Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2020; 8(1): 273-276

Received: 11-11-2019
Accepted: 13-12-2019

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Population dynamics of chilli thrips *S. dorsalis* (Hood) and their natural enemies: Effect of weather factors in chilli agro-ecosystem

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Abstract
Observations for incidence of thrips and natural enemies of the thysanopteran pest were recorded in each meteorological week until harvesting of crop from three untreated quadrates of size of 6.0 m x 4.5 m each. In each observation, sampling for the pest and its natural enemies were done from five plants chosen randomly in each quadrate. Population of *S. dorsalis* started on 1st week of March (9 MSW) at vegetative stages of the crop bearing almost 6-8 leaves. Population build up gradually increased and reached at peak during flowering stage (13.81/leaf) of crop on 1st week of May (16 MSW), after which, the pest population sharply decreased and very low population (0.21/leaf) was noticed at the end of the experiment during the middle of June. Similarly, incidence of the most commonly found natural enemies consisting of coccinella and spiders was recorded as low as 0.84/plant on second week of March (10 MSW) to the maximum of 3.41/plant during the last week of April (15 MSW), after which, the pest defender population gradually decreased. Correlations between thrips and their natural enemies with the weather parameters revealed that minimum relative humidity played a significant role (r= 0.643*) on thrips population only. Multiple regression analyses revealed that combined effect of abiotic factors on population build-up of thrips was 89.8% (R^2 =0.898*) and 85.5% (R^2 = 0.855) on their natural enemies.

Keywords: chilli thrips, *Scirtothrips dorsalis*, pest defender, population fluctuation, weather factors

Introduction
Chilli (*Capsicum annum* L.) is one of the important vegetable and condiments crop grown throughout the year. The crop has immense commercial dietary and therapeutic values. India is the major producer of this solanaceous cash crop but productivity is far below than the countries like USA, China, South Korea and Taiwan (Anonymous, 2013) [1]. The pest spectrum of chilli crop is complex with more than 293 insects and mite species debilitating the crop in the field as well as in storage. Among which, chilli thrips *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera) is considered to be most destructive pest leading to 30 to 50 per cent yield loss under severe infestation (Bhede *et al*., 2008) [3]. Due to variation in the agro climatic conditions of different regions, insects show varying trends in their incidence on crop. Research in this line would thus give an insight on causes of population fluctuation of insect pests throughout the crop growing season which might be helpful in developing sound pest management strategy.

Materials and Methods
Population dynamics of *S. dorsalis* and their natural enemies were studied in chilli agro-ecosystem on "*Suryamukhi*" variety during the summer 2018. Observations on both pest and natural enemies population were started one week after transplanting of the crop and continued at an interval of 7 days at each meteorological standard week till the end of experiment during early morning hours between 7:00 to 8:00AM. The crop was grown in three quadrates each of which measuring about 6.0 m x 4.5 m. Five plants per quadrate were randomly selected during each observation. In early stages of the crop, thrips population was recorded from whole plant but in latter periods, two branches per plant were selected randomly and the pest population was recorded as number of insect per leaf. For observation, whole plant or branch was shaken gently over a piece of white paper (A4 size) smeared with gummy substance which was used to restrict the movement of thrips. Insects that fell on the white paper were counted with the help of 10x magnifying glass. In this way, seasonal fluctuation of thrips population was recorded during the crop growing season at different crop growth stages while, population of

natural enemies (coccinella beetle and spiders) was recorded from five plants selected randomly and expressed the natural enemies population as number per plant.

The experimental details for population dynamics of thrips and natural enemies

Crop: Chilli
Variety: *Suryamukhi*
Experimental design: Randomized Block Design (RBD)
Plot size: 6.0 m x 4.5 m (Population dynamics study)
Number of quadrates: 3 (Population dynamics study)
Number of treatment: 13 including control plot
Spacing (p-p x r-r): 45 cm x 60 cm
Date of sowing: 20/01/2018
Date of transplanting: 24/02/2018
Basal dose of fertilizer: N: P: K (kg/ha) = 150:75:75
Plant protection: Pesticide free (Population dynamics study)
Number of irrigations: 4
Number of weeding: 3

Results and Discussion

Population dynamics of chilli thrips

The data presented in Table1 revealed that thrips population was initiated on first week of March (9 MSW) at early growth period when the crop was in almost 6-8 leaves stage. Population build up gradually increased and reached at peak during flowering stage (13.81/leaf) of crop on 1st week of May (16 MSW). Thrips population remained high in the field for about 7 weeks w. e. f. 13-19 MSW just before peak vegetative stage (5.91/leaf) to early peak fruiting stage (5.87/leaf). After which, the pest population sharply decreased and very low population (0.20/leaf) was noticed at the end of the experiment during the middle of June (22 MSW). Manjunathan *et al*. (2001) [8] and Narvaria (2003) [10] observed the higher level of thrips population at temperature above 30° C at different stages of chilli crop viz. vegetative, flowering, fruiting and maturity stages. Whereas, Borah (1987) [4] reported that population of *S. dorsalis* remained active all the year round. Whereas, Borah (1987) [4] reported that population of *S. dorsalis* remained active all the year round.

Population dynamics of natural enemies of thrips

Population of natural enemies of thrips first recorded on 10 MSW i.e. on second week of March when temperature ranged between 35.35^{0}C to 17.05^{0}C and humidity ranged between 62.38% to 39.63% with an average 8.78 hour of sunny days. Population build-up of natural enemies gradually increased and reached peak (3.41/plant) at 15 MSW after which population gradually decreased and remained at low level (0.11/plant) at the end of the experiment during the middle of June (22 MSW) (Table 1). Similar observations were also recorded by Chintkuntlawar *et al.* (2015) [6] who first observed coccinellid population at reproductive stage of the crop and remained active till the end of experiment.

Role of weather parameters on the population fluctuation of chilli thrips and their natural enemies

Insects are poikilothermic animal and its activity, development, life cycle etc. very much dependent on fluctuation of weather parameters. Therefore, correlation studies between thrips population and weather parameters were carried out and the findings have been presented in Table 2. Results revealed that weather parameters played important role on population build-up of chilli thrips on which all the weather parameters exerted positive impact except maximum temperature (r = -0.410) which had negative role on population build up. However, minimum relative humidity had significant correlation (r= 0.643*) only. This is in corroboration with the investigation done by Chakraborty (2011) who recorded significant negative correlation of thrips population with maximum temperature and positive significant correlation with minimum relative humidity.

Impact of different weather factors on population build up of natural enemies were also recorded. Weather parameters like both maximum and minimum temperatures as well as maximum relative humidity had negative correlation on natural enemies population while minimum relative humidity, rainfall and bright sunshine were positively correlated. However, none of the weather parameters had significant correlation (Table 2). Similar findings were recorded by Batt *et al.* (2018) who observed non-significant correlations between natural enemies population (both spider and coccinellids) with majority of weather parameter except sunshine and relative humidity.

Table 1: Incidence of thirps and their natural enemies in chilli agroecosystem during crop growing season of 2018

MSW	Growth Stage of Crop	Thrips (No./ Leaf)	Natural Enemies (No./ Plant)	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Sunshine (h)
				Max	Min	Max	Min		
8	4-6 Leaves	0	0	Transplanting of crop					
9	6-8 Leaves	0.16	0	35.17	18.06	66.57	41.00	0.01	7.59
10	1-2 Twigs	0.92	0.84	35.35	17.05	62.38	39.63	0	8.78
11	2-3 Twigs	2.31	1.29	35.69	19.00	64.14	39.43	0.02	7.71
12	>3 twigs	4.03	2.67	35.23	23.27	73.11	56.44	0.08	6.38
13	Vegetative	5.91	3.00	33.00	18.83	74.29	56.57	0.35	6.44
14	Peak Vegetative	7.84	3.28	34.13	21.04	77.29	64.29	5.09	8.27
15	Flower Initiation	9.64	3.41	36.84	24.57	74.00	63.57	0	8.99
16	Flowering	13.81	2.95	34.02	23.27	80.00	61.56	3.22	7.04
17	Peak Flowering	12.53	2.49	34.49	23.83	77.57	65.86	2.94	6.67
18	Fruiting Initiation	9.00	1.47	34.81	23.06	81.86	70.86	5.56	6.37
19	Fruiting	5.87	1.22	34.33	23.69	77.29	61.29	0.70	5.96
20	Peak Fruiting	2.18	0.82	36.49	26.54	74.30	65.70	0	6.29
21	Fruiting	1.21	0.41	35.36	26.50	76.71	71.86	4.71	5.70
22	Fruiting	0.20	0.11	36.16	26.63	74.86	74.71	5.27	4.8

MSW: meteorological standard week

Multiple interactions of ecological parameters with thrips and their natural enemies

The thysanopteran pest was reported to cause massive potential damage to the chilli crop in congenial weather. Hence, an attempt has been made to study the combined effect of weather factors on the abundance of population build up of this noxious pest in chilli. Multiple regression analysis were carried out to find out the combined effect of abiotic factors on population build-up of thrips. Coefficient of determination (R^2) was computed 0.898*, which indicated that all the weather factors had 89.8% effect to the variation of population build-up of thrips (Table 3) while combined effect of weather factors on the variation of population abundance of natural enemies of thrips during the crop growing season was recorded 85.5% (R^2 = 0.855) (Table 4). Meena and Kunwat (2010) [9] have observed similar results. Regression analysis revealed that the population densities of thrips reduced by 0.04 & 0.03 to 0.03 constantly per unit of rainfall and maximum relative humidity, respectively. Similar results have been reported by Gopal *et al.* (2018) [7] significant negative correlation with rainfall, maximum relative humidity, and positive correlation with sunshine.

Table 2: Correlations of different weather parameters with mean population of thrips and their natural enemies in chilli agroecosystem during 2018

Weather Parameters	Thrips (No./Leaf)	Natural Enemies (No./Plant)
X1: Max. Temp. (^{0}C)	-0.410	-0.386
X2: Min. Temp. (^{0}C)	0.146	-0.060
X3: Max. R.H. (%)	0.242	-0.040
X4: Min. R.H. (%)	0.643*	0.365
X5: Rainfall (mm)	0.333	0.124
X6: Sunshine (h)	0.185	0.393
*: Significant at p=0.05		

Table 3: Regression coefficients between weather parameters and thrips population in chilli agroecosystem during 2018

Independent Variables	Partial regression coefficient(b)	Standard error of 'b'	Standard partial Regression coefficient (β)	Student 't' (p=0.05)	Statistical significance
X1: Max. Temp. (^{0}C)	-1.224	1.880	-0.279	-0.651	0.536
X2: Min. Temp. (^{0}C)	0.669	0.967	0.471	0.692	0.511
X3: Max. R.H. (%)	-0.056	0.553	-0.029	-0.102	0.921
X4: Min. R.H. (%)	0.907	0.461	1.137	1.966	0.090
X5: Rainfall (mm)	-0.256	0.270	-0.656	-0.947	0.375
X6: Sunshine (h)	2.423	1.057	0.637	2.293	0.056

The prediction equation for insect population:

$Y= -35.217-1.224X_1+0.669X_2-0.056X_3 +0.907X_4-0.256X_5+2.4237X_6$

Coefficient of determination (R^2) = 0.898*

Contribution of all independent variables (weather parameters) on the abundance of insect population = 89.8%

Table 4: Regression coefficients between weather parameters and natural enemies population in chilli agroecosystem during 2018

Independent Variables	Partial regression coefficient(b)	Standard error of 'b'	Standard partial Regression coefficient (β)	Student 't' (p=0.05)	Statistical significance
X1: Max. Temp. (^{0}C)	-0.768	0.589	-0.658	-1.304	0.233
X2: Min. Temp. (^{0}C)	0.117	0.303	0.311	0.387	0.710
X3: Max. R.H. (%)	-0.235	0.173	-0.451	-1.360	0.216
X4: Min. R.H. (%)	0.033	0.145	0.157	0.231	0.824
X5: Rainfall (mm)	0.061	0.085	0.584	0.716	0.497
X6: Sunshine (h)	0.894	0.331	0.884*	2.701	0.031

The prediction equation for insect population:

$Y= 14.22-0.768X_1+0.117X_2-0.235X_3 +0.061X_5+0.894X_6$

Coefficient of determination (R^2) = 0.855^{NS}

Contribution of all independent variables (weather parameters) on the abundance of insect population = 85.5%

NS: Non-significant

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