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Assessment of Pesticides Use and its Effects on Honeybee Colonies in West and East Hararghe Zones of Oromia region, Ethiopia

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Abstract

The study was conducted in Darolabu and Oda Bultum from west Hararghe and Metta and Kersa districts East Hararghe zones; With the objective of assessing and identifying the impacts of commonly used pesticides on honeybee health and bee products. From each Districts three PA were selected purposively based on potentiality of beekeeping and two beekeeping technician or experts and twenty farmers from each P A were selected using purposive and random sampling design respectively. A total of 240 farmers were interviewed on sim structured questionnaires for their attitudes and knowledge's of chemicals used in the area and the possible effects of chemicals on honeybee colonies and their products. The agro-chemicals mostly used in the study areas were 2,4D, DDT, malathioin, roundup and mancozeb. From the survey results majority of the respondent farmers use agrochemicals (92.9%) for the purpose of weeds control, produce quality of products, fruit and seed color change, insect control, fungi and disease control. From the study area 74.9% of the respondent buy the agrochemical from the local agro-chemical suppliers that donot give any advices on the way of handling and safe uses of the chemicals. Moreover, the majority of the respondents (51.6%) declared that they do not understand the instructions enclosed with the agro-chemicals and 88% of the farmers assisted by others to apply agrochemicals to their agricultural fields. Farmers use different application methods to apply agrochemicals on their crops. The study indicated that, majority of the farmers (89.2%) were use spray different application methods and they apply at different seasons. Most farmers (78%) apply the chemicals as they observe insects, herbs as well as weeds in their crops. Thus the indiscriminate use of agrochemicals has major threats to transform honey bees production. Therefore, taking urgent solution by concerned and responsible stakeholder on the impact of agrochemicals on honey bees. Generally, training farmers on negative effect of agrochemical on honey bee, select appropriate method and time of agrochemical application, using less toxic chemicals for honey bees and properly following instruction is recommended for the study area.

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Keywords

Hararghe, Agrochemicals, Farmer, honey bees, beeswax.

Introduction

With about seven million honeybee populations, the Ethiopia's annual honey and beeswax production is estimated to be over 54,000 and 5000 tons, respectively (MoA, 2013). With this, the country is ranking ninth highest honey producer in the world and the leading producer of honey and beeswax in Africa (CIAFS, 2012).

Honey bees are a vital part of our agricultural system, as are many other species of pollinators. The value of honey

bee pollination services to U.S. Agriculture has been estimated to be greater than 14 million dollars (Morse, 2000) with their value topping $215 billion worldwide (Gallai, 2008). More than three-quarters of all flowering plants must be pollinated by an animal visitor; usually an insect (Klein *et al.,* 2007). In addition, it often takes several floral visits by pollinators to ensure maximum fruit set and quality (National Research Council, 2006). The increased use of pesticides, reduction in the number of wild colonies, and the increased value of bees and the crop they pollinate have all added to the importance of protecting bees from pesticides. The use pesticide for crop pests, weeds, mosquitoes and household pests control brings into focus the real possibility of damaging the delicate equilibrium in the colony, as well as the contamination of hive products (Kerealem and Tila, 2009). Potential exposure of bees to pesticides can vary greatly depending on the type of pesticide, formulation, application method, label restrictions, and other factors (Ellis *et al.,* 2014). The goal in using a pesticide is to achieve maximum benefit (success) with minimum negative impact, and these factors should always be considered in pesticide selection.

The introduction of pesticide in Ethiopia to control agricultural pests' dates back to the 1960's (EPA, 2004). Although, the volume fluctuates across the pesticide types, the country on the average imports 3346.32 metric tons of pesticides annually (Gizachew Assefa, 2011). Use of pesticides is widely spread following modern agriculture and areas with high crop farming parts of Ethiopia are yearly receiving different types and amounts of pesticides.

Today, unwise application of herbicides and various pesticides are killing number of honeybee colonies annually and thus have become critical in the developments of sub sector. By selecting the least toxic and applying them when pollinators are not active, harms can be minimized (Eris and Nanct, 2012). Creation of awareness, having pre warning regulation and strong coordination among beekeepers, chemical applicators and crop growers are very essential to minimize the effect of honeybee poisoning. There is evidence that extensively use of pesticides in agricultural practices has resulted in presence of residues in honey and wax and this changes our honey products from organic into inorganic and decrease the foreign income of the country.

The toxicity effects of commonly used agrochemicals to Ethiopian honey bees were studied at Holeta Bee Research Center and the result indicated that all chemicals tested, except Agro 2, 4-D Amin 720A, were significantly toxic to Ethiopian honeybees when ingested with food (Amssalu Bezabeh *et al.,* 2015). The Pacific Northwest extension publication how to reduce bee poisoning from pesticides (year) states that Malathion should never be applied to flowering crops as it has a 2-5 day residual toxic effect. The apiculture program of North Carolina state university states Malathion to be "highly toxic" and that "severe bee losses may be expected" when used in the vicinity of honeybees. Therefore, these and other toxic pesticides must be applied during late evening, before blooming of honeybee plants and there should be a policy that enforce the crop growers using these chemicals to aware the beekeeper nearby at least a day before pesticides applied so that the beekeeper move colonies temporarily to untreated sites or close up hives during application. The objective of this study was to assess pesticides use and its effects on honeybee colonies in East and West Hararghe zones.

Materials and Methods

Sampling methods and sample size

For the study, purposive sampling was employed to identify district(s) and the rural kebele (sites) in which the study was conducted. Accordingly, Daro Labu and Oda Bultum disricts of West Hararghe and Metta and Kersa district of East Hararghe zones Were selected, considering the potentiality of beekeeping. From each zone two districts and from each district three kebele administrations (KAs) were purposively selected based on their beekeeping and crop production potentials. From each KA, two beekeeping technician experts and twenty model farmers (beekeepers and crop growers) were selected and total 240 beekeepers from the four districts were interviewed on pre structured questionnaires for their attitudes and knowledge's of chemicals used including types of chemicals, their application protocols and their effects on bee colonies and their products.

The study was conducted in Metta and Kersa districts of East Hararghe zones and Daro Labu and Oda Bultum districts of West Hararghe zones at 2016 and 2017. From each zone two districts and from each district three kebele administrations were purposively selected based on their beekeeping and crop production potentials. Totally, about 240 respondents were interviewed using sim-structured questionnaires from both zones. From each Kebele, two beekeeping technician experts and

twenty model farmers (beekeepers and crop growers) was selected and interviewed on sim-structured questionnaires for their attitudes and knowledge's of chemicals used including types of chemicals, their application protocols and their effects on bee colonies and their products. To collect additional information and strengthened households ideas one groups discussion was were held at each kebele with respective key informants using checks lists developed for this purpose.

Results and Discussion

Socio- Economic Characteristics of Households

Household characteristics

According to the result of the study majority of the sampled respondents interviewed were male (85.8%) and the rest were female (14.2%) (Table1). This indicated that majority of the beekeepers in the study area were males, although beekeeping is an activity which can be done regardless of sex differences. The participation of very limited number of females in beekeeping in the study area was in agreement with Abebe Jenberie (2008); Adebabay kebede *et al.,* (2008) and Kerealem Ejigu *et al.,* (2007). Our finding in this regard is also in line with reports of Hartmann (2004) who noted that beekeeping is men's job in Ethiopia. This might be due to the fact that although females have significant involvement in all or parts of beekeeping, it has been reported that beekeeping is duties and responsibilities of men which underscores beekeeping to be men's job due to physical works it requires.

The age of the respondents range from 18 to 76 years with mean of 40.9±12.18 and bee keeping experience of the respondents was also range from 1 to 50 years with mean of 10.06±9.58 years. Of the total households interviewed, 96.2% of the respondents were married while 2.1%, 1.3% and 0.8% were single, widowed and divorced respectively (Table 1).

Educational status of respondents

Education is believed to be an important and one entry point for faster transfer of knowledge on improved beekeeping technologies (Adebabay kebede *et al.,* 2007). 31.7% of respondents were illiterate while 67.1% were literate (this includes read and write to high school level (Table 1). From very few (1.2%) of respondent beekeepers have Certificate and College diploma/Degree (Table 1).

Purpose of crop Production

Crop production and importance of bees for pollination in the study areas are presented in table 2. About 35% of the respondents in the study areas produce crops for home consumption. The highest home consumption were revealed from Oda Bultum (15%) and the lowest in Kersa and Meta districts (4.6%). There was significant difference among districts on purpose of crops production for consumption (X^2= 72.52, P<0.001). Except 40.4% of the respondents in the study areas, the rest (59.6%) have no information or knowledge about honey bee's crop pollination service in enhancing the quantity and quality of crops. The level of importance of honey bee for crop pollination had shown significance difference at 0.05 probability level.

Sources of Pesticides and Buying Practices

Although chemical pesticide use in Ethiopia was historically low, recent developments in food production and expansion in the floriculture industry have resulted in higher consumption of chemical pesticides. Recently, Ethiopia has been considered as one of the country that having the largest accumulations of pesticides in Africa. It was estimated that there were 402 stores at 250 sites containing 1,500 tons of pesticides (MoARD, 2007). The use of different agro-chemicals or pesticides is an important and common practice in crop production to fight against most crop damaging pest populations and diseases to produce high quantity of food. However, if they are not used properly (according to their prescription for time of application and dosage), they bring about very crucial damage to pollinators. The mostly used agro-chemicals in the study areas are 2, 4-D, DDT, malathioin, roundup, mancozeb. Almost all respondent farmers(92.9%) apply pesticides on their crops (Table 2).The survey result revealed that respondents were used pesticide for herb control, quality of products, fruit color change, insect control, fungi and disease control. The chi-square result was portrayed on purpose of pesticide application among district indicated highly significant difference at 0.01 probability level (Table 2). The respondent farmers were buy the pesticides from different sources (National market, Local market, union, informal dealer, agricultural office and multiple) which indicated that more of the farmers buy pesticides from local market suppliers that would not give advices on the proper handling and safe uses (74.9%). Similar finding revealed that farmers buy different types of agrochemicals from local market in smaller quantities (Begna, 2015; Belay *et al.,* 2017;

Zewdie, 2017; Gebrecherkos, 2018). From the result it indicates that there is highly significant difference in source of agro-chemicals among the districts. In the study areas majority of the respondents (51.6%) were not understand the instruction how to use the chemical and 88% of the respondents were need help from the other to use the agrochemicals and also significant difference in source of agrochemicals among districts (table 3).

Method and Time of Pesticides Application

Honey bees may be exposed to harmful chemicals mainly when they collect pollen and/or nectar and water to cool their hives on warm days or to dilute their honey to feed to their offspring (Jennifer *et al.*, 2012). Most insecticides are applied on the crop while herbicides and fungicides are usually applied directly on the soil before the planting of crops. In all these cases, droplets and dust from the applications can fall directly on the bees that fly across the treated fields or nearby because wind can carry the tiny droplets and dust particles hundreds of meters away from the crop (Marinelli *et al.*, 2004). In the study areas more of the farmers respondents (89.2%) (Table 2) were use spray method to apply agrochemicals while dusting and combination of spray and fumigation are the rarely used methods in the study areas. According to this survey majority of respondents apply pesticides as they see insects or weeds (as required) (78%) while others apply pesticides during June, July, august 67%) (Table 3). The result of this survey showed that most of the respondents spray chemicals before 9 am (43%) and others apply 3-10 pm (23%).This indicates that pesticide are applied when honey bees are actively foraging and thus they have high chance to be exposed to pesticides. Similarly, Desalegn (2015) reported that about 64.4% of respondents from western Amahara were sprayed pesticides at 6:00-9:00am. of western Amahara region. From the survey result time of application of the pesticides have highly significant difference among the studied districts (X^2=108.48, P<0.001).

Table.1 Demographic characteristics of respondents

Variable	Categories	N	F (%)
Location	Daro Labu	60	25
	Oda Bultum	60	25
	Metta	60	25
	Karsa	60	25
Sex	Male	206	85.8
	Female	34	14.2
	Total	240	100
Marital status	Married	230	96.2
	Single	5	2.1
	Widowed	3	1.3
	Divorced	2	0.8
Ed. status	Illiterate	76	31.7
	Read and write	19	7.9
	Grade 1-4	55	22.9
	Grade 5-8	57	23.8
	Grade 9-12	30	12.5
	Certificate	1	0.4
	College diploma/Degree	2	0.8
	Minimum	Maximum	Mean ± SD
Age (year)	18	76	40.9±12.18
Bee keeping Experience	1	50	10.06±9.58

N= Number of respondents, f (%) = percent from number of respondent, SD= standard deviation

Table.2 Crop production and importance of bees for pollination in the study areas

Variable	Categories	Districts				Total 240 N (%)	X2
		Karsa	Meta	D/Labu	O/Bultum		
Purpose of crop production	Seed	0	3(1.2)	0	4(1.7)	7 (2.9)	72.52**
	Home consumption	11(4.6)	11(4.6)	26(10.8)	36(15)	84(35)	
	Market	1(0.4)	0	1(0.4)	0	2(0.8)	
	Animal feed	1(0.4)	8(3.3)	0	0	9(3.8)	
	All Except animal feed	39(16.2)	26(10.8)	17(7.1)	16(6.7)	98(40.8)	
	Multiple choice	4(1.7)	12(5)	16(6.7)	8(3.3)	40(16.7)	
Uses of bee for crop pollination	Yes	20(8.3)	21(8.8)	29(12.1)	27(11.2)	97(40.4)	4.07
	No	40(16.7)	39(16.2)	31(12.9)	33(13.8)	143(59.6)	
Level of importance	Less important	3(3.1)	5(5.2)	13(13.4)	8(8.2)	29(29.9)	19.26*
	Medium Important	2(2.1)	3(3.1)	9(9.3)	11(11.3)	25(25.8)	
	Very important	15(15.5)	13.4)	7(7.2)	8(8.2)	43(44.3)	

Multiple choice= Seed, home consumption, market and animal feed, N= Number of respondents, X^2 = chi-square,**= P(<0.01), *=P(<0.05)

Table.3 Purpose and Source of Pesticides uses in the Study Areas

Variable	categories	Districts N (%)				Total 240 N (%)	X2
		Kersa	Meta	D/Labu	O/Bultum		
Uses of chemicals	Yes	57(23.8)	53(22.1)	55(22.9)	58(24.2)	223(92.9)	3.74
	No	3(1.2)	7(2.9)	5(2.1)	2(0.8)	17(7.1)	
Purpose of uses	Weed control	0	11(21.6)	26(46.4)	20(34.5)	57(25.6)	79.11**
	For quality of products	1(1.72)	0	2(3.6)	0	3(1.3)	
	Fruit and seed color change	1(1.72)	0	1(1.8)	0	2(0.9)	
	Insect control	16(27.6)	26(51)	6(10.7)	46.9)	52(23.2)	
	Fungi and disease control	5(8.6)	0	0	1(1.7)	6(2.7)	
	Multiple	35 (60.3)	14(25.4)	21(37.5)	33(56.9)	103(46.2)	
Source of Agro-Chemicals	National market	0	6(2.7)	5(2.2)	5(2.2)	16(7.2)	40.68.**
	Local market	35(15.7)	37(16.6)	45(20.2)	50(22.4)	167(74.9)	
	Union	12(5.4)	2(0.9)	0	2(0.9)	16(7.2)	
	Informal dealer	1(0.4)	1(0.4)	2(0.9)	0	4(1.8)	
	Agricultural office	4(1.8)	4(1.8)	3(1.3)	0	11(4.9)	
	Multiple	5(2.2)	2(0.9)	1(0.4)	1(0.4)	9(4)	
Buying within instruction	Yes	17(7.6)	22(10)	38(17)	31(13.9)	108(48.4)	19.26*
	No	41(18.4)	30(13.5)	17(7.6)	27(12.1)	115(51.6)	
Need help from other	Yes	9(6.5)	21(15.2)	23(16.7)	35(25.4)	88(63.8)	
	No	15(11)	14(10.1)	6(4.3)	15(11)	50(36.2)	

N= Number of respondents, X^2 = chi-square,**= P(<0.01), *=P(<0.05)

Table.4 Methods, season and time of Pesticides application

Variable	categories	Districts				Total 240 N (%)	X2
		Karsa	Meta	D/Labu	O/Bultum		
Methods of application	Spray	51(22.9)	49(22)	44(19.7)	55(24.7)	99(89.2)	17.31*
	Dusting	2(0.9)	0	4(1.8)	1(0.4)	7(3.1)	
	Spray and Fumigation	1(0.4)	3(1.3)	1(0.4)	0	5(2.2)	
	spray and dust	2(0.9)	1(0.4)	7(3.1)	2(0.9)	12(5.4)	
Season of Application	December January and February	15(6.7)	14(6.3)	6(2.7)	2(0.9)	37(16.6)	80.33**
	September ,October and November	5(2.2)	2(0.9)	4(1.8)	8(3.3)	19(8.5)	
	June, July and August	49(1.8)	5(2.2)	35(15.6)	23(10.3)	67(30)	
	March, April and May	8(6.3)	11(4.9)	3(1.3)	0	22(10)	
	As required	26(11.7)	19(8.5)	8(3.6)	25(11.2)	78(35)	
Time of application	Before 9:00 Am	9(4)	3(3.1)	46(20.6)	38(17)	96(43)	108.48**
	11:00Am-1:00PM	2(0.9)	2(0.9)	3(1.3)	2(0.9)	9(4)	
	3:00-4:00PM	15(6.7)	16(7.2)	0	3(1.3)	34(15.20	
	After 5:00 PM	12(5.4)	17(7.6)	1(0.4)	3(1.3)	33(14.8)	
	Before 9:00 Am and After 5:00 PM	19(8.5)	14(6.3)	6(2.7)	12(5.4)	51(23)	

N= Number of respondents, X^2 = chi-square,**= P(<0.01), *=P(<0.05)

Table.5 Bee keeping practice, honeybee colony holding and price of honey and honeybee colony

Variable	Min	Max	Mean±SD
Number of colonies	1	30	4.12 ±4.8
Bee keeping Experience	1	50	10.06±9.58
Amount of honey loss/year	1	80	9.466±11.8
Price of honey/kg	160	260	203.2±32.85
Price of honey bee colonies	1500	4000	2471.4±875.1
colony lost due to pesticide	1	18	4.31±3.731

SD= standard deviation

Table.6 Problems observed by the respondent After Pesticide application in the study area

	Woreda				Total(240)	X^2
	Kersa(60)	Meta(60)	DaroLabu(60)	Oda Bultum(60)		
Dead bees in applied field	5(9.1%)	1(2.0%)	17(32.7%)	11(21.2%)	34(16.2)	
Dead bees in the hive	5(9.1%)	2(3.9%)	12(23.1%)	9(17.3%)	28(13.3%)	
Low production of honey	1(1.8%)	1(2%)	0	0	2(1%)	48.33**
Absconding of bees	4(7.3%)	7(13.7%)	1(1.9%	5(9.6%)	17(8.1%)	
Narcotized bees	1(1.8%)	4(7.8%)	1(1.9%)	0	6(2.9%)	
Low production and narcotized of bees	0	0	0	1(1.9)	1(5%)	
Combination (1-5)	39(70.9%)	36(70.6)	21(40.4%)	26(50%)	122(58.1%)	
Total	55(100%)	51(100%)	52(100%)	52(100%)	210(100%)	

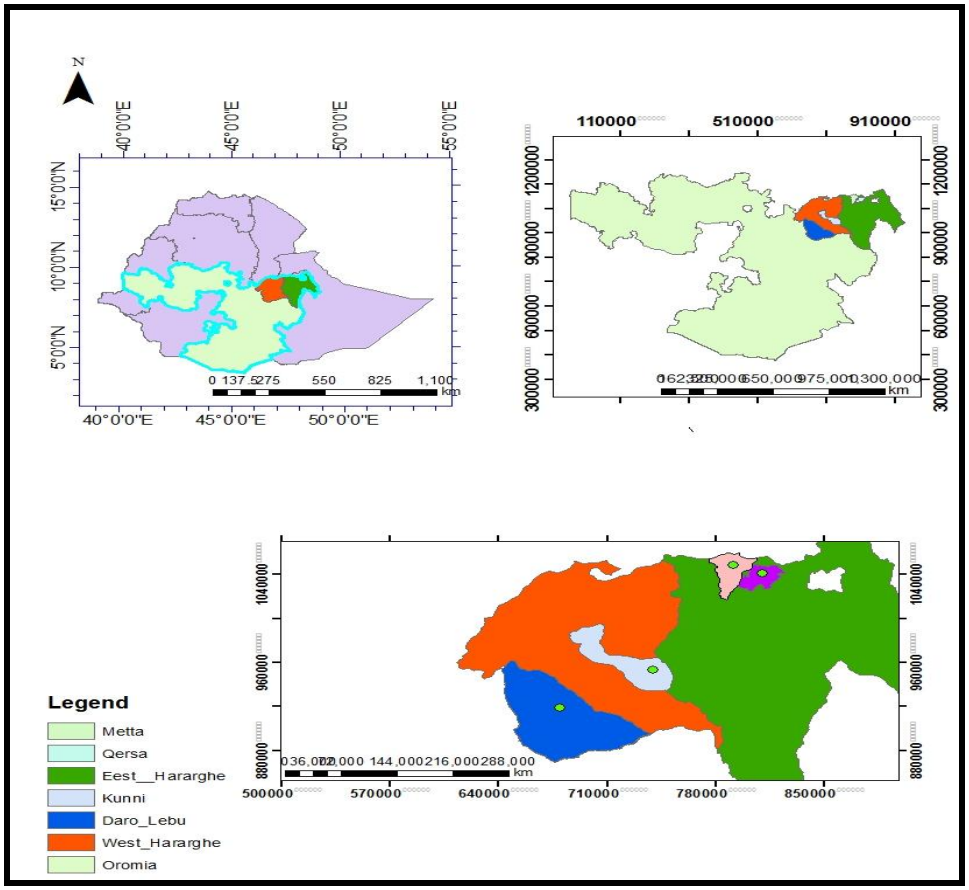
X^2 = chi-square

Table.7 Stage of the crop sprayed, Formulation and Target Pest

	Pesticides and herbicides									
Variables	**24D**		**DDT**		**Malathion**		**Roundup**		**Mancozeb**	
Target Pest	F	P	F	P	F	P	F	P	F	P
herbs	27	90.0	14	10.9	17	27.9	57	63.3	1	10.0
insect	1	3.3	88	68.2	32	52.5	9	10.0	2	20.0
herbs and insect	2	6.7	23	17.8	12	19.7	21	23.3	6	60.0
herbs, insect and fungi	0	0	4	3.1	0	0	3	3.3	1	10.0
Stage of the crop sprayed										
before sowing	0	0	9	8.8	3	7.3	37	62.7	0	0
only at vegetative	20	74.1	32	31.4	8	19.5	4	6.8	0	0
at vegetative and flowering	6	22.2	0	0	3	7.3	0	0	0	0
only at flowering	0	0	0	0	0	0	0	0	8	88.9
at any stage if pest occur	1	3.7	0	0	27	65.9	6	10.2	1	11.1

F=frequency, p=percent

Fig.1 Map of Study area (source: Own computational GIS data)



Status of Honey bee Colonies and its products in the study area

The average colonies holding and beekeeping experience of the respondents of the study areas range from 1to 30yrs and 1to 50yrs with mean of 4.12 ±4.8 and 10.06±9.58 respectively. As indicated in table 4, the annual honey price in the study area ranges from 160 to 260 birr with the mean of 203.2±32.85 birr. This study indicated that each respondent in the study areas loss on average 4.31±3.731honeybee colonies annually due to pesticide poisoning.

Effect of Pesticides on honey bees and its Production

Recently, there is growing consensus that pesticides have killed honeybees and their food source plants and resulted in bee death and their products declines (Kerealem *et al.,* 2009; Marta Zelalem *et al.,* 2014). Honeybees exposed to agrochemicals in different ways. Fischer and Moriarty (2011) indicated older worker bees' forage outside the hive for pollen and nectar, and thus are vulnerable to contact exposure to pesticides during foraging as well as dietary exposure during collection or ingestion of pollen and nectar. Workers also serve as a vector for bringing contaminants back to the hive. Young workers clean cells and attend brood, whereas middle-aged workers do a variety of tasks mainly within the hive. All the young and middle-aged workers, queen and drone can have secondary exposure to pesticides through contaminated food brought back to the hive.

The main symptom of honey bee pesticide kill is large numbers of dead bees in front of the hives. Another symptom is a sudden loss of the colony's field force. After a honey bee pesticide loss the colony may suffer additionally from brood diseases and chilled brood. Among the problem raised by the more farmers were, dead of bees in applied field (16.2%) and in the hive (13.3%).

Commonly used Pesticides and herbicides in the study areas

According to the survey results, about five different agrochemicals were applied to protect their crops in study areas. Those major pesticides are namely; 2, 4-D, DDT, Malathion, roundup and Mancozeb. The survey result has revealed that the respondents were applying those chemicals as wetable powder spray, powder, wp/ec spray and Emulsified concentrate which is different from chemical to chemical. However, more of the respondent farmers were use in liquid from to spray those chemicals.

Among these chemicals, 24D (90%), Malathion (70%) and roundup (64.6%) use in liquid form formulation to spray. For DDT and Mancozeb they were use in the form of powder (68%) and wetable powder (81.8%) respectively.

According to EPA (2011), 2, 4-D is a Group III chemical that has relatively less toxicity to honey bees if it is applied at evening time and at the non-blooming stage of the plant. In the study area also more of the respondent farmers were use the 2-4-D at vegetative (74.1%) stages of the crops.

Recommendation

In Ethiopia agriculture is one of the sectors that play great role in the development economy and the country use different input to increase the production of agriculture. One of inputs used by farmers was different agrochemical that used to control herbs or insects that damage their crops and also they use agrochemicals to increase the productivity of their crops.

Agrochemicals have its own disadvantages and advantages if it not use properly and they bring about very crucial damage to pollination fauna. In the study areas majority of the respondents apply pesticides and herbicides on their crops and more of them were not understand the instruction how to use the chemical and 88% of the respondents were need help from the other to use the agrochemicals. Farmers in the study area buy the agrochemicals from different source especially from those that have no enough information and the study also indicate that 74.9% farmers buy pesticides from local market suppliers that would not give advices on the proper handling and safe uses. Method and time of application of pesticides or herbicides have its own effect on honey bees.

In the study areas the respondent's farmers were applied the agrochemicals at different time and season which is potentially affect honey bees during foraging. In general the farmers and beekeepers in the study areas were not have enough information on the effect of pesticides or herbicides on honey bees and they were not take care the effect of these pesticides on honey bees so that they apply the chemicals without considering the time and season which are more difficult for honey bees. The result of the study indicated that more of the farmers apply the chemicals as they see pests/herbs and disease and they apply the agrochemicals on crops at different stages of crops especially at blooming stage. From the current study the following recommendation were drawn:

Training farmers how to use label instructions and put into practice safety measures like not to apply agrochemicals on blooming crops in the morning time.

There should be a clear mechanism of working and chain of communication between the beekeeper, crop grower and experts.

This study was limited to only assessment of pesticides use and its effects on honeybee. Therefore, further study will be conducted on the toxicity, how long do pesticides stay on air and its poisons level should be studied for each pesticides or herbicides that were identified from the study areas.

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