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Assessment of Pesticide Use Practice Impact on Honeybee Colony in Selected Districts of East Shoa and West Arsi Zones of Oromia, Ethiopia

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Abstract

During 2009/2010, study was carried out to assess agro chemicals use practice and its potential risk on honeybees and beekeeping activities in selected districts of East Shoa and West Arsi zones of Oromia. A total of 240 farmer respondents from eight rural peasant associations in four districts were interviewed using pretested partially structured questionnaires. Focus group discussion was held in all eight previously surveyed rural peasant associations for substantiation of the collected data. About 83.3 % of the study participants used different types of agrochemicals (insecticides, herbicides and fungicides) at different levels 50.8%, 22.2%, 13.3%, 7.9%, 3.8% and 2.1% of the respondents did use agrochemicals for fungal, insect, weed, quality product, others and other diseases in decreasing order of importance respectively. Majority of Farmers in the study area have practiced spray form of agrochemicals application as compared to other forms. Even though, there was variability, farmers apply agrochemicals mainly at flowering stage of nearly all cultivated crops. Most of the farmers apply agrochemicals during winter season following irrigation farming in the study area. The respondent farmers confirmed that agrochemicals had affected beekeeping activities in several ways. From the respondents view and field observation in the present study, it is evident to report that agrochemical are recklessly used and do have high risk to beekeeping activities and honeybees population in the study area. Therefore, all stake takers should cooperate to mitigate agrochemicals use practice impact on honeybee population in the ecosystem. Frequent training has to be provided for both beekeepers and crop growers on the sustainable use of agrochemicals and approaches that will lessen potential harm that might be posed to honeybees due to misuse of agrochemicals. Further study is needed to examine actual impact of agrochemicals on beekeeping and honeybees using a rigorous research approach under laboratory and field conditions.

Keywords: Beekeeping; Pesticides survey; Honeybee colony; Risk assessment

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Introduction

For several decades now outbreak of pests and diseases of agricultural crops has led to excessive use of agrochemicals in developing countries. Agrochemicals use has been used protect pests and diseases of agricultural crops to boost production and ensure food security. In most countries the use o f pesticides in agriculture is an accepted practice as it ensures a reliable yield of good quality produce [1]. However, the unchecked and misuse of agrochemicals has reportedly been brought about the loss of biodiversity [2]. This phenomenon has been acknowledged to be extensive and even serious in developing countries as farming activities are always characterized with low skill and improper use of agricultural technologies [3]. Agrochemicals choice in the developing world is often older, broad-spectrum compounds belonging to the organophosphate, organ chlorine and carbamate class's chemical families noted for their acute toxicity [4]. It could be from potential pesticide exposures from living near farm, in an agricultural spray area, near a pesticide factory, or other environmental exposures and consuming pesticide contaminated food [5]. As a matter of fact, misuse of agrochemicals has been known to harm non-target organisms ranging from beneficial soil microorganisms to insects, plants, fishes, and birds in the ecosystem [4]. Although agricultural chemicals use in Ethiopia was historically low, recently increased trends of irrigation based agricultural production has resulted in higher consumption of chemical pesticides [6]. Recently, Ethiopia has been considered as having the largest accumulations of obsolete pesticides in the whole of Africa. It was estimated that there were 402 stores at 250 sites containing 1, 500 tones of obsolete pesticides. At this point in time, therefore, it is important to assess the risk posed by the

multitude of different pesticides that are used within the agricultural communities in Ethiopia. In the country, beekeepers in particular and farming community in general have poor awareness as to how agrochemicals have to be safely used to the non-targeted organisms in the agro ecosystem. Good pesticide management practices could help to minimize the risks of pesticide poisoning and pollution of the environment. Some of the good management practices to consider when working with pesticide are: follow pesticide label directions, use protective devices, avoid spills, disposal of pesticide wastes and containers properly, elimination of unnecessary application and use of proper pesticide storage [7]. It is unfortunate that there are very limited studies that address this subject in the country. Therefore, the present study was conducted to assess agrochemicals use practice and its potential impacts on honeybees and beekeeping in East Shoa and West Arsi zones of Oromia, Ethiopia. Bura et al. [5] put forward that sensitizing the local community plays immense role in minimizing negative consequences of misuse of agrochemicals on non-targeted organisms in the surrounding.

Material and Methods

Study sites

The study was conducted in Dugda, Lume (East shoa), Negele Arsi and Dodela (west Arsi) Zones of oromia, Ethiopia.

Study population and methods of data collection

The Source of population included beekeeping farmers in districts located in East Shoa and West Arsi zones of Oromia, Ethiopia. Two rural kebeles were purposively selected per each district totaling to 8 rural Kebeles. These study rural kebeles were selected based on the information received from the agricultural experts in agricultural and rural office for the study (Table 1). A study was conducted using self administered questionnaires. Respondents were selected randomly from those Kebeles and the intended data was collected accordingly. The questionnaire was developed by referring different literatures and modified according to the objectives of the study. The questionnaire has four parts which enabled to collect information on general background to the household and farmers, pesticide practice, pesticide knowledge and perception and pesticide use and effects on beekeeping. Prior to data collection, the questionnaire was pre-tested on some farmers in the study area who were not included for actual data collection. It was, therefore, checked for its clarity and some corrections (Table 2). For further validation of the data for this research, a focus group discussion was arranged at each rural kebeles from where data was previously collected in which model beekeepers, development agents and district level livestock experts were involved.

Data analysis and treatment

Frequency and percentage were used to describe the profile of the respondents in terms of socio-demographic, educational and beekeeping practices and pesticide utilization related factors. Results were presented using charts and tables.

Results and Discussion

Socio-demographic characteristics

The description of some important socio-demographic characteristics of the respondents of the current study is given in Table 1. The mean age of study participants was 43.5 with minimum of 15 years and maximum of 70 years, (93 %) were male and (7%) were female, (33.5%) were illiterate, (7.5%) were with basic education, (18.3 %) were with grade 1 to 4 , (23.3%) were with grade 5 to 8 and (15%) were with high school level, (0.41%) were with certificate and (1.7%) were with diploma/degree level. most of the respondents (83.3%) were married, (6.7%) were both unmarried and divorced while few (3.3%) were widowed.

Table 1: Proportion of household characteristics of the sampled bee keepers of the study area.

Socio economic indicators	Categories	(n)	(%)
Sex	Male	223	93
	Female	17	7
Marital status	Married	200	83.3
	single	16	6.7
	widowed	8	3.3
	Divorced	16	6.7
Educational status	Illiterate	81	33.75
	Basic education	18	7.5
	Grade 1-4	44	18.3
	Grade 5-8	56	23.3
	Grade 9-12	36	15
	Certificate	1	0.41
	Diploma/Degree	4	1.7
Age	<15	3	1.25
	15-24	33	13.75
	24-64	112	46.7
	>64	91	37.9
Religion	Muslim	121	50.4
	Orthodox	82	34.2
	Protestant	37	15.4

Table 2: Mean ± SD hectare of agricultural land as classified by farming category of respondents.

Agricultural land use class	Description of the land use system				
	N	Mean ± SD	Min.	Max.	Range
Rain Fed	240	1.9 ± 1.5	0	12	12
Irrigation	228	0.06 ± 0.15	0	0.5	0.5
Grazing	240	0.24 ± 0.34	0	2	2
Forest	236	0.07 ± 0.21	0	1	1
Eroded	240	0.56 ± 0.20	0	1	1
Homestead	240	0.40 ± 0.14	0	4	4
Mountainous	234	0.053 ± 0.04	0	0.25	0.25
Lake	240	0.10 ± 0.06	0	0.5	0.5
Others	222	0.00 ± 0.00	0	0	0

Agricultural land resource and farming condition

The respondents allocate their agricultural land for different purposes. Accordingly, farmers allocated 1.9 ± 1.5 for cultivated land under rain fed condition with a range of 12; 0.06 ± 0.15 for cultivated land under irrigation with a range of 0.5; 0.24 ± 0.34 for grazing land with a range of 0.5; 0.07 ± 0.21 for forestation with a range of 1; 0.56 ± 0.20 was eroded land with a range of 1; 0.40 ± 0.14 for homestead with a range of 4; 0.053 ± 0.04 as mountainous with a range of 0.25; and 0.10 ± 0.06 for lake with a range of 0.5.

Beekeeping practices

In this study respondents were engaged in bee keeping activities

Table 3: Proportion of beekeeping practices of respondents in the study area.

Variable	Variable value	(n)	(%)
Do you have honeybee colony?	Yes	218	90.8
	No	22	9.2
Do you know honeybees are important for improving crops productivity	Yes	149	62.1
	No	91	37.9
If yes, what is the level of importance for improving crops productivity	High	27	11.25
	Medium	93	38.75
	Low	120	50

Table 4: List of the agrochemicals used in the study area.

No.	Pesticide trade name	Pesticide use type	Target pest	Target pest category	Application rate(kg/ha)	Spray volume (L)	Frequency of application
1	2-4D	Herbicide		weed	1-1.5		1
2	Atlantis	Herbicide		weed	0.5		1
3	Palace	Herbicide		weed	0.5		1
4	Tilt	Fungicide		Fungus	12		2-3
5	Topic	Fungicide		Fungus	0.5		2-3
6	Natura	Fungicide		Fungus	0.25		2
7	Carate	Herbicide		weed	0.5		2
8	U-46	Fungicide		Fungus			2
9	Agro	Fungicide		Fungus	0.5		2
10	Ridomel	Fungicide		Fungus	2-3		2
11	Rashido	Fungicide		Fungus			2
12	Rexcido	Fungicide		Fungus	0.5		2
13	Endosulfun	fungicide		fungus	0.5		2

with apparently differing proportions (Table 3). At the time of this study, (90.8%) of the respondents had honeybee colonies; whereas (9.2%) of them do not have honeybee colonies. Most of the respondents (62.1%) had awareness that honeybee colonies can improve productivity of cultivated crops through pollination and (37.9%) of the respondents do not believe that honeybees can improve productivity of cultivated crops. However, most of the respondents have a low (50%) to moderate (38.75%) believe that honeybees are important for improving productivity of cultivated crops. But very few (11.25%) of the respondents said that honeybees are highly important for improving productivity of cultivated crops.

Agrochemicals use practices

Majority of farmers used agrochemicals to improve the yield of their agricultural products by preventing foreign plants or insect pests and diseases especially at times it occurs on a large scale. According to most of the respondents (83.3%) agrochemicals are used in the study area. This result has been found to be comparable with finding of who has reported that 84.3% of the respondents used pesticides and among which about 61% of the pesticides used by the farmers were identified as herbicides, 21% insecticides and 18% both types at western Amhara. Our study has also verified that 78.9%, 57.6% and 40.4% of the sampled respondents were using pesticides to protect the crops from pests, herbicides to control weeds and chemicals (DDT) as anti malaria respectively. Yet, 4.2% and 12.5% of the respondents did not use agrochemicals and even did not have the idea of agrochemicals use respectively.

List of the agrochemicals used in the study area

It was identified that the farmers in the study area used agrochemicals of different types (Table 4). The respondents specified that the types of agrochemicals used in the study area include pesticides, herbicides and fungicides. Fifty (50) different agrochemicals were documented (Table 5) out of which thirteen commonly used agrochemicals have been identified under farmers condition (Table 4).

It's of agrochemicals existing in the local market/pesticide stores

Respondents were questioned to explain purpose of using agrochemicals in their locality. Respondents mentioned the reasons of use of agrochemicals were for protection of crop pests, fungicides, and other diseases and also for quality products. Accordingly 50.8%, 22.2%, 13.3%, 7.9%, 3.8% and 2.1% of the respondents did use agrochemicals for fungal, insect, weed, quality product, others and other diseases in decreasing order of importance respectively. It was explored that farmers practiced different methods of agrochemicals application at each sample districts (Table 6). In this manner, (78.3%, 75%, 100% and 85%), (15%, 18.35, 0% and 15%) and (6.7%, 6.7%, 0% and 0%) in Dugda, Negele Arsi, Dodola and Lume districts in the form of spray, dust and fumigation respectively. Looking in the decreasing order of importance the respondents had used spray, dust and fumigation forms of agrochemicals application in all study districts. The other factor described in this study was distribution of growth stage of the crop on which agrochemicals were applied at the study districts (Table 6). Accordingly, (35%, 30%, 53.3% and 43.3%), (55%, 51.7%, 35% and 51.7%) (0%, 6.7%, 0% and 0%) and (6.7%, 28.3%, 11.7% and 5%) applied agrochemicals in Dugda, Negele Arsi, Dodola and Lume at 'vegetative', 'vegetative& flowering', 'seed setting' and 'any stage' of

Table 5: List of agrochemicals existing in the local market/pesticide stores.

No.	Common name	Pesticide use class	Target pest	Target pest category	Application rate (g/ha)	Frequency of application	Agricultural crop applied
1	2-4D	Herbicide		weed	1-1.5		Wheat, teff
2	Atlantis	Herbicide		weed	0.5		
3	Palace	Herbicide		weed	0.5		
4	Tilt	Fungicide		Fungus	0.5		
5	Topic	Fungicide		Fungus	0.012		
6	Natura	Fungicide		Fungus	0.25		
7	Carate	Herbicide		weed	0.5		
8	U-46	Fungicide		Fungus	0.5		
9	Agro	Fungicide		Fungus	0.5		
10	Ridomel	Fungicide		Fungus	2-3		
11	Rashido	Fungicide		Fungus			
12	Rexcido	Fungicide		Fungus	0.5		
15	Logger	Fungicide		Fungus	0.5		
16	Malathion	Herbicide		Weed	10		
17	Mancozeb	Herbicide		Fungus	0.5		
18	Tutan	Fungicide		Fungus	0.5		
19	Galigal	Herbicide		Weed	0.5		
20	Supergalant	Herbicide		Weed	1		
21	Bassagram	Herbicide		Weed			
22	fusiled	Herbicide		Weed	2		
23	stomp	Herbicide		Weed	0.75		
24	Dimethiote	Insecticide		Weed			
25	Hanclopa	Wormicide	bollworm	Worm			
25	Helarate	Wormicide	cat worm	Worm			
26	Alpha-cyproid	insecticide	Aphids	Insect			
27	perfecto	Insecticide	trips	Insect			
28	Bestfield	Insecticide	trips	Insect			
28	Malamare/malathion	Wormicide	stalk worm	Worm			
29	Ethiolathion	Insecticide	trips	Insect			
30	Globe	Insecticide	Trips	Insect			
31	Locslay	Insecticide	Trips	Insect			
32	proven	Wormicide	Stalk borer	Worm			
33	Decis	Insecticide		Insect			
34	prayor	Fungicide		Fungus			
35	Confidence	Fungicide		Fungus			
36	profid	Fungicide		Fungus			
37	Matco	Fungicide		Fungus			
38	Cropaxyl	fungicide		Fungus			
39	Cropzeb	Fungicide		Fungus			
40	Unizeb	Fungicide		Fungus			
41	Mancolaxyl	Fungicide		Fungus			
42	Amstar	fungicide		Fungus			
43	Rebus	Fungicide		Fungus			
44	Nativo	Fungicide		Fungus			
45	roundup	Fungicide		Fungus			
46	Greenstar	Herbicide		weed			
47	Dipricon	Fungicide		Fungus			
48	Jaba	Fungicide		Fungus			
49	Crust	Wormicide		worm			
50	Diaznone	Wormicide		Worm			

Table 6: Stage of crop and methods of agrochemicals application in the study districts.

Agrochemicals utilization practices		Agrochemicals utilization practices in the study districts							
		Dugda		Negele Arsi		Dodola		Lume	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Method of agrochemicals application	Spraying	47	78.3	45	75	60	100	51	85
	Fumigation	9	15	11	18.3	0	0	9	15
	Dusting	4	6.7	4	6.7	0	0	0	0
Stage of crop at agrochemicals application	Vegetative	21	35	18	30	32	53.3	26	43.3
	Vegetative and flowering	33	55	31	51.7	21	35	31	51.7
	Seed setting	0	0	4	6.7	0	0	0	0
	Any stage	4	6.7	17	28.3	7	11.7	3	5

growth of the cultivated crops respectively. However, as compared to others according to the result of this survey majority (46.6%) of the respondents apply agrochemicals during winter and about 20% of the respondents apply the chemicals during summer. The 13.8% of the respondents apply agrochemicals both in winter and summer and 10% of the respondents apply during autumn. Not much but like 4.2% of the respondents apply during spring and the rest 7.9% apply at any season. In this study, it was described that the application time of agrochemicals is highly unpredictable and differs from farmers to farmers in the study area. The majority of respondents (44.2%) stated that agrochemicals are applied in the morning time. Other significant number of respondents (35%) cited 'afternoon' as preferable time for agrochemicals application. And like 15% of the respondents did apply agrochemicals in the evening while only 5.8% of them had applied at the midday. According to the results reported by Desalegn Begna, though 64.4% of the users at western Amhara prefer 6:00 am to 9:00 am as appropriate spray time, application time is fixed by Knapsack renters and forced to be sprayed at convenient time determined by them. Proper timing of spray can greatly reduce hazards to bees. Often spraying in evening is recommended for insecticides that have short residuals Hunt. However, from this study it was evident that most farmers were using recommendation from their friends who might not have been trained in the area of pesticide application and who might not be knowledgeable on the undesirable impact of pesticides on honeybees. As a result, the time of insecticide spraying and honeybees foraging time were overlapped, which increased the risk of honeybees exposure to insecticides. As the pesticide knowledge was examined in this work, 63.8% of the respondents mentioned that they are able to read and understand information on labels of pesticide use instruction whereas 67.9% of the respondents indicated that they are able to understand information on pamphlets. But 70.9% of the respondents get help to read and understand information on pamphlets.

Perceived effects of agrochemicals on beekeeping

Like 58.8% (Table 7) of the respondents responded that agrochemicals do harm honeybees. Furthermore, the respondents mentioned that agrochemicals affect honeybees and beekeeping in different ways. Accordingly, the respondents experienced/observed those agrochemicals: killed honeybees in sprayed fields (58.8%), killed honeybees inside the hive (50.3%), caused absconding of honeybees (78.3%), caused dwindling of honeybees (79.6%) and caused low production of honey product (84.6%) in the study area. Alemu Tsagaye reported that 86.9% of beekeepers believed that agrochemicals negatively impact honeybee colonies and beekeeping. Similarly, Desalegn Begna who reported that 69% of the beekeepers noticed negative influence of agrochemicals to honeybees. Awareness on the nature of pesticide and their effect by farmers is crucial to prevent risk associated to pesticide application. However do farmers have awareness about health effects of various pesticides being utilized? From this we can conclude that almost all of the farmers need further training and education on pesticide management, handling and associated adverse effects. In line with the damages pesticides could cause, the farmers were asked if it would be possible to protect the damage and only few of them responded that it is possible.

Table 7: Response frequency of knowledge of respondents on impact of agrochemicals on beekeeping.

Variables	Values	(n)	(%)
Do you believe agrochemicals harm honeybees	Yes	141	58.75
	No	99	37.97
Dead bees in the sprayed field	Yes	71	29.58
	No	139	57.92
Dead bees in the hives	Yes	122	50.83
	No	118	49.2
Absconding of bees	Yes	188	78.3
	No	52	21.7
Dwindling of honeybees	Yes	191	79.58
	No	49	20.42
Low production of honey	Yes	203	84.58
	No	37	15.42

Estimated economic loss

Respondents mentioned that agrochemicals affect honeybees by influencing them in three major ways. As the example in case, the beekeepers mentioned that application of different agrochemicals influenced beekeeping by bringing about loss of most of their honeybee colonies by making them abscond, dwindle and die in all the sampled districts. Therefore, beekeepers loss their honeybee colonies to complete death (14% Lume, 9% Dugda, 15% Negele Arsi, 18% Dodola), leaving or absconding (31% Lume, Dugda, 41% Negele Arsi, and 36% Doddola), and dwindling (11% Lume, 17% Dugda, 25% Negele Arsi, and 26% Dodola). Frequency percentage comparison of different ways of honeybee colony loss due to agrochemicals in the study districts. In this study, average honey yield/colony, honey price/Kg and honeybee colony price/hive was collected and summarized. It was stated that the average honey yield was found to be 12 Kg for Lume, 21 Kg for Dugda, and 23 Kg for Negele Arsi and 15 Kg for Dodola. The price of an a kilo honey was reported to be 120 for Lume.

But it was reported to be 200 for Dugda, Negele Arsi and Dodola. The price of honeybee colony was mentioned to be 300, 400, 450 and 350 for Lume, Dugda, Negele Arsi and Dodola respectively. In this study, the total monetary loss was estimated per individual beekeepers because of massive application of agrochemicals in the study area. Accordingly, the monetary loss incurred per individual beekeeper per district was calculated as 57240, 2800, 34200 and 36050 for Lume, Dugda, Negele Arsi and Dodola respectively.

Conclusion and Recommendation

The increase in pesticide use has gave rise to concerns about potential adverse effects on environment and biodiversity, particularly in countries where regulations are not strictly implemented and farmers' knowledge of safe handling procedures is often inadequate. This paper assessed the potential health effects pesticide use on honeybee colonies and beekeeping activities in East Shoa and West Arsi zones of Oromia, Ethiopia In the areas, most of the farmers extensively apply variety of agrochemicals. The use practice of agrochemicals by the farmers in the study area was found to be reckless and can potentially affect honeybee population and beekeeping activities in general. Even though it is with an inconsistent distribution, in the zones, agrochemicals are applied at all seasons of the year to control agricultural crop pests and diseases in the study area. Farmers in the study area opted to apply agrochemicals mainly during the morning and afternoon times of the day where honeybees are usually expected to be active at field activities and foraging. As a result, agrochemicals are supposed to having considerable effects in killing honeybees and affecting beekeeping activities in general. In conclusion, the study availed balanced information on the side effects of pesticides on honeybees and their products that is leading to developing strategies, policy and practices towards mitigating the risks. Mitigating damage of pesticide use to honeybees is the responsibility of all parties involved and requires concerted effort to minimize the risk. Hence, based on this study the below are presented as possible recommendations, which are aimed at minimizing the ill effects of pesticides on honeybees and their products. Farmers and beekeepers need to be educated on how to use label instructions and put into practice safety measures like not to spray on blooming crops, to keep bee colony away from the farm receiving pesticides, adjust the application time to late evening etc. Regulatory body that oversees the total supply, transportation, storage, appropriateness etc of pesticides at all levels should be in place. Conventional way of pest management known should be encouraged to protect bees and the environment; and to ensure the products are natural. Comprehensive research into the effects of pesticides on honeybees and their products decline to which this study targeted to contribute is important. As it is clear, proper application of pesticide can minimize, environmental and public health impacts being caused by inappropriate utilization of pesticides. Well planned training is needed on the safe use of pest management and less risk to bees in the study area. This study highlighted the need for further study and monitoring of the different pesticides on honeybees in different aspects. Key to effecting change in response to pesticide contaminations is community based programs that replace toxic pesticides with alternative non-chemical practices and products.

References

1. Sánchez-Bayo F. Impacts of Agricultural Pesticides on Terrestrial Ecosystems. Ecological Impacts of Toxic Chemicals. 2011;63-87.
2. Sponsler DB, Grozinger CM, Hitaj C, Rundlöf M, Botías C, Code A, et al. Pesticides and pollinators: A socioecological synthesis. Sci Total Environ. 2019;662:1012-27.
3. Ahmad S, Aziz MA. A review: risk assessment of pesticides on honey bee and pollination of agriculture crops in Pakistan. Asian J Agri Biol. 2017;5(3):140-50.
4. Biswas SK, Rahman S. A Review on Impact of Agrochemicals on Human Health and Environment. Development. 2014;31-5.
5. Rişcu A (Jivan), Bura M. The Impact of Pesticides on Honey Bees and Hence on Humans. Animal Science and Biotechnologies. 2013;46(2).
6. Asogwa E. Problems associated with pesticide usage and application in Nigerian cocoa production. Afr J Agric Res. 2009;4(8):675-83.
7. Goka FSB. Impacts of Pesticides on Honey Bees. 2016.