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Assessing the impact of micro climate on population dynamics of onion thrips in gangetic west bengal

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ABSTRACT

Onion thrips (Thripstabaci L. (Thysanoptera: Thripidae)), is the most important poly-phagous pest in onion crop as it significantly affects the productivity and marketability of onion bulbs globally. However, spatial and temporal variability in the infestation of onion thrips is highly variable and generally inconsistent with environmental conditions, which regulate its development and reproduction. In fact, thrips population gets affected due to varying weather pattern under different agro-climatic conditions. However, the information on seasonal thrips population density and their relationship with microclimate, is scarce in New Alluvial Agro Climatic Zone of West Bengal under varying management practices. In view of the above, the present study was conducted at Research Farm, Gayespur of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during kharif seasons of 2014 and 2015, and rabi seasons of 2014-15 and 2015-16. The results revealed that temperature and relative humidity within the onion crop canopy were higher at early growth stages for all treatments. In contrast, incident photosynthetic active radiation (PAR) and reflected PAR were observed to be maximum during reproductive phases and minimum during vegetative phases of the crop.Soil temperature in the cropped field, followed a consistently upward trend during active vegetative period, followed by drastic reduction at the initiation of reproductive phases. No abiotic stress was observed for kharif onion. During rabi season, planting date was found to be significantly influencing the microclimatic environment of onion crop However, spacing schedules exerted less influence on behaviour of microclimate. Treatment combinations of P4S1(22nd November, 15cm×10cm)and P4S2(22nd November, 20cm×15cm), shortened the onion maturity by 20 days. Canopy temperature and relative humidity exhibited higher values, during later part of onion growth. Results on temporal dynamics of thrips population in kharif season showed that earliest incidence of thrips was recorded at 65DAP and 58 DAP in the crop planted on 14th August and 21st August, respectively and at 51DAP for both P3 (28th August) and P4 (4th September) planted crops. In case of rabi season, it was found that first incidence of thrips started at 40 DAP, which went on increasing till 68 DAP for each treatment. Moreover, declining trend was also noted from 75 DAP onwards. Increase in thrips population was observed to be associated with changes in cumulative degree days during active reproductive phase. Significant correlations of thrips population with canopy temperature, canopy humidity and soil temperature were observed.

Key words: Onion Thrips and micro-climate

INTRODUCTION

Onion thrips (Thrips tabaci Lindeman; Thysanoptera: Thripidae) are a polyphagous pest that causes serious damage on vegetables and ornamentals all over the world (Murai 2000). Weather as well as diseases and arthropod pests attack on onion crop that can reduce yield and quality, resulting reduction in productivity. Among the insect pests, onion thrips, Thripstabaci Lindeman (Thysanoptera: Thripidae), is a major pest of onion crops throughout the world. Its damages result in yield reduction due to reduced size and weight of onion bulb. The attack of thrips population not only kills onion seedlings, but also may cause the older crops to mature early, which results in reduction of yields. Agro-climatic conditions with varying weather patterns affect the population of thrips. However, temperature has a pronounced effect on the population dynamics of thrips on onion crops. Faster development and higher number of generations of thrips was reported, when temperature was increased. In addition, T. Tabaci population is also significantly influenced by relative humidity on onion crop.

Rainfall has exerted greater control of thrips than either planting date or the chemical application. During rainfall, a decline in the number of larvae and adults of thrips was observed and thus may reduce the infestation level on onion plants. However, they breed fast during dry and warm weather, so as to attain harmful proportions causing the losses to various Allium vegetables. Mean bright sunshine hours and wind velocity did not significantly affect the population of T. tabacion onion. It is necessary to understand the relationship between different stage of thrips and weather conditions for the development of an integrated management strategy of onion crops. Therefore, it is desired to study the population dynamics of T. Tabaci (adult and immature stages) under field conditions in relation to weather conditions.

MATERIALS AND METHODS

Monitoring of Onion Thrips (Thripstabaci Lindeman). To illustrate population dynamics of onion thrips over a year, we used monitoring results of this pest in an onion in field. To compare the seasonal fluctuation of pest dynamics mainly thrips infestation in onion experiment. The present study was conducted at Research Farm, Gayespur of Bidhan Chandra KrishiViswavidyalaya, Kalyani, Nadia, West Bengal during kharif seasons of 2014 and 2015, and rabi seasons of 2014-15 and 2015-16.

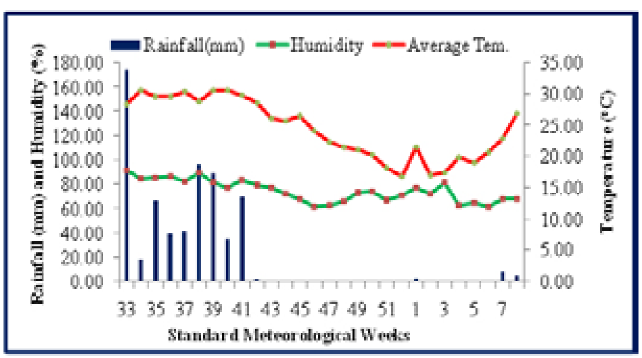

Fig.1 Weekly rainfall, humidity and average temperature during the crop season of 2014-2015

The meteorological data obtained from the Department of Agricultural Meteorology & Physics, Bidhan Chandra Krishi Vishwavidayalaya, Mohanpur for 2014-15 and 2015-16 is depicted in Fig.1 and 2.The maximum average temperature recorded during 20-26 August and 01-07 October (34th - 40th SMW) during 2014-15 crop season and 03-09 September (36th SMW) during 2015-16 crop season ranged between 30.5°C and 30.5°C respectively, whereas the minimum average temperature ranged between 16.9°C during 24-31 December (52nd SMW) in 2014-15 to 18.21°C during 10-16 December (50thSMW) in 2015-16.

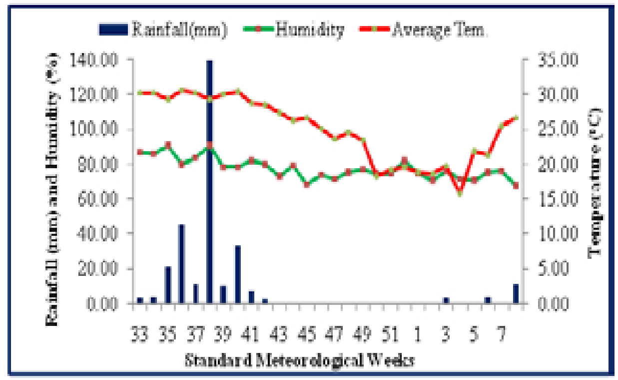

Fig. 2 Weekly rainfall, humidity and Avg. Temp. during the crop season of 2015-2016

RESULTS AND DISCUSSION

As discussed in the chapter of materials and methods, different phenological phases of onion were observed and the results have been summarized in table 1 of experiment conducted in 2014 of the experiment conducted in 2015. Dates of planting had immense effect on duration to reach different phenological phases of onion. To initiate first leaf after planting under different planting dates ranged from 7.6 to 9.8 days, whereas from third leaf to bulb initiation crop planted on 4th September, 2014 (P4) takes maximum days to attain the phases. To complete onion life cycle P4 (4th September 2014) takes maximum duration of 116 days. The treatment differences were significant.

Spacing had very less impact on the initiation of different phases of onion during 2014, where non-significant differences among the treatments were analysed. The mixed effect of planting dates and spacing to initiate different phases were very less. However, significant changes were noted during emergence of fifth leaf. During 2015, initiation of first leaf stage was also remarkably affected by date of planting. Crop planted on 4th September (P4) had the same effect on different phenophases, which was statistically at par with 2014. To complete the entire growth cycle, onion

Table 1.Computation of duration to reach different phenological phases of onion as influenced by dates of planting and spacing during Kharif Season of 2014 and 2015

Factor	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
	1st leaf	1st leaf	3rd leaf	3rd leaf	5th leaf	5th leaf	Initiation of bulb	Initiation of bulb	Physiological maturity	Physiological maturity	Harvesting	Harvesting
P1	8.44	8.44	23.33	23.56	39.56	39.78	53.78	53.89	89.67	89.78	111.00	111.00
P2	7.67	7.89	23.67	23.89	39.67	39.33	54.67	54.67	89.67	90.00	113.00	112.00
P3	8.33	9.44	23.11	23.11	40.89	41.00	54.00	53.56	92.00	92.00	114.00	114.00
P4	9.89	9.67	25.00	25.22	43.67	43.44	55.00	55.11	91.33	91.33	116.00	115.00
SEm (±)	0.25	0.23	0.22	0.28	0.20	0.24	0.22	0.21	0.23	0.28	0.00	0.00
CD at 5%	0.75	0.68	0.65	0.83	0.59	0.69	0.66	0.61	0.69	0.82	0.00	0.00
S1	8.75	9.08	23.92	24.00	40.92	40.83	54.75	54.67	90.83	91.08	113.50	113.00
S2	8.67	8.58	23.58	24.00	41.00	41.17	53.83	54.00	90.58	90.67	113.50	113.00
S3	8.33	8.92	23.83	23.83	40.92	40.67	54.50	54.25	90.58	90.58	113.50	113.00
SEm (±)	0.22	0.20	0.19	0.25	0.17	0.20	0.19	0.18	0.20	0.24	0.00	0.00
CD at 5%	NS	NS	NS	NS	NS	NS	0.57	0.53	NS	NS	0.00	0.00
P1S1	8.33	8.67	23.33	23.33	40.00	40.00	54.00	54.00	89.67	90.33	111.00	111.00
P2S1	8.33	8.00	24.00	24.00	40.00	39.67	55.33	55.33	90.33	90.67	113.00	112.00
P3S1	8.67	9.67	23.33	23.33	40.67	40.67	54.00	53.67	91.67	91.67	114.00	114.00
P4S1	9.67	10.00	25.00	25.33	43.00	43.00	55.67	55.67	91.67	91.67	116.00	115.00
P1S2	8.67	8.33	23.33	24.00	39.00	39.67	53.33	53.67	90.00	89.67	111.00	111.00
P2S2	7.00	7.67	23.33	24.00	39.33	39.33	54.00	54.00	89.00	89.67	113.00	112.00
P3S2	8.67	9.00	23.33	23.33	41.67	41.67	53.67	53.67	92.00	92.00	114.00	114.00
P4S2	10.33	9.33	24.33	24.67	44.00	44.00	54.33	54.67	91.33	91.33	116.00	115.00
P1S3	8.33	8.33	23.33	23.33	39.67	39.67	54.00	54.00	89.33	89.33	111.00	111.00
P2S3	7.67	8.00	23.67	23.67	39.67	39.00	54.67	54.67	89.67	89.67	113.00	112.00
P3S3	7.67	9.67	22.67	22.67	40.33	40.67	54.33	53.33	92.33	92.33	114.00	114.00
P4S3	9.67	9.67	25.67	25.67	44.00	43.33	55.00	55.00	91.00	91.00	116.00	115.00
SEm (±)	0.44	0.40	0.38	0.49	0.35	0.41	0.39	0.36	0.41	0.49	0.00	0.00
CD at 5%	NS	NS	NS	NS	1.02	NS	NS	NS	NS	NS	0.00	0.00

Kharif Season: Dates of planting as P1-14th August, P2-21st August, P3-28th August., P4-4th September; Spacing as S1-15×10cm; S2-20×15cm; S3-15×15cm]

takes 111to115 days under different planting dates. Spacing and mixed effect were at par with 2014. Different environmental factors affect the development and growth of crop primarily by influencing their physiological activity. In the present study, favorable weather condition under later date of planting, accelerates the plants vegetative growth which was continued for long time. After that, increase in ambient temperature was preferred by the crop for bulbing, which might delay the maturity. Actually photoperiod (day length) might play a key role here in attaining different phenophases. Study of Okporie and Ekpe, (2008) revealed that onions react to day length for bulb initiation.There are evidences that delayed sowing date accelerated the emergence of onion seedlings in Iran (Ansari, 2007).

However, in the present study, increase in more number of leaves under early date of plantings resulted in late maturity. This may be explained on the basis of findings of Butt (1968), who reported that young seedlings do not respond to bulbing stimulus as rapidly as older ones and which might have attributed to more number of days to maturity. Vegetative growth and bulb formation are greatly influenced by growing environment (Rahim and Fordham, 1988). Various factors including cultivar selection, plant size, nutritional treatment, temperature, light interception have the potentiality to affect bulb formation as well as maturity of onions (Mondal et al., 1986; Sinclair, 1989).

Duration to attain different phases of any crop, have important role in production component

Table 2.Computation of duration to reach different phenological phases of onion as influenced by dates of planting and spacing during Rabi Season of 2014-15 and 2015-16

Factor	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
	1st leaf	1st leaf	3rd leaf	3rd leaf	5th leaf	5th leaf	Initiation of bulb	Initiation of bulb	Physiological maturity	Physiological maturity	Harvesting	Harvesting
P1	20.22	20.11	34.11	34.44	54.22	54.44	65.22	65.44	85.56	85.44	96.00	97.00
P2	19.67	19.56	33.44	33.33	56.56	56.67	65.67	65.67	85.44	85.33	95.00	95.00
P3	20.44	20.56	36.33	36.33	53.33	53.56	64.56	64.44	82.56	82.56	93.00	93.00
P4	25.44	25.56	38.44	37.56	50.56	50.56	60.56	60.56	77.78	77.78	90.00	90.00
SEm (±)	0.15	0.19	0.22	0.18	0.21	0.17	0.22	0.17	0.19	0.20	0.00	0.00
CD at 5%	0.43	0.55	0.65	0.52	0.61	0.49	0.63	0.50	0.56	0.59	0.00	0.00
S1	21.58	21.42	35.58	35.33	53.83	53.83	64.17	64.00	83.08	83.00	93.50	93.75
S2	21.50	21.58	35.67	35.50	53.67	53.75	63.83	64.17	82.75	82.75	93.50	93.75
S3	21.25	21.33	35.50	35.42	53.50	53.83	64.00	63.92	82.67	82.58	93.50	93.75
SEm (±)	0.13	0.16	0.19	0.15	0.18	0.15	0.19	0.15	0.16	0.17	0.00	0.00
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.00	0.00
P1S1	20.33	20.00	34.33	34.00	55.00	54.67	65.33	65.00	86.00	85.67	96.00	97.00
P2S1	20.00	19.67	33.67	33.33	56.67	57.00	66.00	65.67	85.67	85.67	95.00	95.00
P3S1	21.00	20.67	36.00	36.33	53.33	53.00	64.67	64.33	82.67	82.67	93.00	93.00
P4S1	25.00	25.33	38.33	37.67	50.33	50.67	60.67	61.00	78.00	78.00	90.00	90.00
P1S2	20.67	20.67	33.67	34.67	54.33	54.33	64.67	65.67	85.33	85.33	96.00	97.00
P2S2	19.33	19.33	33.33	33.33	56.33	56.33	65.67	66.00	85.33	85.33	95.00	95.00
P3S2	20.00	20.33	37.00	36.67	53.33	54.00	64.67	64.67	82.67	82.67	93.00	93.00
P4S2	26.00	26.00	38.67	37.33	50.67	50.33	60.33	60.33	77.67	77.67	90.00	90.00
P1S3	19.67	19.67	34.33	34.67	53.33	54.33	65.67	65.67	85.33	85.33	96.00	97.00
P2S3	19.67	19.67	33.33	33.33	56.67	56.67	65.33	65.33	85.33	85.00	95.00	95.00
P3S3	20.33	20.67	36.00	36.00	53.33	53.67	64.33	64.33	82.33	82.33	93.00	93.00
P4S3	25.33	25.33	38.33	37.67	50.67	50.67	60.67	60.33	77.67	77.67	90.00	90.00
SEm (±)	0.25	0.32	0.39	0.31	0.36	0.29	0.37	0.30	0.33	0.35	0.00	0.00
CD at 5%	0.75	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.00	0.00

[Rabi Season:Date of planting as P1-1st November, P2-8th November, P3- 15th November, P4-22nd November, Spacing as S1-15×10cm; S2-20×15cm; S3-15×15cm] of that crop. Different pests prefer selective phases to infest the crop.After planting of onion seeds, duration to attain first initiation of leaf to maturity, were monitored and the results have been summarized in Table 2 of experiment conducted in 2014-15 and 2015-16.

Dates of planting had immense effect on duration to reach different phenological phases. To initiate first leaf after planting under different planting dates ranged from 20.22 to 25.44 days, whereas from third leaf to initiation of bulb planted on P1 (1st November) takes maximum days (65 days). To complete onion life cycle for P1 (1st November) takes maximum duration of 96 days and minimum duration of 90 days for P4 (22nd November). In case of planting dates starting from P2 (8th November) to P4 (22nd November), more or less same trend of duration for 3rd leaf initiation to physiological maturity were monitored. The treatment differences were significant. As per plan of work, three various spacing were selected but surprisingly the changes due to the effect of different spacing on initiation of different phases of onion during 2014-15, were not significant. The interaction effect of planting dates and spacing was also non-significant except initiation of 1st leaf. In 2015-16, similar trend of treatment effect due to dates of planting and spacing on different phenological phases of onion were observed.

Environmental conditions especially temperature played an important role in determining the onset of various phenophases in onion. Temperature most predominantly influences bulb formation.

High temperatures between 25-27°C are favorable for bulbing and enhance earlier bulb initiation and maturity. Day length and incident solar radiation had also some important role on attaining various phenophases of certain crop. A thermal degree day is an important variable which have potential impact on development of crop. Previous study indicates that onion plants must accumulate thermal time of approximately 600 degree days (growing degree days above 5°C) from emergence (Lancaster et al., 1996), for successful advancement of crop ages. The final bulb size depends on the physiological process regulating the development of bulbs and is also related to the thermal time accumulated before bulbing (Lancaster et al., 1996). Increase in photoperiod can induce bulb formation in onion where the minimal requirements are between 12 to 16 hours of light, varying from cultivar to cultivar (Jones & Mann, 1963; Brewster, 1990).

Actually, the development of onion as well as its growth rate and the number of days to maturity, is dependent on environmental conditions such as photoperiod and temperature (Steer, 1980). It was evidenced that during early growth and development, onions require cool temperatures (6 to 20°C), but during bulb initiation and development, warmer temperatures (25 to 27°C) are required (Comrie, 1997). Due to the fact that photoperiod and temperature influences onion growth, and cultivars are also specific with regard to minimum day length required for bulbing, time of sowing is critical and may also differ from year to year (Brewster, 2008).

Canopy temperature within the crop canopy, were

Table 3.Measurement of Canopy temperature (oC) as affected by dates of planting and spacing during Kharif season of 2014

2014 (Kharif Season)									
Days after planting									
Treat-ments	30	37	44	51	58	65	72	79	86
P1	24.92	24.54	19.24	23.53	19.42	18.64	16.82	12.54	11.60
P2	25.43	25.46	20.07	24.82	22.96	19.29	17.46	13.83	12.75
P3	24.63	24.56	19.72	23.03	22.10	17.71	15.77	13.26	11.79
P4	25.89	24.36	14.59	23.43	19.04	17.10	21.06	13.13	16.49
SEm (±)	0.22	0.24	0.32	0.39	0.26	0.25	0.24	0.23	0.23
CD at 5%	0.64	0.71	0.94	1.15	0.76	0.72	0.69	0.67	0.66
S1	25.23	24.55	18.19	22.79	20.74	18.28	17.40	13.43	13.26

S2	25.25	24.64	18.33	23.10	20.87	18.22	18.08	12.92	13.00
S3	25.18	25.00	18.70	25.22	21.03	18.05	17.85	13.22	13.21
SEm (±)	0.19	0.21	0.28	0.34	0.23	0.21	0.20	0.20	0.20
CD at 5%	NS	NS	NS	1.00	NS	NS	NS	NS	NS
P1S1	25.17	24.83	19.27	22.00	19.27	18.73	16.87	12.77	11.90
P2S1	26.00	25.90	19.93	24.20	22.67	19.57	17.40	14.07	12.93
P3S1	24.32	24.10	18.58	22.02	21.62	18.08	15.40	13.65	11.88
P4S1	25.43	23.35	14.98	22.95	19.42	16.73	19.92	13.22	16.33
P1S2	24.93	24.33	19.02	22.47	19.77	18.67	16.87	12.13	11.17
P2S2	25.10	25.17	19.63	24.00	23.20	19.16	17.43	13.53	12.60
P3S2	24.82	24.82	20.45	22.90	21.70	17.48	16.25	12.87	11.82
P4S2	26.15	24.23	14.20	23.03	18.82	17.58	21.78	13.15	16.43
P1S3	24.67	24.47	19.43	26.13	19.23	18.53	16.73	12.72	11.73
P2S3	25.20	25.30	20.65	26.27	23.00	19.13	17.53	13.88	12.72
P3S3	24.75	24.75	20.13	24.17	22.98	17.57	15.65	13.25	11.68
P4S3	26.08	25.50	14.58	24.32	18.90	16.98	21.47	13.02	16.72
SEm (±)	0.38	0.42	0.55	0.68	0.45	0.43	0.41	0.40	0.39
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Kharif Season: Date of planting as P1-14th August, 2014; P2-21st August, 2014; P3-28th August., 2014; P4-4th September 2014; Spacing as S1-15×10cm; S2-20×15cm; S3-15×15cm]

Table 4. Measurement of Canopy temperature (oC) as affected by dates of planting and spacing during Kharif season of 2015

2015 (Kharif Season)									
Days after planting									
Treat-ments	30	37	44	51	58	65	72	79	86
P1	24.39	24.01	23.00	18.89	18.11	16.29	18.71	12.01	11.07
P2	24.30	24.32	23.69	21.82	18.15	16.32	18.94	12.69	11.62
P3	24.96	24.89	23.36	22.43	18.04	16.10	20.06	13.59	12.13
P4	24.89	23.36	22.43	18.04	16.10	20.06	13.59	12.13	15.49
SEm (±)	0.12	0.15	0.25	0.12	0.08	0.14	0.16	0.09	0.07
CD at 5%	0.34	0.43	0.72	0.34	0.24	0.41	0.47	0.27	0.21
S1	24.65	23.96	22.21	20.16	17.70	16.81	17.61	12.84	12.68
S2	24.67	24.05	22.52	20.29	17.64	17.50	17.74	12.34	12.42
S3	24.59	24.42	24.64	20.45	17.47	17.26	18.12	12.63	12.63
SEm (±)	0.10	0.13	0.21	0.10	0.07	0.12	0.14	0.08	0.06
CD at 5%	NS	0.37	0.62	NS	NS	0.36	0.41	0.23	0.18
P1S1	24.63	24.30	21.47	18.73	18.20	16.33	18.73	12.23	11.37
P2S1	24.87	24.77	23.07	21.53	18.43	16.27	18.80	12.93	11.80
P3S1	24.65	24.43	22.35	21.95	18.42	15.73	18.92	13.98	12.22
P4S1	24.43	22.35	21.95	18.42	15.73	18.92	13.98	12.22	15.33
P1S2	24.40	23.80	21.93	19.23	18.13	16.33	18.48	11.60	10.63
P2S2	23.97	24.03	22.87	22.07	18.03	16.30	18.50	12.40	11.47

P3S2	25.15	25.15	23.23	22.03	17.82	16.58	20.78	13.20	12.15
P4S2	25.15	23.23	22.03	17.82	16.58	20.78	13.20	12.15	15.43
P1S3	24.13	23.93	25.60	18.70	18.00	16.20	18.90	12.18	11.20
P2S3	24.07	24.17	25.13	21.87	18.00	16.40	19.51	12.75	11.58
P3S3	25.08	25.08	24.50	23.32	17.90	15.98	20.47	13.58	12.02
P4S3	25.08	24.50	23.32	17.90	15.98	20.47	13.58	12.02	15.72
SEm (±)	0.20	0.25	0.43	0.20	0.14	0.24	0.28	0.16	0.12
CD at 5%	0.59	0.74	1.25	0.59	0.42	0.71	0.81	NS	0.36

Kharif Season: Date of planting as P1-14th August, 2015; P2-21st August, 2015; P3-28th August., 2015; P4-4th September 2015; Spacing as S1-15×10cm; S2-20×15cm; S3-15×15cm]

measured at 7 days interval starting from 30DAP and the results have been presented in table 3 and 4 of the experiment conducted in 2014 and 2015. Date of planting had important effect on canopy temperature. At 30-37 DAP, maximum canopy temperature was observed for all dates of planting during 2014. From 44 DAP to 86 DAP, a decreasing trend of canopy temperature was recorded, however, the treatment differences for all dates of planting were significant. Same trend was also observed for spacing and the treatment differences due to spacing for each measured dates were not significant. Interaction effect of planting dates and spacing were absolutely not significant. Same trend of results for planting dates were noted in 2015 also. But in case of spacing 30-37 DAP and 51-58 DAP showed maximum trend of canopy temperature, where the treatment differences for 30 DAP, 51 DAP and 58 DAP were not significant. In case of mixed influence of planting dates and spacing, there was a significant change on canopy temperature except 79 DAP.Canopy temperature is a useful indicator of plant water status. Plant water status by regulating the vital physiological and morphological characteristics of plants proved to be an important factor in determining the grain yield. According to Kaur et al. (2002), there is ample scope of mid-day canopy temperature as a possible tool for monitoring plant water status and grain yield prediction.

Maximum development of canopy was noticed during early growth stage of crop at 30 DAP to 37 DAP. The canopy temperature maintains a specific trend since very early growth stages upto 65 DAP. After that a continuous decrease in canopy temperature was observed. Sudden fall of atmospheric temperature with residual soil moisture after cessation of monsoon, are responsible for this less canopy temperature. Onion crop under different date of planting were faced with different type of climatic conditions resulting variations in canopy architecture. Crop geometry along with leaf orientation, leaf angle and stem elongation could regulate the crop micro climatic environment. Canopy temperature exhibited significant associations with leaf area index, total crop biomass in earlier study of Das et al., 1984.

Table 5. Relationships of thrips population with macro climatic, micro climatic and growth parameters using Stepwise Regression analysis (Two years pooled data of 2014 and 2015, Kharif Season)

Stepwise Regression	R2	Adjusted
R2		
Thrips = 6.451 + 0.007CT-79DAP** + 0.003CH58DAP*** - 0.005CH86DAP** + 0.0015PAR (R)65DAP** - 0.001(PAR (R)79DAP*** - 0.001PAR (R)86DAP* - 0.018ST 5cm-51DAP*** + 0.004ST 5cm-65DAP*** + 0.011ST 10cm 79DAP - 0.009ST 15cm51DAP** - 0.009ST 15cm58DAP** + 0.022ST 15cm72DAP*** - 0.099AT51DAP*** - 0.134AT-58DAP*** - 0.035AT65DAP*** + 0.039Rainfall58DAP*** + 0.025RH51DAP*** + 0.014RH-86DAP*** + 0.002plant hieght14DAP** + 0.003plant hieght28DAP** - 0.002plant hieght56DAP** - 0.014No.of-leaves42DAP***	0.9986	0.998

[Significance level 0.05% *; Significance level 0.01%**; Significant level 0.001%***][CT: Canopy temperature, CH: Canopy humidity, IPAR: Incident photosynthetic active radiation, RPAR:

Reflected photosynthetic active radiation, ST: Soil temperature, AT: Air temperature, RH: Relative humidity; Date after planting are subscripted]

Another prediction model have also been developed using all the recorded parameters including macro climatic (ambient temperature, rainfall, RH), micro climatic (canopy temperature, canopy humidity, PAR as incident and reflected and soil temperature within soil profile) variables and growth characters (plant height and number of leaves), at particular time intervals to predict seasonal thrips infestation through stepwise regression analysis.

Results reflected that most of the independent variables showed their significant influence on thrips population intensity. However, such model must need some validation.

Table 6. Relationships of thrips population with macro climatic, micro climatic and growth parameters using Stepwise Regression analysis (Two years pooled data of 2014-15 and 2015-16, Rabi Season)

	Stepwise Regression	R^2	Adjusted R^2
Rabi	Thrips = 2.375 - 0.069CT-47DAP* + 0.181CT-75DAP*** + 0.0352CH-47DAP + 0.0357CH54DAP* - 0.103CH75DAP*** + 042PAR(I)47DAP*** - 0.002PAR(I)54DAP* - 0.016PAR (R)68DAP* + 0.093AT40DAP** - 0.181AT 75DAP*** + 3.04Rainfall75DAP*** - 0.082RH-54DAP*** + 0.121RH-61DAP*** + 0.0188plant hieght28DAP** - 0.019plant hieght56DAP*** - 0.097No. ofleaves28DAP*	0.9566	0.9440

[Significance level 0.05% *; Significance level 0.01%**; Significant level 0.001%***][CT: Canopy temperature, CH: Canopy humidity, IPAR: Incident photosynthetic active radiation, RPAR: Reflected photosynthetic active radiation, ST: Soil temperature, AT: Air temperature, RH: Relative humidity]

Relative humidity showed significant negative correlation with thrips population. Rainfall emerged a poor predictor of thrips population even though it is directly related to relative humidity and has frequently been demonstrated as a decisive thrips mortality factor (Kirk, 1997). Karar et al. (2014) reported that Rainfall had highly significant and negative effect on pest number (-9.3X, -77.5X and -8.4X in 2008, 2009 and 2010 respectively). Population dynamics of thrips on onion crop reveal that thrips population significantly declined with rainfall. Correlation analysis clearly mentions significant effect of maximum temperature on average population of thrips/plant (0.516) during 2008 and 2009. Significant effect of minimum temperature was witnessed in 2009 (0.581).

Researchers across the world have employed regression analysis to investigate the population change of thrips under the influence of temperature, humidity, precipitation, wind velocity, sampling method, and location of the installed monitoring facilities (Li, 2010;Kumar et al., 2014). In the present study, another linear step wise regression was carried out to develop forewarning model for prediction of population density of onion thrips based on macro, micro climatic environment and growth parameters in different time interval. The host bio physical condition also significantly affects the thrips dynamics. Stepwise regression analysis assessed that most of the independent variables, had significant influence on thrips population intensity. Around 96% variations have been analyzed in thrips population due to combination of all the micro, macro and growth parameters of onion (Table 6) Zada et al. (2014), revealed that weather parameters had some specific contribution in total variation in the population of C. pomonella.

Waiganjo et al. (2008) reported that regression analysis (stepwise selection model) showed the minimum relative humidity as the only significant weather variable that could predict thrips infestation in the onion plants (R_2=0.15, P=0.0046, N=53; y = 60.342-0.1022x). Akram et al. (2013). The regression model regarding the impact of weather factors on thrips population in non-Bt varieties, revealed that minimum temperature was most important factor which contributed maximum i.e. 66.1% and 79.7% in the fluctuation of thrips population.

Association among thrips population and micro climatic parameters for Kharif season

Thrips population density of onion crop during kharif season of 2014 and 2015 was significantly associated with micro climatic parameters viz. canopy temperature, canopy humidity, incident PAR, reflected PAR and soil temperature at different depths.

Linear stepwise regression analysis was also carried out between average thrips population and crop eco climatic parameters during the kharif seasons of 2014 and 2015. The results denoted that there were about 60-89 per cent variations in average thrips population due to microclimatic parameters during 2014 and 2015. Reflected PAR from crop soil and incident PAR within crop canopy were noted as best predictor for thrips population dynamics in 2014. Whereas, canopy temperature, canopy humidity, PAR as incident and reflected as well as soil temperature at 10 and 15cm played an important role in kharif season of 2015 also. In general, micro climatic environment reflect the interactions among plant, soil and atmosphere. Here ambient temperature played an important role to regulate the crop bio-climatic environment which ultimately affects thrips infestation densities on onion crop (table 7).

Table 7.Effect of microclimate on Thrips population during Kharif Season of 2014 and 2015

Year	Regression Equation	R^2	Adjusted R^2
2014	Thrips= 0.259 + 0.040 RPAR* + 0.033IPAR**-	0.60	0.50
2015	Thrips=5.48+0.13 1CT**-0.067CH*** -0.023RPAR*+0.03 7IPAR***+0.019ST-5cm-0.20ST10cm**+0.104ST15cm*	0.89	0.86

[Significance level 0.05% *; Significance level 0.01%**; Significant level 0.001%***] [CT: Canopy temperature, CH: Canopy humidity, IPAR: Incident photosynthetic active radiation, RPAR: Reflected photosynthetic active radiation, ST: Soil temperature]

Association among thrips population and microclimatic parameters for Rabi season

In earlier studies various types of phenology models for forewarning the insect pest have been employed to predict general patterns and time of peak occurrence of insect population (Kim and Lee, 2008; Fandet al., 2014). However, several correlation studies have been carried out to develop the relationship between weather parameters and thrips population, where temperature has been reported as an important contributing factor for the thrips population fluctuation (Ananthakrishnan, 1993; McDonald et al., 1999). In the present study, a stepwise regression analysis have been done to find out the associations among thrips population density of onion crop during rabi season of 2014-15 and 2015-16 and various bioclimatic parameters viz. canopy temperature, canopy humidity, transmitted PAR within canopy, reflected PAR from soil and soil temperature at different depths (Table 4.66). Results indicated about 60% and 57% variations in thrips population due to bioclimatic parameters during 2014-15 and 2015-16 respectively. However, stepwise regression analysis revealed that among different micro climatic parameters, soil temperature at different depths is found to be most effective in predicting thrips population dynamics (table 8).

Table 8. Effect of micro climate on Thrips population during rabi Season of 2014-15 and 2015-16

Year	Regression Equation	R_2	Adjusted
2014-2015	Thrips = 0.94 - 0.65ST5cm* + 0.466ST10cm + 0.272ST15cm**	0.60	0.50
2015-2016	Thrips= 19.68- 0.704 ST5cm* - 0.848ST15 cm**	0.57	0.47

[Significance level 0.05% *; Significance level 0.01%**; Significant level 0.001%***][CT: Canopy temperature, CH: Canopy humidity, IPAR: Incident photosynthetic active radiation, RPAR: Reflected photosynthetic active radiation, ST: Soil temperature]

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