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Comparative Evaluation of Mekonen Beehive Technology with Zander and KTB Beehive Types on Honey Yield and Cost Benefit Analysis Under Sidama Condition, Ethiopia

Dinku Negash*, Mekonen Debara, Bangu Bekel, Amare Aregaw

South Agricultural Research Institute, Hawassa Research Center, Hawassa, Ethiopia

Email address:
negash.dinku@yahoo.com (D. Negash)
*Corresponding author

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Abstract: Hive is essential for honey bees to build their nests in such a way that it is easy to manage and maintain them. This study examined three beehive types: namely Mekonen, Zander model and Kenya Top Bar Hive (KTB), based on honey yield performance and profitability under Sidama condtion, Ethiopia. A total of 9 honeybee colonies which had similar strength were selected for comparison of different beehive in Remeda and Dilla substation. Honey yield data from each hive per harvesting season was recorded immediately after harvest. The overall average annual honey yield performance clearly revealed that Mekonen hive (26.77 ± 3.25 kg/hive) were significantly higher ($p < 0.05$) than zander hive (20.77 ± 2.33 kg/hive) and KTB hive (17.61 ± 4.20 kg/hive). While, in both sub research station there was no significant difference in honey yield among the three hives. Mekonen hive stands first due to honey yield and preference while, KTB hive was affordable to the farmers due to cost and durability of the frame and ventilation followed by improved frame hive compared to Mekonen hive. It is therefore recommended to use the Mekonen hive as an alternative technology in addition to KTB and frame hive.

Keywords: Bee Hives Type, Honey Yield, Production Cost

1. Introduction

The presence of diverse agro-climatic zones resulted from the diverse topographic variations make the country suitable for many bee floras. This situation plays role for the large number of honeybee colonies present in Ethiopia. The sole purpose of a hive is to encourage the bees to build their nests in such a way that it is easy to manage and maintain them [5, 10]. Ethiopia has long tradition with most of the colonies nested under traditional hives. To improve the livelihoods of rural people in Ethiopia, several beekeeping development projects over the last 50 years have introduced different designed equipment to actively manage their colonies and increase honey production. In recent years, Kenya Top Bar Hive (KTB) and improved frame hives are in the country introduced to the beekeepers in the study area though the rate of adoption is very low [9].

In addition to these, Mekonen hive model was innovated by Hawassa Agricultural research center. It is a circular structure which is designed by Mr. Simamelak Mokonen for local honey bee eco-type. It is enclosed made of wooden materials and it's have 30 circular frames, three open doors, queen excluder and best suited for local honey bee type for honey production. The designed hive is horizontal and circular position for local eco-type bees similar with traditional bee hive. High yield of honey, ease of inspection to know the status of colony and ease of product harvesting are the major advantage of modern and KTB hives over traditional ones. Improved frame hives enhance honey production because they save bees' effort in creating beeswax comb: for that reason, improved frame hives enable harvests of honey rather than beeswax [6]. However, the colony strength and hive preference of honeybees varied in different environmental conditions and different honeybee races [1].

So far, there is no study undertaken to assess the performances of colonies in different beehives and their

profitability under the environmental conditions of the study areas. In order to improve beekeeping sector, selection and adoption of hive types has to be based on productivity, affordability, availability and profitability. Thus, the purposes of this study were to identify suitable beehive to honeybees, to evaluate yield performance and profitability of beehive types at Sidama and Gedeozone condition

2. Materials and Methods

2.1. Study Area

The study was conducted at Hawassa Agricultural Research Center (HARC), Sidama Region, during 2016 and 2018. Elevation of the area ranges from 1500 to 3500 m.a.s.l. and mean annual rainfall varies between 1200mm to 1999mm with 15°C to 19.9°C mean annual temperature. The main crops cultivated in the study area is coffee, Enset, Barley, Wheat, Maize, Chickpea, Bean, Pea, Lentil and Haricot bean. The major livestock raised in the zones are cattle, donkey, goats, sheep, mules, and chicken and honeybee colonies [11].

2.2. Experimental Treatments and Data Collection

Three beehive types namely: improved frame hive (Zander model), Kenya Top Bar hive (KTB) and Mekonen bee hives were used as treatments. Each beehive type was replicated three times. All hives types were purchased from Hawassa bee hives technology dealer. Three strong and well-established honeybee colonies from each hive type were selected and kept under uniform environmental condition. Equal honeybee management practice was undertaken to each beehive type.

During the study period the data was collected on honey yield and production cost of each beehive types. Data on honey productivity (yield performance) of each of three beehive types were recorded. Hence, total cost of production was calculated for consecutive years of honey flow seasons. Finally, selling price for a kg of honey in local market was assessed in the study areas. Assuming that, an average beekeeper will have 5 bee hives in the apiary, cost benefit analysis of each beehive types was determined using the following formula [7, 8].

$$NI = GR - TC,$$

Where;

NI = Net Income, GR = Gross Return, TC = Total production Cost

2.3. Data Analysis

The data was analyzed using SPSS software programs version 23. Every comparison was made assuming variation between the beehive types in honey productivity. Two-way ANOVA were computed to compare honey productivity means per annum by using GLM and Tukey's honest significant difference (HSD) at 5% level of significance was used for mean separation whenever significant results encountered between beehive types.

3. Result and Discussion

3.1. Honey Yield Performance of Beehive Types

The highest average honey yield per hive was recorded from Mekonen (26.77 ± 3.25 kg) than Zander hive (20.77±2.23 kg) and 17.61 ± 4.20 kilogram of honey from KTB hive were harvested. The present study revealed that there was no significant difference in honey production per hive between Zander and KTB ($p>0.05$). However, Mekonen hive showed significantly high average production of honey from other hives ($p<0.05$) (Table 1). The productivity of Mekonen hive in this study is more than that of Zander hive and KTB hive, which might be due to suited to establish their colonies earlier, similarity of the hive with traditional hive for local honey bee it's known before practiced and maintain optimum hive temperature during hot and cold season than other hive types. The difference in honey yield between KTB hive with Mekonen and Zander hive might be due to the difference in the time of honey bees spent for building comb in the Kenyan top bar hive. In the present study, lower honey yield was obtained from Zander hive and higher honey yield from KTB than Bonga area. which indicate that average annual honey yield of KTB and Zander hives at south west Ethiopia level was reported 15.71 ± 2.22 kg (crude honey/hive) and 30.09 ± 2.69 kg/hive, respectively [4, 3]. while, the average annual honey yield of zander hive was (21.02 kg/hive) in mid Rift Valley of Ethiopia and average honey yield per year/colony was 22 ± 4.56 kilogram from Zander hive and 16.2 ± 4.12 from KTB [2, 10, 12, 13] in Jimma and Gonder Zone respectively.

Table 1. *Honey Productivity of Different Hive Ty pes.*

Type of hives	Mean±SD	95% Confidence Interval	
		Lower Bound	Upper Bound
Mekonen	26.77 ± 3.25 b	25.117	28.439
Zander	20.77±2.23 a	19.117	22.439
KTB	17.61 ± 4.20 a	15.950	19.272

The result of variance analysis showed that hive type had significant effect on honey yield per hive (Table 2). There was a statistically significant main effect for hive type [$F(2, 36)=40.29$, $p=0.000$]; however, the main effect for year [$F(2, 36)=0.885$, $p=0.422$], location [$F(1, 36)=0.007$, $p=0.934$] and the interaction effect [$F(4, 36)=0.025$, $p=0.999$] did not reach statistical significance (Table 2).

Although location and harvesting year had no significant effect on honey yield/ hive $p>0.05$ (Table 2), this is might be the existence of similar bee forage, management practice and

environmental condition of the study research station. This finding differ with results suggested by also indicated that as there is a variation in the seasonal availability of honeybee forages in different agro-ecology resulted in different for honey yield of Tigray region.

Table 2. *Tests of Between-Subjects Effects.*

Source	Sum of Squares	df	Mean Square	F	Sig.
Intercept	24066.667	1	24066.667	2268	0.000
location	0.074	1	0.074	0.007	0.934
Type of hive	855.111	2	427.556	40.293	0.000
year	18.778	2	9.389	0.885	0.422
location * type of hive	4.148	2	2.074	0.195	0.823
location * year	2.704	2	1.352	0.127	0.881
Type of hive * year	125.444	4	31.361	2.955	0.033
location * type of hive * year	1.074	4	0.269	0.025	0.999
Error	382	36	10.611		
Total	25456	54			

The present study revealed that honey yield is not different in three harvesting year of Mekonen and zander hive ($p>0.05$). But, there is a significant interaction effect on honey yield of KTB hive in different harvesting year. Honey yield from 2017 is higher than 2016 and 2018 harvesting season of all hive types. Honey yield achieved relatively better performance in 2017 year. This might be due to availability of ample bee forage and suitable climatic conditions for honeybees to provide high honey yield in 2017 harvesting year of all hive types.

Table 3. *Effect of Year and Hive Type on Honey Yield.*

Type of hives	Year	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Mekonen	2016	26.0 a	1.419	23.123	28.877
	2017	28.0 a	1.419	25.11	30.877
	2018	26.3 a	1.419	23.456	29.210
Zander	2016	19.5 a	1.419	16.623	22.377
	2017	22.0 a	1.419	19.123	24.877
	2018	20.8 a	1.419	17.956	23.710
KTB	2016	16.3 a	1.419	13.456	19.210
	2017	20.0 b	1.419	17.523	22.877
	2018	16.5 a	1.419	13.623	17.377

A statistical analysis was run to determine differences in honey yield between hive types. Significant differences ($p < 0.05$) were observed in the results presented below; all hive types are statistically significantly different from one another. That is, Mekonen, Zander and KTB bee hives differ significantly in terms of their honey production. This variation might be due to the larger comb size and thickness of Mekonen combs than the other hives. This result also indicates that if all frames in Mekonen hive are filled with ripened honey at good times, the production potential of Mekonen would exceed much higher than modern and KTB hives under such ideal conditions. On farm evaluation of the productivity of KTB and modern hives in Begasheka and Debrekidan districts of Tigray regional state indicated that KTB provided average honey yield of 17.82kg/hive while modern hive provided 22.80kg/hive of average honey yield. Such variations indicate that local environmental factors particularly of climate and bee flora availability and hive preference have impact on honey yield of the different hives.

Table 4. *Multiple Comparisons for Honey Yield for Hive Type Interaction Turkey HSD.*

X	Y	Mean Difference	Std. Error	Sig.	5% Confidence Interval	
					Lower Bound	Upper Bound
Mekonen	Zander	6.4444*	1.085	0.000	3.790	9.098
	KTB	9.5556*	1.085	0.000	6.901	12.209
Zander	Mekonen	-6.4444*	1.085	0.000	-9.098	-3.790
	KTB	3.1111*	1.085	0.019	0.457	5.765
KTB	Mekonen	-9.5556*	1.085	0.000	-12.20	-6.901
	Zander	-3.1111*	1.085	0.019	-5.765	-0.457

The error term is Mean Square (Error) = 10.611. * The mean difference is significant at the 0.05 level.

3.2. Cost and Return Analysis of Beehive Types

Gross return of Mekonen hive was stands first when compared to other beehive types (Tables 5 & 6). However, total cost of production for KTB hive was much cheaper than Mekonen and zander hive (See table 5). Significant amount of money can be earned from selling of pure honey produced per Mekonen hive than from zander hive. This indicated that

13038 ETB from Mekonen hive, 12450 ETB from KTB and 12450 ETB from Zander hive afford net income per beekeeper from 5 hives. The study clearly showed that Mekonen and KTB hive were the better income generation per beekeeper from selling of honey.

Table 5. *Presentation of Production Costs of Each Beehive Types.*

Major items	Unit price (ETB)	Service year of items	Items per beekeeper	Mekonen	Zander	KTB
Casting mould	5000	10	1	500	500	
Honey extractor	5000	10	1	500	500	
Beeswax (kg)	300	2	10	2000	2000	
Overall	1000	5	1	1000	1000	1000
Glove	100	1	2	200	200	200
Mekonenn	1500	10	5	1500		
Zander	1800	10	5		2000	
KTB	900	10	5			900
Shelter	3000	5	1	1000	1000	1000
Smoker	200	4	1	400	400	400
Battery	100	2	1	100	100	100
Feeding	200		5	200	200	200
Hive stand	200	10	5	200	200	200
Honey container	100	5	5	250	250	250
Total production cost				7850	8150	4350

Table 6. *Yearly Cost and Return of Each Beehive Types Per Beekeeper Owned 5 Bee Hives.*

Beehive type	Total production cost (ETB)	Gross return (ETB)	Net income per beekeeper (ETB)	Net income per hive (ETB)
Mekonenn	7850	20888	13038	2607.6
Zander	8150	16000	7850	1570
KTB	4350	16800	12450	2490

Table 7. *Characteristic View After 3 Years of Keeping Different Types of Beehives.*

Characteristic	MH	Zander	KTB	NOTES
Hive management	**	****	**	KB hives require more time to manage due to frameless combs. Great difficulty was encountered in the inspection of established Mekonenn hives. The combs were not easily removable, because the built combs were firmly glued to frames and hives wall. Attempt to remove the combs would lead to destruction of the combs. If swarm season coincide with a busy month at work, I can just slap on a few Frame hive to give my co workers more. In a KBH and MH, we don't have this comfort.
Ventilation	*	**	***	MH make worse to emit heat and moisture to rise up and out of the hive rather than KTB and Zander
Cost	**	**	****	MH and Zander hives set-up for one hive will cost about 1500 -2000 birr, plus another 6000 birr for additional equipments
Harvesting honey	**	****	**	Crushing honey comb by hand from a KBH and MH, while ease of harvesting honey from a Zander hive is using a extractor
Frame durability	**	****	****	In terms of durability, only the MH hive frame had short life span. It is more or less a seasonal hive type that cannot survive the forces of rain, bush fire and human or animal activities.
Preference	****	***	***	Once you are done harvesting honey, the frame can't returns into position and unfeasible The performance by the best was an indication that bees show preference for MH and this may account for why it is similar with traditional hive its known befor
Yield	****	***	**	Amount of honey production from MH was better than the others, due to the preference and rapid colony establishment rate

**** The more stars =the better, MH= Mekonen hive and KTB= Kenya top bar

4. Conclusion and Recommendation

Overall, we concluded that the Mekonen hive had better performance in terms of honey yield compared to the Kenyan top bar hive and zander hive. In Dilla station the Kenyan top bar hive and the frame hive had similar honey yields. While, in Remeda station the Mekonen hive had higher honey yield than the Kenyan top bar hive and frame hive. Season of honey harvesting had no effect on honey yield per hives. Hence, Mekonen hive stands first due to honey yield and preference while, KTB hive was affordable to the farmers due to cost and durability of the frame and ventilation followed by improved frame hive compared to Mekonen hive. It is therefore recommended to use the Mekonen hive as an alternative technology in addition to KTB and frame hive.

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