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Performance Evaluation of Herbaceous Bee Forages for Beekeeping Development

Mekonnen Wolditsadik*, Taye Beyene, Desta Abi

Apiculture Research Team, Oromia Agricultural Research Institute (IQQO), Adami Tulu Agricultural Research Center, Batu/Ziway, Ethiopia

Email address:

Mokewolde2020@gmail.com (Mekonnen Wolditsadik)

*Corresponding author

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Abstract: Availability of adequate perennial and annual sources of nectar and pollen is the most limiting factor in the survival, abundance and distribution of honey bees. The study was conducted to evaluate and characterize the best performing bee forages from ten plant species with a view to selecting for honey production for mid and lowland agro-ecologies. The planting materials were *Nigella sativa, Coriander sativum, Dolchus lablab, Brassica carinata, Ocimum sanctum, lathyrus satives, phaseolus vulgaris, Glycinemax* and *Helianthus annus*. The species were evaluated and characterized based on pollen yield, germination rate, number of flower heads perplant, time to set flower, foraging intensity of honey bees and flowering length. Accordingly, *Helianthus annus*, *Brassica carinata, Ocimum sanctum, Coriander sativum* and *Glycine max* were good at Adami Tulu and Nagele Arsi districts. Mean number of flower heads per1m^2 for all studied plant species was different. *Helianthus annus* and *Brassica carinata* had higher pollen yield at each study site. Honey Bees foraging intensity was higher for *Helianthus annus*. From these studies, it is concluded that *Helianthus annus*, *Coriander sativum, Brassica carinata, Ocimum sanctum, Nigella sativa, Glycine max, lathyrus satives* and *Dolchus lablab* showed better performance at mid and lowland agro ecology, however, these species requires further evaluation particularly on Carrying capacity and honey production potential of the selected plant should be investigated in different agro ecology.

Keywords: Bee Forage, Herbs, Flowering Period, Foraging Intensity

1. Introduction

Apiculture is a floral based industry and bees wholly depend on plants for their food. From 250,000 plants in the world, about 40,000 plant species are important for honey bees as a food source [4, 13]. Bee colony performance as well as production of honey, wax and other hive products depends on bee forage plants from which honey bees obtain nectar and pollen as main food [1]. Among them any flowering plants some of plant species supply both nectar and pollen abundantly and others provide nectar or pollen only [10]. The diversity of flowering plants and their flowering duration differ from one place to another depending on variation in topography, climate and other cultural and farming practices [2, 12]. The extensive knowledge on type of plants, abundance, density and quality of bee flora resources enabled beekeepers to utilize the resources efficiently at the maximum level. This would help to harvest a good yield of honey and other honey bee products in addition to effective pollination for better crop yields. Thus, the success of beekeeping primarily depends on availability and abundance of potential honey bee flora [2]. Currently the scarcity of bee flora is a major limiting factor in development of beekeeping in most parts of the country. The central rift valley of Oromia is frequently affected by the recurrent droughts and deforestation and hence honey bees are facing serious food shortage during the dry period leading to colony absconding and loss of honey yield. As a result of the scarcity of bee forage, demand for dearth period bee flora is currently increasing from time to time from different stake holders. Therefore to respond to the demand, it is necessary to adapt and evaluate and Characterize bee plants that adapt to the short and erratic rain fall conditions of the area that could improve the food base of the local honey bee colonies and significantly contribute to honey production. Herbaceous plants are the major honey source plants in the central lowland of Ethiopia

because the majority of the forest is changed to agricultural land and resettlement. Since the honey bee forages have good merit, it is essential to evaluate their adaptability and potentiality for honey production in the semi-arid rift valley of Oromia where the scarcity of the bee forage was the constraints' of beekeeping. The aim of this study was to evaluate and characterize performance of selected herbaceous honey bee forages.

2. Materials and Methods

The studies were conducted at Adami Tulu Agricultural Research Center (ATARC) and Negele Arsi districts under rain fed conditions. Adami Tulu Agricultural Research Center is located 167km south of Addis Ababa at an altitude of 1650m 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 760mm. The mean minimum and maximum temperature is 12.6 and 27°C, respectively. Nagele Arsi district is located between 7.15°-7.75°N and 38.35°-38.95°E. The annual temperature varies from 10-25°C with annual rain fall between 500-1000mm. The altitude ranges from 1500-3000masl. (Lowland<1600m with semi-arid climate, midland 1600-2200m with mild climate and highland>2200m with cold climate).

For this study seeds of Nigella *sativaL*, *Vignaunguiculata*, *Criander sativum, Dolchus lablab*, *Brassica carinata*, *Ocimum sanctum*, *Lathyru ssatives*, *phaseolus vulgaris*, *Glycine max* and *Helianthus annus* were collected. The plant species were selected on the basis of agro-ecology. Preliminary field observation and information obtained from beekeepers and literature for their importance as bee forages, similarity of their growth habit (herbaceous) and ease of propagation from seeds. Seeds were collected from each plant species by selecting mature fruits. Immediately after collection, seeds were packed in perforated polyethylene bags and allowed to dry for one to one and half weeks at room temperature. The packages were maintained at room temperature until the day of sowing. To evaluate the performance of the selected plant materials, seed beds were prepared by digging the ground and smoothing the field.

Figure 1. *Land prepared for planting.*

Seeds were then taken out of the packages and planted on these prepared seed beds by covering with a thin layer of the same soil of the seed bed on aplot size of 3mx3m arranged in randomized block design with four replications. The necessary agronomic practices (viz., weedingetc.) Were carried out except no fertilizer application to keep its natural growing state. The planting was done under rain fed conditions.

Then, data on days to germinate and average flower opening time was recorded. At 50% flowering, the number of flower heads was counted for each species by taking1m^{2}plot are as well as foraging intensity of honey bees on flowers was counted starting from 6:00a.m. to 6:00p.m. for ten minutes at every 2hour interval. Also pollen yield of each species was determined by collecting 50 matured flower heads having similar age and was kept for certain days to dry. For removal from the flower, pollen was shaken on a paper tray and weighed using a sensitive weighing balance. More over time from blooming to shedding and shedding were also recorded. The collected data were statistically analyzed by GenStat and descriptive statistics using Statistical Package for the Social Sciences) (SPSS) version20.

3. Results and Discussion

In this study Plant species, *Brassica carinata*, *Coriander sativum*, *Vignaunguiculata*, *Dolchus lablab*, *Glycine max, Helianthus annus, Lathyrus satives*, *Nigella sativa* L and *Ocimum sanctum* were planted in two districts of Adami Tulu and Nagele Arsi and mean values for the investigated traits were indicated in tables 1 and 2. Values of germination date (GD) of the plant species are shown in figures 1 and 2. There were different germination dates among different experimental sites between the same plant species. *Brassica carinata*, *Dolchus lablab*, *Helianthus annus*, *lathyrus satives* and *Ocimum sanctum* had the shortest germination date at Adami Tulu Research station.

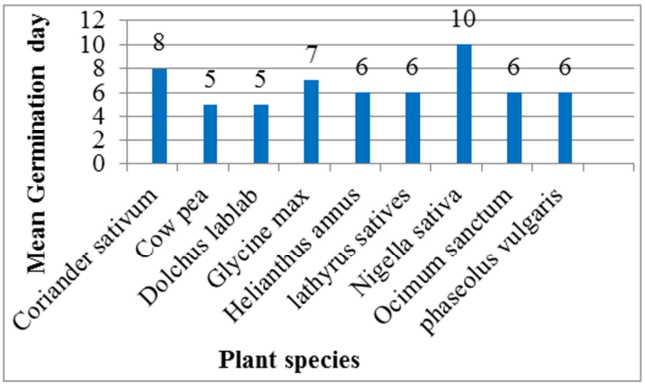

Figure 2. *Mean Germination day of bee forages at Adami Tulu Agricultural Research Center.*

In this study most plant species had a long germination date at Negele Arsi (Ashoka) which might be related to low temperature in this site (figure 1). This may be due to the variation of the temperature, soil condition and germination behavior of the plants at each study site [6]. The life cycles of plants germination and emergence of plants are the two most important factors that determine the efficient use of the nutrients and water resources available to plants [9]. *Helianthus annus*, *lathyrus satives, Brassica carinata, Ocium sanctum* and *Dolchus lablab* started Seed germination 5-6 days at Adami Tulu. In contrast, germination of *Brassica*

carinata, *Helianthus annus*, *Negella sativa* began after about 8, 7 and 12 days respectively at Negele Arsi (Figure 2).

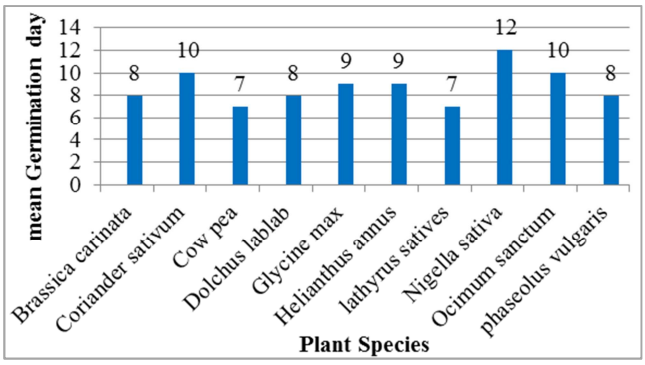

Figure 3. *Mean Germination day of bee forages at Nagelle Arsi District.*

Mean time taken to set flower for *Lathyrus satives* was 45days, the shortest of all plants and flower shedding occurred after 18 and 25 days at Adami Tulu and Ashoka respectively. Time taken to set flower was 78 days and flower shedding occurred after 28 days at Adami Tulu and 90 days flower shedding occurred after 35 days at Ashoka for *Hellianthu sannus* (Tables 1and 2). Mean time taken to set flower for *Brassica carinata* was 46 and 68 days at Adami Tulu and Ashoka site respectively, these shows tha tmean time taken to set flower at each agro ecology were statistically significant ($P<0.05$). The longest mean days to set flowers were recorded for *Helianthus annus* 90 and 78 days at Ashoka and Adami Tulu Respectively. (Tables 1 and 2) The mean time required to set flowers among plant species was different because they are different plant species.

At Adami Tulu number of flower heads per1m^2 for *Ocimum sanctum* and cowpea were higher 9721.4 and 8118.2 respectively (Table 1). The number of flower heads produced per *H. annus* per 1m^2 at Adami Tulu was 4294.6 compared to that of *H. annus* which produced at Asoka site produced 4289. However, the mean numbers of flower heads per1m^2 were similar for *H. annus* at each study site. Mean number of flower heads perm^2 for *Brassica carinata*, *Coriander sativum* and *Nigella Sativa* 7762.2, 5244.2 and 1237.4 at Ashoka site respectively (Tables 1 and 2). More branching produces more flower heads per plant also revealed that the more vegetative growth of a plant develops to more flowers and seeds, and also plants that grow longer vegetative before flowering are typically bigger and able to support more reproductive growth [5, 13]. Mean time taken from the start of blooming to shedding was similar for *Brassica carinata, coriander sativum, Cowpea, Glycine max, Nigella sativa and Ocimum sanctaum* with the range of 30 to 47 days at Adami Tulu (Table 1). Lower for *lathyruvis satives* with 18 days short blooming period respectively (Table 1). *Brassica carinata, coriander sativum, Cowpea, Glycinemax, Nigella sativa, Hellianthus annus and Ocimum sanctaum* took long days from flower opening until shedding at Ashoka site (Table 2). These occur due to different factors such as growing temperature; photo period [9, 11]. More over availability of moisture in the soil also increases the duration of flowering. Bee forage plants which take a long time from blooming to shedding are very important for honey production where as those that have short flower shedding time may be only used for bee colony build up.

1. Ocimum sanctum

2. Helianthus annus

3. *Nigella sativa*

4. *Coriander sativum*

5. *Brassica carinata*

Figure 4. *Performance of planted plants.*

Pollen yields wer ehigher for *Hellianthus annus* and *Brassica carinata* compared to other plant species at Adami Tulu and Ashoka site (Tables 1and 2). Which are very crucial for larvae feeding. This is used to increase the bee colony

population. Foraging is essential to a honey bee colony's survival. To forage success fully, a bee has to learn and remember not only the color and shape of flowers that contain nectar and pollen, but also how to get to them [3, 7, 11].

Table 1. *Mean time taken to set flower (MTSF), total number of flower head per 1 m² (TNFP), pollen yield of 50 flower heads by gram (PY), and time taken from blooming to shedding (TBSH) of the following plant species at Adami Tulu Agricultural Research Center. ± Shows SE is standard error of the mean.*

Plantspecies	PY+SE	MTSF+SE	FIB+SE	TNFPM²+SE	TBS+SE
Brassicacarinata	0.76±0.6	46±5	32.4±2.46	7762.2±2219.3	47±0.0
Coriandersativum	0.25±0.6	53±0.0	8±1.26	5244.2±807.58	31±0.0
Cowpea	0.01±0.0	62±0.0	0.8±0.2	8118.2±131.74	36±0.0
Dolchuslablab	0.012±0.0	56±3.92	3±0.316	6235.4±1324.82	26±0.0
Glycinemax	0.21±0.0	67±0.0	8±1.22	5024.6±200.68	35±0.0
Helianthusannus	0.85±0.2	78±0.0	36±4.84	4294.6±371.59	28±0.0
Lathyrussatives	0.02±0.0	45±0.0	20.4±1.47	2083.2±72.310	18±0.0
NigellasativaL	0.11±0.0	66±0.0	7.6±0.98	1227.4±202.379	30±0.0
Ocimumsanctum	0.4±0.0d	51±0.0	26.2±3.23	9721.4±1411.82	42±0.0
Phaseolusvulgaris	0.023±0	46±0.0	0.6±0.4	3064.2±80.952	18±0.0

Table 2. *Mean time taken to set flower (MTSF), total number of flower head per 1 m² (TNFP2), pollen yield of 50 flower heads by gram (PY), and time taken from blooming to shedding (TBS) of the following plant species at Ashoka site. ± Shows SE is standard error of the mean.*

Plantspecies	PY+SE	MTSF+SE	FIB+SE	TNFPM²+SE	TBS+SE
Brassicanapus	0.66±0.0	68±5	32.4±2.46	8762.2±1219.3	67±0.0
Coriandersativum	0.26±0.0	65±0.0	8±1.26	5290.2±799.58	45±0.0
Cowpea	0.01±0.0	69±0.0	0.8±0.2	7721.4±301.82	45±0.0
Dolchuslablab	0.012±0.0	59±3.92	3±0.316	5235.4±124.82	33±0.0
Glycinemax	0.21±0.0	74±0.0	8±1.22	4024.6±80.68	38±0.0
Helianthusannus	0.83±0.0	90±0.0	36±4.84	4289±271.59	35±0.0
Lathyrussatives	0.02±0.0	56±0.0	20.4±1.47	3083.2±720.310	25±0.0
NigellasativaL	0.11±0.0	68±0.0	7.6±0.98	1237.4±52.379	41±0.0
Ocimumsanctum	0.1±0.0	63±0.0	26.2±3.23	9566.2±231.74	62±0.0
Phaseolusvulgaris	0.023±0.0	57±0.0	0.6±0.4	3078.2±31.952	21±0.0

The number of bee visits with in ten minutes per1m^2 at each study site was different for each species. *Helianthus annus* was highly visited by bees followed by *Ocimum sanctum*, *Coriander sativum*, *Brassica carinata, Nigella sativa* and *lathyrus satives* were highly visited by honey bees at Adami Tulu and Ashoka sites. 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 8a.m-4p.m and 4a.m-4p.m at Adami Tulu and Ashoka site respectively. (Figures 5 and 6). *Helianthus annus and Brassica carinata* were visited by bees' starting early in the morning at each study sites.

They also produced a high amount of pollen. As a result of their pollen, they were visited starting early in the morning. Because honey bees usually collect pollen in the morning and nectar in the afternoon. Early in the morning the concentration of nectar is low due to higher humidity to attract the bees. Bees synchronize their behavior with daily floral rhythms, foraging only when nectar and pollen are at their highest levels. At other times, they remain in the hive, conserving energy that otherwise would be exhausted on non productive foraging flights [8, 14]. 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. The intensity of bee visit is a measure of potentiality of plants for nectar and pollen production [4, 15, 16].

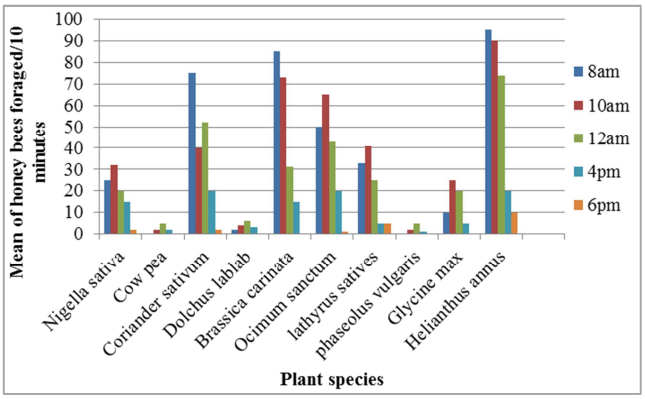

Figure 5. *Foragingtime (10minutes) of honey bees at different time of day on different species of plants at Adami Tulu AgriculturalResearchCenter.*

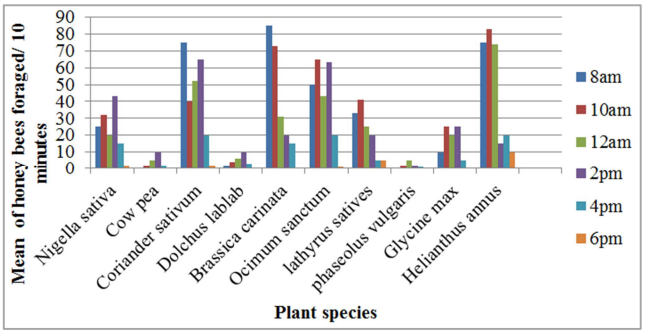

Figure 6. *Foraging time of honey bees at different time of day on different species of plants atNegeleArsi.*

4. Conclusion and Recommendation

In conclusion this study revealed that *Helianthus annus*, *Coriander sativum*, *Brassica carinata*, *Ocimum sanctum*, *Nigella sativa*, *Glycine max*, *lathyrus satives* and *Dolchus lablab* were performed well at Adami Tulu and Ashoka sites. *Helianthus annus*, *Brassica carinata* and *Ocimum sanctum* were highly visited by bees at each study site. 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. Finally *Helianthus annus*, *Brassica carinata*, *Ocimum sanctum*, *Coriander sativum* and *Nigella sativa* were performed very well both at Adami Tulu and Nagelle Arsi Districts where as *laythrus sative s*and *Dolchus lablab* performed well at Ashoka site because it needs long rain seasons for seed sets. From this it isconcluded that *Helianthus annus*, *Coriander sativum*, *Brassica carinata*, *Ocimum sanctum*, *Nigella sativa*, *Glycine max*, *lathyrus satives* and *Dolchus lablab* showed better performance at mid and lowland agro ecology, however, these species of plants requires further evaluation particularly on Carrying capacity of the colony and Honey production potential of the plant should be tested under different agro ecologies of the country.

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