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Effect of indigenous bee attractants on foraging behavior of bees in sesame (*Sesamum indicum* L.)

Hitesh, KL Painkra, GP Painkra, PK Bhagat and Neelam Chouksey

Abstract
A field experiment was conducted with bee attractants *viz*., jaggery solution, sugar solution, milk powder and Glucon-D solution with different concentrations on foraging activities/visits of bees in sesame (*Sesamum indicum* L.) crop. The results revealed that the day before spray, visitation of all bees was found uniform, however after sprays of bee-attractants the bees species *viz*., rock bee (*Apisdosata*), Indian bee (*A. cerana indica*), Italian bee (*A. mellifera*) and little bee (*A. florea*) visits were recorded maximum in 15% jaggery solution (with 7.02, 6.48, 4.55 and 4.29 bees/5min/m2 respectively), followed by 15% sugar solution (6.18, 5.80, 4.20 and 3.88 bee visits/5min/m2, respectively). The sugar + jaggery solution10% (with 6.04, 5.49, 3.76 and 3.44 bees/5min/m^2respectively) was the second best bee attractant, followed by jaggery solution 10% (5.72, 5.46, 3.99 and 3.41 bees/5min/m^2), sugar solution 10% (5.53, 5.47, 3.80 and 3.56 bees/5min/m^2),glucon-D + milk powder solution 10% (5.22, 5.17, 3.72 and 3.33 bees/5min/m^2), while the least visits of bees were on Glucon-D solution15% (4.85, 4.82, 3.56 and 2.95 bees/5min/m^2respectively).

Keywords: Sesame, indigenous bee-attractants, foraging behaviour, honeybees

Introduction
Sesame (*Sesamum indicum* L.) commonly known as til is one of the important oilseed crops belonging to the family Pedaliaceae with longest history of cultivation in India and is indigenous to Asia and some African countries (Bedigian, 2003). It is also believed that sesame is one of the oldest crops in the world, cultivated for over 4,300 years in Babylon and Assyria (Hwang, 2005). Is most likely the oldest oil seed plant grown in many parts of the world, China, India, and Myanmar (Burma) are currently the world's main sesame growers, followed by Sudan, Nigeria, Pakistan, Bangladesh, Ethiopia, Thailand, Turkey, and Mexico. Asia and Africa account for roughly 90% of all cultivated land (Desai, 2004).

It is one of the important oil seed crops of Chhattisgarh to with an area of 0.3 lakh hectares and production and productivity of 0.14 lakh tones and 452 kg/ha which is considerably low compared to the national average productivity of 448 kg/ha (Anonymous 2019). The area, production and productivity of sesame in India are 1.60 million hectare, 0.76 million tones and 473 kg/ha during 2018-19 respectively (Anonymous, 2020), and the largest producer of sesame is Gujarat, it contributes 22.3% of total production, followed by 19.2% (West Bangle), 13.5% (Karnataka), 9.8% (Rajasthan), 9.06% (Madhya Pradesh), 4.7% (Tamil Nadu), 4.52% (Andhra Pradesh) and 4.52% (Maharashtra) (Anonymous, 2019).

Honey bees are the primary visitors of sesame flowers, and the best pollinators which contribute nearly 80% of the total insect pollination (Thapa, 2006). Ali and Alam (1933) reported that, *Apisdorsata, A. cerana, Andrena ilerda, Apisflorae, Ceratinasexmaculata, Trichometall aepollinosa, Ceratinasp*., *Nomiasp*.,*Meghachile*sp. and *Xylocopa sp*. were the common insect visitor of sesame. Besides honeybees and other pollinators such as flies, butterflies and wasps were also recorded on sesame flowers in open pollination. However, their frequency of visit was very less compared to honeybees. The honeybees visited more numbers of sesame flowers per minute compared to other pollinators (Panda *et al*. 1989).

Bee pollination results in the increase of yield in various oilseed crops and improves their quality. The role of insect pollinators in enhancing the crop yield helps the farmers to exploit for betterpollination service and honey production. Bees are the best pollinators, which contribute nearly 80%of the total insect pollination. Bee pollination enhances the yield of sesame when compared to that of pollination exclusion (Panda *et al*. 1989; Sanganna and Eshwarappa 2015) [16].

Keeping all these points in view of the above, the present study entitled "Effect of indigenous bee attractants on foraging behaviour of bees in sesame (*Sesamum indicum* L.)" was conducted during *Kharif* season 2020-21.

Materials and Method

The field experiment was conducted in sesame crop and variety RT-351 was taken with all packages of practices. The experimental detail sare follows-

Crop - Sesame
Variety - RT - 351
Date of sowing - 28/07/2020
Distance (R x P) - 30 x 30 cm
Plot size - (3m x 5 m) = 15 m^2
Treatment - 8
Replication - 3
Design - RBD (Randomized Block Design)

Treatment details

S. No.	Treatments	Formulation or dose/ha
T_1	Jaggery solution	10%
T_2	Jaggery solution	15%
T_3	Sugar solution	10%
T_4	Sugar solution	15%
T_5	Glucon -D + milk powder	10%
T_6	Glucon-D solution	15%
T_7	Sugar + Jaggery	10%
T_8	Control	-

Method of observation

The foraging behaviour of different bee species were recorded at 0800-1000, 1000-1200, 1400-1600hrs (2hrs interval) from randomly selected 1m^2 area within 5 minutes. Such observations were made a day before the spray of bee attractants and one, three, five and seven days after each spray on the crop. Each treatment was replicated in the three times and the data was subjected to RBD analysis.

Results and Discussions

Observation on effect of indigenous bee attractants on foraging behavior of in sesame was recorded at various time of interval during 10 and 50 percent of flowering stage. There was a distinct change in bee visitation after the spray of bee attractant, which was not seen before to the spray, and bee visitation was found to be enhanced in all treatments after the spray. A day before the 1st spray the result revealed that the average number of bee visitations was recorded uniform on sesame flower among in all the treatments.

Overall visitations of rock bees after 1st and 2nd sprays the jaggery solution 15% (7.02 bees/5 min/m^2) was showed significantly superior followed by sugar solution 15% (6.18 bees/5min/m^2) and jaggery + sugar solution 10% (6.04 bees/5min/m^2). The second best treatments were found on jaggery solution 10% (5.72 bees/5min/m^2), sugar solution 10% (5.53 bees/5min/m^2), Glucon –D + milk powder solution 10% (5.22 bees/5min/m^2), and Glucon –D solution 15% (4.85 bees/5min/m^2) over control. Control without any spray was counted to be the least efficient in attracting average number of bees (3.85 bees/5min/m^2), which are presented in (Table 1). After 1st and 2ndspray, jaggery solution 15% (6.48 bees/5 min/m^2) treated plots was maintain superiority with higher number of Indian bee visits. Sugar solution 15% (5.80 bees/5min/m^2) sprayed plot was second best treatment followed by sugar + jaggery solution 10% (5.49 bees/5min/m^2), sugar solution 10% (5.47 bees/5min/m^2), jaggery solution 10% (5.46 bees/5min/m^2) and glucon - D + milk powder solution 10% (5.17 bees/5min/m^2) which were on par with each other.Glucon-D solution 15% (4.82 bees/5min/m^2) was intermittent but higher bee visits on sesame as compared to control (3.61 bees/5min/m^2), which are presented in Table 2.

The Italian bee visits after 1st and 2ndspray, jaggery solution 15% (4.55 bees/5 min/m2) was attracted significant higher number of bee visits followed by sugar solution 15% sprayed plots (4.20bees/5min/m^2). The second best treatment was jaggery solution 10% (3.99 bees/5min/m^2)followed by sugar solution 10% (3.80bees/5min/m^2) sugar + jaggery solution 10% (3.76bees/5min/m^2), glucon-D +milk powder solution 10% (3.72bees/5min/m^2) and glucon -D 15% (3.56bees/5min/m^2), whereas minimum number of bee visits was noticed on control plot with 3.07bees/5min/m^2 (Table 3).

The foraging behavior of little bee after 1st and 2ndspray showed that jaggery solution 15% (4.29 bees/5min/m^2) was the superior treatment (Table 4). The second best treatment were sugar solution 15% (3.88 bees/5min/m^2) followed bysugar solution 10% (3.56 bees/5min/m^2), sugar + jaggery solution 10% (3.44 bees/5min/m^2),jaggery solution 10% (3.41 bees/5min/m^2) and glucon-D + milk powder solution 10% (3.33 bees/5min/m^2).Least number of bee visits was recorded in untreated control (2.39 bees/5min/m^2).

These results are in close agreement with finding of Kumari and Rana (2018) contrived about the efficacy of different bee attractants in attracting insect pollinators to onion (*Allium cepa* L.) bloom after spraying both, Bee Scent @ 7.5% proved best in attracting higher number of insect pollinators of each group up to third day followed by Bee Scent @ 5%, Bee Scent @ 2.5%, followed by sugar solution @ 10% and honey solution @ 2%. The least number of insect pollinators of each group were recorded in open pollination without spray (untreated control). Similarly, supported by Chandrashekhar and Sattigi (2009) who worked on **t**he effect of bee pollination on qualitative and quantitative parameters of radish by spraying of bee attractants like (10%) cacambe and (10%) jaggery solution were significantly superior in enhancing both quantitative and qualitative parameters of radish seed.

Current findings are partially supported with the work of Sivaram *et al*. (2013) who observed that applications of Bee-Q at 12.5 g/l and fruit boost at 0.75 ml/l on niger plots significantly increased the number of bee foragers over the control plots.

Table 1: Effect of indigenous bee attractants on foraging behavior of *Apisdorsata* in sesame during *Kharif* 2020-21

S. No.	Treatments	Bee visitation/5minute/m^2										Overall mean
		First spray (10% flowering)					Second spray (50% flowering)					
		DBS	1st DAS	3rd DAS	5th DAS	7th DAS	DBS	1st DAS	3rd DAS	5th DAS	7th DAS	
1	Jaggery solutions (10%)	1.11 (1.45)	2.11 (1.76)	3.96 (2.22)	5.91 (2.63)	7.9 (2.98)	6.54 (2.74)	8.07 (3.01)	9.49 (3.24)	4.48 (2.34)	1.79 (1.67)	5.46
2	Jaggery solutions (15%)	1.10	2.44	5.1	7.07	9.29	8.16	9.21	10.92	5.70	2.14	6.48

		(1.45)	(1.85)	(2.47)	(2.84)	(3.20)	(3.02)	(3.19)	(3.45)	(2.59)	(1.77)	
3	Sugar solutions (10%)	0.98 (1.40)	2.1 (1.76)	3.64 (2.15)	5.05 (2.46)	8.94 (3.15)	7.59 (2.93)	8.01 (3.00)	9.97 (3.31)	4.31 (2.30)	1.75 (1.65)	5.47
4	Sugar solutions (15%)	1.10 (1.45)	2.23 (1.80)	4.38 (2.32)	5.22 (2.49)	9.07 (3.17)	7.99 (2.99)	8.44 (3.07)	10.41 (3.38)	4.62 (2.37)	2.00 (1.73)	5.80
5	Glucon -D+ milk powder(10%)	1.03 (1.42)	1.8 (1.67)	3.71 (2.16)	4.74 (2.39)	8.6 (3.10)	5.94 (2.63)	7.08 (2.84)	9.36 (3.22)	4.46 (2.34)	1.61 (1.60)	5.17
6	Glucon-D (15%)	0.89 (1.37)	1.61 (1.61)	3.5 (2.12)	4.72 (2.39)	7.89 (2.98)	6.77 (2.79)	7.37 (2.89)	8.99 (3.16)	3.27 (2.06)	1.20 (1.48)	4.82
7	Sugar + jaggery (10%)	1.35 (1.45)	2.32 (1.82)	4.04 (2.25)	5.15 (2.48)	8.53 (3.09)	6.36 (2.60)	8.20 (3.03)	9.56 (3.25)	4.08 (2.25)	2.05 (1.74)	5.49
8	Control	1.14 (1.46)	1.4 (1.55)	2.92 (1.98)	3.93 (2.22)	5.92 (2.62)	3.60 (2.14)	4.85 (2.42)	5.62 (2.57)	3.06 (2.02)	1.16 (1.47)	3.61
SEm+-		0.14	0.04	0.09	0.06	0.06	0.10	0.05	0.04	0.07	0.06	
CD at 5%		N/A	0.12	0.26	0.19	0.20	0.28	0.16	0.14	0.21	0.20	

*Figures in the parentheses are √(x+0.5) transformed values, DBS = Day before spray, DAS = Day after spray

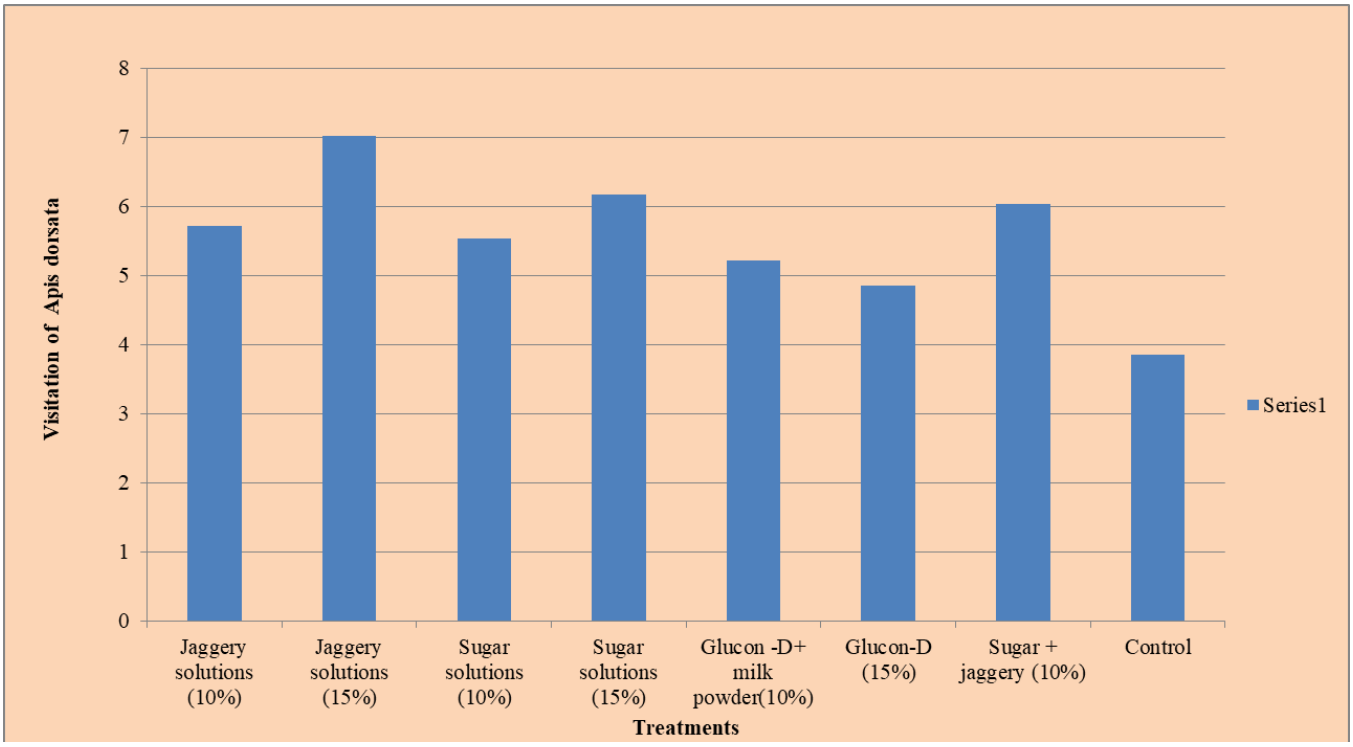

Fig 1: Effect of indigenous bee attractants on foraging behavior of *Apis dorsata* in sesame during *Kharif*2020-21

Table 2: Effect of indigenous bee attractants on foraging behavior of *Apisceranaindica* in sesame during *Kharif* 2020-21

S. No.	Treatments	Bee visitation/5minute/m^2										Overall mean
		First spray (10% flowering)					Second spray (50% flowering)					
		DBS	1st DAS	3rd DAS	5th DAS	7th DAS	DBS	1st DAS	3rd DAS	5th DAS	7th DAS	
1	Jaggery solutions (10%)	1.11 (1.45)	2.11 (1.76)	3.96 (2.22)	5.91 (2.63)	7.9 (2.98)	6.54 (2.74)	8.07 (3.01)	9.49 (3.24)	4.48 (2.34)	1.79 (1.67)	5.46
2	Jaggery solutions (15%)	1.10 (1.45)	2.44 (1.85)	5.1 (2.47)	7.07 (2.84)	9.29 (3.20)	8.16 (3.02)	9.21 (3.19)	10.92 (3.45)	5.70 (2.59)	2.14 (1.77)	6.48
3	Sugar solutions (10%)	0.98 (1.40)	2.1 (1.76)	3.64 (2.15)	5.05 (2.46)	8.94 (3.15)	7.59 (2.93)	8.01 (3.00)	9.97 (3.31)	4.31 (2.30)	1.75 (1.65)	5.47
4	Sugar solutions (15%)	1.10 (1.45)	2.23 (1.80)	4.38 (2.32)	5.22 (2.49)	9.07 (3.17)	7.99 (2.99)	8.44 (3.07)	10.41 (3.38)	4.62 (2.37)	2.00 (1.73)	5.80
5	Glucon -D+ milk powder(10%)	1.03 (1.42)	1.8 (1.67)	3.71 (2.16)	4.74 (2.39)	8.6 (3.10)	5.94 (2.63)	7.08 (2.84)	9.36 (3.22)	4.46 (2.34)	1.61 (1.60)	5.17
6	Glucon-D (15%)	0.89 (1.37)	1.61 (1.61)	3.5 (2.12)	4.72 (2.39)	7.89 (2.98)	6.77 (2.79)	7.37 (2.89)	8.99 (3.16)	3.27 (2.06)	1.20 (1.48)	4.82
7	Sugar + jaggery (10%)	1.35 (1.45)	2.32 (1.82)	4.04 (2.25)	5.15 (2.48)	8.53 (3.09)	6.36 (2.60)	8.20 (3.03)	9.56 (3.25)	4.08 (2.25)	2.05 (1.74)	5.49
8	Control	1.14 (1.46)	1.4 (1.55)	2.92 (1.98)	3.93 (2.22)	5.92 (2.62)	3.60 (2.14)	4.85 (2.42)	5.62 (2.57)	3.06 (2.02)	1.16 (1.47)	3.61
S.Em+-		0.14	0.04	0.09	0.06	0.06	0.10	0.05	0.04	0.07	0.06	
CD at 5%		N/A	0.12	0.26	0.19	0.20	0.28	0.16	0.14	0.21	0.20	

*Figures in the parentheses are √(x+0.5) transformed values, DBS = Day before spray, DAS = Day after spray

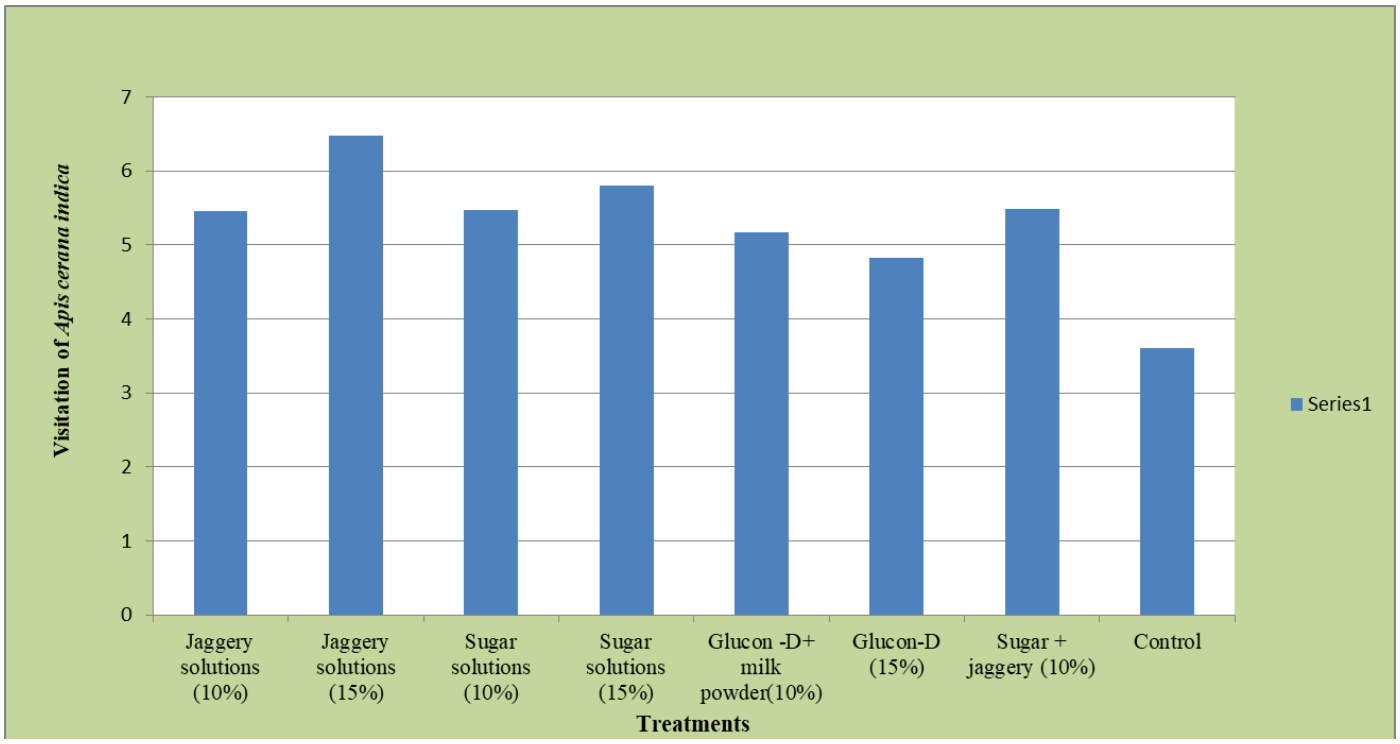

Fig 2: Effect of indigenous bee attractants on foraging behavior of *Apis cerana indicia*n sesame during *Kharif* 2020-21

Table 3: Effect of indigenous bee attractants on foraging behavior of *Apismellifera* in sesame during *Kharif* 2020-21

S. No.	Treatment	Bee visitation/5minute/m^2										Overall mean
		First spray (10% flowering)					Second spray (50% flowering)					
		DBS	1st DAS	3rd DAS	5th DAS	7th DAS	DBS	1st DAS	3rd DAS	5th DAS	7th DAS	
1	Jaggery solutions (10%)	0.99 (1.40)*	1.38 (1.54)	3.4 (2.08)	4.87 (2.42)	6.53 (2.74)	4.55 (2.40)	5.16 (2.77)	6.67 (2.36)	2.49 (1.87)	1.44 (1.6)	3.99
2	Jaggery solutions (15%)	1.19 (1.48)	2.12 (1.76)	4.34 (2.30)	5.44 (2.54)	7.61 (2.94)	4.68 (2.37)	4.99 (2.93)	7.57 (2.38)	2.67 (1.91)	1.69 (1.64)	4.55
3	Sugar solutions (10%)	1.02 (1.42)	1.55 (1.59)	3.3 (2.07)	4.86 (2.42)	6.31 (2.70)	4.08 (2.39)	4.82 (2.68)	6.18 (2.25)	2.19 (1.79)	1.20 (1.48)	3.80
5	Sugar solutions (15%)	1.18 (1.47)	2.00 (1.73)	4.07 (2.25)	5.22 (2.49)	7.06 (2.840	4.66 (2.39)	5.13 (2.77)	6.64 (2.38)	2.23 (1.80)	1.27 (1.51)	4.20
6	Glucon -D + milk powder (10%)	1.14 (1.46)	1.65 (1.63)	3.92 (2.20)	4.45 (2.33)	6.37 (2.72)	4.05 (2.33)	4.76 (2.55)	5.49 (2.24)	1.89 (1.70)	1.26 (1.50)	3.72
7	Glucon-D (15%)	0.99 (1.41)	1.2 (1.48)	3.39 (2.09)	4.44 (2.33)	6.29 (2.70)	3.4 (2.38)	4.81 (2.50)	5.26 (2.10)	2.0 (1.73)	1.07 (1.44)	3.56
8	Sugar + jaggery (10%)	0.95 (1.39)	1.49 (1.58)	3.41 (2.09)	3.89 (2.21)	6.65 (2.76)	4.21 (2.31)	4.38 (2.69)	6.26 (2.28)	2.51 (1.86)	1.45 (1.57)	3.76
	Control	0.86 (1.36)	1.16 (1.47)	2.79 (1.94)	3.7 (2.16)	5.67 (2.58)	3.1 (2.16)	3.89 (2.47)	5.1 (2.47)	1.17 (1.47)	1.05 (1.43)	3.07
S.Em+-		0.07	0.04	0.10	0.06	0.05	0.09	0.04	0.07	0.08	0.02	
CD at 5%		N/A	0.14	0.28	0.19	0.16	0.26	0.13	0.18	0.24	0.07	

*Figures in the parentheses are √(x+0.5) transformed values, DBS = Day before spraying, DAS = Day after spraying

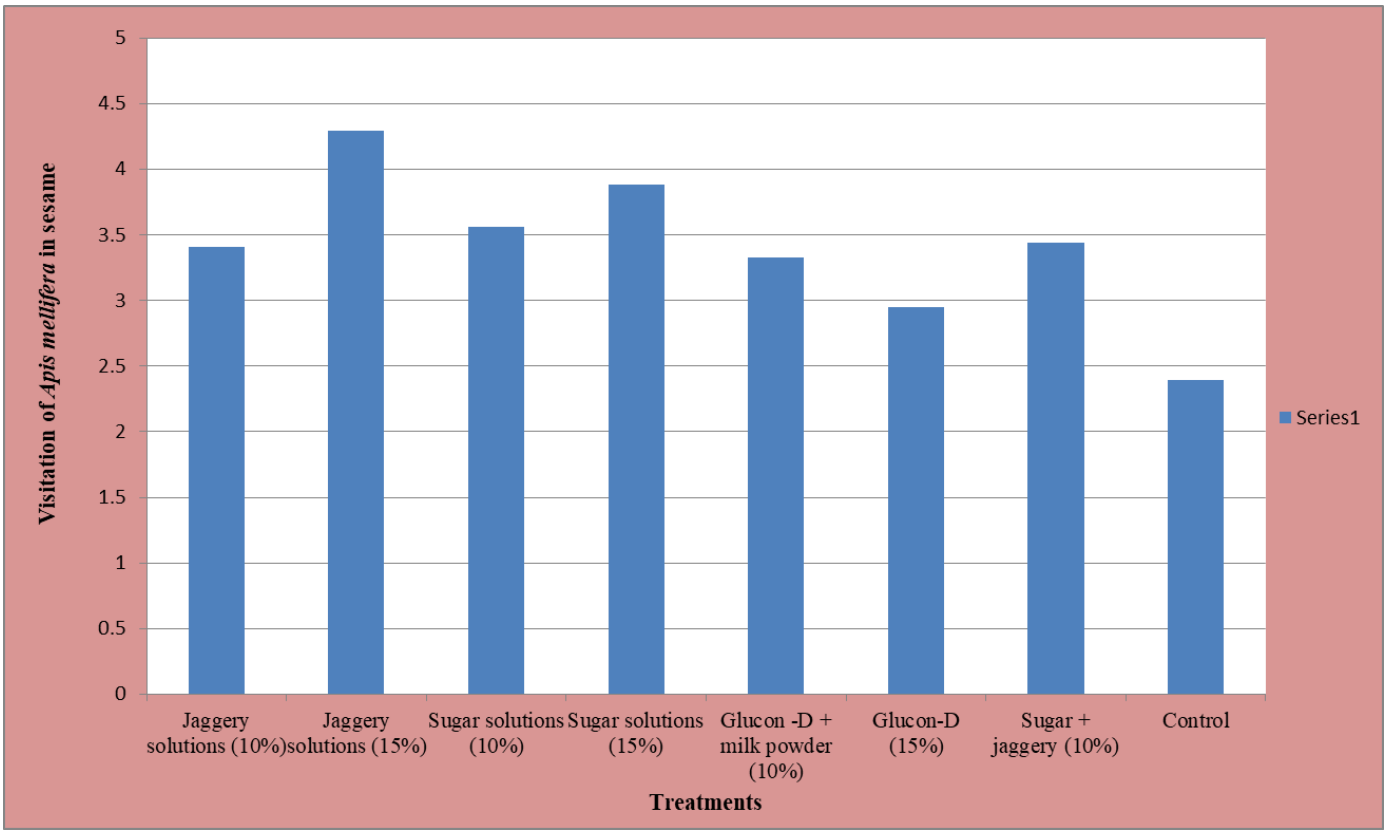

Fig 3: Effect of indigenous bee attractants on foraging behavior of *Apis mellifera* in sesame during *Kharif* 2020-21

Table 4: Effect of indigenous bee attractants on foraging behavior of *Apisflorea* in sesame during *Kharif* 2020-21

S. No.	Treatment	Bee visitation/5minute/m^2										Overall mean
		First spray (10% flowering)						Second spray (50% flowering)				
		DBS	1st DAS	3rd DAS	5th DAS	7th DAS	DBS	1st DAS	3rd DAS	5th DAS	7th DAS	
1	Jaggery solutions (10%)	1.08 (1.44)*	1.33 (1.53)	2.28 (1.80)	4.04 (2.24)	6.17 (2.68)	5.15 (2.48)	6.03 (2.65)	3.88 (2.20)	2.26 (1.81)	1.26 (1.50)	3.41
2	Jaggery solutions (15%)	1.21 (1.48)	2.20 (1.78)	3.30 (2.07)	4.79 (2.40)	7.29 (2.88)	5.78 (2.60)	7.5 (2.92)	4.58 (2.36)	2.64 (1.91)	2.00 (1.73)	4.29
3	Sugar solutions (10%)	1.00 (1.41)	1.78 (1.66)	2.87 (1.96)	4.32 (2.30)	6.24 (2.69)	4.68 (2.38)	6.10 (2.67)	3.99 (2.23)	1.88 (1.70)	1.27 (1.51)	3.56
4	Sugar solutions (15%)	1.22 (1.49)	2.03 (1.74)	3.08 (2.02)	4.17 (2.26)	6.95 (2.82)	5.32 (2.42)	6.51 (2.74)	4.57 (2.36)	2.27 (1.81)	1.42 (1.56)	3.88
5	Glucon -D + milk powder (10%)	1.23 (1.49)	1.73 (1.65)	2.37 (1.83)	3.48 (2.09)	6.32 (2.71)	5.14 (2.67)	5.84 (2.61)	3.76 (2.18)	1.83 (1.68)	1.28 (1.51)	3.33
6	Glucon-D (15%)	0.96 (1.40)	1.25 (1.50)	1.91 (1.71)	2.54 (1.88)	5.85 (2.62)	4.58 (2.36)	5.86 (2.62)	3.37 (2.09)	1.72 (1.65)	1.09 (1.44)	2.95
7	Sugar + jaggery (10%)	1.08 (1.38)	1.35 (1.52)	2.25 (1.80)	3.62 (2.15)	6.27 (2.69)	3.49 (2.11)	6.19 (2.68)	4.03 (2.24)	2.32 (1.82)	1.45 (1.56)	3.44
8	Control	0.85 (1.36)	1.12 (1.46)	1.53 (1.58)	1.78 (1.66)	4.36 (2.31)	3.03 (1.96)	5.12 (2.47)	3.10 (2.03)	1.17 (1.47)	0.91 (1.38)	2.39
S.Em+-		0.13	0.07	0.09	0.13	0.05	0.22	0.06	0.07	0.05	0.05	
CD at 5%		N/A	0.20	0.27	0.39	0.17	N/A	0.18	0.20	0.16	0.15	

*Figures in the parentheses are $\sqrt{x+0.5}$ transformed values,DBS = Day before spraying,DAS = Day after spraying

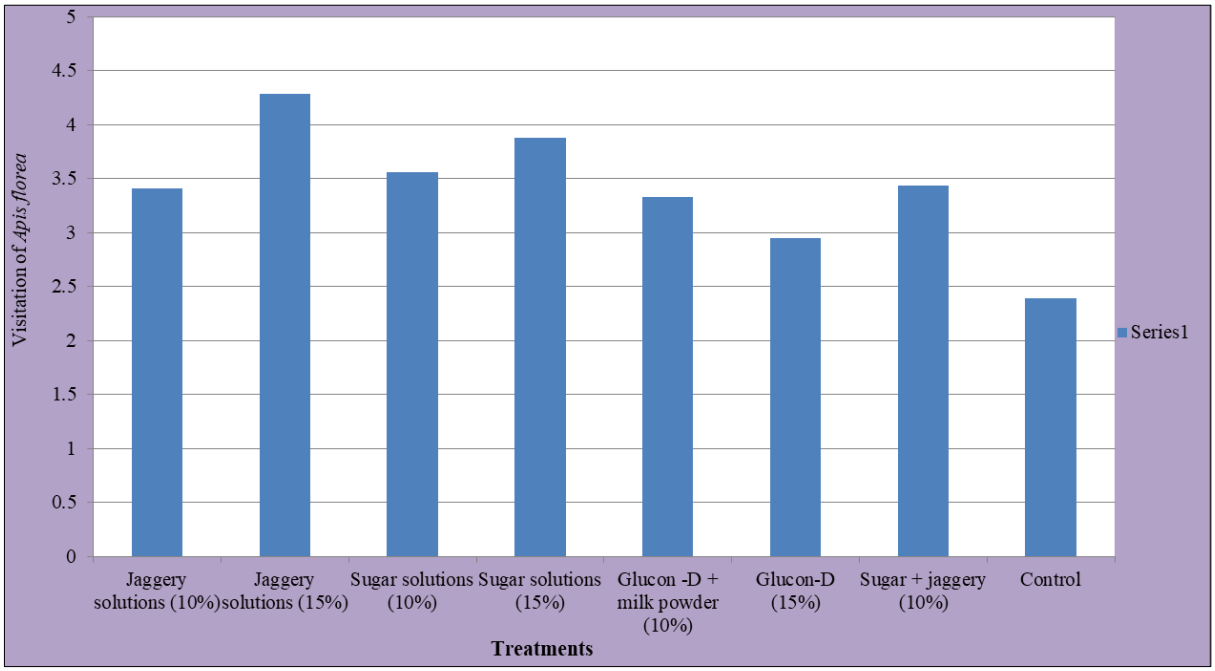

Fig 4: Effect of indigenous bee attractants on foraging behavior of *Apisflorea* in sesame during *Kharif* 2020-21

Apiscerena indica visiting on sesame flower

Apisdorsata visiting on sesame flower

Apis meliffera visiting on sesame flower

Apis florea visiting on sesame flower

Conclusion

The study demonstrated that the jaggery solution (15%) was a best bee attractant to increases the production of sesame crop followed by sugar solution (15%). Timely spraying of bee attractants boosted bee population, resulting in more visits of bees. So 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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