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Evaluation of Transitional and Modern Hives for Honey Production in Mid Rift Valley of Ethiopia

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ABSTRACT

The study was conducted in Adami Tulu and Arsi Negelle districts from September 2009 to June 2012 to evaluate the productivity performance of transitional and modern bee hives. For this study purpose, three representative sites namely: Asebo, Adami Tulu research station and Ashoka Lepis site were used. Based on farmers' capacity, one modern hive and one transitional hive made from locally available materials were used for the trail at each of the experimental farmer back yard. Before actual commencement of this study, theoretical and practical training session was given for a total of 30 beekeeper farmers at the selected sites. Data were collected for three years and analyzed using the General Linear Model analysis variance procedure of the statistical Analysis System (SAS) programmme. The average honey yield per hive/year from transitional hive was 13.88 kg, 13.21 kg and 10. 45 kg at Asebo, Adami Tulu Research station and Ashoka Lepis site respectively. There was a ($p < 0.05$) variation between Adami Tulu Research station and Ashoka Lepis site in honey yield per hive per year from transitional hive. Whereas the mean of honey yield from transitional at Adami Tulu Research Center and Asebo site was not significantly different ($p>0.05$).Significantly higher and lower honey yield from transitional hive was recorded at Asebo and Ashoka Lepis site respectively. The average honey yield per hive/year from modern hive was 23.18 kg, 21.61 kg and 18.45 kg at Adami Tulu Research center, Asebo and Ashoka Lepis site respectively. There was ($p < 0.05$) difference between the three representative sites in honey yield per hive/year from modern hives. The mean yield obtained from modern hive at all study sites was statistically higher when compared to transitional and traditional hives. The mean honey yield per hive/year from traditional hive was 6.08 kg, 5.94 kg and 4.94 kg at Adami Tulu Research Center, Asebo and Ashoka Lepis site respectively. There was no ($P < 0.05$) variation between all study sites in terms of honey yield from traditional hives. Generally, there was highly significant difference ($p < 0.05$) between the three types of hives in terms of honey yield per hive/year. Location and hive types interaction had significant effect on honey yield per hive at study area. Whereas hive types and season of honey harvesting interaction had no significant effect on honey yield per hive at the study area. It was concluded that using improved bee hives with improved management practices can improve honey yield and ensure better quality. Modern hive demand high expensive beekeeping equipments and accessories as well as skilled personnel compare to transitional and traditional hives. It is therefore recommended that government and non government organization should focus on scaling up and promoting the adoption of transitional bee hives to improve farmers' income with little skills and low costs.

Key words: Bee colonies, Ethiopia, evaluation, honey, modern hives, transitional hives, yield

INTRODUCTION

Ethiopia is the leading honey producer in Africa and one of the ten largest honey producing countries in the world. Due to its wide climatic and edaphic variability, Ethiopia is home to some of the most diverse flora and fauna in Africa that provide surplus nectar and pollen source to foraging bee colonies (Girma Deffar, 1998).This is assisted for the existence of more than 12 million honey bee colonies in the country (Gezahegn, 2001).Despite the favorable agro-ecology for honey production and the number of bee colonies the country is endowed with, the level of honey production and productivity in the country is remain low. One of the prominent factors for this low honey productivity is traditional hives. According to the study made by Tesfaye Kebede and Tesfaye Lemma (2007) on the distribution of bee hives, about 98% beekeepers' in mid rift valley of Oromia still use traditional bee hive for honey production. Ethiopia has the potential to produce about 500,000 tones of honey per year and 50,000 tones of beeswax per year, but currently production is limited to 43,000 tons of honey and 3,000 tones of beeswax (MOARD, 2008). As it is true in many beekeeping regions, honey production in mid rift valley area has recurrently been reported to be very low because of poor management of bee colonies and traditional production systems. Low productivity and poor quality of bee products are the major economic impediments for beekeepers (Nuru, 1999).

In Ethiopia in general and in mid rift valley of Oromia regional state in particular, beekeeping has been practiced since an old age (Tesfaye, 2007). However, the role of this subsector in diversifying income of farmers is very low as compared to the country bee colonies resource base. Beekeeping plays a major role in diversifying farmers' income in developing countries where source of income for farmers is limited. Nuru (2002) stated that honey bee and bee products provide direct cash income for beekeepers especially in the area of other agricultural activity is difficult.

There are three different hives types in Ethiopia by which honey is produced based on their technology level. These are traditional, transitional and modern bee hives (GDS, 2007).The major portion of honey production in Ethiopia is done by using traditional bee hives. Traditional bee hives accounts for more than 95% of honey produced. This way of honey production makes the management of honey bees for better quality and quantity of honey more difficult. Gezahegne (2001) stated that under Ethiopian farmers' management condition, the average amount of crude honey cropped from traditional hive is estimated to be 5 kg /hive per year. Transitional hive is one of the modern hive types being promoted in the country since 1978 and types of hives used are: Kenya Top-bar hives, Tanzania Top-bar hives and mud block hives. Among these Kenya Top-bar hive is widely known and commonly used in many parts of the country (HBRC, 1997).It is also known as intermediate bee hive, has two version are made from a wooden box and the other from locally available material such as bamboo (GDS, 2009). High yield and other quality, ease of inspection and ease of product harvesting are the major relatively advantage of modern hives. Top-bar hive in an ideal condition can yield about 50 kg of honey per year, but under Ethiopian condition, the average amount of crude honey produced would be 7-8 kg/hive per year (Gezahegne, 2001). These hives have been considered as better hives over traditional ones in that the honey yield is relatively high and are easy to inspect the status of colony. So, the importance of this study is to introduce transitional hives made from locally available materials and modern box hives and evaluate their performance in the mid rift valley of Oromia, Ethiopia.

MATERIALS AND METHODS

Study Area

The study was conducted in Adami Tulu and Arsi Negelle districts from September 2009 to June 2012 to evaluate the productivity performance of transitional and modern hives.

Adami Tulu district is situated at latitude of 7° 19' N to 7° 40' N and ’35 38° 30' E to 38° 53 'E and an altitude ranges from 1500 to 2000 meter above sea level (ATARC, 1998). The district is located at 160 km to the south of Addis Ababa the capital city of Ethiopia. It covers an area of 1403.3 km^2 (140,330 hectare) with the total population of 177,492 which more than 79% living in the rural area. The agro ecological zone of the district is semi-arid and sub-humid in which 90% of the area is low land while the remaining 10% is intermediate. The mean annual rain fall ranges from 750 to 1000 mm with the average minimum and maximum of temperature is 25° C and 28° C respectively. Rain fall distribution is highly variable between and within years. Arsi Negelle district is situated at latitude of 7^o09’ N to 7^o41 N and 38^o25’ E to 38^o54’ E and an altitude ranges 1500 to 2300 meter above sea level (Arsi Negelle Agriculture and rural development office, 2013). It is located at 225 km South of Addis Ababa the capital city of Ethiopia. The average of rain fall ranges from 800 to 1400 mm with the average minimum and maximum of temperature is 15° C and 20° C respectively. The rain fall is bimodal, the long rain occurs from June to September and the short rain fall is from March to April with highest usually record in July and August, respectively (Arsi Negelle Office of Agriculture and Rural Development, unpublished data). Arsi Negelle district is divided in to three major climatic zones on altitude including low, mid and high altitudes. Mixed crop-livestock system is the mode of agriculture in both districts.

Treatments

To evaluate the productivity performance of transitional and modern hives in mid rift valley of Ethiopia, a total of 30 bee colonies which had similar strength were selected and transferred from traditional hives to transitional and modern hives in active season. Based on farmers’ capacity, one traditional hive, one modern hive and one transitional hive made from locally available materials were used for the trail at each of the experimental farmer but for those farmers who do not have the three types of hives in the area two farmers were organized under one experimental group. Traditional hives were used as control during the study time.

Farmers and Experimental Sites Selection

For this study purpose, beekeeping potential sites were purposively selected with the criteria of having large number of participants in beekeeping, beekeepers experience and interest, potential area for beekeeping, abundance of honey bee colonies in traditional hives, availability of common bee forage, accessibility of the areas to transportation service and socio-economic value of bee products. Accordingly, Asebo PA from Adami Tulu district, Ashoka Lepis PA from Arsi Negelle district and Adami Tulu research station were purposely selected and used for this study purpose.

Farmers Research Group (FRG) Approach Followed

After sites and farmers selected, theoretical and practical training session was given for a total of 30 beekeeper farmers, district honey experts and development agents at study sites since transitional and modern hives were new to beekeepers of both districts. Training topics focused on bee biology, beekeeping system, routine honey bee colony management and inspection, procedure of bee colony transferring from traditional hives to transitional and modern hives, honey harvesting and post-harvest handling, bee product marketing, importance of transitional and modern hives. One transitional bee hive was constructed from locally available materials at each the study site in mass during the training session and demonstrated to all participants. After training, every farmer was constructed two additional transitional bee hives (Kenya Top-bar) from locally available materials by themselves. The project was provided technical support and input materials such as modern hives, queen excluders, and refined beeswax for farmers. Farmers were also made to share experience at Holeta Bee Research Center with established well performing FRG members. This was performed before honey bee colony transferring to transitional and modern bee hives.

Honey Bee Colony Management Practices

Bee Colony Transferring

Bee colonies were transferred from traditional hives to transitional and modern hives with the participation of researchers, technical assistance and farmers at each study site in the time of bee forage are abundantly available in the area. During colony transferring, all materials including honey, pollen and bee brood were attached on top-bars and frames and put for the newly transferred bee colonies for maintenance and to minimize colony absconding but for honey, pollen and brood less colonies, external colony feeding with sugar syrup and bean flour (shiro) was undertaken at each experimental site.

Bee Colony Feeding and Watering

Bee colonies normally obtain pollen, nectar and water from various plant species and natural water sources but during dearth period (both in wet and dry seasons) there is a shortage of pollen, nectar source of plants and water in the study area. To minimize bee colony absconding and maintain during dearth period, various supplementary feed such as bean flour (shiro), sugar syrup and water were undertaken at each study site.

Bee Colony Inspection

Unlike traditional bee hives, transitional and modern bee hives have movable combs so that the beekeepers easily can open their hives and inspect to follow up bee colonies. Hives were inspected regularly by researchers, technical assistant and farmers at each study site to follow up the progress of the bee colonies problems, examine the condition of brood, check food store, attachment of top-bar with the wall of hives, honey ripe, pests and predators attack and look for sign of diseases.

Honey Harvesting and Processing

Honey is considered ripe when the combs sealed with thin wax layer. In traditional beekeeping system, honey quality is poor due to harvesting of unripe honey, excessive using of smoking materials during honey harvesting, mix of honey with beeswax, pollen, bee brood and propolis. The thin wax layer was uncapped first using knife. This was the first step of honey processing. The harvested honey from transitional hives was squeezed or pressed from the combs and strained/filtered soon as harvested through fine sieve and clothe but honey harvested from modern hives was extract and strained by using honey extractor and stored in sealed containers and put in dry place until marketed. The amount of honey harvested per transitional, traditional and modern hives was measured with farmers at each study site in all honey harvesting seasons by using sensitive balance weigh.

Method of Data Collection and Analysis

Data Collection

Data collection sheets and check lists were developed by the researches at team level for each study site. Data related honey yield per hive were collected for three years (2009-2012).The amount of honey yield was soon measured and recorded on honey collection sheets.

Statistical Analysis of Data

The collected data were statistically analyzed using the General Linear Model (GLM) analysis of variance procedure of the statistical Analysis System (SAS) programmed (SAS Institute Inc., 2006). Means were separated using least square significant difference (LSD) whenever they were statistically significant at $p < 0.05$.

RESULTS AND DISCUSSIONS

The Mean Honey Yield from Transitional, Traditional and Modern Hives

Transitional and modern hives were evaluated at three sites for three years and the means yield obtained per hive/year were shown in (Table 1). The study result indicated that the mean of honey yield per hive/year from transitional hive was 13.88 kg, 13.21 kg and 10.45 kg at Asebo, Adami Tulu Research station and Ashoka Lepis site respectively. There was ($p < 0.05$) difference between Asebo and Ashoka Lepis as well as Adami Tulu Research Center and Ashoka Lepis site in honey yield per hive/year from transitional hive.

Table 1: The mean honey yield of traditional, transitional and modern hives per year

Sites	Transitional hive Mean yield (in kg)	Modern hive Mean yield (in kg)	Traditional hive mean yield (in kg)
ATARC	13.21^{a}	23.18^{a}	6.08^{a}
Asebo	13.88^{a}	21.61^{b}	5.94^{a}
Ashoka Lepis	10.45^{b}	18.61^{c}	4.94^{a}
LSD (5%)	2.0051	2.17	2.03
SE(±)	0.60	0.79	0.50
CV (%)	9.54	4.57	4.01
Over all mean	12.51	21.02	5.65

The mean in table having different superscript are show statistically variation at $p<0.05$.

Whereas the yield from transitional between Adami Tulu Research Center and Asebo site was not significant different ($p > 0.05$). Significantly higher volume of honey yield from transitional hive was recorded at Asebo site. Whereas lower honey yield from transitional hive was recorded at Ashoka Lepis site. In an ideal condition, Kenya top bar hive can yield about 50 kg of honey per year (FAO, 1990). The mean yield obtained from transitional hive in this study area is similar to the report indicated by Workneh *et al.*, (2008), which is 10-15 kg per hive per year but it is higher than the national average yield of traditional hive by Jacobs *et al.*, (2006) and Workneh *et al.*, (2007), which is 5-6 kg and 5 kg per hive/year respectively. However, the mean honey yield obtained from transitional hive in this study area is lower than the result indicated by Nebiyu and Messele (2013) in districts of Gamo Gofa indicated zone southern Ethiopia, which is 14.07 kg per hive/year. The mean honey yield obtained per hive/year from modern hive was 23.18 kg, 21.61 kg and 18.61 kg at Adami Tulu research station, Asebo and Ashoka Lepis site respectively. There was ($p < 0.05$) difference between the three study sites in honey yield per hive/year from modern hive. The mean honey yield obtained from modern hive in this study area is similar to the national average yield indicated by Workneh *et al.*, (2008) in Atsib Wonberta district of Tigray region, which is 20-25 kg hive/year but it is above the average yield indicated by Tessega (2009) in Burie district of Amhara region, which is 15.6 kg per hive/year. The mean honey yield per hive/year from traditional hive was 6.08 kg, 5.94 kg and 4.94 kg at Adami Tulu Research Center, Asebo and Ashoka Lepis site respectively. Significantly higher honey yield from traditional and modern hives was recorded at Adami Tulu Research station (Table 2).

Table 2: Mean square error of season, location, hive type and their interaction on honey yield

Source of variation	1st season	significant	2nd season	significant	Av. yield	significant
Hive type	2547.216	***	2626.56	***	2586.736	***
Sites	132.025	***	124.561	***	124.821	***
Year	28.505	*	7.68	NS	7.972	NS
Hive type * sites	9.391	NS	8.182	NS	8.639	*
Hive type * year	3.854	NS	22.045	*	9.875	*
Sites * year	0.185	NS	7.207	NS	1.784	NS
Hive type* Sites * year	8.029	NS	1.558	NS	3.695	NS

*** Significant at $\alpha = 0.05$,* Significant at $\alpha = 0.01$, NS-Non-significant

Whereas lower honey yield from traditional and modern hives was recorded at Ashoka Lepis site. Generally, there was highly significant difference ($p < 0.05$) between the three types of hives in terms of honey yield per hive/year.

The costs of modern hive are three times as much as a transitional hive. Transitional hives are give more honey yield than traditional hives and do not require expensive beekeeping equipments and accessories compared to modern hive. The only costs required are providing the design of the hives and training. Although movable frames hives are recommended for experienced beekeepers that what to optimize honey production, the Kenya top-bar hive (KTBH) has been proved to be most suitable because of its low cost and the fact that the beekeepers or local carpenters can easily construct it, significantly cheaper and easier to use (Tessega 2009; FAO, 1990).

Location and type of hive interaction had significant effect on honey yield per hive at the study area. Whereas type of hive and harvesting season interaction had no significant effect on honey yield per hive at the study area (Table 3 and 4).

Table 3: Interaction effects of hive types and site on honey yield at the study area

Hive type	Sites	Av. yield
Modern	Asebo	21.61[b]
Modern	Ashoka	18.61[c]
Modern	ATARC	23.18[a]
Transitional	Asebo	13.88[d]
Transitional	Ashoka	10.45[f]
Transitional	ATARC	13.22[e]
LSD (5%)		0.424
CV		10.4

Gidey and Mekonen (2010) also indicated that location and hive type interaction has an effect on honey yield per hive. This is most probably due to differences on the type and availability of bee forage, bee management practice and environmental factors such as climate changes, pests and predators and disease (Gidey and Mekonen, 2010).

Table 4: Interaction effects of hive type and year on honey yield at the study area

Hive type	Year	Av. yield	2nd season
Modern	2009	21.29[ab]	20.27[b]
Modern	2010	20.34[b]	20.62[b]
Modern	2011	22.08[a]	22.76[a]
Transitional	2009	11.27[c]	10.83[c]
Transitional	2010	10.25[c]	10.37[c]
Transitional	2011	10.03[c]	10.03[c]
LSD (5%)	-	1.196	1.615
CV		10.4	14

Honey Harvesting Season

The study result indicated that in the both districts honey was harvested twice. Large honey harvesting season in Adami Tulu district is September to early November, while small amount of honey harvesting season is in May. Large honey harvesting season in Arsi Negelle district is January, while small honey harvesting season is in June (Table 5, 6, 7).

Table 5: Main effect of hive type, site and season on honey yield at the study area

Hive type	Av. yield	2nd season	1st season
Modern	21.24[a]	21.22[a]	21.26[a]
Trans	10.52[b]	10.41[b]	10.62[b]
SE	0.245	0.331	0.388
LSD (5%)	0.691	0.932	1.095
Site			
Asebo	16.91[a]	16.48[a]	17.34[a]
Ashoka	13.53[b]	13.53[b]	13.53[b]
ATARC	17.2[a]	17.44[a]	16.96[a]
SE	0.3	0.405	0.476
LSD (5%)	0.846	1.142	1.341
Year			
2009	16.28[a]	15.55[ab]	17.01[a]
2010	15.3[b]	15.49[b]	15.1[b]
2011	16.06[ab]	16.4[a]	15.72[b]
SE	0.3	0.405	0.476
LSD (5%)	0.846	1.142	1.341
CV	10.4	14	16.3

Table 6: Cost and profitability of transitional bee hives at study area

Gross output	Unit	Ave. yield	Quantity	Unit price	Total
Production	kg	13.88	208.2	110	22,902
Total gross income	Birr				**22,902**
Cost of production					
Cost of sugar	kg		30	24	720
Cost of bean flour	kg		35	18	630
Total variable cost	Birr				1,350
Gross margin	Birr				**20,100**
Fixed cost					
Cost of hive	Birr		15	150	2,250
Annual depreciation of hives (25%)	Birr		15	37.5	562.5
Total fixed cost	Birr				2,812.5
Total overall cost	Birr				4,107.5
The net income attribute to farmer	Birr				**18,794.8**

Table 7: Cost and profitability of modern hives at study area

Gross output	Unit	Ave. yield	Quantity	Unit price	Total
Production	kg	23.18		130	347.7
Total gross income	Birr				**45,201**
Cost of production					
Cost of sugar	kg		30	24	720
Cost of bean flour	kg		35	18	630
Cost of refined beeswax	kg		40	140	5,600
Total variable cost	Birr				**6,950**
Gross margin	Birr				41,350
Fixed cost					
Cost of hive	Birr		15	850	12,750
Annual depreciation of hives (25%)	Birr		15	212.5	3,187.5
Cost of hive tools	Birr				12,000
Total fixed cost	Birr				29,937.5
Total overall cost	Birr				34,887.5
The net income attribute to farmer	Birr				**10,313.5**

CONCLUSIONS

From the study result it concluded that transitional and modern bee hives had better performance in terms of honey yield and quality compared to traditional hives in the study area. Significantly higher honey yield from transitional, modern and traditional hives were recorded at Asebo and Adami Tulu research station respectively. Whereas low honey yield from the three hive types were recorded at Ashoka Lepis site.

The average honey yield per hive/year from transitional hive was 13.88 kg, 13.21 kg and 10. 45 kg at Asebo, Adami Tulu Research station and Ashoka Lepis site respectively. There was ($p < 0.05$) difference between Adami Tulu Research Center and Ashoka Lepis site in honey yield per hive/year from transitional hive. Whereas the yield from transitional hive at Adami Tulu Research Center and Asebo site was not significant different ($p > 0.05$). The average honey yield per hive/year from modern hive was 23.18 kg, 21.61 kg and 18.45 kg at Adami Tulu Research center, Asebo and Ashoka Lepis site respectively. There was ($p < 0.05$) difference between the three study sites in honey yield per hive/year from modern hives. The mean yield obtained from the three hive types was statistically significant at ($p < 0.05$). Location and hive type interaction had significant effect on honey yield per hive in study area. Whereas hive type and honey harvesting season interaction had no significant effect on honey yield per hive at the study area. From the result of the study the average of honey yield per hive/year was found to be low from traditional and transitional hives compared to modern hive but modern hive demand high expensive beekeeping equipments and accessories as well as skilled personnel compare to transitional and traditional hives. The costs of modern hive three times as much as a transitional hive. It is therefore recommended that government and non government organization should focus on scaling up and promoting the adoption of transitional bee hives to improve farmers' income with little skills and low costs.

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