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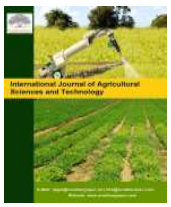

Research Paper

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Performance Evaluation of Herbaceous Bee Forages in Lowland of East Hararghe Zone of Oromia, Ethiopia

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Abstract

The availability of adequate sources of nectar and pollen is the most limiting factor for the honey production and survival of honeybees. To improve the current shortage of bee forage and increase honey production, selecting the best-performing bee forage species across the study areas is of paramount importance. Thus, the study was conducted to evaluate the performance of five herbaceous bee forage species in the lowland agroecology of the East Hararghe zone of Oromia.. The planting materials were *Fagopyrum esculentum, Sinapis alba, Phacelia tanacetifolia, Guizotia abyssinica*, and *Carthamus tinctorius* (safflower)**.** The species were planted under rainfed condition and evaluated based on germination date, days to set flower, number of flowers per plant, duration of flowering and foraging intensity of honeybees. All evaluated bee forage species had a short germination date of 6 to 7 days except for *Phacelia tanacetifolia* which took 11 days to germinate. Regarding days to set flowers, *Fagopyrum esculentum* had the shortest time to set flowers followed by *Sinapis alba, Phacelia tanacetifolia*, and *Guizotia abyssinica*, while *Carthamus tinctorius* had a longer time to set flowers. *Sinapis alba* had the highest number of flowers per head followed by *Fagopyrum esculentum, Guizotia abyssinica*, *Carthamus tinctorius* and *Phacelia tanacetifolia*. *Phacelia tanacetifolia* was highly visited by honeybees followed by *Fagopyrum esculentum, Guizotia abyssinica*, and *Sinapis alba* while less number of honeybees was visited on *Carthamus tinctorius, Fagopyrum esculentum* which took a long time to shed flowers followed by *Synapsis alba, Carthamus tinctorius, Phacelia tanacetifolia*, and *Guizotia abyssinica*. Hence, bee forages including *Sinapis alba, Phacelia tanacetifolia, Fagopyrum esculentum*, and *Guizotia abyssinica* were recommended for honeybees in the lowland and the similar agro-ecology of the East Hararghe zone. Further study on the inter-cropping system of these forages with other crops, and evaluating their performance under irrigation systems are necessary. Furthermore demonstration and scaling up the selected bee forages for the end users are also recommended.

Keywords: *Herbaceous, Bee forage, Germination date, Flowering period, Foraging intensity*

1. Introduction

Beekeeping is one of the most important farming activities in Ethiopia (Workineh *et al.*, 2008). The previous studies of Ayalew (2001), Gezahegn (2007), and Fichtl and Admassu (1994) indicated that Ethiopia has a longer tradition of beekeeping than any country in the world. The contributions of beekeeping to poverty reduction and natural resource conservation

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are great and these have been established and well-stressed by the government of Ethiopia (Tura *et al*., 2014) However, the success of beekeeping primarily depends on the availability of prevalent bee forages which is based on its population density, nectar and pollen potentiality and prolonged flowering periods (Baptist and Punchihewa, 1983). The presence of adequate bee forages is the most limiting factor in the survival, abundance, and 527 distributions of honeybees (Tura *et al*., 2014). Honeybees obtain nectar, pollen, or both from flowers, which are the main pillars of a honeybee's life (Crane, 1990). Ethiopia is a leading honey producer in Africa and one of the ten largest honey-producing countries in the world. Despite the favorable agro-ecology for honey production and the large number of bee colonies, the level of honey production and productivity in the country is still low.

One of the prominent factors for low honey production is a shortage of bee forages due to the expansion of farmland for crop cultivation and overgrazing. The application of agrochemical also affects important herbaceous bee forages that grow in cultivated fields and fallow lands causing food shortages for honeybees. Therefore to respond to the problem it is necessary to identify and evaluate bee plants that adapt to the short and erratic rainfall conditions of the area which could improve the food base of the local honeybee colonies and significantly contribute to honey production. Herbaceous bee forages that grow as weeds on cultivated fields, neglected open land, wastelands and grown as ornamental are important sources of bee forage (Edward, 1976), because they grow & flourish in a short period and their seeds can be collected easily and sown for the next growing season (Tura and Admassu *et al*., 2018).

Different species of perennial and annual herbaceous bee plants are identified as major source of honey for semiarid climate of Ethiopia (Tura and Admassu, 2018). This includes *Becium grandiflorum*, which provides white honey in northern parts of the country, and *Melilotus alb*a, *Fagophyrum esculetum*, which are potential sources of golden honey in other parts of the world including Ethiopia (Admassu *et al.,* 2014). In Eastern Harerge honey bees are facing serious food shortages during the dry period leading to colony absconding and loss of honey yield. As a result, demand for dearth period bee flora is currently increasing from different stakeholders Hence, to gain optimum benefit from honey bee colonies; evaluating and selecting the best performing herbaceous bee forage species is crucial for sustaining honeybee colonies during the dry period. Hence, the study was initiated to evaluate and recommend well-performed herbaceous bee forage species for honey production and to recommend the promising bee forages in similar agro-ecologies of the East Hararghe Zone of Oromia.

2. Materials and Methods Description of Study Area

The study was conducted at Fedis Agricultural Research Center, in Fedis District on Boko station, at Idobaso and Nagaya Umarkule farmers training center (FTC) under rain-fed condition. The study area is situated at an altitude of 1200 to 1600 m a.s.l. The amount of rainfall varies between 650 and 750 mm and the average temperature of the area ranges between 25 and 30 °C.

2.1. Bee Forage Seed Collection and Sowing

The five herbaceous bee forage seeds were selected based on their merit for honey production and the similarity of their growth habit, ease of multiplication, and multipurpose value of the plant were also considered. For this study, mature seeds of *Sinapis alba*, *Phacelia tanacetifolia*, *Fagopyrum esculentum*, *Carthamus tinctorius***,** and *Guizotia abyssinica* were used. Immediately after collection, seeds were kept in paper bags and allowed to dry for one to two weeks at room temperature 528.

2.2. Experiment Design

To undertake the performance evaluation of the selected plant materials, seedbeds were prepared by digging the ground and smoothing the field, and Seeds of candidate bee forages were sown with recommended seed rates in a plot size of 2m* 1.5 m and 1m, 20 cm and 30 cm between Block, plants, and rows respectively. The treatments were arranged in randomized complete block design with three replications. The necessary agronomic practices such as weeding, watering, and pest control applied uniformly. The planting was carried out without chemical fertilizer application to keep its natural growing condition. The data collection was carried out on days to germinate days to flowering, duration of flowering (time taken from blooming to shedding) at 50% flowering, the number of flowers per head per plant and foraging intensity of Honeybees. The foraging intensity of honey bees on flowers was counted by taking 1m2 plot area starting from 7:00 am to 3: 00 p.m. for ten minutes every 2-hours interval.

3. Statistical Analysis

The collected data was analyzed using descriptive statistics using Statistical Package for the Social Sciences (SPSS) version 20.

4. Results and Discussion

4.1. Germination Date and Days to Flowering

All treatment plants were emerged after sowing at all tested locations. Seed germination of the tested bee forages at different location was not significant ($p < 0.05$).The germination date was short for *Sinapis alb*a, *Fagopyrum esculentum*, *Carthamus tinctoriu*s, and *Guizotia abyssinica* and the mean germination percentage date ranged from six days up to seven days while germination date for *Phacelia tanacetifolia* is is relatively longer which has taken ten days with mean germination date (10.72) ranging from six days to eleven days (Table 1). This indicated that there is no germination problem and no further seed treatment for the plants to germination. The result also agreed with Bareke *et al.,* (2014) who reported that the emergence time was 5 and 8 days after sowing for *Sinapis alba* and *Fagopyrum esculentum* respectively. The mean time taken to set flowers for *Fagopyrum esculentum* and *Sinapis alba* was the shortest with mean values of 34.72 and 45.6 days respectively. On the other hand, the time taken for *Phacelia tanacetifolia*, *Guizotia abyssinica*, and *Carthamus tinctoriu*s was long with a mean value of 80.9,82.4, and 85.4 days respectively. The result of *Fagopyrum esculentum* and *Guizotia abyssinica* was lower than the finding of Bareke *et al.* (2014) who reported the days to flowering were 40.3 and 103.7 days. However, the result of *Sinaps alba* was similar with Bareke *et al.* (2014) who reported the days to flowering were 44.7 days.

Table 1: Mean Germination Date and Days to Flowering of Herbaceous Bee Forage Species at Different Locations

Parameters and Plant Species	Site			
	Nagaya Umarkule	Boko Station	Idobaso	Mean
DG				
Fagopyrum esculentum	6.5	6.5	6.16	6.39±0.19
Guizotia abyssinica	6.5	7	6.5	6.67±0.42
Phacelia tanacetifolia	10.5	11.166	10.5	10.72±0.38
*Carthamus tinctoriu*s	6.666	7.166	6.33	6.72±0.42
Sinapis alba	6.5	6.5	6.33	6.44±0.09
DF				
Fagopyrum esculentum	34	37.165	33	34.72±2.1
Guizotia abyssinica	84.31	85.89	78.333	82.84±3.9
Phacelia tanacetifolia	83.333	86.05	73.33	80.90±6.6
*Carthamus tinctoriu*s	85.333	88.82	82.33	85.49±3.2
Sinapis alba	45.5	47.005	44.295	45.60±1.35

Note: DG = Days to germination; DF = Days to flowering.

4.2. Number of Flower Head per Plant

The overall mean number of flower head per plant for the study location was showed in Table 2. All the tested bee forage species had different number flowers per head. There is no significant variation in number of flower heads per plant at different locations. The highest number of flower head per plant was recorded for *Sinapsis alba* followed by *Fagopyrum esculentum* and *Guizotia abyssinic*a. The least was recorded for *Carthamus tinctoriu*s and *Phacelia tanacetifolia*. The variation of flower head per plant is due to nature of the plants that able to produce more inflorescence which is governed by gentical and environment. The presence of higher number of flower head per plant could provide ample food source for honeybees for production of honey and sustain honeybee colony during the dearth period.

4.3. Number of Flower Head per Meter Square

The mean number of flowers per head per meter square indicated that *Sinapis alba* had a higher number of flowers per head per square meter followed by *Fagopyrum esculentum* and *Guizotia abyssinica* over the locations (Table 2). This shows that there were more flowers per square meter in *Fagopyrum esculentum* and *Guizotia abyssinica*for honeybee to forage. However, *Carthamus tinctoriu*s and *Phacelia tanacetifolia* species had the lowest number of flowers per head per square meter.

Table 2: Mean Number of Flower Heads (NFH) and Number of Flower Per Meter Square (NFHM2) Germination Date and Days to Flowering of Herbaceous Bee Forage Species at Different Locations

Parameters and Plant Species	Site			
	Mean	Nagaya Umarkule	Boko Station	Idobaso
NFH				
Fagopyrum esculentum	94.334	104.5	104	100.94±5.7
Guizotia abyssinica	86	85.344	93	88.11±4.2
Phacelia tanacetifolia	41.667	47.56	49.83	46.35±4.2
*Carthamus tinctoriu*s	48.5	50.167	61.33	53.33±6.9
Sinapis alba	199.8	221.63	225	215.49±13.6
NFHM^2				
Fagopyrum esculentum	1500.3	1626.8	1622	1583.1±71.6
Guizotia abyssinica	1315.3	1279.3	1395	1329.9 ±59.1\
Phacelia tanacetifolia	634.6	801.8	790.16	742.2±93.2
*Carthamus tinctoriu*s	756	809.8	904.5	823.29±75.1
Sinapis alba	3446.6	3358	3446.6	3417.1 ±51.1

4.4. Time Taken from Blooming to Shedding

The time taken from the start of blooming to shedding for the different bee forage species at all locations was not significantly different (Table 3). *Fagopyrum esculentum, Sinapis alba, and Carthamus tinctoriu*s took a long time to

Table 3: Foraging Intensity and Flower Shedding Time for the Selected Herbaceous Bee Forages

Parameters and Plant Species	Site			
	Nagaya Umarkule	Boko Station	Idobaso	Mean
NFH				
Foraging intensity				
Fagopyrum esculentum	89.333	99.5	105.334	98.06
Guizotia abyssinica	89	88	61.665	79.56
Phacelia tanacetifolia	106	111	122	113.00
*Carthamus tinctoriu*s	32.666	44	41	39.22
Sinapis alba	71	69.84	72.834	71.22

Table 3 (Cont.)

Parameters and Plant Species	Site			
	Nagaya Umarkule	Boko Station	Idobaso	Mean
Flowering Duration				
Fagopyrum esculentum	27.83	41	47.833	38.89
Guizotia abyssinica	28.833	29.165	27.5	28.50
Phacelia tanacetifolia	32.667	29.98	32.33	31.66
Carthamus tinctorius	42	34.49	33.498	36.66
Sinapis alba	45	38	44.664	42.55

shed their flowers whereas *Phacelia tanacetifolia* and *Guizotia abyssinica* have taken a short time to shed flowers. These bee forage species have a long flowering duration from blooming to shedding. This parameter is important for the honey production and sustainability of the honeybees during the dearth period.

5. Conclusions and Recommendations

This study revealed that among the five bee forage species evaluated *Sinapis alba*, *Phacelia tanacetifolia*, *Fagopyrum esculentum*, and *Guizotia abyssinica* were well performed under local condition However *Carthamus tinctorius* was less preferred by honeybees as compared to other four herbaceous forages species. Therefore *Sinapis alb*a, *Phacelia tanacetifolia*, *Fagopyrum esculentum* , and *Guizotia abyssinica* were recommended in the lowlands of East Hararghe zone and similar agroecology. Thus distributing these bee forages through demonstration and scaling up is very important. Further study such as; inter-cropping bee forage species with other crops and evaluating their performance under irrigation systems during dearth periods in the study area is also recommended.

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