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Research Article

Pesticide Utilization, Practices, and Their Effect on Honeybees in North Gonder, Amhara Region, Ethiopia

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The use of pesticides is increasing from time to time due to their significant importance in maximizing crop production. This situation raised concerns about their potentially adverse effects on honeybee health and the environment, particularly in countries where regulations are not strictly implemented and farmers' knowledge of safe handling procedures is inadequate. This study was conducted in Chilga district, North Gonder, to assess utilization, types, and supply routes of pesticides. Quantitative and qualitative data were collected using semistructured questionnaires, key informant interviews, and focus group discussions. A multistage sampling technique was used to select 353 respondents (155 beekeepers and 198 nonbeekeepers), and a semistructured questionnaire was administered to the selected respondents. The result indicated a rapid increment in pesticide use regardless of its recent introduction to the district. Out of the ten different kinds of pesticides being used in the study area (2,4-D, diazinon 60%, glycel 41%, diazinon 60%, DDT, a mixture of 2-4-D with glycel, mancozeb 80%, malathion 50%, endosulfan 35%, agrothoate 40%, and ethiosulfane 10%), 2,4-dichlorophenoxyacetic acid, glycel, diazinon, and endosulfan 35% are the most widely used ones. Most of the farmers access these pesticides from illegal traders. About 71.3% of the respondents had no access to advice, and 86.9% of them had no training on how to apply pesticides safely to themselves, to the honeybees, and to the environment. The respondents keep extra pesticides at home and use empty pesticide containers for storing food items. In general, integrated efforts are needed to make farmers in Chilga district aware of their knowledge gap on the safe handling and utilization of pesticides.

1. Introduction

Honey bees benefit human beings directly through their valuable products (honey, wax, pollen, royal jelly, venom, broods, and propolis) and indirectly through their pollination service. They deliver nearly 85% of crop pollination, contributing about 34% of the world's food supply, because of their unique natural characteristics such as their greater number of foragers, full-time foraging ability, and consistency while foraging [1–3]. This plainly denotes that honey bees play a very important role in ensuring food security and maintaining biodiversity. Regardless of this fact, the role of honey bees has not been well recognized by farmers and other responsible bodies, which has resulted in the honey bees' exposure to harmful effects of unwisely used agrochemicals. The problem gets more critical in developing countries where insufficient regulatory and protective measures are undertaken [4].

Pesticide is an extensive term for compounds encompassing insecticides, herbicides, fungicides, rodenticides, molluscicides, and plant growth regulators. They significantly minimize preharvest and postharvest losses of agricultural products through protecting pests, pathogens, and vectors [5]. The fast growth rate of the world population is significantly elevating the volume of pesticides imported. Several studies imply that by 2050, the world population will reach over 30% of the current level, raising the current food/feed demand by 50%. This beckons for yield maximization from the available limited land through the use of agricultural inputs such as improved seeds, fertilizers, and pesticides [6].

The development of commercial farms in Ethiopia in the 1960s marked the introduction of pesticides in the country. Then, the use of pesticides as an integrated package was followed in projects such as the Chilalo Agricultural Development Unit (CADU), the Wolaita Agricultural Development Unit (WADU), and the Minimum Package Project (MPP) under the Extension and Project Implementation Department (EPID) of the Ministry of Agriculture [7, 8]. Today, Ethiopia is one of the African countries that uses different kinds of pesticides for agricultural, industrial, and health care purposes [7]. According to Central Statistics Agency (CSA) report, pesticides were being applied to more than 3.2 million hectares of cultivated land in the year 2014–15 [9]. The need for pesticides in modern agriculture is increasing, while their unwise utilization poses a considerable threat to the environment, including farmers and honey bees. Pesticides use and illegal trading of pesticides in Ethiopia are increasing from time to time, and it has resulted in the deaths of 22,987 honeybee colonies only in the Bure district of the Amhara Region, which is equivalent to economic loss of $819,291.37 USD [10].

Beekeepers in Chilga district were blaming the indiscriminate use of pesticides for the loss of honey bee colonies in their areas. They repeatedly reported the decline in honeybee population in the colony, the decrease in reproductive swarms, which are sources of colonies for start-up or expanding beekeeping businesses, and a significant reduction in honey yield. However, these claims need to be proved or disproved through scientific methods based on substantial qualitative and quantitative data. Therefore, this study was initiated to assess the types, supply routes, utilization, and effects of commonly used pesticides on honeybees in the Chilga districts of Northern Gonder, Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area. The assessment was conducted in Chilga district, which is found in the North Gonder zone of the Amhara National Regional State (ANRS) (Figure 1). Chilga is located 63 km west of Gonder and 230 km west of Bahir Dar, the capital city of the Amhara National Regional State. It has a total area of about 322,596 hectares, of which 33% is midaltitude and 67% is lowland, with an altitude ranging from 900 to 2250 meters above sea level. Chilga district is characterized by a unimodal rainfall pattern with an annual average rainfall of 995–1179 mm and an air temperature of 11–32°C. Agriculture is entirely rain-fed, and the rainy season lasts from June to September. The area is dominated by mixed-cropping systems. Most (88.76%) of the farmers raise both crops and livestock, while the remaining 8.57% grow only crops, and 2.68% of them raise only livestock [12]. The farmers have an average land holding of 0.61 hectares [12]. A large portion (64.53%) of the land in Chilga district is usually occupied by cereals like *teff*, maize, and finger millet; 8.3% by oil crops and 2.81% by pulses, while the rest of the land is occupied by coffee, root crops, and vegetables.

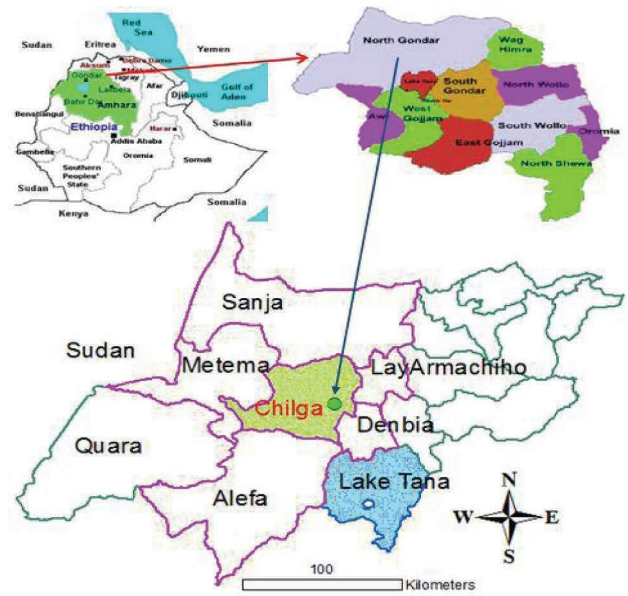


Figure 1: Map of the study area and its borders [11].

Table 1: Number of respondents in respective PAs and agroecologies.

Agro ecology	PAs	Sample size	Total (by agro-ecology)
Midland	Eyaho seraba	88	198
	Chalia	110	
Lowland	Walideba	50	155
	Kuaber lomeye	105	
Total sample size			353

2.2. Sampling Technique and Frame. A multistage sampling procedure was employed to select respondents. In the first stage, Chilga district was purposefully sampled based on beekeeping activity, honey production potential, and accessibility. In the second stage, four Peasant Associations (PAs) were purposively selected from the district based on their beekeeping and crop production practices, and agroecology representation (2 PAs from lowland and the rest 2 from midland). In the third stage, the population was stratified into two groups as beekeepers and nonbeekeepers, and finally respondents were sampled from each group using the simple random sampling technique. Proportionate sampling was used to fix the sample size for each PA and stratum.

Sample size of respondents was determined using Yamane's formula [13]:

$$n = \frac{N}{1 + N(e)^2}, \tag{1}$$

where n is the sample size; N is the total population; and e is the sampling error ($e = 0.05$).

Accordingly, 353 respondents (155 beekeepers and 198 nonbeekeepers) were interviewed. The number of respondents selected in each one of the four PAs and agroecologies is indicated on Table 1.

Table 2: Utilization of pesticides by beekeepers and nonbeekeepers and demographic characteristics of respondents.

Category		Number of observations		Using pesticides		Not using pesticides		X^2	p value
		Frequency	Proportion	Frequency	Proportion	Frequency	Proportion		
	Beekeepers	155	43.9%	133	43.1%	22	50%	0.757	0.384
	Nonbeekeepers	198	56.1%	176	56.9%	22	50%		
Sex	Male	343	97.16%	301	97.41%	42	95.45%	0.54	0.460
	Female	10	2.84%	8	2.59%	2	4.45%		
Age	Age below 14 years	1	0.28%	0	0	1	100%	0.36	0.830
	b/n 14 and 60	304	86.11%	265	87.17	39	12.83		
	Above 60	48	13.60	43	89.58	5	10.42		
Education level	Illiterate	146	41.36	126	86.30	20	13.7	3.63	0.460
	Basic education	149	42.21	132	88.59	17	11.41		
	Grade 1–4	35	9.91	33	94.3	2	5.7		
	Grade 5–8	14	3.97	11	78.57	3	21.43		
	Grade 9–12	9	2.55	7	77.78	2	22.22		
Marital status	Married	330	93.50	290	87.88	40	12.12	5.95	0.110
	Divorced	14	3.96	12	85.71	2	14.29		
	Widowed	5	1.42	5	100	0	0		
	Single	4	1.13	2	50	2	50		
Training	Yes	50	14.16	43	86	7	14	0.12	0.720
	No	303	85.84	266	87.79	37	12.21		
Advice	Yes	98	27.76	94	95.92	4	4.08	83.84	0.001
	No	244	69.12	215	88.11	29	1189		
	No answer (missing)	11	30.88	0	0	11	100		

2.3. Data Sources and Methods of Data Collection

2.3.1. Data Sources. In this study, both primary and secondary sources of data were used. Primary data were collected from sample respondents through a semistructured questionnaire; while secondary data were collected through desk review of various documents from different Governmental institutions mainly to draw information regarding types and volume of imported pesticides, trends of utilization, and efforts made to promote safe use, guidelines, and policies of pesticide use.

2.3.2. Methods of Data Collection. Both quantitative and qualitative data collection methods were used to produce valid and substantial findings to offset the weaknesses inherent in one method with the strengths of the other. Qualitative data was generated using key informant interview (KII), focus group discussion (FGD), and observation to triangulate and cross-check the quantitative data collected using semistructured questionnaires.

2.3.3. Data Management and Statistical Analysis. The data collected from the questionnaire survey were coded and stored into a computer, which is loaded with SPSS software programs version 20 and cleaned for consistency and accuracy. Descriptive statistical analysis was used to analyze the data. Summarized data is presented in the form of tables and figures. A chi-square was used to test the significance of differences between or among values.

3. Results and Discussion

3.1. Result

3.1.1. Utilization of Pesticides. During the study period, about 43% and 56% of the beekeepers and nonbeekeepers, respectively, were using pesticides to control weeds and pests (Table 2). There is no statistically significant difference between nonbeekeepers and beekeepers in terms of pesticide use ($X^2 = 0.757$, $p = 0.384$), while there is a statistically significant difference in terms of land holding between pesticide users and nonusers (Table 3).

The respondents expressed that the initial introduction of pesticides to the district dates back to 1999. However, relatively large-scale utilization of pesticides in the study area has begun since 2004 (Figure 2).

3.1.2. Types of Pesticides Used in the Study Area. Ten different kinds of pesticides were in use in the study area during the study period. These are: 2, 4- dichlorophenoxyacetic acid (2, 4-D), glycel, DDT, diazinon 60% animal, diazinon 60% plant, dimethoate, ethiosulfan, mancozeb, malathion, and endosulfan (Table 4). More than 80% of the respondents had been using 2, 4-D for the control of weeds. Around 67.0% of the respondents were using diazinon to control pests of animal. Glycel and DDT were used by 32.6% and 30% of the respondents, respectively. Dimethoate and ethiosulfan pesticides were the least utilized in terms of utilization. There is also a tradition of using a mixture of 2, 4-D and glycel. There is no statistically significant difference between beekeepers and nonbeekeepers in terms of pesticide use (Table 5).

Table 3: Statistical test of continuous variables.

Variables	Pesticide user		Pesticide nonuser		Total		t-test
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	
Family size	4.30	0.09	4.15	0.25	4.28	0.08	0.29
Land size in hectare	2.19	0.07	1.49	0.08	2.10	0.06	0.0003

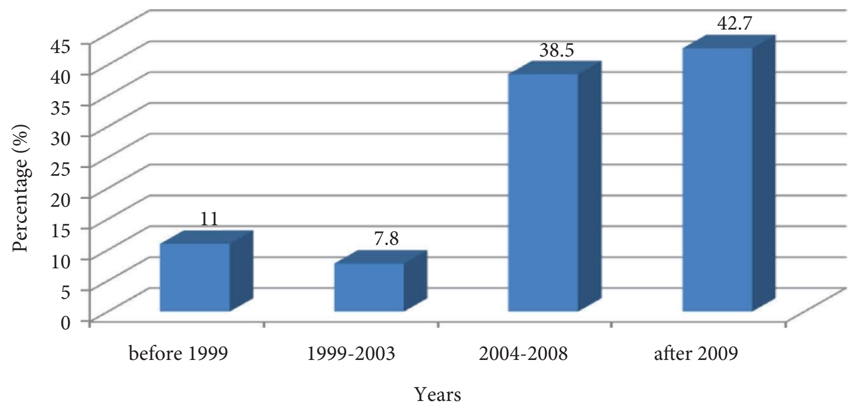


Figure 2: Utilization of pesticides in the study areas according to the respondents.

Table 4: Major types of pesticides used by the respondents.

Types of pesticides	Beekeepers		Nonbeekeepers		Overall
	Users	Not users	Users	Not users	Users (%)
2, 4-Dichlorophenoxyacetic acid	83.9%	16.1%	88.9%	11.1%	86.7
Number of observations	130	25	176	22	
Diazinon 60% (animal)	70.8%	29.2%	63.9%	36.1%	67.0
Number of observations	109	45	124	70	
Glycel	30.3%	69.7%	34.3%	65.7%	32.6
Number of observations	47	108	68	230	
Diazinon 60% (plant)	26.5%	73.5%	35.9%	64.1%	31.7
Number of observations	41	114	71	127	
DDT	25.8%	74.2%	33.3%	66.7%	30.0
Number of observations	40	115	66	132	
Mixture of 2,4-D and glycel	16.8%	47.1%	15.7%	57.1%	23.5
Number of observations	26	73	31	113	
Mancozeb	12.9%	87.1%	16.2%	83.8%	14.7
Number of observations	20	135	32	166	
Malathion	12.9%	87.1%	6.1%	93.9%	10.5
Number of observations	20	135	12	186	
Endosulfan	12.3%	87.7%	8.6%	91.4%	10.2
Number of observations	19	136	17	181	
Dimethoate	6.5%	93.5%	6.1%	93.9%	6.2
Number of observations	10	145	12	186	
Ethiosulfan 10%	0.6%	99.4%	—	—	0.3
Number of observations	1	154	—	—	

Majority of the respondents were using pesticides for the control of weeds, and crop and animal pests. They were applying glycel for land clearing for *teff* (87%), sorghum (78.3%), and sesame (42.6%) crops and 2, 4-D for weed control on the fields of *teff* (70.8%), sorghum (50.7%), finger millet (49.9%), wheat (6.5%), and pastureland (51.3%). They were using Diazinon, Dimethoate, and Endosulfan to control pests on the fields of *teff* and maize crops. In addition, they were spraying Malathion on chickpea (8.8%), tomato (10.5%), and potato (14.7%) crops to control diseases and pests and Mancozeb on the fields of tomato and potato crops to treat different diseases and pests (Table 6).

The extent of pesticides utilization varied among different crops in the study area. The mean amount of glycel that was applied to *teff*, sorghum, and sesame crops was 1.42 ± 0.45, 1.53 ± 0.42, and 1.45 ± 0.61 liters per hectare, respectively. A low dosage of 2, 4-D was used for weed control on the fields of *teff* (0.92 ± 0.37) and pasture land

Table 5: Major types of agrochemicals used by respondents and statistical analysis.

Types of agrochemicals	Agrochemical utilization				X^2 (p value)
	Beekeepers		Nonbee keepers		
	N	%	*N*	%	
2.4-D	130	42.48	176	57.52	1.89 (0.17)
Diazinon 60%	41	36.60	71	63.4	0.02 (0.88)
Agrotyte 40%	10	45.45	12	54.45	3.55 (0.05)
Endosulfan 40%	19	52.78	17	47.22	1.28 (0.25)
Malathion 50%	20	54.05	17	45.95	1.72 (0.18)
Macozeb 80%	20	38.46	32	61.54	0.73 (0.39)
Glycel (aymerta) 41%	47	40.86	68	59.14	0.64 (0.42)

Table 6: Types of pesticides applied to different crops in the study area.

Pesticides	*Teff*	Sorghum	Sesame	Barley	Finger millet	Wheat	Pasture land	Maize	Chickpea	Tomato	Potato
Glycel	100 (87)	90 (78.3)	49 (42.6)	107 (30.3)	176 (49.9)	23 (6.5)	18 (51.3)	—	—	—	—
2, 4-D	250 (70.8)	179 (50.7)	—	—	176 (49.9)	23 (6.5)	181 (51.3)	—	—	—	—
Diazinon	110 (31.2)	—	—	—	—	—	—	4 (1.1)	—	—	—
Dimethoate	12 (3.4)	—	—	—	—	—	—	24 (6.8)	6 (1.7)	—	—
Endosulfan	19 (5.4)	—	—	—	—	—	—	75 (21.2)	—	—	—
Ethiosulfan	—	—	—	—	—	—	—	1 (0.3)	—	—	—
Malathion	—	—	—	—	—	—	—	—	31 (8.8)	37 (10.5)	52 (14.7)
Mancozeb	—	—	—	—	—	—	—	—	—	2 (0.6)	52 (14.7)

NB: numbers in the parenthesis are percentages while others indicate frequency.

(0.41 ± 0.32). The rate of diazinon application on the fields of *teff* and maize crops was similar, that is, 1 L/ha. An average amount of 1.20 ± 0.24, 1.33 ± 0.45, and 1.00 ± 0.31 L/ha of dimethoate was applied to the fields of *teff*, maize, and chickpea, respectively. On the other hand, 1.95 ± 0.86 and1.40 ± 0.86 L/ha of endosulfan were applied to the fields of *teff* and maize crops, respectively. Similar rates of malathion (0.80 ± 0.40 L/ha) and mancozeb (0.80 ± 0.40 kg/ha) were used for the control of diseases and pests in potatoes. Malathion was applied at the rates of 1.1 ± 0.33 and 1.16 ± 0.56 L/ha in the fields of tomato and chickpea, respectively, to control diseases and pests (Table 7).

Pesticides application in the study area has shown an increasing trend from time to time (Figure 3). The application of 2, 4-D, glycel, diazinon, endosulfan, dimethoate, ethiosulfan, mancozeb, and malathion was increased by 57.93%, 68.32%, 76.54%, 108.75%, 400%, 25%, 44.71%, and 214.1%, respectively, from the years 2014 to 2016. This implies that the practice of using pesticides for agricultural activity is becoming a very common one.

3.1.3. Sources of Pesticides. The market for pesticides was dominated by illegal traders. Illegal traders are those who do not have legal permission/accreditation from responsible bodies of the government to trade in pesticides. All the respondents (100%) who were using glycel had purchased it from illegal traders. About 33.8% and 66.2% of the respondents purchased 2, 4-D from cooperatives and illegal traders, respectively. Pesticides such as diazinon, dimethoate, endosulfan, ethiosulfan, malathion, and mancozeb were supplied by illegal traders (Table 8).

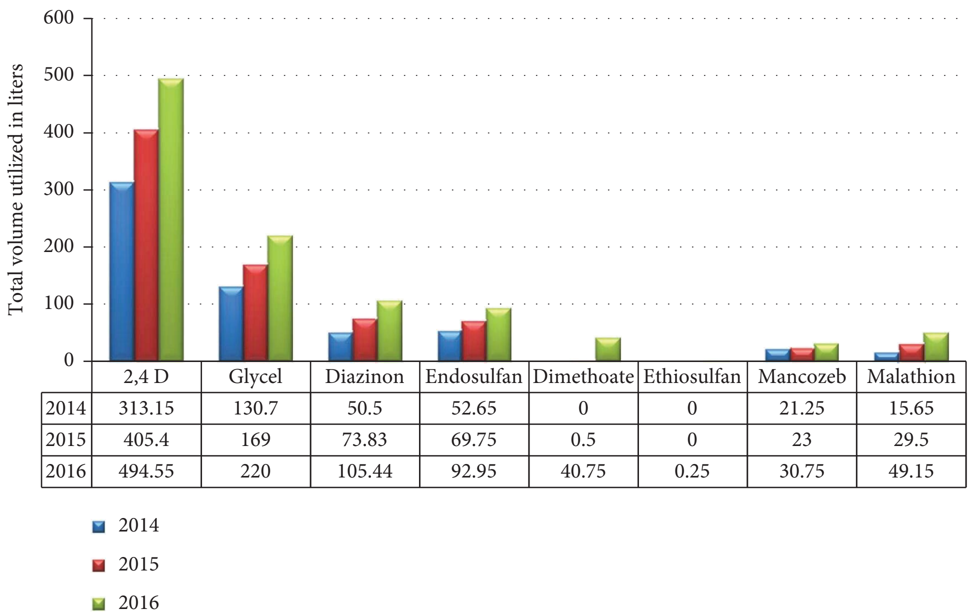
3.1.4. Time and Months of Pesticide Application. Most of the respondents were applying diazinon, dimethoate, endosulfan, and 2, 4-D during morning times, while they were spraying malathion, mancozeb, and glycel on different crops at any time of the day (Table 9). Furthermore, all pesticides were applied in the period between July and October. These results reveal that pesticides application time and season (months) coincide with the active foraging time and season of the honeybees.

3.1.5. Farmer's Knowledge about the Application and Handling of Pesticides. This study revealed that most (71.3%) pesticides users did not obtain any advice on which pesticide to use, for what purpose, or how to use it. About 86.9% of the respondents didn't obtain training on how to use pesticides following safety precautions for their own and the environment's well-being. Consequently, about 89% of the respondents did not use protective cloths while spraying, and 87.2% of the respondents did not follow the labeled instructions while applying (Table 10). Some of the respondents (12.89%) had no idea about the expiry dates of the pesticides they are using or the importance of paying attention to the chemicals' expiry dates (Table 10). Key informants also witnessed that they did not receive any instructions from either pesticides suppliers or agricultural development agents. According to the respondents, the reason behind spraying chemicals without wearing recommended protective clothes was a lack of trust in the protective ability of the clothes, a lack of understanding of the importance of the clothes in protecting them from the negative effects of the chemicals, or a lack of money to

Table 7: The rate (L/ha) of application of different pesticides on the fields of major crops.

Chemical	*Teff*	Sorghum	Sesame	Barley	Finger millet	Wheat	Pasture land	Maize	Tomato	Chickpea	Potato
Glycel	1.42 (0.45)	1.53 (0.42)	1.45 (0.61)								
2, 4-D	1.14 (0.44)	1.16 (0.40)		1.00 (0.27)	1.26 (0.45)	0.92 (0.37)	0.41 (0.32)				
Diazinon	1.00 (0.54)							1.00 (0.30)			
Dimethoate	1.20 (0.24)							1.33 (0.45)		1.00 (0.31)	
Endosulfan	1.95 (0.86)							1.40 (0.86)			
Ethiosulfane	1							1			
Malathion									1.1 (0.33)	1.16 (0.56)	0.80 (0.40)
Mancozeb									1.25 (0.35)		0.80 (0.40)

The values in the parenthesis are standard deviations.



	2,4 D	Glycel	Diazinon	Endosulfan	Dimethoate	Ethiosulfan	Mancozeb	Malathion
2014	313.15	130.7	50.5	52.65	0	0	21.25	15.65
2015	405.4	169	73.83	69.75	0.5	0	23	29.5
2016	494.55	220	105.44	92.95	40.75	0.25	30.75	49.15

Figure 3: The trend of pesticide utilization in liters from the year 2014 to 2016 in Chilga district.

Table 8: Sources of pesticides for the respondents.

Pesticides	Source of pesticides (%)		
	Cooperatives	Legal traders	Illegal traders
Glycel (ayemerta)	—	—	100
2, 4-D	33.8	—	66.2
Diazinon	13	—	87
Dimethoate	41.9	3.2	54.8
Endosulfan	35.4	—	64.6
Ethiosulfan	—	—	100
Malathion	5.3	—	94.7
Mancozeb	—	5.3	94.7

purchase the protective clothes (Figure 4). Apart from that, almost all of the respondents (94.1%) were not aware of the role of honeybees in crop production through pollination services, and thus they do not give bees due care while applying pesticides to their crops.

Most (63.4%) of the respondents were disposing of empty pesticide containers anywhere in their surroundings; about 35.1% of the respondents were recycling the containers for water and/or food storage; and the remaining 1.5% of the respondents were selling them. About 58.4% of the respondents were keeping leftover pesticides for the next cropping season, while 23.1% of the respondents were selling them out to their neighboring farmers who were in need of it. The majority (77.2%) of the respondents who were keeping the leftover pesticides for the next cropping season have stored the pesticides anywhere in their house, while 22.2% of them have stored the pesticides in a separate place specified for pesticide storage, and 0.6% of them have stored the pesticides in the kitchen (Table 11). About 44.3% of the respondents have continued to use obsolete pesticides, and only 3.3% of the respondents have disposed of obsolete pesticides in a way that can have a devastating effect on the environment (they dig a hole and bury the pesticides) (Table 11).

3.1.6. Effect of Pesticides on Honeybees. Most of the respondents (86.9%) were aware of the adverse effects of pesticides on honeybees (Table 12). About 84.2% of the respondents stated that they usually find dead bees in the field after they have applied pesticides, while about 12.2% and 3.6% of the respondents have found dead bees on the ground near their hives and on the landing board of their hives, respectively (Figure 5).

4. Discussion

Most beekeepers are aware of the ill effects of pesticides on honeybees, but they continued using pesticides due to a labor shortage for weeding their crops and the control of pests and diseases. This is partially in agreement with the findings of [14], who stated that using pesticides for pest

Table 9: Time of the day that the respondents were applying pesticides on their crops.

Pesticides	Crop type	Time of application (%)			
		Morning (9–11 am)	Midday (12 am–3 pm)	Anytime	Night
Glycel (ayemerta)	*Teff*	13	10	77	
	Sorghums	5.5	16.5	78	
	Sesame	6.8	4.8	88.4	
2, 4-D	*Teff*	59.8	4.8	35.4	
	Barley	70.1	0.9	29	
	Finger millet	63.3	2.3	34.4	
	Sorghum	60.3	2.8	36.9	
	Wheat	87	4.3	8.7	
Diazinon	*Teff*	48.6	51.4		
	Maize	50			50
Dimethoate	Maize	60	8	32	
	Teff	25		75	
	Chickpea	100			
Endosulfan	*Teff*	68.4		31.6	
	Maize	29.7		69.3	
Malathion	Tomato	29.7	2.7	67.7	
	Chickpea	16.1		83.3	
Mancozeb	Potato	23.1		76.9	
	Tomato	100			

Table 10: Farmers' awareness on pesticides application practices.

Respondents perception	Yes (%)	No (%)	I do not know (%)
Did you get any advice from extension agent on how to use chemicals safely on the honeybees and the environment?	28.7	71.3	
Do you use protective clothes while spraying pesticides?	11	89	
Have you ever felt any discomfort while or after you spray pesticides?	40.9	59.1	
Have you had training concerning the use of pesticides?	13.9	86.1	
Do you follow the labeled instructions of the pesticides you use?	12.8	87.2	
Do you think that honeybees have a role in crop production?	5.9	94.1	
Is there an expiry date on the containers of the pesticides that you use?	49.7	37.4	12.9

control in poor countries releases labor from hand weeding, which in turn enables children to go to school. The beekeepers further indicated that nonbeekeepers in their neighborhood continue to use pesticides even if they abstain from using pesticides, and this inevitably exposes their honeybees. Hence, their unilateral decision may not be sufficient to bring about the desired wellbeing of the bees and the environment.

The introduction of pesticides into Ethiopia to control agricultural pests dates back to the 1960s [7]. According to the respondents, the use of pesticides in the study area started around 1999, but wider application commenced in 2004 (Figure 2). The results revealed that even though the use of pesticides in the study area was very recent compared to other parts of the country, their utilization is increasing at an alarming rate.

The questionnaire survey revealed that among the ten different kinds of pesticides that were in use in Chilga district, 2, 4-D is the most commonly used (80%), followed by Diazinon, which is utilized by 67% of the respondents, while Dimethoate and Ethiosulfan are the least used ones. Apart from that, DDT, which was banned in developed countries 50 years ago, is still in use in the study areas, mainly to control malaria outbreaks. This concurs with the findings of [15–17], who reported the utilization of DDT in different parts of the country.

The farmers were also using a mixture of different pesticides; there is a habit of using a mixture of 2,4-D and glycel. This implies that the respondents were using pesticides as they wished to use them without considering the safety precautions specified for the safe use, handling, and storage of those particular pesticides they were using. This is in agreement with the findings of [17, 20], who revealed that farmers do not follow instructions on the labels while using pesticides.

The majority of beekeepers and nonbeekeepers were using pesticides for the control of weeds, crop pests, and animal pests. Studies show that using pesticides for weed control in poor countries releases labor from hand weeding, and this enables adults to engage in other more off farm activities [18] and children for schooling [14]. But in Chilga district, none of the farmers who were utilizing herbicides were seen using the labor saved from hand weeding to generate additional household income.

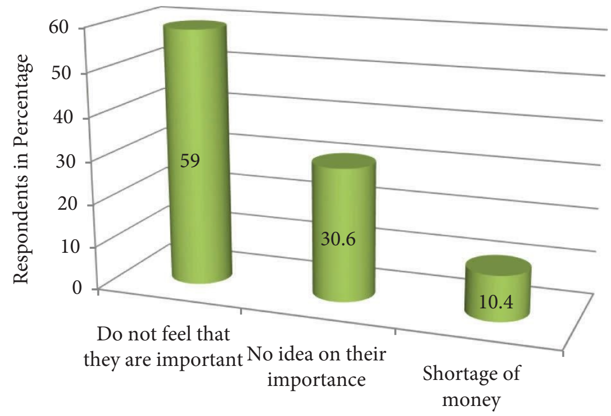


Figure 4: Reasons why the respondents were not using protective cloths.

Table 11: Management of empty containers, expired pesticides, and storage of pesticides.

	Category	Frequency (*N*)	Percentage (%)
Management of empty containers	Use it for water and/or food storage	117	35.1
	Sell it	5	1.5
	Dispose it anywhere	211	63.4
Management of expired pesticides	Continue to use it	148	44.3
	Dispose it	11	3.3
	Ask advise of DA	39	11.7
	Didn't buy	136	40.7
Placement of pesticides	In the kitchen	2	0.6
	Anywhere in the house	257	77.2
	In separate places	74	22.2

Table 12: Awareness of farmers and their observations on the effect of pesticides on bees.

Description	Response	Frequency	Proportion
Are you aware of the effect of pesticides on honey bees?	Yes	306	86.9
Did you find dead bees after you have applied the chemical?	Yes	139	39.4

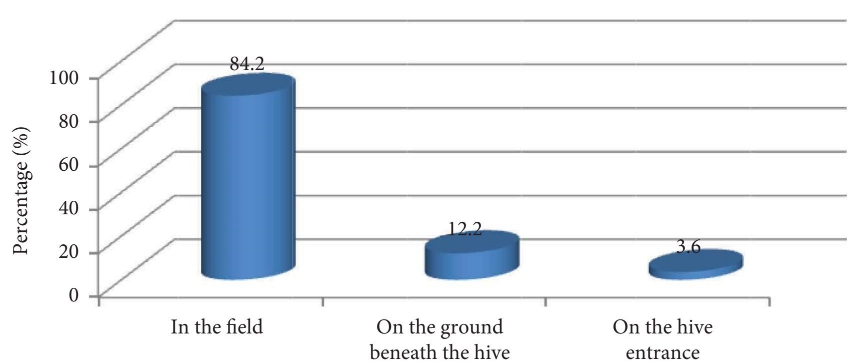


Figure 5: Proportion of the respondents who have found dead bees at different places.

The questionnaire survey revealed that the respondents were not using the recommended doses of pesticides. Most of the pesticides, like glycel, mancozeb, dimethoate, endosulfan 35%, and malathion 50%, were applied below the recommended doses: 3-4, 2.5–3, 1, 2, and 2 lit/ha, respectively. The respondents associated this situation with financial constraints and a lack of awareness. Application of pesticides below the recommended dose may lead to the development of resistant strains of pests and diseases of crops, and this will have an unwanted implication on the efficacy of pesticides in the future. On the contrary, [17] stated that most farmers in Adami Tulu districts of Oromia region were applying insecticides more than the recommended rate, and [19] indicated that the use of high levels of pesticides is common in developing countries.

Almost all marketing of pesticides is handed over by illegal traders. This is attributed to many factors, among which the main ones are: (1) as there is no monitoring or regulation of pesticides sales and utilization in the study area, very few licensed pesticide traders and cooperatives are engaged in this business. (2) Even though cooperatives are the main suppliers of pesticides, they are inaccessible to most of the users and are not supplying all the needed chemicals because they are not confident enough about their ability to get a sufficient market to sell out all their stock if they supply a wide range of pesticides in large volume. Due to these and other reasons, pesticides are being sold in open markets, shops, veterinary pharmacies, and by farmers engaged in retailing pesticides. This is in line with the findings of [11, 12, 14], which show that most farmers in different areas purchase pesticides from open market and unlicensed vendors or individuals. The purchase of pesticides from unlicensed vendors or individuals may not ensure the user the opportunity to raise any complaints against suppliers if something undesirable happens and/or to check whether the pesticides are genuine and effective against target pests or weeds.

The season and application timing of pesticides in the study area coincide with the active foraging season and timing of honeybees, posing a higher chance of poisoning honeybees. Furthermore, pesticides application practice is not in accordance with pesticide use regulation but rather is based on the interests of farmers [17]. Pesticides are more effective at controlling target weeds and pests when they are applied at the right time, following the instructions provided by producers and responsible regulatory bodies; otherwise, they may inflict undesirable damage on the environment, including on beekeepers and honeybees.

Most of the respondents did not obtain training or advice on the safe use of pesticides so that they could keep the side effects of the chemicals to a minimum. This implies that there is a lack of due attention to regulate and monitor the utilization of pesticides to reduce the probable hazards that would happen due to misuse, and there is a lot to be done by the agricultural extension service to capacitate and make farmers aware of how to keep themselves and their environment safe from the ill effects of agrochemicals. This argument is supported by the finding that more than 59% of the respondents declared they always feel discomfort while and after spraying pesticides. The health complaints, such as headache, nausea, vomiting, skin and eyes irritation, chest pain, and problems in breathing/respiration, were reported by farmers in different parts of the country in relation to pesticide handling and application [11, 20].

Most of the respondents do not utilize the whole pesticides in the cropping season they purchased. This implies that farmers may not have knowledge about the amount of pesticides they need for their fields, or they might be applying the pesticides at less than the recommended doses. On the other hand, farmers do not know the safe handling and utilization instructions of the pesticides and how hazardous they are to themselves and to the environment. This may be due to the fact that farmers may not have enough access to pesticide application extension services [11, 14, 21–23]. The improper use and storage of pesticides and the disposal or use of empty pesticide containers could expose humans, animals, and the environment to pesticide toxicity, and this needs to be addressed in order to improve the wellbeing of farmers and the environment.

Nearly half of the respondents were using outdated pesticides. This implies that there is a lack of awareness of the ill effects of using obsolete pesticides on human health and the environment. In principle, disposal of obsolete chemicals is the responsibility of the government, as it requires advanced procedures and regulations appropriate for the wellbeing of the environment. But it seems like responsible bodies didn't give it their due attention, and consequently, the wellbeing of the community and the environment are at risk.

Most of the respondents were aware of the adverse effects of pesticides on honeybees through observing dead honeybees around the beehives and on crop fields where pesticides are applied. Similarly, farmers in the Wujraba watershed of Chilga district and other parts of the country reported the decline of their honeybee colony populations due to pesticides [11, 24].

5. Conclusion and Recommendation

The introduction of pesticides in Chilga district is very recent as compared to other parts of the country. But the utilization of pesticides is growing very rapidly to control weeds and pests and diseases of crops and animals. Different pesticides, including the banned DDT, and a mixture of two herbicides (2, 4-D and glycel), are being used in Chilga district. The major suppliers of these pesticides are illegal traders, and the chemicals are being traded in an open market, in shops along with food and other consumable items, and in veterinary drug stores. Farmers in general and beekeepers in particular have little or no access to advice and training on how to use and handle pesticides. Consequently, most farmers, including beekeepers, were: (1) storing left-over pesticides and empty pesticide containers with consumable items at home; (2) storing food items in empty pesticide containers; (3) not following the instructions enclosed with pesticides; (4) applying pesticides when bees are actively foraging in the fields; and (5) not using protective clothing to minimize the risk of exposure while applying pesticides. Generally, farmers in Chilga district have a huge knowledge gap on the safe handling and utilization of pesticides. The market for pesticides was overwhelmed by illegal vendors, and there is no strong regulation and monitoring of the chemicals that are being used in the area. This situation poses the environment and the users with varied risks. Therefore, integrated efforts are needed to educate farmers on how to handle, manage, and utilize pesticides properly. The local government should act proactively with responsible bodies to save the market from illegal traders. Strong monitoring and regulation have to be put in place. Legal vendors and cooperatives need to be supported by the necessary information and techniques so that they can provide the required kind and quantity of agrochemicals for farmers. In addition, they need to increase delivery points to reduce the farmers' time, energy, and cost that would be incurred to acquire the chemicals.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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