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Farmers' insecticide use practice and its effect on honeybees (*Apis mellifera*) foraging on onion flower in Adami Tullu district of Ethiopia

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The survey was conducted in Adami Tullu district to assess farmers' perception of insecticide side-effects on honeybees. It was conducted in six peasant associations (PAs) and ten farmers were interviewed from each selected PA. On one hand, the results revealed that almost all (96.7%) of onion producers were aware of the undesirable -effects of insecticides on honeybees. On the other hand, the majority (96.7%) of the interviewed farmers applied insecticides (profenofos, endosulfan, diazinon, malathion, lambda-cyhalothrin, delteramethrin, dimethoate and DDT) at any stage of onion development whenever incidence of insect pests was noticed. The insecticide DDT has been banned from use in agriculture. It was found that 48.3% of the beekeepers abandoned beekeeping and they indicated that pesticide application was the major driving force for abandoning beekeeping and bee colony losses. About 53.3% of the interviewed farmers knew about the importance of honeybees in pollinating onion flowers. However, farmers in the study area did not pay due attentions to honeybees and to honeybees' role in onion seed production. As a result, farmers were spraying their onions at any developmental stages, including flowering. This eventually leads to loss of honeybee colonies and abandoning beekeeping in the area and reduction of onion seed yield.

Key words: Insecticide, honeybees, farmer's perception

INTRODUCTION

The farming system in most parts of Ethiopia such as in the Adami Tullu district is typically small scale mixed type of farming system where field crops, vegetables, livestock (cattle, goat, sheep, and poultry) and honey are produced for household consumption and market.

Onion is one of the most important condiment, vegetable and cash crops in Ethiopia. As a condiment it is used nearly by every household on daily bases especially for making '*wot*' (stew). It is produced by small farmers, commercial growers and state farms for both domestic and export markets under rainfed (June to September) and irrigated (October to May) condition for bulb and/or seed production (Lemma, 1998; MOWR, 2007). For instance, in the 2013/14 rainfed season alone, it was grown by 774 thousands households on an area of more than 24,000 hectares (CSA 2014). The average national yield of onion is estimated at about 9.0 t/ha.

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With respect to honey, Ethiopia produces 43,373 tons of honey and 3,658 tons of beeswax annually, which is worth of about 360 million to 480 million Birr and 125 million Birr per year, respectively (Nuru, 2002). Honeybees are the primary pollinators of most crops (Hagler *et al*., 1989). The value of crops that benefit directly from honeybee pollination approaches US$20 billion annually (Levin, 1970). In Ethiopia, yield increments due to honeybee pollination on niger seed (*Guizotia abyssinica)*, faba bean (*Vicia faba)* and onion (*Allium cepa)* was 43, 28 and 84%, respectively (Admasu and Nuru, 2000; Admasu *et al*., 2006).

Onion crop is attacked by various insect pests like onion thrips, onion spider mite, lesser armyworm and western flower thrips (PPSE, 2009) and to overcome the problem different insecticides have been recommended. Thus, in the Rift Valley of Ethiopia, indiscriminate application of insecticides against onion thrips on onion is a common practice (Banchiamlak *et al*. 2012), which has deleterious effects on non-target but beneficial insect like honeybees *(Apis mellifera* L.). On the other hand, onion seed production requires pollinators such as honey bees and blow flies *(Phorma terronovae)* (Munawar et al. 2011).

Ethiopia is dependent on imported onion seeds and on average it imports annually more than 20,000kg of onion seeds from different countries (Lemma et al. 2008). On the other hand, because of Ethiopia's potential of onion seed production, onion seed production program was introduced in the Rift valley mainly to diversify farmers' income and exploit onion seed production potential of the country (Lemma et al. 2008). Also they indicated that onion seed yield under farmers management can reach up to 2t/ha if proper agronomic practices are applied and the activity of pollinators is very high.

However, in recent years onion seed production in the country has generally declined and at the same time farmers are abandoning beekeeping. Various kinds of insecticides applied on onion crop as a part of pest management are considered as one of major factors that pose problems on the beekeepers (Kamara *et al*, 2004) as the killing of honeybees due to the misuse of these agrochemicals causes reduction of honeybee colonies, which eventually results in reduction of bee products and crop yield, thereby affecting the economic return of bee products and agricultural crops (Amssalu, 2010). However, systematic studies have never been carried out to identify farmers' opinion concerning insecticide effects on honeybees and their importance for pollinating onion. Therefore, this study was undertaken to assess farmers' perception regarding the effect of insecticides on onion flower foraging honeybees.

MATERIALS AND METHODS

Because of the mixed type farming system in the Adami Tullu district, purposive sampling method was used to select peasant association (PAs). The number of households engaged in onion seed production, onion production area and average number of beehive kept by beekeepers were used as criteria for selecting the PAs. The information was obtained from the District Agriculture and Rural Development Office. On the basis of the three criteria six PAs viz. Abbene-germama, Bochesa, Dodicha, Edo-gojola, Golba and Halko were selected and the survey was conducted. Structured questionnaire, which consisted of 26 short questions, was prepared in English and translated into Oromifa during interview and discussion. From each selected PAs, 10 farmers (i.e. total of 60 farmers) who were onion seed producers and had an experience of beekeeping were interviewed each for about 25 to 30 minutes at their onion field. The data was analyzed using SPSS version 20 and mean responses were determined based on the 60 respondents.

RESULTS AND DISCUSSION

Social and demographic characteristics

All the respondent households were headed by males with an average age of 47.3 years (standard deviation = 15.82). Most of the respondent onion producers were married. The education level of respondents was variable and majority of them (68%) were literate.

Perception of farmers on service of honeybees as pollinator

The survey result identified that, about 53.3% of respondents knew the importance of honeybees on pollination of onion plants. Of these respondents, 46.9, 18.8 and 34.4% believed that honeybees were less important (i.e. onion can set seed without pollination by honey bees), important and very important, respectively, in pollinating onions. McGregor (1976) explained that pollination made by honeybee improves both quantity and quality of onion seed production. Admasu *et al*. (2006) found 84% onion seed yield increment as a result of honey bee pollination. Adequate pollination could be resulted via the involvement of honeybees. In contrast, inadequate pollination may result deformed and smaller seeds which have low germination capacity (Kozin, 1968).

Commonly used insecticides to protect onions from insect pests

According to the respondent farmers, a total of eight different insecticides were applied to protect onion from infestation by onion thrips, aphids and mites (Table 1). Among these various insecticides, profenofos was the most frequently applied. In the study district, most onion

Table 1: Commonly used insecticides to protect onion from damage by insects in Adami Tullu District (2012/13)

Type of insecticide	Frequency	Percent (%)	Ranking
Profenofos	57	95.00	1st
Endosulfan	51	85.00	2nd
Diazinon	42	70.00	3rd
Malathion	38	63.40	4th
Lambda-cyhalothrin	35	58.30	5th
Deltamethrin	28	46.70	6th
Dimethoate	12	20.00	7th
DDT	1	1.70	8th

producing farmers are using insecticides which are formulated in two forms. The majority (96.6%) of the farmers used pesticides formulated as emulsifiable concentrates while only 3.4% of them use the dust form.

Dosage used by the respondent farmers

Even though most of the farmers were literate and able to read labels on insecticide containers, they do not follow instructions on labels and as a result rate of insecticide application was not uniform. Most (91.5%) of the respondent farmers applied insecticides more than the recommended rate, while the others (8.5%) applied less than the recommended rate (Table 2). This is in agreement with Dinham (2003) who stated that the use of high level of pesticide is common in developing countries. Moreover, onion growers not only applied overdosed insecticides but also they reduced the spray volume (Table 2). This in turn increases the consecration of spray solution. The farmers who applied overdosed insecticides claimed that they sprayed above the recommended rate due to resistance of onion thrips to the insecticides. Preliminary study on the resistance of onion thrips to commonly used insecticides in the Rift Valley, where Adami Tullu district is located, has shown the presence of resistant onion thrips biotypes (Banchiamlak *et al*. 2012). Moreover, high rates of insecticides are known to have undesirable effect on beneficial insects, including honeybees. According to Tadesse and Asferachew (2008), bees and other pollinating insect populations have been declining in the last few years, which may be a result of injudicious utilization of insecticides and lack of awareness on the poisonous effect of insecticides to bee colony.

Method and Time of Insecticide Application

The most common method of insecticide application in the study area was through spraying. Farmers prepared up to 200 liters of insecticide solution in big tanks that are usually located near water sources around the farm. This might also be a possible source of water pollution.

Time of insecticide application differs from farmers to farmers. Majority of the respondents (45%) reported spraying their onion in the afternoon (12:00 am – 6:00 pm) followed by 28.5% before noon (7:00 am-12:00 am), whereas 26.7% of farmers applied during any time of the day. The respondent farmers indicted that they got the recommendation from different sources. Most of the farmers learnt about the time of insecticide application from their friends (65%), from development agents (DAs) (20%), through training (10%), from experts (1.7%), from chemical dealer (1.7%) and both friends and training (1.7%). Proper timing of spray can greatly reduce hazards to bees. Often spraying in evening is recommended for insecticides that have short residuals (Hunt, 2000). 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.

Growth stages of onion at which insecticides are applied

It was found that majority (96.7%) of respondents applied insecticides at any stage of onion development whenever insect pests were detected. Therefore, it is possible to infer that flowering stage is one of the stages at which pesticides are applied. Flowering stage of development is the only suitable stage for foraging bees to collect nectar and pollen. As a result, applying insecticide at this stage can increase the possibility of honeybee colonies to be affected by toxicity (Hunt, 2000).

Table 2: Comparison on label recommended rates of insecticides and rates applied by farmers in Adami Tullu District in 2012/13

Type of insecticide	Recommended Application		Farmers' application	
	Rate (L/ha)	Spray Volume (L)	Rate (L/ha)*	Spray Volume (L)*
Profenofos	0.60	1200	0.67	347.54
Endosulfan	0.20	1000	1.28	249.56
Diazinon	0.50	1000	1.11	247.10
Malathion	0.20	1000	1.15	236.84
Lambda-cyhalothrin	0.32	1000	1.01	299.42
Deltamethrin	0.11	917	1.02	206.42
Dimethoate	0.60	1200	1.33	250.00
DDT	Banned	-	1.00	400.00

*Framers' practice was obtained by calculating mean from collected data

Table 3: Pesticide use related problems recognized by farmers in Adami Tullu District in 2012/13

Problems recognized	Respondents (No)	Respondents (%)
Dead bees in the sprayed field and poor seed set of onion	25	41.6
Dead bees in the hives and low production of honey	8	13.3
Absconding of bees	7	11.6
Low production of honey	6	10.0
Dead bees in the hives and poor seed set of onion	4	6.7
Absconding of bees and low production of honey	3	5.0
Poor seed set of onion and absconding of bees	3	5.0
Dead bees in the sprayed field and absconding of bees	2	3.4
Dead bees in the sprayed field, hive and low production of honey	2	3.4
Total	**60**	**100**

Impact of Agro-chemicals on beekeeping

The survey result showed all of onion producers were aware of the side-effects of pesticides on honeybees. The major challenges that farmers encountered in the field were losing of bee colonies and poor seed set of onion, followed by dead bees in the hives and low honey production (Table 3). Few farmers (6.7%) protected their bee colonies from insecticide poisoning either by keeping beehives far away from the insecticide sprayed area or by closing the entrance of the hive and giving supplementary feeds during spraying.

Major reasons for abandoning beekeeping

The result of this study revealed that, almost half (48.3%) of the beekeepers had abandoned bee colonies. Among this most (28.3 %) of onion producers revealed that pesticides was ranked first as the major factor for abandoning bee colonies (Table 4). This result did not agree with the report by Arse *et al.* (2010) who indicated that agro-chemicals did not significantly affect bee colonies. However, the contradicting result might be due to the difference in crop culture in the studied regions, where Arse et al. (2010) studied high potential regions for beekeeping and where onion production is minimal. Other reasons for abandoning beekeeping were honeybee diseases and pests and absconding of bees from their hive.

Table 4: Factors constraining beekeeping in Adami Tullu district

Constraints	Percent	Rank
Poisoning due to pesticides	28.3	1st
Absconding problems	1.7	4th
Prevalence of honeybee diseases and pest	10.8	3rd
Pesticide poisoning and pest problems	12.5	2nd

CONCLUSION AND RECOMMENDATION

Generally, farmers in the study area did not pay due attentions to honeybees and to honeybees' role in onion seed production. As a result, farmers sprayed their onions at any developmental stages, including flowering. This eventually leads to loss of honeybee colonies and abandoning beekeeping. Farmers were also not aware of modern beekeeping practices and methods of minimizing honeybee exposure to insecticides. Therefore, from the current study the following recommendation were drawn: creating awareness among onion producing farmers about the role of honeybees in onion seed production is necessary and training beekeepers and farmers on how to protect their bees from insecticide attack and modern insecticide spraying methods is needed. Moreover, integrated pest management method should be followed

to minimize further build up of population of insecticide resistant onion thrips biotypes and the undesirable effect of insecticides on foraging honey bees.

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Appendix: Questionnaire

Part-1 General Information

1.1 Name of respondent_____
1.2 Region _____1.3. Zone _____ 1.4.Woreda_____
1.5. PA/Kebele _____ 1.6. Village (Got)_____

Household Characteristics

1. Age of the respondent _____
2. Household head 1) Male 2) Female
3. Number of years lived in the area_____
4. Marital status: 1. Married 2. Single 3.Widowed 4. Divorced
5. Education level of the respondent:
1) Illiterate, **2)** Basic education 3) Grade 1-4, **4**) Grade 5-8 **5**) Grade 9-12. 6) Certificate 7) College diploma/degree

Part -2 Onion Production

1. When did you start onion production? _____
2. For what purpose do you produce onion?
1) Seed 2) Bulb 3) Flower stalk 4)1 and 2
3. When do you plant your onion for bulb production?
1) Sep-Nov 2) Dec -Feb 3) March-May 4) June - Aug
4. When do you plant your onion for seed production?
1) Sep-Nov 2) Dec -Feb 3) March-May 4) June - Aug
5. Which variety of onion do you grow? 1) Bombay red 2) Adama red 3) If any other, specify
_____
7. Do you think that honeybees are important for pollination of onion?
1) Yes 2) No
8. If yes, what is the level of importance?
1) Somewhat important
2) Important
3) Very important

Part-3 Insecticide

1. Do you use insecticide in onion production? 1) Yes 2) No
2. List according to their importance the pesticides that you apply on onion

Insecticide names	**Formulation (EC, WP, P etc.)**	**Target pest**	**Dosage**	**Source (where do you purchase)**	**Total area sprayed (ha)**	**Stag of crop applied***

* I) Only at vegetative II) At vegetative and flowering III) Only at flowering VI) At Seed setting
V) Spray at any stage if pest occurred
3. What is your method of application?
1) Spraying 2) Dusting 3) Fumigation 4) If others specify_____
4. When do you spray your onion?
1) Morning (7: 00 am -12:00) 2) Day (12:00- 16:00) 3) Evening (after 16:00)
5. Who recommended the above application time?
1) Experts 2) DAs 3) Friends 4) Through training 5) Merchants 6) If others specify_____

Honeybee

1. Do you have experience of keeping honeybees? 1) Yes 2) No

2. When did you start beekeeping?_____
3. Do you keep honeybees now? 1) Yes 2) No

4. If yes, when did you start beekeeping? _____Year(s).
5. If no, when did you stop beekeeping?_____ and why stopped beekeeping?
1) Due to agro-chemical effect
2) Lack of interest
3) Due to disease and pest attack
4) Others specify _____

6. Do you know that insecticides sprayed on onion affect honeybees?
1) Yes 2) No
7. If you know that insecticides have side effects on honeybees, did you note such problems in the field? 1) Yes 2) No
8. If yes, what are the problems you observed?
1) Dead bees in sprayed fields
2) Poor seed set of onion when sprayed
3) Dead bees in the hive
4) Low production of honey
5) Absconding of bees
6. Others (please specify) _____
9. What kind of measures do you take to protect your bee from pesticide problem?
_____