

Floral Biology of Litchi and Effect of Bee Pollination on Yield and Yield Attributing Parameters

Matangi Mishra, Neeraj Kumar

Received 23 January 2018; Accepted 12 February 2018; Published on 3 March 2018

Abstract The floral biology of litchi was found best suited for insect pollinators especially for honey bees. Insect pollination is crucial in the production of many commercially important crops. Litchi is excellent honey plant and seems to depend on insect for cross pollination. Bee pollinated crop and open pollinated crop showed significant increase in both qualitative and quantitative characteristics of litchi cv Shahi. The increase in yield was 28.55% in bee pollinated crop and 30.61% in open pollinated crop over self pollination. The result indicated that there was 24.89% increase in fruit set. Insect pollination significantly increases the fruit quality viz., TSS, aril weight, seed-

pulp ratio. The nectar-sugar concentration in litchi flowers ranged from 61.00% to 78.00% which indicated that litchi is a good bee flora attracting several insect pollinators for collecting floral reward.

Keywords Floral biology, Bee pollination, Nectar-Sugar concentration, Litchi.

Introduction

Litchi is an evergreen subtropical plant, indigenous to areas where cool, dry winters and warm, wet and humid summers prevail. *Litchi chinensis* Sonn. is a dense, round topped tree with a smooth grey trunk and limbs. The litchi inflorescence are many branched panicle, 5—30 cm long, many flowered, flowers small, yellow white functionally staminate or pistillate, calyx four to numerous, corolla absent, stamens usually 6, rarely 10, filaments long in staminate flowers and short in pistillate flowers. Honey bees contribute for increased quality and quantity in litchi crop. Honey bees have an edge over other pollinators because their population can be easily managed and precisely manipulated as per pollination requirement. Litchi is excellent honey plant and seems to depend on insect for cross pollination. The role of honey bees in agricultural production has been surprising. The variation in nectar sugar concentration may be due to geographical locations or may be due to varietal differences, which determines the preferences of honey bees.

Matangi Mishra*, Neeraj Kumar
Department of Entomology,
Dr Rajendra Prasad Central Agricultural University,
Pusa, Samastipur, Bihar 848125, India
e-mail : matangi.gaurav@gmail.com
*Corresponding author

Mustard (1960) reported that in litchi all the flowers have male and female reproductive tissues and they were classified as hermaphrodite. Pandey and Yadava (1970) found that honey bees collect pollen mainly at the beginning and the end of the flowering. Earlier workers also reported that in litchi another dehiscence takes place throughout day and night, mostly from morning to mid-afternoon and pollen is not attractive to most of the pollinators (Das and Choudhary 1958, Chadha and Rajpur 1969).

Shukla and Bajpai (1974) considered the appearance of enlarged leaf primordia and lateral meristems on the elongating main axis to be the first indications of floral differentiation in litchi. Kumar et al. (1996) studied the floral biology of litchi and reported that anthesis occurred throughout the day and flower had a life of 4–5 days. Stern and Gazit (1996) found that litchi inflorescence were rich source of nectar and also highly attractive to insects. Mahanta and Rehman (1997) observed in litchi that the bee pollination resulted in an average yield of 64.75 fruits per branches that weighed 20.55 g while the flower that had no visits yielded 26.49 fruits weighing 13.98 g per branch. Fruit yield per hectare was 70 tonnes in bee pollinated plots as compared to 36.8 tonnes in self pollinated crops. Choudhary et al. (2001) found that in litchi fruits per panicle, fruit set and fruit yield was significantly higher in both bee pollination and open pollination treatment over self-pollination. Abrol (2010) stated that there were 11.20% malformed fruits in open pollinated plots of litchi as compared to 17.44% in control plots. Nair (1988) reported that sugar concentration in the nectar of litchi varied from 61–78% and highest concentration was observed at 1130 h when the temperature was highest with lowest humidity. Stern and Gazit (1996) reported a correlation between bee density on the M1, F and M2 flowers and sugar in the nectar but a negative correlation between bee density and nectar volume for M2 and F flowers in litchi. The proportion of glucose (43%), fructose (39%) and sucrose (18%) in the nectar was similar for the three flower types.

Materials and Methods

The floral biology of litchi variety Shahi was studied

Table 1. Floral biology of litchi cv Shahi.

Parameters	Result
1. Flowering period	First week of March to First week of April
2. Type of inflorescence	Cymose
3. No. of panicle/m ²	20–28
4. No. of flowers/panicle	2206–2388
5. Time of anthesis	Throught day and night
6. Life of individual flower (day)	3–5
7. Color of flower	Creamy white or Yellowish green
8. Size of flower	3–7 mm wide and 7–10 mm long having 4–5 serrated sepals without petal (apetalous)
9. Type of flowers	3 Types
(a) Type I flowers (Staminate)	Morphologically and functionally male possessing 1.5 mm long 6–8 stamens having abundant of pollen
(b) Type II flowers (Pistillate)	Morphologically hermaphrodite, functionally female with a well developed two carpel pistil and two lobed stigma. The 5–8 stamens did not dehisce normally and have less visible pollen
(c) Type III flowers (Pseudohermaphrodite)	Morphologically hermaphrodite with a rudimentary pistil, lacking style and stigma
10. Basal gap between stamens (mm)	0.4–0.7
11. Sex ratio (male : female)	1.85:1
12. Amount of nectar secretion (µl)	1.4–6.30
13. Pollen viability	12–36
14. Time taken for fruit maturity (days)	80–84

at Pusa farm. The observations were recorded on the parameters viz., number of panicles per square meter, number of flowers per panicle, time of anthesis, time of anther dehiscence, life of individual flower (days), amount of nectar secretion (µl) and time taken out for fruit maturity (days).

To assess bee pollination on litchi crop cv Shahi, an experiment was carried out with three treatments and having seven replications in RBD : T₁ - Open to all pollinators (OP), T₂ - Pollinator Exclusion (PE), T₃ - Caged with *Apis mellifera* (5-frame colony).

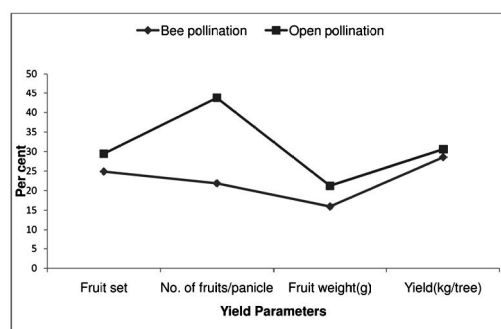


Fig. 1. Per cent increase in yield parameter in bee pollination and Open Pollination over Pollination Exclusion (Control) in litchi cv Shahi.

The observation were recorded on the following parameters: (a) Fruit set (per panicle)- By visual observation, (b) Fruit weight (g)- By electronic balance, (c) Fruit yield (kg/tree)- By electronic balance, (d) Weight of pulp (g)- By electronic balance, (e) Weight of skin (g)- By electronic balance, (f) Weight of seed (g)- By electronic balance, (g) Seed-Pulp ratio- seed/pulp, (h) TSS ($^{\circ}$ Brix)- By hand refractometer.

The percent concentration of sugar in nectar of litchi flowers cv Shahi was recorded with the help of hand refractometer.

Results and Discussion

Floral biology

Present study was undertaken to information on floral biology of litchi cv Shahi. The results obtained are presented in Table 1. The flowering started in the 1st week of March to 1st week of April. About 20–28 panicles were recorded in a square meter area. The inflorescence was cymose type. The individual flowers were cup shaped calyx with stamen and pistil inserted on it. The litchi flowers were 3–7 mm wide and 7–10 mm long having 4–5 serrated sepals without petal (apetalous). The color of flower was creamy white or yellowish green. The inflorescence bears three types

Table 2. Per cent increase in yield parameter in Bee Pollination and Open Pollination Exclusion in litchi cv Shahi.

Treatments	Fruit set	No. of fruits per panicle	Fruit weight (g)	Yield (kg/tree)
Pollination Exclusion	–	–	–	–
Bee Pollination	24.89	21.87	15.93	28.55
Open Pollination	29.46	43.75	21.24	30.61

of flower. Type I flowers (staminate) were morphologically and functionally a male possessing 1.5 mm long 6–8 stamens having abundance of pollen. Type II flowers (pistillate) were morphologically a hermaphrodite, functionally female with well developed two carpel pistil and two lobed stigmas. The 5–8 stamens did not dehisce normally and have less visible pollen. The type III flowers (pseudo-hermaphrodite) function as male, although it was morphologically a hermaphrodite with a rudimentary pistil, lacking style and stigma. There were 2206–2388 flowers were present on a panicle having sex ratio of 1.85:1 (male : female) with 35.00% female flowers. The anthesis of flowers occurred throughout day and night. The observations recorded on pollen viability in litchi flower indicated that the pollen of 0-day old flowers showed maximum viability being 36 h while 4-day old flowers showed minimum viability being 12-h. There was declining trend in pollen viability with the age of flower increased. It was found that the anthesis was throughout the day and night, the life of individual flower was of 3–5 days, the amount of nectar secreted was 1.40–6.30 μ l, pollen viability was of 12–36 h and the time taken for fruit maturity was 80–84 days.

Gupta and Koul (2000) studied the floral biology of the three promising cultivars of litchi, namely Dehradun, Seedless and Calcuttia. Dehradun was the first to flower and had longer flowering period as compared to the two other cultivars. The number of flowers per panicle was also highest (838) in Dehradun. Male flowers were bigger than female ones except in Calcuttia. In all the three cultivars, flower anthesis occurred between 04.00–08.00 h, with peak at 06.00 h. Ray et al. (2000) studied the floral biology of ten litchi

Table 3. Effect of honey bee pollination on fruit quality of litchi cv Shahi. Data are mean of 7 replications.

Treatments	TSS (°Brix)	Weight of pulp (g)	Weight of skin (g)	Weight of seed (g)	Seed- pulp ratio
Pollination Exclusion (PE)	54.60	10.20	4.61	4.21	0.41:1
Bee Pollination (PE)	57.62	13.49	4.52	4.02	0.29:1
Open Pollination (PE)	60.11	14.91	4.29	3.86	0.25:1
SEm (±)	0.94	0.41	–	–	–
CD ($p=0.05$)	2.75	1.21	NS	NS	–

cultivars under North Bihar ecological conditions. They found that anthesis started in second week of March and continued upto first week of April in different cultivars. There were three type of flowers that is staminate, pistillate and pseudohermaphrodite. In the cultivar cv Shahi, no. of flowers per panicle was 2388.00 having 34.97% female flower. Somnuk and Suavansri (2005) studied the floral biology of lychee *Litchi chinensis* cv Khoom. The Khoom produced only pistillate flowers, while the remaining stamens were staminodes such that all anthers could not dehisce.

Effect of bee pollination

To assess the bee pollination on litchi crop, experiment was carried out at University Apiary in 2012 comprising of three treatments with seven replications. The data recorded is presented in Table 2. The maximum number of flowers per panicle in litchi was recorded in OP (2388.0) followed by BP (2231.5) and was least in PE (2206.3) and showed non-significant variation. The fruit set was highest in the OP (3.12%) followed by BP (3.01%) and lowest in case of PE (2.41%). The number of fruits per panicle was 13.8, 11.7 and 9.6 in open pollination, bee pollination and pollination exclusion treatments, respectively. The fruit weight was 23.06, 22.05 and 19.02 in OP, BP and PE respectively; highest in open pollination followed by bee pollination and lowest in pollination exclusion

treatment. The yield was obtained maximum in OP (120.3 kg/tree), followed by BP (118.4 kg/tree) and lowest in PE being 92.1 kg/tree. Considering the above facts it can be concluded that pollination is essential for better yield in litchi crop.

To know the impact of pollination, the data were again analyzed in terms of per cent increase. The per cent increase in yield parameters in OP and BP over PE treatment was calculated and presented in Table 3 and Fig. 1. The result indicated that there was 24.89% increase in fruit set in BP treatment while 29.46% in OP treatment. The no. of fruits per panicle was also observed higher in OP (43.74%) while it was 21.87% in BP treatment. The increase in fruit weight was 21.24% in OP while 15.93% in BP treatment. There was 30.61% increase in yield (kg/tree) in OP treatment while it was 28.55% in BP treatment. The data showed that all the above mentioned parameters were highest in open pollination treatment (OP) in comparison to bee pollination treatment (BP). This might be due to the fact that in OP treatment, pollination was done by the large number of pollinators including different honey bee species present in the ecosystem while in BP treatment only 5-frame *A. mellifera* was used for pollination. The PE treatment was debarred from insect pollinators by caging and it was self-pollinated. Due to visit of large number of pollinators, OP treatment showed superiority in all the parameters over BP and PE.

The effect of honey bee pollination on fruit quality of litchi cv Shahi is presented in Table 3. The observation recorded on the effect of honey bee pollination on fruit quality of litchi cv Shahi indicated that the TSS was maximum in open pollination (60.11° Brix) followed by bee pollinated (57.62° Brix) and lowest in case of pollination exclusion being 54.60° Brix. The weight of pulp was found maximum in open pollination (14.91 g) followed by bee pollination (13.49 g) and was observed minimum in pollination exclusion treatment being 10.20 g. There were non-significant variation in weight of skin and seed in all the treatments. However, the weight of skin and seed was found maximum in case of pollinator exclusion having 4.61 g and 4.21 g, respectively and it was minimum in case of open pollination being 4.29 g and 3.86 g, respectively. The seed-pulp ratio was lower in case of

Table 4. Nectar sugar concentration (%) at different hours of day in *Litchi chinensis* cv Shahi.

Date	Hour of the day			Mean
	0900	1200	1500	
15.03.2012	61.00	65.00	63.00	63.00
19.03.2012	65.00	73.00	70.00	69.33
23.03.2012	72.00	78.00	74.00	74.66
27.03.2012	70.00	75.00	71.00	72.00
31.03.2012	64.00	70.00	66.00	66.66
Mean	66.40	72.20	68.80	69.13
Factors	SEm (\pm)		CD ($p=0.05$)	
Date	0.65		1.89	
Hour	0.67		1.95	
Date \times Hour	–		NS	

open pollination (0.25:1) followed by bee pollination (0.29:1) and it was highest in case of pollination exclusion treatment being 0.41:1. Considering the above parameters it might be concluded that pollination in litchi significantly increases the fruit quality.

Choudhary et al. (2001) also found that in litchi open pollination and bee pollination increased the yield of litchi upon extent of 234.75% and 336.72%, respectively over self pollination Ray (2004) reported that Shahi cultivar of litchi has fruit weight of 22.05 g, aril weight of 14.91 g and having TSS of 21.2°Brix. Abrol (2010) stated that there were 11.20% malformed fruits in open-pollinated plots of litchi as compared to 17.44% in control plots. The percentage of fruit set was much higher in open-pollinated plants than the control.

Nectar sugar concentration

Honey bees are known to respond differently to sugar solutions of different compositions and molarities. The nectar concentration was recorded by using hand refractometer (40–85%) on five different dates at different hours of the day in litchi flowers. The data have been presented in Table 4.

The observations recorded on nectar sugar concentration on different dates of observations in litchi flower indicated that the maximum nectar sugar concentration was on 23.03.12 being 74.66% and minimum on 15.03.12 being 63.00%. The data recorded at

different hours of the day showed that the maximum nectar sugar concentration was at 1200 h (noon) being 72.20%, followed by 1500 h (evening) being 68.80% and minimum at 0900 h being 66.40%. The nectar sugar concentration in litchi flowers ranged from 61.00% to 78.00%. The nectar sugar concentration was low in the morning hours, it might be due to the fact that in morning hours relative humidity was high and the temperature was low.

Chand et al. (1994) and Tanda (1984) found that the nectar sugar concentration was low in the morning and reached a peak in afternoon. Kumar and Singh (2008) reported that nectar concentration in safflower varied between 30.33% to 31.28%. They also observed that nectar sugar concentration varied significantly at different hours on different dates of observation. Kumar et al. (1997) observed that sugar concentration in the nectar of litchi ranged from 60–75%.

Conclusion

The present findings indicated that there was a declining trend in pollen viability with the age of flower increased. It was found that the pollination in litchi significantly increases the fruit quality; it might be due to the fact that the pollination done by insect pollinators, fertilizers ovules in flowers in better way resulting into better quality fruit as compared to self-pollination. The nectar sugar concentration was higher which indicated that litchi is a good flora attracting several insect pollinators for collecting floral reward.

References

- Abrol DP (2010) Differential floral attractiveness as a determinant of foraging decision in honey bees. *Curr Sci* 99 (10) : 1330.
- Chadha KL, Rajput MS (1969) Studies on floral biology, fruit set and its retention and quality of some lychee varieties. *Ind J Hort* 26 : 124–129.
- Chand H, Singh R, Hameed SF (1994) Population dynamics and insect pollination in Indian mustard, *Brassica juncea* L. *J Ent Res* 18 (3) : 233–239.
- Choudhary DK, Singh AK, Singh PP (2001) Influence of honey bee pollination on fruit set and yield of litchi. *Ind Bee J* 63 (1 & 2) : 54–56.
- Das CS, Choudhary KR (1958) Floral biology of litchi (*Litchi chinensis* Sonn.). *South Ind Hort* 6 : 17–22.
- Gupta SP, Koul A (2000) Floral biology of litchi (*Litchi chi-*

- nensis* Sonn.). Haryana J Hort Sci 29 (3 & 4) : 143—144.
- Kumar N, Singh R (2008) Relative abundance of honey bees foragers visiting safflower (*Carthamus tinctorious* L.) and nectar sugar concentration in bloom. Pest Manag and Econ Zool 16 (2) : 135—141.
- Kumar R, Chaudhary OP, Lenin JK (1996) Studies on pollination of litchi (*Nephelium litchi* Camb.) in Dehradun, India. Ind Bee J 58(1) : 10—12.
- Kumar S, Mishra PK, Singh R, Yazdani SS (1997) Qualitative and quantitative study of floral nectar of litchi. Shashpa 4(2) : 121—126.
- Mahanta M, Rehman A (1997) Studies on pollination of litchi by honey bees (*A. cerana* Fab.). Ind Bee J 59(2) : 74—75.
- Mustard MJ (1960) Megagametophytes of lychee (*Litchi chinensis* Sonn.). Proc Am Soc Hort Sci 75 : 292—304.
- Nair KS (1988) Evaluation of importance of litchi as a source of nectar source. Ind Bee J 45(4) : 108—109.
- Pandey RS, Yadava RPS (1970) Pollination of litchi (*Litchi chinensis*) by insects, with special reference to honey bees. J Apicul Res 9 : 103—105.
- Ray PK (2004) Litchi : Production technology and post-harvest handling for export. Pub RAU Pusa (Samastipur), Bihar, pp 43.
- Ray PK, Rani R, Singh SK (2000) Sex ratio and fruit set pattern in ten cultivars. Prog Hort 34 (1) : 17—21.
- Shukla RK, Bajpai PN (1974) Blossom bud differentiation and ontogeny in litchi (*Litchi chinensis* Sonn.). Ind J Hort 31 : 224—228.
- Somnuk B, Suavansri T (2005) Study on pollinating cultivars for fruit setting of Khoom lychee. Acta-Hort 665 : 111—116.
- Stern RA, Gazit S (1996) Lychee pollination by honey bee. J Am Soc Hort Sci 121 : 152—157.
- Tanda AS (1984) Foraging behavior of three honey bees species of *Apis* on Raya in relation to the sugar concentration in its nectar. Ind Bee J 46 : 5—6.