) on behalf of the Government of Tanzania and the Tanzania Commission for Science and Technology (COSTECH).

Table 2. Sampling adequacy and sphericity tests (n = 185)

Test	Result
Kaiser–Meyer–Olkin measure	0.734
Bartlett's test of sphericity (chi-square)	256.321
Degrees of freedom	120
Significance (p)	<0.001

Table 3. Cronbach's alpha coefficients

Scale	Number of items (as reported)	Cronbach's alpha
Compliance with pesticide-use guidelines	5	0.832
Knowledge of pesticide use	5	0.832
Attitude toward pesticide use	6	0.755
Practice of pesticide use	6	0.840

RESULTS

Demographic characteristics

Of 185 respondents, 131 (71.0%) were male and 54 (29.0%) were female (Table 4). The largest age group was above 45 years (92; 49.7%), followed by 36–45 years (66; 35.7%). Education was concentrated at primary (50.8%) and non-formal (44.0%) levels. Experience was long: 39.5% had more than 24 years in horticulture and none reported less than one year.

Knowledge

Knowledge was mixed (Table 5). Almost all farmers bought pesticides in original containers (184/185 strongly agreed; mean 4.99). Awareness of suitable weather and time of day was high (84.3% agreement; mean 4.12). In contrast, only 15.7% agreed they read and followed labels (mean 1.97), 5.4% understood container signs and symbols (mean 1.41), 2.7% disposed of empty containers according to guidelines (mean 1.43), and 3.2% were aware of government pesticide-use guidelines (mean 1.39). Knowledge of recommended dosage and method was intermediate (38.4% agreement; mean 2.81).

Attitudes

Handwashing after handling pesticides was widely endorsed (85.4%; mean 4.12), as was awareness of health risks from incorrect handling (84.3%; mean 4.10) and willingness to learn best practices (98.4%; mean 4.86) (Table 6). Safer hygiene and storage were uncommon: 25.9% showered and washed clothes after application, 4.9% washed spray clothing separately from domestic laundry, and 2.2% stored pesticides in a locked dedicated place. Only 27.0% sought extension or expert advice before use.

Table 4. Demographic characteristics of respondents (n = 185)

Characteristic	Category	Frequency	Percent
Sex	Male	131	71.0
	Female	54	29.0
Age (years)	Below 25	11	6.0
	25–35	16	8.6
	36–45	66	35.7
	Above 45	92	49.7
Education	Non-formal	82	44.0
	Primary	94	50.8
	Secondary	6	3.2
	College	2	1.1
	University	1	0.5
Horticultural experience	Below 1 year	0	0.0
	1–5 years	4	2.2
	6–10 years	26	14.1
	12–17 years	36	19.5
	18–23 years	46	24.9
	Above 24 years	73	39.5

Table 5. Farmers' knowledge items related to pesticide-use guidelines (n = 185)

Item	SA n (%)	A n (%)	N n (%)	D n (%)	SD n (%)	Mean	O
I usually buy pesticides in their original containers	184 (99.5)	1 (0.5)	—	—	—	4.99	0.74
I read and follow the instructions on pesticide labels carefully	9 (4.9)	20 (10.8)	8 (4.3)	67 (36.2)	81 (43.8)	1.97	1.165
I understand the signs and symbols on pesticide containers	3 (1.6)	7 (3.8)	4 (2.2)	35 (18.9)	136 (73.5)	1.41	0.843
I am aware of the appropriate weather conditions and time of day to apply pesticides	89 (48.1)	67 (36.2)	3 (1.6)	15 (8.1)	11 (5.9)	4.12	1.161
I dispose of empty pesticide containers properly according to guidelines	1 (0.5)	4 (2.2)	1 (0.5)	62 (33.5)	116 (62.7)	1.43	0.674
I am aware of pesticide-use guidelines issued by government or agricultural authorities	1 (0.5)	5 (2.2)	2 (1.1)	50 (27.0)	127 (68.6)	1.39	0.70
I know the recommended dosage and application method for the pesticides I use	10 (5.4)	61 (33.0)	17 (9.2)	78 (42.2)	19 (10.3)	2.81	1.162

SA = strongly agree; A = agree; N = not sure; D = disagree; SD = strongly disagree.

Table 6. Farmers' attitude items related to pesticide-use guidelines (n = 185)

Item	SA n (%)	A n (%)	N n (%)	D n (%)	SD n (%)	Mean	SD
I wash my hands after handling or application of pesticides	61 (33.0)	97 (52.4)	16 (8.6)	11 (5.9)	—	4.12	0.801
I take a shower and wash clothes after pesticide application	4 (2.2)	44 (23.8)	14 (7.6)	72 (38.9)	51 (27.6)	2.34	1.178
I wash spray clothes separately from domestic washing	2 (1.1)	7 (3.8)	13 (7.0)	83 (44.9)	80 (43.2)	1.75	0.831
I store pesticides in a locked and separate place specified for pesticide storage	—	4 (2.2)	6 (3.2)	53 (28.6)	121 (65.4)	1.42	0.664
I am aware of the potential health risks associated with incorrect pesticide handling	75 (40.5)	81 (43.8)	7 (3.8)	13 (7.0)	8 (4.3)	4.10	1.056
I am cautious about using pesticides near water sources to prevent contamination	27 (14.6)	88 (47.6)	21 (11.4)	16 (8.6)	33 (17.8)	3.32	1.328
I seek advice from agricultural extension services or experts before using pesticides	24 (13.0)	26 (14.1)	1 (0.5)	37 (20.0)	97 (52.4)	2.15	1.50
I am willing to invest time and effort in learning about best practices for pesticide use	165 (89.2)	17 (9.2)	—	3 (1.6)	—	4.86	0.468

SA = strongly agree; A = agree; N = not sure; D = disagree; SD = strongly disagree.

Practices

Measuring tools (78.4%) and dedicated mixing equipment (85.4%) were the main compliant practices (Table 7). PPE use was intermediate (37.9% agreement; mean 2.88). Storage and handling according to guidelines (2.7%), regular sprayer calibration (1.6%), record-keeping (5.4%), receipt of training (4.9%) and proper disposal of leftover or expired product (1.6%) were rare.

Table 7. Farmers' practice items related to pesticide-use guidelines (n = 185)

Item	SA n (%)	A n (%)	N n (%)	D n (%)	SD n (%)	Mean	SD
I store and handle pesticides on my farm according to the recommended guidelines	2 (1.1)	3 (1.6)	3 (1.6)	44 (23.8)	133 (71.9)	1.36	0.702
I calibrate my sprayers regularly to ensure accurate application of pesticides	—	3 (1.6)	—	76 (41.1)	105 (56.8)	1.46	0.59
I use personal protective equipment (PPE) while dealing with pesticides	31 (16.8)	39 (21.1)	7 (3.8)	89 (48.1)	17 (9.2)	2.88	1.32
I usually use a measuring cup or measuring tool to add the exact amount mentioned on the label	117 (63.2)	28 (15.1)	5 (2.7)	27 (14.6)	8 (4.3)	4.18	1.268
I use special tools (only for pesticide usage) to mix and apply pesticides	146 (78.9)	12 (6.5)	—	4 (2.2)	23 (12.4)	4.37	1.366
I keep records of the pesticides I apply, including type, quantity and application date	1 (0.5)	9 (4.9)	2 (1.1)	20 (10.8)	153 (82.7)	1.30	0.768
I have received training on proper pesticide use and safety	1 (0.5)	8 (4.3)	2 (1.1)	41 (22.2)	133 (71.9)	1.39	0.767
I properly dispose of leftover or expired pesticides	3 (1.6)	—	—	51 (27.6)	131 (70.8)	1.32	0.564

SA = strongly agree; A = agree; N = not sure; D = disagree; SD = strongly disagree.

Table 8. Pearson correlation matrix (n = 185)

Variable	Compliance	Knowledge	Attitude	Practice
Compliance with pesticide-use guidelines	1			
Knowledge of pesticide use	0.544**	1		
Attitude toward pesticide use	0.321**	0.500**	1	
Practice of pesticide use	0.431**	0.511**	0.632**	1

** Correlation is significant at the 0.01 level (two-tailed).

Table 9. Standardized multiple linear regression of compliance on knowledge, attitudes, and practices (n = 185).

Predictor	β	SE	t	p	95% CI for β	VIF
Knowledge of pesticide use	0.451	0.074	6.14	<0.001	0.306, 0.596	1.46
Attitude toward pesticide use	−0.052	0.082	−0.64	0.524	−0.213, 0.109	1.79
Practice of pesticide use	0.233	0.082	2.84	0.005	0.071, 0.395	1.82

Dependent variable: compliance with pesticide-use guidelines. Model: $F(3, 181) = 29.64$, $p < 0.001$; $R^2 = 0.329$; adjusted $R^2 = 0.318$. Coefficients are standardized (β) estimated from the study Pearson correlation matrix.

Correlation and regression

All three KAP constructs correlated positively with compliance at $p < 0.01$ (Table 8): knowledge $r = 0.544$, practices $r = 0.431$, attitudes $r = 0.321$. Attitude correlated strongly with practice ($r = 0.632$). Standardized regression of compliance on the three constructs was significant, $F(3, 181) = 29.64$, $p < 0.001$, $R^2 = 0.329$, adjusted $R^2 = 0.318$ (Table 9). Knowledge was the strongest independent predictor ($\beta = 0.451$, SE = 0.074, $t = 6.14$, $p < 0.001$). Practices also predicted compliance ($\beta = 0.233$, SE = 0.082, $t = 2.84$, $p = 0.005$). Attitudes were not significant after mutual adjustment ($\beta = -0.052$, SE = 0.082, $t = -0.64$, $p = 0.524$). VIFs were 1.46, 1.79 and 1.82.

DISCUSSION

The study findings indicate that knowledge and practice regarding pesticide use were independently and significantly associated with compliance with pesticide-use guidelines among horticultural farmers in the study area. Knowledge emerged as the strongest predictor ($\beta = 0.451$, $p < 0.001$), followed by pesticide-use practices ($\beta = 0.233$, $p = 0.005$). Although attitudes were positively correlated with compliance ($r = 0.321$, $p < 0.01$), their association was not statistically significant after adjusting for knowledge and practices ($\beta = -0.052$, $p = 0.524$). The regression model explained 32.9% of the variation in compliance, indicating that the three KAP components collectively accounted for a meaningful proportion of differences in farmers' adherence to pesticide-use guidelines.

The significant association between knowledge and compliance reflects important gaps in horticultural farmers' understanding of pesticide-safety requirements. Although 99.5% reported purchasing pesticides in their original containers and 84.3% were aware of appropriate

application weather conditions, only 15.7% reported reading and following pesticide labels, 5.4% understood hazard symbols, and 3.2% were aware of official pesticide-use guidelines. This pattern is consistent with Kapeleka (2024), who identified knowledge gaps and inappropriate pesticide application among smallholder vegetable farmers in Tanzania. Similar concerns regarding pesticide-handling knowledge and safety practices were documented by Lekei *et al.* (2014) and Matowo *et al.* (2020). These similarities suggest that inadequate understanding of technical pesticide information remains an important issue in smallholder farming systems, even where farmers are familiar with basic handling procedures.

Despite generally positive attitudes toward pesticide safety, the adjusted association between attitudes and compliance was not statistically significant. Most respondents expressed willingness to learn improved pesticide-use practices (98.4%) and recognized the health risks associated with incorrect pesticide handling (84.3%). However, reported adherence to recommended safety behaviors, including separate washing of pesticide-contaminated clothing (4.9%) and locked pesticide storage (2.2%), remained low. This difference between safety awareness and reported behavior is consistent with the Theory of Planned Behaviour (Ajzen, 1991), which recognizes that attitudes alone may not explain behavioral performance. Comparable differences between awareness and safe pesticide-handling practices have been documented among agricultural workers in Tanzania and Ethiopia (Olirk *et al.*, 2025; Zeleke *et al.*, 2026). Nevertheless, the present study did not directly measure perceived behavioral control or behavioral intentions, limiting the extent to which these mechanisms can explain the observed relationships.

Pesticide-use practices were also significantly associated with compliance, although adoption varied considerably across individual safety measures. While 78.4% of respondents reported using measuring equipment and 85.4% used dedicated pesticide-mixing tools, only 37.9% reported using personal protective equipment, 1.6% regularly calibrated their sprayers, and 5.4% maintained pesticide application records. Similar deficiencies in pesticide-handling practices have been reported by Mengistu *et al.* (2024) and Temesgen *et al.* (2025), particularly regarding protective equipment and other safety precautions. The low proportion of respondents who had received pesticide-safety training (4.9%) is also consistent with concerns about limited training access reported by Mwezi *et al.* (2026). These findings demonstrate that the application of pesticide-safety measures is uneven, with some routine handling practices more commonly reported than other recommended precautions.

The observed relationships may also reflect contextual factors beyond the KAP components examined in this study. Previous research has identified the cost and availability of protective equipment, limited access to reliable pesticide information, and inadequate training as barriers to safe pesticide use (Kapeleka, 2024; Chilipweli *et al.*, 2025; Ndirangu *et al.*, 2025). Such factors may help explain why farmers with positive safety attitudes do not consistently follow recommended practices. However, these potential influences were not independently assessed in the present regression model. The findings therefore support an interpretation of pesticide-use compliance as a behaviour associated with farmers' knowledge and reported practices, while recognizing that additional socioeconomic and institutional conditions may contribute to the observed variation.

Several limitations should be considered when interpreting these findings. The cross-sectional design prevents causal inference, while reliance on self-reported information introduces potential recall and social desirability biases. Furthermore, purposive selection of the three study wards limits the generalizability of the findings beyond the surveyed horticultural farmers. The regression model also did not account for demographic and contextual characteristics, including education, farming experience, access to extension services and differences between wards. Despite these limitations, the study contributes evidence on the relative associations of knowledge, attitudes and practices with pesticide-use guideline compliance among smallholder horticultural farmers in Babati District.

CONCLUSION

This study achieved its aim of determining whether knowledge, attitudes and practices determine compliance with pesticide-use guidelines among horticultural farmers in Ayalagaya, Arri and Kiru, Babati District. The main findings were that knowledge and field practices independently determine compliance, whereas attitudes do not after the three constructs are entered together.

Guideline-critical knowledge (labels, pictograms and official guidelines) and safety routines (PPE, locked storage, calibration, records and leftover disposal) were low, even though willingness to learn and health-risk awareness were already high.

The major outcome is that, in this low-literacy irrigated horticulture setting, compliance is knowledge and practice-constrained rather than attitude-constrained. The practical application is that district extension will raise compliance only if it teaches what farmers can read on the container and what they can do in the field, together with affordable protective equipment. The result is limited by a cross-sectional, self-reported sample from three purposively chosen wards and by a standardized regression that does not adjust for sex, education or ward. Those limits qualify causal claims but do not change the operational conclusion for Babati.

RECOMMENDATION(S)

Based on these findings, the following recommendations are made

District extension services should prioritize practical demonstrations of label interpretation, correct dosing, PPE use, sprayer calibration, safe storage and disposal, supported by affordable equipment and accessible guidance in Kiswahili. These recommendations should be evaluated in future intervention studies.

Attitude-only campaigns, posters and "willingness" workshops are not sufficient, because farmers are already willing and already aware of health risks.

For agricultural offices and agro-input suppliers: It is recommended that affordable personal protective equipment be made regularly available in Ayalagaya, Arri and Kiru, and that sellers be discouraged from remaining the sole source of dose and safety advice. Knowledge without accessible kit cannot become compliant practice.

For future research: Further studies should use probability samples across more wards, observe spraying and storage directly, and test whether sex, education and access to extension modify the knowledge–practice–compliance paths reported here.

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