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Effect of Insect Pollination on Fruit Production in the Cucurbit Crop, Ash Gourd (*Benincasa hispida* Thunb. *and* Cogn.)

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ABSTRACT: *Study on Ash gourd (*Benincasa hispida *Thunb.* and *Cogn.), an entomophilic cucurbit crop was carried out in commercial vegetable farm represented by local type commonly found 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. During the flowering season the first foragers on the flowers were the Coleoptera, followed by Lepidoptera and Hymenoptera. Floral visitation was highest during the mid phase of flowering season, which was followed by a decline. Results indicate that insect pollination had a positive influence on fruit production in this crop.*

Keywords: *Pollination, Ash gourd, Cucurbit crop, Fruit production.*

INTRODUCTION

Pollination system and insect pollination in particular remain threatened today in many agricultural areas, by an inadequate number or complete lack of sustainably managed pollinators (Kevan and Phillips, 2001). Most crop species rely upon some kind of agent to accomplish the transfer of pollen grains from the anther of a stamen to the stigma of a carpel, which are well known as pollination vectors or pollinators. From an applied stance, evaluation of the role of flower visitors is necessary to enable objective decisions to be reached over the choice of pollinators to maximize crop pollination (Torchio, 1990). Inadequate pollination can result not only in reduced yields but also in delayed yield and a high percentage of inferior fruits. A global shortage of pollinators, which is destroying crops around the world, could lead to far higher prices for fruits and vegetables. Pollination is a key concept in fruit production that must be understood in order to maximize productivity and yield. 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). Many studies have attempted to estimate the value of crop pollination and pollinator dependency in financial terms, generating net dollar values for this ecosystem service (Southwick and Southwick, 1992; Costanza *et al.*, 1997; Losey and Vaughan, 2006; Gallai *et al.*, 2009).

MATERIALS AND METHODS

The crop selected for the study was Ash gourd. It is a native of Japan and Java. It is generally grown throughout India and all other tropical warm countries, such as China, Malaysia, Singapore, Turkey and Iraq for its edible fruits. It is a long running vine with brown hairy stem and broad hairy oval leaves. It is monoecious and has solitary yellow flowers. The staminate flowers have long peduncles, the pistillate ones are short stalked or almost sessile. The three stigmas lead to many ovules. It produces nearly spherical to oblong long fruit. The unripe fruit is somewhat hairy and is not covered with waxy bloom. The ripe fruit has a whitish waxy surface.

Study was conducted in the farms at Madayipara (12º1′N and 75º15′E) in Kannur district of Kerala, India. It is a less disturbed habitat with laterite soil. Experiment was laid out in a randomized block design with six replicates. There were 2 beds per replication

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and 12 hills per bed. All crops were grown on raised bed of 2 meters breadth and 6 meters length. Spacing between beds was 1.5 meters with interplant spacing of 1meter and the inter-replicate spacing of 10 meters. Each replicate measured 33 sq. m. with sequential plantings.

Observations were made on randomly selected plants. One plant from each bed was selected for observation. Twelve staminate flowers were observed on each day i.e. 4 staminate flowers each during each diurnal phase. Each staminate flower in a plant was observed for five minutes. Observations were carried out in three diurnal phases of two hours each - initial diurnal phase (idp: 0700 h.-0900 h), middle diurnal phase (mdp: 0900 h.-1100 h) and late diurnal phase (ldp: 1100 h.-1300 h) and in three seasonal phases -12 days in the Initial Seasonal Phase (ISP), 18 days in the Middle Seasonal Phase (MSP) and 12 days in the Late Seasonal Phase (LSP) according to the anther dehiscence, longevity of flowers and peak time of pollinator visitation. The insect was counted as a pollinator if it went so deep into the flower and made contact with anthers and pistils. Insect landing on any part of the flower was counted as a visit. All plot areas and foraging insects were chosen randomly for observation. Pollinators were caught by sweeping with a long handled insect net and later identified.

To estimate fruit production, bagging experiment was done. Individual plants of the test cultivars were chosen randomly each day for treatment. 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. The number of fruits formed in different controlled and pollinated samples was recorded. Fruits were analyzed according to the shape and size variations. Size was measured by measuring the length (l) and breadth (b) of fruits. Fruits which had normal shape and growth were categorized as normal fruits and those which were shapeless and under grown were included in the category of malformed fruits.

All observations were made on warm sunny days. The data from each diurnal phase and seasonal phase were pooled for analysis. Statistica '99 version was used to carry out all statistical analyses. Comparisons of fruit production in different phases were made using Analysis of Variance (ANOVA). Significances in the pollinator abundance were found using Chi-square test.

RESULTS

Insect Pollinators of Ash gourd

A total of sixteen insects were recorded from 3 orders as pollinators (Table 1). The most abundant order was the Hymenoptera followed by Coleoptera and Lepidoptera. The variety of insects encountered and the visits they made were more numerous in the MSP than in ISP and LSP (Table 2). Highest 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.

Table 1
List of pollinators of Ash gourd

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

Table 2
Frequency of pollinator visit /day

		Diurnal phases		
Seasonal Phases	*Sex of flower*	*idp*	*mdp*	*ldp*
ISP	♂	5.91	10.58	2.16
	♀	5.91	9.5	1.58
MSP	♂	8.33	13.99	5.25
	♀	6.99	12.74	4.16
LSP	♂	6.41	10.24	3.58
	♀	4.99	9.08	2.24

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

Within each season, the visits of different insect groups varied with the flowering phase, the middle phase receiving the larger number of visits. Variation in the case of different diurnal phases in each phase of the season was also observed. It was observed that a mean of 18.66 and 15.25 hymenopterans and 5.25 and 4.25 coleopterans visited the male (♂) and female (♀) flowers / day respectively in the initial phase (ISP) of the season. In middle phase (MSP) a mean of 25.66 and 22.25 hymenopterans, 1.41 and 1.25 coleopterans and 0.5 and 0.41 lepidopterans visited the male (♂) and female (♀) flowers /day respectively. In late phase (LSP) of the season a mean of 14.08 and 11.41 hymenopterans and 6.16 and 4.91 coleopterans visited the male (♂) and female (♀) flowers/day respectively. Highest 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. Significant difference was found in visitation frequency shown by different orders of insects [ISP ($p < 0.05$); MSP ($p < 0.05$); LSP ($p < 0.05$)]. The most dominant group was Hymenoptera followed by Coleoptera and Lepidoptera. Variation in visitation frequency shown by different species of insects belonging to Hymenoptera, Coleoptera and Lepidoptera was also observed. The visitation frequency shown by different species of insects varied significantly [ISP ($p < 0.05$); MSP ($p < 0.05$); LSP ($p < 0.05$)]. *Trigona iridipennis* was the most frequent pollinator. It was followed by *Halictus timidus, Apis cerana, Ceratina heiroglyphica and Halictus taprobanae.* They were regular, consistent and made the higher number of visits compared to other insects, at all sites. No significant difference in visitation frequency on staminate (♂) and pistillate (♀) flowers was observed ISP ($p > 0.05$); MSP ($p > 0.05$); LSP ($p > 0.05$). Frequency of visitation during different diurnal phases varied significantly [ISP ($p < 0.05$); MSP ($p < 0.05$); LSP ($p < 0.05$)]. Different seasonal phases also showed significant differences in visitation frequency ($p < 0.05$).

Fruit Set

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

Table 3
Percentage of fruit production in different phases of flowering season

	Diurnal phases		
Seasonal Phases	*idp*	*mdp*	*ldp*
ISP	10.58%	16.47%	7.05%
MSP	12.94%	18.82%	8.23%
LSP	25.88%	9.41%	11.76%

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

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 ≤ 15 cm. x 12 cm. were included in small sized ones, ≤ 25 cm. x 20 cm. and ≤ 30 cm. x 25 cm. 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 found when size and shape were considered together for the assessment of nature of fruits. [ISP (idp) = 10.58% small normal; (mdp) = 16.47% medium normal; (ldp) = 7.05% malformed; MSP (idp) = 12.94% medium normal; (mdp) = 18.82% optimum normal; (ldp) = 8.23% small normal; LSP (idp) = 9.41% malformed; (mdp) = 11.76% small normal; (ldp) = 4.71% malformed] (Fig.1). 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 varied significantly within seasonal phases ISP ($p < 0.05$)); MSP ($p < 0.05$); LSP ($p < 0.05$) and between the seasonal phases ($p < 0.05$).

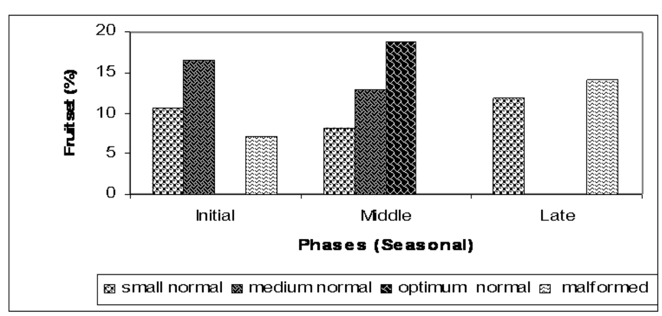

Figure 1: Percentage of fruit production in different phases of flowering season

Correlation between pollinator abundance and fruit production

Positive correlation was observed between pollinator abundance and the percentage of fruit set (r = 0.38) (Fig. 2).

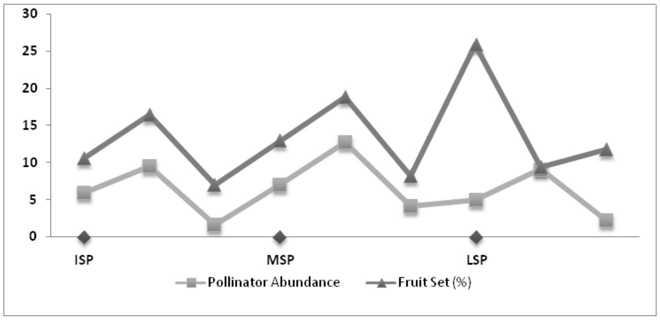

Figure 2: Correlation between pollinator abundance and the percentage of fruit set

DISCUSSION

The results of the present study demonstrate the importance of insects in the pollination of Ash gourd. It was noted that fruit set varied with pollinator abundance, it being larger in the middle phase than in the initial 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, 1976; Free, 1993; Cauto and Calmona, 1993). The relationship between fruit set and insect number was significant in this study which is in conformity with Stanghellini *et al*., (1998). Flowers that had the greatest number of pollinator visits had the greatest number of fruits, which is in agreement with the studies on cucumbers by Gingras *et al*., (1999). Pollinators thus play an important role in the maximum production of this cucurbit crop because the number of visit to flowers is correlated positively to the number of fruits produced. This study also demonstrates the absolute necessity of insect pollination on fruit set in the cucurbit species studied as there was 100 percent abortion of all pistillate flowers that received no entomophilous visitation when they were covered with nylon nets. Total abortion of pistillate flowers in the absence of pollinators found in these experiments confirms the results of other studies on cucumber (Seaton *et al*., 1936; Morris, 1968; Rahmlow, 1970), watermelon (Adlerz, 1966; Spangler and Moffett, 1979), cantaloupe (Iselin *et al*., 1974; Rosa, 1924) and squash (Cauto *et al*., 1990; Skinner and Lovett, 1992). The fact is that non pollinated cucurbit flowers, with the exception of those of parthenocarpic cultivars, will not produce fruit (McGregor, 1976; Free, 1993). The studies of Stanghellini *et al*., (1997) also demonstrate the absolute necessity of insect pollination on fruit set in non parthenocarpic cucumber and water melon varieties as there was 100 percent abortion for all pistillate flowers that received no entomophilous visitation. This study also revealed that percentage of fruits with greater growth and normal shape was in the middle diurnal phase (mdp) of middle phase (MSP) of season where high pollinator abundance was found. 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. Flowers that received inadequate pollination resulted in the formation of malformed fruits as stated by Hodges and Baxendale (1995). The number of malformed fruits was higher in late pollination phase as compared to those in other phases. So it is very clear that adequate pollination is essential for fruit quality, which is in conformity with the studies on strawberry by Abrol (1989).

The results indicate a positive correlation between the abundance of insect pollinators and the fruit production. This is in concordance with the studies of Roubik (1995), who found that biotic pollination improves the fruit quality or quantity in tropical crops. The populations of wild pollinator species are found declining in several regions (Kluser and Peduzzi, 2007), and so potential global 'pollination crisis' threatens our food supply (Withgott, 1999; Kremen and Ricketts, 2000; Richards, 2001;Westerkamp and Gottsberger, 2002; Steffan-Dewenter *et al*., 2005). Pollinator conservation and management, thus is an important global concern in the context of agricultural and natural productivity (Kevan *et al*., 1990; Torchio, 1994).

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.

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.

Costanza R., d'Arge R., de Groot R., Farber S., Grasso M. and B. Hannon, (1997), The value of the world's ecosystem services and natural capital, *Nature*, **387**: 253-260.

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, Academic press, London, U.K, pp. 544.

Gallai N., Salles J. M., Settele J. and B. E. Vaissière, (2009), Economic valuation of the vulnerability of world agriculture confronted with pollinator decline, *Ecological Economics*, **68**: 810-821.

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).

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.

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

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.

Klein A. M., Vaissière B. E., Cane J. H., Steffan-Dewenter I., Cunningham S. A. and C. Kremen, (2007), Importance of pollinators in changing landscapes for world crops, *Proceedings of the Royal Society*: *Biological Sciences*, **74**: 303-313.

Kluser S. and P. Peduzzi, (2007), Global pollinator decline: a literature review, Geneva: UNEP/GRID.

Kremen C. and T. Ricketts, (2000), Global perspectives on pollination disruptions, *Conservation Biology*, **14**: 1226-1228.

Losey J. E. and M. Vaughan, (2006), The economic value of ecological services provided by insects, *Bio Science*, **56**: 311-323.

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

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

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

Richards A. J., (2001), Does low biodiversity resulting from modern agricultural practice affect crop pollination and yield? *Annals of Botany*, **88**: 165-172.

Rosa J. T., (1924), Fruiting habit and pollination of cantaloupe, *Proc. Amer. Soc. Hort. Sci.*, **21**: 51-57.

Roubik D. W., (1995), Pollination of cultivated plants in the tropics, FAO *Agricultural Services Bulletin*, Rome, 118.

Seaton H. L., Hutson R. and J. H. Muncie, (1936), The production of cucumbers for pickling purposes, *Spec. Bull. Mich. Agr. Exp. Stn.*, **273**: 31.

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

Southwick E. E. and L. J. R. Southwick, (1992), Estimating the economic value of honey bees (Hymenoptera: Apidae) as agricultural pollinators in the United States, *Journal of Economic Entomology*, **85**: 621-633.

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., Ambrose J. T. and J. R. Schultheis, (1998), Seed production in watermelon: A comparison between two commercially available pollinators, *Hort. Sci.*, **33**: 28-30.

Steffan-Dewenter I., Potts S. G. and L. Packer, (2005), Pollinator diversity and crop pollination services are at risk, *Trends in Ecology and Evolution*, **20**: 651-652.

Torchio P. F., (1990), Diversification of pollination strategies for U.S. crops, *Environ. Entomol.*, **19**(6): 1646-1656.

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

Westerkamp C. and G. Gottsberger, (2002), The costly crop pollination crisis. In: Kevan P, Imperatriz Fonseca V, editors, Pollinating bees – The conservation link between agriculture and nature, Brasilia: Ministry of Environment, pp: 51-56.

Withgott J., (1999), Pollination migrates to top of conservation agenda, *Bioscience*, **49**: 857-862.