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Impact of bee attractants on bee visitation on buckwheat (*Fagopyrum esculentum* L.) crop

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Abstract
A field experiment was undertaken with bee attractants on bee visitation on qualitative and quantitative parameters on buckwheat *Fagopyrum esculentum* L. crop. The use of different concentrations of Sugar solution, Sugarcane juice, Jaggery and Honey solution were evaluated to understand honeybee visitation pattern of target crop and pollination efficiency. Treatments involved were, spraying of Honey solution (10%), Sugar solution (10%) and (15%), Sugarcane juice (10%) and (15%), Jaggery solution (10%) and (15%) and without any spray. The results revealed that a day before the first spray, the number of Indian honey bee (*Apis cerana indica*) visiting on buckwheat flower ranged from 1.70 to 3.70 and 0.28 to 5.95 bees/m^2/min in 10 per cent and 50 per cent flowering condition and did not differ significantly among the treatments. However, the following day after the first spray, Honey solution (10%) attracted the higher number of *Apis cerana indica* 6.17, 6.14, 4.54 and 3.45 bees/m^2/min in the 1DAS, 3DAS, 5DAS and 7DAS in 10 per cent flowering. The plot receives the bee attractants significantly increased the number of seed per cyme, number of seed per plant, seed yield per plot and seed yield per hector.

Keywords: *Apis cerana indica*, Bee- attractants, Bee visitation, Buckwheat

1. Introduction
Buckwheat, *Fagopyrum esculentum* L is belong to the family Polygonaceae. It is a moisture loving, cool-climate, annual cereal crop and native of Central Asia, cultivated in China and other eastern countries as a cereal grain, but the plant does not belong to the family Poaceae (Ahmad and Raj, 2012) [2]. Buckwheat is a most important crop of the mountain as well as the hill region above 1600 m MSL both grain and green manure. It occupies about 90% of cultivated land in the Himalayas with a solid stand. It is a short duration crop and fits well in the high Himalayas where a crop growing season is of limited period because of early winter and snow fall. In the higher hilly up to 4500m, this is the only crop grown. Buckwheat is the best source of high quality, easily digestible protein, having a balanced amino acid composition (Eggum *et al*., 1981) [4] and a good source of minerals.

In India buckwheat is widely grown in Jammu and Kashmir in the west, and Arunachal Pradesh. Its cultivation is confined in high mountains of Jammu and Kashmir (Ladakh, Udhampur), Himachal Pradesh (Bharmaur, Pangi, Kulu, Shimla and Kinnaur), Uttar Pradesh (Uttar Kashi, Chamoli, Pauri, Almora and pithoragarh), West Bengal (Darjeeling), Sikkim (Lachan and Lachoong), Meghalaya Arunachal Pradesh (Tawang, Bomdilla and Dirang) and Manipur. In South India, it is sporadically grown in the Nilgiris and Palni hills (Joshi, 1999) [10]. In Chhattisgarh, buckwheat is grown extensively in the north hill zone in an area of about 1430 ha at Mainpat block in Surguja district by the "Tibbti" refuge people in the past 8-10 year.

Buckwheat is an important cross pollinated and an entomophilic plant honeybees are the major pollinators. The cultivation of buckwheat along with beekeeping may produce 50 to 100 kg of honey per hectare due to its extended flowering period more than 30 days (Rajbhandari, 2010) [20].

Bees are one of the most important pollinator therefore, understanding the scale at which they forage has important ecological implications and conservation applications. The foraging ranges for most bee species are unknown. The foraging distance information is critical for understanding the scale at which bee populations respond to the landscape, assessing the role of bee pollinators in affecting plant population structure, planning conservation strategies for plants and designing bee habitat refugia that maintain population function for wind and crop plants (Greenleaf *et al.* 2007) [7].

A day before the first spray, the number of bees visiting the onion flower ranged from 1.66 to 2.50 bees/m/2min and did not differ significantly among the treatments. However, the following day after the first spray, Bee-Q(15g/lit) attracted the higher number of bees 5.17 bees/m/2min. Trigona spp. treatment with Bee-Q(15 g/lit) 4.00 bees/m/2min was significantly superior in attracting more number of bees and was at par with Bee-Q (12.5g/lit),Bee-Q (10 g/lit), sugar syrup 5 per cent and molasses 10 per cent recorded (3.83, 3.67, 3.67 and 3.60 bees/m/2min on 1st day after 1st spray. Open pollination without spray recorded the lowest number of bees 2.30 bees/m/2min (Patil *et al*. 2010) [19].

2. Materials and methods

The present investigation was carried out in Rabi season during 2016-17 at Department of Entomology, at the research cum instructional farm of Rajmohini Devi College of Agriculture and research Station, Ambikapur. The sowing was done on 24 October 2016 by using Local variety with spacing 20x20 cm. The experiment was conducted with simple Randomized Block Design with eight treatments and three replications. T_1 sugarsolution (10%), T_2 sugar solution (15%), T_3 sugarcane juice (10%), T_4 sugarcane juice (15%), T_5 jaggery solution (10%), T_6 jaggery solution (15%), T_7 honey solution (10%) and T_8-without any spray.

The attractants were sprayed at 10% flowering (1st spray) and 2nd spray were done at 50% flowering on buckwheat crop. Observations were recorded in one square meter area and demarcated by bamboo sticks in each plot and number of pollinators visiting those flowers per minute were recorded throughout the day from 0600hrs to 1800hrs at two hours intervals. The observation was made a day before the first spray and later 1st day, 3rd day, 5th day, and 7th day observations were made the population of pollinators and 2nd spray same interval was taken.

3. Results

Observation was recorded on *Apis cerana indica* on buckwheat treated with different bee attractants at 10 and 50 per cent of flowering (Table 1).

3.1 First spray

A day before the spray, the number of bees visiting the buckwheat flower ranged from 0.30 to 3.70 bees/m^2/min and significantly among the treatment. However, the day after the first spray, Honey bee solution (10%) attracted higher number of bees 6.17 bees/m^2/min and significantly superior over treatments sugar solution (15%), sugarcane juice (10%), jaggery (10%) and without any spray. Further, next treatment sugarcane juice (10%) and sugar solution (10%) were both the treatment recorded 4.66 bees/m^2/min and 4.61 bees/m^2/min. Followed by the treatment with sugarcane juice (15%) recorded 4.52 bees/m^2/min. The bee visitation varied from 4.28 to3.86 bees/m^2/min on the treatment spray sugar solution (15%) and jiggery (10%). Least number of bees were recorded in control treatment without any spray 0.55 bees/m^2/min.

On 3rd day after first spray, honey solution (10%) recorded maximum number of bees (6.14 bees/m^2/min) and found superior over jaggery solution 15% and without any spray. The next best treatment was found sugar solution (10%) 5.90 bees/m^2/min followed by sugarcane juice (15%) 5.88 bees/m^2/min, sugarcane juice (15%) 5.88 bees/m^2/min, sugar solution (15%) 5.24 bees/m^2/min. The next best treatment were jaggery (10%) 3.81 bees/m^2/min, jaggery (15%) 4.94 bees/m^2/min and sugarcane juice (10%) 4.71 bees/m^2/min respectively. Control treatment without any spray was recorded lowest number of bees 0.78 bees/m^2/min.

On 5th day after first spray, honey solution (10%) 4.54 bees/m^2/min and jaggery solution (15%) 4.27 bees/m^2/min treated plots recorded significantly higher bee visits against sugar solution (10%) 2.44 bees/m^2/min and sugar solution (15%) 2.16 bees/m^2/min. Jaggery (15%) 4.27 bees/m^2/min and sugarcane juice (10%) 3.85 bees/m^2/min were next best attractants and were on par with each other. Least number of bees was recorded in without spray plots 0.31 bees/m^2/min.

On 7th day after first spray, honey solution (10%) (3.45 bees/m^2/min) was significantly superior over treatments jaggery (15%) 2.00 bees/m^2/min and sugarcane juice (15%) 1.76 bees/m^2/min in attracting. The plot which received jaggery (10%) was the next best treatment 2.24 bees/m^2/min which was at par with sugar solution (10%) and sugar solution (15%) and wererecorded 1.21 bees/m^2/min and 1.78 bees/m^2/min, respectively. Sugarcane juice (10%) treated plots were received 2.16 bees/m^2/min. Open pollination without spray recorded lowest number of bees (0.29 bees/m^2/min).

3.2 Second spray

Day before the second application of bee attractants, there was a significant difference in bee visiting different plots which varied from 0.29 to 3.28 bees/m^2/min.

One day after second spraying, maximum number of bees were noticed in honey solution 10% (3.28 bees/m^2/min.) treated plots. The second best treatment was sugar solution (15%) sprayed plots (3.00 bees/m^2/min) followed by sugarcane juice (10%) 2.61 bees/m^2/min and jaggery solution (15%) 2.47 bees/m^2/min applied plots which were however on par with each other. Sugar solution (10%) received plots attracted 2.30 bees/m^2/min followed by sugarcane juice (15%) 1.71 bees/m^2/min. Open pollination without any spray found to be the least efficient in attracting more number of bees (0.28 bees/m^2/min).

On third day after second spray sugar solution (10%) 8.52 bees/m^2/min was significantly superior over without spray plots found at par with honey solution (10%) (7.61 bees/m^2/min), jaggery (15%), and sugarcane juice (10%) which recorded (6.71bees/m^2/min, 6.28 bees/m^2/5min) respectively. Other best treatment were jaggery (10%) 5.95 bees/m^2/min, sugarcane juice (15%) 5.57 bees/m^2/min followed by sugar solution (15%) (5.57 bees/m^2/min).Control treatments without any spray were least effective in attracting bees (0.62 bees/m^2/min).

Fifth day after second spray treatment with honey solution (10%) (4.85 bees/m^2/min) was significantly superior over without spray. The second best treatment was sugarcane juice (15%) (4.52 bees/m^2/min) followed by sugar solution (15%) (4.42 bees/m^2/min), sugarcane juice (10%) (3.80 bees/m^2/min) and sugar solution (10%) (3.62 bees/m^2/min), respectively. It was found at par with jaggery solution (15%) and jaggery (10%) which recorded (3.57 bees/m^2/min and 2.81spray found to be the least efficient in attracting less number of bees (0.46 bees/m^2/min).

On 7th day after second spray honey solution (10%) (4.14 bees/m^2/min) treated plots recorded significantly higher number of bee visits followed by sugar solution (15%) (3.35 bees/m^2/min).The next best treatments were found sugar solution (10%), jaggery (15%) and sugarcane juice (10%) (3.19 bees/m^2/min, 3.14 bees/m^2/min and 2.75 bees/m^2/min), respectively. Sugarcane juice (15%) (2.19 bees/m^2/min) and jaggery (10%) were recorded next more superior bee attractant treated plots. Control treatments without any spray were found least number of bees (0.14 bees/m^2/min).

Table 1: Impact of bee attractants on visitation of *Apis cerana indica* on Buckwheat

Treatment	Bee visitation/square meter/minute									
	Frist spaya (10 per cent flowering) Second spray (50 per cent flowering)									
	DBS	1DAS	3DAS	5DAS	7DAS	DBS	1DAS	3DAS	5DAS	7DAS
T_1Sugar Solution (10%)	2.04 (1.6)*	4.61 (2.25)	5.9 (2.53)	2.44 (1.71)	1.20 (1.30)	2.30 (1.65)	3.66 (2.00)	8.52 (3.00)	3.61 (2.00)	3.9 (2.09)
T_2Sugar Solution (15%)	1.7 (1.47)	4.28 (2.18)	5.24 (2.39)	2.16 (1.61)	1.78 (1.50)	2.99 (1.86)	4.95 (2.32)	5.52 (2.45)	4.42 (2.21)	3.68 (2.04)
T_3Sugarcane juice (10%)	1.85 (1.53)	4.66 (2.27)	4.71 (2.28)	3.85 (2.07)	2.15 (1.62)	2.61 (1.75)	3.04 (1.88)	6.28 (2.59)	3.80 (2.07)	3.46 (1.98)
T_4Sugarcane juice (15%)	2.07 (1.60)	4.52 (2.24)	5.88 (2.53)	3.04 (1.85)	1.75 (1.49)	1.71 (1.48)	2.71 (1.79)	5.56 (2.46)	4.52 (2.24)	3.95 (2.10)
T_5Jaggery (10%)	2.76 (1.79)	3.27 (1.94)	3.81 (2.01)	3.75 (2.04)	2.23 (1.65)	2.32 (1.65)	4.71 (2.28)	5.95 (2.53)	2.80 (1.81)	3.61 (2.01)
T_6Jaggery (15%)	3.7 (2.04)	3.85 (2.06)	4.94 (2.31)	4.27 (2.18)	1.99 (1.57)	2.56 (1.74)	5.80 (2.5)	6.71 (2.68)	3.56 (2.01)	3.23 (1.93)
T_7Honey solution	2.42 (1.67)	6.17 (2.58)	6.14 (2.58)	4.54 (2.24)	3.44 (1.98)	3.33 (1.95)	5.94 (2.53)	7.61 (2.84)	4.85 (2.31)	4.71 (2.28)
T_8Without any spray	0.3 (0.89)	0.55 (1.02)	0.78 (1.13)	0.31 (0.89)	0.28 (0.88)	0.28 (0.88)	0.42 (0.94)	0.61 (1.05)	0.45 (0.97)	0.3 (0.89)
S.E.	0.13	0.20	0.18	0.21	0.13	0.12	0.18	0.16	0.18	0.10
C.D.(P=0.05)	0.41	0.61	0.55	0.65	0.39	0.38	0.55	0.49	0.54	0.30

*Figures in the parentheses are $\sqrt{x + 0.5}$ transformed values

DAS= Day after spraying
DBS= Day before spraying

4. Discussion

The present research was conducted to investigate the different bee attractants on buckwheat flowers at 10 and 50 per cent of crop flowering depicted in Table 1.

The treatments were including T_1 sugar solution (10%), T_2 sugar solution (15%), T_3 sugarcane juice (10%), T_4 sugarcane juice (15%), T_5 jaggery solution (10%), T_6 jaggery solution (15%), T_7 honey solution (10%) and without any spray. A day before the spray, the number of bees were visiting the buckwheat flower ranged from 0.30 to 3.70 bees/m^2/min and significantly among the treatment. However, the day after first spray, Honey bee solution (10%) attracted higher number of bees 6.17 bees/m^2/min and significantly superior over treatments, sugar solution (15%), sugarcane juice (10%), jaggery (10%) and without any spray. Further, next treatment sugarcane juice (10%) and sugar solution (10%) were both the treatment recorded 4.66 bees/m^2/min and 4.61 bees/m^2/min. Followed by the treatment with sugarcane juice (15%) recorded 4.52 bees/m^2/min. The bee visitation varied from 4.28 to3.86 bees/m^2/min on the treatment spray sugar solution (15%) and jaggery (10%). Least number of bees were recorded in control treatment without any spray 0.55 bees/m^2/min.

After first spray of 3rd day, honey solution (10%) recorded maximum number of bees (6.14 bees/m^2/min) and found superior over jaggery solution 15% and without any spray. The next best treatment were jaggery (10%) 3.81 bees/m^2/min, jaggery (15%) 4.94 bees/m^2/min and sugarcane juice (10%) 4.71 bees/m^2/min respectively. Control treatment without any spray was recorded lowest number of bees 0.78 bees/m^2/min.

5th days of spray, honey solution (10%) 4.54 bees/m^2/min and jaggery solution (15%) 4.27 bees/m^2/min treated plots recorded significantly higher bee visits against sugar solution (10%) 2.44 bees/m^2/min and sugar solution (15%) 2.16 bees/m^2/min. Jaggery (15%) 4.27 bees/m^2/min and sugarcane juice (10%) 3.85 bees/m^2/min were next best attractants and were on par with each other.

On 7th days, honey solution (10%) (3.45 bees/m^2/min) was significantly superior over treatments jaggery (15%) 2.00 bees/m^2/min and sugarcane juice (15%) 1.76 bees/m^2/min in attracting. Open pollination without spray recorded lowest number of bees (0.29 bees/m^2/min).

Before the second application of bee attractants, there was significant difference in bee visiting different plots which varied from 0.29 to 3.28 bees/m^2/min.

After second spraying after one day, maximum number of bees were noticed in honey solution 10% (3.28 bees/m^2/min.) treated plots. However, Open pollination without any spray found to be the least efficient in attracting more number of bees (0.28 bees/m^2/min).

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On fifth days treatment with honey solution (10%) (4.85 bees/m^2/min) was significantly superior over without spray. It was found at par with jaggery solution (15%) and jaggery (10%) which recorded (3.57 bees/m^2/min and 2.81spray found to be the least efficient in attracting less number of bees (0.46 bees/m^2/min).

On 7th days after second spray honey solution (10%) (4.14 bees/m^2/min) treated plots recorded significantly higher number of bee visits followed by sugar solution (15%) (3.35 bees/m^2/min). Sugarcane juice (15%) (2.19 bees/m^2/min) and jaggery (10%) were recorded next more superior bee attractant treated plots. Control treatments without any spray were found least number of bees (0.14 bees/m^2/min).

The present results obtained on the efficacy of Bee-Q and suger syrup are in close agreement. Gallert *et al.* (1985) [6] reported that honey bees were attracted to the Lucerne plots sprayed with a crude extract of dried fruit of *Evodiahupehensis*. Al Sahf (2002) [1] reported that rose water spray was effective in attracting bees to the onion crop. Viraktamath and Patil (1999) [26] who observed the efficacy of bee-Q and sugar syrup (5%) were in close agreement on onion, Lingappa *et al.* (1999) [14] reported on watermelon and

safflower, Patil *et al*. (2000) [18] on sesame, Murasing (2000) [15] on mustard and Guru prasad (2001) [8] on niger. Menon *et al*. (2012) [16] on guava had also observed that spray of 1.00ml/L fruit boost significantly enhanced visitation rates of pollinators in guava and Sattigi (2009) [3] reported on radish. Other workers Chandrasekhar and Sattagi (2009) [3] on radish, Elmstrom (1990) [5] on watermelon, Guruprasad and Viraktamath (2013) [9] on niger, Jayaramappa and Bhargava (2013) [11] on ridge gourd, Jayaramappa and Shivram (2013) [11, 12, 23-25] on pumpkin, Jayaramappa *et al*. (2011) [13] on ridge gourd, Nithya (2012) [17] on sesame, Sattagi *et al.* (2001) [21] on niger, Schulthesis *et al* (1994) [22] on cucumber and watermelon Shivram and Jayaramappa (2013) [11, 12, 23-25] on mustard, Shivram and Jayaramappa (2013) [11, 12, 23-25] on pigeon pea, Shivram *et al.* (2013) [11, 12, 23-25] on niger crop had reported.

5. Conclusion

The basic objective of the bee attractants is the uses of indigenous bee attractants is the best option under beekeeping. Hence, the best indigenous bee attractants is honey solution (10%) and jaggery solution (15%) to increasing the production of buckwheat. The spray of bee attractants should be done in right time and good weather condition may be increase per hectare seed yield.

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