Farmers' Practice, Knowledge and Perception on Agrochemicals Utilization and Its Effects on Honeybees in Tigary Region, Northern Ethiopia

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Abstract

Bees are the predominant and most economically important group of pollinators in most geographical regions.Recently there is an alarming decline in honeybee colony population around the world and the toxic effects of different agrochemicals are currently being scrutinized as a contributing factor. This study was conducted to assess farmers perception on agrochemicals utilization and the effects those agrochemical impose on honeybee health in selected districts of Tigrai region. During the survey study, 300 farmers (212 beekeepers and 88 non-beekeepers) were interviewed. In addition, focus group discussion (FGD) sessions were held for triangulation of quantitative data. Analysis was done using SPSS software program (SPSS, version 20). Out of the agrochemicals applied in the study area, 64 % of them were insecticides while 18% of them were herbicides and the other 18% were fungicides. The study result revealed that the use of agrochemicals in the study area was dramatically increasing over the past five consequetive (2013-2017) years. Non-beekeepers were found to be more significantly higher agrochemicals users than that of beekeepers (x^2 =12.26, df = 1, P=.000). The study also showed that farmers of the study area overuse, misuse, and neither aware of safe handling nor proper disposal of agrochemicals.

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Introduction

Bees are the predominant and most economically important group of pollinators in most geographical regions (UNEP, 2010). The Food and Agriculture Organization of the United Nations (FAO, 2009) estimates that out of some 100 crop species which provide 90% of food worldwide, 71 of these are bee-pollinated. In Europe alone, 84% of the 264 crop species are animal pollinated and 4000 vegetable varieties exist thanks to pollination by bees (Williams, 1996). The production value of one tone of pollinator-dependent crop is approximately five times higher than one of those crop categories that do not depend on insects (Gallai *et a*l., 2009). Pollinators can also improve the quality (especially fruit quality), shelf life and commercial value (for instance, poorly pollinated strawberries are malformed and look less attractive for consumers) of crops (Klatt *et al*., 2014) and increase the genetic diversity of wild flowering plants (Benadi *et al*., 2013).The essential and valuable activities of honeybees depend upon the healthy population of honeybees (FAO, 2012).

However, over the past decades, there is an alarming decline in honeybee colony around the world, and native pollinating species are suffering enormous losses as well. Honey bees (*Apis mellifera*), the most common managed pollinator, have experienced exacerbated rates of colony losses across the global North in recent years, from an average of 30% in the United States to as high as 85% in the Middle East (Neumann and Carreck, 2010). Among the threatening factors chemical pesticides take a great share.

The indiscriminate use of these agrochemicals against pests and weeds has a subsequent effect on some non-target and beneficiary animals like that of honeybees. The impacts of agrochemicals in Ethiopia are likely to be aggravated by the limited knowledge among users on toxicological and chemical properties of these substances (Tadesse Amera and Asferachew Abate, 2008).

Therefore, this study was conducted to identify commonly used agrochemicals in the area and to investigate farmers' agrochemical utilization practices in the study area.

Methodology

The study was conducted in three districts of Tigrai Regional State: thus Kilte-Awlae'lo, Atsbi-Wemberta and Kola-Temben were the survey study sites(**Figure 1**). These districts were selected purposively based on their beekeeping potentiality, agro-ecology representativeness, agrochemicals application intensity and accessibility to transport facility. Atsbi-womberta district represent highland agro ecology whereas Kilte-Awlae'lo represents midland and Kola-Temben represents the lowland agro ecologies.

Atsbi-Wemberta district is located in Eastern zone of Tigrai Region at about 65 km northeast of Mekele, the regional capital city at 13° 36" N and 39° 36" E. It has an altitude, which ranges from 2400– 3000 meters above sea level. The district has a total area of about 1223 km^2, with 70% and 30% highland and midland respectively. The average temperature of the area is 18ºC. Rainfall is usually intense and short in duration, with an annual average of about 667.8 mm.

Kilte -Awlae'lo district is geographically located between 39° 30' E – 39° 45' E and 13 ° 45' N -14° 00' N located in the eastern part of Tigrai at a distance of 45 km from Mekelle. The district is classified as midland. The altitude of the district ranges from 1980 to 2500 meters above sea level. The average daily air temperature ranges from 15ºC to 30ºC. The mean annual rainfall is about 558 mm.

Kolla-Temben district is a dry land located in lowland agro-ecological zone with an elevation ranging from 1600 to 1750 meters above sea level. The administrative center of the district, Abyi-Adi, is found 95 km away from the Mekele city towards west direction. The latitude and longitude of the area is 13^{0}37'23"North and 38^0 00'05".

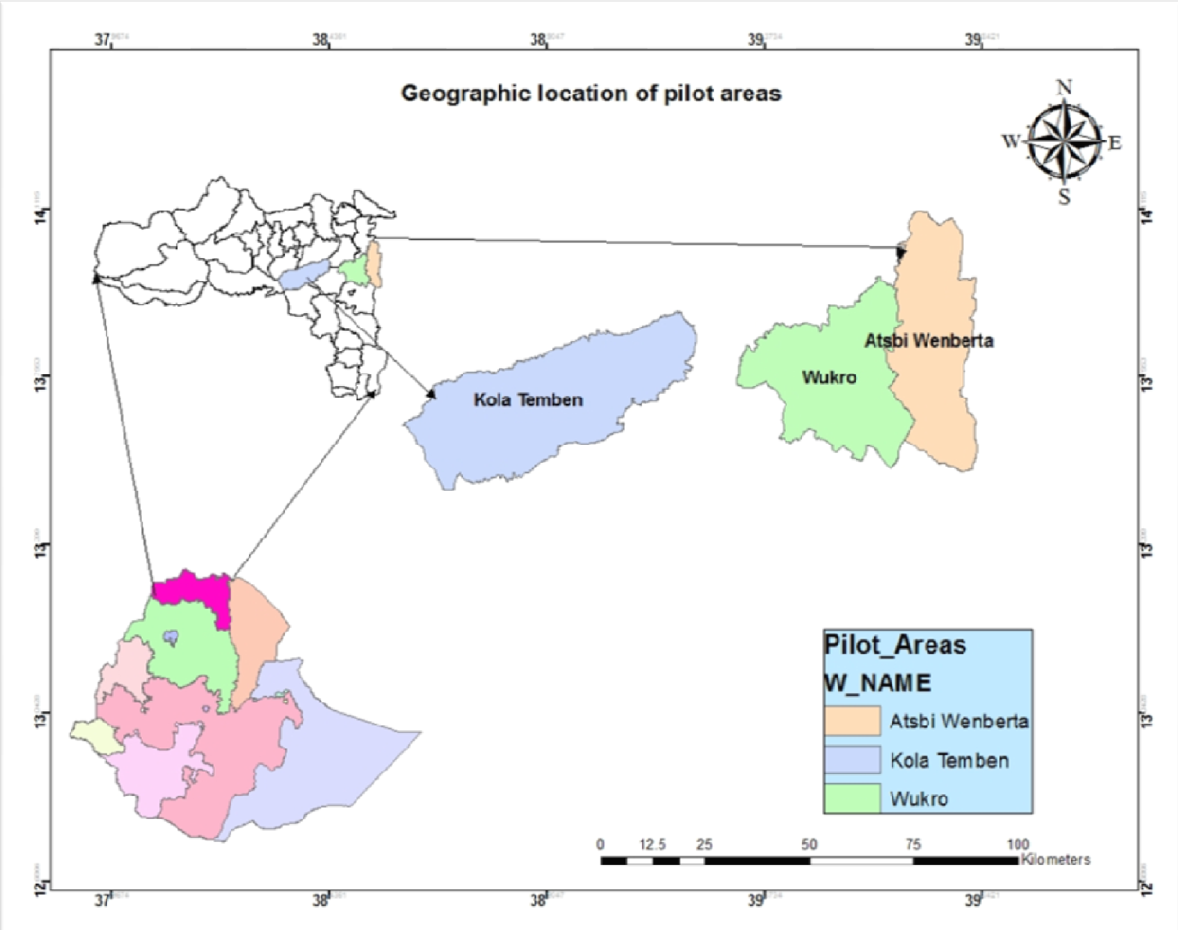

Figure 1: Map of the study districts

Data source and Method of Data Collection

In course of the study both primary and secondary data sources were employed.

Primary data collection

Primary data were collected through semi-structured questionnaire, focused group discussion, key informants' interview and personal observation. Beekeepers, non-beekeeper (crop growers), bee and crop experts, agrochemical retailers were part of the interview.

Questionnaire

Semi-structured questionnaire was prepared to collect various information related to socioeconomic characteristics of the households, beekeeping and crop production system and its constraints, agrochemical utilization and handling practices, honey production, current status of beekeeping with respect to agrochemicals. The sampled respondents were interviewed with the help of trained enumerators both in center area and house to house visit. Besides, enumerators were closely supervised by the researcher and assisted at the time of generating the required data. Two separate questionnaires were prepared (one for the beekeepers and the other for the non-beekeeper). The questionnaire was pre-tested to check its appropriateness to generate all the necessary information that can address all the stated objectives and was fine-tuned. Finally, the questionnaire was interpreted to the local language (Tigrigna) for simplicity.

Focus group discussion

In order to triangulate the information collected through household interview, the researcher also undertook focused group discussion which were held in each kebele. One composite group for each respective kebele and a total of 9 FGDs were formed. The group comprises experienced elder farmers , women and youths of 8 individual members per group were part of the discussion The sessions were moderated by the researcher using a checklist including major crops grown in the area, honeybee colony and honey production trend, trend of bee forage, kinds of agrochemicals used and the effects on honeybees, farmers' agrochemicals utilization, agrochemicals application time and frequency.

Key informants

With the help of extension workers, individuals whom the researcher believed as resource persons to generate the intended information were purposively selected. Similarly, key informant interviews were held with knowledgeable people from the community, including the agricultural staff and agrochemical retailers. These were individuals who have access to information related to agrochemicals commonly utilized in the areas, overall trend of beekeeping and honey production, and constraints for the beekeeping sub sector.

Personal observation

Researchers' observation was also undertaken while visiting respondents' houses, backyard apiary sites and farm fields. The way the farmers store and handle the agrochemicals, time of agrochemicals application, personal safety while spraying, disposal of the empty containers, apiary site location (for the bee keepers), label of the containers and for the agrochemical sellers their arrangements in the shop etc were observed.

Sampling Method and Sample Size Determination

A multistage sampling procedure was employed to select respondents during the survey session. Purposive sampling was employed to identify study zones and districts. At first stage, two administrative zones were selected based on purposive sampling method according to beekeeping potentiality and intense of agrochemical application. In the second stage, three districts were selected (one from Central and two from Eastern zone) purposively based on their relative beekeeping potential and agroecology representativeness as high land, mid land and low land agro ecologies. In the third stage, three rural kebeles from each district were selected using purposive sampling based on their relative beekeeping potential, irrigation practices and transport accessibility. In the fourth stage, first the total population was stratified in to two groups as beekeepers and non beekeepers. Then finally 300 respondents (100 from each district) were, randomly selected using (Yamane, 1976) formula as follows;

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

Where,
n=the sample size
N=size of population
e=the error of 5 percentage points

Data Management and Statistical Analysis

Analysis was done using SPSS software program (SPSS, version 20). Data were summarized and presented in tables and figure forms. Most of the survey data obtained in this study were analyzed using descriptive statistics and the ranking of the different types of beekeeping and farming constraints in the study were done by rank index calculation using a formula of (Musa *et al*., 2006). Chi-square test(x^2) was used to test the significance difference between beekeepers and non-beekeepers with respect to agrochemical utilization.

Result and Discussion

Of the total sample respondents 92.3 % of them were male and only 7.7% of them were female respondents (**Table 1**). This showed that male headed households are dominantly participating in beekeeping and general farming activities in the study area. This might be due to the fact that most of the female headed households shared/rent out their farm lands to male farmers. On one hand it is related to the existing longstanded tradition that plaughing is managed by men and on the other women headed households face labor shortage to manage their farm by their own. Beekeeping in the study area was dominantly practiced with the traditional method using local bee hives. The traditional hives are placed around homestead and hanged on big tree branches.

The survey result revealed that, about 53.7 % of the respondents attended their elementary school followed by 39%, 5.7% and 2% illiterate high school and higher education respectively (**Table 1**). Educational level of the household head is determinant in adopting new technologies, recording any experience, easily communicate with experts, easily grasp any training and can read manuals. The current result is in agreement with previous works of Tadele Adisu (2016) which reported that household head farmers who can read and write are more advantageous in understanding new technology and apiculture practices when compared with those who cannot read and write .

Table 1: Socio-demographic characteristics of the Respondents

Demographic characteristics	Category	N	Percentage (%)
Sex	Male	277	92.3
	Female	23	7.7
Educational level	Illiterate	117	39
	Elementary	160	53.7
	High school	17	5.7
	Higher education	6	2
Other livestock keeping	Yes	297	99
	No	3	1

N=Number of Respondents

The mean age of the study participants was 45.37 years old (**Table 2**). This shows that the very economically productive age groups are actively engaged in the general farming and specifically in beekeeping activity. The age of a farmer is a very important factor that can be used to determine the type of agricultural activities engaged in. According to Workneh Abebe (2008) beekeepers are generally reluctant to experiment with new technology as they get older. The average family size of the respondents was 5.8 members per house hold (**Table 2**). This study revealed that farmers of the study area have large family size. This may probably because highest labor is involved in watching during swarming times, beehive construction, honey extraction and colony multiplication. Workneh Abebe (2011) stated that beekeepers with large family size opt for improved technologies to improve productivity and incomes.

Farm size was thought to be a good proxy indicator of wealth. The average farm & grazing land holding of the study participants was 0.6 and 0.1 hectare respectively (**Table 2**). This indicate that the average farm land holding of the study participants was below the national average land size, which is 1.5ha

Table 2: Age, family size and land holding of the sample respondents

Scio economic variable	N	Mean	Std. Deviation
Age	300	45.37	10.677
Family size	300	5.85	1.784
Farm Land	288	.5885	.33221
Grazing land	288	.0599	.15110

Beekeeping Practice and Sources of Honeybee Colony

The study revealed that, about 59.2% of beekeepers started the beekeeping activity by purchasing honeybee colonies from market centers and/or from neighbor fellow beekeepers (**Figure 2**). On the otrher hand, about 22.7% of the beekeepers got their starting honeybee colonies by catching swarms followed by gifts from parents (15.6%). About 2.4% also obtain colonies through supports by governmental & nongovernmental organizations (**Figure 2**).

The survey result also revealed that honeybee colony marketing is a common practice in the study area. Like other animals and agricultural commodities it is a common practice to observe farmers exchanging honeybee colonies in the open market and they earn extra income from the sellof honeybee colonies. The result is in consistent with that of Workneh Abebe (2008) who stated that the beekeepers in Atsbi Wemberta get extra income from the sale of honey and honeybee colonies. Teweldemedhn Gebretinsae and Yayneshet Tesfay (2014) also reported that honeybee colony marketing is an important venture in Wereileke districts of Tigrai region.

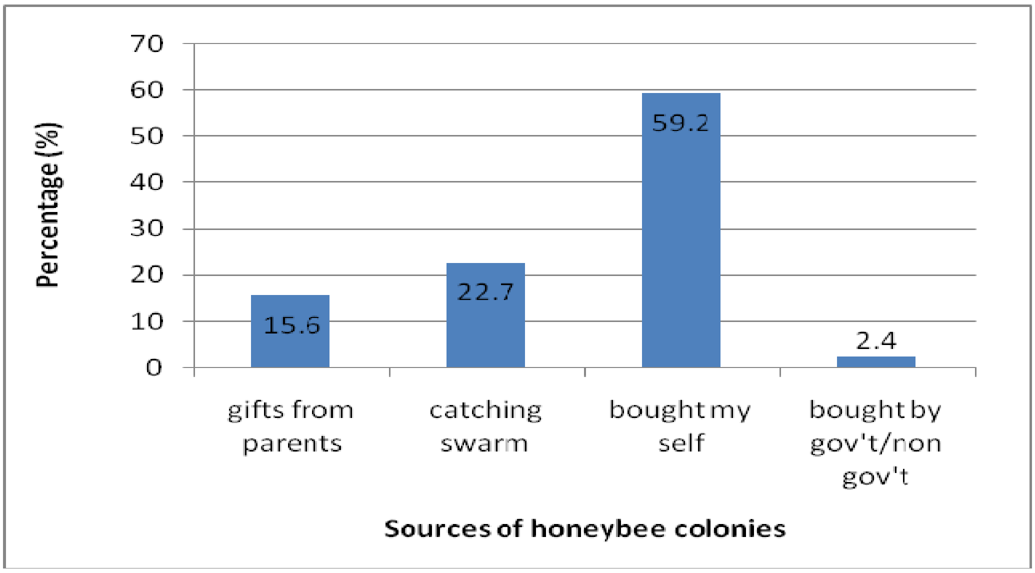

Figure 2: Sources of honeybee colonies in the study area

Trends of Honeybee colony and Honey production

As presented in (**Figure 3)** there was a steady increment in the mean numbers of honeybee colonies in improved box frame hives per household between 2013 and 2017. On the other hand, in the same years the mean numbers of honeybee colonies in traditional hive remained almost constant (**Figure 3**). According to the survey results, in the study areas, both movable frame box hive and traditional hives are coexisted and used. However, may be due to governmental and non-governmental organization interventions to promote the technology, nowadays there is an increasing demand for the movable frame box hive than traditional hives. Moreover, as stated by the respondents higher honey yields with better quality, ease of inspection and ease of product harvesting are some of the major reasons for the increasing demand high adoption rate for the movable frame box hive.

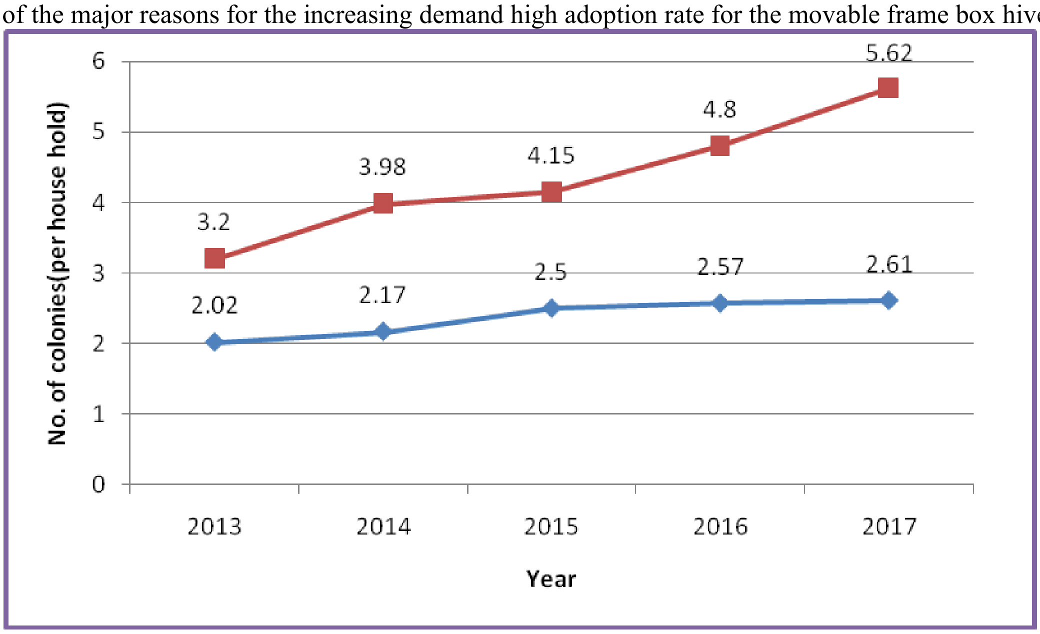

Figure 3: Trend of Honeybee colonies in traditional & movable frame box hives over five years (2013-2017).

In the study area the mean honey productivity of movable frame box hive and traditional hives didn't show consistent trend in the past five years(2013-2017). The mean annual honey productivity from movable frame box hive was highest(13.32 k.g) in 2013. and lowest (10.58 k.g) in 2013 (**Figure 4**). Moreover , the mean annual prodcutivity of honey from movable frame box hive and traditonal hive were ranged from 10.58 to 13.32 kg. & from 7.46 to 8.16 kg during the study period (2013-2017) (**Figure 4**).

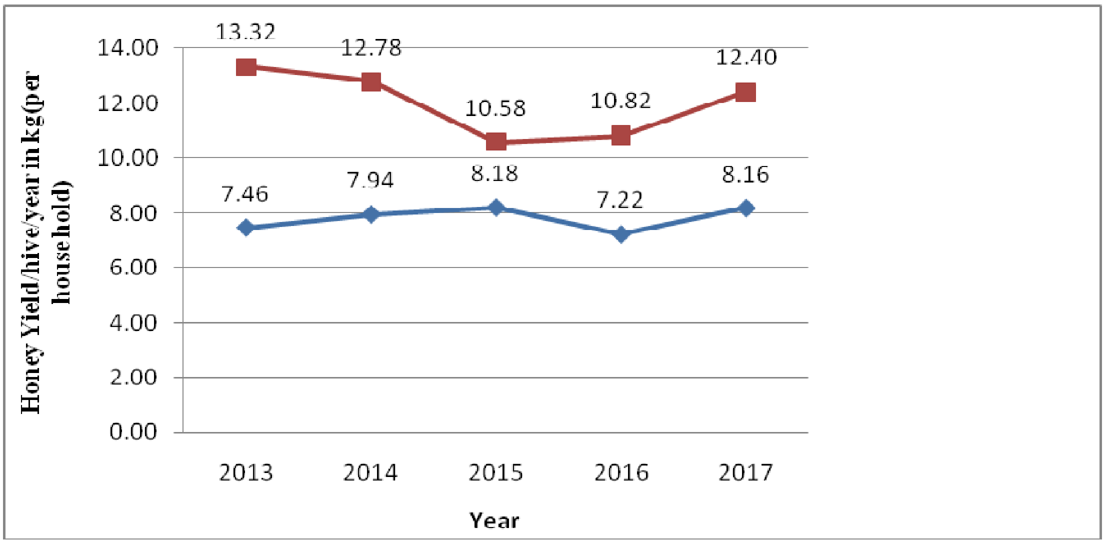

Figure 4: Trend of honey productivity (2013-2017)

Major Beekeeping Constraints

Currently beekeepers are facing a number of interrelated problems and constraints that limited honey production and productivity. Beekeepers in the study area identified about eight major challenges for their beekeeping activities.Inorder of their importance these include agrochemicals application, drought , honeybee pest & predators, honeybee disease, lack of bee forage, absconding , increased cost of production and decreased price of honey.The problems were ranked based on their index value beekeepers put in order of their severity(**Table 3**).

This result suggests that, the improper and indiscriminate application of agrochemicals in the area is the most challenge confronts the beekeeping development followed by pests and predators. Other mentioned and unmentioned problems are also contributing for the lower productivity of the the beekeeping sector in the region.

The result supports previous study findings by Workneh Abebe (2007), Gidey Yirga and Kibrom Ftwi (2010), Workneh Abebe *et al.* (2011), Taye Beyene *et al.* (2014), Atsbaha Hailemariam *et al.* (2015), Guesh Godifey (2015), Yetimwork Gebremeskel (2015), Dawit Meslie *et al.* (2016), Teklu Gebretsadik *et al.* (2016) that reported honeybee pests and predators, lack of bee forage, agrochemicals application are the major bottle necks for beekeeping development in Tigrai region and in Ethiopia as well .

Agrochemicals are the main cause for honeybee colony absconding (Desalegn Begna, 2014; Dawit Meslie *et al.,* 2016). (Workneh Abebe, 2007) also found out that the existence of honeybee pest was one of the determinant factors for less adoption of improved hives

Table 3: Major apiculture constraints in the study area

Major beekeeping challenges	Relative Degree of Importance									
	1st	2nd	3rd	4th	5th	6th	7th	8th	Index	Overall Rank
Agrochemicals	83	50	27	0	2	0	0	0	0.22	1
Drought	49	44	38	16	4	0	0	0	0.19	2
Pests & Predators	34	51	26	41	9	1	0	0	0.19	2
Disease	19	16	37	26	23	12	0	0	0.14	4
Lack of bee forage	8	24	27	23	30	10	3	0	0.12	5
Absconding	2	3	12	18	19	30	1	0	0.07	6
Increased cost of production	7	7	7	20	21	14	12	0	0.07	7
Decreasing price of honey	0	0	4	1	2	3	2	0	0.01	8

Note: Index = sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3* ranked 6th+2* ranked 7th+ 1*ranked 8th); for individual reasons divided the individual sum by the total sum

Farmers perception on availability of bee forage

According to survey results, most of the respondents (45%) indicated that honeybee forages in the area is decreasing from time to time due to different reasons (**Figure 5**). On the contrary, about 35% of the respondents declared that due to soil and water conservation efforts there is an increase trend in bee forage (**Figure 5**). In addition, about 17.1% of the respondents replied as there was no change in the availability of bee forage and

2.8% of them don't have any observation about the trend of bee forage (**Figure 5**).

According to the information generated from the group discussion, in the areas trees, bushes, herbs and grasses which were served as sources of honeybee forages are now either disappeared or exist in rare amount. This attributed to unwise management of forest, indiscriminate and improper application of agrochemicals (especially herbicides), war and concurrent drought. The current results is in agreement with Alemtsehay Teklay (2011) who indicated that though, beekeeping practice in recent years is improving, the contribution of honey production of the region to national honey production is still small, due to degradation of natural resource and/or degradation of honeybee flora that affect the diversity of honeybee plant.

Despite of these problems, there are different interventions to revert the condition like area closures and watershed management. Consequently, peoples of the area have begun benefiting from this especially from beekeeping. There were extension activities which encourage beekeepers to grow indigenous bee forages in Atsbi womberta (Workneh Abebe *et al.,* 2011).

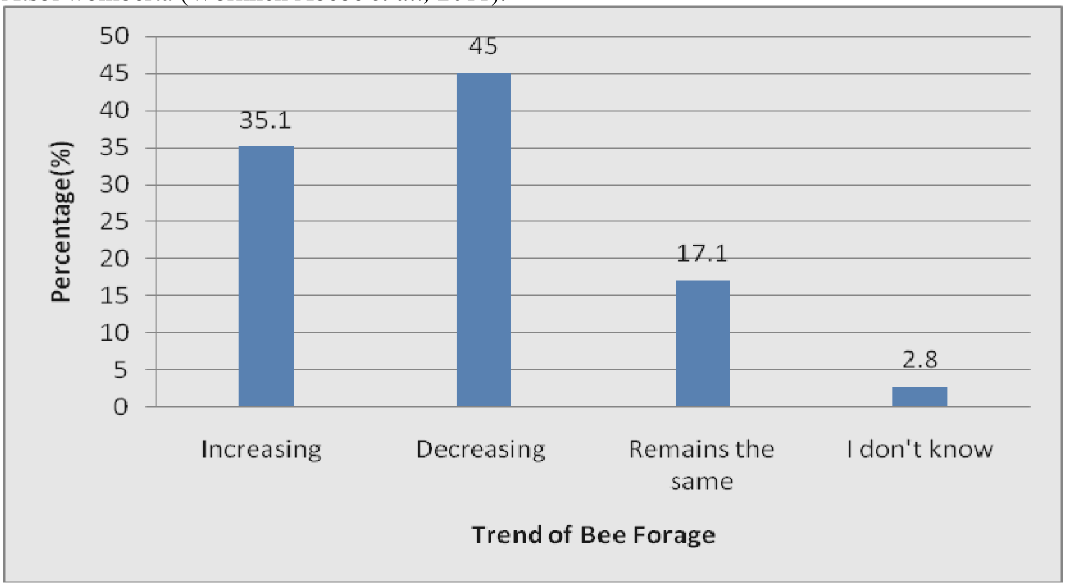

Figure 5: Trend of honeybee forage in the study area

Utilization of Agrochemicals

The study revealed that Both beekeepers and non beekeepers in the study area use agrochemicals as control measures for crop pests and diseases. About 84% and 63.7% of the respondents from the non beekeepers and beekeepers reported that they applied different agrochemicals to their crops, respectively(**Table 4**).

The result is supported by earlier studies (Tadesse Amera and Asferachew Abate 2008) who stated that, although agro-chemical use in Ethiopia was historically low, recent developments in increased food production and expansion in floriculture industry have resulted in higher consumption of chemical pesticides. However, the current result was contradicted with earlier study reported by Sintayehu Fetene and Tibebu Habtewold (2016), who shown that there is zero preference for herbicides in Endamekoni wereda of southern Tigrai where the use of herbicides on wheat fields has largely been abandoned by majority of the farmers with the objective of safeguarding their honeybee colonies.

To investigate whether beekeepers and non beekeepers differ on agrochemicals utilization, a chi-square statistic was used. To this end beekeepers and non beekeepers are significantly different on the utilization of agrochemicals (x^2 =12.26, *df* = 1, P=.000) (**Table 4**). Non beekeeper is more likely to use agrochemicals than beekeepers. So, one can perceive that beekeepers are more aware of on the effects of agrochemicals to non target organisms (especially honeybees) and the environment they live than that of non beekeepers.

Table 4: Agrochemicals utilization beekeepers Vs non beekeepers

Utilization of agrochemicals	Beekeepers	Non beekeepers	$x2$	P- Value
Yes	135(63.7%)	74(84.1%)		
No	77(36.3%)	14(15.9%)	12.261	.000

Types of agrochemical utilized

Regarding the types of agrochemicals utilization, eleven different types of agrochemicals were used by both beekeepers and non beekeepers (**Table 5**). Thus, 2-4-D (62.4%),Mancozeb (34.8%), Malathion (29.2%), Pallas (19.2%), Ridomil (12.4%), Karate (7.2%), Phenotrotine (5.8%), Tilt (3.9%) (**Table 5**) were used by both beekeepers and non beekeepers concurrently though the number of farmers were varied between beekeepers and non beekeepers. However, Dimethoate, Profit and coragen were used by the non beekeepers only. The easy access to the agrochemicals in the local market, limited knowledge of agrochemicals environmental effects, possibly unrealized agrochemical expenses and the associated public health effects may be among the factors for indiscriminate uses of agrochemicals. However, the other possible cause of indiscriminate use of pesticide could be shortage of extension that could accordingly advice the farmers on other alternative methods for pest controls

This result is in agreement with Tadesse Amera and Asferachew Abate (2008), 2-4-D, Malathion, Mancozeb and Ridomil were used by farmers of Ziway and Arsi Negele. Moreover, the result is in agreement with the findings of Nonga *et al.* (2011), Desalegn Begna (2014), Guesh Godifey (2015), Dawit Melisie *et al*. (2016), and Belay Mengistie *et al*. (2015) which reported that the most commonly used agricultural pesticides by smallholder vegetable farmers in Central Rift Valley of Ethiopia were Mancozeb, Selecron, Redomil, Malathion, Karate, Thionex and Profit. Most farmers used more than four types of pesticides during one cropping season.

Table 5: Beekeepers, non beekeepers and their preference of agrochemicals use in the area

Types of agrochemicals	Beekeepers				Non beekeepers				Over all
	Yes		No		Yes		No		
	N	%	N	%	N	%	N	%	Yes
Malathion	35	16.5	100	47.2	26	29.5	48	54.5	61(29.2)
Dimothoate 40%	0	0	133	62.7	2	2.3	72	81.8	2(1)
Phenotrotine	12	5.7	164	77.4	3	3.4	77	87.5	15(5.9)
Karate	6	2.8	127	59.9	9	10.2	66	75.0	15(7.2)
Tilt	2	.9	130	61.3	6	6.8	66	75.0	8(3.9)
2-4-D	89	42.0	47	22.2	42	47.7	32	36.4	131(62.4)
RIDOMIL	10	4.7	124	58.5	16	18.2	59	67.0	26(12.4)
Mancozeb	43	20.3	92	43.4	29	33.0	45	51.1	72(34.8)
Pallas	24	11.3	109	51.4	16	18.2	59	67.0	40(19.1)
Profit	0	0	134	63.2	3	3.4	71	80.7	3(1.4)
Coragen	0	0	133	62.7	3	3.4	72	81.8	3(1.4)

Amount used annually and class of agrochemicals

Agriculture, globally, now uses the highest volume of pesticides than at any other point in history (Tilman *et al.*, 2001). Large quantities of chemicals are imported annually to Ethiopia and agrochemicals take the great share. In this regard, over 3000 tons of various types of pesticides that are worth more than USD 20 million are imported annually (FEPA, 2004).

Farmers generally use a higher dosage of pesticides than recommended, under the misconception that a higher dose means better eradication of pests. Although farmers keep no records of the amount of pesticides sprayed, they explained that their spraying frequency varied, depending on climatic conditions (rainy and dry season) and crop types. The mean number of agrochemicals applied annually were almost the same for all the agrochemical types. The results also show that on average 2.50±1.50 li. of profit, 1.66±.50 li. of 2-4-D, 1.34±1.97 k.g of mancozeb, 1.33±.62 li. of malathion, 1.31±.45 li. of pallas, 1.27±0.80 kg. of Redomil, 1.03±.39 li. of karate, 1.00±.72 li.of phenotrotine, 1.00±00 li. of dimethoate 40% and 1.00±.86 li. of coragen were applied per hectare (**Table 6**). Of those agrochemicals used in the study area, 64 % of them were applied for insect pest control, thus categorized as insecticides, while 18% of them applied for weed infestation control collectively named as herbicides and the other 18% was used for fungi/rust control and were fungicides (**Table 6**).

The current result was in line with Belay Mengistie *et al*. (2015), who reported insecticides (58 %) were the most used pesticides because of serious insect pests in vegetable production in Central Rift Valley of Ethiopia followed by fungicides (42 %). Among the different categories of agrochemicals, insecticides and fungicides appear to be the most used in African horticulture (Hubert de Bon *et al*., 2014). According to study conducted in Ogbomoso, Nigeria by Adeola (2012), 62% of the farmers used pesticides to control weeds while majority (81.3%) of the vegetable farmers used pesticides to control insects and most (93.8%) farmers used pesticides for fungi and mould control. Only 6.3% used pesticides to control rodents.

However, on the other hand, the current result was in contrary with the findings of the same author that reported herbicides were not used in Ogbomoso, Nigeria probably because hired laborers manually carry out weeding. Since their farm plots are very small and can be managed manually farmers of Nyeri Counti, Kenya don't use agrochemical herbicides to control weeds (Gitahi, 2014).

Table 6: Class of agrochemicals and amount used per hectare in the study districts

Agrochemical Name	Class	Mean ±SE
Malathion	Insecticide	1.33±.62
Dimothoate 40%	Insecticide	1.00±00
Phenotrotine	Insecticide	1.00±.72
Karate	Insecticide	1.03±.39
Tilt	Insecticide	.53±.31
2-4-D	Herbicide	1.66±.50
RIDOMIL	Fungicide	1.27±0.80
Mancozeb	Fungicide	1.34±1.97
Pallas	Herbicide	1.31±.45
Profit	Insecticide	2.50±1.50
Coragen	Insecticide	1.00±.86

Trend of agrochemicals utilization

Although agrochemical use in Ethiopia was historically low, recent developments in increased food production and expansion in floriculture industry have resulted in higher consumption of chemical pesticides. Majority of the respondents (67.4%) replied that the utilization of agrochemicals was increasing from time to time where as 19.4%, of them indicated that there was constant trend, 10.3% decreasing and 2.9% of them didn't know the trend in agrochemical utilization (**Figure 6**).

The current finding is in consistent with findings Amsalu Bezabeh *et al. (*2010) and Tadesse Amera & Asferachew Abate (2008) that reported the use of agro chemicals in Ethiopia is increasing from time to time and mainly used to control pests. In addition, Nonga *et al*. (2011) reported although the amount and intensity of pesticides use in Tanzania vary across provinces, indiscriminate use of pesticides and other agrochemicals has rapidly increasing these times. Belay Mengistie *et al.* (2015) indicated that in Central Rift Valley of Ethiopian an increasing trend in pesticide use during the past five years. Majority of farmers in South Western Ethiopia claimed that agrochemicals use increases each year (Fikre Lemessa *et al.,* 2016).

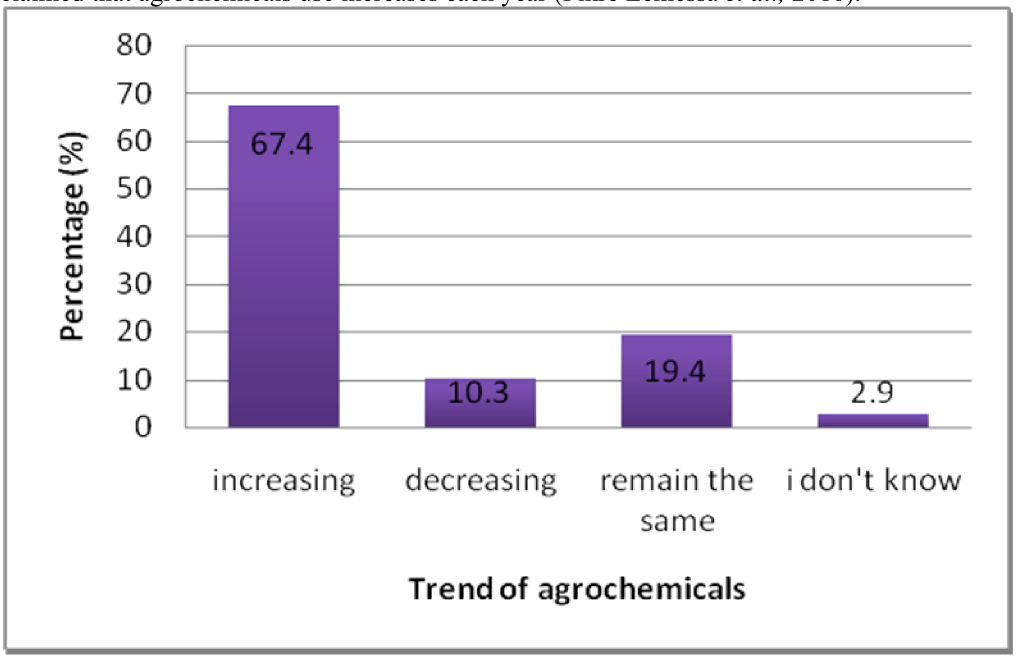

Figure 6 :Trend of agrochemical utilization in the study areas.

Reasons for increasing utility of agrochemicals

Farmers apply agrochemicals on their crops to control pests and diseases that threaten the survival and yield potential of their crops. Efforts were made to identify reasons why farmers increasingly applyagrochemicals in the study districts.

The result indicated that the extension service promots and encourages farmers to use agrochemicals (22.9%). Besides 21.1% of respondents stated that the emergence of new pests, diseases and weed infestations are the second reasons for increment of agrochemical utilization (**Table 7**). Other reasons such as the need to increase yield (18.7%), expansion of irrigation practice (18.1%) to save labor time and energy(9.6%), increasing labor cost for hand weeding (6%) and hesitation of hand weeding (3.6%), contributed for the increased use of agrochemicals(**Table 7**).

The current study is in agreement with the finding of Gitahi (2014) which showed that 52% percent of the farmers used agrochemicals in order to increase yield as well as to control pest and disease. On the other hand, 20.7% did so to improve marketability of their produce while 27.6 % did so as advised by the agricultural extension agent in Nyeri County, Kenya.

Table 7: List of reasons for the increasing trend of agrochemicals utility in the study area

Variables	Frequency(N)	Percent (%)
Expansion of irrigation practices	30	18.1
Emergence/occurrence of new pests or disease	35	21.1
Extension system promote for increasing	38	22.9
Increased labor cost for manual weeding	10	6.0
Farmers hate hand weeding	6	3.6
To save time and energy	16	9.6
To increase yield	31	18.7

Frequency of agrochemicals application per cropping cycle

The study found out that the frequency of application of agrochemicals is different for selected agrochemicals and the target crops. Concerning the frequency of application of individual agrochemicals, majority of the respondents reported that their application frequency depends on the crop type and intended objectives. Mostly herbicides (2-4-D & Pallas) were applied one time and rarely two times as a means to control weed infestations while the other agrochemical types (insecticides and fungicides) were applied up to four times and above (**Table 8**). This means the application frequency and volume depends on the level of damage and duration of the crop cycles.

The overall agrochemicals application frequencies were found to be much less than that of previously reported application frequencies in Africa. In Malawi, farmers spray on tomatoes on average 19 times and on cabbage 14 times (Orr and Ritchie, 2004). In Tanzania, application frequency was a weekly base in many situations (Ngowi *et al*.,2007). In Senegal, weekly frequencies of agricultural pesticides applications on vegetable crops was underway depending on the areas of cultivation (Cissé *et al.*,2008).

Table 8: Frequency of agrochemicals application for a single crop per one cropping season

Agro-chemical	Frequency				
	One time	Two times	Three times	Four times	When needed
Malathion	6.5	6.5	30.6	1.6	54.8
Ddimothoate 40%	-	-	100	-	-
Phenotrotine	81.3	12.5	-	-	6.3
Karate	46.7	33.3	-	-	20
Tilt	75	12.5	-	-	12.5
2-4-D	97.7	2.3	-	-	-
RIDOMIL	13	17.2	47.8	13	9
Mancozeb	10.3	16.2	51.5	19.1	3
Pallas	94.9	5.1)	-	-	-
Profit	-	-	-	33.3	66.6
Coragen	-	66.7	-	33.3	-

Perception of Respondents on the Effects of Agrochemicals to Honeybees

The results revealed that both the beekeepers (94.3%) and non beekeepers (86.4%) were aware of the adverse effect of agrochemicals on honeybees, (**Table 9**). In spite of that they continue spraying agrochemicals to their crops frequently without taking care of honeybees from the exposure to toxic agrochemicals.

These results are in agreement with Marta Zelalem and Tariku Jibat (2014) findings which showed about 85% respondents in West Gojjam zone of Mecha district were aware of the effects of agrochemicals on honeybees through their experience and personal and extension workers' advice. It is also in consistent with Dawit Melisie *et al.* (2016) which reported that all onion producers in Adami Tullu district of Ethiopia were aware the side-effects of pesticides on honeybees. However, the findings of the current study do not support the previous research of Belay Mengistie *et al.* (2015) which reported that, although 76 % of the farmers indicated that pesticides cause damage to human health, the majority on the other hand indicated that pesticides do not cause damage to animal health (75 %) or water bodies (91 %).

Table 9: Perception of respondents on the agrochemicals effect on honeybees

Category	Beekeeper		Non beekeeper		Total
	Frequency(N)	Percent (%)	Frequency (N)	Percent (%)	(%)
Yes	199	94.3	70	86.4	92.1
No	10	4.7	10	12.3	6.8
I don't know	2	.9	1	1.2	1.0

Dead honeybees frequently found

Agrochemicals can affect honeybees in different ways based on the ways of exposure and nature of the agrochemicals. Some kill bees on contact in the field, others may cause brood damage or contaminate pollen, thus killing house bees. Dead and dying off honeybees were found in different location.

Accordingly from this study, poisoned dead and dying honeybees were majorly observed on the ground under hive stand (52.7 %), in the hive entrance (48.3%) and followed by 39.8%, and 10.1%, in the sprayed agricultural farm land and inside the hive respectively (**Figure 7**). This observation depends on the beekeepers' level of honeybee management and awareness.

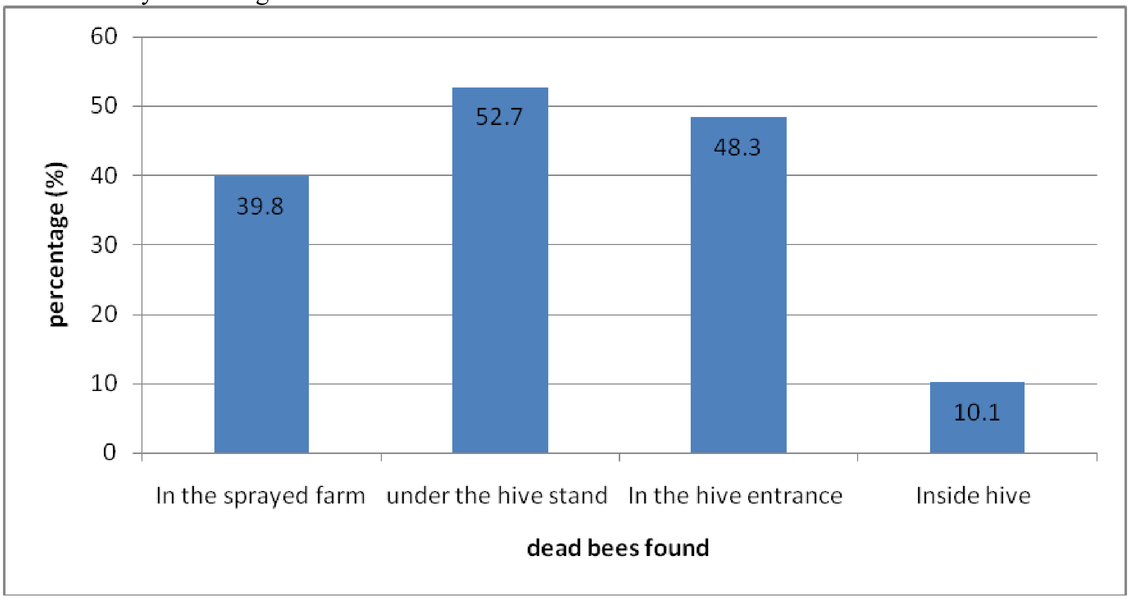

Figure 7: Agrochemicals poisoned dead honeybees found in different places.

Forager bees were poisoned by agrochemicals while foraging sprayed crops, by wind drift and house bees with contaminated pollen and nectar. Consequently, beekeepers have been experienced with dead honeybees in different locations. Based on the study result, dead bees were found in the agricultural filed, most of them were found in cereal crops (70.1%), dead bees were also observed in vegetables, cereals and in fruit trees 16.5%, 12.4% and 1% respectively (**Figure 8**).

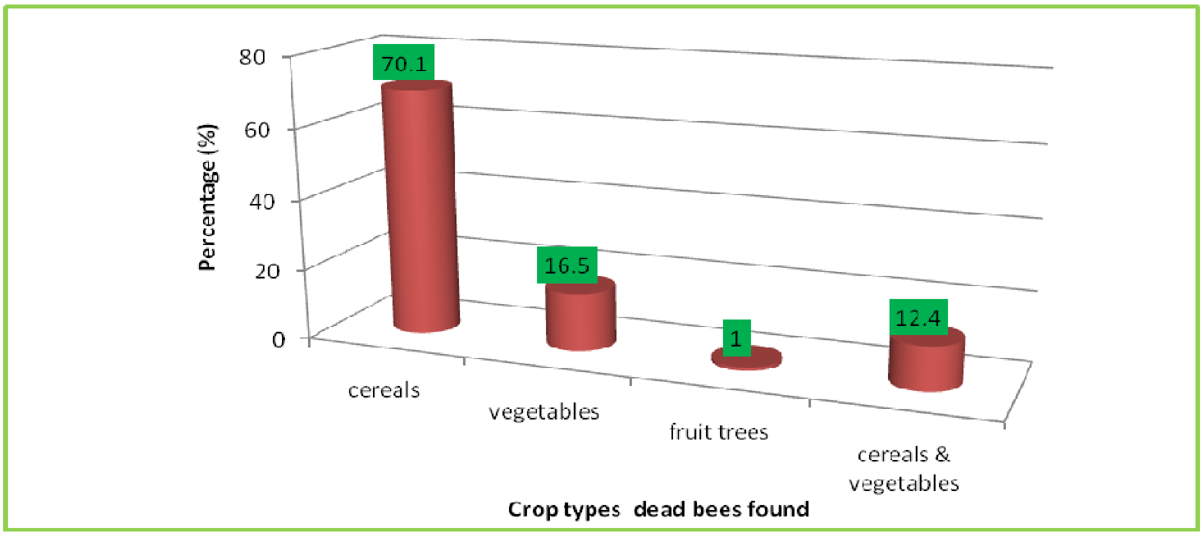

Figure 8: Farmers' observation on which crop types dead honeybees found frequently.

Mixing Practice of Different Agrochemicals

Honeybees can be exposed in the field to combination of agrochemicals both whenever an area is involved in consecutive treatments with different products, and when a mixture of products is used for a single treatment (Maria, 2013). The result revealed that, of those who applied agrochemicals 83.4% didn't practice mixing different agrochemicals while about 16.6% mix two different agrochemicals before application. They mix different agrochemicals to save time and energy (67%), for synergy effect (19%) and to minimize the rental cost of spraying material(14%)o (**Figure 9**).

Ngowi *et al*. (2007) reported that interactions between insecticides, fungicides and water mineral content can influence the efficacy (more toxic, less efficient, neutralized or resistant) of pesticides against fungal pathogens and insect mortality, while some mixtures induced phytotoxicity on tomato, onion and cabbage. However, farmers did not recognize that this kind of mixing of products could be less effective and cause adverse effects to their health or the environment. As per the respondents replay, during mixing of different agrochemicals, there is no any clear ratio amount to mix it is rather individual based.

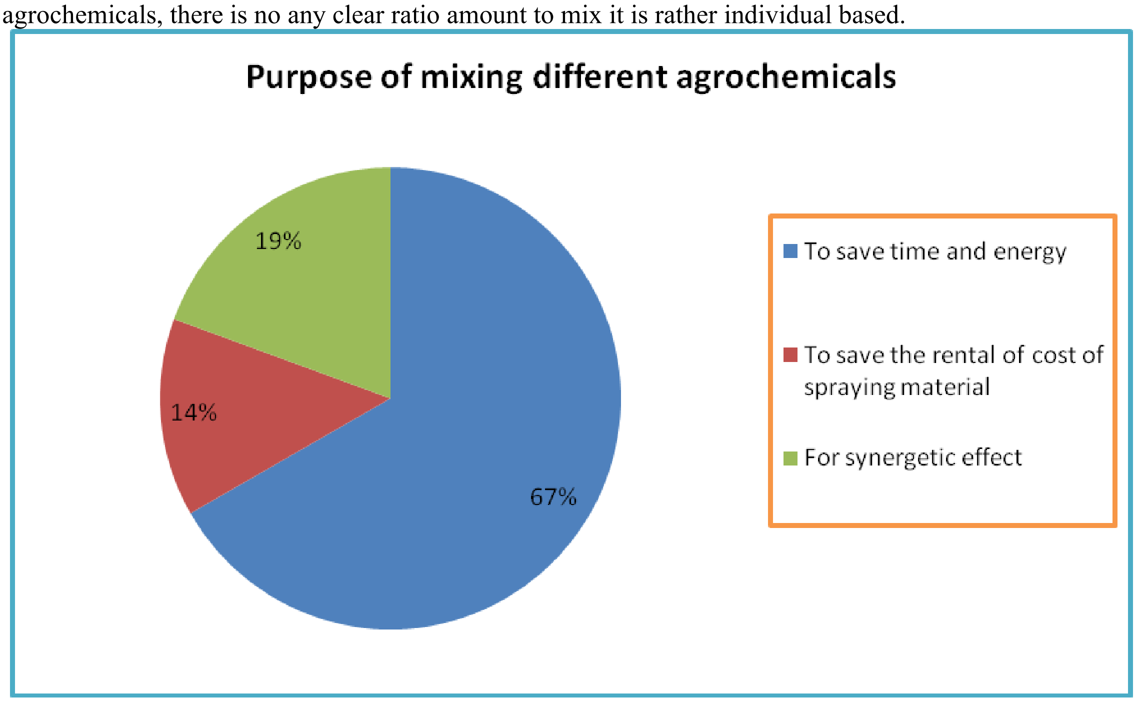

Figure 9: Purpose of mixing different agrochemicals

Handling and storage of agrochemicals

Majority of the respondents (42.4%) in the study areas store agrochemicals out of reach of children and other domestic animals, while 30.4% of them store inside resident in tight container, 16.6% hang on under the roof or under their bed, 10.1% store anywhere in the house and 5%, store inside the kitchen (**Table 10**).

Another factor that could cause adverse effect on health and environment is the way the empty agrochemical containers are disposed. Most of the disposal measures of the packaging materials of pesticides are causing significant environmental and health risks, as usually around 2 % of the pesticides still remain in the empty packaging (Briassoulis *et al*., 2014). The study result has shown that majority (68.7%) of the farmers throw empty agrochemical containers anywhere in the farm or around residence, 20.7% dispose it by burying in the soil, while 5.5 % destroy it by burning with fire and about 5.1% of them used it as house utensil (**Table 10**). These results are in agreement with Belay Mengistie *et al*. (2015) that showed common way of disposing empty pesticide containers was throwing in the field and irrigation canals or rivers. The other ways of disposing pesticide containers were buried, burned, reuse for water or food storage, and selling out.

Regarding obsolete/expired agrochemicals in the hands of farmers, about 58.1% respondents reported that they continue using it while about 14.7% of respondent dispose it, and 6% of them store it for some other unintended purposes (**Table 10**).

These results further support the idea of Oluwole and Cheke (2009), which reported that many agricultural pesticide user farmers in Ekiti state, Nigeria store their pesticides improperly and they finally leave the emptied containers in the open field. Furthermore, rural agricultural households with limited resources often reuse pesticide containers. Where residues are not entirely cleaned from a container's internal surface and family members will ingest the contents later put into the containers (collected water, stored grains, etc.), the potential for also consuming pesticide residues is high.

Table 10: Storage and management of agrochemicals, empty containers, and expired agrochemicals in the study

	Category	Frequency (N)	Percent (%)
Agrochemicals storage	In the kitchen	1	.5
	Anywhere in the house	22	10.1
	In separate place	92	42.4
	Hanging in the roof of the house	36	16.6
	Inside resident house but in tight container	66	30.4
Disposal of agrochemical containers	Use it for water or food container	11	5.1
	Dispose it any where	149	68.7
	Dispose it by burying it in the soil	45	20.7
	Burning with fire	12	5.5
Management of expired agrochemicals	Continue to use it	126	58.1
	Consult DAs	18	8.3
	Dispose it	32	14.7
	Store it	13	6.0
	Never left with excess	28	12.9

Conclusion

- Agrochemicals, drought, pest and predators, honeybee diseases, lack of bee forage, absconding and increased cost of production are the major problems and constraints that limited productivity and production of honey in the study areas
- Unwise and indiscriminate use of agrochemical to protect crops poses a potential honeybee health threat and to the environment in general
- Beekeepers are relatively aware of agrochemicals effects on honeybees and the environment than that of non-beekeepers.
- Utilization of agrochemicals in the study area is increasing from time to time. Different kinds of agrochemicals were repeatedly and unwisely applied by both beekeepers and non-beekeepers in the study area.

Recommendation

- Initiating and enforcing community-based bylaws on agrochemicals utilization, to safe guard honeybees, that give full right of supervise and corrective measures to the community should be in place
- There should be a clear channel of working and chain of communication between crop protection experts, bee experts, health and environmental specialists
- There should be a joint effort from government and other concerned organizations that focus on devising rules, regulations and policies that enforce the importation of agro-chemicals that effectively control the target and being less toxic to none target insects

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