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Sujata Kumari
Department of Seed Science and Technology, School of Agriculture Sciences, Baba Farid Institute of Technology Dehradun, Uttarakhand, India

Kiran Rana
Department of Entomology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India

Correspondence
Sujata Kumari
Department of Seed Science and Technology, School of Agriculture Sciences, Baba Farid Institute of Technology Dehradun, Uttarakhand, India

Efficacy of bee attractants in attracting insect pollinators in onion seed crop

Sujata Kumari and Kiran Rana

Abstract
The efficacy of different bee attractants in attracting insect pollinators to onion (*Allium cepa* L.) bloom was carried out using cultivar Palam Lohit in the experimental field of Seed Science and Technology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during *Rabi* 2012-13. The experiment was laid out in randomised block design (RBD) with eight treatments replicated thrice. There were eight treatments T_1-Bee Scent @ 1%, T_2-Bee Scent @ 1.25%, T_3-Bee Scent @ 1.50%, T_4-Sugar solution @ 5%, T_5-Sugar solution @ 10%, T_6-Honey solution @ 1%, T_7-Honey solution @ 2% and T_8-Untreated control (crop without any spray). The results revealed that one day before both sprays of bee attractants (first at 5% flowering and second after 10 days of first spray), the number of insect pollinators of each group (bees, syrphids and other pollinators) visiting the onion bloom did not differ significantly among the treatments. A after both sprays, 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).

Keywords: Bee attractants, bees, onion, insect pollinators, seed

Introduction
Onion (*Allium cepa* L.) is one of the most important vegetable crops grown in India. The seed production of the crop is peculiar owing to bienniality, allogamy, entomophily and low ovule to seed ratio. One of the major problems in onion seed production is pollination and fertilization of their flowers. Out crossing becomes more critical due to the protandrous nature of the onion plant (Muller, 1983) [11] and the amount of out-crossing may vary from 8 to 71% under different conditions (Van and Van, 1972) [16]. Onion does not produce good quality seed in the absence of abundant pollinators (Chandel *et al.*, 2004 [3] and loss of bulb yield may be as high as 28% after three consecutive generations of inbreeding. The non availability of pollinators at the time of flowering of onion causes only 17% fruit setting whereas good availability of pollinators increased fruiting up to 73% (Rao and Suryanarayana 1989) [14].
Onion seed crop is pollinated by insects including honeybees as the main pollinators (Bohart, 1972, McGregor, 1976) [2, 10]. Therefore, any material that increases the bee's visits to onion crop would be of great value to harness the benefits of cross pollination to enhance seed quality and quantity. Commercial bee attractants viz., Bee Line, Bee Here, Bee Scent, Bee Scent Plus, Fruit Boost and Bee-Q are being used to boost the yield of crops in the United States, Spain and Canada However, in India, the studies on the use of bee attractants are meager and a very few attempts have been made for exploring the possible use of different bee attractants to boost the production of vegetable crop seeds Hence, keeping in view the importance of insect pollination in seed set the main goal was to study the effectiveness of different bee attractants in attracting bees and other insect pollinators of onion bloom.

Material and Methods
The present investigation was carried out at Pandah Experimental Farm of Seed Science and Technology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, HP during *Rabi* season 2012-13. The experiment was laid out in randomised block design (RBD) with eight treatments replicated thrice. The treatment were T_1-Bee Scent @ 1%, T_2-Bee Scent @ 1.25%, T_3-Bee Scent @ 1.50%, T_4-Sugar solution @ 5%, T_5-Sugar solution @ 10%, T_6-Honey solution @ 1%, T_7-Honey solution @ 2% and T_8-Untreated control (crop without any spray).
Crop was raised following recommended package of practices all the attractants were sprayed at 5% flowering of the crop and repeated after 10 days. The different species of insect pollinators recorded on the onion bloom were grouped in three main pollinator groups' viz. bees (bees honey and wild bees), syrphids and other pollinators.

In each plot, one square meter area was randomly selected and number of different insect pollinators of each group visiting these flowers per five minute were recorded at 0900, 1200 and 1500 hours. Such observations were made a day before and 1,2,3,4 and 5 days after each spray. Mean of all the observations were pooled time wise and further subjected to suitable statistical analysis for inference after square root ($\sqrt{x+0.5}$) transformation.

Results and Discussion

Efficacy of bee attractants in attracting the bees to onion bloom

One day before first spray (at 5% flowering) the number of bees did not differ significantly among various treatments (Table 1). After spray, Bee Scent @ 7.5% proved best treatment in attracting overall mean higher number (6.29 bees/m2/5 min) of bees and was at par with Bee Scent @ 5% (5.13 bees/m2/5 min), Bee Scent @ 2.5% (3.49 bees/m2/5 min). The rest of the treatments were inferior to above treatments but attracted significantly more number of bees than control (1.15 bees/m2/5 min). Irrespective of treatments the total number of bees attracted on day one were 2.49 bees/m2/5 min increased to 3.42 bees/m2/5 min on day second and were maximum on day third (4.36 bees/m2/5 min) and afterwards started decreasing and was least (1.79 bees/m2/5 min) on day fifth. Similar results were obtained after second spray (10 days after first spray), Bee Scent @ 7.5% attracted maximum mean number of bees (8.58 bees/ m2/ 5 min) (Table 2).

Mayer *et al*. (1989) [9] observed that Bee Scent and Bee Scent plus when applied on blooming pear, plum and apple increased the number of foraging bees honey (Apis mellifera) and fruit set in treated plots. Nakamura (1997) [12] found that Bee Line and Bee Scent could be used to attract bees to areas small enough to be sprayed with effective of them. Stimulatory effectiveness of jaggery solution, molasses, Bee-Q and sugar solution on Niger was reported by AICRP (2000) [1] and on radish by Chandrashekar and Sattigi (2009) [4]. The increased bee visitation has been reported on crops sprayed with attractants in watermelon (Elmstrom and Maynard, 1991, Sattigi *et al.*, 2001) [5, 15] apple, pear and plum (Mayer *et al.*, 1989) [9], sesamum (Patil *et al.*, 2000, Viraktamath and Anagoudar, 2002) [13, 17].

Table 1: Effect of bee attractants in attracting the bees on onion bloom after 1st spray (at 5% flowering)

Treatment	Concentration (%)	Number of bees/m²/5 minutes						
		1 DBS*	1 DAS**	2 DAS	3 DAS	4 DAS	5 DAS	Mean
Bee Scent	2.5	1.67 (1.82)	1.44 (1.16)	4.67 (2.14)	5.67 (2.34)	3.44 (1.85)	2.22 (1.46)	3.49 (1.79)
Bee Scent	5.0	1.67 (1.94)	4.56 (2.12)	6.89 (2.61)	7.00 (2.65)	4.44 (2.11)	2.78 (1.61)	5.13 (2.22)
Bee Scent	7.5	1.67 (1.79)	6.22 (2.46)	7.22 (2.69)	9.56 (3.07)	5.11 (2.26)	3.33 (1.77)	6.29 (2.45)
Sugar solution	5.0	1.11 (1.66)	1.78 (1.33)	1.89 (1.37)	2.33 (1.44)	1.56 (1.24)	1.23 (1.09)	1.76 (1.29)
Sugar solution	10.0	1.00 (1.78)	1.89 (1.37)	1.89 (1.36)	2.78 (1.62)	1.67 (1.29)	1.55 (1.24)	1.96 (1.38)
Honey solution	1.0	2.33 (1.67)	1.22 (1.09)	1.78 (1.33)	2.78 (1.53)	1.45 (1.20)	1.00 (0.99)	1.65 (1.29)
Honey solution	2.0	1.89 (1.72)	1.55 (1.24)	2.00 (1.41)	3.33 (1.73)	1.67 (1.28)	1.22 (1.08)	1.96 (1.35)
Crop without any spray (Control)	-	2.22 (1.51)	1.11 (1.08)	1.00 (0.99)	1.44 (1.18)	1.11 (1.04)	1.00 (0.99)	1.15 (1.05)
Mean	-	1.69 (3.67)	2.49 (1.48)	3.42 (1.74)	4.36 (1.94)	2.56 (1.53)	1.79 (1.28)	-
*DBS- Day Before Spray, **DAS- Day After Spray								
Figures in parentheses are square root ($\sqrt{x+0.5}$) transformed values								
CD (p= 0.05)								
Treatment (T) :		0.24						
Days (D) :		0.19						
T × D :		0.54						

Table 2: Effect of bee attractants in attracting the bees on onion bloom after 2nd spray (10 days after 1st spray)

Treatment	Concentration (%)	Number of bees/m²/5 minutes						
		1 DBS*	1 DAS**	2 DAS	3 DAS	4 DAS	5 DAS	Mean
Bee Scent	2.5	7.22 (2.69)	7.89 (2.81)	8.56 (2.90)	8.89 (2.98)	6.78 (2.58)	6.44 (2.53)	7.71 (2.68)
Bee Scent	5.0	7.67 (2.77)	8.11 (2.85)	8.78 (2.96)	8.89 (2.98)	7.11 (2.66)	7.22 (2.68)	8.02 (2.79)
Bee Scent	7.5	7.33 (2.70)	8.56 (2.93)	8.89 (2.97)	10.33 (3.21)	7.78 (2.79)	7.34 (2.69)	8.58 (2.91)
Sugar solution	5.0	4.67 (2.16)	7.33 (2.72)	7.56 (2.73)	7.67 (2.75)	6.55 (2.56)	6.00 (2.44)	7.02 (2.64)
Sugar solution	10.0	4.56 (2.13)	8.11 (2.85)	7.89 (2.77)	8.89 (2.97)	6.67 (2.58)	6.11 (2.46)	7.53 (2.78)
Honey solution	1.0	4.33 (2.08)	7.34 (2.70)	7.45 (2.71)	8.00 (2.79)	6.22 (2.49)	4.89 (2.21)	6.78 (2.59)
Honey solution	2.0	5.44 (2.33)	7.33 (2.70)	8.44 (2.90)	8.56 (2.92)	6.33 (2.51)	5.44 (2.33)	7.22 (2.73)
Crop without any spray (Control)	-	4.22 (2.06)	5.33 (2.31)	5.67 (2.38)	5.78 (2.37)	5.67 (2.38)	4.44 (2.10)	5.38 (2.31)
Mean	-	5.07 (2.26)	7.50 (2.73)	7.90 (2.79)	8.38 (2.87)	6.64 (2.57)	5.99 (2.43)	
*DBS- Day Before Spray, **DAS- Day After Spray								
Figures in parentheses are square root ($\sqrt{x+0.5}$) transformed values								
CD (p= 0.05)								
Treatment (T) :		0.16						
Days (D) :		0.13						
T × D :		0.36						

Efficacy of bee attractants in attracting the syrphids to onion bloom

The data recorded on number of syrphids one day before first spray (at 5% flowering) showed no significant difference among various treatments (Table 3). Bee Scent @ 7.5% attracted significantly more number (4.45 syrphids/m2/5 min) of syrphids and was at par with Bee Scent @ 5% (3.95 syrphids/m2/5 min). Whereas in remaining treatments the number of syrphids varied from 1.64-3.78 syrphids/m2/5 min which were statistically at par with each other. The data

further showed that Irrespective of treatments, the maximum number (4.29 syrphids/m2/5 min) of syrphids were attracted on third day after first spray of bee attractants followed by on day second (3.72 syrphids/m2/5 min) and day one (3.45 syrphids/m2/5 min), respectively.

After second spray (10 days after Ist spray), Bee Scent @ 7.5% attracted maximum number (5.13 syrphids/m2/5 min) followed by Bee Scent @ 5% (4.29 syrphids/m2/5 min), Bee Scent @ 2.5% (3.89 syrphids/m2/5 min), honey solution @ 2% (3.62 syrphids/m2/5 min). Data further revealed that sugar solution 5% (2.65 syrphids/m2/5 min), sugar solution @ 10% and honey solution @ 1% attracted the same number (2.38 syrphids/m2/5 min) of syrphids. The least number (1.78 syrphids/m2/5 min) were recorded in control open pollinated crop without any spray of bee attractants (Table 4). Irrespective of treatments, maximum number (5.67 syrphids/m2/5 min) of syrphids were recorded on day third after second spray of bee attractants.

It is evident from present studies that Bee Scent has some stimulatory effect in attracting syrphids to the onion bloom. Manjunath (2003) [8] and Chandrashekhar and Sattigi (2009) [4] reported the influence of Bee-Q, a bee attractant on other pollinators including syrphids.

Table 3: Effect of bee attractants in attracting the syrphids on onion bloom after 1st spray (at 5% flowering)

Treatment	Concentration (%)	Number of syrphids/m²/5 minutes						
		1 DBS*	1 DAS**	2 DAS	3 DAS	4 DAS	5 DAS	Mean
Bee Scent	2.5	3.33 (1.82)	4.11 (2.02)	4.44 (2.06)	5.00 (2.13)	2.89 (1.68)	2.45 (1.40)	3.78 (1.83)
Bee Scent	5.0	3.78 (1.94)	4.22 (2.05)	4.55 (2.12)	5.11 (2.25)	3.22 (1.68)	2.66 (1.42)	3.95 (2.92)
Bee Scent	7.5	3.33 (1.79)	4.67 (2.07)	5.22 (2.27)	5.67 (2.38)	3.67 (1.89)	3.00 (1.63)	4.45 (2.02)
Sugar solution	5.0	2.78 (1.66)	2.89 (1.69)	3.22 (1.72)	4.11 (2.02)	2.56 (1.55)	2.33 (1.51)	3.02 (1.70)
Sugar solution	10.0	3.22 (1.78)	3.11 (1.75)	3.55 (1.82)	4.55 (2.13)	2.55 (1.59)	2.33 (1.49)	3.24 (1.73)
Honey solution	1.0	2.89 (1.67)	2.67 (1.62)	3.00 (1.70)	3.89 (1.93)	2.00 (1.40)	1.56 (1.20)	2.62 (1.55)
Honey solution	2.0	3.00 (1.71)	3.78 (1.94)	4.44 (2.06)	4.66 (2.11)	2.22 (1.48)	1.67 (1.29)	3.35 (1.82)
Crop without any spray (Control)	-	2.33 (1.51)	2.22 (1.62)	1.67 (1.29)	1.33 (1.15)	1.67 (1.29)	1.33 (1.73)	1.64 (1.53)
Mean	-	3.08 (1.68)	3.45 (1.83)	3.72 (1.88)	4.29 (2.01)	2.83 (2.27)	2.37 (1.46)	
*DBS- Day Before Spray, **DAS- Day After Spray								
Figures in parentheses are $(\sqrt{x+0.5})$ transformed values								
CD (p= 0.05)								
Treatment (T) :		1.00						
Days (D) :		0.79						
T × D :		2.24						

Table 4: Effect of bee attractants in attracting the syrphids on onion bloom after 2nd spray (10 days after 1st spray)

Treatment	Concentration (%)	Number of syrphids/m²/5 minutes						
		1 DBS*	1 DAS**	2 DAS	3 DAS	4 DAS	5 DAS	Mean
Bee Scent	2.5	3.22 (1.78)	3.67 (1.91)	4.44 (2.07)	6.11 (2.47)	2.56 (1.59)	2.56 (1.59)	3.89 (1.75)
Bee Scent	5.0	2.78 (1.62)	4.00 (1.99)	5.00 (2.21)	7.11 (2.96)	2.67 (1.60)	2.67 (1.60)	4.29 (1.82)
Bee Scent	7.5	4.22 (2.05)	4.56 (2.13)	6.55 (2.81)	8.77 (3.01)	3.11 (1.75)	2.67 (1.61)	5.13 (1.99)
Sugar solution	5.0	4.11 (2.03)	3.00 (1.71)	4.22 (2.05)	6.00 (2.60)	2.45 (1.56)	2.45 (1.56)	3.62 (1.94)
Sugar solution	10.0	4.11 (2.02)	2.89 (1.68)	3.33 (1.79)	3.11 (1.71)	2.67 (1.63)	2.45 (1.52)	2.38 (1.93)
Honey solution	1.0	4.33 (2.07)	2.67 (1.63)	3.22 (1.76)	3.00 (2.00)	1.67 (1.27)	1.67 (1.27)	2.38 (1.68)
Honey solution	2.0	4.00 (2.00)	2.56 (1.57)	2.78 (1.65)	3.55 (1.88)	2.34 (1.52)	2.00 (1.36)	2.65 (1.81)
Crop without any spray (Control)	-	2.11 (1.44)	1.55 (1.23)	2.01 (1.84)	2.67 (1.62)	1.22 (1.49)	1.44 (1.20)	1.78 (1.55)
Mean	-	3.61 (2.07)	3.11 (1.73)	4.13 (1.99)	5.67 (2.31)	2.46 (1.55)	2.24 (1.46)	
*DBS- Day Before Spray, **DAS- Day After Spray								
Figures in parentheses are square root $(\sqrt{x+0.5})$ transformed values								
CD (p= 0.05)								
Treatment (T) :		0.21						
Days (D) :		0.17						
T × D :		0.47						

Efficacy of bee attractants in attracting the other pollinators to onion bloom

The number of other pollinators recorded on one day before first spray (at 5% flowering) was statistically at par in all treatments ranged between 1.11-1.67 other pollinators/m2/5 min, (Table 5). After first spray of bee attractants, Bee Scent @ 7.5% attracted significantly more number (6.20 other pollinators/m2/5 min) of other pollinators and was at par with Bee Scent @ 5% (5.40 other pollinators/m2/5 min) and Bee Scent @ 2.5% (4.73 other pollinators/m2/5 min) respectively. Irrespective of treatments, the number of other pollinators recorded on day first were 1.46 other pollinators/m2/5 min followed by day second (3.85 other pollinators/m2/5 min) and were maximum (4.46 other pollinators/m2/5 min) on day third.

The number of other pollinators, one day before second spray were statistically at par with each other in different treatments (Table 6). However, Bee Scent @ 7.5% attracted significantly more mean number (6.18 other pollinators/m2/5 min) of other pollinators followed by Bee Scent @ 5% (5.93 other pollinators/m2/5 min), Bee Scent @ 2.5% (5.56 other pollinators/m2/5 minute) and sugar solution @ 10% (5.24 other pollinators/m2/5 min). Irrespective of treatments, the maximum number (6.04 other pollinators/m2/5 min) of other pollinators were attracted on day third after second spray of

bee attractants which was at par with day second (5.38 other pollinators/m2/5 min).

Manjunath (2003) [8] reported attraction of other pollinators after spray of Bee-Q, a bee attractant in sunflower. The increase in other pollinator's visitation on onion sprayed with cacambe (10%) and jiggery solution (10%) was reported by Kalmath and Sattigi (2002) [6].

Table 5: Effect of bee attractants in attracting the other pollinators on onion bloom after 1st spray (at 5% flowering)

Treatment	Concentration (%)	Number of other pollinators/m²/5 minutes						
		1 DBS*	1 DAS**	2 DAS	3 DAS	4 DAS	5 DAS	Mean
Bee Scent	2.5	1.33 (1.15)	4.44 (2.00)	6.00 (2.43)	6.11 (2.45)	4.00 (1.90)	3.11 (1.76)	4.73 (2.11)
Bee Scent	5	1.33 (1.15)	4.78 (2.13)	6.89 (2.61)	7.00 (2.60)	4.56 (2.11)	3.78 (1.94)	5.40 (2.27)
Bee Scent	7.5	1.56 (1.24)	5.11 (2.15)	7.33 (2.67)	8.89 (2.96)	5.11 (2.15)	4.56 (2.13)	6.20 (2.41)
Sugar solution	5	1.11 (1.04)	1.78 (1.29)	2.00 (1.36)	2.78 (1.61)	1.78 (1.32)	1.56 (1.27)	1.75 (1.25)
Sugar solution	10	1.44 (1.19)	2.22 (1.48)	3.00 (1.71)	4.00 (1.81)	2.11 (1.33)	1.33 (1.15)	2.47 (1.47)
Honey solution	1	1.56 (1.23)	1.55 (1.24)	1.66 (1.28)	2.11 (1.45)	1.44 (1.19)	1.29 (1.08)	1.61 (1.19)
Honey solution	2	1.67 (1.29)	2.11 (1.45)	2.33 (1.53)	3.11 (1.72)	1.67 (1.26)	1.22 (1.05)	2.09 (1.40)
Crop without any spray (Control)	-	1.67 (1.25)	1.33 (1.15)	1.55 (1.23)	1.67 (1.27)	1.33 (1.07)	1.00 (1.00)	1.37 (1.20)
Mean	-	1.46 (8.94)	2.91 (1.61)	3.85 (1.85)	4.46 (1.98)	2.75 (1.54)	2.04 (1.32)	
*DBS- Day Before Spray, **DAS- Day After Spray								
Figures in parentheses are square root ($\sqrt{x+0.5}$) transformed values								
CD (p= 0.05)								
Treatment (T) :		0.34						
Days (D) :		0.26						
T × D :		0.75						

Table 6: Effect of bee attractants in attracting the other pollinators on onion bloom after 2nd spray (10 days after first spray).

Treatment	Concentration (%)	Number of other pollinators/m²/5 minutes						
		1 DBS*	1 DAS**	2 DAS	3 DAS	4 DAS	5 DAS	Mean
Bee Scent	2.5	4.89 (2.19)	5.56 (2.36)	6.11 (2.46)	7.11 (2.65)	4.78 (2.18)	4.22 (2.05)	5.56 (2.32)
Bee Scent	5	5.00 (2.23)	5.67 (2.37)	6.22 (2.49)	8.00 (2.82)	5.33 (2.28)	4.45 (2.10)	5.93 (2.40)
Bee Scent	7.5	5.22 (2.29)	6.11 (2.47)	6.45 (2.52)	8.00 (2.82)	5.44 (2.33)	4.89 (2.21)	6.18 (2.47)
Sugar solution	5	5.56 (2.36)	3.89 (1.96)	4.89 (2.19)	5.55 (2.34)	4.36 (2.07)	3.11 (1.76)	4.36 (1.96)
Sugar solution	10	5.67 (2.37)	5.00 (2.23)	5.78 (2.40)	6.78 (2.59)	4.66 (2.15)	4.00 (1.99)	5.24 (2.26)
Honey solution	1	6.44 (2.52)	3.56 (1.87)	5.00 (2.23)	5.00 (2.23)	3.55 (1.88)	3.00 (1.72)	4.02 (1.98)
Honey solution	2	6.22 (2.49)	4.89 (2.21)	5.22 (2.28)	5.22 (2.25)	3.55 (1.87)	3.67 (1.89)	4.51 (2.02)
Crop without any spray (Control)	-	3.33 (1.82)	3.22 (2.21)	3.33 (1.82)	2.67 (1.62)	4.66 (2.15)	2.92 (1.70)	3.36 (1.96)
Mean	-	5.29 (1.96)	4.74 (1.79)	5.38 (2.30)	6.04 (2.42)	3.11 (1.75)	3.78 (1.93)	
*DBS- Day Before Spray, **DAS- Day After Spray								
Figures in parentheses are square root ($\sqrt{x+0.5}$) transformed values								
CD (p= 0.05)								
Treatment (T) :		0.18						
Days (D) :		0.14						
T × D :		0.40						

Conclusion

Influence of bee attractants on visitation of different insect visitors showed that Bee Scent @ 7.5% was the best treatment in attracting bees, syrphids and other insect pollinators on onion bloom after 1st spray (5% flowering) and 2nd spray (10 days after 1st spray) also up to third day. Therefore, it may be suggested that for increased pollinator activity we can repeat the spray after fourth day. It can be concluded from present study that application of bee attractants has positive influence in increasing the visitation of insect pollinators to onion crop thereby resulted in effective cross pollination.

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