Advances in Life Science and Technology
ISSN 2224-7181 (Paper) ISSN 2225-062X (Online)
Vol.97, 2023

Adaptation and Evaluation of Improved Bee Forages at Haro Sabu Districts of Kelem Wollega Zone, Western Ethiopia

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Abstract
The study was conducted to adapt and evaluate the performance of improved bee forage and recommend the best performing species for honey production at Haro Sabu districts from 2013-2014 G.C. The evaluated plant species were *Medicago sativa*, *Phocilia* indicum, *Melilotus officinalis, Trifolium ruppellianum*, *Fagophyrum japonicum, Fagophyrum esculentum, Coriandrum sativum* and *Sinaps alba* which were sown on station with Randomized complete block design and replicated three times with 2m x 2m ($4m^2$) plot sizes. Germination, duration on flowering, number of flower heads per m^2 and honey bee foraging intensity on flowers per m^2 were parameters used to evaluate the adaptation of the introduced improved bee forages and analyzed using ANOVA. Statistically the longer (68) and shorter (27) days it took on flowering was observed on *Medicago sativa* and *Coriandrum sativum,* respectively under the experiment. *Fagophyrum japonicum* and *Fagophyrum esculentum* produces statistically higher number of flower head per m^2 plot area while *Phocilia indicum*, *Sinups alba* and Medicago *sativa* produces statistically similar and the least flower head per m^2 which are 153, 196 and 202, respectively. Regarding on the mean number of bee visits on plants, *Trifolium ruppellianum* was statistically significantly visited by higher number of bee foragers (579) while *Coriandrum sativum* was the least (162). The data revealed that *Melilotus officinalis*, *Trifolium ruppellianum*, *Fagophyrum japonicum, Fagophyrum esculentum, Sinaps alba, Phocilia indicum and Medicago sativa* were performed well in terms of flower head per plant, number of bee visits and duration on flowering for honey production.
Keywords: Coriandrum sativum, Fagophyrum esculentum, Fagophyrum japonicum, Medicago sativa, Melilotus officinalis, Phocilia indicum, Sinaps alba and Trifolium ruppellianum.
DOI: 10.7176/ALST/97-04
Publication date: January 31st 2023

1. Introduction

Ethiopia is an agrarian country whose economy is based largely on renewable natural resources.
Between six to seven thousand species of flowering plants, wide areas of natural forest and two rainy seasons to provide honey flow, Ethiopia has immense resources for apiculture (Edwards, 1976). The current harvested honeybee population is estimated to consist of some seven million colonies which produce 43,000 tons of honey and 3000 tons of beeswax every year (MOARD**,** 2008). Availability of adequate annual and perennial source of nectar and pollen is the most limiting factor for the survival, abundance and distribution of honeybee colonies. Herbaceous plants that grow as weed on cultivated field, neglect open lands, wastelands and marginalized areas, are important source of bee forage (Edward 1976).

Over 50% of the identified plant species in Ethiopia are herbaceous bee flora (Admassu *et al*., 2014). These herbaceous floras are significantly contributing to large proportion of honey production in the country and beekeepers produce considerable amount of honey from these plants. Among these, *Bidens prestinaria*, *Guizotia scabra, Trifolium rupplianum,* oil crops, and pulses have been reported as the major sources of honey in central highlands (Admassu 1996; Admassu *et al*., 2014; Nuru *et al.* 2002; Amssalu 2004). Moreover, *Guizotia scabra*, *Trifolium rupplianum*, *Bidens prestinaria* and *Caylusea abyssinica* are the most common weeds in wide range of Ethiopian condition and they are important source of honey (Stroud and Parker 1989). Some introduced plants species like *Melilotus alba* and buckwheat (*Fagophyrum esculentum* and *Fagophyrum japonicum*) are also major source of golden honey in other parts of the world (Nuru *et al.* 2002)

Beekeepers use buckwheat to produce honey because its flowers produce a large volume of rich and flavorful nectar. The flour of this plant is used as fodder for livestock and to make traditional buckwheat bread in Japan. Most of these plant species are annuals and they grow and flourish fast after summer rain. Moreover, their seeds can be collected easily and sown for the next growing season. Currently beekeepers are complaining that the scarcity of bee forage is becoming a serious problem due to rapid population growth, expansion of agriculture and deforestation. To keep and maintain the bee colony strong through continuous major bee flora availability, beekeepers, researchers and farmers have a responsibility to cultivate and/or grow pollen and/or nectar source bee forages at the nearby of their apiaries. Therefore introduction and evaluation of the adaptability of improved bee forages are paramount important for sustainable production of beekeeping. The objectives of this study was to adapt and evaluate the performance of improved bee forage at Haro sabu districts and

recommend the best performing species for honey production.

2. Materials and Methods.

Eight species of honeybee forages: *Medicago sativa, Phocilia indicum, Melilotus officinalis, Trifolium ruppellianum, Fagophyrum japonicum, Fagophyrum esculentum, Coriandrum sativum and sinaps alba* were introduced to Haro Sabu agro ecological condition and evaluated for their performance at Haro Sabu Agricultural Research center. Each bee forage sown on 2m x 2m ($4m^2$) plot sizes with three replications in randomized completed block design. The distance between row, plot and block were 20cm, 1m and 1.5 m respectively. The seed rate of 25kg/ha was used for each of the evaluated species. Day to germinate, blooming time, peak flowering time, shedding time were recorded. Moreover, number of flower heads was counted for each species by taking $1m^2$ plot areas and at peak flowering time honey bee foraging intensity on flowers was counted on $1m^2$ plot area starting from 9h– 14hrs for ten minutes at every hour intervals. All collected data were subjected to statistical analysis using SAS 9.1 Computer software and mean differences were analyzed by using least square significant test.

2.1. Data analysis

SAS version 9.1.3 (SAS Institute, 2003) computer package was used for analyzing all the data. Means and standard deviations of the recorded data were calculated using SAS Software (SAS Inc., 2003). Determination of the significant differences between honey samples was done using one-way ANOVA. Germination Date, Flowering Duration, Flower Heads per M^2 and Bee Visits were used for mean separation.

3. Results and Discussion.

3.1. Germination Date.

The Table 1 below reveals that there was no statistical difference in germination rate among *C. sativum, T. ruppellianum*, *P. indicum* and *M. officinalis* ($p>0.05$) and all took more than two weeks to germinate but they statistically vary from rest of species ($p<0.05$). However, *S. alba*, *F. esculentum* and *F. japonicum* germinate faster than all the rest bee forages. They germinate less than a week (Table 1). *M. sativa* was statistically significant ($p<0.05$) from rest of the evaluated bee forages which took 11 days to germinate. The germination data indicated that introduced improved bee forages germinated in different time length. This might be due to the germination character of their seeds as well as moisture requirement to germinate. For instance the seeds of *C. sativum, T. ruppellianum, P. indicum and M. officinalis* are hard and took long days to break their seed as compared with other evaluated materials.

3.2. Flowering Duration.

M. sativa stays in flower statistically longer (68 days) than all the other bee forages under experiment and followed by *T. ruppellianum, M. officinalis* and *S. alba* in decreasing order. The rest bee forages such as *C. sativum, F. esculentum, F. japonicum* and *P. indicum* stayed in flower from 27 to 36 days. Days on flowering was calculated by counting the days from blooming to shedding of their flowers during the study. The variation from flower opening until shedding might be due to different factors such as growing temperature, photoperiod and availability of moisture in the soil (Evans, 1957). As it was observed during the flowering time of *T. ruppellianum, M. officinalis* and *S. alba* bee forages under experiment, their flowering character was indeterminate which means opening one after another that result long duration on flowering.

3.3 Flower Heads per M^2

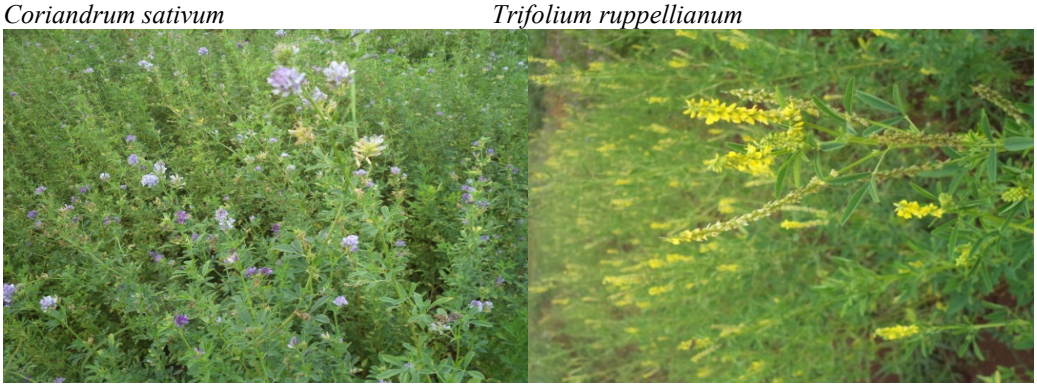
With concerns to number of flower head per m^2 plot area, *F. esculentum* produces high (451) and statistically similar with *F. japonicum*, *M. officinalis* and *C. sativum* in decreasing order while *P. indicum* was statistically significant different ($p<0.05$) and the least flower head producers from other evaluated materials under experiment (Table 1). The highest and lowest flower head per m^2 was produced by *F. esculentum* and *P. indicum* species respectively which might be due to their growing characteristics. Branching and Flower head per plants are directly proportional. Tura Bareke Kifle *et al*. (2014) revealed that more branching produces more flower heads per plant. Excessive irrigation during the vegetative growth induces more flower production (Stolp, 1955). From beekeeping point view, it is reasonable to prefer plant species with more flower heads and longer flowering period which produces sufficient pollen and nectar, provides continuous food source and invites more bee foragers than bee forages that produces less plant branches and short flowering time.

3.4. Bee Visits

T. Ruppellianum was statistically significantly ($p<0.05$) visited by higher number of bees (579) compared to other bee forages under experiment and followed by *S. alba* while *C. sativum* was bee forage that significantly least visited by bees during its flowering period (Table 1). During flowering time of *C. sativum,* insect

competitor was observed which is fly (Order Diptera) that might brought small number of bee foragers. There was statistically similar bee foragers were counted on *F. japonicum F. esculentum* and *P. indicum* during their peak flowering time. Nectar and pollen foragers sometimes prefer one food source over another as well as the specific position of one flower over another (Abou-Shaara 2014). Tura Bareke Kifle *et al*.(2014) found that 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. Moreover, the potentiality of plant for its bee resource production is measured by the intensity of bee visits on that flower plant (Crane, 1990).

Coriandrum sativum *Trifolium ruppellianum*



Phocilia indicum *Melilotus officinalis*

Medicago sativa *Sinapis alba*

Fagophyrum esculentum *Fagophyrum japonicum*

Figure 1: Performances of the evaluated bee forages.

Table 1: Shows the mean number of measured parameters to evaluate the best performance of bee forages.

Plant species	Days to germination	Days on flowering	Number of flower head per m^2	Number of bee visits per m^2
Coriandrum sativum	18.16[a]	26.50[f]	321.42[bc]	161.60[e]
Trifolium ruppellianum	17.83[a]	57.00[b]	239.63[dc]	579.00[a]
Phocilia indicum	17.50[a]	30.33[e]	153.03[e]	235.55[d]
Melilotus officinalis	16.66[a]	45.83[c]	361.77[b]	296.63[c]
Medicago sativa	11.00[b]	68.33[a]	201.70[de]	293.00[c]
Sinapis alba	6.16[c]	35.83[d]	196.25[de]	337.33[b]
Fagophyrum esculentum	5.83[c]	29.50[ef]	450.70[a]	223.47[d]
Fagophyrum japonicum	6.16[c]	30.66[e]	380.32[ab]	240.53[d]
CV (%)	20.7	7.7	24.4	11.0
Lsd (0.05%)	3.01	3.68	82.27	38.34

* Means with the same letter are not significantly different.

4. Conclusion and Recommendation

In general, the present work showed that there were differences within parameters between the evaluated bees forage species. Depending on bee visits on forage flowers, duration on flowering and flower head production by plants *M. officinalis, T. ruppellianum, F. japonicum, F. esculentum, S. alba, P. indicum* and *M. Sativa* species are the most adaptable and major herbaceous bee forages at the study area as compared with *C. sativum.* Therefore, if the above adapted bee forages are demonstrated and disseminated around apiary site of beekeepers, they can maintain bee colonies as well as increase honey production of the area.

Acknowledgment

Great thanks to Oromia Agricultural Research Institute who allocates the budget for this activity. I also thankful Haro Sabu Agricultural Research Center and my team particularly Mr Tariku Lema and Temesgen Terefe who assists me during data collection.

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Appendix 1: mean square values of different parameters at haro sabu on station.

Source of variation	Degree of freedom	Mean Square			
		Days to germination	Days on flowering	Number of flower head per m^2	Number of bee visits per m^2
Plant Species	7	196.9**	1383.6**	66833.8**	95881.6**
Year	1	30.0*	225.3**	104766.7**	106.5^{ns}
Replication	2	3.5^{ns}	65.6**	4750.9^{ns}	9354.0**
Error	37	6.6	9.9	4946.9	1074.5
Cv(%)		20.7	7.7	24.4	11.0
Lsd(0.05%)		3.01	3.68	82.27	38.34

**,* and ns –means highly significant at 1 %($p<0.01$), significant at 5 %($p<0.05$) and non significant at $p>0.05$ probability level.