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ORIGINAL ARTICLE

Insect Pollinators and their Pollinating efficiency on fruit yield of chilli

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ABSTRACT
Fourteen species of insect pollinators, belong to 4 orders under 10 genera having 10 families were observed visiting Bullet a variety of chilli (Capsicum annuum) at Jaguli, Nadia, West Bengal, India. Amongst genera, the genus Apis was found to be the second most dominant one only after an unidentified species. The foraging rate of the insect pollinators/ m^2/ hour was observed to be highest during forenoon hour i.e. 1100-1200 h, followed by 0800-0900 h and 1500-1600 h. The effect of different pollination methods on fruit yield of crop were differed significantly from each other. The number of flowers/plant, number of fruits setting/plant, length of fruit (cm) and yield (q/ha) was 234.45, 43.93, 5.89 and 103.07 during 1st year 195.36, 44.73, 6.12 and 102.87 during 2nd year, respectively was significantly higher in natural pollination (NP) followed to bee pollination with 231.52, 43.27, 6.04 and 94.51 during 1st year and 187.69, 44.60, 6.24 and 96.23 during 2nd year, respectively.
***Key words**: Apis mellifera, Capsicum annuum, Pollinator, Insect pollination, Yield*

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INTRODUCTION

Chilli (*Capsicum annuum* L.; family Solanaceae) is native to the New World, but have spread around the globe to become one of the most important tropical and subtropical crop on the basis of its high consumption, nutritional contribution, and cash value to farmers and consumers, both in developed and developing countries. It is grown around 1.5 million hectare area worldwide, with 7 million tonnes production as green and dry chilli [1]. India is the largest producer, consumer and exporter of chilli in the world and contributes about 25% of total world production. It is the most common spice cultivated in the country. The major chilli growing areas in India include Andhra Pradesh, Orissa, Maharashtra, Karnataka, Madhya Pradesh, Tamil Nadu and West Bengal. Among states, Andhra Pradesh alone contributes to 51% of the chilli production in India [2]. It is well known for its high nutritious values as rich source of vitamins A and C, potassium, folic acid and vitamin E, and also free from cholesterols [3].

It is highly self and cross-pollinated crops and cross-pollination varying from 7 to 36% was found to be accomplished mainly by insects, even though, honeybees visited chillies to collect pollen [4]. Pepper (*C. annuum*), even being self pollinated, was reported to be insect pollinated to the extent of 20% [5]. But the chilli growers of West Bengal state were reported to the present workers, the number of fruits setting had reduced due to regular visits of honeybees during flowering period. Keeping this facts in mind, an attempts was made to the know the different species of insect pollinators including honeybees and their peak visiting hours in a day during flowering period *vis-à-vis* the effect of different pollinating methods on fruit yield of chilli.

MATERIAL AND METHODS

Field experiments were carried out in a randomized block design with three replications at 'Instructional Farm' of Bidhan Chandra Krishi Viswavidyalaya at Jaguli, Nadia, West Bengal, India, during 2008-09 and

2009-10, under new alluvial zone at locations of 22.9^{0}N latitude, 88.53^{0}E longitudes with an elevation of 9.75 meters above the mean sea level, to know the foraging activity of different species of insect pollinators including honeybees and their peak visiting hours in a day as well as effect of different pollinating methods on fruit yield of Bullet a variety of chilli (*Capsicum annuum*). For conducting the experiment, all locally recommended cultural practices were adhered to. Seedlings of chilli was transplanted in plot size of 5 x 3 m with spacing of 60 x 45 cm.

The movable frame bee hives or Langstroth-model hives with European bee, *Apis mellifera* having 3 to 4 frames (40 x 20 cm in both the brood frame and super frame) per colony was introduced before the flowering period starts. The foraging activity of different insect pollinators, an area of 1 m^2 was selected randomly for recording the population at three different hours of a day *viz.*, between 0800-0900 h, 1100-1200 h and 1500-1600 h, respectively. Hence, the data recordation of insect pollinators started from flower initiation and continued till end of flowering was over. The pollinators were collected visiting chilli flowers, brought to the laboratory, prepared and labeled, and were identified by Zoological Survey of India, Kolkata.

Impact of different pollinating methods *viz.* bee pollination, natural pollination and self pollination on yield attributing characters like number of flowers setting/plant, number of fruits setting/plant, length of fruit (cm) and fruit yield (q/ha) of chilli were ascertained and such effects were recorded. For treatment bee pollination, a colony of *A. mellifera* was kept in each plots and fully covered with nylon net (size, 5 x 3 x 3 m) to avoid entry of other pollinators, for treatment natural pollination, the crops were left fully open for natural pollinators and for self pollination, each plots was fully covered with nylon net (size, 5 x 3 x 3 m) to avoid the entry of pollinators.

Consequently, data obtained during the investigation period from 2008-09 and 2009-10 were pooled and analyzed using SPSS statistical software version 16.0. Analysis of variance (ANOVA) of means was done to determine the significance of the treatments at 95% level. The standard deviation (SD) was used as a post-ANOVA test.

RESULTS AND DISCUSSION

Foraging activity of insect pollinators

As a results, 14 insects belonging to 4 orders *viz.* hymenoptera, lepidoptera, coleoptera and diptera under 10 genera *viz., Apis, Megachile*, *Vespa*, *Xylocopa*, *Pelopidas*, *Papilio*, *Pieris*, *Coccinella*, *Henosepilachna*, *Bactrocera*, and some were identified up to "family" level only having 10 families *viz.,* Apidae, Megachilidae, Vespidae, Xylocopidae, Hesperidae, Noctuidae, Papilionidae, Pieridae, Coccinellidae and Tephritidae observed visiting chilli flowers.

During the present study the maximum per cent of pollinators' species were recorded in order hymenoptera (70.48) during first year and (65.63) in second year, followed by lepidoptera (16.44% and 19.03%), coleoptera (8.08% and 9.37%), and least per cent was 5.01 and 5.97 in diptera, visiting chilli, respectively (Fig. 1 and 2). Amongst these, hymenoptera was most dominant one, recording maximum number of pollinators, which were 13 times, 7 times and 3.5 times more than diptera, coleoptera and lepidoptera, respectively.

In the midst of 14 genera, genus *Apis* was found to be the second most dominant one in all the varieties 28.98 to 33.43% only after an unidentified species and *A. mellifera* was recorded to be most dominant pollinator during both the years.

In our study, the 3rd week of February was found to be the peak period for insect pollinators in chilli crop. Further, the foraging rate of insect pollinators/ m^2/ hour was observed to be highest during forenoon hour *i.e.* 1100-1200 h, which was more than 1.5 times as recorded at 0800-0900 h and 1500-1600 h (Fig. 1 and 2) during both the years. The present findings in respect of the peak visiting hour of the pollinators is corroborated with results of [6]. The foraging rate/ flower/ 5 minutes in mango inflorescence was observed to be highest at 1200 h, as compared to 0700 h and 1500 h.

The present findings were in agreement with the earlier workers. Honey bees and other bees were recorded to visit the flowers of pepper on warm bright days or during dry periods [7]. In *Capsicum* spp., the solitary bees, honey bees, bumble bees, aphids and thrips were recorded to transfer the pollen grains, especially those that obtained pollen by buzz pollination and shaking the anthers [8] [9] [10] [11] [12]. Foraging activities of *Scirtothrips dorsalis* within the same flower caused self-pollination [13]. The pollination effects of the drone fly, *Eristalis tena* (L.), on greenhouse sweet pepper, *C. annuum* L. was assessed by measuring fruit characteristics [14]. *Bombus impatiens* was found to be effective pollinating agent of sweet pepper (*C. annuum* L. var. *grossum* cv. Superset) inside a screened greenhouse [15]. *A. mellifera, Dorylus labiatus, E. vigintioctopunctata, Rhapidopalpa* (*Aulacophora*) *foveicollis, M. domestica* and dipterous flies visiting chilli during flowering period [16]. [17] reported honey bees, bumble bees,

and halictid bees such as sweat bees being effective pollinators of peppers under natural conditions. *M. subnitida*, a stingless bee, was found to be an efficient pollinator of greenhouse sweet pepper (*C. annuum* L.) [18], while *Nannotrigona perilampoides*, also a stingless bee was observed to be good alternative to the use of mechanical vibration and non native bees for pollination of peppers in enclosures under tropical conditions [19]. Sweet pepper, during days of maximum blooming, were visited by twelve species of insects, of which *Exomalopsis* spp. (Apidae: Hymenoptera) were the commonest ones with 53, 9% visits, while honeybees were efficient as the other insects [20]. Twenty major insect pollinators, were observed visiting sunflower capitulum, and out of them, genus *Apis* was found to be the most dominant ones, However, *A. mellifera* L. was recorded to be most dominant pollinator followed by *A. dorsata* F. [21]. However, the findings of the above workers are in conformity to the observations recorded by the present researches on pollinating efficiency of honeybees in chilli.

Table 1 : Insect visitors of chilli (var. Bullet) during flowering period at Jaguli, Nadia, West Bengal, India

Order	Family	Scientific Name
Hymenoptera	Apidae	*Apis mellifera*
	Apidae	*A. florea*
	Apidae	?
	Megachilidae	*Megachile* sp.
	Vespidae	*Vespa* sp.
	Vespidae	?
	Xylocopidae	*Xylocopa* sp.
Lepidoptera	Hesperidae	*Pelopidas mathias*
	Noctuidae	?
	Papilionidae	*Papilio demoleus*
	Pieridae	*Pieris brassicae*
Coleoptera	Coccinellidae	*Coccinella* sp.
	Coccinellidae	*Henosepilachna* sp.
Diptera	Tephritidae	*Bactrocera cucurbitae*

? = These insect visitors were identified up to "family" level only

Effect of different pollinating methods on crop yield

It may be seen from the table 2 that all the treatments significantly differed from each other in respect of number of flowers setting/plant, it was recorded to be highest (234.45) in treatment NP which was found to be more than 1.01 times in BP and 1.58 times in SP during 1st year, while during 2nd year these were 195.36, 187.69 and 164.54 in NP, BP and SP, respectively. The maximum number fruits setting/plant was 43.93 in treatment NP which was more than 1.02 times in BP and 3.76 times in SP, respectively.

There were appreciable differences observed among treatments for a period of two years in respect of fruit length, where the average length ranged between 6.04 to 6.24 cm, 5.89 to 6.12 cm and 5.40 to 5.62 cm in treatments with BP, NP and SP, respectively.

In the same way, the highest fruit yield 103.07 q/ha was recorded in treatment with NP which was 1.09 and 6.51 times more than treatment with BP and SP during 1st year, respectively, while during 2nd year it was 102.87 q/ha in treatment NP which was more than 1.07 times in BP and 5.30 times in SP, respectively. Consequently, the fruit setting/ plant were found to be more influenced by insect pollinators as compared to self pollination.

In support of the results achieved by the present investigator, [22] observed increase in fruit weight and number of seed per fruit in paprika (*C. annuum*) due to honeybee pollination, while higher seed set and greater percentage of heavier fruits were observed in sweet pepper due to insect pollination, as compared to those produced from unvisited flowers [14]. [23] found average higher fruit set of 445.6% and fruit length of 9.98% through covering chilli plants with nylon bag than muslin net bag, respectively, along with highest number of fruits (224.1), fruit length (12.60 cm) and number of seeds per fruit (87) in open-pollinated plants. [18] recorded significantly heavier and wider fruits of better quality with more number of seeds in sweet pepper using stingless bees for pollination, as against self-pollination. Percentages of seed set per fruit were strongly related with the number of bee visits, but weakly with duration of visits. [24] observed larger and heavier fruits of sweet pepper due to visits of bumble bees to flowers along with higher seed set, fruit diameter, length and weight than non-visited flowers. [20] also achieved similar findings in the same crop due to pollination by honeybees. [25] found increased fruit set, fruit quality and quantity with better appearance in brinjal and chilli through pollinating the crop with honeybees, as

compared to control. [6] observed that the highest weight/ fruit/ treatment in mango was 165.75 g and yield/ panicle/ treatment was 215.75 g in the treatment natural pollination which were at par with 155.75 g and 203.25 g with the bee pollination, respectively. Thus 233.20% increase in yield was with the crop fully left open for natural pollination, and it was followed by 213.90% increase with bee pollination, as compared to self pollination.

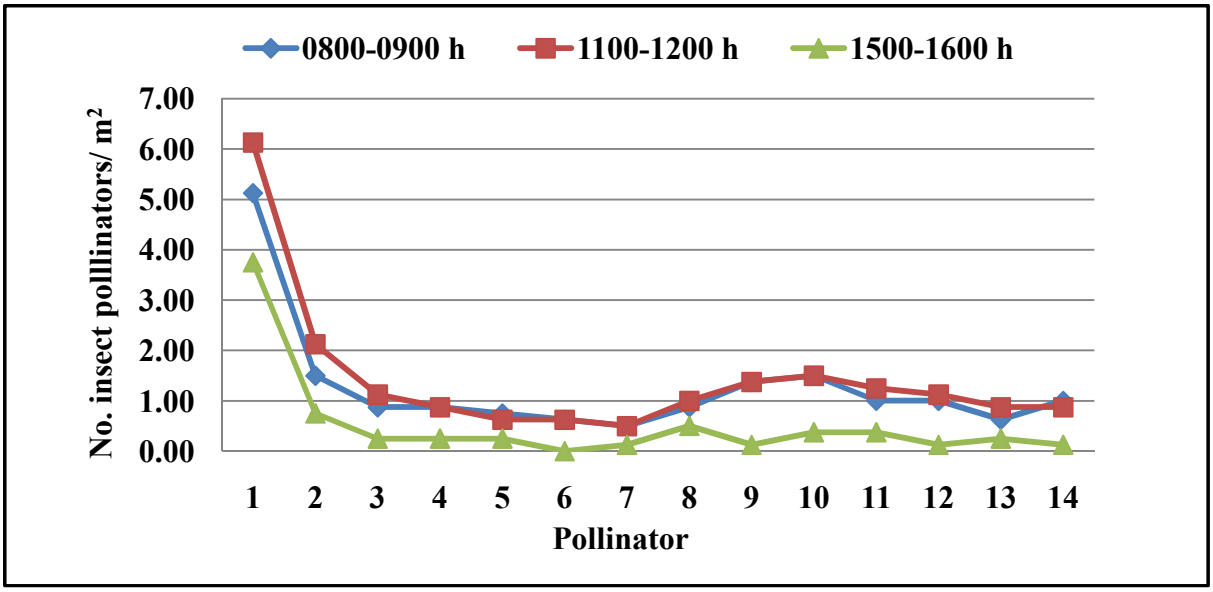
From the present study, it can be concluded that amongst genera, the genus *Apis* was alone responsible to produce maximum per cent of pollination only after an unidentified species of pollinator. The peak foraging activity of insect pollinators/ m^2 / hour was observed at 1100-1200 h. It may be pertinent to mention here that the impact of natural pollination as well as bee pollination using *A. mellifera* in Bullet a variety of chilli was more pronounced as compared to self pollination as reflected through higher crop yield. The corolla of the flowers had only dropped which have already pollinated. This is an important findings for imploring farmers to conserve insect pollinators. In such a scenario, farmers would improve pollinator population to get better yields.

Table 2 : Effect of different treatments on yield attributing characters and yield of chilli (var. Bullet) (Mean of three replications)

Parameters	1st year			2nd year		
Treatment	T_1	T_2	T_3	T_1	T_2	T_3
Number of flowers setting/plant	231.52 ± 4.42	234.45 ± 15.31	148.71 ± 2.23*	187.69 ± 9.38	195.36 ± 7.48	164.54 ± 7.15
Number of fruits setting/plant	43.27 ± 3.35	43.93 ± 2.57	11.67 ± 1.53	44.60 ± 4.79	44.73 ± 2.14	12.33 ± 1.53
Length of fruit (cm)	6.04 ± 0.16	5.89 ± 0.31	5.62 ± 0.23	6.24 ± 0.77	6.12 ± 0.08	5.40 ± 0.27
Fruit yield (q/ha)	94.51 ± 4.34	103.07 ± 5.14	15.83 ± 1.56	96.23 ± 5.55	102.87 ± 6.64	19.40 ± 1.15

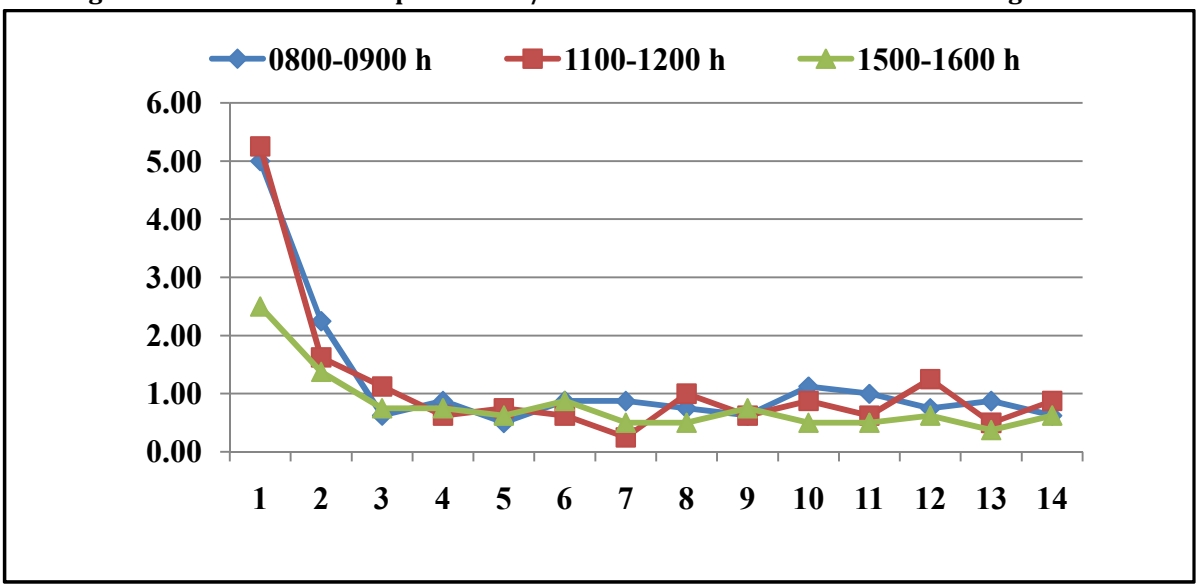
Where, T_1 - Bee pollination ; T_2 – Natural pollination ; T_3 – Self pollination
*** Values given as average ± Standard Deviation**

Figure 1: Number of insect pollinators/ m^2 area visited chilli var. Bullet during 2008-09



Where, 1 - ? ; 2 - *Apis mellifera* ; 3 - *A. florea*, 4 - *Megachile* sp. ; 5 - *Vespa sp.* ; 6 - ? ; 7 - *Xylocopa* sp. ; 8 - *Pelopidas mathias* ; 9 - ? ; 10 - *Papilio demoleus* ; 11 - *Pieris brassicae* ; 12 - *Coccinella* sp. ; 13 - *Henosepilachna* sp. ; 14 - *Bactrocera cucurbitae*

Figure 2: Number of insect pollinators/ m² area visited chilli var. Bullet during 2009-10



Where, 1 - ? ; 2 - *Apis mellifera* ; 3 - *A. florea*, 4 - *Megachile* sp. ; 5 - *Vespa sp.* ; 6 - ? ; 7 - *Xylocopa* sp. ; 8 - *Pelopidas mathias* ; 9 - ? ; 10 - *Papilio demoleus* ; 11 - *Pieris brassicae* ; 12 - *Coccinella* sp. ; 13 - *Henosepilachna* sp. ; 14 - *Bactrocera cucurbitae*

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