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AgriQuality NZ Ltd Insect Pollination of Crops
14/1/2001. J.B. Free

Chapter 23

Cucurbitaceae

Cucurbita L.

The genus *Cucurbita* contains numerous species of pumpkin, squash, gourd and vegetable marrow and includes *C. maxima* Duch, *C. mixta* Pang., *C. moschata* Duch and *C. pepo* L.

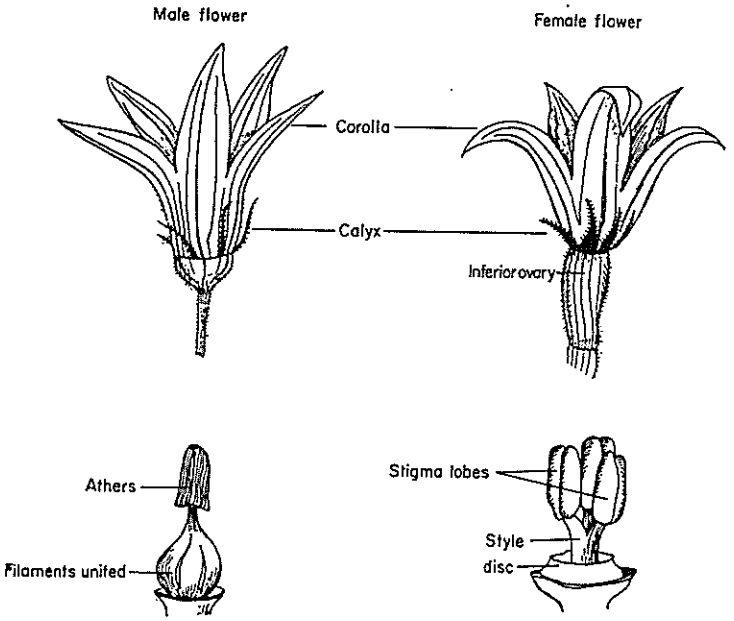

Fig. 115. Male and female flowers of *Cucurbita pepo* (after Cobley, 1956).

The yellow flowers are monoecious and occur singly in the axils of the leaves (Fig. 115). The corolla is divided into five pointed lobes. The pistillate flower surmounts an easily recognizable undeveloped fruit; the style usually has three stigmatic lobes corresponding with three chambers in the ovary;

a ring-like nectary surrounds the base of the style; the stamens are rudimentary. The staminate flowers have five stamens, with united filaments and anthers; they are always more numerous than the pistillate flowers and sometimes there are even twelve times as many of them (Robbins, 1931). The ratio of staminate to pistillate flowers is influenced by the season and the numbers of developing fruits already present (Whitaker and Jagger, 1937), and relatively low temperatures and short day length tend to increase the proportion of pistillate flowers (Nitsch *et al.*, 1952). Shaw (1953) found that the nectar sugar content of *C. maxima* ranged from 18–38% with an average of 30%.

Seaton and Kremer (1939) found that pumpkin and squash flowers opened and the anthers dehisced at 9–10°C (48–50°F) so they were always open at daylight when the temperature was above 10°C (50°F). When the temperature was relatively low and the humidity high, they remained open until noon or later, but under conditions of high temperature and low humidity the corollas started to wither as early as 08.00 h. However, the response to temperature and humidity probably differs with different species because under the same environmental conditions flowers of some species open early in the morning and close at about midday while others remain open for about 24 h. Bhambure (1958a) listed the approximate time of day at which flowers of seven species of gourd and pumpkin opened and closed near Bombay; of the five that opened at 06.00 h, one closed at 12.00 h, one at 14.00 h, one at 17.00 h and two at 18.00 h; another species opened at 08.00 h and closed at 13.00 h. The remaining species did not open until 17.00 h and closed sometime during the night.

Different varieties of the same species of *Cucurbita* will, of course, cross freely and so should not be grown near each other. Crossing can also occur between some species of *Cucurbita* but not others; according to Whitaker and Davis (1962) *C. moschata* can cross with *C. pepo* and *C. mixta*, so isolation of these species is necessary to produce pure seed; but, *C. pepo* and *C. mixta* do not cross with each other and neither of these nor *C. moschata*, crosses with *C. maxima*. However, pollen from one of these species can stimulate the production of parthenocarpic fruit by others, and although this will not result in contaminated seed, it may reduce the total seed yield. Therefore, to obtain the greatest yield it is probably best to separate all species from each other.

Because the male and female organs do not occur in the same flower, and the pollen grains are too large and sticky to be carried by wind, mechanical transfer of pollen is necessary. In glasshouses this is usually done by hand (e.g. vegetable marrow, Bewley, 1963) and in the field by insects. Verdieva and Ismailova (1960) found that pollination of squash by honeybees is as effective as hand pollination, or even more so. The staminate flowers have

long peduncles and are at approximately the same level as the upper leaves of the plant but the pistillate flowers have short peduncles and lie under the leaves; consequently, bees are more inclined to visit the more obvious male flowers when they arrived on a field and so cross-pollination is facilitated.

Wolfenbarger (1962) demonstrated in three ways the value of honeybees in pollinating squash plants. Firstly, in each of 3 years he caged squash plants to exclude insects and found that their average yield was only 19% of that of uncaged plants; secondly, he found that the yield of fruit decreased with distance from a group of twenty honeybee colonies put at one end of the field; and thirdly, he found there was a positive correlation between the number of honeybee colonies per hectare of field and the number of baskets of fruit obtained, i.e. an average of 0, 1·2, 2·5, 5 and 7·5 colonies/ha gave an average of 366, 383, 398, 415 and 427 baskets of fruit/ha. Battaglini (1968) found that only 7% of caged female *C. pepo* flowers set fruit compared to 61% of female flowers of 38 uncaged plants.

Sănduleac (1959) suggested that one or two honeybee colonies are necessary to pollinate 10 ha of a cucurbit crop. He found that varieties of *Cucurbita maxima*, *C. pepo* and *C. moschata* were worked intensively by bees from 06.00 h to 12.00 h daily, and the numbers of bees reached a peak between 08.00 and 09.00 h. The male flowers were preferred to female indicating that they were collecting pollen deliberately. However, Linsley (1960) found that honeybees only managed to scrape pollen from the anthers with great difficulty and their pollen loads were very small compared with those of solitary bees of the genera *Peponapis* and *Xenoglossa* which visited the flowers earlier in the day when the pollen was first available. Because of the difficulty honeybees have in collecting pollen, their numbers are strongly influenced by the presence of competing crops. This also applies to the Indian honeybee, *Apis cerana*, which Bhambure (1958) found sometimes collects pollen from *Cocus nucifera* and grasses in preference to gourds.

Numerous insects, most of which belong to the Hymenoptera, Diptera and Coleoptera, have been recorded visiting cucurbit flowers. Durham (1928) suggested that the striped cucumber beetle, *Acalymma vittata*, pollinated summer squash, but too many beetles may perhaps be detrimental to pollination as Fronk and Slater (1956) found an inverse relationship between the number of beetles per flower and the number of times it was visited by bees; although bees alighted on all flowers indiscriminately, they avoided entering those that contained many beetles. In the Ukraine, Nevkryta (1937) recorded 63 species of Hymenoptera, 16 Diptera, 7 Lepidoptera, 1 Hemiptera, and 1 Coleoptera on cucurbit flowers. In Iowa, Fronk and Slater (1956) found that 98% of all insects visiting *Cucurbita pepo*, *Cucurbita maxima* and *Lagenaria siceraria* were Hymenoptera and Coleoptera; only 2% of the Hymenoptera were honeybees, and the most important Hymenoptera were *Xenoglossa*

strenua and *Peponapis pruinosa*. They suggested that the superficial resemblance of these solitary bees to honeybees, especially when their bodies are dusted with pollen, might explain reports of many honeybees visiting cucurbit flowers (e.g. Jones and Rosa, 1928; Pammel and King, 1930).

It has long been known (see Hurd and Linsley, 1964) that species belonging to the genera *Peponapsis* and *Xenoglossa* (Anthophoridae: Eucerinae) obtain their pollen solely from the indigenous and domestic cucurbit species, although they may obtain nectar from several other sources. Because of their close association with squash, pumpkin and gourd, they are known as "squash bees". The available data suggest that certain species of bees exhibit a preference for pollen of certain species of *Cucurbita* including domestic species.

The genera *Peponapis* and *Xenoglossa* share in common a number of features which are adapted to the *Cucurbita* flowers (see Hurd and Linsley, 1964). Unlike many insect-pollinated plants, *Cucurbita* pollen is available very early in the day, sometimes before daylight, and the bees of both genera are able to fly at low temperatures and at low light intensities to collect it, with the result that their activity is synchronized with the opening of the flowers and competition with insects that arrive later is avoided. "Squash bees" are ideally equipped to gather and manipulate the large pollen grains, and females of both genera have a narrow band of dense hairs along the anterior margin of the hind basitarsi which may be a special adaptation for this purpose. The male bees habitually spend much of the day and night in closed, mostly staminate flowers of *Cucurbita*; they are usually covered with pollen which they carry with them when they visit newly opened flowers the following morning; however, the viability of such pollen has yet to be determined. Female bees that have not yet begun to nest, also spend the night in flowers.

The majority of species of *Peponapis* and *Xenoglossa* are found in Mexico and Central America, probably because the genus *Cucurbita* reached its maximum development there, and there is some evidence that the distribution of the different species of bees in America was altered after aboriginal man developed and introduced domestic species of *Cucurbita* (Hurd and Linsley, 1964, 1966a,b). Today, these domestic species have been introduced into many parts of the world but the "squash bees" have remained in America. Because of their value in pollinating these crops, it has been suggested that "squash bees" should also be introduced, due care being taken to select species of bees suited both to the particular *Cucurbita* species concerned and to the climatic and topographical characteristics of the area where they are being grown (Michelbacher *et al.*, 1968).

Despite the great importance of "squash bees" in pollinating cucurbits, Hurd (1964) emphasized that the value of other Hymenoptera should not be minimized because in some places at certain times of year "squash bees" may be few or absent, and bumblebees, carpenter bees, halictid bees or stingless bees may account for most of the pollination.

Cucumis sativus L.

Most varieties of *C. sativus*, cucumber, are monoecious and bear staminate and pistillate yellow five-lobed flowers (Fig. 116). There are usually many more staminate than pistillate ones. The staminate flowers each have three

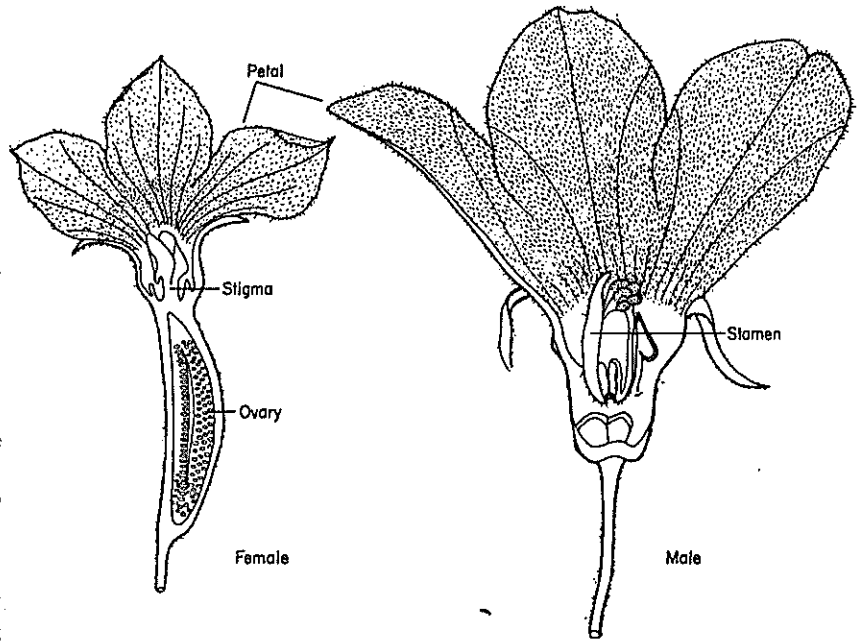

Fig. 116. Male and female flowers of *Cucumis sativus*, cucumber (after Purseglove, 1968).

stamens, two of which have two anthers and one of which has one anther only; dehiscence begins at about 17°C (63°F) and reaches its optimum at 18–21°C (64–70°F) (Seaton and Kremer, 1939). The pistillate flowers have rudimentary stamens but each has a well-developed, three-chambered ovary, each with several rows of ovules and a short thick style.

Maturing fruits of fertilized flowers have an inhibitory effect on the further development of the plant and on the formation of pistillate flowers, but maturing parthenocarpic fruits have no such effect (Tiedjens, 1928; McCollum, 1934). The ratio of pistillate to staminate flowers also decreases with decrease in the availability of nitrogen.