Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 889-894
Received: 15-01-2020
Accepted: 17-02-2020

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Seasonal incidence and management of red cotton bug (*Dysdercus koenigii*) infesting Bt cotton under Red lateritic zone of West Bengal

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DOI: https://doi.org/10.22271/phyto.2020.v9.i2o.10968

Abstract
A field study was undertaken in the Institutional Research Farm, Institute of Agriculture, Visva-Bharati, Sriniketan to evaluate the seasonal incidence and population variation of red cotton bug with respect to weather conditions and its insecticidal management during kharif, 2018-19. Experiments were conducted in a Randomized Block Design (RBD) with three replications having nine different insecticidal treatments including one untreated control. Red cotton bug population was recorded from Second week of August and continued till harvest with a peak population Peak population at Second week of November. Multivariate correlation studies showed that the red cotton bug population was significantly positively correlated with Temperature Gradient and significantly negatively correlated with Relative Humidity and Rainfall. Among the different insecticides tested combination of Imidacloprid 6% + Lambda Cyhalothrin 4% SL @ 500 ml/ha proved most effective and giving 71.14% and 94.84% pest population reduction in two consecutive treatment imposition.

Keywords: Red cotton bug, Bt Cotton, Seasonal Incidence, Population dynamics, Insecticides.

Introduction
Agriculture has always been an ancient practice in India and most of our community is relying on it. Among the commercial crop, cotton is one of the crucial cash crop in India playing a significant role in Indian economy. Almost all the tropical and sub-tropical countries are growing it on a large scale due to its wider adaptability (Chauhan, Vekaria & Chaudhary, 2017) [3]. The major insect-pests infesting cotton were the boll worm complex and the cotton strainers. But after the entry of GM cotton boll worm complex of cotton population were reduced. Whereas on the other hand the population of sucking insect-pests were on upraise. Cotton stainer (red cotton bug) was often treated as a minor pest earlier but due to the consequent adoption of such cotton varieties have allowed the cotton stainer *Dysdercus cingulatus* (Fab) (Hemiptera: Pyrrhocoridae) to become a potential pest of cotton (Rafiq *et al*. 2014) [14]. It is a serious pest of cotton in many parts of the world including India (David & Ananthakrishnan, 2004; Sahayaraj 2007; Karihaloo & Kumar, 2009) [4] [15] [9]. Damage may go upto 40% in Bt cotton feeding on developing cotton bolls and ripe cotton seeds (Sammaiah 2012; Freeman 1947) [12] [6]. Due to their sucking into the developing bolls it results in transmitting fungi on the immature lint and seed, which later on stain the lint with typical yellow colour, hence the name "Cotton Strainer" (Gadewad *et al*., 2017) [7]. Heavy infestations on the cotton seeds affect the oil content, crop mass and the marketability of the crop (Sontakke *et al*., 2013) [17]. Therefore, the present study was undertaken to analyse the seasonal incidence along with the influence of abiotic factors on population fluctuation of red cotton bug and its insecticidal management in Bt cotton in the red lateritic areas of Birbhum district, West Bengal.

Materials and Methods
The present experiment was conducted at Institutional Research Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, during kharif season of 2018-19. All the meteorological data were obtained from the Agro-meteorology Office, Sriniketan, Birbhum, West Bengal. The population of red cotton bug was assessed from fifty random plants. The number of red cotton bug per plant was counted for assessing their population from plants which were kept free from any insecticidal spraying. The average population per cotton plant was worked out. The other experiment pertaining to management of red cotton bug through insecticide imposition was worked out in a Randomized Block Design with three replications and nine treatments.

The treatment included eight different insecticides and an untreated control. The pest incidence was recorded in Bt cultivar KCH-149 (BGII), which was obtained from Maharashtra, Akola. The seeds were sown in 4 m X 4 m sized plot on 15th June, 2018 with 90 cm X 60 cm spacing. Except the plant protection approaches rest all recommended practices has been carried out for raising the crop. Weekly survey, monitoring has been carried out for the pest emergence and data was taken from ten randomly selected plant from each plot during the morning hours. One pre-treatment data and data on 1st, 3rd, 5th, 7th and 14th days after treatment imposition was taken. The data thus obtained were transformed as necessary and put to statistical analysis for analysing the results of the experiment. The correlation studies of different abiotic factors and red cotton bug population was carried out in the statistical package SPSS version 16.

Result and Discussion

Seasonal incidence of red cotton bug in Bt cotton

Red cotton bug population was observed for the first time during 4th standard week (correlated with the standard week 33th) that was second week of August as depicted in Table-1. Highest population about 31.33 numbers of Red Cotton Bug was noticed during 17th standard week (co-related with the 46th standard week) that was second week of November. The abiotic condition was maximum temperature 31.27 ^{0}C, minimum temperature 15.97 ^{0}C, relative humidity 77.29% and sunshine hours 7.26. The second highest population was found during 16th standard weeks having 20.5 nymphs and adults per plant.

The obtained results were in closer agreement with the findings of Varma, H.S., 2012 [18] who found that the population of red cotton bug (*D. koenigii*) commenced from second week of November (46th standard week) with 4.5 red cotton bugs per plant. Then, the red cotton bug population was gradually increased and reached to peak level (103.40 red cotton bugs/plant) during fourth week of December (52nd standard week) and thereafter, the population of red cotton bugs slowly decreased and reached to a level of 10.0 per plant during fifth week of January. Similar results were also stated by Ali *et al*., 2013 [2] and Dugger & Richter (1998) [5]

Table 1: Seasonal incidence of Red Cotton Bug infesting cotton with respect to certain abiotic parameters during the year 2018-19.

Standard Week	Red cotton bug population/ plant	Important weather parameters as recorded during the respective standard week						
		Correlated with the standard week	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Temperature Gradient (^{0}C)	Relative Humidity (%)	Rainfall (mm)	Sunshine Hours
1st	0.00	30th	31.49	26.30	5.19	88.29	18.21	1.06
2nd	0.00	31th	32.66	26.01	6.65	83.86	1.73	1.96
3rd	0.00	32th	33.74	26.66	7.08	84.29	5.03	6.06
4th	0.07	33th	34.54	27.21	7.33	81.71	0.94	6.97
5th	0.20	34th	33.80	26.70	7.10	82.86	7.32	5.20
6th	0.00	35th	32.80	26.39	6.41	82.57	7.44	5.33
7th	0.73	36th	33.14	25.73	7.41	84.57	9.94	6.19
8th	2.60	37th	34.13	25.77	8.36	83.86	11.83	5.40
9th	4.47	38th	33.21	25.20	8.01	81.86	6.57	5.96
10th	6.00	39th	35.30	25.61	9.69	81.00	1.06	6.76
11th	9.30	40th	35.07	23.39	11.68	73.71	0.00	3.26
12th	18.00	41th	30.27	22.56	7.71	82.57	5.11	2.46
13th	18.56	42th	33.34	20.50	12.84	79.29	0.00	2.64
14th	19.00	43th	2.19	18.84	13.35	74.71	0.31	2.50
15th	18.52	44th	31.44	20.49	10.95	79. 43	0.00	5.96
16th	20.50	45th	31.11	17.86	13.25	75.57	0.00	7.14
17th	31.33	46th	31.27	15.97	15.30	77.29	0.00	7.26
18th	16.40	47th	30.01	12.86	17.15	75.14	0.00	7.84
19th	11.12	48th	29.46	15.86	13.60	74.86	0.00	6.10
20th	8.30	49th	27.53	12.03	15.55	78.00	0.00	6.69
21th	1.22	50th	28.14	12.73	15.41	71.86	0.00	6.33
22th	0.34	51th	22.54	11.96	10.58	87.29	4.07	5.26
23th	0.04	52th	24.34	8.15	16.19	72.38	0.00	8.50

Effect of ecological parameters on the populations fluctuations of red cotton bug in Bt cotton

It was found that ecological parameters play an important role on the population fluctuation of Red cotton Bug as depicted in Fig-1.The variation of Red Cotton Bug population among the different standard weeks of observations revealed that highest significant Red Cotton Bug populations was observed in case of 17th standard weeks that is 31.33 red cotton bug per plant. On other hands 12th, 13th, 14th, 15th, 16th and 18th standard week population were at par with each other, whereas 19th, 20th, and 11th were statistically similar. Same results were shown by 8th, 9th, 10th and 5th, 7th, 21st, 22nd and 23rd standard weeks. The population was nil at the rest of the standard weeks.

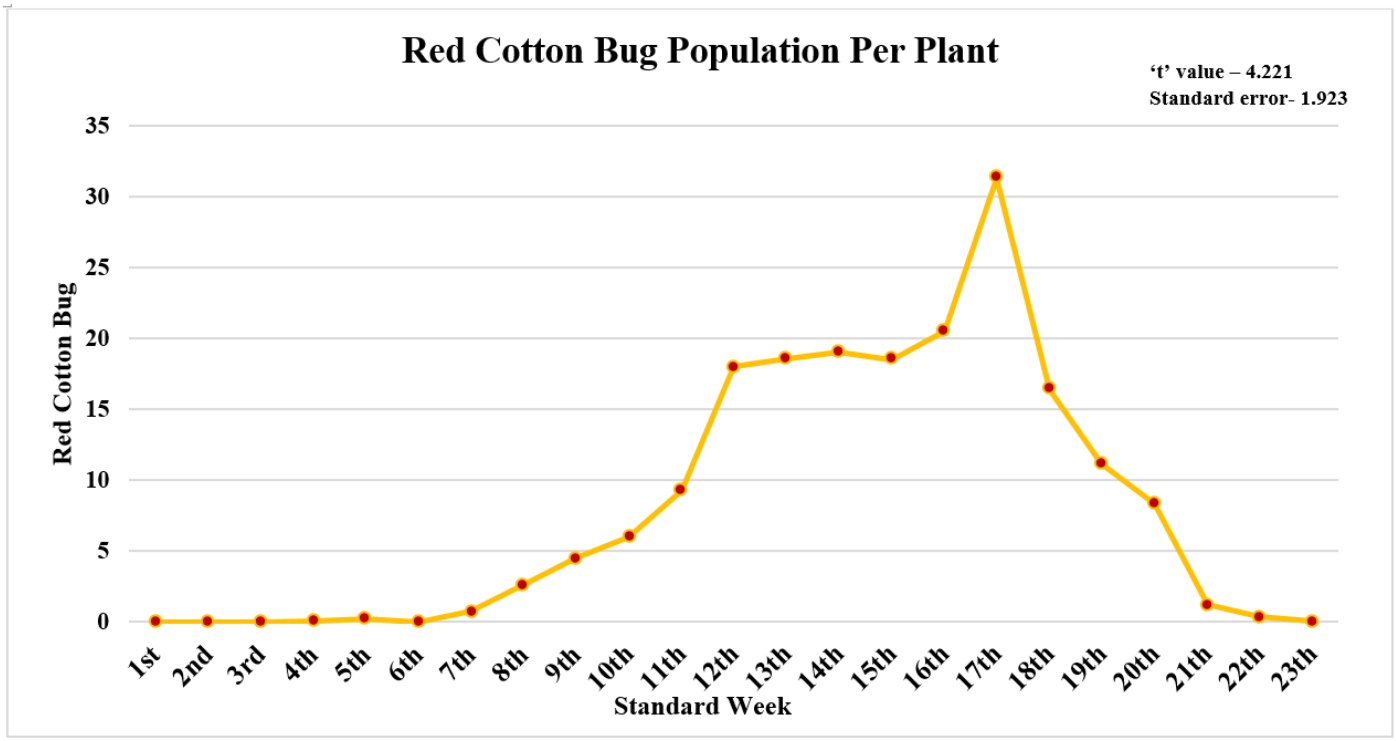

Fig 1: Population variation Red Cotton Bug population in different standard weeks.

Correlation studies of weather parameters with red cotton bug population

Independent effect of weather parameters on Red cotton bug:

The independent effect of all the weather parameters with population fluctuation of Red cotton bug has been studied and depicted in Table-2. The temperature gradient, relative humidity, rainfall are main responsible factors which induce maximum variation in Red cotton bug population and their respective regression equations stands Y= 1.315x - 5.994, Y= 76.857 - 0.861x and Y= 11.251 - 0.906x respectively.

Table 2: Bi-variate Regression analysis for the effect of independent weather parameters on Red Cotton Bug population.

Parameters	Regression Equation	'T'	Significance	Df
Red Cotton Bug (Y) X Temp. Max. (X)	Y= 5.709 + 0.077x	0.124	0.902	22
Red Cotton Bug (Y) X Temp. Min. (X)	Y= 17.873 – 0.473x	-1.492	0.151	22
Red Cotton Bug (Y) X Temp. Grad. (X)	Y= 1.315x – 5.994	2.853	0.010	22
Red Cotton Bug (Y) X RH (X)	Y= 76.857 -0.861x	-2.259	0.035	22
Red Cotton Bug (Y) X Rain Fall (X)	Y= 11.251 – 0.906x	-2.491	0.021	22
Red Cotton Bug (Y) X SH (X)	Y= 7.688 + 0.080x	0.081	0.936	22

Multivariate correlation studies of red cotton bug with weather parameters

The multivariate correlation studies were conducted to perform the analysis, where the results suggest that temperature gradient, relative humidity and rainfall were significantly correlated with the Red cotton bug population. The population of the Red cotton bug was positively correlated with temperature gradient at 5% level of significance, negatively correlated with relative humidity and rainfall at 1% level of significance with the correlation co-efficient of 0.528,-0.442 and -0.478 respectively. The other weather parameters like maximum temperature, minimum temperature and sunshine hours were not related with the population fluctuation of Red cotton bug. Presented results support the findings of Gogoi *et al*., 2000 [8] reported that meteorological parameters play a key role in the population fluctuation of sucking insect pests (Murugan, Uthamasamy & Panickar 2001) [11] [8]. The results are also in partial agreement with Sammaiah *et al.* (2012) [16] who mentioned that minimum temperature and rain fall shows moderate negative correlation with *D. cingulatus*. Result of the experiment also supports the findings of Ali *et al*., 2013 [2].

Table 3: Multivariate Correlation between different weather parameters and Red cotton bug population.

Parameter	Red cotton bug	Max.Temp.	Min.Temp.	Temp.Grad.	RH	Rainfall	SH
Red cotton bug	1						
Max.Temp.	.027	1					
Min.Temp.	-.310	.849**	1				
Temp.Grad.	.528**	-.508*	-.886**	1			
RH	-.442*	.199	.622**	-.840**	1		
Rainfall	-.478*	.210	.551**	-.715**	.747**	1	
SH	.018	-.258	-.425*	.467*	-.373	-.372	1

1% level of significance (**)
5% level of significance (*)

Evaluation of some newer insecticide molecule against Red Cotton Bug of Bt-cotton

The next part of the experiment was done to evaluate some newer insecticide molecules along with one combination product with varied doses against Red Cotton Bug. There were 9 different treatments along with one untreated control. The treatments comprises of Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA) @ 350 ml/ha; Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA) @ 400 ml/ha; Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA) @ 450 ml/ha; Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA) @ 500 ml/ha; Lambda Cyhalothrin 5% EC @ 500 ml/ha; Imidacloprid 70% WG @ 35 g/ha; Buprofezin 25% SC @ 1000 ml/ha; Diafenthuron 50% WP @ 600 g/ha.

Table 4: Effect of different insecticides against Red Cotton Bug infesting Cotton (2018).

Sl. No.	Treatment	Dose (ml/g/ha.)	Effect of different insecticides against Red Cotton Bug. (After 1st spray)						Mean population reduction	Percent population reduction (Abott's Correction)
			PT	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS		
1.	T1 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	350 ml/ha	8.87 (3.06)	7.42 (2.81)	6.88 (2.71)	5.42 (2.43)	5.00 (2.34)	4.23 (2.17)	5.79	45.07
2.	T2 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	400 ml/ha	8.73 (3.03)	5.73 (2.49)	4.79 (2.30)	3.56 (2.01)	3.06 (1.88)	2.84 (1.72)	3.92	62.77
3.	T3 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	450 ml/ha	8.52 (3.00)	5.21 (2.38)	4.07 (2.13)	3.42 (1.97)	2.45 (1.71)	1.38 (1.37)	3.31	68.63
4.	T4 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	500 ml/ha	8.83 (3.05)	5.20 (2.38)	3.68 (2.04)	2.89 (1.84)	2.10 (1.61)	1.32 (1.34)	3.04	71.18
5.	T5: Lambda cyhalothrin 5% EC	500 ml/ha	9.12 (3.10)	7.06 (2.74)	5.64 (2.47)	5.12 (2.37)	4.67 (2.27)	4.54 (2.24)	5.41	48.71
6.	T6: Imidacloprid 70% WG	35 g/ha	8.82 (3.05)	5.62 (2.47)	4.94 (2.33)	4.59 (2.25)	3.72 (2.05)	2.92 (1.84)	4.36	58.65
7.	T7: Buprofezin 20% SC	1000 ml/ha	8.82 (3.05)	5.78 (2.50)	4.34 (2.20)	3.72 (2.05)	3.33 (1.95)	2.82 (1.82)	4.00	62.07
8.	T8: Diafenthuron 50% WP	600 g/ha	9.07 (3.09)	6.94 (2.72)	5.93 (2.53)	5.43 (2.43)	4.96 (2.33)	4.52 (2.24)	5.56	47.29
9.	T9: Untreated Check	-	9.09 (3.09)	9.29 (3.12)	10.28 (3.28)	10.72 (3.34)	10.85 (3.35)	11.56 (3.47)	10.54	-
C.D. (0.05%)			NS	0.67	0.56	0.78	0.69	0.89	-	
Se(m)			-	0.30	0.28	0.32	0.31	0.40		

Figure in brackets represents the square root transformed value
* Mean of ten plants

Table 5: Effect of different insecticides against Red Cotton Bug infesting Cotton (2018).

Sl. No.	Treatment	Dose (ml/g/ha.)	Effect of different insecticides against Red Cotton Bug. (After 2nd spray)						Mean population reduction	Percent population reduction (Abott's Correction)
			PT	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS		
1.	T1 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	350 ml/ha	4.23 (2.17)	3.66 (2.03)	2.79 (1.81)	2.45 (1.71)	2.70 (1.78)	3.72 (2.05)	3.06	78.36
2.	T2 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	400 ml/ha	2.48 (1.72)	1.87 (1.53)	1.35 (1.36)	1.15 (1.28)	1.00 (1.22)	0.93 (1.19)	1.26	91.09
3.	T3 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	450 ml/ha	1.38 (1.34)	1.10 (1.26)	0.98 (1.21)	0.86 (1.16)	0.72 (1.10)	0.64 (1.06)	0.86	93.92
4.	T4 : Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA)	500 ml/ha	1.32 (1.34)	1.06 (1.24)	0.81 (1.41)	0.69 (1.09)	0.60 (1.04)	0.52 (1.00)	0.73	94.84
5.	T5: Lambda cyhalothrin 5% EC	500 ml/ha	4.54 (2.24)	2.03 (1.59)	1.66 (1.46)	1.49 (1.41)	1.27 (1.33)	0.89 (1.22)	1.47	89.60
6.	T6: Imidacloprid 70% WG	35 g/ha	2.92 (1.84)	2.50 (1.73)	2.10 (1.61)	1.78 (1.50)	1.56 (1.43)	1.35 (1.36)	1.85	86.92
7.	T7: Buprofezin 20% SC	1000 ml/ha	2.82 (1.82)	2.45 (1.71)	2.21 (1.64)	1.91 (1.55)	1.70 (1.51)	1.28 (1.33)	1.91	86.49
8.	T8: Diafenthuron 50% WP	600 g/ha	4.52 (2.24)	3.76 (2.06)	3.34 (1.95)	3.01 (1.87)	2.86 (1.83)	1.93 (1.55)	2.98	78.93
9.	T9: Untreated Check	-	11.56 (3.47)	12.31 (3.57)	13.88 (3.79)	14.65 (3.89)	14.97 (3.93)	15.14 (3.95)	15.31	-
C.D. (0.05%)			0.89	0.62	0.89	0.72	0.72	0.63	-	
Se(m)			0.40	0.29	0.40	0.30	0.31	0.28		

Figure in brackets represents the square root transformed value
* Mean of ten plants

Both the tables (Table-4 and Table-5) represents the reduction in population for first and second spray respectively. The pre-treatment data for the first spray ranged from 9.12 to 8.52 whereas for the second spray it was 1.32 to 11.56. It is clear

from the data of the first spray that the treatment with Imidacloprid 6% + Lambda Cyhalothrin 4% SL (INOVEXIA) @ 500 ml/ha gave the best results recording 71.18 % population reduction of red cotton bug which is immediately followed by Imidacloprid 6% + Lambda Cyhalothrin 4% SL (INOVEXIA) @ 450 ml/ha, Imidacloprid 6% + Lambda Cyhalothrin 4% SL (INOVEXIA) @ 400 ml/ha recording 68.63 % and 62.77 % population reduction. On the other hand the treatments with Buprofezin 25% SC @ 1000 ml/ha, Imidacloprid 70% WG @ 35 g/ha, Lambda Cyhalothrin 5% EC @ 500 ml/ha, Diafenthuron 50% WP @ 600 g/ha, and Imidacloprid 6% + Lambda Cyhalothrin 4%SL (INOVEXIA) @ 350 ml/ha recorded the population reduction of whitefly to the tune of 62.07, 58.65, 48.71, 47.29 and 45.07 percent respectively. All the treatments were significantly superior over control. Here it can be mentioned that the treatment with Buprofezin 25% SC @ 1000 ml/ha and, Imidacloprid 6% + Lambda Cyhalothrin 4% SL (INOVEXIA) @ 400 ml/ha gave quite similar result. Similar results were obtained in the second spray also where Imidacloprid 6% + Lambda Cyhalothrin 4%SL @ 500 ml/ha gave the best results with 94.84 % of red cotton bug population reduction. The next best treatments were in the order of Imidacloprid 6% + Lambda Cyhalothrin 4%SL @ 450 ml/ha > Imidacloprid 6% + Lambda Cyhalothrin 4%SL @ 400 ml/ha > Lambda Cyhalothrin 5% EC @ 500 ml/ha > Imidacloprid 70% WG @ 35 g/ha > Buprofezin 25% SC @ 1000 ml/ha > Diafenthuron 50% WP @ 600 g/ha.). Pyrethroids gives 76% and 94% population reduction after 24 hours and 94% after 72 hours of application. Similarly, Neo-nicotinoids gives 42% and 91% of population reduction after 24 hours and 94% after 72 hours of application (Rafiq *et al.* 2014) [14].

It is evidient from those tables that the combination product of Lambda Cyhalothrin and Imidacloprid (Imidacloprid 6% + Lambda Cyhalothrin 4%SL) at three different doses viz; 500 ml/ha, 450 ml/ha and 400 ml/ha gave better outcome in respect with other tested insecticides. This may be due to the fact that Lambda Cyhalothrin is a broad spectrum contact insecticide whereas Imidacloprid is a systemic insecticide. Therefore when an insecticidal treatment is imposed with the above mentioned combination chemical Lambda Cyhalothrin and Imidacloprid, Lambda cyhalothrin initially reduces the insect population by quick knock down due to its contact nature and at the later days after treatment imposition Imidacloprid being systemic in nature maintains the pest population to very low tune. This explanation does not arise with other sole treatment impositions.

Conclusion

In context of the results obtained through the present research, it can be concluded that the red cotton bug population started commencing from second week of August with highest population at second week of November. The studies also revealed that population of the Red cotton bug was positively correlated with temperature gradient, negatively correlated with relative humidity and rainfall at 1% level of significance. Thus we can regulate the population of Red cotton bug before it causes serious damage by the application of Imidacloprid 6% + Lambda Cyhalothrin 4% SL (INOVEXIA) @ 500 ml/ha at fortnightly interval.

Acknowledgement

Authors are cordially acknowledges the contributions Dr. Hirak Chatterjee, Professor and Head, Department of Agricultural Entomology, Institute of Agriculture, PSB, Visva- Bharati, Santiniketan for providing necessary facilities and encouragement during course of present investigation.

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