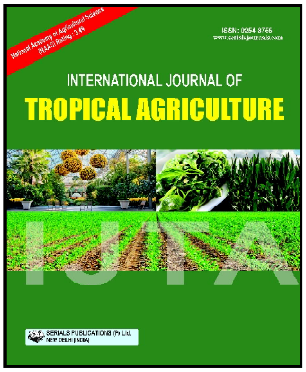

INTERNATIONAL JOURNAL OF TROPICAL AGRICULTURE

ISSN : 0254-8755

available at http: www.serialsjournal.com

Volume 35 • Number 4 • 2017

Temporal Variation in Pollinator Diversity and its effect on Fruit Production in Muskmelon (*Cucumis melo* L.)

Leena P.T.[*] and M. Nasser[**]

[*] Department of Zoology, Pazhassi Raja NSS College, Mattanur , Kannur, Kerala, India-670702
E-mail: leena.n.nambiar@gmail.com;leinapt@yahoo.com
[**] Department of Zoology, University of Calicut, Kerala, India-673635
E-mail: na_sher@yahoo.co.in

Abstract: Study on Muskmelon (Cucumis melo L.),an entomophilic cucurbit was carried out in commercial vegetable farm in Kerala,india. Observations were done at different time intervals in the flowering season to understand the effect of pollination on fruit production. Insects belonging to the orders, Hymenoptera, Coleoptera and Lepidoptera were the common visitors. Floral visitation was highest during the midphase of flowering season, which was followed by a decline. Results indicate that insect pollination had a positive influence on fruit production in the crop.

Key words: Muskmelon, Pollinator, Diversity, Temporal variation, Fruit production

INTRODUCTION

Pollination by insects is largely unique to the angiosperms, and diversification of pollination systems has been one of the most important factors in the radiation and abundant success of this group of plants (Regal, 1977; Crepet, 1984; Willemstein, 1987). In many parts of the country, fruit and vegetable growers are concerned about declining numbers of wild bees as human activities destroy bee habitat and forage. Bohart (1972) pointed out that the most drastic effect of the absence of pollinating insects would be in uncultivated areas, where, as a result, most soil-holding and soil-enriching plants would die out. A well known estimate proposed that about one-third of our food derives from animal pollinated, mostly bee pollinated crops (McGregor, 1976). This estimate has recently been confirmed by Klein *et al.* (2007). According to Kevan and Phillips (2001), pollination systems in many agricultural areas today are threatened by an inadequate number or complete lack of sustainably managed pollinators, either indigenous or imported. Benedek *et al.* (2006) found that even partial exclusion of pollinators resulted in a decrease in fruit yield. So conservation concerns for pollination have started to take on a greater profile than ever before (Kevan *et al.*, 1990; Torchio,1994).

MATERIALS AND METHODS

Crop selected for the study was Muskmelon. It is a very popular and a widely cultivated vegetable in India. It is a monoecious trailing annual and its upright stem enables leaves to form a protective arbor like canopy over the flowers and fruit. Flowers are solitary and yellow coloured. Staminate flowers borne in axillary position with five petals united to slightly beyond the staminal column, then separated and broadly spreading. The staminate flower, supported on a thin stem, consists of a corolla, a single whorl of five stamens, two pairs of which are united with the anthers almost filling the small corolla tube. The pistillate flower have a broad usually three lobed stigma on a style. The corolla of the flower is on the end of the elongated ovary. Melons develop from the yellow pistillate flower of the leaf and is round to oblong at maturity.

Study was conducted in the farms at Madayipara (12°1¾N and 75°15¾E) in Kannur District of Kerala, India. It is less disturbed habitat with laterite soil.

Experiment was laid out in a randomized complete block design with 6 replicates of 2 beds for each. There were 2 beds /replicate and 12 hills / bed. All crops were grown on raised bed of 2m. wide and 6m. length. Spacing between beds was 1.5m. with interplant spacing of 1m. and the inter-replicate spacing of 10m. Each replicate measured 33sq.m.with sequential plantings.

To quantify pollinator visitation and its consequences on fruit set observations were made on randomly selected plants. One plant from each bed was selected for observation. To quantify pollinator visitation each staminate and pistillate flower in a plant were observed for 5 minutes. 12 staminate and 12 pistillate flowers were observed on each day i.e. 4 staminate and 4 pistillate flowers each during each diurnal phase. Observations were carried out in three diurnal phases - initial phase (idp), middle phase (mdp) and late phase (ldp) according to the longevity of flowers and peak time of pollinator visitation [idp: 0730 h.-0930 h., mdp: 0930h.-1130 h., ldp 1130h.-1330 h.]. Duration of each phase was two hours. They were made for 12 days during initial phase (ISP), 18 days during middle phase (MSP) and 12 days during late phase (LSP) of flowering season. An insect landing on any part of the flower was counted as a visit. The insect was counted as a pollinator if it went so far into the flower that contact with anthers and pistils was probable. Pollinators were caught by sweeping with a long handled insect net and later identified.

The fruit setting was estimated to know the effect of pollinator visitation. For this bagging experiment was done. The pistillate flowers of each crop were bagged in the early evening before anthesis to control insect visits on the following day. On the day of treatment selected pistillate flowers were unbagged in each phase and insect visits were allowed on each flower. After each flower had received the visits the bags were resealed and tagged with treatment type and date in each phases of pollination. The no visit controls remained bagged for the entire day of anthesis. All bags were removed from the flowers after 1900 h. of the day of treatment after the insect activity in the field ceased. In all experiments the developing fruits were allowed to mature to a maximum size. The fruits from different samples were handpicked. The harvested fruits were counted. All treatment and control flowers that aborted were recorded. Fruits were analysed according to the shape and size variations and sorted them as normal small sized, normal medium sized, normal optimum sized, malformed and aborted.

Fruits which had normal shape and growth were categorized as normal fruits. And those shapeless and undergrown were included in the category of malformed fruits.

All observations were made on warm sunny days. The sampling period per day was restricted to morning intervals based upon observation on anther dehiscence, stigmatic receptivity and peak foraging activity. The data from each diurnal phase and seasonal phase were pooled for analysis. Statistica '99 version was used to carry out all statistical analysis.

RESULTS

Pollinator Diversity

Insects from 3 orders were recorded during the study (Table 1). The most abundant order was the Hymenoptera followed by Coleoptera and Lepidoptera.

Table 1
List of pollinators

Order	*Family*	*Species*
Hymenoptera	Halictidae	*Halictus timidus* Smith
		Halictus taprobanae *Cameron*
		Trigona iridipennis Smith
	Apidae	*Ceratina heiroglyphica* Smith
		Apis cerana Fabricius
		Amegilla parhypate Lieftinck
		Apis dorsata Fabricius
		Apis florea Fabricius
		Braunsapis picitarsis Cameron
		Ceratina smaragdula Fabricius
	Xylocopidae	*Xylocopa tenuiscapa* Westwood
		Xylocopa aestuans Linnaeus
Coleoptera	Chrysome-lidae	*Aulacophora lewisii* Baly *Aulacophora foveicollis* Lucas
Lepidoptera	Sphingidae	*Cephonodes picus* Cramer
		Macroglossum troglodytus Boisduval

Frequency of Pollinator Visit

The variety of insects encountered and the visits they made were more numerous in the middle phase (MSP), than in initial phase (ISP) and Late phase (LSP)(Table 2). It was observed that a mean of 19 and 15.58 hymenopterans and 2.16 and 1.66 coleopterans visited the male (♂) and female (♀) flowers /day respectively in the initial phase (ISP) of the season. In middle phase (MSP) a mean of 22.33 and 19.5 Hymenopterans, 1.83 and 1.41 Coleopterans and 0.41 and 0.41 Lepidopterans visited the male (♂) and female (♀) flowers /day respectively. In late phase (LSP) of the season a mean of 12.75 and 10.91 hymenopterans and 4.33 and 2.16 coleopterans visited the male (♂) and female (♀) flowers /day respectively. Variation in the case of different diurnal phases in each phase of the season was also observed. Higher frequency of visit was observed in middle diurnal phase of middle phase of season. Lowest frequency of visit was observed in late diurnal phase of late phase of season. The most dominant group was Hymenoptera followed by Coleoptera and Lepidoptera. Significant difference was found in visitation frequency shown by different orders of insects [ISP ($p<0.05$); MSP ($p<0.05$); LSP ($p=0.00$)]. Variation in visitation frequency shown by different species of insects belonging to Hymenoptera, Coleoptera and Lepidoptera was also obsereved. *Halictus timidus* was the most frequent pollinator. It was followed by *Ceratina heiroglyphica, Halictus taprobanae, Trigona iridipennis and Apis cerana.* They were regular, consistent and made the higher number of visits compared to other insects, at all sites. The visitation frequency shown by different species of insects differ significantly [ISP ($p<0.05$); MSP ($p<0.05$); LSP ($p<0.05$)]. No significant difference in visitation frequency on staminate (♂) and pistillate (♀) flowers [ISP ($p>0.05$); MSP ($p>0.05$); LSP ($p>0.05$)] was found. Frequency of visitation during different diurnal phases and seasonal phases differ significantly [ISP ($p<0.05$); MSP ($p<0.05$); LSP ($p<0.05$)].

Table 2
Frequency of pollinator visit/day

Seasonal Phases	*Sex of Flower*	*Diurnal Phases*		
		idp	*mdp*	*ldp*
ISP	♂	6.57	10.74	3.83
	♀	5.33	9.24	2.66
MSP	♂	7.9	12.33	4.33
	♀	6.82	11.16	3.32
LSP	♂	5.57	8.99	2.49
	♀	4.08	7.82	1.16

ISP-Initial Phase of Season; idp-initial phase of day; ♂ - Staminate flower
MSP-Middle Phase of Season; mdp-middle phase of day; ♀ - Pistillate flower
LSP-Late Phase of Season; ldp-late phase of day

Fruit Set

From the bagging experiment it was observed that percentage of fruit set increased from initial phase to middle phase of the day and season. All non pollinated flowers were aborted. Highest fruit set was recorded in middle diurnal phase of middle seasonal phase. Lowest fruit set was recorded in late diurnal phase of late seasonal phase (Table 3). Percentage of fruits within each seasonal phase and between the seasonal phases were significantly different ($p<0.05$).

Nature of Fruits

Fruits with varied shape and size were produced in the different phases of season. When size was measured in terms of length (l) and breadth (b) it was observed that fruits formed in different diurnal and seasonal phases were differed in the maximum size they attained. By comparing each other fruits with lb ≤ 12cm x 6cm were included in small sized ones, ≤ 16cm x 8cm and ≤ 20cm x 10cm were included in the group of medium and optimum sized ones respectively. Also on the basis of shape the fruits were categorized into normal and malformed ones. So four categories like small normal, medium normal, optimum normal and malformed fruits were recorded when size and shape were considered together for the assessment of nature of fruits [ISP (idp)=10.76% small normal; (mdp)=18.46% medium normal; (ldp)=4.61% malformed; MSP(idp)=13.84% medium normal; (mdp)=23.07% optimum normal; (ldp)=6.15% small normal; LSP(idp)=7.69% malformed; (mdp)=12.31% small normal; (ldp)=3.07% malformed]. All non pollinated flowers were aborted in all phases. Majority of fruits formed in the initial and middle phase were normal shaped and in late phase were malformed. Size and shape of the fruits differ significantly within seasonal phase ISP ($p<0.05$); MSP ($p<0.05$); LSP ($p<0.05$) and between the seasonal phases ($p<0.05$) (Fig. 1).

Table 3
Percentage of Fruit Production in Different Phases of Flowering Season

Seasonal Phases	*Diurnal Phases*		
	idp	*mdp*	*ldp*
ISP	10.76%	18.46%	4.61%
MSP	13.84%	23.07%	6.15%
LSP	7.69%	12.31%	3.07%

ISP-Initial Phase of Season; idp-initial phase of day
MSP-Middle Phase of Season; mdp-middle phase of day
LSP-Late Phase of Season; ldp-late phase of day

Correlation between pollinator abundance and fruit production

Positive correlation was observed between pollinator abundance and fruit set (r=0.98) (Fig. 2).

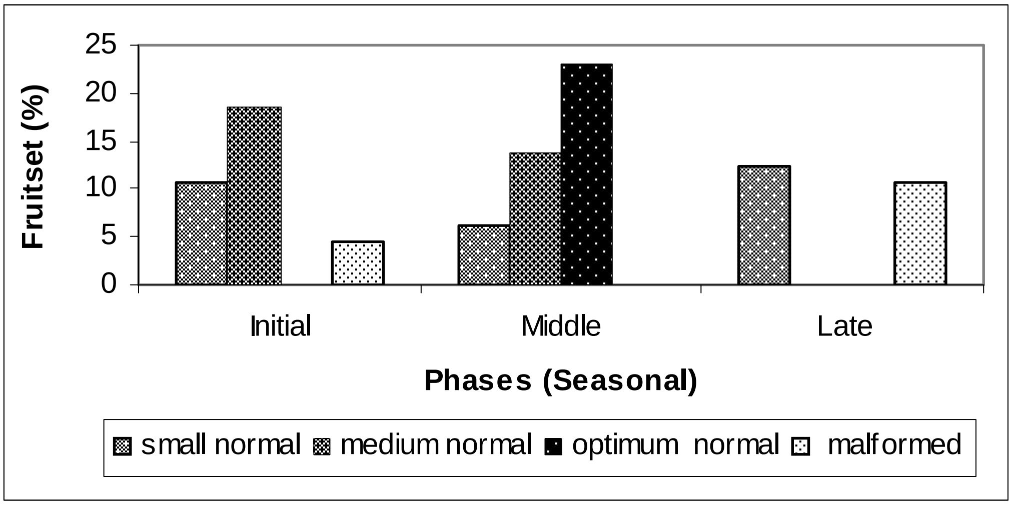

Figure 1: Percentage of fruit production in different phases of flowering season

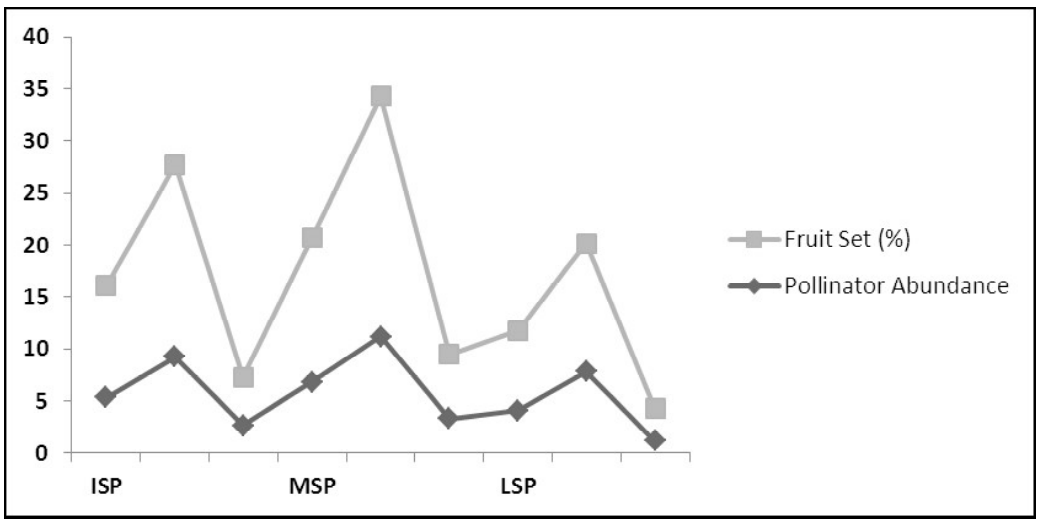

Figure 2: Correlation between pollinator abundance and percentage of fruit set

DISCUSSION

Almost all commercially grown vine crops (Cucurbitaceae) rely on insect pollination to set fruit. The nonpollinated cucurbit flowers abort and drop from the vine. When pollination occurs but is incomplete, fruits do not develop properly (Motes, 1977). The results of the present study demonstrate the importance of insects in the pollination of the cucurbit, Muskmelon. The relative contribution of the order Hymenoptera to this crop was major compared to other pollinators. Other visitors could be seen as complementary pollinators. The indigenous bee *Halictus timidus* was the major species found in this study had higher frequency of flower visitation in muskmelon and was regular visitor. Tepedino (1981) opined that there may be indigenous flower visitors for native crop species that are at least as adequate as pollinators. Stanghellini *et al.* (2002) also stated that in their native ranges, cucumber and muskmelon plants may be visited and pollinated by bee species that are smaller in size than the European honeybees (*Apis mellifera* L.) or North American *Bombus* spp. In the present study not only the honey bees but the solitary bees also were found to be the most frequent pollinators of these crops. This is in conformity with Jaycox *et al.* (1975), Alex (1957) and Rosa (1925) who identified solitary bees as pollinators of these crops. Michelbacher *et al.* (1964) also credit both honeybees and wild bees. Not only Hymenopterans but also Coleopterans and Lepidopterans also have been identified as pollinators in the present study. This is supported by Tontz (1944), Annand (1926) and Durham (1928) who have identified insect groups such as ants, thrips and cucumber beetles respectively as possible pollinators of cucurbits. Hurd (1966) also stated that other insects such as cucumber scarabs, meloid beetles, flies and moths were involved in pollination but to a lesser extent than bees. The number of pollinators changed significantly over the day and over the season. Willis and Kevan (1995) reported the same effect in pumpkin. Also in the studies of Stanghellini *et al.* (2002) the total number of bees increased over time of day on cucumber, muskmelon and watermelon. The middle phase of flowering received the largest number of visits. The decline at midday may have been due to excessive heat as opined by Pandey and Yadava (1970).

The influence of insect pollinators was assessed by studying the pomological aspects such as quantity and quality of fruits. In the present study number of fruits produced in middle seasonal phase was greater than that recorded in other phases. After that a decline in visit by pollinators and a concordant decline in fruit set were observed. In vine crops, the dependency of fruit set on insect pollination was well established (Free, 1993; Mcgregor, 1976). In the present study it was noted that fruit set varied with the diurnal phases also, it being larger in the middle phase (mdp) than in the first as visitation frequency increased from initial to middle. Overall fruit set was smaller in the late phase flowers than in the early phase. The increased insect visitation and subsequent increase in fruit set found in these studies was comparable to the results obtained by other researchers working with various vine crops (Mcgregor and Todd, 1952; Cauto and Calmona, 1993;Leena and Nasser,2015). Similar studies on cauliflower and cabbage (Verma and Partap, 1993) have shown that bee pollination increased the yield. Flowers that had the greatest number of visits had the greatest number of fruits, which is in conformity with the studies on cucumbers by Gingras *et al.* (1999). Flowers that produced fruits in Muskmelon had been visited more frequently than those did not set fruit. Pollinators thus play an important role in the maximum production of this cucurbit crop because the number of visit is correlated positively to the number of fruits produced. The results showed that percentage of fruit set was much higher in insect pollinated plants than in those isolated from insect visits. So insect pollination is essential for maximum yield as stated by Abrol (1989) in the studies on strawberry. Total abortion of female flowers in the absence of insect visitation found in these experiments confirms the results of other studies on cucumber (Rahmlow, 1970; Morris, 1968; Stanghellini *et al.* 1997), watermelon (Spangler and Moffett, 1979; Adlerz, 1966), cantaloupe (Iselin *et al.*, 1974),squash (Skinner and Lovett, 1992; Cauto *et al.,* 1990) and pumpkin(Leena and Nasser,2012). This study also revealed that percentage of fruits with normal shape was in the middle diurnal phase (mdp) of middle phase (MSP) of season. It was due to greater number of pollinators. Malformed fruits were higher in late pollination phase as compared to those in other phases. Flowers that received inadequate pollination resulted in the formation of malformed fruits as stated by Hodges and Baxendale (1995). Anderson (1941) also stated that malformed fruits in cucumbers were the result of poor pollination resulting from too few bee visits per flower. Higher frequencies of insect visit resulted in more number of maximum sized fruits in the plots at harvest which was in concordance with the studies of Free (1968) who found that pollination by honeybees increased percentage of well formed fruits in strawberry. In the present study direct correlation was found between yield and number of insects. The absence of sufficient pollinators can result in low fruit yield and reduced fruit size (Walters and Taylor, 2006). So it is very clear that insect pollination is essential for quantity and quality of fruits.

REFERENCES

Abrol, D. P. (1989), Studies on ecology and behaviour of insect pollinators frequenting strawberry blossoms and their impact on yield and fruit quality. *Trop. Ecol.*, **30**(1): 96-100.

Adlerz, W.C. (1966), Honeybee visit numbers and watermelon pollination. *J. Econ. Entomol.*, **59**:28-30.

Alex, A. H. (1957), Honeybee aid pollination of cucumbers and cantaloupes. *Glean. Bee Cult.,* **85**(7): 398-400.

Anderson, W. S. (1941), Growing cucumbers for pickling in Mississippi. *Bull. Miss. Agric. Exp. Stn.,* pp: 355: 17.

Annand, P. N. (1926), Thysanoptera and the pollination of flowers. *Am. Nat.*, **60**: 177-182.

Benedek, P., Erdos, Z., Skela, I., Nyeki, J. and L. Szalay. (2006), The effect of reduced bee pollination period to the fruit set of apricots. *Acta Horticulturae*, **701**: 723-725.

Bohart, G. E. (1972), Management of wildbees for the pollination of crops. *Ann. Rev.Entomol.*, **17**:287-312.

Cauto, R. H. N. and R. C. Calmona. (1993), Entomophilous pollination in Cucumber (*Cucumis sativus* L. var. Aodai Melhorada). *Naturalia (*Sao Paulo*),* **18**:77-82.

Cauto, R. H. N., Periera, J. M. S and L. A. Cauto. (1990), Effects of pollination in *Cucurbita pepo* (summer squash). *Cientifica,* **18**(1):21-27.

Crepet, W. L. (1984), Advanced (constant) insect pollination and mechanisms: pattern of evolution and implications vis-à-vis angiosperm diversity. *Annals of the Missouri Botanical Garden*, **71**: 607-630.

Durham. G. B. (1928), Pollen carriers in summer squash. *Jour. Econ. Ent.,* **21**:436.

Free, J. B. (1968), The pollination of strawberries by honey bees. *J. Hort. Sci.,* **43**:107-111.

Free, J. B. (1993), Insect pollination of crops, *2nd. Ed.* Academic press, London, U. K. pp: 544.

Gingras, D.. Gingras, J. and D.De Oliveira. (1999), Visits of Honeybees (Hymenoptera :Apidae) and their effects on Cucumber yields in the field. *Journal of Economic Entomology*, **92** (2): 435-438.

Hodges, L. and F. Baxendale. (1995), Bee pollination of cucurbit crops. Nabraska Cooperative Extension (NF 91-56).

Hurd, P.D. Jr. (1966), The pollination of pumpkins, gourds and squashes (Genus *Cucurbita*). *Bee World*, **47**(1): 97-98.

Iselin, W. A., Jensen, M. H. and H. G. Spangler. (1974), The pollination of melons in air inflated greenhouses by honeybees. *Environ. Entomol.*, **3**(4): 664- 666.

Jaycox, E. R., Guynn, G., Rhodes, A. M. and J. S. Vandemark. 1975. Observation on pumpkin pollination in Illinois. *Amer. Bee. J.*, **115**(4): 139-140.

Kevan, P. G. (1974), Pollination, pesticides and environmental quality. *Bioscience*, **24**: 198-199.

Kevan, P. G. and T. P. Phillips. (2001), The economic impacts of pollinator declines: An approach to assessing the consequences" *Conservation Ecology,* **5**(1):8.

Kevan, P. G.; Clark, E. A. and V. G. Thomas. (1990), Insect pollinators and sustainable agriculture. *Am. J. Alternative Agric.*, **5**: 13-22.

Klein, A. M., Steffan-Dewenter, I. and T. Tscharntke. (2003), Bee Pollination and Fruit set of *Coffea arabica* and *C. canephora* (Rubiaceae). *American Journal of Botany*, **90**(1):153-157.

Leena P.T. and M. Nasser. (2012), Diversity of pollinators and the impact of their abundance on Fruit production in Pumpkin(*Cucurbita moschata* L.).*Agrobiodiversity:Status, Trends and Prospects*-Edited by A. Biju Kumar, M.P. Nayar, R.V. Varma and C.K. Peethambaran.pp:91-98.

Leena P.T. and M. Nasser. (2015), Effect of insect pollination on fruit production in the cucurbit crop, Ashgourd (*Benincasa hispida* Thunb. And cogn.),*I.J.T.A.*,**33**:831-835.

McGregor, S. E. (1976), Insect pollination of cultivated crop plants. *Agriculture Handbook*, **496**:306-312.USDA, Washington, DC.

McGregor, S. E., and F. E. Todd. (1952), Cantaloupe production with honeybees. *J. Econ. Entomol.,* **45**(1):43-47.

Michelbacher, A. E., Smith. R. F. and P. D. Hurd Jr. (1964), Bees are essential in pollination of squashes, gourds and pumpkins. *Calif. Agr.,* **18**(5):2-4.

Morris, H. (1968), Pollination of cucumbers. *Glean. Bee Cult.,* **1**:14-16.

Motes, J. E. (1977), Pickling cucumbers: Production harvesting. Mich. St. *Univ. Ext. Bull.*, **837**: 8.

Pandey, R. S. and R. P. S. Yadava. (1970), Pollination of Litchi (*Litchi chinensis* by insects with special preference to honey bees. *Journal of Apicultural Research,* **9**(2):103-105.

Rahmlow, H. J. (1970), Cucumbers need the honeybee. *Glean. Bee Cult.*, **98**(10):585- 587, 634.

Regal, R. (1977), Ecology and evolution of flowering plant dominance. *Science*, **196**: 622 - 629.

Rosa, J. T. (1925), Pollination and fruiting habit of the watermelon. Proc. *Amer. Soc. Hort. Sci*. 21:51-57.

Skinner, J. A., and G. Lovett. (1992), Is one visit enough? Squash pollination in Tennessee. *Amer. Bee J.,* **132** (12):815.

Spangler, H. G. and J. O. Moffett. (1977), Honey bee visits to tomato flowers in polyethylene greenhouses. *Am. Bee j.*, **117**(9): 580-582.

Spangler, H. G., and J. O. Moffett. (1979), Pollination of melons in greenhouses. *Glean. Bee Cult.,* **107**:17-18.

Stanghellini, M. S., Ambrose, J. T. and J. R. Schultheis. (1997), The effects of honey bee and bumble bee pollination on fruit set and abortion of cucumber and water melon. *Am. Bee J.*, **37**(5): 386-391.

Stanghellini, M. S., Schultheis, J. R. and J. T. Ambrose. (2002), Pollen mobilization in selected Cucurbitaceae and the putative effects of pollinator abundance on pollen depletion rates. *J. Amer. Soc. Hort. Sci.,* **127**(5): 729-736.

Tepedino,V. J. (1981), The pollination efficiency of squash bee (*Peponapis pruinosa)* and the honeybee (*Apis mellifera*) on summer squash (*Cucurbita pepo*). *Journal of the Kansas Entomological Society,* **54**(2): 359-377.

Tontz, C. (1944), Ants pinch hit for bees. Glean. *Bee Cult.,* **72**:482.

Torchio, P. F. (1994), The present status and future prospects of non-social bees as crop pollinators. *Bee World,* **75**:49-53.

Verma, L. R. and U. Partap. (1993), Asian hive bee *Apis cerana* as a pollinator in vegetable seed production: *An awareness handbook*. ICIMOD;Kathmandu, Nepal. pp:52.

Walters, S.A. and B.H. Taylor. (2006), Effects of honey bee pollination on pumpkin fruit and seed yield. *Hortscience*, **41**: 370-373.

Willemstein, S. C. (1987), An evolutionary basis for pollination ecology. *E. J. Brill*, Leiden.

Willis, D. S. and P. G. Kevan. (1995), Foraging Dynamics of *Peponapis pruinosa* (Hymenoptera: Anthophoridae) on pumpkin (*Cucurbita pepo*) in Southern Ontario. *Canada Entomol.*, **127**(2): 167-175.