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Research Article

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

Mekonen Wolditsadik Beyi*, Taye Beyene Lema, Desta Abi Gemadi

Department of Apiculture, Adami Tulu Agricultural Research Center, Ziway, Ethiopia

Abstract

Honey production relies heavily on the availability of diverse and consistent floral resources. This study assessed the performance of eight shrub species commonly found in the mid and lowland agro-ecological zones of Ethiopia to identify the most suitable ones for beekeeping. The selected species included *Parkinsonia aculeata*, *Leucaena leucocephala*, *Vernonia amygdalina*, *Callistemon citrinus*, *Cajanus cajan*, *Dovyalis caffra*, *Sesbania sesban*, and *Dodonaea angustifolia*. Key parameters evaluated were the number of flower heads per plant, honeybee visitation rates, flowering period, and pollen production. Results revealed that *Parkinsonia aculeata*, *Leucaena leucocephala*, *Vernonia amygdalina*, *Callistemon citrinus*, and *Dovyalis caffra* exhibited extended flowering durations ranging from two to three and a half years, with *Parkinsonia aculeata* displaying the highest flower head count. These species also bloomed predominantly during floral scarcity periods, offering critical support to bee colonies. Notably, *V. amygdalina* and *C. citrinus* were intensively foraged during late mornings, whereas *P. aculeata* attracted bees primarily in the afternoon. Given their high foraging intensity, extended bloom, and pollen yield, these species hold significant potential for apiculture development. Further research is recommended to assess their nectar quantity and quality, and their integration into watershed restoration initiatives.

Keywords

Bee Plants, Pollen Production, Foraging Activity, Nectar Shrubs, Ethiopia

1. Introduction

Beekeeping plays a crucial role in rural livelihoods by harnessing natural nectar and pollen sources that might otherwise remain unused, contributing substantially to household income [9]. In Ethiopia, it aligns with broader national goals in poverty reduction, environmental conservation, and sustainable forest use. Since honeybees are entirely reliant on floral resources, apiculture is inherently a plant-dependent venture [5]. The productivity of bee colonies and the yield of honey and other hive products is shaped by the availability and quality of forage, which includes nectar and pollen as essential sources of carbohydrates and proteins, respectively [2].

In recent decades, however, there has been a notable decline in forage availability due to deforestation, agricultural expansion, overgrazing, and charcoal production [11]. Shrubs, which can thrive in diverse settings such as degraded landscapes, watersheds, farmlands, and even ornamental gardens, offer great potential as bee forage. Many flowers during both peak and dearth periods, providing year-round support to bee populations. Yet, limited data exists on their growth patterns, flowering behavior, and attractiveness to pollinators. Filling

*Corresponding author: mokewolde2020@gmail.com (Mekonen Wolditsadik Beyi)

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these knowledge gaps is critical for selecting optimal shrubs for honey production. This study aimed to evaluate the growth and floral characteristics of selected shrubs to identify the most promising species for apiculture development.

2. Materials and Methods

2.1. Study Site Description

The study was implemented under rain-fed conditions at Adami Tulu Agricultural Research Center (ATARC), situated in Ethiopia's mid-Rift Valley, approximately 167 km south of Addis Ababa at 1650 meters elevation. The area experiences a semi-arid to sub-humid climate with average annual rainfall of 760 mm. The mean minimum and maximum temperatures are 12.6 ℃ and 27 ℃, respectively, and the natural vegetation is dominated by acacia woodland.

2.2. Plant Selection and Seed Collection

Eight shrub species were selected based on literature, local knowledge, and field observations of honeybee visitation during flowering. The identified species included *Vernonia amygdalina*, *Callistemon citrinus*, *Dovyalis caffra*, *Dodonaea angustifolia*, *Cajanus cajan*, *Sesbania sesban*, *Parkinsonia aculeata*, and *Leucaena leucocephala*. Mature seeds were collected from multiple sites, air-dried, and stored at room temperature until planting.

Experimental Design and Data Collection

Seedlings were raised in nurseries before being transplanted to 4m x 4m plots, with 0.5 m intra-row and 1 m inter-row spacing. The experiment followed a randomized complete block design (RCBD) with three replications. Data were collected on flowering onset, number of flower heads per plant, pollen yield, and honeybee foraging activity. Bee visitation was recorded at two-hour intervals from 6:00 AM to 6:00 PM when plants reached 50% bloom. For survival analysis, the percentage of surviving plants was calculated as:

$$\text{Survival Rate (\%)} = \frac{\text{Number of surviving plants}}{\text{Total planted}} \times 100$$

Canopy cover was assessed using:

$$\text{Canopy Cover (cm)} = \frac{\text{D1 + D2}}{2}$$

where D1 and D2 are the largest and smallest canopy diameters, respectively. All data were statistically analyzed using GenStat and descriptive statistics.

3. Results and Discussion

All eight shrub species were established successfully at ATARC. *Parkinsonia aculeata*, *Dovyalis caffra*, and *Callistemon citrinus* exhibited delayed but prolonged flowering, while *Vernonia amygdalina* and *Leucaena leucocephala* began flowering within 1–2 years. Flowering duration varied widely among species, with *P. aculeata* flowering for over six months, providing critical resources during dearth periods.

The number of flower heads was highest in *P. aculeata*, attributed to its branching structure and broad canopy [8, 13]. This aligns with [7, 3]. who noted that plants with more vegetative mass tend to produce more flowers. Pollen yield was also higher in *P. aculeata*, *V. amygdalina*, *D. caffra*, and *L. leucocephala*. Long blooming durations are advantageous for consistent nectar and pollen supply, vital for colony maintenance and honey harvests.

Honeybee foraging intensity varied by species and time of day. *V. amygdalina* and *C. citrinus* attracted more bees in the late morning, whereas *P. aculeata* was preferred in the afternoon. This variation can be linked to differences in nectar availability, floral structure, and weather conditions [5, 8].

Shrubs like *P. aculeata* and *D. angustifolia* had greater canopy spread, which may contribute to higher flower numbers and bee visitation. From an apicultural standpoint, species combining high pollen/nectar yield, extended flowering, and high foraging intensity are economically valuable. Therefore, *Parkinsonia aculeata*, *Leucaena leucocephala*, *Vernonia amygdalina*, *Callistemon citrinus*, and *Dovyalis caffra* are recommended for further promotion and integration into forage enhancement and watershed restoration projects.

Table 1. *Mean germination rate, number of flower heads per plants, pollen yield and canopy cover 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

Plant species	MNFHP ±SD	MTGF ±SD	PY ±SD	TBSH ±SD	C.C
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

Dodonaea angustifolia *Dovyalis caffra* *Vernonia amygdalina*
Parkinsonia aculeate *Callistemon citrinus* *Leucaena leucocephala*

Figure 1. *Performance of selected plants.*

Honeybee Foraging Intensity

The frequency of bee visits within a 10-minute observation window showed notable differences among plant species. *Callistemon citrinus* received the highest number of bee visits during the late morning to early afternoon hours (approximately 10:00 a.m. to 12:00 p.m.), followed closely by *Vernonia amygdalina*, *Leucaena leucocephala*, and *Dovyalis caffra*. In contrast, pollinator activity was relatively low during the early morning and late afternoon hours.

Bee foraging patterns varied significantly across plant species, often peaking between 8:00 a.m. and 4:00 p.m. These variations are closely linked to the timing of nectar secretion and the quantity of pollen available in each plant species. In the local area, *V. amygdalina* typically flowers from December or January through March. During this season, herbaceous forage plants tend to dry out, leaving only a few flowering species available for honeybee foraging [6, 10]. Notably, during this floral scarcitycommonly known as the "dearth period"*Parkinsonia aculeata* and *Callistemon citrinus* bloom, offering essential forage for bees.

These species are particularly important because, during the dry season, environmental conditions are harsh, and few other nectar sources remain available. The continuous growth and flowering habit of *P. aculeata* and *C. citrinus* throughout the year help support bee colonies during these critical times.

Honeybees possess the cognitive ability to associate specific times of day with higher resource availability [4]. They can efficiently identify and avoid resource-poor flowers or plants [14, 1]. Differences in bee visitation rates are influenced by several factors, including the visual appeal of the flower, the number of flower heads per plant, pollen and nectar output, and prevailing weather conditions [12].

Among the species studied, *Parkinsonia aculeata* and *Callistemon citrinus* had longer daily foraging peaks than *Leucaena leucocephala* and *Vernonia amygdalina*. Notably, *P. aculeata* is drought-tolerant and capable of flowering throughout the year, making it a valuable forage plant during both abundance and scarcity.

Table 2. *Survival Rate of Assessed Shrub Species.*

Plant Species	Survival Rate (%)
Parkinsonia aculeata	71%
Callistemon citrinus	82%
Vernonia amygdalina	47%
Leucaena leucocephala	66%
Cajanus cajan	1%

Plant Species	Survival Rate (%)
Dovyalis caffra	100%
Sesbania sesban	0%
Dodonaea angustifolia	100%

4. Conclusions and Recommendations

This study identified *Parkinsonia aculeata*, *Leucaena leucocephala*, *Vernonia amygdalina*, *Callistemon citrinus*, *Dovyalis caffra*, and *Dodonaea angustifolia* as promising shrub species for apiculture development in the mid-Rift Valley of Ethiopia. These species demonstrated notable bee visitation rates, with *P. aculeata*, *L. leucocephala*, *V. amygdalina*, *C. citrinus*, and *D. caffra* being particularly attractive to foraging bees.

The attractiveness and foraging duration are largely influenced by the availability of nectar and pollen in the flowers, which directly affects bee foraging time. Thus, plant species that offer prolonged flowering periods and substantial nectar/pollen yields are essential for sustaining colonies, especially during the dearth period.

From this evaluation, it is evident that *P. aculeata*, *L. leucocephala*, *V. amygdalina*, *C. citrinus*, and *D. caffra* are among the most suitable species for year-round beekeeping support. However, to optimize their use, further studies are recommended to assess their nectar volumes and sugar content. In addition, their integration into watershed restoration projects is advisable, given their fast growth and ecological adaptability.

To improve honey production during periods of floral scarcity, promoting the cultivation of these species is highly encouraged.

Abbreviations

ATARC	Adami Tullu Agricultural Research Center
MNFHP	Mean Number of Flower Heads Preplant
TBSH	Total Time from Blooming to Shading
C.C	Canopy Cover

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Author Contributions

Mekonen Wolditsadik Beyi: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Supervision, Writing – original draft, Writing – review & editing

Taye Beyene Lema: Funding acquisition, Project administration, Supervision

Desta Abi Gemadi: Visualization

Conflicts of Interest

The authors declare no conflicts of interest.

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