3

Indian Journal of Entomology 83(3): 321-325 (2021)

DoI No.: 10.5958/0974-8172.2020.00216.3

IMPACT OF STINGLESS BEE *TETRAGONULA IRIDIPENNIS* SMITH POLLINATION IN WATER MELON

AVINASH CHAUHAN* AND H K SINGH

Department of Entomology, School of Agricultural Sciences and Rural Development
Nagaland University, Medziphema 797106 Nagaland, India
*Email: avi_shimla@hotmail.com (corresponding author)

ABSTRACT

In this study, pollination in water melon with stingless bee *Tetragonula iridipennis* Smith, open pollination and control (pollinator's exclusion) have been evaluated. Comparative pollination index worked out using foraging parameters, and fruit production and quality parameters was used. Data revealed that *T. iridipennis* bee pollination resulted in heavier fruits (3.428 kg) with bigger size (26.39 cm) as compared to control (0.583 kg), and open pollination treatments (2.996 kg). Fruit set (89.75%) and healthy fruits (81.62%) were more in stingless bee pollination than other modes. Significantly less fruit set (39.57%) was observed without pollination.

Key words: *Tetragonula iridipennis*, water melon, pollination index, pollination, fruit set, TSS, healthy fruits, fruit size, weight, seed number, seed weight

Pollination is one of the important processes responsible for fruit and seed set in plants. Among insects, bees are the main pollinators of crops, and honey bees, stingless bees and bumble bees are important pollinators, in those crops which solely depend on flowers for their development. Honey bees and bumble bees are well studied for their pollination potential but stingless bees are still unexplored. Water melon is a cucurbit cultivated in many parts of the tropics (Cobley, 1965; Masefield et al., 1969). In India, it is grown for its fruits in all subtropical and tropical regions and it is an important source of vitamins, minerals, carotenes, proteins and natural lycopenes (Denton, 2004). The cucurbit vegetables require pollinators for fruit set due to separate male and female flowers on the vines (Roubik, 1995).

Stingless bees are small bees belonging to the order Hymenoptera. Eight species of stingless bees are known from the northeastern states. Of these, five species (*Tetragonula iridipennis* Smith, *T. laeviceps* Smith, *Lepidotrigona ventralis* Smith, *L. arcifera*, *Lophotrigona canifrons* Smith) occur in Nagaland (Chauhan et al., 2019). These bees are used as pollinator in greenhouse crops in both temperate and tropical regions; and some of them are buzz pollinator such as *Melipona quadrifasciata* (Sarto et al., 2005; Santos et al., 2009). Heard (1999) reported that stingless bees are effective pollinators of *Cocos nucifera*, *Mangifera indica*, *Sechium edule*, *Averrhoa carambola* and *Macadamia intergrifolia*. These bees are better pollinating agents due to their characteristics viz., can pollinate small flowers, thrive much better in tropical areas, harmless to humans, coexistent with other bees, can adjust in confined space of greenhouse, more environment friendly, very less swarming ability, less chances of insect pests and disease attack, and short foraging range etc. Further utilization of stingless bees reduces the labour requirement and tedious procedure of hand pollination. Stingless bees are valuable for cross pollination of crops in nethouse condition (Gadhiya, 2015). Keeping these in view, their dominant prevalence in Nagaland and their ability to perform well under greenhouse conditions, present study evaluated the pollination potential of *T. iridipennis* Smith in water melon.

MATERIALS AND METHODS

The experiment was carried out at the Experimental farm AICRP Honey Bees and Pollinators, Department of Entomology, School of Agricultural Sciences and Rural Development (25.75961°N,93.853698°E) under protected conditions. All agronomical practices were done as per good agricultural practices for crop raising and kept same. Two colonies of stingless bee *T. iridipennis* were shifted in the caged plots at 5% flowering and data was recorded. Pollination efficiency index was worked out using foraging parameters as per Bohart and Nye (1960). Impact of stingless bee pollination was evaluated with % fruit set. The female flowers/ vine were pre-counted. Thirty plants from each treatment viz., stingless bee pollinated, control and open pollinated were selected and tagged randomly. The fruit set on these plants were then recorded and total yield was calculated on fruit set basis, and % healthy fruits was also calculated. A sample of thirty fruits was taken for calculating the fruit TSS, rind thickness, diameter and fruit weight (10 fruits/ treatment). The fruit diameter, rind thickness and weight were measured with the scale, digital Vernier caliper and digital weighing balance, respectively. Similarly, 30 mature fruits were taken (10 from each treatment), seeds were removed and kept separately in water for 24 hr. After washing the seeds, these were dried in temperature controlled chambers for 24 hr, and then counted. Weight of 1000 seeds was also observed. The % increase in the fruit set, healthy fruits, diameter, weight, TSS, number of seeds, weight of 1000 seeds were computed along with % decrease in deformed fruits. The data were statistically analysed with suitable transformation in RBD design as per Gomez and Gomez (1984). Data on temperature and humidity was recorded using the digital thermometer and hygrometer.

RESULTS AND DISCUSSION

Different insect visitors were observed in water melon flowers- main ones being: *Tetragonula iridipennis* Smith, *T. laeviceps* Smith, *Lophotrigona canifrons* Smith, *Lepidotrigona ventralis* Smith, *Apis mellifera* L., *A. cerana* F., *A. dorsata* F., *A. florea* F., *X. tenuiscapa* Westwood, *Halictus semiaerinus* and *Megachile lanata* F., visiting the crop throughout the day; however *Musca* sp., *Monomorium* sp. and *Episyrphus* sp. were frequent visitors while *Mylabris pustulata*, grasshoppers, lemon butterflies and pumpkin beetles were found as less frequent under open conditions (Table 1). Chauhan et al. (2019) reported considerable numbers of stingless bees followed by honey bees on ash gourd. Similarly, in 1978, *A. florea, A. mellifera, A. dorsata, Halictus* sp. and *Bombus* sp. were observed by Grewal and Sidhu as main insect visitors of cucurbits. Twenty-four insects were observed to visit cucumber crop by Sajjanar et al. (2004), and hymenopterans were the predominant.

Pollination Efficiency Index was calculated on the basis of relative abundance, foraging rate, foraging speed and loose pollen grains. Data collected on pollinator relative abundance presented in Table 2 revealed that stingless bee activity was maximum during 0800 hr (31.66 bees) followed by 1000 hr (20.33 bees). *T. iridipennis* (12.26 stingless bees/ 5 min/ m^2) significantly outnumbered the honey bees (6.69 honey bees/ 5 min/ m^2) and other pollinators (4.42 other pollinators/ 5 min/ m^2) in visits on water melon. The activity of pollinators started at 0600 hr, became maximum at 0800 hr with maximum activity at 1000 hr. The activity then started decreasing up to 1600 hr and was minimum at 1800 hr. Chauhan et al. (2019) reported maximum activity of pollinators on ash gourd at 1000 hr, and after 1200 hr, started decreasing and ceased at 1800 hr. Such variation in activity of pollinators with time depends on the availability of pollen and nectar in flowers. According to Devanesan et al. (2002), the foraging activity of *T. iridipennis* at Thiruvanthpuram (Kerala) started at 0700 hr with a gradual rise in activity reaching its first peak at 1200 hr. A decline in activity

Table 1. Insect visitors of water melon under open conditions

S. No.	Scientific name	Order	Family	Frequency of occurrence
1.	*Tetragonula iridipennis* Smith	Hymenoptera	Apidae	MFV*
2.	*Lophotrigona canifrons* Smith			MFV
3.	*Lepidotrigona ventralis* Smith			MFV
4.	*Tetragonula laeviceps* Smith			FV
5.	*Apis mellifera* L,	Hymenoptera	Apidae	MFV
6.	*Apis cerana* F,			MFV
7.	*Apis dorsata* F.			MFV
8.	*Apis florea* F.			FV
9.	*Halictus semiaerinus*	Hymenoptera	Halictidae	FV
10.	*Xylocopa tenuiscapa* Westwood	Hymenoptera	Apidae	FV
11.	*Episyrphus* sp.	Diptera	Syrphidae	FV
12.	*Musca* sp.	Diptera	Muscidae	LFV
13.	*Mylabris pustulata*	Coleoptera	Meloidae	LFV
14.	*Monomorium indicum*	Hymenoptera	Formicidae	FV
15.	*Megachile lanata* F.	Hymenoptera	Megachilidae	FV

*MFV= Most frequent visitor; FV= Frequent visitor; LFV=less frequent visitor

Table 2. Foraging activity and pollination Efficiency Index of pollinators on water melon

Time (h)	Stingless bees				Honey bees				Other pollinators			
	*Relative abundance	Foraging Rate	Foraging speed	Loose Pollen grains	Relative abundance	Foraging Rate	Foraging speed	Loose Pollen grains	Relative abundance	Foraging Rate	Foraging speed	Loose Pollen grains
0600	8.67 (2.94)	6.33	7.10		3.25 (1.80)	5.33	5.67		1.99 (1.41)	3.67	14.69	
0800	31.66 (5.62)	6.33	5.00		18.33 (4.28)	4.72	4.66		10.14 (3.18)	4.33	13.67	
1000	20.33 (4.50)	7.33	6.33		8.77 (2.96)	5.02	5.67		6.94 (2.63)	2.67	11.66	
1200	14.11 (3.75)	7.66	4.67	1981 ± 31	9.11 (3.01)	6.00	4.11	2130 ± 49	5.54 (2.35)	4.66	9.33	675 ± 67
1400	7.36 (2.71)	8.66	2.67		3.62 (1.90)	6.11	2.33		3.67 (1.91)	8.67	6.60	
1600	3.67 (1.91)	5.67	2.00		2.77 (1.66)	2.67	2.11		1.67 (1.29)	1.67	3.99	
1800	1.00 (1.00)	4.49	1.67		1.00 (1.00)	4.13	1.67		1.00 (1.00)	2.00	4.66	
Mean	12.26 (3.52)	6.64	4.21		6.69 (2.58)	4.85	3.75		4.42 (2.10)	3.95	9.23	
$CD_{0.05}$	0.350	0.256	0.920		0.350	0.256	0.920		0.350	0.256	0.920	
Pollination Efficiency Index	21				16				3			

*Relative abundance= number of foragers/ 5 min/ m^2; Foraging rate= Number of flowers visited / 5 min; Foraging speed= time spent / flower (in seconds)

was observed at 1300 hr, and then increased until it reached its second peak at 1500 hr. There was almost no activity at 1800 hr. Danaraddi (2007) observed the peak activity of *T. iridipennis* between 1000-1200 hr. Kishan et al. (2017) found that stingless bees can be a good pollinator for crops growing under protected conditions. Similarly, the activity of *T.iridipennis* was observed by Roopa (2002)- during summer, major peak of pollen and nectar foragers was between 1000 to 1200 hr and 1200 to 1300 hr, and second peak between 1400 to 1500 hr and 1500 to 1600 hr, respectively.

The foraging rate of pollinators on water melon revealed that stingless bees significantly visited more number of flowers (6.64 flowers/ 5min) as compared to honey bees (4.85 flowers/ 5min) and other pollinators (3.95 flowers/ 5min) (Table 2); foraging rate was found maximum on ash gourd flowers as compared to other pollinators including honey bees (Chauhan et al., 2019). Similarly, Devanesan et al. (2002), observed the activity of *T. iridipennis*. The researchers found maximum numbers of flowers for pollen were visited in the morning and early evening hours. Stingless bees spent significantly less time (4.21 sec/ flower) than other pollinators (9.23 sec/ flower). Chauhan et al. (2019) also reported less foraging speed of stingless bees in ash gourd. Honey bees carry more number of loose pollen grains (2130) on their body as compared to stingless bees (1981) and other pollinators (675) (Table 2). Several researchers recorded high pollen carrying capacity of honey bees due to more hairs on their body (Free, 1970; 1993). Similarly, Chauhan et al. (2019) observed that stingless bees carry less loose pollen grains than honey bees and other pollinators.

Pollination efficiency observed in water melon revealed that stingless bees have more efficiency (21.00) as compared to honey bees (16.00) and other pollinators (3.00). Similar observations were made by Chauhan et al. (2019) and stingless bees were the efficient pollinators on ash gourd under protected conditions. Titayavan and Burgett (2010) also studied the pollination efficiency of two different *Trigona* species at Thailand. After fruit setting, the colony was removed from the greenhouse and the effect of different modes of pollination on the production and quality of watermelon were evaluated. Significantly large fruits (26.39 cm dia) were obtained from vines pollinated by stingless bees as compared to the open pollinated ones (23.86 cm), and the least (11.22 cm) in pollinators excluded block (control). Similarly, significantly increased weight (3.428 kg) of fruits was observed in the stingless bee pollination which is at par with the weight (2.996 kg) obtained in open pollination conditions. In control pollination, the fruit weight (0.583 kg) was significantly low. TSS was found maximum (10.32°Bx) in stingless bee pollination which is at par with open pollinated one (9.96°Bx); the least TSS (8.31 °Bx) was observed in plants without pollination (Table 3). Similar results were obtained by Azmi et al. (2017) in Malaysia that the cucumbers pollinated by stingless bee and hand-cross pollination produced heavier, longer and larger fruits. A significant increase was seen in fruit length, girth, and weight, number of fruits/ plant and yield/ plant in cucumber pollinated by stingless bees (Tej et al., 2017). Likewise, several researchers reported that honey bees pollinate tomatoes, pepper, egg plant, melon, watermelon, cucumber, strawberry, cranberry etc, but are less efficient than bumble bees (Free and Butler, 1959; Holm, 1966).

Open pollinated flowers yielded fruits which produced more seeds (522) as compared to the seeds produced in stingless bee pollinated flowers (489). The numbers of seeds/ fruit were 114 in the fruits produced from flowers with no pollination facilities and are significantly less as compared to other treatments. The weight of 1000 seeds was significantly more (33.68 g) in stingless bee pollinated crop as compared to open pollinated one (30.59 g) and 19.66 g extracted from fruits of control plots (Table 3). Similar results were obtained in ash gourd by Chauhan et al. (2019) when they employed stingless bees for pollination under protected conditions.

Maximum fruit set (89.75%) was observed with stingless bee pollination, significantly higher as compared to open pollinated crop (72.91%); significantly minimum fruit set to the tune of 39.57% was observed with plants excluded from pollinators. Howsoever, significantly less deformed fruits (18.38%) were obtained from stingless bee pollinated plants followed by 31.04% in open pollinated plants. Significantly more deformed fruits (38.90%) were observed from pollination excluded plots. Similarly, Hodges and Baxendale (1991) reported less deformed fruits in bee pollinated plants of cucumber and observed a greater number of deformed fruits in control and open conditions. Chauhan and Thakur (2014) observed less crooked fruits in cucumber when pollinated by bumble bees under protected conditions. Similarly, Chauhan et al. (2019) recorded better quality ash gourd fruits when pollinated by stingless bees as compared to honey bees. On the contrary, significantly maximum healthy fruits (81.62%) were produced from stingless bee pollinated plots followed by open pollinated crop (68.96%) and pollinator excluded (61.10%) condition. In stingless bee pollinated plants, increase in the fruit set and healthy fruits was 126.81 and 33.58% over the control; also, a reduction in deformed fruits (111.64%) was observed in stingless bee pollinated plants (Table 3). Westerfield (2014) concluded that misshaped or undersized fruit could be the result of poor or incomplete pollination.

An increase in fruit diameter (135.20%) and weight (413.89%) of water melon was obtained with stingless bees over the plants with no pollination (control); similar was the results with seed number and weight (1000 seeds), an increase of 328.94 and 71.31% in stingless bee pollinated plants. While, an increase of 24.18% was observed in TSS was also found in stingless bee pollinated fruits. Melendez et al. (2002) reported that stingless bees are efficient pollinators of pumpkin that resulted in higher quality fruits. However, Occhiuzzi (2000) observed that *Trigona carbonaria* Smith effectively pollinated sweet pepper under greenhouse conditions in Australia resulted in 11% increase in fruit weight and number of seeds/ fruits by 34% compared to crops that were not pollinated by bees. Viana et al. (2014) also found that stingless bees when utilized with honey bees in apple yields higher seed and fruit production. Similarly, Cahuich et al. (2006) reported stingless bees as better pollinators than honey bees under protected conditions in Habanero pepper. It was reported that *Scaptotrigona* aff. *depilis* and *N. testaceicornis* Lepeletier effectively pollinated greenhouse cucumber in

Table 3. Impact of modes of pollination on fruit quality and production in water melon

Treatment	Fruit diameter (cm)	Fruit weight. (kg)	TSS (°Bx)	Rind thickness (cm)	Fruit set (%)	Healthy fruit (%)	Deformed fruits (%)	Number of seeds/ fruit	Weight of 1000 seeds (g)
**Tetragonula iridipennis* pollination	26.39	3.428	10.32	1.31± 0.25	89.75	81.62	18.38	489	33.68
Open pollination	23.86	2.996	9.96	1.21± 0.17	72.91	68.96	31.04	522	30.59
Pollinator exclusion (control)	11.22	0.583	8.31	1.35± 0.14	39.57	61.10	38.90	114	19.66
CD=0.05	2.11	0.95	0.95		3.97	4.66	4.10	39	1.92

*Stingless bee

Brazil, resulting in a higher fruit production, higher fruit weight and a higher % of perfect fruits (Santos, 2004). Nunes-Silva et al. (2013) reported that *M. fasciculata* was an efficient pollinator of eggplant, increased the fruit set by 29.5% and fruit quality as compared to control in Brazil. Similarly, Rajasri et al. (2012) studied the effect of bee pollination on seed yield of sunflower and observed improvements.

REFERENCES

Azmi W A, Zulqurnain N S, Ghazi R. 2017. Melissopalynology and foraging activity of stingless bees, *Lepidotrigona terminata* (Hymenoptera: Apidae) from an apiary in Besut. Journal of Sustainability Science and Management 10 (1): 27-35.

Bohart G E, Nye W P. 1960. Insect pollination of carrots in Utah. Bulletin of Utah Agriculture Experimental Station 419: 16-17.

Cahuich O, Quezada Euan J J G, Melendez R V, Valdovinos Nunez O, Moo Valle H. 2006. Pollination of habanero pepper (*Capsicum chinese*) and production in enclosures using stingless bee *Nannotrigona perilampoides*. Journal of Apicultural Research 45: 125-130.

Chauhan A, Singh H K, Kumaranag K M. 2019. Pollination potential of stingless bee, *Tetragonula iridipennis* Smith in ash gourd. Indian Journal of Entomology 81 (4): 854-859.

Chauhan A, Thakur R K. 2014. Studies on nest architecture and pollination potential of bumble bee *Bumbus haemorrhoidalis*. Indian Journal of Ecology 41(1): 158-164.

Cobley L S. 1965. An introduction to the botany of tropical crops. Longman, London.

Danaraddi C S. 2007. Studies on stingless bee, *Trigona iridipennis* Smith with special reference to foraging behaviour and melissopalynology at Dharwad, Karnataka. MSc Thesis. University of Agricultural Sciences, Dharwad.

Denton O A. 2004. *Citrullus lanatus* (watermelon). Plant resources of tropical Africa. 2. Vegetables. Grubben G J H, Denton O A (eds). Prota Foundation, Wageningen, Netherlands.

Devanesan S, Nisha M M, Bennet R, Shailaja K K. 2002. Foraging behaviour of stingless bees, *Trigona iridipennis* Smith. Insect Environment 8 (3): 131-133.

Free J B. 1970. Insect pollination of crops. Academic Press London. 353 pp.

Free J B. 1993. Insect pollination of crops, 2nd edn. U.K. Academic Press, London. 544 pp.

Free J B, Butler C G. 1959. Bumble bees. Collins, London. 221 pp.

Gadhiya V K C. 2015. Studies on utilization of stingless bees, *Tetragonula laeviceps* (Smith) in net house condition. PhD Thesis. Department of Agricultural Entomology, N M College of Agriculture, Navsari Agricultural University, Navsari, Gujarat.

Gomez K A, Gomez A A. 1986. Statistical procedure for agricultural research. 2nd edn, John Willey and Sons, U K. 680 pp.

Grewal G S, Sidhu G. 1978. Insect pollination of some cucurbits in Punjab. Indian Journal of Agricultural Science 48: 79-83.

Heard T A. 1999. The role of stingless bees in crop pollination. Annual Review of Entomology 44: 183-206.

Hodges L, Baxendale F. 1991. Bee pollination of cucurbit crops. Report of University of Nebraska-Lincoln Cooperative Extension, NF: 91-150.

Holm S N. 1966. Problems of the domestication of bumble bees. Bee World 47: 179-186.

Kishan T M, Srinivasan M R, Rajashree V, Thakur R K. 2017. Stingless bee *Tetragonula iridipennis* Smith for pollination of greenhouse cucumber. Journal of Entomology and Zoology Studies 5(4): 1729-1733.

Masefield G B, Wallis M, Harrisson A, Nicholson B E. 1969. The Oxford book of food plants. Oxford University Press, London.

Melendez R V, Magana R S, Ayala B R, Navarro A J. 2002. Diversity of native bee visitor of cucurbit crops (Cucurbitacae) in Yucatan, Mexico. Journal of Insect Conservation 6: 135-147.

Nunes-Silva P, Hrncir M, Da Silva C I, Roldao Y S, Imperatriz-Fonsica V L. 2013. Stingless bees, *Melipona fasciculata* as efficient pollinators of eggplant (*Solanum melongena*) in greenhouses. Apidologie 44: 537-546.

Occhiuzzi P. 2000. Stingless bees pollinate greenhouse capsicum. Aussie Bee 13, 15. Australian Nature Bee Research Centre, North Richmond NSW Australia.

Rajasri M, Kanakadurga K, Durga R V, Anuradha. 2012. Honey bees potential pollinators in hybrid seed production of sunflower. International Journal of Applied Biology and Pharmaceutical Technology 3 (2): 123-125.

Roopa C A. 2002. Bioecology of stingless bees, *Trigona iridipennis* Smith. M.Sc Thesis. University of Bangalore.

Roubik D W. 1995. Pollination of cultivated plants in the tropics. FAO Agricultural Services Bullettin 118: 53 pp.

Sajjanar S M, Kuberappa G C, Prabhuswamy H P. 2004. Insect visitors of cucumber (*Cucumis sativus*) and the role of honey bee *Apis cerana* F., in its pollination. Pest Management and Economic Zoology 12(1): 23-31.

Sarto M C L, Peruquetti R C, Campos L A O. 2005. Evaluation of the Neotropical stingless bee, *Melipona quadrifasciata* (Hymenoptera: Apidae) as pollinator of greenhouse tomatoes. Journal of Economic Entomology 98: 260-266.

Santos S A B. 2004. Pollination of cucumber *Cucumis sativus* by stingless bees (Hymenoptera, Meliponini), Proceedings. 8th IBRA International Conference on Tropical Bees and VI Encontro sobre Abelhas. 689 pp.

Santos S A B, Roselino A C, Hrncir M, Bego L R. 2009. Pollination of tomatoes by the stingless bee *Melipona quadrifasciata* and the honey bee *Apis mellifera* (Hymenoptera, Apidae). Genetics and Molecular Research 8 (2): 751-757.

Titayavan M, Burgett M. 2010. Aspects of the pollination and fruit production of teak (*Tectona grandis* Linn.). Naresuan Phayao Journal 3 (2): 61-66.

Tej M K, Srinivasan M R, Vijayakumar K, Natarajan N, Kumar S M. 2017. Morphometry analysis of stingless bee *Tetragonula iridipennis* Smith. International Journal of Current Microbiology and Applied Sciences 6 (10): 2963-2970.

Viana B F, Coutinho J G E, Garibaldi L A, Gastagnino G L B, Gramacho K P, Silva F O. 2014. Stingless bees further improve apple pollination and production. Journal of Pollination Ecology 14 (25): 261-269.

Westerfield R R. 2014. Pollination of vegetable crops. UGA Extension. pp.1-6.

(Manuscript Received: June, 2020; Revised: September, 2020;
Accepted: September, 2020; Online Published: October, 2020)
Online published (Preview) in www.entosocindia.org Ref. No. e20154