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# Analysis of the production factors and productivities of traditional and modern beehives in the Kingdom of Saudi Arabia (BEE/051/2021/3)

*Strengthening MoEWA's Capacity to implement its Sustainable Rural Agricultural Development  
Programme (2019-2025) (UTF/SAU/051/SAU)*

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## Summary

Analysis of production factors and productivity of local bee colonies in traditional and modern hives was conducted as the part of FAO Technical Cooperation project “Strengthening MoEWA's Capacity to implement its Sustainable Rural Agricultural Development (SRAD) Programme (2019-2025)” (UTF/SAU/051/SAU) in which the beekeeping and honey production sector has been identified as one of the promising commodities with development potential in south west regions of the country.

The analysis of production factor and productivity local bees in box and local hives has been conducted through collecting pertinent data using checklists developed for this purpose. Data from a total of 30 and 33 beekeepers who are managing 9 979 and 7 320 bee colonies in traditional and box hives respectively were taken and analyzed. According to the current study, the honeybee colonies holding size of beekeepers with local bee colonies in local hives was varying from 35 to 1 800 with mean and median of 332.6 and 200 colonies/beekeeper respectively. The colony holding sizes of beekeepers with local colonies in box hives were varying from 15 to 800 with mean and median of 221.8 and 190 bee colonies/beekeeper respectively. According to this sample survey study, the average honey yield of local colonies in local hives was 3.6kg/annum with the range of 2.3 to 7.5 kg/annum. The average honey yield of local bee colonies in box hive was 7.5kg/annum and varied from 3.7 – 10.5 kg/annum. The variation in the honey yield of colonies in local and box hives was statistically significantly different at  $P < 0.0001$ .

In this study, the production costs considered were initial investment costs for the purchasing of hives and the annual operational costs like laborer's salary, maintenance feeding, medication, hive stands and covers and colony transport costs. The average annual production cost per hive was SAR 166.4 and 314.81 for traditional and modern hives, respectively. The average net benefits of honey production using local bees per one traditional and box hives were SAR 716.0 and SAR 1 558.4 respectively. With these net benefits beekeepers with 100 local bee colonies in traditional and box hives estimated to earn about SAR 71 600 and 155 840 net benefits per annum respectively.

Despite the relatively high production cost of colonies in box hives, the net benefit of box hives was almost double to that of traditional hive. The high net benefit of box hive is mainly associated with the relative high productivity of local bee colonies in box hives. In box hive, the provision of input (wax foundation sheet) and recycling of the comb after honey extraction may assist the colonies to save their time and resources required to build honey combs which is an important production factor significantly differentiating these two types of hives. Moreover, in box hive due to their relatively larger volume, bee colonies can build- their population (workforce) to optimum levels and it allows applying different

improved honeybee colony management practices related to inspection, swarm and disease controlling that contribute to enhance the productivity of colonies in box hives. In which such management options are limited in the case of local hives.

The high net benefit of honey production in Saudi Arabia is generally due to the high price of locally produced honey, in that the price of a kg locally produced honey in Saudi Arabia is 5 to 6 times higher than the production cost of a kg of honey that makes beekeeping a very lucrative business in the country. Generally, it is possible to conclude that with a minimum management input, the productivity of colonies in box hives can be doubled compared to the traditional hive and it is therefore suggested to implement sustainable and improved beekeeping technologies and good beekeeping practices accompanied by need based training to fill the skill and knowledge gaps of beekeepers.

One of the limitation of the current and previous studies on production and productivity of beekeeping with different hive types is that they are based on survey data collected from beekeepers. However, beekeepers do not weigh the honey while harvesting and therefore the study was based on estimates given by beekeepers. Therefore it is recommended to design and conduct further studies to compare the productivity of local bee colonies in local and modern bee hives overcoming the limitations of the current and previous studies.

## 1. Introduction

Beekeeping is an ancient practice in the Kingdom of Saudi Arabia (KSA). It is a source of livelihoods for about 5 000 beekeepers of the Kingdom of Saudi Arabia who keep around one million local and one million imported honeybee colonies (Discroll, 2018). It contributes for about 30 percent of the beekeeper's annual incomes. Beekeeping also provides significant self-employment opportunities along the honey value chain and it also contributes to natural conservation, functioning of ecosystem and biodiversity through its pollination services. It is a feasible agricultural activity that significantly improves the incomes of many rural households in Saudi Arabia (Al-Ghamdi and Nuru, 2013; Nuru *et al.*, 2014).

Beekeeping and honey consumption have a close association with Saudi Arabia's culture, religion and economy. Honey is a highly regarded product, for its medicinal and nutritional values in the country. Daily honey consumption increases during religious and festive ceremonies. Culturally, honey is widely used as important ingredient in preparation of several homemade foods. As a result, the country is among the largest honey buyers' and consumers' countries in the world. The total annual honey production of the country is around 2 600 tonnes while the country imports about 20 000 tonnes of honey annually to fill the gaps in honey demand. The average price of locally produced honey is around SAR 250/kg which is 10 times more than the unit price of honey in developed countries.

The average honeybee colony holding size of the majority (75 percent) of apiaries in the Kingdom of Saudi Arabia is around 350 to 400 colonies with a range of 5 to 3000. The bee colony holding size makes the beekeeping sector a remunerative business in relation to the economics of scale. These might indicate the presence of a positive association between a return of profit from beekeeping and the optimum holding size of bee colonies. Moreover, the exceptionally high price of locally produced honey makes beekeeping to be one of the most viable businesses in the KSA. Though beekeeping has tremendous benefits, still most beekeepers in the country are using traditional hives. The low adoption of improved beekeeping technologies and practices are emanating from the lack of comprehensive information on the production factors and differences in productivity related to the hive types.

According to Jones (2004), honey yield per colony indicates the productivity of beekeeping and it is the major indicator of the profitability of beekeeping. Furthermore, floral composition, queen quality and age, colony strength and swarming behaviour, type of technologies used, ecological conditions and beekeeping management practices are among some of the production factors influencing the productivity (profitability) of beekeeping enterprises (Tucak *et al.*, 2004).. Generally, the adoption of improved technologies in agriculture and related value chains proved to have a potential gain in the

efficient utilization of the available resources and associated better productivities (Pretty *et al.*, 2006; Fan *et al.*, 2012).

Despite longstanding beekeeping practices and long years of efforts to introduce modern beekeeping technologies, beekeeping is still dominantly traditional with 70 percent of the bee colonies in the country kept in traditional (local) hives. Lack of skills, training, financial capacities and limited technical support have contributed for the low adoption of modern hives in the country. Moreover, absence of tangible information on the productivity of modern hives in comparison with traditional hives also may have negatively influenced its adoption rate in the country.

A comparative study on traditional and improved beekeeping technologies and practices is therefore useful for providing evidence on productivity differences between traditional and box hives. Such study may further help in encouraging the beekeepers to make a knowledge and evidence-based decision on the adoption of box hive and improved beekeeping practices. Similarly, the information will be important for those who want to start small to large scale investment in the beekeeping business. Moreover, such information is important for government bodies to design and implement knowledge-based development strategies towards transformation of the beekeeping sector of the country.

In this regard some information on production factors and productivity of bee colonies in local and box hives was studied and reported for the country already earlier by Al-Ghamdi *et al.*, (2017). However, the honeebes colonies sampled in this earlier study did not distinguish between local and imported bees in both local and box hives. Therefore the study report does not clearly show the productivity of local bees in local hives versus in modern hives which is the main targets of the current study. This specific information is important in the development efforts of adoption of suitable hives with local bees in the country. With this general background, the main objective of the current study was to analyze the production factors and productivity of local bee colonies in traditional and box hives in selected regions of the Kingdom of Saudi Arabia.

## **2. Methodologies**

The study was conducted in southwestern regions of Saudi Arabia, namely, Al-baha, Aseer, Jazan, Al-Madina, Makkah and Hail regions. A total of 30 and 33 beekeepers with traditional and box hive beekeeping respectively were randomly selected over all regions. For the study, beekeepers were interviewed using questionnaires prepared for data collection (Annex 1). The beekeepers owned either traditional or box hives or both and managed a total of 9 979 and 7 320 honeybee colonies in traditional and box hives, respectively.

The major data collected were, colony holding size, numbers of colonies managed by hive types, the major production expenses on annual base such as salary of laborer for colony inspection, management, and guarding; colony maintenance (feed and medications), transportation expenses during colony migration and hive stands and shelter costs were considered. Moreover, costs for the purchase of traditional and box hives were considered. The current purchasing costs of local and modern box hives in local workshops were 50 and 120 Saudi Riyal. Further, information on total honey yield per hive per annum by hive types, and, average price of honey per kg was gathered and analyzed. Moreover, to cross check and validate the data, focus group discussions were conducted and figures on average honey yield of colonies, annual production costs and price of honey per kg were taken after the groups reached consensus. The collected data were analyzed using simple descriptive statistics and using T-tests for unequal variances.

### **3. Results and discussion**

#### **3.1 Honeybee colonies holding size**

The honeybee colonies holding size of beekeepers with local colonies in local hives were varying from 35 to 1 800 with mean and median of 332.6 and 200 colonies respectively, while the holding size of beekeepers with local colonies in box hives were varying from 15 to 800 with mean and median of 221.8 and 190 colonies per beekeeper (Table 1). The detailed compiled data by hive types are given in Annex 2 and 3. The current average colony holding size of beekeepers is slightly lower than the findings of Nuru *et al.* (2014) who reported an average holding size of 352 colonies per beekeeper. The difference could be due to sample size variations and also the holding size given here is only local bee colonies by hive types and did not consider the imported bee colonies per beekeeper.

#### **3.2 Average honey yield of local bee colonies in box and local hives**

According to this sample survey study, the average honey yield of local colonies in local hives was  $3.6 \pm 1.04$  kg/annum with the range of 2.3 to 7.5 kg/annum (Table 1). According to the beekeepers estimation, the given average annual honey yield per colony in local hive is a cumulative of about 3 harvests per annum with estimate of 1.2kg honey per harvest. The current result is very close to the findings of Al-Ghamdi *et al.* (2017) who reported an average yield of 3.7 kg of honey per local hive per annum. However, Abdulaziz (2012) has reported an average annual honey yield of 5.8 kg for local bees in local hives, for the Al-Baha region.

The average honey yield of local colonies in box hive was  $7.5 \pm 1.59$  kg/annum which varies from 3.7 – 10.5 kg/annum. The average yield of local colonies in box hives was significantly higher  $p < < 0.0001$  (Table 2) and nearly double to that of local bees in local hives. Similarly the given average annual honey yield per colony in box hive was based a cumulative of about 3 harvests per annum with the beekeepers estimated amount of 2.5 kg honey per harvest. The current average honey yield report for box hive is slightly higher than the findings of Nuru *et al.* (2014) and Al-Ghamdi *et al.* (2017) who reported  $6.64 \pm 5.64$ kg and 6.6kg per box hive per annum, respectively. Relatively, higher yield (9 kg) of honey per colonies/annum for colonies in box hives was reported for the Al-Baha Region (Abdulaziz, 2012). The yield variations could be due to the variations in the types of races of bees used because the previous studies only consider the hive types without considering the type of races by taking the honey yield of local and imported bee races yield together. The current study considered only local bee race and compared their productivity in box hive and in traditional hives.



The possible important factors contributing for variation in honey yield of colonies within hive type and among beekeepers is due to the variations in frequency of migration of colonies. Some beekeepers reported to migrate only two time while others migrate more which may bring significant annual honey yield variations among colonies managed by different beekeepers. In the current study most beekeepers reported to migrate their colonies 2 – 3 times per annum for the purpose of honey collection. The average frequencies of harvest for colonies both in local and box hives were 3 harvest per colony per annum with the variation of 2 to 5 times per annum (Nuru *et al.*, 2014). The variation in productivity within hive types mainly depends on the frequencies of harvest that also depends on frequency of migration of colonies. Under Saudi Arabia conditions, since static beekeeping with permanent apiary is not this much productive, migration of colonies is one of the very important production factors that determine productivity of a colony. The more beekeepers migrate their colonies, the more productivity of colonies per annum.

Generally, the honey yield of colonies in the Kingdom of Saudi Arabia is much lower than the world average honey yield per colony per annum which is about 20 kg. Canada is reported to have the highest in average productivity of colonies which is 50 kg/annum per colony (Melhim *et al.*, 2010). The ecological (bee forage and climatic conditions), genetic factors and management skill and knowledge are the main contributing factors for the variations in honeybee colony strength and subsequent honey yield among different races, countries and regions.

**Table 1.** Average honey yield, production costs, sell and net profitability of keeping local bee colonies in local and modern box hives

Hive types	Number of beekeepers	Mean and range of colony holding size	Median colony holding size	Total number bees colonies	Average and range of honey yield/ hive per annum (kg)	Median of honey yield per hive (kg)	Average production cost per /hive in SAR	Average honey price in Kg SAR	Average honey sell /hive SAR	Net Average benefit/ Hive/annum SAR
Local bees in local hive	30	332.6 (35-1800)	200	9 979	3.6 (2.3 -7.5)	3.5	166.4	250	881.8	716.0
Local bees in modern hive	33	221.8 (15-800)	190	7 320	7.5 (3.7-10.5)	7.5	314.8	250	1 873.6	1558.4

**Table 2.** Summary of the T-test results of honey yield of colonies in box and local hives

Hive types	N	Mean±SD (Kg)	Lower 95%	Upper 95%	DF	t-value	Prob >  t
Box hive	33	7.5±1.59 <sup>a</sup>	6.9301	8.0578	55.50	11.647	<.0001
Local	30	3.6±1.04 <sup>b</sup>	3.2026	3.9761			

Levels connected by different superscript letters are significantly different and N is the number of observations.

### **3.3 Profitability of beekeeping in modern and local hives**

The profitability of beekeeping in different hives analysed by taking the production costs and net benefits obtained from honey selling. In this study, the production costs such as annual operational costs like laborer's salary, colony maintenance expenses (feeding) and medication, hive stands and covers and transport costs for colony migration and initial costs for purchasing of local and modern box hives were considered.

As summarized in Table 1, the average annual production costs per hive were SAR 166.4 and 314.8 for traditional and modern hives, respectively. The average net benefits of honey production using local bees per one traditional and box hives were SAR 716.0 and SAR 1558.4 respectively. Despite relatively high production cost of colonies in box hives, the net benefit of box hives is almost double to that of the net benefit of traditional hive (Tables 1 and 2). The high net benefit of box hive is mainly associated with the relative high productivity of local colonies in box hives. The finding is in line with the study of Workneh (2011) that stated beekeepers got more than double profit using box hives than traditional hives. Similarly, three times higher productivity of box hives over traditional hives have been reported for bee colonies kept in box than traditional hives in Ethiopia (Welay and Tekeberhan, 2017).

Under local conditions the major beekeeping annual operating costs are worker's monthly salary, maintenance feeding and transport costs in their degree of importance for both hive types (Table 3). The high maintenance feeding and transporting costs are associated with the long dry seasons conditions of the country that require continuous colony maintenance feeding and migrating of colonies for honey production and searching for better bee forages. High worker's monthly salary is due to the fact that most beekeepers permanently use workers to manage their bee colonies.

**Table 3. Average production costs of beekeeping with local and box hives**

No.	Items description	Average production costs	
		Local hives	Box hives
1	Annual worker's salary	15 600.0	20 090.9
2	Feed expenses	5 526.7	6 954.5
3	Medication expenses	3 275.0	2 798.5
4	Transport expenses	5 473.3	5 507.6
5	Beeswax foundation sheet	0.0	3 131.8
6	Hive stand hive cover	5 150.0	4 340.9
7	Purchase of hives	16 631.7	26 618.2

Beekeepers with 100 local bee colonies in traditional hives with their annual net benefits of SAR 716.0 per hive can earn a total of SAR 71 600 annual net benefits. With this estimation, one smallholder beekeeper with 100 local bee colonies in traditional hives can monthly earn about SAR 5 967. While beekeepers with 100 local bee colonies in modern hives with their annual net benefits of SAR 1 558.4 per hive can earn a total of SAR 155 840 annual net benefits which is about SAR 12 987 per month. The monthly earing from 100 local colonies in traditional and box hives can optimally support average monthly household expenses. Similarly, overall average total production cost and net income of SAR 52 397 and SAR 221 016 per annum, respectively were reported for beekeeping in Saudi Arabia (Nuru *et al.*, 2014) which indicate that beekeeping is relatively lucrative agricultural business.

The high net profitability of beekeeping in Saudi Arabia is mainly stemmed with the high price of locally produced honeys which is again associated with the high purchasing power of the middle- and high-income groups of people who are willing to pay high prices for locally produced honeys.

According to the current study data, the annual production costs of one kg of honey in traditional hive is only SAR 47.5 and with its average price of local honey SAR 250/kg the selling price is nearly 5 times more than the production cost and its profit margin is extremely high. Similarly, the production cost of one kg of honey from modern hive is about SAR 42 only and with average price of one kg honey SAR 250/kg, the selling price of honey from box hive is nearly 6 times more than

the production cost and its profit margin is higher than the profit margin of honey production from local hives.

The average price of honey in Saudi Arabia is SAR 250/kg however over SAR 500/kg is reported for some special honeys (Zulial *et al.*, 2014). Generally, the average price of honey in Saudi Arabia is 10 times more than the unit price of honey in Europe and The United State of America which make beekeeping and honey production one of the most profitable businesses in Saudi Arabia. Modern (box) hive besides its better honey productivity over the traditional hives, it allows to produce diverse bee products such as pollen, propolis, royal jelly and others which values are 10 to 20 times more than the value of honey. So, to improve the production and productivity of beekeeping and to utilize the diverse bee products and thereby increase the incomes of beekeepers it is very important to encourage the adoption of box hives, together with training on sustainable and good beekeeping practices. Regardless of its low productivity, beekeeping in traditional hives is still profitable because of the high price of locally produced honeys in the country. However, this does not mean that in real term beekeeping in the country is efficient and cost effective.

In the country it was observed that there is a high trends of beekeepers to keep large numbers bee colonies in one site without considering the carrying capacity of the bee forages of a given area. In this regard beekeepers with high numbers of bee colonies (upto 500) do not split their bee colonies into different sites. This certainly contribute for overcrowding and resource competitions and subsequent low productivity of bee colonies in the country. In this regard extremely overcrowding of bee colonies beyond the carrying capacity of bee forages and its negative effect on productivity and profitability of beekeeping is well documented for Saudi Arabia (Al-Gamdi *et al.*, 2014) which indicate the importance of keeping colonies based on the carrying capacity of a given area.

### **3.4 Production factors explaining differences in the productivity of box (modern) and local hives**

The volume of box hives is much higher than the volume of traditional hives and box hive volume can be adjusted as required at different seasons that allow the bee colonies to build its population (brood and adult bees) to have optimum work forces for honey collection. The local hive volume is relatively small (< 30 liter) and fixed with no option to adjust its volume. Such small and restricted volume in local hives may encourage colonies to undergo reproductive swarming that ultimately

weaken the population which subsequently leads in declining of honey yield. The low productivity of colonies as result of fixed volume hive has been well documented (Vaziritabar and Esmaeilzade, 2016). The presence of significantly high correlation between population size and honey yield of a colony is also well reported (Taha and Al-Kahtani, 2013). Moreover, the presence of honey yield variations as result of variations in hive types have been well documented (Teferi *et al.*, 2011; Cherkoses, 2018).

Moreover, colonies in box hives can be assisted through providing them with important production factor input (beeswax foundation sheet) to save their time of construction of honeycombs. After a honey harvest the honeycombs can be recycled and can be filled again with honey very quickly. While colonies in local hives, once the honeycombs are harvested there is no means to return the comb and the bees must secret beeswax and build new combs again for storing honey. Secretion of beeswax for comb construction takes time and done on the expenses of consuming stored honey in the hive. To secret one kg of beeswax, the bees required to consume about 8 kg of honey which contributes for low productivity of colonies in traditional hives. In addition, colonies in box hives can be regularly inspected to control honeybee diseases, pests and reproductive swarming of colonies that has direct impact on production and productivities of colonies. But local hives do not allow hive inspection to control diseases, pests and reproductive swarming which are important factors in variations of the performances of colonies. Under local conditions management practices such as frequency of migration, seasonal colony management, bee forage conditions are also important factors in determining the production and productivity of beekeeping irrespective of hive types.

In addition to the above factors in the country several challenges of beekeeping are contributing for low production and productivity of beekeeping irrespective of hive types. Regarding to this detail challenges of the sector and possible intervention initiatives has been analysed and reported see (FAO, 2021) for further reference. Finally it is recommended to conduct further well designed studies covering large sample sizes and regions and filling the current and the previous study reports gaps.

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برنامج التعاون الفني بين وزارة البيئة والمياه والزراعة ومنظمة الأغذية  
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