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Performance Evaluation of Potential Shrubs for Beekeeping Development in Mid Rift Valley of Ethiopia

Mekonen Wolditsadik[1*], Taye Beyene[2] and Desta Abi[3]

[1]Department of Biology, Adami Tulu Agricultural Research Center, P.O. Box 35, Ziway, Ethiopia. E-mail: mokewolde2020@gmail.com
[2]Department of Biology, Adami Tulu Agricultural Research Center, P.O. Box 35, Ziway, Ethiopia. E-mail: tayebeye@yahoo.co.uk
[3]Department of Biology, Adami Tulu Agricultural Research Center, P.O. Box 35, Ziway, Ethiopia. E-mail: gurree2007@gmail.com

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Abstract

Availability of adequate honeybee forage plants is very important for honey production. The study was conducted to evaluate the best performing bee forages from eight plant species with a view to selecting for honey production for mid and low land agro-ecologies. The planting materials were Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus, Cajanus cajan, Dovyalis caffra, Sesbania Sesban and Dodonaea angustifolia. The species were evaluated based on the number of flower heads per plants, foraging intensity of honeybees, flowering length and amount of pollen. Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus, Dovyalis caffra, were set flower with the ranges of two to three and half years. Parkinsonia aculeate, Leucaena leucocephala and Callistemon citrinus, provides higher pollen yield. Average number of flower heads per plant was highest for Parkinsonia aculeate from the rest. The flowering time of Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus and Dovyalis caffra are almost during the dearth period at which only a few bee forage plant species in flower around the area. V. amygdalina and C. citrinus was highly foraged by honeybees from 10:00am12:00 am, while Parkinsonia aculeate 2:00pm-10:00pm. Parkinsonia aculeate has the highest flowering time with duration up to seven months in a blooming state having lots of flower heads and the rest months with few flowers. Generally, the study revealed that Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus and Dovyalis caffra were selected as major bee forage plants. However, it requires further evaluation particularly on nectar volume and sugar concentration for these plants and their integration with watershed development is recommended.

Keywords: *Bee forage, Pollen, Foraging intensity, Shrub*

1. Introduction

Beekeeping is one of the important agricultural sectors that utilize natural nectar and pollen which otherwise would be wasted and contributed to the income of smallholder farmers (Melaku *et al.*, 2008, Abou-Shara, 2014). Beekeeping is recognized as being a very important sector in the recent government program for development, poverty reduction and conservation and sustainable use of forest resource, diversifying the export base (FAO, 1990). According to Crane (1990), apiculture is floral based industry and bees wholly depend on plants for their food. Bee colony performance as well as production of honey, wax and other hive products depends on bee forage from which honey bees obtain nectar

* *Corresponding author: Mekonen Wolditsadik, Department of Biology, Adami Tulu Agricultural Research Center, P.O. Box 35, Ziway, Ethiopia. E-mail: mokewolde2020@gmail.com*

and pollen as main food (Ahmad *et al*., 2013). These food sources provide the nutritional requirements of the bee colonies: nectar as sources of honey provides heat and energy for honey bees and pollen provides protein, vitamins, fatty substance, and other nutrients (Amsalu, 2000).

Success of beekeeping depends on many factors, among which availability of honeybee forage is the fundamental one. Honey production is continuously declining because, principal resource base for beekeeping has become seriously degraded in the course of time mainly due to clearing of trees for charcoal production, overgrazing and expansion of agricultural lands leads to shortage of bee forages (Tesfaye and Tesfaye, 2007).

Shrub species can grow on degraded land, water shade area, cultivated land, neglected open lands and grown as ornamentals are important sources of bee forage, because they grow and flourish in a different period of time (dearth and active season) However, there is knowledge gap on their agronomic character, plant annual growth rate, flowering length, flowering abundance time taken from blooming to shading and honey bee foraging intensity. Such information is give in sight to select and screen for further utilization as bee forage source for honey production and create awareness to protect and conserve them.

Therefore, the objective of the study was to evaluate the performance of selected shrubs for honey bee forage and recommend best performing for the users.

2. Materials and Methods

2.1. Description of Study Areas

The studies were conducted at Adami Tulu Agricultural Research Center (ATARC) under rain fed conditions. Adami Tulu Agricultural Research Center is located 167 km south of Addis Ababa at an altitude of 1650 m above sea level in mid rift valley. The agro ecological zone of the area is semi-arid and sub-humid with acacia wood land vegetation type. The mean annual rain fall is 760 mm. The mean minimum and maximum temperature are 12.6 and 27°C, respectively. Candidate Bee Forage Plant Selection Potential shrubs were identified through interview of farmers, observation of foraging bees on each flower of candidate shrubs during different flowering seasons and literature review. Accordingly, 8 shrub bee forages were put under investigation (Table 1).

Table 1: Identified Candidate Bee Forage and Their Range of Distribution

S. No.	Botanical Name	Common Name
1.	*Vernonia amygdalina*	Eebicha (Or), Girawa(Am)
2.	*Callistemon citrinus*	Bottle brush (Eng)
3.	*Dovyalis caffra*	Koshim(Amh)
4.	*Dodonaea angustifolia*	Ittacha (Or)
5.	*Cajanus cajan*	peagon pea (Eng)
6.	*Sesbania sesban*	Sesbania (Eng)
7.	*Parkinsonia aculeate*	Jerusalem thorn (Eng), Abbaa dammaa(Or)
8.	*Leucaena leucocephala*	Leucaena (Eng)

2.2. Seed Collection

Matured seeds of *Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus, Cajanus cajan, Dovyalis caffra, Sesbania Sesban and Dodonaea angustifolia,* were mature plant species collected from different areas. Immediately after collection, seeds were packed and allowed to dry. The packages were maintained at room temperature until day of sowing.

2.3. Experimental Design

Seed was sown and seedlings of the species were raised in nursery bed. The seedlings were transplanted to plots size 4mx4m, with 0.5 m spacing between plants and 1m between rows. Completely randomized block design (RCBD) was used with three replications. All necessary data such as, flowering date, number of flowers heads per plant, pollen grain and

foraging intensity of honeybees were recorded. At 50% flowering, number of flower heads/plant was counted Foraging bee intensity on flowers was counted starting from 6: 00 a.m. to 6: 00 p.m. for ten minutes at every 2-hour interval. Survival rate is calculated by counting the number of plants of each species that have survived, divide it by the number of plants originally planted of that species and multiply by 100 to express as a percentage of survival.

Daily Survival Rate = (Number of Survivors / Total Number of Individuals) * 100

Canopy cover was calculated by using the formula,

$$C.C = (D_1 + D_2)/2$$

where D_1 is diameter of the plant towards the larger canopy coverage and D_2 is diameter of the plant towards the small canopy coverage and $C.C$ reprsents canopy cover of the plant in cm. So the canopy cover of the plant was expressed in terms of the average diameter in cm

Finally, the collected data were statistically analyzed using descriptive statistics and GenStat

3. Results and Discussion

In this study Plant species, *Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus, Cajanus cajan, Dovyalis caffra, Sesbania Sesban and Dodonaea angustifolia,* were planted at Adami Tulu Agricultural Research Center (ATARC) and mean values for the investigated traits were indicated in Table 2.

Table 2: Mean Number of Flower Beads per Plants (MNFHP), Mean Time to Give Flower (MTGF), Pollen Yield (PY) and Time from Blooming to Shedding (TBSH) ± Standard Deviation (SD) of Selected Bee Forages

Plant Species	MNFHP ± SD	MTGF ± SD	PY ± SD	TBSH ± SD	C.C
Parkinsonia aculeate	1356.8 ± 349.1	3.5.00 ± 0.3	0.15 ± 0.05	190.9 ± 3.8	350
Callistemon citrinus	151.2 ± 21.0	3.29 ± 0.4	0.08 ± 0.03	61.1 ± 5.2	150
Vernonia amygdalina	82.6 ± 8.2	2.53 ± 0.3	0.11 ± 0.03	53.4 ± 2.5	190
Leucaena leucocephala	197.2±25.2	2.62±0.2	0.13±0.04	72±4.2	250
Cajanus cajan	67.4± 7.5	1.5±0.1	0.01±0.02	53±6.5	60
Dovyalis caffra	149.7±31.2	3.7±0.41	0.12±0.03	35±4.6	255
Sesbania Sesban	59.09±6.01	1.8±0.12	0.02±0.01	25±3.2	59
Dodonaea angustifolia	100.33± 18.3	3.01±0.1	0.01±0.001	39±2.1	375

Mean time taken to set flower for *Parkinsonia aculeate*, *Dovyalis caffra* and *Callistemon citrinus*, was higher than other plant species. *Vernonia amygdalina* and *Leucaena leucocephala* needs 1-2 years to set flower. Flower shading occurred for *Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus, Cajanus cajan and Dovyalis caffra* after 190,72,53,61 and 53 days respectively. The mean time required to set flowers among plant species was different, because they are different plant species.

Mean number of flower heads per plant: Average number of flower heads per plant was higher for *Parkinsonia aculeate* and lower for *Leucaena leucocephala, Vernonia amygdalina and Callistemon citrinus.* This is due to their growing habit and crown size. Plant with more branching produces more flower heads per plant (Tura *et al*, 2014; Mekonen *et al.*, 2023). John *et al*. (1987) also revealed that plants with more vegetative growth produce more flowers. Pollen yield: the mean amount of pollen yield of *Leucaena leucocephala*, *Vernonia amygdalina*, *Dovyalis caffra* and *Parkinsonia aculeate* was higher when compared to other plant species (Table 2). Time from blooming to shedding: The mean flowering length of *Parkinsonia aculeate* was the highest which stayed up to six months with a lot of flowers and some flower throughout the year. Whereas, *Vernonia amygdalina and Callistemon citrinus* stayed almost for two and three months respectively. Bee forage plants which take a long time from blooming to shedding are very important for honey production where as those have short flower shedding time is used for bee colony buildup only (Table 2). The variation of number of bee count is associated with different factors such as attractiveness of the flower, number of flower heads per plants, nectar and pollen yield of plants and weather condition (Mekonen *et al.,* 2023). This is also in agreement with (Crane, 1990) the intensity of bee visit is measure of potentiality of plants for nectar and pollen production.

Generally, from beekeeping point of view it is economical to select plant species with high bee foraging intensity (showed the quality of pollen and or nectar), more flower heads, and longer flowering period which provides continuous food source for the honeybee colonies (Tura *et al.,* 2014).

Canopy cover: canopy cover was higher for *Parkinsonia aculeate and Dodonaea angustifolia,* lower for other species (Figure 1).

Figure 1: Performance of Selected Plants

3.1. Foraging Intensity of Bees

The number of bee visits with in ten minutes was different for each species. *Callistemon citrinus* was highly visited by bees from 2-12 am followed by *Vernonia amygdalina*. *Leucaena leucocephala and Dovyalis caffra.* The observations recorded the foraging rates of the pollinators which were few in the early morning and late in the evening. The foraging time of honey bees to different plant species varied and with peak foraging time ranges from morning 8 am to 4 pm (Figure 2). The foraging time of honeybee is varying from plant species to species based on nectar secretion time and pollen potentiality of plants. *Vernonia amygdalina* is flowered from December/January -March in the area. Depending on the rainfall, and honeybees collect pollen and nectar from the flowers frequently. In these months herbaceous bee forage plants dried and there is only a few bee forage plant species in flower around the area (Fichtl and Admasu, 1994; Qayyoum *et al*., 2013). *Parkinsonia aculeate and Callistemon citrinus* flower in dearth period in the area. This is the dry season in the area, in which there only little bee forage is available. This time is also considered as dearth period in view of beekeeping because only a few bee forage plant species in flower, the weather condition is very dry and difficult for honeybees to get food in the area. *Parkinsonia aculeate Callistemon citrinus* flowered throughout the year. Honeybees are able to remember the period of the day when the resources are higher (Kevan, 2012). They can quickly identify unrewarding patches and might leave them if the amount of resources gained does not compensate for the energy spent collecting it (Zimmerman, 1981). The variation of number of bee count is associated with different factors such as attractiveness of the flower, number of flower heads per plants, nectar and pollen yield of plants and weather condition (Tura *et al*., 2104).

Parkinsonia aculeate and Callistemon citrinus has long peak foraging time in a day than *Leucaena leucocephala* and *Vernonia amygdalina.* *Parkinsonia aculeate* drought tolerant plant flowered in all seasons (flower year-round).

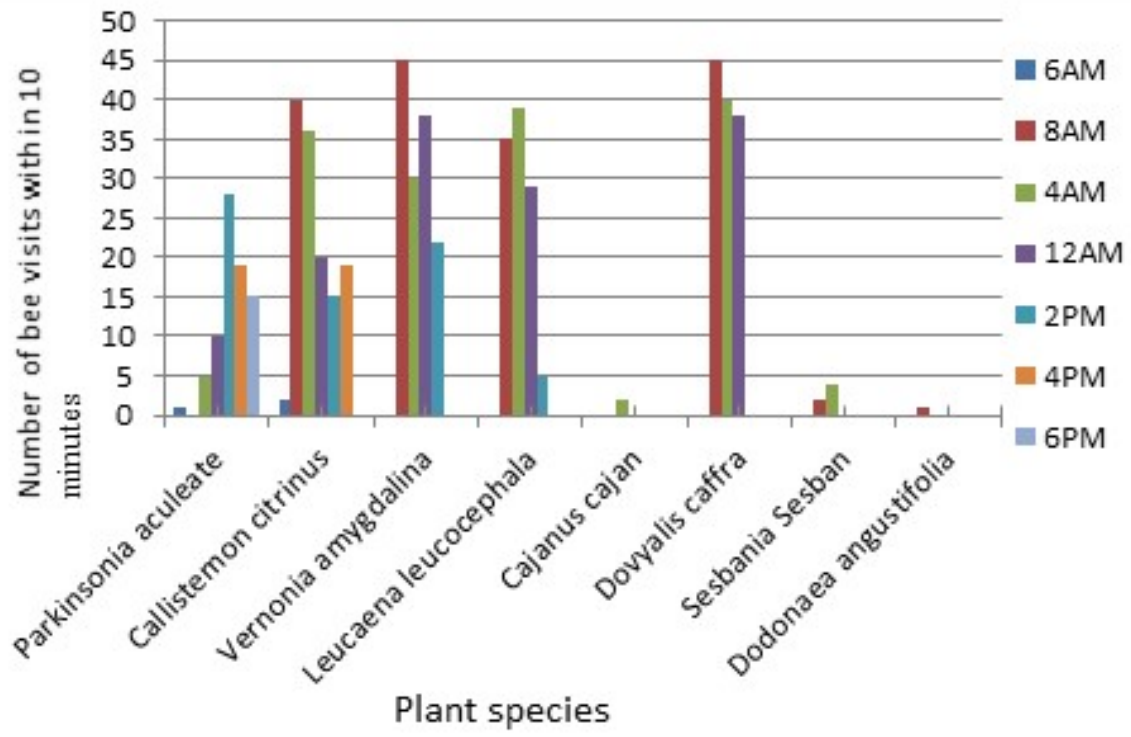

Figure 2: Foraging Intensity of Bees on the Three Different Plant Species

Table 3: Survival Rate of the Selected Plant Species

Plant species	Survival rate (%)
Parkinsonia aculeate	0.71
Callistemon citrinus	0.82
Vernonia amygdalina	0.47
Leucaena leucocephala	0.66
Cajanus cajan	0.01
Dovyalis caffra	100
Sesbania Sesban	0
Dodonaea angustifolia	100

4. Conclusion and Recommendations

In conclusion this study revealed that *Parkinsonia aculeate, Leucaena leucocephala,Vernonia amygdalina, Callistemon citrinus, Dovyalis caffra and Dodonaea angustifolia were performed* well and visited by honey bees. *Parkinsonia aculeate, Leucaena leucocephala,Vernonia amygdalina, Callistemon citrinus and Dovyalis caffra* were highly visited by bees. The time spent by bees for foraging on the flowers depends on the amount of nectar and pollen present in the flower. The peak foraging time is associated with nectar and pollen potentiality and floral preference of honeybees. From this it is concluded that *Parkinsonia aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus and Dovyalis caffra* showed better performance at mid rifty valley, and selected as major bee forages plants in this trial, however, it requires further evaluation particularly on nectar volume and sugar concentration for these plants and their integration with watershed development is recommended because they are fast growth plants. Since *Parkinsonia*

aculeate, Leucaena leucocephala, Vernonia amygdalina, Callistemon citrinus and Dovyalis caffra were flowered in dearth period and their planting is recommended to increase honey production.

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