Survey and monitoring of insect pollinators of cocoa

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 Received: 22.1.2019/Accepted: 9.4.2019

ABSTRACT

Cocoa is the third important beverage crop grown for its beans which are mainly used in chocolate industry. Cocoa flowers are produced in large numbers but only few of them develop into fruits. Field experiments were carried out to study the insect pollinators of cocoa through survey and monitoring in major cocoa growing districts of Tamil Nadu during 2013-2014. Maximum of 114 pollinators emerged from the decomposed leaf litter collected from thirteen years old cocoa plantations at Sethumadai, Coimbatore district. Positive correlation was observed between age of the trees and number of pollinators emerged. Another field experiment was conducted to monitor the pollinators of cocoa by installing coloured sticky traps during 2013-2014 in the farmers' holdings at Sethumadai, Coimbatore district. The highest number of pollinators was trapped on the blue sticky traps followed by white sticky traps. Abundance of cocoa pollinators in the field was positively correlated with weather parameters viz soil moisture and rainfall and negatively correlated with soil temperature.

Keywords: Cocoa; pollinators; decomposed leaf litter; coloured sticky traps

INTRODUCTION

Cocoa (*Theobroma cacao* Linnaeus) a native plant of Amazon basin in South America is the third important beverage crop grown for its beans which are used mainly in chocolate industry. It was first used by the Mayan people 3,000 years ago and first discovered by Hormande Cortez in 1519. It was introduced in India in the early half of the 20th century (Peter 2002). Globally 39.42 lakh MT of cocoa has been produced during 2013. Côte d'Ivoire, Ghana and Indonesia are the largest cocoa producing countries with the share of 34, 24 and 14 per cent of the world total production respectively (Anon 2013a). In India cocoa cultivation is largely confined to southern states viz Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Cocoa is usually planted as inter-crop in coconut and arecanut plantations. India ranks eighteenth among the countries cultivating cocoa having an area of 66,470 ha with a production of 13,420 MT of which Tamil Nadu covers an area of 22,390 ha with a production 1,040 MT (Anon 2013b).

Tiny dipteran midges of 2 to 3 mm length belonging to the family Ceratopogonidae are the principal pollinators of cocoa. The most prominent ones belonging to the genus *Forcipomyia* are reported to be the effective pollinators of cocoa because the floral morphology generally excludes or deters pollination by other insects (Bystrak and Wirth 1978). In addition to Ceratopogonids there are several other insects like ants, *Drosophila*, thrips and aphids which aid in pollination.

Flowering plants use colour, fragrances, size and shape of the flowers and rewards viz pollen and nectar to attract pollinators (Niesenbaum et al 1998). Colour is one of the most important attractants for the insects (Kevan 1972). However studies on monitoring of cocoa pollinators using coloured sticky traps are not yet attempted in India. Hence the present study was carried out to monitor the abundance of cocoa pollinators using coloured sticky traps.

MATERIAL and METHODS

Survey and laboratory monitoring of pollinators

The field survey was carried out in major cocoa growing districts of Tamil Nadu viz Coimbatore, Tirupur, Dindigul, Erode, Kanyakumari, Karur, Krishnagiri, Salem, Theni and Tanjore to study the abundance of

insect pollinators. Decomposed and wet cocoa leaf litter and cocoa pod husk (breeding sites of cocoa pollinators) weighing 2 kg were collected from the farms at all locations (Table 1). The samples were brought to the laboratory, transferred to plastic trays and kept inside the insect rearing cages to observe the emergence of adult pollinators. Twenty per cent sucrose solution was provided in glass vials with absorbent cotton as adult feed for the emerging adult pollinators.

Table 1. Locations surveyed for insect pollinators of cacoa

Location	Age of the tree (years)	Location	Age of the tree (years)
Aliyar	4	Salem	4
Dindigul	8	Sethumadai	13
Erode	5	Tanjore	4
Kanyakumari	5	Thadiyankudisai	3
Karur	5	Theni	4
Krishnagiri	4½	Udumalpet	3½

Adult emergence was observed daily for a period of four months from 4th week of November 2013 to 3rd week of March 2014 and expressed as number of pollinators emerged per week per 2 kg of leaf litter. Adult pollinators emerged were collected using aspirator and stored in 70 per cent ethanol for comparing the specimens with the one collected from flower cushions in the farmers' holdings. After collecting the adults the samples were sprinkled with water once in three days to keep the substrate wet and to make it suitable for breeding of pollinators.

Monitoring of pollinators

A field experiment was conducted to monitor the pollinators by installing coloured sticky traps smeared with white grease and castor oil in 50:50 ratio and tied near the flower cushions during 2nd week of December 2013 (13 Dec 2013) in the farmer's holding at Sethumadai village, Pollachi Taluk of Coimbatore district. The experiment was laid out in a randomized block design with five treatments (T_1: Yellow sticky trap, T_2: Blue sticky trap, T_3: Green sticky trap, T_4: Red sticky trap, T_5: White sticky trap) with four replications in an area of 10,000 m^2.

Regular agronomic practices were followed as per the Tamil Nadu Agricultural University Horticulture Crop Production Guide. The adult pollinators visiting cocoa flowers were trapped on the sticky traps which were monitored at weekly intervals. Observations were made on number of pollinators trapped per week per trap from 3rd week of December 2013 to 3rd week of May 2014. Number of adults trapped in each treatment indicated the abundance and colour preference of pollinators.

Number of pollinators trapped per week was correlated with weekly weather parameters viz temperature, relative humidity, wind velocity, solar radiation, soil temperature, rainfall and soil moisture obtained from the automatic weather station installed in the cocoa farm at Sethumadai by the Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore to study the influence of weather parameters on the abundance of cocoa pollinators.

RESULTS and DISCUSSION

Survey and laboratory monitoring of pollinators

Field survey was conducted in various cocoa growing districts of Tamil Nadu. The results of field survey and monitoring in the laboratory for a period of four months revealed that the maximum number of pollinators emerged from the decomposed leaf litter collected from Sethumadai (114) followed by Dindigul (83), Erode (59) and Karur (48) while pollinator emergence was found to be minimum from the decomposed leaf litter collected from Udumalpet (19). Pollinator emergence was recorded to be 43, 41 and 39 from the decomposed leaf litter collected from Kanyakumari, Krishnagiri and Theni respectively.

The results on correlation analysis between age of the tree and pollinator emergence from the decomposed leaf litter collected from the respective farms revealed that age of the tree was positively correlated with the number of pollinators emerged from the decomposed leaf litter, the breeding substrate of cocoa pollinator with the r-value of 0.965 and was found to be statistically significant at 5 per cent level.

Adjaloo and Oduro (2013) carried out similar survey for cocoa pollinators for the period of three years from 2006 to 2008 in the cocoa fields at Ghana and recorded 2,721 insects belonging to 36 species and 7 orders.

Table 2. Monitoring of cocoa pollinators using coloured sticky traps during 2013-14

Treatment	Number of cocoa pollinators trapped per week*											
	SW 50	SW 51	SW 52	SW 01	SW 02	SW 03	SW 04	SW 05	SW 06	SW 07	SW 08	SW 09
T_1	7.3 (1.51)^{bc}	4.3 (1.28)^{ab}	1.3 (0.93)^{b}	0.5 (0.81)^{b}	0.5 (0.81)^{c}	0.3 (0.76)^{c}	0.3 (0.76)^{b}	0.8 (0.86)^{d}	0.5 (0.81)^{b}	0.3 (0.76)^{d}	0.3 (0.76)^{c}	0.8 (0.86)^{d}
T_2	16.8 (2.04)^{a}	6.0 (1.44)^{a}	8.5 (1.62)^{a}	8.8 (1.63)^{a}	12.5 (1.86)^{a}	8.5 (1.60)^{a}	9.8 (1.65)^{a}	6.3 (1.46)^{a}	6.3 (1.46)^{a}	5.3 (1.38)^{a}	6.3 (1.46)^{a}	19.0 (2.19)^{b}
T_3	3.8 (1.25)^{c}	2.3 (1.08)^{b}	0.8 (0.86)^{b}	2.0 (1.02)^{b}	0.8 (0.85)^{c}	3.0 (1.13)^{bc}	2.5 (1.10)^{b}	2.5 (1.11)^{bc}	2.0 (1.05)^{b}	2.8 (1.14)^{c}	1.8b (1.02)^{c}	3.0 (1.17)^{d}
T_4	3.8 (1.20)^{c}	1.8 (1.02)^{b}	2.3 (1.05)^{b}	2.3 (1.08)^{b}	4.5 (1.30)^{b}	5.8 (1.40)^{ab}	3.0 (1.16)^{b}	2.3 (1.09)^{c}	2.5 (1.11)^{b}	4.8 (1.32)^{ab}	3.5 (1.22)^{b}	11.5 (1.80)^{c}
T_5	11.3 (1.76)^{ab}	7.0 (1.48)^{a}	2.8 (1.13)^{b}	2.3 (1.08)^{b}	5.3 (1.37)^{b}	4.3 (1.29)^{b}	5.0 (1.33)^{ab}	3.8 (1.24)^{b}	6.3 (1.45)^{a}	3.3 (1.19)^{bc}	5.5 (1.40)^{a}	26.5 (2.50)^{a}
SEd	3.15	1.52	1.22	1.09	1.03	1.55	2.67	0.62	0.95	0.59	0.82	1.85
$CD_{0.05}$	6.87	3.31	2.67	2.38	2.24	3.39	5.83	1.36	2.07	1.28	1.80	4.03

Table 2 contd…..

Treatment	Number of cocoa pollinators trapped per week*											Mean
	SW 10	SW 11	SW 12	SW 13	SW 14	SW 15	SW 16	SW 17	SW 18	SW 19	SW 20	
T_1	0.8 (0.86)^{d}	0.5 (0.81)^{d}	0.3 (0.76)^{d}	0.0 (0.71)^{d}	0.0 (0.71)^{d}	0.0 (0.71)^{d}	0.3 (0.76)^{c}	0.3 (0.76)^{c}	0.0 (0.71)^{c}	0.0 (0.71)^{c}	0.0 (0.71)^{c}	0.87
T_2	14.8 (1.98)^{b}	11.3 (1.79)^{a}	13.5 (1.92)^{b}	6.8 (1.50)^{b}	5.0 (1.36)^{b}	4.5 (1.31)^{ab}	1.8 (1.01)^{a}	1.5 (0.99)^{b}	4.8 (1.34)^{a}	1.5 (0.96)^{ab}	0.8 (0.86)^{b}	7.84
T_3	6.5 (1.48)^{c}	4.3 (1.29)^{b}	1.8 (1.02)^{d}	1.0 (0.91)^{d}	2.0 (1.05)^{c}	2.8 (1.14)^{c}	0.8 (0.86)^{bc}	1.5 (0.99)^{b}	2.0 (1.05)^{b}	1.0 (0.90)^{bc}	0.5b (0.81)^{c}	2.23
T_4	15.8 (2.03)^{b}	5.5 (1.40)^{b}	6.3 (1.46)^{c}	4.8 (1.34)^{c}	3.5 (1.22)^{bc}	3.5 (1.22)^{bc}	0.3 (0.76)^{c}	3.0 (1.17)^{a}	1.0 (0.91)^{bc}	1.3 (0.95)^{bc}	0.3b (0.76)^{c}	4.06
T_5	20.5 (2.25)^{a}	9.3 (1.67)^{a}	15.8 (2.03)^{a}	13.3 (1.91)^{a}	7.8 (1.57)^{a}	5.3 (1.38)^{a}	1.3 (0.95)^{ab}	1.8 (1.01)^{b}	5.3 (1.38)^{a}	2.8 (1.14)^{a}	2.0 (1.05)^{a}	7.33
SEd	1.77	1.01	0.92	0.67	0.85	0.77	0.42	0.38	0.47	0.64	0.33	-
$CD_{0.05}$	3.85	2.21	2.01	1.46	1.86	1.68	0.93	0.83	1.04	1.39	0.73	-

T_1: Yellow sticky trap, T_2: Blue sticky trap, T_3: Green sticky trap, T_4: Red sticky trap, T_5: White sticky trap; Figures in parentheses are square root transformed values, SW: Standard week, In a column means followed by a common alphabet(s) are not significantly different by DMRT,

*Mean of four replications

Monitoring of pollinators using coloured sticky traps

The pollinators trapped on the coloured sticky traps installed in the farmer's field at Sethumadai were monitored for six months at weekly interval. The results revealed that the maximum number of pollinators was trapped on blue sticky traps with the mean trap catch of 7.84 followed by 7.33 adults per trap per week on white sticky traps. The mean trap catch of 4.06 and 2.23 adults per trap per week was recorded on red and green sticky traps respectively. Yellow sticky traps recorded the lowest mean trap catch of 0.87 per trap per week (Table 2).

On blue and white sticky traps the maximum trap catch of 19.0 and 26.5 adults per trap was observed during ninth standard week followed by 14.8 and 20.5 adults per trap during tenth standard week respectively whereas the trap catch was recorded to be the lowest during twentieth standard week irrespective of the colour. The results are in accordance with the findings of Campbell and Hanula (2007) who reported that blue colour pan traps attracted more number of flower visiting insects.

In contrast Frimpong et al (2009) reported that UV-bright yellow traps recorded the highest number

of midges. In the present study yellow sticky traps attracted more number of aphids rather than pollinators. As cocoa flowers are white in colour, the white sticky traps might have attracted more number of flower visiting insects next to blue sticky traps. Apart from coloured sticky traps sweeping on foliage, flowers and around the cocoa tree trunk with an insect net was adopted as one of the techniques in monitoring of cocoa pollinators (Brew 1985).

In Central America Young et al (1989) used baited traps with floral oils extracted from four species of *Theobroma* including *T cocoa* as pollinator monitoring device. They reported that seventy two per cent of the dipterans attracted to the traps were from Cecidomyiidae and more than half of these belonged to three species *Mycodiplosis ligulata*, *Clinodiplosis* spp and *Aphidodiplosis triangularis* which are believed to be the pollinators of *T cocoa*.

From the results of the present study it is concluded that decomposed leaf litter and pod husk left out in the fields supported the breeding of insect pollinators of cocoa. The highest number of pollinators was trapped on the blue sticky traps followed by white sticky traps.

ACKNOWLEDGEMENT

The authors are grateful to Mondelez Foods India Private Limited for providing financial assistance to carry out this research.

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