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*Dolichogenidea stantoni (*Hymenoptera: Braconidae) a potential biocontrol agent for melon borer, *Diaphania indica*

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ABSTRACT: Potential of *Dolichogenidea stantoni* (Ashmead) as a biocontrol agent for the melon borer *Diaphania indica* (Saunders) was investigated during 2014-15 at field level. Influence of abiotic and biotic factors on the population dynamics of *D. indica*indicted that it was positively correlated with morning relative humidity and rainfall and was negatively correlated with evaporation, parasitism by parasitoids *D. stantoni* and *Goniozus sensorius*. Both abiotic and biotic factors collectively contributed 73.7 per cent to the variation in the *D. indica* population, in which 62.70 per cent of the fluctuation could be predicted by parasitism by *D. stantoni* alone indicating that parasitism by *D. stantoni* plays a major role in regulating the population of *D. indica.*

KEYWORDS: Bitter gourd, *Diaphania indica, biocontrol*, *Dolichogenidea stantoni*

INTRODUCTION

Bitter gourd (*Momordica charantia* L) is an important cucurbitaceous vegetable that has nutritive and medicinal values. The melon borer *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae) is a potential pest of all cucurbits like, muskmelon, cucumber, gherkin, bottle gourd, bitter gourd, snake gourd and more (Ke *et al*., 1988; Peter and David, 1990; Ravi *et al*., 1997a; 1997b; 1998; Radhakrishnan and Natarajan, 2009; Pandy, 1977; Tripathi and Pandy, 1973), causing 14 - 30 *per cent* yield loss (Kulkarny, 1956; Jhala *et al.*, 2005; Singh and Naik, 2006).

The natural pest control provided by predators and parasitoids is an important ecosystem service that supports agricultural production (Losey and Vaughan, 2006). Estimation of parasitism in the field over a period of time is the foremost step in quantifying the natural mortality of pests by different natural enemies. A diverse array of natural enemies was recorded on *D. indica* worldwide. In India, 25 species of natural enemies were recorded from the *D.indica* that infested cucurbits (Peter and David, 1991a), of which the larval parasitoid *Dolichogenidea stantoni* (Ashmead) (Hymenoptera: Braconidae) was reported as a potential natural enemy (Ganga Visalakshy, 2005; Krishnamoorthy *et al.*, 2003).

Although biological control of *D. indica* represents a key strategy, its potential has gone largely unrealized in many cucurbit cropping systems throughout the world. The significant factor that disrupts biological control of arthropod pests in most

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of the cropping systems is the heavy reliance on insecticides (Stern *et al*., 1959; Croft, 1990). So if we are able to mass multiply and release the most promising natural enemy, the pesticide showers can be avoided, which is more critical in medicinally important vegetable like as bitter gourd. Hence the present study was conducted to assess the role of natural enemies and abiotic factors on the population of *D. indica* on bitter gourd and thereby identify and evaluate the potential of *D. stantoni* as an effective biological control agent for controlling *D.indica.*

MATERIALS AND METHODS

The experiment was conducted on bitter gourd (*Momordica charantia* L) plants that were raised in a staggered manner from December 2014 to December 2015 (four consecutive cropping seasons) so as to expose the all the sages of crop at any point of time line in the Indian Institute of Horticultural Research (ICAR-IIHR), Bangalore (13°58¹ N, 77°35¹ E), India. The test field consisted of bitter gourd crop (the Arka Harit variety) grown in two blocks of 50m x 20m, with a plant-to-plant spacing of 2m. These plants were not exposed to any chemical pesticide sprays and since all the plants that were being considered for the study were in one contiguous block, there were no differential natural variables (abiotic factors) influencing them.

Population dynamics of *D. indica* and its parasitoid species

The population density of *D.indica* on bitter gourd was assessed during December 2014 - December 2015 and expressed as the number of larvae per plant. From each block as mentioned above, 75 plants were randomly selected and number of larvae from each plant was recorded and collected separately. Since the plants of different age groups will have different height and canopy size, different sampling methods were adopted for bittergourd plants of different age, to ensure enough sampling size from each age group.

The bitter gourd plants were categorized into three growth stages based on the age of the host plants, *viz.*, pre-flowering stage (less than a month old plants), flowering stage (1–2 months old plants) and fruiting stage (above 2 months old plants). In the pre-flowering stage (bitter gourd plants, which were less than one meter tall), each block was sampled for a duration of 30 minutes and in the flowering stage (bitter gourd plants, which were 0.5-1.5 meter) for 1 hour. Bitter gourd plants, which were more than 1.5 meter tall, were divided into three sections (i.e. upper, middle, and lower parts) and each section was searched 30 minutes for infestation. The larvae that were found during this sampling period were collected in plastic jars with bitter gourd leaves.

A record of the parasitoids reared from the field-collected larvae was maintained and later converted to percentage parasitism. Observations on the total number of larvae collected, pupated and parasitized were also recorded from each collection, to assess the potential of different parasitoids as a mortality factor of *D. indica* during different months. This was repeated weekly for one year (2014 December–2015 December).

Carl Pearson's correlation analysis was utilized to investigate the impact of different abiotic components on the population of *D.indica*. Correlation coefficients among the pest population (number of *D.indica* larvae per plant), parasitoids (*D. stantoni*, X_8, *G. sensorius,* X_9, and *E. brevicornis,* X_{10}) and weather parameters viz., maximum temperature ($X_{1)}$, minimum temperature ($X_{2)}$, morning relative humidity ($X_{3)}$, evening relative humidity ($X_{4)}$, evaporation ($X_{5)}$, wind speed ($X_{6)}$ and rainfall ($X_{7)}$, were computed during 2014–2015. The population densities of *D.indica* and its natural enemies as well as the weather parameters seven days before the date of observation were analyzed by using backward multiple regression analysis to find the most effective mortality factor for *D. indica* (Snedecor and Cochran, 1967). The model's adequacy was judged by computing the value of the coefficient of determination (R^2) (Draper and Smith, 1981) and statistical analysis of the data was carried out by using the SPSS software (SPSS Inc; version 21).

RESULTS AND DISCUSSION

Population dynamics of *D. indica* and its parasitoid species

The population density of *D. indica* ranged from 0.50 to 35.14 larvae per plant during the study period. The highest population density of *D. indica* was observed from June to November and the lowest from April. The population density of *D. indica* steadily increased from May and reached its peak in September. A mean infestation of 27.89 larvae per plant was recorded during the month of September. The population density of *D. indica* showed a gradual decline from December 2014 - April 2015 (6.75 - 0.88 larvae per plant). Inverse density dependence was observed between *D. indica* and *D. stantoni* during the study period (Table 1).

Three larval parasitoids - *D. stantoni*, *E. brevicornis* and *G. sensorius* - were found attacking *D. indica* during the study period. During this period, the impact of *E. brevicornis* and G. *sensorius* were negligible, whereas the parasitoid *D. stantoni* was actively prevailing throughout the study period. The percentage parasitism of *D. stantoni* ranged from 6.53 to 53.99 per cent during 2014 - 15. The parasitism as recorded in December, 2014 was 38 per cent that reached a peak of 53.99 per cent in March, 2015 and fluctuated until the next December (Table 1). Similarly, the population of *G. sensorius* and *E. brevicornis* ranged from 0.00 to 10.00 per cent and 0.00 to 4.58 per cent, respectively, during December 2014 - December 2015.

Effect of abiotic factors and biotic factors on *D. indica*

The impact of the larval parasitoids and the weather parameters, on the population of *D. indica* were assessed during 2014 - 2015 (Table 2). *D. indica* population increased during the months of maximum rainfall (r=0. 56) and humidity(r=0. 58). The population of *D. indica* was significantly and

Table 1. Abundance of *Diaphania indica* (mean number / plant) and its natural enemies (percentage parasitism) on bitter gourd during 2014-15

Months	*Diaphania indica* (Number/plant)	Percentage parasitism by *D. stantoni*	Percentage parasitism by *G. sensorius*	Percentage parasitism by*E. brevicornis*
December 14	1.58	38.00	10.00	0.00
January 15	2.32	39.53	10.00	0.00
February 15	1.92	39.31	7.50	0.00
March 15	1.00	53.99	0.00	0.00
April 15	0.88	50.00	2.75	0.00
May 15	6.01	16.55	1.00	0.00
June 15	8.31	25.25	0.00	4.58
July 15	11.17	6.53	0.00	3.10
August 15	21.93	10.53	0.00	0.00
September 15	27.89	8.11	0.00	0.00
October 15	16.92	9.00	5.00	0.00
November 15	13.34	19.18	5.00	0.00
December 15	6.75	26.96	10.00	0.00

negatively correlated with evaporation (r=-0.36) whereas no significant relationship was observed with other weather factors (Table 2). Parasitism by *D. stantoni* and *G. sensorius* had a negative significant correlation (r = $^{-}0.79$, $^{-}0.36$).Whereas parasitism by *E. brevicornis* couldn't establish a significant relationship with *D. indica*. The regression equation that fit with all the parasitoids and weather parameters to predict *D. indica* incidence was $Y = 22.9 - 11X_1 - 0.41X_2 + 0.26X_3 - 0.23X_4 - 0.536X_5 - 0.16X_6 + 0.39X_7 -0.28X_8 - 0.51X_9$.

Table 2. Correlation between the *Diaphania indica* population, weather factors and parasitoids

Variable	Correlation coefficient Y (r) value
X_1 (Maximum temperature)	0.004^{NS}
X_2 (Minimum temperature)	0.210^{NS}
X_3 (Morning relative humidity)	0.582^{**}
X_4 (Evening relative humidity)	0.187^{NS}
X_5 (Evaporation)	0.357^{**}
X_6 (Wind speed)	0.025^{NS}
X_7 (Rainfall)	0.557^{**}
X_8 (Parasitism by *D. stantoni*)	0.793^{**}
X_9 (Parasitism by *G. sensorius*)	0.360^{**}
X_{10} (Parasitism by *E. brevicornis*)	0.009^{NS}

**Significant at P = 0.01
*Significant at P = 0.05

The results indicated that 73.70 per cent (R^2=0.737) of the variation present in the *D. indica* population could be predicted by abiotic factors and parasitism. To reach the optimized model 4, four variables - maximum temperature, evening relative humidity, wind speed and evaporation - were removed, which were collectively responsible for only 0.03 *per cent* of the variation. The optimized model 7 revealed the combined effect of rainfall and parasitism by *D. stantoni* on the variability in total infestation up to 69.7 per cent (R^2=0.697) during 2014 - 2015. The remaining three variables viz. *G. sensorius*, morning relative humidity and minimum temperature contributed 3.4 per cent only. The optimized model 8 revealed that *D. stantoni* alone could cause up to 62.70 per cent (R^2=0.627) variability in pest incidence and rainfall could make a contribution of 6.65 per cent (Table 3).

Abiotic and biotic factors collectively contributed about 73.7 per cent to the variation in the *D. indica* population. But the main population fluctuations (62.7 %) were due to one factor, namely, *D. stantoni*, which was the dominant parasitoid that was associated with *D.indica. E. brevicornis* and *G. sensorius* were also present but at lower levels. These findings were in agreement with that of Peter and David (1991a), who reported *Apanteles* (=*Dolichogenidea*) *taragamae* as the dominant parasitoid affecting *D. indica*.

Table 3. Regression analysis of weather factors and parasitism on *Diaphania indica*

Model type	Statistical model	R2
Full regression model	$Y = 22.9 - 11_{X1} - 0.41_{X2} + 0.26_{X3} - 0.23_{X4} - 0.536_{X5} - 0.16_{X6} + 0.39_{X7} -0.28_{X8} - 0.51_{X9}$	0.737
Optimized model 1	$Y= 20.64 - 0.42_{X2} + 0.26_{X3} - 0.23_{X4} - 0.63_{X5} - 0.15_{X6} - 0.39_{X7} - 0.28_{X9} - 0.50_{X9}$	0.737
Optimized model 2	$Y= 20.343 - 0.46_{X2} + 0.25_{X3} - 0.21_{X4} - 0.63_{X4} + 0.40_{X7} - 0.28_{X8} - 0.47_{X9}$	0.737
Optimized model 3	$Y= 24.124 - 0.71_{X2} + 0.13_{X3} - 063_{X5} + 0.43_{X7} - 0.31_{X8} - 0.47_{X9}$	0.734
Optimized model 4	$Y=18.85 - 0.77_{X2} + 0.19_{X3} + 0.43_{X7} - 0.32_{X8}$	0.731
Optimized model 5	$Y= 30.15 - 0.60_{X2} + 0.50_{X7} - 0.36_{X8} - 0.32_{X9}$	0.719
Optimized model 6	$Y= 17.690 + 0.50_{X7} - 0.35_{X8} - 0.19_{X9}$	0.705
Optimized model 7	$Y= 17.041 + 0.54_{X8} - 0.36_{X7}$	0.697
Optimized model 8	y=20.26-0.42X8	0.627

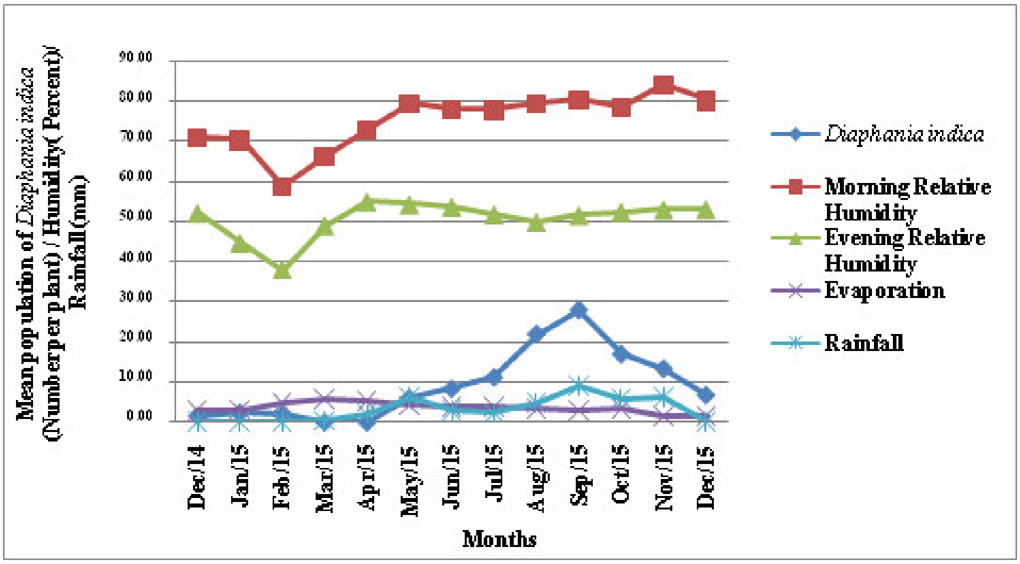

Fig. 1. Population fluctuations of *Diaphania indica* in relation to rainfall, humidity and evaporation during 2014-15

Activity of *D. stantoni* during December - April was high and could have caused a corresponding decrease in the population of *D. indica*. This is in near agreement with the findings of Peter and David (1991b), who observed the peak activity of *A. taragamae* was during October–March when the total mortality of the pest was the highest as compared to the period May–November. Therefore, it was evident that although the pest was present throughout the year, its activity was greatest from May to November, when the activity of *D. stantoni* was at its lowest. During December to April when the activity of *D. stantoni* was at its maximum, the population of *D. indica* was correspondingly reduced, suggesting a major role of this parasitoid as a mortality factor operating on *D. indica* (Fig. 1). Hence, D. *stantoni* could be used as a promising candidate for biological control of *D. indica* due to its aggregative response to host density. Additional studies on aggregation behavior, pattern of parasitism and functional response are required to explore the implications of this parasitoid on *D. indica* population.

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