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Avinash Udikeri
Department of Entomology, College of Agriculture, Faizabad Narendra Deva of University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Umesh Chandra
Department of Entomology, College of Agriculture, Faizabad Narendra Deva of University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Correspondence
Avinash Udikeri
Department of Entomology, College of Agriculture, Faizabad Narendra Deva of University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Pollination efficiency of different insects on Phalsa *Grewia subinaequalis* D.C

Avinash Udikeri and Umesh Chandra

Abstract
A field experiment was conducted to evaluate efficiency of different pollinators on Phalsa, *Grewia subinaequalis* D.C. a fruiting shrub at Faizabad (U.P) during 2015. The foraging activity started from April month. *Apis dorsata* found to visit more number of flowers (10.01) in a minute by spending very less time (2.27 sec) per flower. *A. mellifera, Halictus sp., Polistes olivaceus* and *Megachile sp*. found visiting 9.35, 6.27, 4.16 and 3.92 number of flowers in a minute and spent 2.82,6.55,7.89,7.31 seconds on flower respectively. *A. dorsata* appeared to be most efficient pollinator on Phalsa with pollination index of 85066 followed by *Apis mellifera.* Highest fruit setting (59.17%) was recorded in the bee pollinated plants followed by open pollinated plants under Kumarganj agro-ecological conditions.

Keywords: bees, foraging rate, pollination index, phalsa

1. Introduction
Phalsa *Grewia subinaequalis* D.C (Order malvales and family Tiliaceae) an indigenous to India and it is mentioned in vedic books. Shrub is known with different names in East and North India. Phalsa was grown naturally at low elevations in dry zone of island of Luzon. Area of Phalsa is very less in the present world, It is only cultivated for research purpose in some places like former Federal Experiment Station, Mayaguez, Puerto Rico, and the Agricultural Research and Education Center, Homestead, Florida (Morton 1987) [10]. It was introduced into Phillipines in 1914 from India and Presently it is cultivated commercially mainly in the Punjab and around Mumbai. Apart from India it is cultivated in Pakistan, Nepal, Bangladesh, Laos, Sri Lanka, Thailand, Philippines, Vietnam and experimental basis in some provinces of United States of America. It bears very hardy fruit, hence can be planted on marginal soils, where rest of the fruits crops cannot be grown. Its cultivation is more popular in peri-urban vicinity. Phalsa fruit is liked for its acidic taste, coloured squash, syrup and medicinal astringent, stomachic values. It decreases inflammation when unripe fruit is eaten and is also administered in respiratory, cardiac and blood disorders, as well as in fever. An infusion of the bark is given as a demulcent, febrifuge and treatment for diarrhea. The root bark is employed in treating rheumatism. The leaves are known to have antibiotic action. It attracts many insects as flower visitors and reported to be pollinated by them Singh *et al.* (2018) [12].
The present studies has been conducted using the various factors such as foraging rate, loose pollen grains sticking to the body, pollination index and fruit set percentage in order to learn about the pollination efficacy of different insects which has not been assessed so far in Phalsa. A better understanding of entomophily may help in better maintenance of Phalsa shrubs and to have better yields.

2. Materials and Methods
The experiments were carried in a well established two years old Phalsa plantation (cv. Dwarf variety) at Main Experimental Station, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) Geographically, it is situated at 26.47^0 N latitude, 82.12^0 E longitude and altitude of 113 meters above mean sea level. The site is located in typical saline-alkaline belt of indo gangetic plains of eastern Uttar Pradesh. The experiment site was having sodic soils. The experiment was conducted in randomized block design. The number of plants selected for observation was ten. The number of treatments were 5 which were replicated 5 number of times.

2.1 Foraging behavior

Foraging behaviour frequent bees associated as the pollinator on Phalsa were recorded as follows:

2.1.2 Working behavior of the pollinators

Each of insect species was observed for its foraging behavior in terms of collection of nectar/pollens. Foraging activity, *i.e*., initiation, peak activity and cessation time of different bee species were visually recorded.

2.1.3 Foraging rate

Foraging rate of bees was recorded in terms of time (second) spent by them on each flower and the number of flowers visited per minute following the method given by Free (1993) [3]. The total of twenty bees of each species were observed for recording time spent by them on flowers of each Phalsa flower and number of flowers visited per minute at two hours interval from 0600 to 1800 h at weekly interval on calm, clear and sunny day during flowering time were counted for alternative 5 days. The time spent was recorded with the help of a stop watch (chronometer) having an accuracy of 0.01 seconds. The number of flowers visited per minute was recorded including the flying time from one flower to another flower.

2.1.4 Pollen grains on body of bees

The loose pollen grains stuck on the body of different species while pollinating were estimated. The bees were captured gently by forceps to avoid shaking of its body from the flowers and its hind legs were amputated following the method given by Kumar (1990) [7]. The bees were captured on their peak activity during peak flowering. The bees were kept in 70 per cent alcohol in glass vial after amputating the hind pair of legs very gently. The bees were shaken vigorously to wash out the pollen grains from their body. Total volume of the rinsate was made to 5 ml before pollen count. An aliquot, 0.1 ml (replicated 6 times) was taken and with the help of a binocular microscope (15x10 magnification), for counting the number of pollen grain. The six individuals of each insect species were captured for counting the pollen grains.

2.2 Pollination efficiency

Comparative pollination efficiency of different insect species *viz*., *Halictus sp*., *Megachile sp*., *Apis dorsata*, *Apis mellifera*, and *Polistes olivaceus* were assessed based on their relative abundance and foraging behavior parameter such as foraging speed, foraging rate and the amount of loose pollen grains sticking to their bodies. The pollination index was calculated by number of loose pollen grains sticking on the body of the bee x abundance of different insect pollinators on flowers of Phalsa. Based on pollination index (number of loose pollen grains sticking to their body x abundance), the pollination efficiency was calculated.

- The minimum time spent per flower is given the highest rank and vice –versa.
- The maximum flowers visited per minute are given the highest rank and vice-versa.
- The insect carrying maximum number of loose pollen grains is given the highest rank and lowest rank is assigned to insect visitors with least number of pollen grains sticking to their bodies.

2.3 Effect of modes of pollination

Effect of pollination such as self-pollination (Without insect pollination), open pollination and bee pollination on fruit set was determined on the plant of Phalsa. In self pollination the five flowering branches were bagged with muslin cloth. open pollination was recorded by tagging the branches and ten plants were covered with mosquito net and bee hives are placed inside the mosquito net. The bags were removed after fruit set. Total number of flowers on the branches was counted and fruit formed from the pre-counted flowers were recorded after one month of flowering to determine the per cent fruit set.

2.4 Statistical analysis

All the data pertaining to relative abundance, foraging speed, foraging rate, loose pollen grains and per cent fruit set, and different aspects were of yields were statistically analyzed by ANOVA and test of significance procedures outlined by Gomez *et al*.(1984) [6]. From the above analysis, standard error of mean (SEm±) as well as, critical difference was calculated at 5% level of probability.

3. Results and Discussion

3.1 Foraging behaviour of insect pollinators

3.1.1. Working behaviour

The data on foraging activity of different bee species on Phalsa flowers presented in Table 1 depicted that *A. dorsata* started collecting pollens from 0600 h of the day, *Apis mellifera* from 0600 h and *Megachile sp*. from 0700 h of the day. Peak activity of pollen collection of all bee species was observed in the morning, i.e., *A. dorsata* peak activity for pollen collecting was 0600-0800, *A. mellifera* peak activity of foraging time was 0700-0900 and as for *Megachile sp*. 0800-1000 was peak time. *A. dorsata* foraging activity for nectar collectors was initiated from 0630 h of the day. In case of *A. mellifera* and *Megachile sp.* it was around 0730h of the day. However, all the three bee species attained their peak nectar foraging activity during 1000-1200 h of the day. This type of working behavior of pollinators appears to be common as Gogoi and Rahman (2007) [5] also observed such pattern from lemon gardens in Assam. Bees visited the flower from 07.00 to 16.00 h while the peak period of foraging was between 10.00 and 11.00 h with 9.42 per minute and the frequency of flower visit was 13.26 per minute. Similarly Deyto and Cervancia (2009) [1], stated that honey bees (*A. mellifera* and *A. cerana*) started foraging activity at 0600 h, while *Trigona spp*. and *Halictus spp*. exploited the flowers at 0630 h and all other insect pollinators at around 0700 h of the day.

3.1.2 Foraging rate

The data on foraging rate, *i.e*., time spent by different bee species on Phalsa flowers during April-May 2015 have been narrated in table 2. Time spent per flower by five insect species differed significantly. The maximum time per flower was spent by *Polistes olivaceus* (7.89 sec/fl) followed by *Megachile sp*. (7.31sec/fl) and *Halictus spp.* (6.55 sec/fl). Further *A. mellifera* (2.82 sec) and *A. dorsata* (2.27 sec) found to spend significantly less time on flowers. Irrespective of different bee species, the mean time spent during different day hours differed significantly. The mean time spent by five insect species during 0600-0800 h of the day (6.30 seconds/flower) was significantly higher than the mean time spent by five insect species during 0800-1000 h (5.51 seconds/flower), 1000-1200 h (5.05 Seconds/flower) and 1600-1800 (4.61 seconds/flower) of the day. As per Gill (2001) [4], *A. florea*, *A. mellifera* and *A. dorsata*, spend about

6.3, 8.4 and 8.8 sec/flowers respectively on any flowering plants. Thus Phalsa also has been accepted as good foraging hosts for these pollinators. On the basis of number of Phalsa flowers visited per minute *A. florea* (8.3 flower/min) considered to be swift pollinator than *A. mellifera* (5.7 flowers/min.) and *A. dorsata* (5.3 flowers/min.).

The data on flowers visited per minute by different bee species on Phalsa flowers (table-3) depicted significant differences. Among different pollinators mean foraging rate was highest in *A. Dorsata* (10.01 flowers/min) followed by *A.mellifera* (9.35 flowers/min), *Halictus spp.* (6.27 flowers/min), *Polistes olivaceus* (4.16 flower/minute). These findings were in close proximity with the finding of Kumar (2010) [9], who reported almost similar trend of these pollinators in bitter gourd flowers.

Significant differences were also found in the foraging rate of different insect species on Phalsa flowers during different hours of the day. Irrespective of different bee species, the mean flowers visited per minute by five insect species were maximum (7.39 flowers/min) during 0800-1000h followed by (7.32 flowers/min) 0600-0800h and (6.20 flowers/min) 1600-1800. During 1000-1200 h of the day (6.02 flowers/min) foraging rate was minimum. The observation for foraging speed and foraging rate of five insect species could not be elucidated for 1200-1600 h due to absence of such activity.

3.2 Loose pollen grains sticking on the body of insect pollinators

The number of loose pollen grains sticking to the body of bees while foraging on Phalsa flowers has been presented in fig 1. *Apis dorsata* had the highest loose pollen grains on their body av. 85066 pollen grains followed by *A. mellifera* with average of 68025 pollen grains, *Megachile sp*. av. 15316 pollen grains and *Halictus spp*. with average of 11116 pollengrains. It was lowest in case of *Polistes olivaceus* with av. 6350 pollen grains. Irrespective of five insect species, the number of loose pollen grains sticking to the body of bee differed non-significantly among different replication of Phalsa. Similarly, Kumar (2002) [8] observed that the number of sunflower loose pollen grains sticking on the body surface of *A. dorsata* was maximum (111109.40 during April 2002 and 90623.45 during May 2002) followed by *A. mellifera* (74998.45 during April 2002 and 72917.70 during May 2002).

3.3 Pollination efficiency

The data on pollination efficiency of different insect species foraging on Phalsa flowers presented in Table-4 depicted that *Apis dorsata* entrapped maximum number of pollen grains av. 85066 pollen grains followed by *A. mellifera Megachile sp*., *Halictus spp.* with an average of 68025, 15316,11116 pollen grains respectively. *Polistes olivaceus* entrapped least number of pollen grains with an average of 6350 number of pollen grains.

The abundance of *Halictus spp*. 4.37 bees/branch/5 minutes was highest followed by *Megachile sp*. *(3.88* bees/branch/5 min) *A. dorsata* (2.89 bees/branch/5 min) and *A. mellifera* (2.53 bees /branch/5 min). While, the abundance was least in case of *Polistes olivaceus*. Further pollination index of *A. dorsata* was highest 245840 followed by *A. mellifera* 172103, *Megachile sp*. 59426, *Halictus spp*. 48576. *Polistes olivaceus* was poor pollinator among the group with pollination index of 15748. Hence, it was observed that *Apis dorsata* was most efficient pollinator followed by *A. mellifera, Megachile spp*. and *Halictus spp*. on Phalsa flowers under agro-ecological conditions of Kumarganj, Faizabad. Such pollinator abundance and efficiency has been evidenced by Rao and Suryanarayana (1988) [11] in watermelon a significant crop of entomophily. Thus Phalsa also found to be a prominent host for great deal of entomophily.

3.4 Effect of different modes of pollination on fruit set

The perusal of data presented in fig 2 revealed that the mean per cent fruit set in different modes of pollination differed significantly among themselves. Bee pollination produced the maximum number of fruits set range per branch (30 inch) 58 to 69 fruits respectively. Significantly less fruits set was observed in self pollinated treatments (30-38 fruits/branch). Here insect pollination was avoided by covering flower with muslin clothes sleep bag of size 30 x5 inch. Thus the result could show that bee pollinated plants have significantly higher fruit set per cent 59.17 than the mean of open pollinated (47.16) and self pollinated (33.25) plants. The present findings are supported by Fracasso and Sazima (2004) [2] who found that fruit-set under natural conditions (70%) was similar to that from hand crosses (74%), but higher than fruit-set from selfed flowers (12.5%).

Thus the present studies revealed a good deal of insect pollination in Phalsa and its advantage in terms of fruit yields

Table 1: Foraging period of different insect species on Phalsa flowers

Bee species	Activity time (h)		
	Initiation	**Peak**	**Cessation**
Pollen foraging (number of bees)			
Apis dorsata	0600	0600-0800	1800
Apis mellifera	0600	0700-0900	1700
Megachile sp.	0700	0800-1000	1700
Nectar foraging (number of bees)			
Apis dorsata	0630	1000-1200	1730
Apis mellifera	0730	1000-1200	1700
Megachile sp.	0730	1000-1200	1730

Table 2: Time spent by different insect species on Phalsa flowers at different hours of the day

Pollinators	Time spent by pollinators on flowers at different time interval of the day (Sec)				
	06.00-08.00	**08.00-10.00**	**10.00-12.00**	**16.00-18.00**	**Mean**
A. dorsata	2.5 (1.72)	4.01 (2.12)	1.34 (1.36)	1.26 (1.33)	2.27 (1.63)
A. mellifera	2.85 (1.83)	4.25 (2.17)	2.15 (1.62)	2.05 (1.59)	2.82 (1.82)
Halictus sp.	8.00 (2.92)	5.29 (2.41)	7.51 (2.83)	5.35 (2.42)	6.55 (2.64)
Polistes olivaceus	9.65 (3.18)	6.79 (2.70)	7.94 (2.90)	7.18 (2.77)	7.89 (2.89)
Megachile sp.	8.5 (3.00)	7.21 (2.78)	6.31 (2.61)	7.21 (2.78)	7.31 (2.79)
Mean	6.3 (2.55)	5.51 (2.44)	5.05 (2.27)	4.61 (2.17)	
SEm±					0.039
CD at 5%					0.115

Figures in the parenthesis are square root transformed values.

Table 3: Number of flowers visited by different insect species at different hours of the day

Insect Visitors	Numbers of flower visited by pollinators in a minute at different day hours				
	06.00-08.00	**08.00-10.00**	**10.00-12.00**	**16.00-18.00**	**Mean**
A. dorsata	13.20 (3.7)	7.90 (2.90)	8.41 (2.98)	10.5 (3.32)	10.01 (3.23)
A. mellifera	11.55 (3.47)	8.15 (2.94)	8.20 (2.95)	9.50 (3.16)	9.35 (3.13)
Hallictus sp.	5.35 (2.42)	8.66 (3.03)	6.73 (2.69)	4.34 (2.20)	6.27 (2.58)
Polistes olivaceus	3.23 (1.93)	6.63 (2.67)	3.85 (2.08)	2.93 (1.85)	4.16 (2.27)
Megachile sp.	3.42 (1.98)	5.61 (2.47)	2.91 (1.85)	3.73 (2.06)	3.92 (2.09)
Mean	7.32 (2.70)	7.39 (2.80)	6.02 (2.51)	6.20 (2.53)	
SEm±					0.084
CD at 5%					0.246

Figures in the parenthesis are square root transformed values.

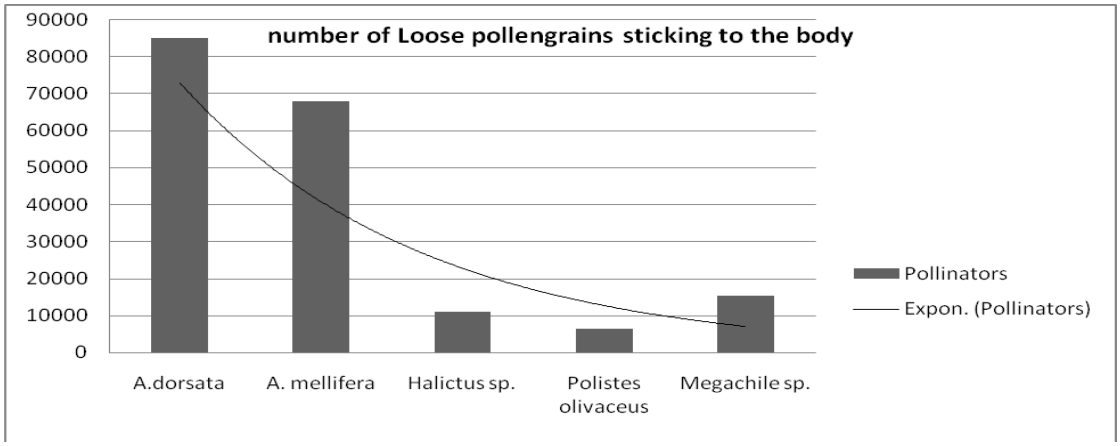

Fig 1: Number of loose pollen grains sticking on the body of different insect species during 2015.

Table 4: Pollination efficiency of different bee species on Phalsa flowers during 2015

Bee species	Time spent per flower	Number of flowers visited/ minute	Abundance (bees/ branch/5 minutes)	Number of loose pollen grains sticking on the body of a bee	Pollination index (abundance × loose pollen grains)	Pollination efficiency (Rank)
A. dorsata	2.27	10.01	2.89	85066	245840	1st
A. mellifera	2.82	9.35	2.53	68025	172103	2nd
Halictus spp.	6.55	6.27	4.37	11116	48576	4th
Polistes olivaceus	7.89	4.16	2.48	6350	15748	5th
Megachile sp.	7.31	3.92	3.88	15316	59426	3rd

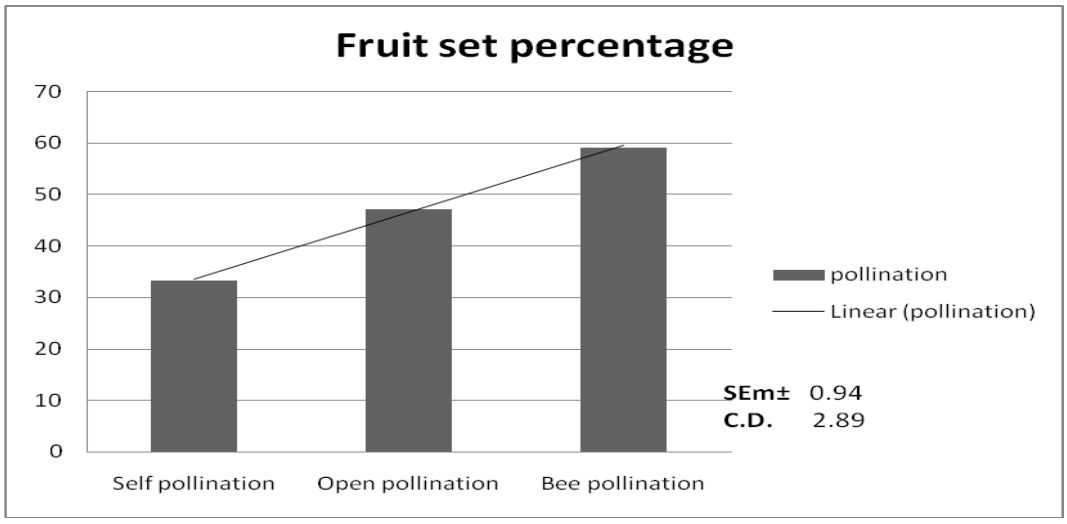

Fig 2: Effect of different modes of pollination on fruit set in Phalsa crop

4. Conclusion

Based on pollination index the present studies revealed that, *A. dorsata* was found to be the most efficient pollinator of Phalsa flowers with the pollination index of 245840 followed by, *Apis mellifera*, *Halictus spp.*, *Megachile spp.* and *Polistes olivaceus* having pollination index 172103, 59426, 48576 and 15748 respectively under agro-ecological conditions of Kumarganj (faizabad).

5. References

1. Deyto RC, Cervancia CR. Floral biology and pollination of Ampalaya (*Momordica charantia* L.). Philipp. Agri.

Scientist. 2009; 92(1):8-18.
2. Fracasso CM, Sazima M. Pollination of *Cambessedesia hilariana* (Kunth) D C. (Melastomataceae): Reproductive success versus bee diversity, behaviour and frequency of visits. Revista Brasileira de Botanica. 2004; 27(4):797-804.
3. Free JB. Insect pollination of crops (2nd ed.). Academic Press, Harcourt Brace Jovanovich Publ., London, 1993, 684.
4. Gill SS, Kaushik HD, Sharma SK. Effect of modes of pollination on fruit set and insect pollinators of Phalsa (*Grewia subinaequalis* D. C.). Res. on Crops. 2001; 2(2):193-196.
5. Gogoi B, Rahman A, Rahman S, Deka MK. Foraging behaviour and effect of *Apis cerana* pollination on fruit set and yield of Assam lemon (*Citrus limon*). Ind. J. of Agricl. Sci. 2007; 77(2):120-122.
6. Gomez KA, Gomez AA. Statistical procedures, John wiley and son, 1984, 644-655.
7. Kumar S. Studies on insect pollination in ber (*Ziziphus mauritiana* Lamk.). M.Sc (Agri). Thesis, CCS Haryana Agricultural University, Hisar, Haryana, India, 1990, 12.
8. Kumar S. Studies on the activities of insect pollinators of cucurbit crops. M.Sc (Agri). Thesis, CCS Haryana Agricultural University, Hisar, Haryana, India, 2002, 14.
9. Kumar BP. Studies on insect pollinators on Bitter gourd (*Momordica Charantia* L.) M.Sc. Thesis, Haryana Agricultural University, Hisar, Haryana, India, 2010, 15.
10. Morton J. Phalsa In: Fruits of warm climates. Julia F. Morton, Miami, FL, 1987, 276-277.
11. Rao GM, Suryanarayana MC. Studies on pollination of watermelon [*Citrullus lanatus* (Thunb) Manst.]. Indian Bee J. 1988; 50:5-8.
12. Singh KK, Singh SP. Cultivation and utilization in Phalsa (*Grewia asiatica* L.) under Garhwal Himalayas region, Journal of Medicinal Plants Studies. 2018; 6(1):254-256.