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Short Communication

FLIES FOR THE POLLINATION OF GREENHOUSE MANGO (MANGIFERA INDICA L., ANACARDIACEAE) IN THE SUBTROPICAL IRIOMOTE ISLAND, JAPAN

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Mango (*Mangifera indica* : Anacardiaceae) is a tropical fruit. De Candolle (1884) described its original home is in South Asia and Malay Archipelago. According to Mukherjee (1951b) mango originated in the Indo-Burma region and later it was spread to the countries of South Asia and also to other parts of the world. Mango is mainly grown throughout the tropical and subtropical areas of the world from nearly sea level to at about 4000 feet height. It is cultivated in open orchard, as well as in greenhouses. In the South East Asian countries some farmers use greenhouses for its cultivation, where they use pollinators. The necessity of pollination of mango depends on the situation, where it is cultivated and its cultivars. According to Mukherjee (1953) and Allard (1960) mango is a cross pollinated plant. When cultivated in greenhouses for commercial production, pollinators are obviously needed (Naik and Rao 1943). Ruehle and Ledin (1955) and Wolfe (1962) revealed that lack of pollination might attribute low yields of mangoes.

The inflorescence of mango is long and branched. It could be over 50 cm long, where several hundred to several thousand individual could have flowers and requires about a month to bloom completely. Naik and Rao (1943), Mukherjee (1951b) and Singh (1961) reported that 65-97% flowers are un-pollinated in nature. There are perfect and staminate flowers in the same panicle. Numbers of male flowers are 70-90%, and 65-85% bisexual flowers are un-pollinated in natural condition. This suggests that by using pollinators production can be increased (0.25-2.4%). Fraser (1927) stated that fruit bud formation and pollination were two big problems in growing mangoes. He pointed out that in some cases only 2 to 3 percent of the flowers on a panicle are perfect, in others 60 to 70 percent. The shape of perfect flower may be 5-8mm long that has globular ovary (rarely two or three) and a lateral style, which is absent in staminate flower. Both generally have one, but sometimes two even three functional stamens and several sterile staminodes. There are usually five greenish-yellow sepals, and three to nine but usually five cream-colored petals that take on a pinkish tinge before falling (Naik and Rao 1943). In the perfect or hermaphrodite flower, a nectar-secreting fleshy disk surrounds the ovary. The stamen is on the outer margin of this disk. The pistil and stamen are of the same length; therefore,

pollinating insects that feed on either nectar or pollen are likely to transfer pollen from the anther to the stigma (Juliano and Cuevas 1932 and Sturrock 1966). Maximum pollen shedding is from 8 am to noon. When the flowers open, considerable quantity of nectar is secreted which attract a large number of insects (Mukherjee 1953). However, relatively little pollen is produced on the anther (Popenoe 1917).

Popenoe (1920), Galang and Lazo (1937) and Sing and Sturrock (1969) reported that mango has entomophiber pollens. Singh (1960) described that honey bees do not visit mango flowers, but Singh (1954) listed this plant as a source of pollen and nectar for bees. Recently Fajardo *et al.* (2008) reported that 21 species of insects under 5 Orders, visit mango flowers in the Phillipines. They mentioned *Trigona biroi*, *Chrysomya* spp. *Eristalis* spp. and also honey bees (*A. cerana* and *A. mellifera*) as primary pollinators of mango. Fajardo *et al.* (2008) also reported that due to introduction of bee colonies, fruit set increased significantly (41%), whereas without bee pollination it was only 0.7%. However, in the present study necessity and rearing methods of flies for mango pollination were investigated.

The study was conducted on Iriomote Island (lat .24º20´N), southwestern archipelago of Japan in the greenhouse mango orchards during 2003 to 2004. Flies specially the carrion breeders were attracted with rotten fish meat placed on an open tray *ca.* 15 days before flowering initiated (Plate-1). To attract the outside syrphid flies and other insect pollinators to the mango flowers, doors and sidewalls of the greenhouse were kept open. The emergence of carrion breeding flies *e.g.* calliphorids were synchronized by calculating the flowering time and the developmental period of the flies, so that when they emerged as adults, flowers were also ready to be pollinated. The flies were collected on the flowers by using an insect nets and tube respirator. Special attention was taken so that the inflorescences were not harmed. The methodology of Mizuno *et al.* (2006) was followed for rearing desired flies.

Table 1. Fly species observed visiting flowers of mango (*Mangifera indica* L., Anacardiaceae) on Iriomote Island, Japan.

Family	Species
Syrphidae*	
1	*Eristalinus arvorum* (Fabricius)
Caliphoridae	
1	*Chrysomya megacephala* (Fabricius)
2	*Chrysomya rufifacies* (Macquart)

*Four more species of Syrphidae are yet to confirm their identification.

Seven promising pollinating species were recorded from Syrphidae and Calliphoridae on the greenhouse mango flowers (Table 1). Among them 1 syrphid was *Eristalinus arvorum* (Fabricius) (Plate-2), and 2 calliphorids were *Chrysomya rufifacies* (Macquart) (Plate-1) and *Chrysomya megacephala* (Fabricius) (Plate-3). All of them were also seen in the open atmosphere.

The main food from the mango flowers for the adult flies was nectar. During the licking of nectar they adhered some pollen grains in the bristle hairs of their mouth parts, especially on their glossae. When they visited other flowers afterward they transferred that to those flowers. In some subtropical islands of Japan *e.g.* Iriomote, Ishigaki, Miyako and Okinawa, commercial mango is cultivated in greenhouses (Plate-4). The orchard owners used pollinators for the pollination of the flowers in order to have good fruit sets, as well as good harvests.

In some South Asian countries like India, Bangladesh, Thailand growers keep honeybee colonies in the mango orchard for pollination, whereas in Japan, Taiwan, and the Philippines they use flies for this purpose. Honeybee is polylectic that goes to any flower attractive to them. Therefore, they are reluctant to stick to a single flower. In case of mango flower, it is open, small and sticky with its concentrated nectar. It is possible that honeybees are not attractive to this flower, but when there is no flower around them they are bound to go to mango flowers. In case of flies, they are regular visitors to the mango flowers. Their presence is much higher than the bees normally, and they also can transfer pollen from anther to stigma that helps mango flowers to be cross pollinated.

Plate 1. Fish meat to attract carrion breeders to lay eggs on it.

Plate 2. A syrphid fly foraging on mango flowers in the greenhouse.

Plate 3. A calliphorid fly foraging on mango flowers in the greenhouse of Iriomote Island Japan.

Plate 4. Mature ‘apple mango’ in the greenhouse Iriomote Island, Japan.

In Iriomote Island the flowering started from the month of February/March and fruit started from the March/April. Farmers kept only 1-3 mangoes per inflorescence. They

removed all the rest at different time intervals. They did not have any use of green mangoes, as a consequence they selected the best ones from one inflorescence, rest all were cut off and left on the floor of the orchard. Selling of ripe mango started from the months of July. Growers kept per tree about 50 (40-60) mangoes. On an average 3 mangoes made 1 kg. When the mangoes matured those were enclosed inside a white paper bag and tied with a hanging rope, so they did not fall down and got damaged. They collected mangoes before two to three days of ripening then boxed and sent to the market. The variety of mango produced on Iriomote is called “apple mango”.

Young (1942) studied pollination of 'Haden' mango in Florida and reported no significant difference between percentages of set in selfed and cross-pollinated flowers. Sturrock (1944) considered the flowers self- fertile. This self-fertility was supported by Popenoe (1917) who stated that the mango is self-fertile but cross-pollination is beneficial to increase fruit set. However, Singh *et al.* (1962) reported that crossed flowers set fruit whereas selfed ones did not, indicating a degree of self-sterility. Ruehle and Ledin (1955) considered that the lack of efficient pollination might be responsible in part for the low yields of some Florida cultivars. The studies indicated that the need for cross-pollination between mango cultivars was not critical, at least for most cultivars, but there was need for pollinating insects to transfer the pollen from anther to stigma within some cultivars to obtain satisfactory crop yields. The present study shows that within the cultivars there was a need for transferring pollen from anther to stigma by an outside agent, without what fruit set was not up to the level of commercially viable in maintaining the orchard. Mangoes outside greenhouse were not comparable with the within greenhouse mangoes on Iriomote Island in respect of quality and quantity, although the quantitative data was not collected from the present experiment. Because of this reason the orchard owner used flies in their greenhouses.

Burns and Prayag (1921) mentioned in Poona, India that flies of the genera *Psychonosoma* and *Pyrellia* are the chief pollinators of mango, but in Florida it was represented by insects of four Orders (Diptera, Hymenoptera, Lepidoptera, and Coleoptera). Singh (1954) also mentioned that flies were the pollinators of mango. In the present study 5 promising species of Syrphidae and 2 species of Calliphoridae were observed on the flowers of the greenhouse mango. Syrphid flies are promising pollinators but calliphorids are also good for mango pollination. Calliphorids were the major pollinators of mango in subtropical Asia (Bhatia *et. al.*, 1965 and Fajardo Jr. *et. al.*2008). Calliphorids also effectively pollinated many other flowering plants (Eardley and Mansell, 1996 and Stone *et al.* 1998). Number of flies in the orchard had very important role. It was necessary to have as many flies as possible per tree, reason being that fly did not move from flower to flower like bees. Flies started visiting flowers from early morning to noon till dehiscence of anthers continued. The flowers opened early in the morning, and the stigma was immediately receptive.

Bangladesh is a big mango producing country and almost all commercial orchards are in the districts of North Bengal (Rajshahi, Shibganj, Volahat, Chapai Nawabganj, Rangpur, Dinajpur). All those orchards are open. So all the natural pollination are held in this case. Only sporadically some commercial orchard owners use *A. cerana* or *A. mellifera* for pollination purposes along with goal to collect honey. In Rajshahi hundreds of *Apis* mostly *A. cerana* were observed on the mango flowers. Most interesting thing was visiting mango flowers by *Xylocopa* sp. The mango growers understood the benefits of using pollinators, but as they did not have easy access to them, consequently they did not use them. If available they are willing to use the pollinators in their orchard.

In Jezan, Saudi Arabia there are some mango orchards where several cultivars are used for the production of mango. No pollinator is used up until now but natural pollination is done by flies that are known from the officials of Agricultural Research Institute in Jezan. Mango growers do not keep *A. mellifera* colony even for honey production, as it is done in some other south Asian countries (Alqarni, unpubl.).

The main problems to use honey bees as pollinators of mango at open orchard are 1) flowers are not attractive to them, 2) they have choice of flowers, as many others bloom at the same time and 3) at over 35°C, which is normal during mango season, they cannot forage and mostly die in the greenhouse. There is no exact limit of using honey bee colonies for pollination of mangoes. Rather it is evident that concentration of colonies within the mango grove would result in increased floral visit and possibly more stabilized set of fruit. Mizuno *et.al*. (2006) tested 2 species of honeybees *A. cerana* and *A. mellifera* and 1 bumblebee (*Bombus ignitus*) for the pollination of “Irwin mango” in the greenhouse. They mentioned that pollination efficiency in superior order was *cerana*>*mellifera*>*ignitus*. Popenoe (1917) reported that honey bees were the most important hymenopteran insect visitors to the mango flowers, but the number present was variable.

It is apparent that there is need for pollinating insects within some cultivars to obtain satisfactory fruit harvest, although the need for cross-pollination between some mango cultivars is not critical, as they could be self fertile. From the present study on Iriomote Island it is understood that the fly visitors increased production both in quantity and quality for that cultivar of ‘apple mango’. Therefore, the utilization of flies for mango pollination was an effective approach for economic profit. Efforts could be employed to use flies even for the open orchard. Calliphorid flies were regular visitor of the mango flowers and its method of propagation is mentioned, as well. Kobayaashi (1981) tried some baits to rear various syrphid flies in artificial condition. However, more organized research is needed to look for easier methods of rearing the syrphids in the greenhouse through future studies that could also be used for mango pollination.

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