7.2 POLLINATION SERVICES AND MELON IN FAMILY FARMING AREAS, NORTHEASTERN BRAZIL

L.H.P Kiill, M.F. Ribeiro, K.M.M. Siqueira and E.M.S. Silva

7.2.1 Introduction

The lack of pollinators is considered a limiting factor for the productivity of many crops worldwide [1], especially given the expansion of agricultural areas. In addition, absence of information about pollinators and factors involved in the efficiency of "ecosystem services" hinders the successful use of those services. Several agricultural inputs and practices that play an important role in current production systems have highly negative effects on the diversity, abundance and use of pollinators, the most severe of which come from the improper use of pesticides [2].

Recent studies performed in Brazil [3] demonstrate the economic value of pollinators, and indicate that a considerable increase in production occurs when the crop is visited by pollinating bees, even for self-pollinating species. In the case of melon (*Cucumis Melo L.*, Cucurbitaceae), production in general depends on the introduction of honey bee colonies [4], as the areas cultivated are usually devoid of pollinators or have very few present. This chapter presents the author's experience with small producers of melon in northeastern Brazil, specifically in Petrolina, Pernambuco and Juazeiro, Bahia. It examines the obstacles encountered and highlights some measures that could enhance pollination services for cultivation.

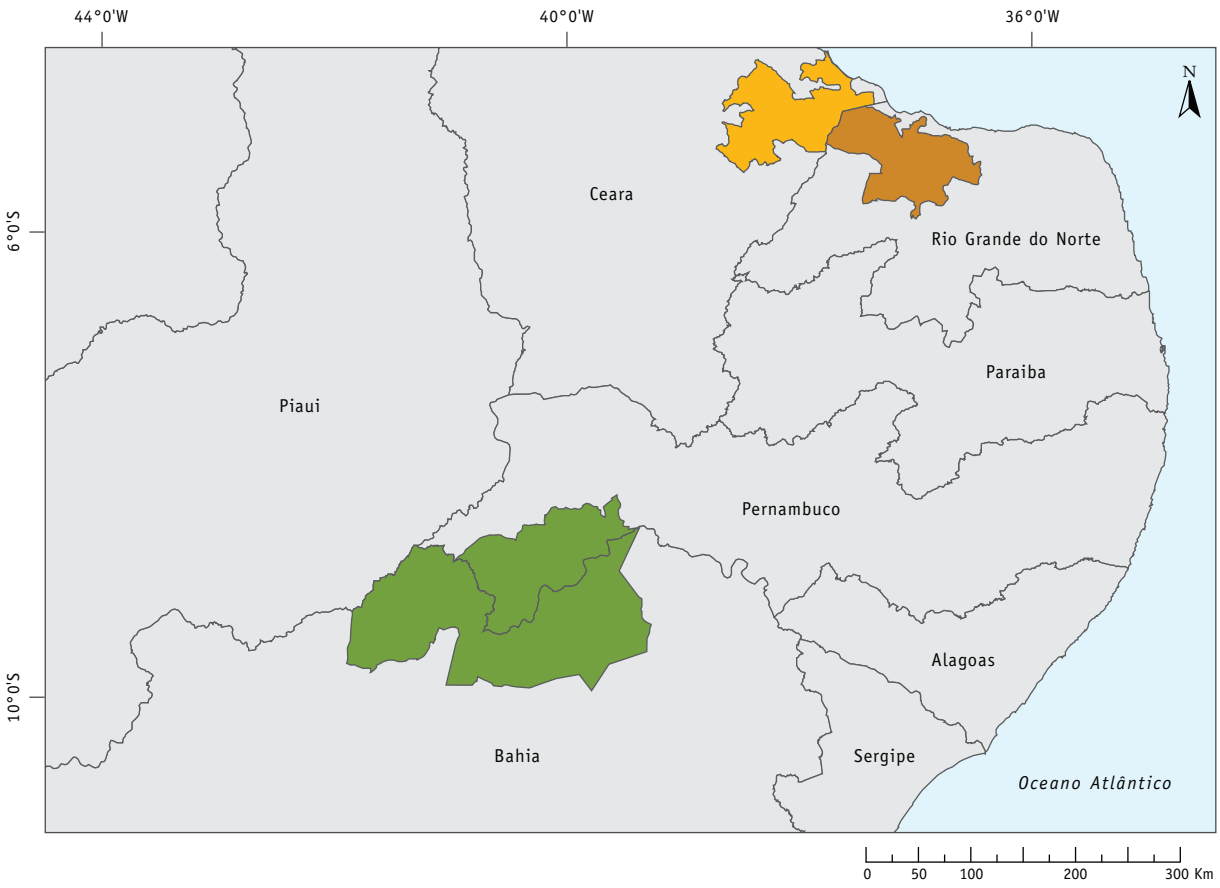
7.2.2 Cultivation expansion

Melon (*Cucumis melo* L.) is an ancient crop that perhaps originated in tropical Africa, spreading thereafter to India and Asia [5]. Other theories regarding the origin of this species suggest it radiated outwards in primary and secondary waves from India [6], Arabia and South Asia [7], and China [8]. The introduction of melon to Brazil occurred with European immigrants. Melon cultivation developed in Rio Grande do Sul, which remained the largest producer until the end of the 1960s. Further expansion of melon culture took place only after 1970, when important production centres emerged in the states of São Paulo (southeast region), Pará (northern region) and the middle lower São Francisco River basin, mainly in Petrolina, Pernambuco and Juazeiro, Bahia, in the northeast. By 1992, the northeast region accounted for 84 percent of Brazil's production [9, 10], with Rio Grande do Norte the largest producer.

Current production centres: As of 2011, Brazilian melon production had reached 499 330 tonnes [11], 93 percent of which came from the northeast. The main producers in the region are the centres of Mossoró and Açu, Rio Grande do Norte, Lower Jaguaribe, Ceará, and Petrolina, Pernambuco, and Juazeiro in Bahia state (Figure 7.3) [12]. In general, the production centres of Mossoró and Açu, Rio Grande do Norte and Lower Jaguaribe and Ceará depend on monocultures and account for 80.59 percent of national production and 100 percent of exports [12, 13]. These regions are characterized by large and medium-sized companies with modern technologies, irrigation equipment, packaging, fruit classification, and high productivity and quality, along with substantial competitiveness in domestic and foreign markets [14].

The growing areas are free of the South American curcubit fruit fly *Anastrepha grandis*, and have characteristic patterns of high solar insolation, low rainfall (except January to May) and low humidity, which enable melon production during almost the entire year [15]. The addition of certain adopted procedures, such as the use of agro-textiles (non-woven fabrics), have further optimized regional production systems (Figure 7.4). This approach has proven very convenient for integrated management of pests and viral diseases [16]. A soil cover of thick plastic reduces surface water evaporation and temperature fluctuation, and prevents direct contact of fruit with the soil. By decreasing direct moisture and injuries to the peel, postharvest diseases and invasive plants are better controlled [17, 18]. Colonies of Africanized *Apis mellifera* are also introduced to improve pollination [19].

Figure 7.3
THREE MAIN CENTRES OF MELON PRODUCTION IN NORTHEASTERN BRAZIL



Adapted from: GIS Laboratory at EMBRAPA Tropic Semiarid Geographic Coordinates Systems Datum SIRGAS 2000

In the production centres of Petrolina, Pernambuco state and Juazeiro, Bahia state, farmers and small rural entrepreneurs in the irrigated perimeters are responsible for most of the planting. They possess moderate to few financial resources and grow melon mainly between February and April, with their product intended for the domestic market [20]. Farm size averages about 6 ha, with one permanent workman and temporary labour. Although melon is predominant, more than one crop (e.g. tomato, watermelon, sweet pepper) is common, with the crop area varying according to current market value [21]. In such areas, mechanized activities require the rental of agricultural machinery and implements [21], and water from the São Francisco River. Some plantations are equipped with furrow or drip irrigation, with use of plastic covers (Figure 7.5) where mainly yellow melon or "piel de sapo" melon are grown. Honey bee hives are seldom moved into the flowering melon fields.

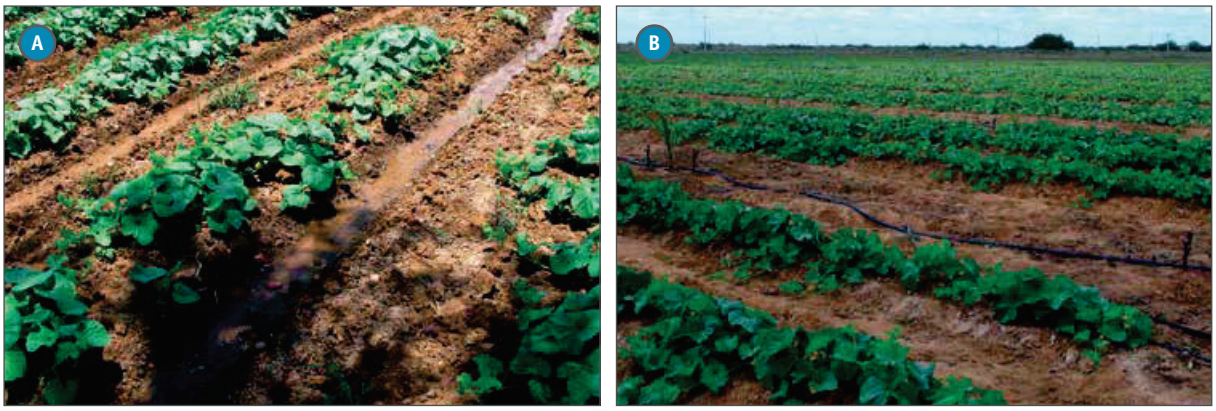
Among crop varieties, the most marketed types in Brazil are *Yellow*® Honey Dew, *Piel de sapo*®, *Charentais*®, *Cantaloupe*® and *Galia*®. The first three belong to the botanical group "Inodorus", and are hardy during transportation and odourless, with a long shelf life. Charentais and cantaloupe melons are aromatic, have a high content of soluble solids and a short post-harvest life [22].

Figure 7.4
APPLIED TECHNIQUES FOR OPTIMIZATION OF CROP SYSTEMS IN CULTIVATION CENTRES OF MOSSORÓ AND AÇU, AND RIO GRANDE DO NORTE, AND LOWER JAGUARIBE AND CEARÁ

(a) area covered with fabric, (b) area with the cover removed, and (c) area with honey bee hives near the melon crop

Source: L.H.P Kiill, M.F. Ribeiro, K.M.M. Siqueira and E.M.S. Silva

Figure 7.5
MELON CROP AREAS IN PETROLINA, PERNAMBUCO AND JUAZEIRO, BAHIA



a) with irrigation by ditch, and (b) drip irrigation (plastic cover removed)

Source: L.H.P Kiill, M.F. Ribeiro, K.M.M. Siqueira and E.M.S. Silva

7.2.3 Pollination ecology

Most melon cultivars are andromonoecious, presenting male and hermaphrodite flowers together [23]. The flowering period starts 25 to 30 days after planting, depending on the variety, cultivar and climatic conditions. The anthesis of male flowers precedes that of hermaphrodites by two to five days, and more male than hermaphrodite flowers are produced. A study conducted in Ceará State reports a sex ratio for male:hermaphrodite ranging from 1:6.1 to 1:11.3 for seven hybrids, with an average of 20.5 days of male flower anthesis and 10.7 days for hermaphrodite flowers [24]. Conversely, in Juazeiro-Bahia the sex ratio for two hybrids of the yellow variety is 1:16 and 1:19, with an average of 22.7 and 19.6 days for the male flowers and 16 to 20 for the hermaphrodite flowers [25].

Floral anthesis occurs in the early morning between 05:00 and 05:30 hours, with no difference between flower types, and with stigma receptivity coincident with anthesis or flower opening [26]. The hermaphrodite flowers are larger than the male ones (Figure 7.6), regardless of the hybrid variety, with the largest differences related to flower height [27]. Melon hybrids have different flower morphologies, possibly resulting in pollinator behaviour that favours hermaphrodite flowers. In hybrids, hermaphrodite flowers seem more visible and have a larger surface, thus increasing visual signal and facilitating the landing of floral visitors [27].

Figure 7.6
MELON MALE FLOWER (LEFT) AND HERMAPHRODITE FLOWER (RIGHT), SHOWING SIZE DIFFERENCE

Source: L.H.P Kiill, M.F. Ribeiro, K.M.M. Siqueira and E.M.S. Silva

Anther dehiscence occurs towards the outside of the flower, not the central portion near the stigma surface. In this way, even viable pollen grains that might otherwise germinate on the stigma of their own flower lie at the base of the corolla, with no possibility of contact with the stigma [28]. This characteristic reinforces the need for outcrossing pollinators to transfer pollen from anther to stigma. Generally, flower lifespan is about 12 hours, and from 15.00 hours petals begin to wilt and lose colour, with no difference between melon or flower varieties.

Nectar is produced by both flower types, but hermaphrodite flowers produce larger amounts. Measurement of nectar volume performed at different times documents a range of 5 028–8 700 µL (microlitres) for hermaphrodite flowers, and 1 851–3 850 µL for male flowers. The difference may explain the higher attraction of hermaphrodite flowers for pollinators [25, 27].

As to reproductive strategy, melon does not develop fruit by parthenocarpy or by self-pollination; it requires pollen transfer by animals [26]. Studies conducted in the Ceará on manual cross-pollination and open pollination (by bees) resulted in 98.3 percent and 75.7 percent fruit set (not necessarily mature fruit, only initiation), respectively [29]. However, the authors reported 100 percent abortion of fruit when flowers self-pollinate in *Yellow*® and *Piel de Sapo*® melon, but confirm fruit development using manual pollination, thus indicating that both types are self-compatible [30]. These results emphasize the importance of insect vectors for pollen transfer between flowers and plants.

In this context, studies on melon pollination in the region of Mossoró (Rio Grande do Norte) record the presence of bees, flies, butterflies and ant visitors of melon flowers [31]. According to observed insect behaviour patterns and frequency of visits, the authors conclude that the presence of Africanized honey bees (feral hybrid *Apis mellifera scutellata*) is essential for proper fruit production. Moreover, they observe that bee visits are more frequent in the morning, and note the presence of up to two individuals visiting a flower simultaneously.

In the same region, the present authors recorded bees, butterflies and flies as visitors of melon flowers (*Yellow*®, *Cantaloupe*® and *Galia*®) [30]. The visitation pattern of *A. mellifera* in dry or rainy season differs notably with regard to the frequency of bee visits. In relation to peak visitation, differences occur in different types of melon. For *Yellow*® and *Cantaloupe*®, most visits occur in the morning, while for *Galia*® the peak is between 14:00 and 15:00 hours during the rainy season, and between 10:00 and 11:00 hours during the dry season. In general, irrespective of melon type, hermaphrodite flowers are visited more than male flowers, and pollen foraging is more frequent in the morning, while visits for nectar collection occur throughout the day.

Studies performed in Ceará on bee foraging behaviour at *Yellow*® melon found that visits are concentrated in the morning, with more intense pollen collection, and without a preference for flower type [32]. The authors also commented that bees display flower fidelity in melon, visiting many flowers uninterruptedly.

Observations made at Mossoró in Rio Grande do Norte state, Pacajus, Ceará, Petrolina in Pernambuco state and Juazeiro in Bahia state, found that 12 insect species visit the flowers including bees, wasps, flies, butterflies and beetles [30]. Bees account for 58 percent of the total species, among which *A. mellifera* and *Xylocopa grisescens* visit all types of melon. The fly *Palpada vinetorum* (Syrphidae) occurs on three melon varieties, although at low frequencies. Additional floral visitors occur sporadically.

Studies in Juazeiro, Bahia, report that *A. mellifera* is a more frequent visitor in the morning and collects pollen mainly from 07:00 to 11:00 hours [25]. In Petrolina, Pernambuco, a comparison of the three melon cultivars showed different visitation peaks for *A. mellifera* on flowers of *Yellow*®, *Cantaloupe*® and *Piel de Sapo*® melons, from 11:00 to 12:00 hours, 10:00 to 11:00 hours and 15:00 to 16:00 hours, respectively [27]. With regard to the foraged floral resource, the authors mention that nectar collection is constant throughout the day, while pollen collection occurs largely in the morning. As for the flower type, hermaphrodite flowers usually receive more visits in *Yellow*® and *Piel de Sapo*® cultivars, while the opposite is found for *Cantaloupe*® when flowering.

7.2.4 Pollination service in family farming areas

As already stated, melon depends on pollinators to achieve adequate fruit set, yield, fruit quantity and quality [29, 33]. That melons often depend on honey bees for pollination is well recognized [34–41]. Various authors observe differences in the quantity and quality of fruit produced by natural cross-pollination related to honey bee foraging [42].

Studies on visitors of melon flowers come from various countries, with an almost exclusive record of *A. mellifera* as the main pollinator [26, 39, 43–46]. Three or four colonies/ha are recommended in areas where there is a pollination deficit [46–48]. In Brazil, honey bee colonies are employed for melon pollination in all monoculture centres of Mossoró and Açu, Rio Grande do Norte state, and Lower Jaguaribe and Ceará, with colony use ranging from two to four hives/ha, depending on other factors, such as the general abundance of insects and native plants in bloom [19]. Nevertheless, the same has not been observed in Petrolina, Pernambuco and Juazeiro, Bahia, where few farmers introduce honey bee hives. This may be related primarily to lack of knowledge regarding the importance of pollination for melon cultivation, with farmers still relying on natural pollinators in remnants of native vegetation (Caatinga). However, the expansion of agriculture and irrigated areas are hindering pollination services, with more malformed fruits and/or low fruit set each year.

The recommended use of managed pollinators now consists of one beehive for each 3 000 plants, depending on the density of planting. In commercial melon areas, yield increases by 40 percent when using this density, and fruit quality and financial gains are augmented [30]. However, the procedure should be executed with caution, given the proximity of crop areas and the potential risk of accidents generated

in the area by honey bee colonies (some of which are explosively aggressive) (Figure 7.4c). It should also be noted that if such hive introduction increases pollination services to melon and other fruits (guava, coconut, lemon), it may also have negative impacts, such as the displacement of pollinators or pollen theft (removal without pollination) on a large scale, which can affect plant reproduction of both crops and native plants. A similar situation exists for plots of yellow passion fruit, which may be visited but not pollinated by honey bees [49].

Taking into account the above-mentioned issues, the addition of hives may not always advisable due to maintenance and other costs. As previously noted, most properties cover 6 ha, with 100 percent of the area used for cultivation (Figure 7.7a), thus a continuous presence of hives on the site is not feasible. In such cases, the renting of colonies for just the flowering period is probably the best strategy. Another advantage is that transport and maintenance remain the responsibility of the beekeeper.

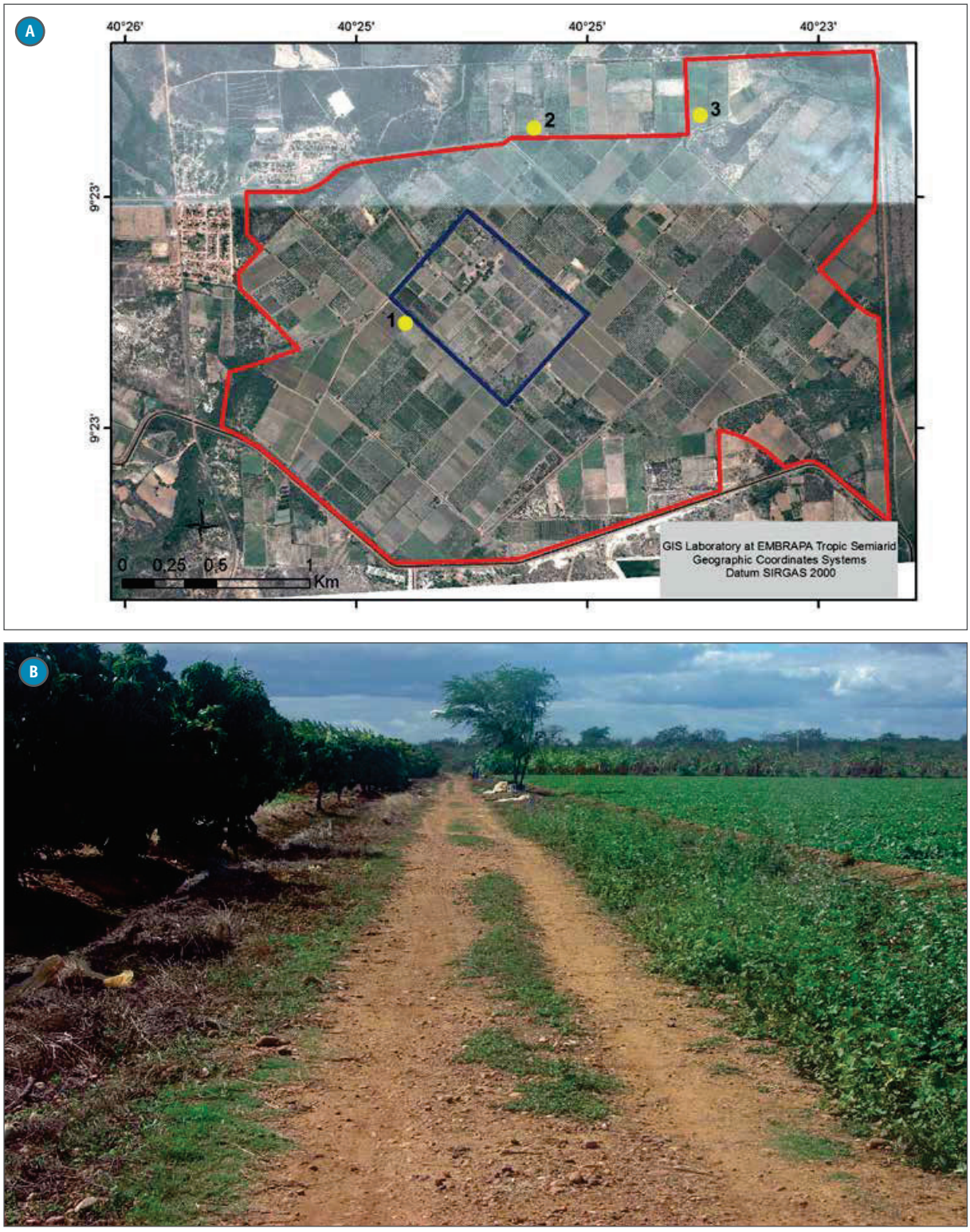
The introduction of hives in the cultivated field should be performed at the beginning of flowering, around the twentieth day after sowing or the sixth day from the initiation of flowering. Thus, colonies will be settled by the time the greatest numbers of hermaphrodite flowers are open, around the tenth day after flowering begins.

7.2.5 Conclusion

In the region studied, issues relating to pollination services remain little known among farmers and technicians, who are largely ignorant of the importance of pollinators for fruit production in general, and seldom bother to keep them at cultivation sites. Raising their awareness is therefore a key objective, so as to enable the adoption of other crop management practices that benefit pollinators, especially for melon cultivation. The dissemination of knowledge to increase awareness and local safety standards is imperative to minimize the risk of accidents, especially given the density of crops and the number of hives needed to ensure full pollination. The issue deserves special attention because if these rules are not obeyed and accidents do occur, the use of colonies in hives will become untenable and melon production in the region will suffer. Farmers, beekeepers, assistant technicians and others involved must be receive clear instruction and be made aware of the importance of complying with safety standards.

Source: B. B. Simpson and M. Connor Ogorzaly. 1986. Economic Botany - plants in our world. New York: McGraw-Hill. page 116. reprinted by permission [in original 1995 book published by FAO and edited by D. W. Roubik]

Figure 7.7
(A) SATELLITE IMAGE OF THE IRRIGATED PERIMETER OF MANDACARU (IN RED), IN JUAZEIRO, WITH PLOT 65 (NUMBER 3), AND (B) PARTIAL VIEW OF THE CROP AREA SHOWING THE SURROUNDINGS AND PROXIMITY BETWEEN CROP AREAS



Source: L.H.P Kiill, M.F. Ribeiro, K.M.M. Siqueira and E.M.S. Silva

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