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Suitability of Hive Wood Type for Italian Honeybee (*Apis mellifera* L.)

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ABSTRACT: Bees are essential to the pollination of many flowering plants. Plant productivity can be significantly impacted by any natural or human-made event that endangers honey bee life. The structure and composition of the hive are essential to the growth and development of the colony. The majority of the materials used to construct beehives are wood. It is crucial to select a sturdy wood because it must withstand the environment and last for multiple seasons. This study investigates the effects of different wood materials used for making hives for Italian bees and how these may influence colony performance. Five different wood species with three replications were selected, Teak (*Tectona grandis*), Acacia (*Acacia nilotica*), Malabar Neem or Malai Vembu (*Melia dubia)*, Rubber (*Hevea brasiliensis*), and Vagai (*Albizia lebbeck*). Factors such as brood development, sealed honey storage and pollen storage were selected as parameters of hive growth and development. Statistically, each hive type produced significant variation ($p< 0.05$) except for *M. dubia* which was on par with *A. lebbeck.* The greatest overall productivity across all factors was for hives made of *T. grandis*, with increase in sealed brood area (17.62%), honey production (10.56%) and pollen storage area (17.12%) in comparison with the standard wood type *A. lebbeck.* The temperature and humidity maintained inside the hives were also recorded which showed statistically no significant difference except for *M. dubia*. Based on the cost of wood and weight of each of the hives, *M. dubia* was found to be light in weight and more economical than other wood types and highly suitable for migratory beekeeping.

Keywords: Hive; wood species; Italian honeybees; brood development; thermoregulation; Honey production.

INTRODUCTION

Apis mellifera L., or the Italian honey bees, is a scientifically and commercially important species. They help pollinate wild flora and crops while also providing direct income to beekeepers who harvest honey and other hive products from managed colonies. Beekeeping is a nature-dependent system that is primarily influenced by climate and vegetation. The Langstroth beehive is a popular choice for beekeepers all around the world. However, environmental problems, particularly extreme hot or cold weather, have prompted several researchers to propose changes to the traditional beehive. Honeybee efficiency is influenced by genotype, internal hive parameters, and external environmental factors like temperature and humidity (Abou-Shaara *et al*., 2012; Abou-Shaara, 2014). Honey bees are noted for their ability to keep their nest temperatures somewhere in the range of 33 and 36 degrees Celsius (Petz *et al*., 2004; Cook *et al.,* 2021). The regulation takes place through a cooling or heating behaviour for which a specific thermally activated receptor has been identified in the flagellum of the antenna of bees (Kohno *et al.,* 2010). Extreme weather, on the other hand, has a negative impact on honey bee workers' ability to undertake thermoregulation within the colony. As a result, materials that can isolate heat and humidity can be used to make the hive more comfortable for honey bee populations (Yaser, 2019).

Despite the fact that there is a lot of study on apiculture around the world, there are few studies on hive types and hive building materials, both of which are critical for beekeeping. One such is the hives built of various materials, including wooden, polystyrene, and composite insulated hives, were utilised to investigate the influence of these materials on colony growth (Yasar, 2019). Hive materials had a big impact on colony factors such as temperature, humidity, honey storage, and pollen storage. The aim of this study is to assess how effective the hive making materials are on the physiological and behavioural characteristics of honeybees and which wood material would be the most ideal.

MATERIALS AND METHOD

This research was performed at the Insectary of Department of Agricultural Entomology, Tamil Nadu Agricultural University, India (11.016°N latitude, 76.929°E longitude, and 411 m altitude), Spring and Summer seasons of 2022. Modified Langstroth Beehive having shallow super chamber and seven frames was used in the study. Body thickness of the Langstroth hive was 25 mm; external dimension of the brood chamber was 505 × 325 × 258 mm. The external dimension of brood frames was 470 × 250 mm. And the external dimension of the super chamber and super frames were 505 × 325 × 150 mm and 470 × 140 mm respectively. The hives were placed in a stand at height 0.5m from the ground level under shade. For this study, the hives were made of T_1-Teak (*Tectona grandis*), T_2- Acacia (Gum arabic) (*Acacia nilotica*), T_3- Malai Vembu (*Melia dubia*), T_4- Rubber (*Hevea brasiliensis*), T_5-Vaagai (*Albizia lebbeck*) and each having three replications. The hives made of *Albizia lebbeck* was kept as standard wood to compare the other types with it. The colonies composed of similarly-aged queens were introduced into these hives and were equalised to four frames having sealed brood. Additional frames with comb foundation sheet were given to hives based on the development of colony. The areas for the sealed brood, honey and stored pollen were measured using a Langstroth frame divided into square centimetres at 14-day intervals.

In this study, the daily humidity and temperature data in the hive and apiary were recorded for two weeks in April. Daily temperature and humidity values inside the hives and apiary were noted down at 13:00 hours. DHRUV-PROMini LCD External Temp/RH data loggers were used to determine the temperature and humidity in the hive and apiary. The external probe of the data logger was put in the centre of the hive, between the frames and in order to determine the temperature and humidity values in the apiary, the data logger was placed in the shade.

The weight of the empty hive consisting of bottom board, brood chamber, super chamber, inner and outer lid were measured for all three replications of each wood type and the mean weight was calculated. The difference in hive weights were proportionate to the density of the wood types, as the volume of wood used was the same for all the hives (as density=mass/volume).

The experiment was set up according to a factorial completely randomized design (FCRD) containing three blocks with the treatments distributed randomly within these blocks. All data were analysed using ANOVA and LSD test was used to compare the means. The significance level was taken as $p < 0.05$ in all analyses. Correlation analysis and test for significance were performed between hive temperature/hive relative humidity and colony growth parameters.

RESULTS AND DISCUSSION

The primary factor in assessing colony development is the size of the brood area. When examining the growth of the brood area over six periods at fortnightly intervals (Table 1), it was seen that the honeybee colonies in hives made of *T. grandis* wood had the development of brood area rate of 17.62% more than the hives of standard wood, *A. lebbeck*. The mean brood area of hives made of *A. lebbeck* and *M. dubia* wood showed no statistically significant difference; however, they showed significant differences with respect to hives made of *H. brasiliensis* and *A. nilotica* ($p< 0.05$). The maximum nectar flow occurred in April, which coincided with the highest brood production period. Neupane and Thapa (2005) reported that the production of bee brood was the highest during spring followed by summer, autumn, winter and lowest during the rainy season.

Table 1: Effect of hive wood types on brood development in *A. mellifera* L.

Trt. No.	Treatment (Hive Wood types)	Pretreatment 15th Jan	Sealed brood area (cm^2)						
			Post treatment (Days after transferring to hive)						
			1st Feb	14th Feb	1st Mar	15th Mar	1st Apr	15th Apr	Mean
T1	*T. grandis*	316.0	619.33a	1662.33a	1867.3a	2383.7a	2980.00a	3559.33a	2178.7a
T2	*A. nilotica*	323.1	438.00c	959.33c	1237.3c	1547.7c	1991.67c	2684.33c	1476.4c
T3	*M. dubia*	321.5	591.33b	1328.33b	1547.3b	1955.0b	2455.00b	3321.00b	1866.3b
T4	*H. brasiliensis*	319.5	362.00d	856.67d	1163.0d	1379.7d	1785.33d	2432.33d	1329.8d
T5	*A. lebbeck*(Standard)	318.2	576.33b	1315.33b	1533.3b	1939.3b	2442.00b	3306.67b	1852.2b
	Mean	319.7	517.40a	1224.40b	1469.67c	1841.07d	2330.80e	3060.73f	
	Treatment CD (0.05)	6.63 (S)							
	Period CD (0.05)	7.26 (S)							
	T × P CD (0.05)	16.23 (S)							

The results for the honey production by *A. mellifera* L. are presented in Table 2. This study showed that the honeybee colonies in *T. grandis* wood hives were capable of storing about 10.56% more honey than in standard hive made of *A. lebbeck* wood. On the other hand, no significant difference in sealed honey were observed in colonies housed in hives made of *A. lebbeck* and *M. dubia* woods. However, when compared with *H. brasiliensis* and *A. nilotica*, it showed significant difference in the mean values of stored honey ($p< 0.05$). This result agrees with a study conducted by Richard and Simon (2021), in which they reported bee hives made from *T. grandis* wood performed very well in terms of honey, beeswax and propolis yield. The honey storage was found varying over the period of observation due to commencement of nectar flow. During early February, the stored honey area was found to be less with mean value of 351.07 cm^2 and there was about five-fold increase in honey storage by the mid of April.

Table 2: Effect of hive wood types on honey storage *A. mellifera* L.

Trt. No.	Treatment (Hive Wood types)	Pretreatment 15th Jan	Sealed Honey Area (cm^2)						
			Post treatment (Days after transferring to hive)						
			1st Feb	14th Feb	1st Mar	15th Mar	1st Apr	15th Apr	Mean
T1	*T. grandis*	195.0	438.67a	977.67a	1003.7a	1327.7a	1875.00a	2216.33a	1306.5 a
T2	*A. nilotica*	189.5	291.00c	789.33c	801.0d	987.3c	1437.67c	1944.33c	1041.8c
T3	*M. dubia*	191.5	392.33b	880.33b	922.3b	1194.3b	1656.67b	2088.33b	1189.1b
T4	*H. brasiliensis*	194.0	247.00d	739.33d	851.0c	927.3d	1322.33d	1648.67d	955.9d
T5	*A. lebbeck* (Standard)	186.5	386.33b	871.33b	913.7b	1187.7b	1650.67b	2080.67b	1181.7b
	Mean	191.3	351.07a	851.60b	898.33c	1124.87d	1588.47e	1995.67f	
	Treatment CD (0.05)	4.58 (S)							
	Period CD (0.05)	5.02 (S)							
	T × P CD (0.05)	11.22 (S)							

The results for the pollen storage in the hives by *A. mellifera* L. are presented in Table 3. The average amount of pollen hoarded per colony in *T. grandis* wood hive was found to be 17.12% more than *A. lebbeck* wood hive. The mean pollen storage values of *A. lebbeck* and *M. dubia* wood hives showed no statistically significant effect; however, they showed significant differences with respect to hives made of *H. brasiliensis* and *A. nilotica* ($p < 0.05$). The average pollen store at the beginning of study was about 56.73 cm^2 which then increased seven times by mid-April; and this was presumably due the nectar flow period. Neupane and Thapa (2005) reported that the amount of pollen stored as beebread was the highest during spring season lowest in rainy season. The pollen collection by honeybee and its storage in the hive is important as it directly influences the colony development in different aspects (Schmickl and Crailsheim, 2002; Omar *et al.,* 2016; Stephen and Robert, 2000).

The elements impacting honey production include the climate and weather conditions, the number of worker bees in the colony, the age of the queen, the health of the colony, the density of flowers in the field, the time when the nectar flows and the number of colonies in the area. The nectar that honey bees bring into the hive must be stored safely without being consumed. The consumption of honey reserves is increased by unfavourable hive conditions and environmental factors. Honey bees regulate the temperature and humidity in their hives to maintain the brood area temperature at 33–36°C. To obtain the energy they need for this task, honey bees consume honey. As a result, less honey is stored in the hive (Kronenberg and Heller, 1982). As wooden hives are traditionally used for beekeeping, so the temperature and humidity retention by the wood plays a major role. The temperature and humidity recorded inside the hive made of different wood types and in the apiary is shown in Table 4 and its correlation with brood development and honey storage are given in Table 5. The internal temperature between the frames was recorded highest in hive made of *M. dubia* (35.1°C) and there was no significant difference in temperature in hives made of other wood types. It was observed that the temperature in the empty hives (without bees and combs) was around 31.2°C except in *M. dubia* (32.5°C). This indicates that the higher temperature in the hives made of *M. dubia* wood was significantly influential in reducing the work load on honey bees in thermoregulation. The temperature was non-significantly positively correlated with brood area and honey storage, which means that the increase in temperature leads to increase in brood development. Since, the temperature in *M. dubia* was higher than other hives, it would have aided in better brood development. The humidity inside the hive between the frame was recorded lowest in *M. dubia* (57%) whereas highest in *A. lebbeck* (73%); however, there was no significant difference in humidity when measured from empty hives (without bees and combs). The relative humidity was non-significantly negatively correlated with the brood area and honey storage, meaning that lower the RH inside the hive, higher is the brood development. In the hives made of *M. dubia*, the RH was lower and this could be a reason for higher brood development when compared to the hives made of other wood types. Yasar (2019) reported that the number of brood area, the amount of honey stored, the likelihood to become aggressive, and the amount of flight activity were all influenced by the temperature and humidity levels in the hive. If heat insulation and air circulation of the hives are good, the workload of honey bees is reduced and their efficiency increases (Yasar, 2019).

The average weight and cost of different wood types are given in Table 6. It can be observed that *Melia dubia* wood hive weighed the lightest (10.19 Kg) whereas, *Acacia nilotica* was found to be the heaviest (17.63 Kg). As hives are made of different wood materials, the entire weight of the empty hive must be taken into consideration. This is due to the reason that heavy hives are difficult to carry at migratory beekeeping. From a study conducted by Bradbear (2009), it was found that the choice of wood species for hive construction must be given due consideration in order to get the required benefit.

Table 3: Effect of hive wood types on pollen storage by *A. mellifera* L.

Trt. No	Treatment (Hive Wood types)	Pretreatment 15th Jan	Pollen storage area (cm^2) Post treatment (Days after transferring to hive)						
			1st Feb	14th Feb	1st Mar	15th Mar	1st Apr	15th Apr	Mean
T1	*T. grandis*	26.3	76.33a	103.67a	211.3a	330.7a	415.67a	488.67a	271.1a
T2	*A. nilotica*	27.5	47.00c	72.00c	113.7c	240.0c	282.6c	332.33c	181.3c
T3	*M. dubia*	26.0	64.00b	90.33b	183.0b	297.3b	371.00b	424.33b	237.7b
T4	*H. brasiliensis*	26.4	36.33d	39.00d	96.3d	137.7d	216.00d	259.00d	130.7d
T5	*A. lebbeck*(Standard)	29.0	60.00b	80.67b	175.3b	289.7b	362.00b	417.33b	231.5b
	Mean	27.04	56.73a	77.13b	155.93c	259.07d	329.47e	384.33f	
	Treatment CD (0.05)	4.89 (S)							
	Period CD (0.05)	5.35 (S)							
	T × P CD (0.05)	11.97 (S)							

Table 4: Temperature and humidity maintained inside the hive and outside shade in Apiary.

Trt. No.	Treatment (Hive Wood types)	Inside hive				Outside shade	
		Temperature (^{0}C)		Humidity (%)		Temperature (^{0}C)	Humidity (%)
		Between frames	Empty hive	Betweenframes	Empty hive		
T1	*T. grandis*	34.5	31.3	69	57	30.2	55
T2	*A. nilotica*	34.3	31.2	70	58	30.4	54
T3	*M. dubia*	35.1	32.5	57	54	30.7	54
T4	*H. brasiliensis*	34.7	31.1	69	58	30.4	54
T5	*A. lebbeck*(Standard)	34.9	31.4	73	56	30.6	55
	Mean	34.72	31.48	67.6	56.6	30.46	54.4

Table 5: Correlation coefficient (R) and Coefficient of determination (R^2) of physical properties of hive (Temperature and Humidity) with colony performance parameters (Brood area and Honey storage area).

Physical Properties	Brood Production		Honey storage	
	R	R^2	R	R^2
Temperature	0.345 ns	0.119	0.131 ns	0.018
Humidity	-0.214 ns	0.046	-0.155 ns	0.024

Table 6: Weight and cost of different wood types.

Trt. No.	Treatment (Hive Wood types)	Weight (Kg)	Cost (Rs/ cu ft.)
T1	*T. grandis*	14.75	2500.00
T2	*A. nilotica*	17.63	1800.00
T3	*M. dubia*	10.19	1250.00
T4	*H. brasiliensis*	13.28	1650.00
T5	*A. lebbeck*(Standard)	15.06	1475.00

CONCLUSION

The study concludes that the type of wood hive significantly influenced colony performance. Although hive made of Teak wood (*T. grandis)* was found to be performing well under the given conditions, but due to its high cost and weight, it cannot be preferred for low budget beekeeping. On the other hand, among all other wood species, *A. lebbeck* has been widely used by beekeeping farmers due to its low cost and durability. From the current study, we can suggest *M. dubia* wood as an alternate to *A. lebbeck,* since its performance was on par with the latter and comparatively the lightest wood and more economical than the other wood types. So, the hives made of *M. dubia* can be recommended to farmers due to their durability, lightness, good ventilation and heat insulation. Since the development and expansion of the bee colony depend greatly on the selection of suitable wood materials for the construction of the hive, further studies will be helpful in understanding the thermal qualities of various wood types and their effect on colony growth parameters.

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Conflict of Interest. None.

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