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Role of insect pollinators in pollination of cucumber

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Abstract
Cucumber, a member of the Cucurbitaceae family, is a widely produced commercial crop in tropical and subtropical regions around the world. The plants are monoicous, which means they produce both male and female flowers separately on the same plant. Cucumbers economic success is determined by high yields of high-quality fruit. Successful pollination is one of the most critical elements affecting quality and yield of cucumber. To carry out the pollination process, pollination agents are required. Cucumber plants have an open blossom form that allows insects easy access. Complete pollination ensures uniform and perfectly formed fruits with even maturity while as improper pollination results in formation of misshapen and small sized fruits, thus leads to low yield of marketable fruits. The insects visiting blooms of cucumber include, *Xylocopa vulga, Apis cerana, Apis mellifera, Bombus impatiens, Megachile atrata* and *Eristalis arbustorum.* Among these insect's honey bees are the major pollinators of cucumber. The pollination efficiency of any pollinator species is determined by foraging speed and foraging rate. Moreover, greater the foraging rate and foraging speed of a pollinator, the greater are the chances of pollination. Many elements influence an insect visitor's foraging behaviour, including instinctual foraging behaviour, floral structure, the type and quantity of floral rewards, and hours of the day. To reap the benefits of cross pollination, the material to boost pollinator visits to cucumber would be of great value. Various bee attractants viz., Bee Q, Sugar solution, Molasses and jaggery are being used to boost the foraging activities of pollinators. Therefore, in order to boost the productivity, there is requirement of insect pollination in cucumber and use of attractants as an additional input in enhancing the yield.

Keywords: Pollinators, foraging activity, attractants, cucurbits

Introduction
Cucumber (*Cucumis sativus* L.) is one of the most trendy vegetable belonging to the family Cucurbitaceae, a part of the Cucumis genus. The Cucumis genus contains nearly 40 species, such as watermelon (*Citrullus vulgaris*), cantaloupe (*Citrullus melo*). Cucumber is native to Asia and Africa. Cucumber has many common names including pepino, gurke, khira, kukamba. In Kashmir cucumber is commonly known as 'Laerr'. Cucumber is a creeping vine, can reach upwards upto 6 feet in length. It is sensitive to frost, annual crop with large, bold, and rough leaves. Cucumber is a good source of minerals, water, protein, lipid, iron, vitamin (Rashid, 1999) [38]. Everyone is fond of consuming this vegetable as raw for refreshment, mostly with fast food as salad (Reshma, 2011) [40]. Tender fruits of cucumber have cooling effect, prevents indigestion and check jaundice. Seeds of cucumber are utilized in ayurvedic preparation and raw fruits are used in cosmetic preparation (Hatwal *et al*., 2015) [16]. Cucumber is a monoecious annual herb with climbing or trailing 4-5 angled stems up to 5m long, branching with tendrils up to 30cm long. The plant is having extensive superficial root system, covered with scaberulous hairs. Leaves are simple, alternate borne on petiole 5-20cm long. Flowers are regular, unisexual, pentamerous. Fruit is roughly elongated, cylindrical with tapering ends and can be as large as 60cm long, 10cm in diameter.

Insect pollinator abundance on cucumber
Cucumber is a cross pollinated/monoecious vegetable, where male and female flowers are present separately on same plant. Male flowers occur in clusters together with each flower using slender stem housing three stamens. Female flowers occur singly so are distinguishable by large ovary at flower base. *Apis florea, Apis dorsata, Apis mellifera* and solitary bees, are main visitors of cucumber (Grewal and Sidhu, 1978) [15]. Flowers are not self-pollinated due to the presence of male and female flowers on the same plant, and pollen grains are sticky and large in size, requiring the need of an external agent to transfer pollen between flowers.

(Sedgley and Scholefield, 1980) [45]. The most common cucumber visitors are *Xylocapa chlorina*, *X. Philipinensis*, *Megachile atrata*, and *A. dorsata* (Cervancia and Bergonia, 1991) [9]. Fruit weight obtained is higher (2.6 kg/plant) in cucumber pollinated by honeybees as compared to self-pollinated plants of cucumber with a fruit weight of 2.03 kg/plant (Rafiq Ahmad, 1992) [39]. It is well acknowledged that insects play a significant role in pollen grain transfer from male to female flowers. (Free, 1993) [13]. Cucurbit pollination requires calm weather, clear skies, low wind speeds (below 25 km/h), low humidity (less than 75 percent), and temperatures in the 20-30˚ Celsius range. Cucumber relies on insect pollination to set fruit, which has been widely documented. Cucumber attracts a variety of insect visitors, but not all of them are pollinators. Honey bees are the most important pollinators among all insect visitors (Connor and Martin, 1969; Wokye and Brownikowska, 1984) [8, 59]. In order to pollinate cucumber flowers, around twenty bees must visit each bloom.

Pollinators of cucumber encompasses ants, beetles, thrips, and solitary bees, whereas honeybees are the most important pollinators in commercial crop production (Free, 1993) [13]. Stanghellini *et al*. (1997) [50] studied effects of bumble bee (*Bombus impatiens*) and honey bee (*A. mellifera*) pollination on fruit set and abortion of cucumber and watermelon. Flowers that aren't visited by insects have a 100 per cent chance of being aborted. As the frequency of bee visits to blooms of cucumber and watermelon increases, the number of fruits aborted decreases, indicating that bumble bees can serve as an alternate pollinator for cucumber and watermelon, and other vine crops cultivated in field and greenhouse. Ants are the most common insect visitors to watermelon blossoms (37.2%), followed by stingless bees (32%), Trigona sp. (9%), flies (9%), beetles (77%) and butterflies (9%) (Malerbo *et al*., 1999) [31]. Pollen grains of cultivated cucurbits are sticky so is not easily dispersed by wind. In cucurbits natural pollination occurs by insects Robinson (2000) [41].

Cucumber is mostly pollinated by honeybees, Honeybees receive nectar from both male and female cucumber blossoms, but pollen is rarely collected. Bumble bees (*Bombus impatiens*) are more efficient pollinators than honey bees (*Apis. mellifera*) for floral visitation, diurnal activity, and pollen deposition in field cultivated cucumber and watermelon (Stanghellini *et al*., 2002) [51]. The blooms of cucumber with 20 bee visits have significantly higher fruit weight (1210 g), number of seeds per fruit (482), and fruit volume (1315 ml) than cucumber with 15 bee visits, which have 1110 g fruit weight, 1205 ml fruit volume, and 448 seeds per fruit. To enhance fruit set rate and reduce fruit drop, at least 10 bee visits are required, and at least 20 bee visits are required to increase fruit volume, number of seeds per fruit, and fruit weight (Prakash *et al*., 2004) [34]. cucumber blossoms are visited by a total of 24 insect species, with Hymenoptera dominating and *Apis dorsat*a being most prevalent honeybee visitor (Sajjanar *et al*., 2004). Njoroge *et al*. (2004) [34, 30] studied pollination ecology in *Citrullus lanatus*, a species sensitive to pollination loss and observed this specie depends massively on honey bees (*Apis mellifera*) for pollination

Honey bees are the predominant pollinators of cucumbers. Honey bee activity is greater even when the humidity is low, with the ideal pollination period being between 9:00 a.m. and 12:00 p.m (Kohli and Vikram, 2005) [22]. There is no varietal significant difference in number of cucumber flowers visited per minute or foraging time per flower by honey bee, *Apis mellifera*. However, bees spent significantly more time (10.95 sec) in morning hours and visit few numbers of flowers as compared to noon and evening hours (Rana., *et al* 2006) [37]. Pollen from male flowers must be transmitted to female flowers by pollen vectors, the most effective of which are insects, in order successfully pollinate watermelon plants (Klein *et al*., 2007) [21]. The ridge gourd crop is visited by 21 insect pollinators during blooming period, including 12 Hymenopteran species, 4 Dipteran species, 3 Coleopteran species, and 2 Lepidopteran species. One of the most abundant honey bee species are *Apis* florea, *Apis cerana*, and *Apis dorsata*, which account for more than 78.9 per cent of all insect pollinators (Ramesh, 2007). Aslam *et al*. (2008) [36, 1] conducted an experiment to find out the effect of honey bee pollination on cucumber. Both open pollinated plants with bees and caged plants with bees significantly increase fruit set percentage, circumference, individual fruit weight and yield per plant as compared to control. They concluded honeybees visits to blooms of cucumber is imperative for pollination as they effect both quantity and quality of cucumber production. Pollination by honeybees is of vital importance because they affect cucumber output quantity and quality (Sarwar *et al*., 2008) Thakur and Rana (2008) [43, 54] examined how honey bee pollination, hand pollination and open pollination impact on quality and quantity of cucumber. Pollination by honey bee result in considerably higher percentage of healthy fruits (92.22 percent) as compared to hand pollination (85.85 per cent). Similarly, fruit size (28.8cm), number of seeds per fruit (472.8), and weight of fruits (1184.5g) is highest when pollinated by honeybees as compared to other pollination methods. The production of fruits and seeds of crops is enhanced when flowers are visited by bees for pollinating them, more the number of visits to female flowers of pumpkin (*Cucurbita moschata*) by *Apis mellifera* the greater is the fruit set, fruit weight, fruit size and number of seeds (Nicodemo., *et al* 2009) [29]. Insects visiting bitter gourd blooms belong to four different orders viz: Hymenoptera (*A. cerana*, *A. mellifera*, *Trigonia* spp, *Halictus spp*, *Xylocopa spp*, and *Formicidae*), Coleoptera (Chysomelidae), Lepidoptera (butterflies), and Diptera (Calliphora spp, Sarcophagidae and Syrphidae). *Trigonia spp*., *Halictus spp*., and lepidopterans are found to be the most prevalent flower visitors, with an average of five daily visits (Deyto & Cervancia, 2009) [10]. Thakur *et al*. (2010) [55] studied effectiveness of bumble bees as pollinators of cucumber blooms under greenhouse conditions at Nauni, in Solan district of Himachal Pradesh and found pollination by bumble bees led to increase in fruit set (4.08 kg/plant), fruit length (20.75cm), fruit diameter (11.01cm), fruit weight (413.62g), number of seeds/fruit (422) and few crooked fruits (16%) over control (no pollination). The study reported importance of utilizing bumble bees as pollinators of cucumber under protected conditions. six hymenopterans, five lepidopterans, and three dipterans are found on bitter gourd blooms. The most common and frequent visitors are *Trigonia iridepennis*, *Halictus guttorus*, and *A. florea*. Hymenoptera, Diptera, and Lepidoptera are the most prevalent pollinator orders (Subhakar *et al*., 2011) [52]. From 2008-2010 the European honey bee, *Apis mellifera*, was compared with two local bee species in New York viz., the common eastern bumble bee (*Bombus impatiens*) and *Peponapis prunosa*. Plants supplemented with *B. impatiens* yield considerably more pumpkins per plant than non-supplemented plants. *B. impatiens* is a better pollinator of pumpkin than *P. pruinosa*, and it should be considered as a

potential alternative for pollination by *A. mellifera* (Nault and Artz, 2011) [27]. Blooms of bitter gourd are visited by nine different bee species from three different families (Apidae, Halictidae and Megachillidae) Halictus *sp*., *Megachile sp*., and *Apis dorsata* are among the most common visitors. The most efficient pollinator of bitter gourd is *Apis dorsata*, followed by *Halictus sp*. and *Megachile sp* (Balina *et al*., 2012) [6]. Insect pollinators visiting summer vegetables such as Bitter gourd (*Luffa cylindrica*) and Ridge gourd (*Luffa cylindrica*) was studied by (Bodlah and Waqar, 2013) [7]. important pollinators of these plants are identified from Hymenoptera and Diptera orders. Six species of pollinators are found in the order Hymenoptera *(Apis spp*., *Xylocopa spp*., *Halictus spp*., *Bombus spp*., and two undetermined species from the Megachillidae and Halictidae families) and three species are found in the order Diptera (*Apis* spp., *Xylocopa* spp., *Halictus Eristalis spp*) and one unidentified specie from family Syrphidae and Muscidae. foraging rates are significantly higher in early hours of the morning, between 6 and 7 a.m., and pollinators belonging to the Hymenoptera order are the most frequent and diverse in their foraging activity. Insect pollination is found to be an extra input in strengthening cucumber yield with honeybees being the most frequent visitors (Shah *et al*., 2015) [46]. Nagar and Maurya (2015) [26] studied effect of pollination time in fruit setting and seed yield. Pollination is carried out at four timings viz., 6.00 AM, 7.00 AM,8.00 AM and 9.00 AM. There is increased percentage of fruit setting (96.97% and 90.25%), number of seeds per fruit (303.55 and 279.52), number of fruits developed to physiological maturity with pollination carried out at 9.00 AM. In the coastal region of Karnataka, Balachandran *et al*. (2017) [5] studied insect pollinator frequencies on *Cucumis sativus*, *Momordia charantia*, *Trichosanthes anguina*, and *Luffa acutangular*, and found that bees including *Apis cerana* and *Apis dorsata* are major visitors on all cucurbits, excluding snake gourd, which is pollinated predominantly by lepidopterans. Cucumber blooms attracts insects from four orders, twelve families, seventeen genera, and twenty-one species. Bitter gourd blooms also attract a huge number of insects from four orders, ten families, eleven genera, and thirteen species, including honey bees such as *Apis cerana*, *Apis mellifera* and *Apis dorsata* contributing for more than 69 per cent of total flower visiting insects (Dorjay *et al*., 2017) [12]. In the bitter gourd habitat, a diversity of insect pollinators is found such as *Apis dorsata*, *Apis florea*, and *Apis cerana*, at different flowering periods, during commencement of bloom, full bloom, and end of bloom of bitter gourd (Painkra, 2018) [32]. *Formica* spp >*Apis mellifera*> *A*pis *cerana*>syrphids>*Apis dorsata* are the most common insect pollinators, Foraging behavior of different pollinators had been examined, among all the foraging behavior of *Apis mellifera* reveal that pollen foragers are far more active in the morning hours (8-9 a.m.), whereas nectar foragers are far more active in the afternoon (Hossain *et al*., 2018) [18]. The foraging behavior of the carpenter bee (*Xylocopa fenestrate*) on ridge gourd (*Luffa acutangula*) was examined by (Gautam and Kumar, 2018) [14] it was found that foraging speed is maximum in the morning and evening hours (17.6 sec and 23.5 sec, respectively) and least in the mid-day hours (11.1 sec) and also that foraging rate and foraging speed have an inverse relation. The maximum pollen load (28.54 mg) is carried by *Xylocopa* in the evening hour (1700 h) and the minimum pollen load (9.75 mg) was carried by *Xylocopa* in the mid-day hour (1300 h) implying that *Xylocopa* collects more pollen in the morning and evening hours. foraging activities are used to identify major bitter gourd pollinators. The number of individuals/ 5 min/ m^2, the number of flowers visited by one individual/ 5 min, and the time spent by one individual (sec) on each flower are used to monitor foraging behavior of major pollinators from 0600 to 1800 hours. Pollinators are often seen foraging on nectar and pollen from flowers. Bees forage on bitter gourd flowers more efficiently between the hours of 0600 and 1600 (Yogapriya *et al*., 2019) [58]. Blooms of cucumber are visited by ten distinct species. Among these hemiptera is the most numerous (5 species), following with hymenoptera (3 species) and lepidoptera (2 species) with coleoptera and diptera each having a single species (Susan *et al*., 2019) [53]. The foraging activity of insect pollinators visiting blooms of ridge gourd (*Luffa acutangula*) reveal that insect species from two orders Hymenoptera and Diptera are major insect pollinators of ridge gourd. The order Hymenoptera include four species viz., *Apis mellifera*, *Apis florea*, *Apis dorsata* and *Xylocopa fenestrate* and are found to be most frequent pollinators. Among Dipterans viz., *Eristalis sp* from Syrphidae family and *Musca domestica* belonging to Muscidae family are found on blooms of ridge gourd during cropping season (Kumar and Rai, 2020) [23]. *Xylocopa confusa*, *Xylocopa latipes*, and *Apis* cerana are by far the most prevalent pollinators visiting cucumber plants, with *Xylocapa confusa* being the most efficient pollinator compared to *Xylocopa latipes* and *Apis cerana* (Hashifah *et al*., 2020) [17]. Pollinators of cucumber includes honey bees and *Xylocopa* spp. Pollination efficiency is highest in *Apis mellifera*, followed by *Apis dorsata*, *Apis cerana*, and *Xylocopa latipes*, with the lowest pollination efficiency in *Xylocopa verticalis*. Thus, on the basis of pollination efficiency, *Apis mellifera* collected the much more loose pollen grains (512565.7), followed by *Apis dorsata* (428160.2) and *Apis cerana* (320718.5), making it one of the most effective pollinators of cucumber (Singh and mall, 2020) [48]. During the morning hours of the day (0800 to 1000h) pollen collection by Indian bee (*Apis cerana indica*) is maximum. At 0800 to 1000h, the maximum average time spent by an *Apis cerana* per flower is 46.75 seconds. Population of *Apis cerana* visited of maximum number of flowers between 0800 to 1000 h (5.0 flowers/minute). At 1400-1600 and 1600-1800h, there is no visitation of the *Apis cerana* population, demonstrating that a significantly higher number of flowers are visited during 0800-1000h than at other timing intervals (Anandhabhairavi *et al*., 2020) [3]. *Apis cerana*, *Xylocopa sp*., *Bombus sp*., and *Syrphus sp*. are found among the major insect pollinators. *Xylocopa sp*. and *Bombus sp*. are found to be the most abundant, with *Xylocopa sp*. and *Apis cerana* having the highest foraging rate and foraging speed. The pollen load carried by *Xylocopa* and *Bombus sp*. is highest, suggesting that they could be effective sponge gourd pollinators (Rachna and Verma, 2021) [35].

Role of attractants in pollination of cucumber

Successful cucumber pollination is one of the most essential aspects. Insect pollination is essential for the production of high-quality fruits and vegetables. However, cucumber experiences still insufficient pollination, resulting in reduced yield, low crop quality and occasional crop failure. Therefore, various attractants are used to increase insect visits to the crop that would be of great practical value to harvest benefit of cross pollination. Various attractants such as sugarcane syrup, molasses, Bee Q can be used to boost yield in cucumber.

Schultheis *et al*. (1994) [44] investigated the efficacy of two commercial bee attractants, Bee- Scent and Beeline, for enhancing pollination in cucumber and watermelon by counting the number of bee visits to cucumber and watermelon flowers, along with their impact on fruit quality, crop profitability, and yield. All these attractants did not increase bee visits, resulting in no substantial increase in cucumber or watermelon yields. Attractants such as bee scent (a worker bee attractant) and beeline (a honeybee feeding stimulant) were applied on blooms of watermelon. These attractants have no effect on activity of pollinators and do not increase the productivity of watermelon (Ambrose *et al*., 1995) [2]. Bee Q enhances 21.80 and 31.80 per cent in number of fruits formed and total yield with the application of bee Q twice on the blooms of watermelon (Lingappa *et al*., 1999) [24]. Cucumber productivity and pollination have both increased as a result of the use of attractants (Viraktamath and Anagoudar 2002; Pateel and Sattagi 2007) [56, 33]. The goal of this study was to see how attractants affect bee attraction to a target crop and how beneficial attractants can boost pollination efficiency. Spraying cacambe and jaggery attracts the maximum number of *Apis dorsata* up to 5 days after the first spray and 1 day after the second spray, according to Kalmath and Sattigi (2002a), whereas attractants have the greatest effect on *Apis florea* at 10 days after the first spray and 5 days after the second spray. spraying Cacambe (10%) and jaggery (10%) on cucumbers have a major impact on attracting the most pollinators. Patches sprayed with cacambe have maximum number of fruits (10 percent) (Dinesh, 2003) [11]. The effect of different attractants in honey bee-caged plots and open pollination plots viz., 10% cacambe, 10% sugarcane juice, 10% sugar solution, 10% jaggery, and 10% molasses was examined. Cacambe, jaggery, and Bee-Q are reported to boost production of bitter gourd. According to the findings, the cacambe treatment produces more fruits per plant (14.00) than open pollination without spray and caged without bees, which produce 8.40 and 5.33 fruits per plant, respectively (Basvaraj, 2004) [4]. The day after first spray of sugar solution, results in substantially higher foraging activity (3.54 bees/m^2 /5 min), followed by the second and third sprays (3.35 and 3.20 bees/m^2 /5min, respectively (Narayanan and Gavigowda, 2005) [28]. Number of fruits per plant, fruit weight (gms), fruit yield (q/ha), and fruit length are improved with fruit boost and bee Q. Bee Q, however, have a phagostimulantory effect, attracting more bees to bitter gourd blooms than fruit boost, owing to its high carbohydrate content. Bee Q attracts bees to both pistillate and staminate blooms, resulting in sufficient pollination (Jayarammpa *et al*., 2011) [19]. To better understand honey bee visitation patterns on the target crop and pollination efficiency, varied concentrations of bee-Q (12.5 g/l) and fruit boost (0.75 ml/l) have been tested. After spraying these attractants, there is considerable increase in the number of bee foragers, that improve seed set, seed weight, and germination of the crop (Sivaram *et al*., 2013). Srikanth *et al*. (2013) [47, 49] carried an investigation on role of attractants on insect pollinators diversity and in increasing the productivity of bottle gourd (*Lagernaria siceraria* L.). Prior to the application of attractants, 10 species of insect pollinators were observed, whereas after the application of citral-a and citral-b, 19 species of insect pollinators were observed during flowering. Among them 8 species of insect pollinators belong to order hymenoptera, 5 species to Diptera, 3 species to lepidoptera and 2 species to coleoptera and 1 species from Hemiptera. The effectiveness of attractants on quantitative and qualitative parameters such as fruit set, fruit weight, fruit volume, and fruit length, test weight, number of sound seeds, as well as germination percentage is maximum when comparing open pollination with citral-a and citral-b to open pollination without attractants and control. Attractants like jaggary solution, sugar solution, molasses, and sugarcane juice, are more successful in attracting insect pollinators to cucumber, resulting in better pollination due to better pollen distribution and increased seed yield of cross-pollinated crops like cucumber (Wankhede *et al*.,2019). Manchare *et al*. (2020) [57, 25] sprayed bee attractants twice, the first time when the plant was at 10 per cent flowering and the second time when it was at 50 per cent flowering. On the first day after spraying, the intensity of *Apis mellifera* foraging activity increased, then decreased as the time progressed. Attractants like honey solution 10 per cent, molasses 10 per cent, and jaggery solution 10 per cent attract the most pollinators up to the 5th day after the first spray and the 7th day after the second spray (*Apis mellifera*).

Insect visitors/pollinators of cucumber (*Cucumis sativus*)

Scientific name	Common name	Order	Family
Eristalis arbustorum	European drone fly	Diptera	Syrphidae
Eristalis aeneus	Sryphid fly	Diptera	Syrphidae
Eristalinus tenux	Drone fly	Diptera	Syrphidae
Musca domestica	House fly	Diptera	Muscidae
Graphomya maculate	Muscid fly	Diptera	Muscidae
Bombus trifasciatus	Three banded Bumble bee	Hymenoptera	Bombicidae
Xylocopa vulga	Carpenter bee	Hymenoptera	Apidae
Apis cerana	Eastern honey bee	Hymenoptera	Apidae
Apis mellifera	European honey bee	Hymenoptera	Apidae
Lassioglossum marginatum	Sweat bee	Hymenoptera	Halictidae
Celastrina argiolus	Hill edge blue	Lepidoptera	Lycaenidae
Catocala deuteronympha	Underwing moth	Lepidoptera	Eribidae
Agrostis ipsilon	Black cut worm	Lepidoptera	Noctuidae
Coccinella septempunctata	Seven spotted ladybird	Coleoptera	Coccinellidae

Fig 1: Photograph of Cucumber blooming (*Cucumis sativus*)

Fig 2: Frequently visited pollinators on cucumber bloom, viz: *Bombus trifasciatus, Apis mellifera, Xylocopa vulga*

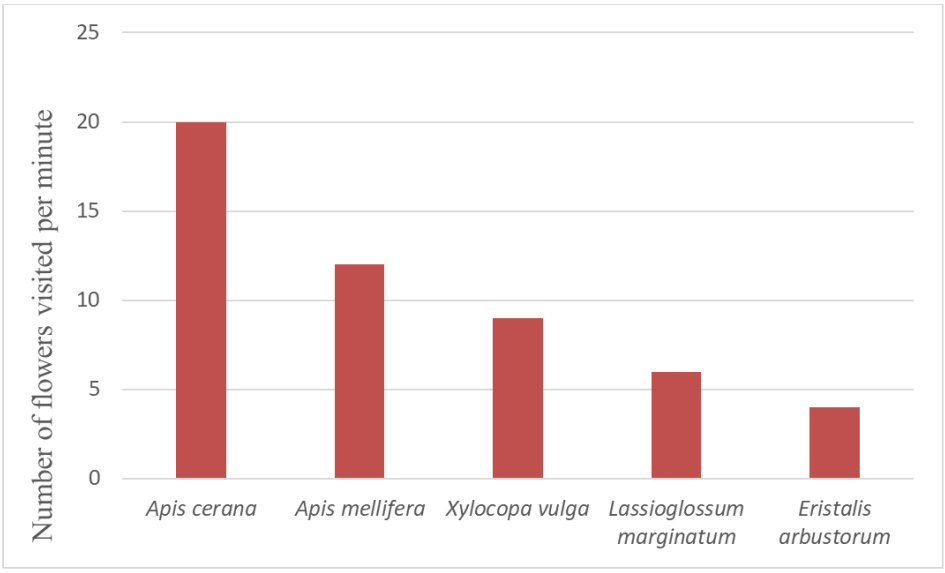

Fig 3: Foraging rate of insect pollinators on cucumber (*Cucumis sativus*)

Conclusion

Improper pollination is thought to be one of the key factors responsible for low productivity of many cross-pollinated crops. The vast majority of cucurbits, including cucumber are monoicous, therefore pollination is a critical component for enhancing the productivity. Pollination enhances the efficiency and quality of crop production. Many insect pollinators facilitate cucumber cross pollination. Honeybees are the most efficient pollinators in particular and other insects are potentially effective in pollination in general in cucumber. foraging activity of pollinators are influenced by the hours of day and insects are most abundant during 09:00-10:00 hours. Cucumber pollinated by honey bees result in higher yield, number of seeds per fruit, fruit weight and weight of thousand seeds. pollination by bees can give the best results and hence should be exploited to enhance the yield and quality of fruits in cucumber. In order to improve the efficiency of pollinators and overcoming pollinator deficits especially in areas where neighboring crops compete for a limited number of pollinators, the use of attractants can help to increase the number of pollinators onto a crop of interest. Therefore, a systematic and efficient use of insect

pollinators and attractants should be done in order to achieve the successful pollination and to boost productivity of cucumber.

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