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Damage assessment and management of fruit bat, *Pteropus giganteus* using traditional method of artificial light in ber crop

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Traditional method of artificial light was evaluated against fruit bat, *Pteropus giganteus* in ber (*Ziziphus jujube*) orchards of Punjab Agricultural University, Ludhiana during 2017-18 and 2018-19, since; no study has been done in Punjab to assess ber fruit damage and management of fruit bats. Ber is a tropical and deciduous fruit crop which is damaged by different pests among which fruit bats are important ones. Our results reported *P. giganteus* damage to ber fruits which was economical and ranged from 9.72-11.6% and per tree from 9.96-13.40 kg having yield of 103.3-117.0 kg. Damage of fruit bats was minimized by using traditional and eco-friendly method of artificial light using LED bulbs having different watts, which requires only one time initial cost. It is concluded that on installation of 16 LED bulbs/acre of 30 watt power at a distance of 50 feet from each other in downward position at height of 6 feet above top of tree canopy in orchard having 72 trees planted at recommended distance of 25×25 feet, we can reduce fruit bat damage to minimum level. This non-lethal and non-polluting method can give huge net economic return of Rs. 10646.0/acre to ber fruit growers which will increase their farm income and also helps in bat conservation.

Keywords: Artificial light method, Ber crop, Fruit bats, LED bulb, *Pteropus giganteus*

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In India, nearly 70% people live in rural areas and depend on agriculture for their livelihoods and to feed nation. They use many indigenous traditional methods to save their crops from different pests at farm and storage level[1]. Indigenous knowledge is adaptation of different agricultural tactics by farmers at grass root level to enhance agricultural production by minimizing adverse effects on environment[2]. Main goal of traditional farming system is to conserve biodiversity which further requires protection of traditional knowledge. Farmer develops traditional knowledge by their necessities, experiments, observations and experiences of indigenous knowledge which is dynamic in nature and there is refinement in these tactics from time to time which is adopted by local farming community[3]. Use of intensive agricultural practices has led to environmental and soil pollution along with reduction in crop productivity. Agricultural crops are attacked by many insect pests, diseases and mammals for which farmers use insecticides, fertilizers and fungicides to get quick results, which are not environmentally safe and sustainable[4]. Today's farmers are moving towards organic farming system and have started using natural products of plant and animal origin which are eco-friendly in nature. Most products in use are mulching, crop residue, green manure, farm yard manure, cow urine, saw dust and several bio-pesticides based on neem, dharek and essential oils to combat agricultural pests[5-7]. These are cost effective, easily available, bio-degradable and environmentally safe.

Ber (*Zizipus jujuba*) also known as poor man's fruit is an important tropical and deciduous fruit crop belonging to family Rhamnaceae. It can withstand adverse climatic conditions and can be easily grown in arid and semi-arid regions[8]. It is extensively cultivated in Southern Asia and South-East Europe. In India, ber is cultivated in Madhya Pradesh, Bihar, Uttar Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Tamil Nadu and Andhra Pradesh[9] and during 2017-18 it was cultivated in an area around 49 thousand hectares with production outcome of 573 thousand MT[10]. It is a rich source of vitamin C, proteins and minerals. Ber crop is attacked by many pests which reduce its yield and fruit bats (*Pteropus giganteus*) are important pest among them[11].

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P. giganteus commonly known as Indian flying fox or fruit bats belong to order Chiroptera and are second most abundant group which comprises 25% of all living mammals. Under schedule V of Indian Wildlife Protection Act 1972 and International Union for Conservation of Nature (IUCN), this species is labeled as 'vermin' as it poaches ripe fruits from orchards and defecates in public places and cause heavy economic loss to different horticultural crops which ranged from 12-30%[12]. Fruit bats cause significant fruit loss in commercial crops such as apples, bananas, carobs, dates, grapefruits, litchi, mandarins, pears, and pomegranates[13]. In a dietary study of *P. giganteus* it was observed that trees of family Moraceae (50.7%), comprised most of bat's diet whereas fruits of *Ficus golmerata* (30.9%) and *F. religiosa* (28.1%) during spring, *Diospyros peregrine* (71.9%) during autumn, *P. guajava* (19.6%), *F. bengalensis* (18.7%) and *Diospyros peregrina* (17.8%) during summer and *F. retusa* (27.5%) and *F. carica* (23.0%) during winter were most preferred[14]. *P giganteus* is widely distributed throughout India and other regions of Asian countries. Bats are nocturnal mammals and usually live in large aggregates as colonies known as roosting sites, which may vary from hundreds to thousands depending on food availability[15] and breeding season. Fruit bats also provide widespread ecological and monetary services via pollination, seed dispersal for hundreds of tree species and reduction in agricultural pest control[16] and they also regulate climate, rejuvenation of forests, nutrient cycling, water filtration, and erosion control etc.

There are many traditional methods to manage mammalian pests like fruit bats in orchards like use of mist nets on trees individually or around orchard, artificial light, crackers, drums and hunting for meat, medicinal, sport and trade purpose[17,18]. Use of hunting by gun is illegal, mist nets is costly whereas drums/crackers require high labour cost except artificial light method which requires only small initial cost of installation and further no input cost is required. Fruit bats are nocturnal, afraid of light and depend on eye sight for foraging activities. In a study, three light colours were evaluated and reported more response in white colour light which avoids foraging activity and change routes of three species of bats as compared to green and red colour lights. Light controls circadian rhythms and triggers response which effects orientation of bats during night[19,20]. So, this behavior of fruit bats was exploited in present study to prevent them from ber orchards to reduce damage. Traditionally, farmer use artificial light in their ber orchards but this method needs standardization i.e., type of bulb used, its wattage (power), where to install, height, distance between bulbs and their quantity required per acre. Since, no study has been done in Punjab to assess damage and control of fruit bats in ber crop. Hence, present study was proposed for two years to investigate damage and standardize traditional artificial light method which may help ber fruit growers to reduce fruit damage which will increase their farm income.

Material and Methods

Selection of site

To estimate ber fruit loss and its control from *P. giganteus*, the experiment was conducted in ber orchards of "New orchard Area", Punjab Agricultural University (PAU), Ludhiana (30°90" N latitude and 75°79" E longitude) during 2017-18 and 2018-19. Ber trees of variety "Gola" and "Umran" were planted at a distance of 25×25 feet (72 trees/acre as recommended by PAU). Ber orchard was 15 year old and surrounded by different kinds of other fruit orchards like, mango, plum, peach, pear and crop fields. During study period, only ber crop was in the fruiting stage. In Punjab, ber crop ripens at the beginning of January and harvesting is over till mid May.

Estimation of *P. giganteus* damage in ber crop

To estimate ber fruit damage, there were three replications and for each replication 10 ber trees were selected. Weeds were removed under the trees manually and with herbicides. White polythene sheets were put under selected trees to record fallen fruits damaged by fruit bats and were recorded at weekly intervals as suggested[21]. Damaged ber fruits were counted and weighed quantitatively using weighing balance. To calculate the weight of damaged ber, first the number and weight of healthy ber fruits were counted per kg (~68 ber/kg in variety Gola and 46 ber fruits/kg in variety Umran) and then multiplied with the number of damaged ber seeds. The yield per tree (selected trees) was recorded separately. Per cent ber fruit damage was calculated by using formula:

$$\text{Damaged fruits (\%)} = \frac{\text{Weight of fruits damaged per tree}}{\text{Fruit yield per tree}} \times 100$$

The damage caused by birds and other predators was excluded. Ber fruits damage by bats can be easily

identified from birds as bats eat fruit juice and spit out seeds and peel (Fig. 1). The data was further used to calculate the net economic benefits and economic loss of farmers caused by fruit bats.

Management of *P. giganteus* in ber orchard using artificial light method

Bat species avoid white light as compared to other colours, hence, to produce artificial light in orchards, we use light emitting diode bulbs (LED bulbs of Phillips Co. Ltd.) of different wattages like 12 and 20 watt during 2017-18; 27 and 30 watt during 2018-19. which produces more white light and consume less electricity There were total three replications and in each replication there were 9 LED bulbs placed at a distance of 50 feet from each other and 6 feet above the centre of tree canopy facing downwards by using long bamboo sticks (~one inch diameter) to cover full tree canopy and adjacent trees (Fig. 2). Power for LED bulbs was electricity which was available from nearby source. The wires used were of 1 mm in thickness (Havels Co. Ltd.), enough to take electricity load of these LED bulbs. The observations were made during night hours @ three nights in a week to check any bat sitting on the ber trees causing fruit damage and lighting conditions i.e., if any bulb get fused, it was changed immediately. Input cost regarding installation of LED bulbs, bulb holders, electric wires, switches and electricity consumed was calculated per acre for one month and then the economic return was calculated to analyze the effectiveness of this technique.

Statistical analysis

Data regarding damage was calculated in percentage (%).

Result and Discussion

Estimation of *P. giganteus* damage in ber crop

In ber orchards at selected location during 2017-18, mean damage done by fruit bats in ber fruit per tree was recorded to be 9.96 kg with yield 103.33 kg/tree and per cent yield loss calculated as 9.72%. In 2018-19, mean damage done by fruit bats in ber fruit per tree was recorded to be 11.93 kg with yield 107.0 kg/tree and per cent yield loss calculated as 11.26% (Table 1). Mean of damaged ber fruits during 2017-18 and 2018-19 was

Fig. 1 — Ber fruits damaged by fruit bats

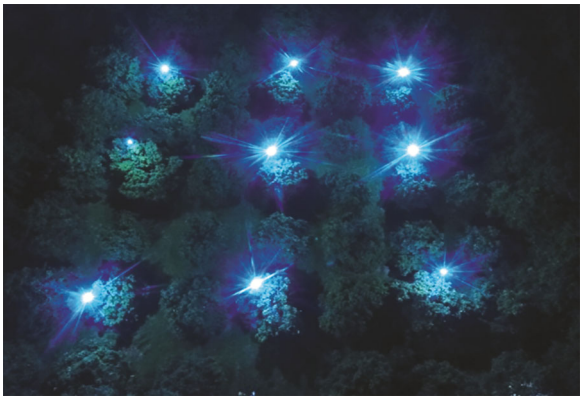

Fig. 2 — LED bulbs of 30 watt installed in ber orchard

Table 1 — Damage assessment of *P. giganteus* in ber orchard during 2017-18 and 2018-19

S. no.	Replications (n=10/ replication)	Damaged fruit / tree (kg)	Total fruit yield/ tree (kg)	Yield loss (%)	Economic fruit loss/ tree (Rs.)	Economic fruit loss/ acre (Rs.)
2017-18						
1	R1	12.40	106.0	11.69	434.0	31248.0
	R2	7.30	110.0	6.63	255.5	18396.0
	R3	10.20	94.0	10.85	357.0	25704.0
	Mean	9.96	103.33	9.72	348.83	25116.0
2018-19						
2	R1	13.40	96.0	13.96	469.0	33768.0
	R2	12.60	118.0	10.68	441.0	31752.0
	R3	9.80	107.0	9.16	343.0	24696.0
	Mean	11.93	107.0	11.26	417.67	30072.0
Mean		10.94	105.16	10.49	383.25	27594.0

Number of trees/acre=72; Price of ber fruit=Rs. 35.0/kg

recorded to be 10.94 kg/tree with yield of 105.16 kg/tree and per cent yield loss recorded to be 10.49%. The mean ber fruit loss per tree during 2017-18 and 2018-19 was recorded to be Rs. 383.25 (price of ber fruit was taken as Rs. 35/kg). The mean ber fruit loss per acre during 2017-18 and 2018-19 was recorded to be Rs. 22759.0 (Table 1). Similar studies have done where damage by fruit bats to various horticultural crops like guava (*Psidium guajava*) (20-28%), areca nut (*Areca catechu*) (18%), mango (*Mangifera indica*) (12-17%) and sapota (*Achrus zapota*) (12-30%) was recorded[21]. Extensive feeding of fruit bats on tender twigs of *Robusta coffee* leads to drying of fruit bearing branches resulting in crop loss from 5.9-9.48%. The fruit bats were estimated by the fruit growers to eat 50,000 kg of litchis per annum and this damage got increased at the rate of 10% annually. There are many reports from Israel where fruit bats consume commercial fruits such as apples, bananas, carobs, dates, grapefruits, litchi, mandarins, pears, and pomegranates. In a study 36 observations were recorded for damage caused by *C. sphinx* in grape vineyard and concluded that bat consumed total of 1579 grape bunches (each weighing up to 750 g), amounting to total yield loss of 1,182 kg[22]. In South-East Thailand, Lyle's flying fox (*P. lylei*) caused about 10% damage to mangoes, bananas, water apples and santol.

Management of *P. giganteus* in ber orchard using artificial light method

Initially during year 2017-18, the experiment was conducted by using LED bulbs of 12 watt and 20 watt. *P. giganteus* caused damage to ber fruits in the range from 8.30-9.75% (Table 2) as compared to control (11.60%). During year 2018-19, the experiment was conducted by using LED bulbs of 27 watt and 30 watt. In orchard where LED bulbs of 27 watt were used the damage to ber fruits recorded was 4.26% as compared to controls (11.46%). Interestingly, a little damage (0.51%) to ber fruits was recorded when LED bulbs of 30 watt were used in the orchards, which was recorded during the month of January, when there was fog in the atmosphere for some days, which reduces the effect of LED light, otherwise neither damage nor bat was observed to be sitting on the ber tree. Once the installation of LED bulbs is over, no human labour was required for using other methods like drums, crackers etc., on daily basis to prevent *P. giganteus* bats at night, which reduces the cost of labour.

Total expenditure for installation of artificial light system per acre was calculated to be Rs. 18208.0 which includes cost of bamboo sticks, LED 30 watt bulbs, bulb holders, wires, switches and electricity used (calculated for four months). The economic fruit loss per acre during 2018-19 in control was calculated to be Rs. 28854.0. Therefore, the net economic return per acre was calculated to be Rs. 10646.0 (Table 3). Thus, farmers can get profit of Rs. 10646.0/acre after installation of LED bulbs of 30 watt which will help them to keep the fruit bats (*P. giganteus*) away from ber orchards which will increase their farm income, help in food security and conservation of fruit bats. A study suggested that by installing artificial lights, illumination of foraging area can reduce or prevent the foraging activity of fruit bats which will reduce damage to fruit crops. Also, an increase in insect density was recorded near illumination area which helps insectivorous bats to feed upon them, thus, also

Table 2 — Efficacy of different wattages of LED bulbs on *P. giganteus* in ber orchard during 2017-18 and 2018-19

Year	Wattages of LED bulbs	Damaged (kg fruit /tree)	Total fruit yield/ tree (kg)	Yield loss (%)	Economic fruit loss/ tree (Rs.)	Economic fruit loss/ acre (Rs.)
2017-18	12	10.2	104.55	9.75	357.0	25704.0
	20	8.2	98.84	8.30	308.0	22176.0
	Control-1	12.6	108.07	11.60	441.0	31752.0
2018-19	27	4.8	112.80	4.26	168.0	12096.0
	30	0.54	104.52	0.51	18.9	1360.8
	Control-2	13.40	117.00	11.46	400.85	28854.0

Number of trees/acre=72; Price of ber fruit=Rs. 35.0/kg

Table 3 — Net economic returns for the management of *P. giganteus* in ber orchard per acre

S. no.	Cost of 16 LED bulbs (Rs.)	Cost of wire (Rs.)	Cost of electricity/LED bulb/8 h/day (Rs.)	Cost of electricity for 16 LED bulbs/ month (Rs.)	Cost of electricity for 16 LED bulbs/ 4 month (Rs.)	Total cost of 16 bamboo sticks (Rs.)	Total expenditure for installation	Economic fruit loss (Rs.)	Net Economic return (Rs.)
1	9600.0	1600.0	2.40	1152.0	4608.0	2400	18208.0	28854.0	10646.0

Cost of 1 unit (1 KW) of electricity = Rs. 10.0

reduce insect pest population[23]. The number of bats passes of *Myotis lucifugus* significantly reduced when a crossing point was artificially illuminated as compared to the time when the lights were turned off, indicating reduced activity. *Rhinolophus hipposideros* showed reduction in their activity with the presence of artificial lighting of high-pressure sodium lamps. Individuals of *Myotis dasycneme* modified their flight trajectories in reaction to being exposed to halogen lamps. By partially covering vulnerable sections of the canopy of fruit trees, illumination and scaring with noises saved 4, 6 and 11% of damaged fruits of sapota, respectively[12]. Many Pteropodid bats are often shot with gun by farmers to protect their orchards from damage. In Thailand, farmers set nets to catch bats visiting their trees. In some cases, attempts were made to destroy the roosts which were near by the cultivated orchards. Fruits such as dates could be protected from bats by covering with cloth bags or nets before ripening.

Conclusion

Damage caused by fruit bats in ber fruits ranged from 9.72-11.6%. By installing 16 LED bulbs/acre of 30 watt at a distance of 50 feet and height of 6 feet from tree canopy, bats can be prevented from ber orchards giving a huge economic return of Rs. 10646.0/acre. There is need to address awareness regarding the impact of artificial light at farmer level which is of eco-friendly and sustainable in nature.

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Conflict of Interest

It is stated that we the all authors of this research manuscript do not have any conflict of interest.

Author's Contributions

RS prepared the framework of research problem, SA took data from fields at regular intervals, RS & SA analyze the data statistically, RS & SA prepare research manuscript.

References

1 Deka M K, Bhuyan M & Hazarika L K, Traditional pest management in Assam, *Indian J Tradit Know*, 5 (1) (2006) 75-78.

2 Altieri M, The socio-cultural and food security impacts of genetic pollution via transgenic crops of traditional varieties in Latin American centre of peasant agriculture. *Bull Sci Tech Soc*, 78 (2003) 350-359.

3 Rana R S, Koundal M, Kalia V, Pathania R & Katoch A, Indigenous traditional knowledge in agricultural activities vis-à-vis climate change in North Western Himalayas, *J Agrometeorol*, 20 (2018) 37-43.

4 Mehta P S, Negi K S, Rathi R S & Ojha S N, Indigenous methods of seed conservation and protection in Uttarakhand Himalaya, *Indian J Tradit Know*, 11 (2) (2012) 277-282.

5 Giday M, Traditional knowledge of people on plant used as insect repellents and insecticids in Raya-Azebo district, Tigray region of Ethiopia, *Indian J Tradit Know*, 17 (2) (2018) 336-343.

6 Lal C & Verma L R, Use of certain bio- products for insect-pest control, *Indian J Tradit Know*, 5 (1) (2006) 79-82.

7 Sinha B, An appraisal of the traditional post- harvest pest management methods in Northeast Indians uplands, *Indian J Tradit Know*, 9 (3) (2010) 536-543.

8 Dalal R S, Godara A K & Thakur A, Evaluation of Ber (*Zizyphus mauritiana* Lamk.) cultivars for fruit quality under semi-arid condition, *Environ Ecol*, 26 (2008)1685-1687.

9 Baloda S, Sehrawt S K, Yadav B S, Ahlawat V P & Singh S, Present status of ber production and future thrusts in India-A Review, *Agric Rev*, 33 (2012) 2556-264.

10 Anonymous, Horticultural Statistics at a glance. Published by Government of India, Ministry of Agriculture and Farmer's Welfare, Department of Agriculture Co-operation and Family Welfare, (Horticulture Statistics Division), 2018, p. 54.

11 Haldhar M S, Karuppaiah V, Muralidharan C M & Sharma S K, Insect Pests of Ber (*Ziziphus mauritiana* Lamarck) and their Management. In: *Insect Pests Management of Fruit Crops* edited by A K Pandey & Pramod M. published by Biotech Books, New Delhi, 2015, p. 271- 294.

12 Hassan M U, Jones M G & Deitz C, The bats of Pakistan, the least known creature, Verlag edited by Mullar S, 2009, p. 168.

13 Chakraverthy A K & Girish A C, Crop protection and conservation of frugivorous bats in orchards of hill and coastal regions of Karnataka, *Zoo Print J*, 18 (2003) 1169-1171.

14 Hassan M U, Gulraiz T L, Rana S A & Javid A, The diet of Indian flying foxes (*Pteropus giganteus*) in urban habitats of Pakistan, *Acta Chiropterol*, 17 (2015) 341-347.

15 Williams N G, McDonnell M J, Phelan G K, Keim L D & Ree R D, Range expansion due to urbanization: Increased food resources attract grey-headed flying-foxes (*Pteropus poliocephalus*) to Melbourne, *Aust Ecol*, 31 (2006) 190-198.

16 Maas B, Clough Y & Tscharntke T, Bats and birds increase crop yield in tropical agroforestry landscapes, *Ecol Lett*, 16 (2013) 1480-1487.

17 Lizarro D, Galarza M I & Aguirre L F, Traffic and trade of Bolivian bats, *Rev Bol Ecoly Cons Amb*, 27 (2010) 63-75.

18 Vardi N H, Benjamin A, Sagiv T & Kronfeld S N, Fitness consequences of chronic exposure to different light pollution wavelengths in nocturnal and diurnal rodents. *Sci Rep*, 12 (1) (2022) 16486. doi: 10.1038/s41598-022-19805-1.

19 Christian C V, Katharina R, Oliver L & Gunars P, Migratory bats are attracted by red light but not by warm white light: Implications for the protection of nocturnal migrants, *Ecol Evol*, 8 (18) (2018) 9353-9361.

20 Katabaro J M, Yan Y, Hu T, Yu Q & Cheng X, A review of the effects of artificial light at night in urban areas on the ecosystem level and the remedial measures, *Front Public Health*, 30 (10) (2022) 969945. doi: 10.3389/fpubh. 2022.969945.

21 Oleksy R, Ayady C L, Tatayah P, Froidevaux C S P, Racey P A & Jones G, The impact of the Endangered Mauritian flying fox *Pteropus niger* on commercial fruit farms and the efficacy of mitigation, *Oryx*, 67 (2018) 1-8.

22 Polak T, Korine C, Yair S & Holderied M W, Differential effects of artificial lighting on flight and foraging behavior of two sympatric bat species in desert, *J Zool*, 285 (2011) 21-27.

23 Eisenbeis P L, Artificial night lighting and insects: attraction of insects to streetlamps in rural setting in Germany. In: Ecological Consequences of Artificial Night Lighting, C Rich & T Longcore (Ed.). Island Press, Washington, 2015, p. 281-304.