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Influence of abiotic factors on the population fluctuation of sesame Hawk moth, *Acherontia styx* West wood (Sphingidae: Lepidoptera)

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Abstract
A field experiment was conducted during *kharif* 2016, at College of Agriculture, V. C. Farm, Mandya to know the influences of abiotic factors were tested on the population fluctuation of sesame Hawk moth, *Acherontia styx*. During *summer* 2016, the population of hawk moth exerted a negative association with morning relative humidity (r = - 0.11) and sunshine hours (r = -0.65) and positive association with, mean maximum temperature (r = 0.24), minimum temperature (r = 0.01) and afternoon relative humidity (r = 0.54). However the influence of mean afternoon relative humidity and sunshine hours was found to be significant. The combined and overall impact of all the significant abiotic factors on hawk moth populations were to the extent of 93.00 (R^2 = 0.93), per cent. During *kharif* 2016, the sunshine hours showed a significant negative correlation with population of *A. styx*. The combined and overall impact of all the significant abiotic factors on *A. styx*, populations were to the extent of 30.00 (R^2 = 0.30), per cent.

Keywords: Hawk moth, *acherontia styx*, influence, sesame

Introduction
Sesame (*Sesamum indicum* L.) is one of the important oilseed crop grown in tropical and warm temperate regions of the world (Tripathi *et al*., 2007) [1]. Sesame is being an important oilseed crop cultivated in tropics and subtropical region of India and other parts of the world (Karuppaiah and Nadarajan, 2013) [2]. Globally, sesame is cultivated over more than seven million hectare with an annual production of four million tonnes and productivity of 535 kg/ha. India and China are the world's largest producers of sesame apart from India and china, its grown in several African countries (Anon., 2015a) [3]. In India it is cultivated with an area of 1.75 million hectare with an annual production of 0.83 million tonnes and productivity of 474 kg/ hectare. The major sesame growing states in India includes Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu and West Bengal which covers 1.56 million hectares. In Karnataka sesame is being grown in Bidar, Raichur, Koppal, Gulbarga, Bellary, Bagalkot, Gadag, Haveri and Dharwad in North Karnataka and Mysore, Mandya, Chamarajnagar, Chikmagalur and Ramanagar districts in South Karnataka accounting for area of 44,000 hectare with a production and productivity of 22,000 tonnes and 500 kg/ha (Anon., 2015b) [4].

In spite of its greater importance, the productivity and yields of sesame is low. The decrease in yields have been attributed to several factors which includes low yielding varieties, poor agronomic practices, saline soils, poor drainage, poor planting methods, weeds, diseases and insect pests (Weiss, 1983; Ssekabembe *et al*., 2001) [9, 10]. Among the factors, insect pests take a heavy toll in yield loss (Ssekabembe *et al*., 2001) [10]. The crop is reported to be damaged by 29 species of insect pests (Rai, 1976) [11], but due to the changed cropping pattern, the insect pest complex has escalated to about 65 species including one mite species, (*Polyphagotarsonemus latus* Blanks) (Ahuja and Bakhetia, 1993) [12].

The number of insects belonging to different orders and family have been recorded on sesame in various parts of the world and most important pests in India are leaf webber, *Antigastra catalaunalis* Duponchel (Pyraustidae: Lepidoptera), gall fly, *Asphondylia sesami* Felt (Cecidomyiidae: Diptera); cotton aphid, *Aphis gossypii* Glover (Aphididae: Homoptera); leaf hopper, *Orosius albicinctus* Distant (Cicadellidae: Homoptera).Among these pests, the sesame sphinx caterpillar, *Acherontia styx* Westw (Sphingidae: Lepidoptera) became a serious threat for yield because of its voracious feeding behavoiur of leaves, shoots and flowers. In recent past, the incidence of hawk moth was regular especially during vegetative stage in almost all sesame growing area of Karnataka. Keeping this in view, the present study was initiated to know the incidence pattern in relation to meteorological variables.

Materials and Methods

A field experiment was laid during *kharif* 2016 under Randomized Block Design (RBD) at College of Agriculture, V. C. Farm, Mandya with 10 Treatments including an untreated control and were replicated thrice. A popular sesame multicapsule variety GT- 1 was sown with a spacing of 30×15 cm, between rows and plants, respectively. For each replication, a plot of size 3×3 mt was maintained. The observations on mean population of sesame Hawk moth, *Acherontia styx* (West wood) were recorded at weekly intervals on 20 designated plants on leaves, flowers/ flower buds and capsule. The data on meteorological variable prevailed during the study period *viz.*, maximum and minimum temperature, morning and afternoon relative humidity, sunshine hours, rainfall and number of rainy days were collected from agro-meteorological observatory unit, College of Agriculture, V. C. Farm, Mandya and weekly means were worked out.

To know the relationship between meteorological variables *viz.*, maximum and minimum temperature, morning and afternoon relative humidity, sunshine hours, rainfall and number of rainy days and pest population, the weekly mean observation made on sesame Hawk moth, *Acherontia styx*were subjected to Pearson's rank correlation. Further, to know the influence of meteorological variables on growth and abundance of pest population, the data were subjected to "Multiple Linear Regression Analysis Techniques (Pans and Sukhatme, 1967) [13] by fitting different functions using software "SAS Syntax Reference Guide 2016, version 16.0 (SPSS 16), South Wacker Drive, Chicago, IL (SPSS, 2009).

Result and discussion

The results on the population dynamics of Hawk moth, *Acherontia styx*and their relationship with meteorological variables are interpreted. The correlation matrix and regression co-efficient indicating relationship between the hawk moth and meteorological variables were presented here under. The population of hawk moth exerted a negative association with morning relative humidity (r = - 0.11) and sunshine hours (r = -0.65) and positive association with, mean maximum temperature (r = 0.24), minimum temperature (r = 0.01) and afternoon relative humidity (r = 0.54). However the influence of mean afternoon relative humidity and sunshine hours was found to be significant (Table 1 and 2; Table 4)

When the data was subjected to multi linear regression analysis (MLR), the results revealed that 93 per cent (R^2 = 0.93) of hawk moth population was influenced maximum temperature negatively and sunshine hours positively (Table 5; Table 4).

Similarly during *kharif* 2016, the population of hawk moth, *A. styx* exerted a positive correlation with mean maximum temperature(r = 0.09), minimum temperature (r = 0.14), morning relative humidity (r = 0.44), afternoon relative humidity(r = 0.33), rainfall (r = 0.20) and rainy days (r = 0.40). Similarly, negative correlation was observed with the sunshine hours (r = -0.55). However, a sunshine hour was found to be significant (Table 1 and 3; Table 5)

When the data was subjected to multi linear regression analysis (MLR), the results revealed 30 per cent (R^2 = 0.30) of hawk moth population was influenced by sunshine hours negatively (Table 4; Table 5).

The results on the incidence of sesame hawk moth and their relationship with meteorological variables are discussed. The correlation matrix and regression co-efficient indicating relationship between the til hawk moth incidence and meteorological variables reveals that, there was a negative association with morning relative humidity (r = - 0.11) and sunshine hours (r = -0.65). Similarly the population exerted positive association with, maximum temperature (r = 0.24), minimum temperature (r = 0.11) and afternoon relative humidity (r = 0.54). However the influence of afternoon relative humidity and sunshine hours was found to be significant (Figure 1). When the data was subjected to multi linear regression analysis (MLR), the results revealed that 93 per cent (R^2 = 0.93) of population was influenced maximum temperature negatively and sunshine hours positively. However, there were no reports to contradict and corroborate the present findings.

During *kharif*, the population of til hawk moth, *A. styx* exerted a positive correlation with mean maximum temperature (r = 0.09), minimum temperature (r = 0.14), morning relative humidity (r = 0.44), afternoon relative humidity (r = 0.33), rainfall (r = 0.20) and rainy days (r = 0.40). Similarly, negative correlation was observed with the sunshine hours (r = -0.55). However, sunshine hours were found to be significant (Figure 2). When the data was subjected to multi linear regression analysis (MLR), the results revealed 30 per cent (R^2 = 0.30) of population was influenced by sunshine hours negatively. The present investigations are in accordance with studies made by Ahirwar *et al.* (2009) [14] who reported a positive relationship with maximum temperature and rainfall.

Table 1: Population dynamics of *A. styx* and natural enemies of sesame, *summer* and *Kharif* 2016

Month	MSW	Population per plant (*A. styx*)	Month	MSW	Population per plant (*A. styx*)
January	2	0.00	August	31	0.00
	3	0.00		32	0.00
	4	0.50		33	0.40
February	5	0.80		34	0.90
	6	1.10		35	1.40
	7	1.30	September	36	1.50
	8	1.30		37	1.80
March	9	2.20		38	1.90
	10	3.80		39	3.50
	11	2.90	October	40	1.80
	12	2.10		41	1.00
	13	1.20		42	0.30
April	14	0.50		43	0.00
	15	0.00	November	44	0.00
Mean		0.59	Mean		1.04
Max		2.30	Max		3.50
Min		0.00	Min		0.00
SD±		0.70	SD±		1.02

N=14; MSW- Meteorological Standard Week

Table 2: Relationship between population of *A. styx* and meteorological variables, *summer* 2016

Parameters	X_1	X_2	X_3	X_4	X_5
Y-*A. styx* population	0.24	0.01	-0.11	0.54*	- 0.65**
X_1- Maximum temperature	1.00	0.59	-0.42	0.56	-0.16
X_2- Minimum temperature		1.00	0.06	0.78	0.19
X_3- Morning relative humidity			1.00	0.10	-0.53
X_4- Afternoon relative humidity				1.00	-0.002
X_5- Sunshine hours					1.00

N= 14; * Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

Table 3: Relationship between *A. styx*and meteorological variables, *kharif* 2016

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y- *A. styx* population	0.09	0.14	0.44	0.33	- 0.55*	0.20	0.36
X_1- Maximum temperature	1.00	- 0.62	- 0.50	- 0.52	0.19	-0.01	0.07
X_2- Minimum temperature		1.00	0.40	0.34	- 0.41	0.32	0.27
X_3- Morning relative humidity			1.00	0.38	- 0.40	0.24	0.09
X_4- Afternoon relative humidity				1.00	- 0.78	0.28	0.31
X_5- Sunshine hours					1.00	- 0.43	- 0.43
X_6- Rainfall						1.00	0.88
X_7- Rainy days							1.00

N= 14; * Significant at $P \leq 0.05$

Table 4: Correlation coefficient and regression equation of *A. styx*, *summer* and *Kharif* 2016

Season	Correlation coefficient (r)								Regression equation
	Temperature (°C)		Relative Humidity (%)		Sunshine hours (X_5)	Rainfall (mm) (X_6)	Rainy days (X_7)	R^2	
	Max. (X_1)	Min. (X_2)							
Summer	0.41	0.01	- 0.22	0.52*	- 0.64**	-	-	0.79	$Y = 3.80+0.32X_1+0.22X_2+0.16X_3+0.52X_4-0.64X_5$
Kharif	0.23	0.03	0.35	0.29	- 0.56*	-0.21	0.31	0.32	$Y = -2.57+0.35X_1-0.25X_2+0.15X_3-0.38X_4-0.56X_5-0.37X_6-0.88X_7$

* Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

Table 5: Stepwise regression analysis showing significant variables against population of *A. styx*, *summer* and *Kharif* 2016

Season	Parameters	Multiple regression co - efficient	Standard error	't' value	'F' value	R^2 Value
Summer	Afternoon relative humidity	0.85	0.01	8.60	46.46	0.93
	Sunshine hours	- 3.07	0.12	5.70		
Kharif	Sunshine hours	- 5.22	0.10	2.17	5.22	0.30

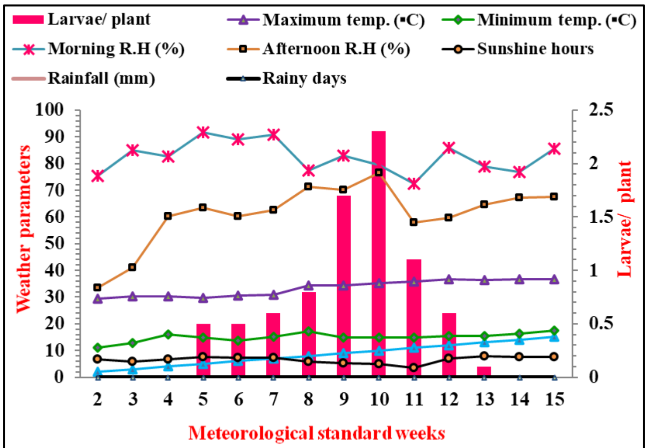

Fig 1: Influence of meteorological variables on the incidence of hawk moth, *A. styx*, *summer* 2016

Conclusion

The correlation matrix and regression co-efficient between meteorological variables and population of sesame hawk moth revealed that, the afternoon relative humidity recorded significant positive correlation with population dynamics of hawk moth during *summer*. The combined and overall impact of all the significant abiotic factors on hawk moth populations were to the extent of 93.00 (R^2 = 0.93), per cent. Whereas, during *kharif*, the sunshine hours showed a significant negative correlation with population of *A. styx*. The combined and overall impact of all the significant abiotic factors on *A. styx*, populations were to the extent of 30.00 (R^2 = 0.30), per cent.

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