Ecological impact on development of hemipterous bug (*dysdercus koenigii*) (hemiptera: pyrrhocoridae) and boll rot disease of cotton (*gossypium hirsutum*) grown in the diversified field

Haider Karara,⇑, Muhammad Amjad Bashirb, Muneeba Haiderc, Najeeba Haiderc, Muhammad Hassand, Mohamed Hasheme,f, Saad Alamrie

a Mango Research Institute, Multan, Pakistan
b Department of Plant Protection Faculty of Agricultural Sciences, Ghazi University Dera Ghazi Khan Punjab, Pakistan
c MNS-University of Agriculture, Multan, Pakistan
d Faculty of Agricultural Sciences & Technology, Department of Soil Science-Bahauddin Zakariya University, Multan, Pakistan
e King Khalid University, College of Science, Department of Biology, Abha 61413, Saudi Arabia
f Assiut University, Faculty of Science, Botany and Microbiology Department, Assiut, 71516, Egypt

**Abstract**

The experiment was conducted at Cotton Research Station, Multan to study the impact of weather factors and Hemipterous bug on development of cotton boll disease in cotton variety bt-886 for three consecutive years i.e., 2012, 2013 and 2014. The results revealed that the population of Red Cotton Bug (RCB) per plant remain 0.50 and 0.34 during years 2012 and 2013, respectively but increased during 2014 i.e., 3.21 per plant. The number of unopened bolls (UOB) were more during 2012 i.e., 13.43% with yellowish lint (YL) 76.30% and whitish lint (WL) 23.70% at average maximum temperature of 34.73°C, minimum temperature of 22.83°C, RH of 77.43% and 11.08 mm rainfall. Similarly during 2013, the number of unopened bolls were less i.e., 0.34 per plant with YL 1.48 and WL 99.53 per plant when average maximum temperature 34.60°C, minimum temperature 23.37°C, RH 73.01% and 9.95 mm rainfall. During 2014, RCB population per plant was 3.22 with no UOB and YL was 0.00% and WL was 100% when average maximum temperature 23.70°C, minimum temperature 23.18°C, RH 71.67% and 4.55 mm rainfall. So our results concluded that the cotton bolls rot disease was more during 2012 due to abrupt changes in environmental factors. The RCB may be the carrier of boll rot disease pathogen during more rainfall.

**Keywords:**

Hemipterous bug
Cotton variety bt-886
Yellowish lint
Whitish lint
Weather factors

1. Introduction

Cotton (*Gossypium hirsutum* L.) is known as white gold and life-blood for the economy of Pakistan. It contributes a primary part in our foreign exchange, which is up to 68% (Khan & Khan, 1995) and shares about 62.3% in the total exports (Anonymous, 2003). It is the most economically important natural fiber material in the world which is known as “The King of Fibers”. Being an important fiber it has lost its quality of lint and viability of seeds few years back due to attack of some pests which not only decrease its market price and but also produce low quality of seed for sowing. For example in the year 2012, there was severe lint staining problem resulting in low market price. It is supposed that major cause of cotton staining is red cotton bug, *Dysdercus koenigii* F. (Anonymous., 2014). In the past, Red Cotton Bug (RCB) has been considered as a minor insect pest of cotton but in recent years it has become a serious insect pest of cotton crop in Pakistan and India resulted in severe lint staining problem. It not only feeds on emerging cotton bolls, mature cotton seeds but also transmits cotton staining fungi (*Nematospora gossypii*) that develops on the immature lint and seed (Maxwell-Lefroy, 1908; Freeman, 1947; Ahmad and Schaefer, 1987; Yasuda, 1992). It not only produces yellowish lint but also effect on seed weight, oil content and seed viability which decline severely. For example several seeds within each lock may be affected or only one or two seeds in the boll and
are called primarily seed feeders (Maxwell-Lefroy 1908; Ahmad & Schaefer 1987). Furthermore, it was observed that this insect stains the lint with their excreta and causes considerable damage by reducing plant vigour, oil content and seed germination. Heavily attacked bolls open badly and the lint is of poorer quality. Furthermore, some experts considered that these bugs transmit fungal pathogen during feeding which causes a reddening of cotton lint.

It has massive host range including lady’s finger, sambhala, holyhock and hibiscus (Kohno & Ngan 2004). Formerly it was considered as minor pest of cotton because there attack was not of significance importance, but during few years back its attack was serious. So it attains status of major pest which contributes to lower yields (Ghosh, 2001). Red bugs have strong piercing/sucking mouthparts, which are capable of feeding on developing mature cotton bolls and seeds (Sprenkel, 2000; Freeman, 1947; Ahmad I. and C. W. Schaefer, 1987; Yasuda, 1992; Kohno and Bui, 2004. It is observed that if these bugs attacked on bolls of two weeks old can kill developing seeds leading to boll shedding. Cotton stainers are also sap sucking insect pests of okra. It does not significantly reduce the yield, but it lowers the quality of the fruits by inflicting a rusty appearance on the surface (Tomas and Gajete, 2008). Further, cotton stainers are also severe pest of some other economically important plants such as legumes, red gram (Singh and Singh, 1991; Singh and Singh, 1978) and portia tree (Peter and Sivasothei, 1999). Cotton stainers was a future threat to Pakistan because when a cropping system is shifted to a better one or new crop introduced may lead to a serious problem (Anon,2014).

The abiotic factors play a vital role in the survival of D. koenigii which can decrease and/or increase its population in cotton growing fields. The information on impact of weather factors on population of red cotton bug resulted yellowish lint is very little.

Keeping in view the importance of red cotton bug as carrier of boll rot disease in cotton and role of weather factors in population fluctuation, the present studies were under taken to identify the reasons of yellowish cotton lint.

2. Materials and methods

The experiment was carried out at the Cotton Research Station, Multan with the coordination of Cotton, Botanist during three consecutive years i.e., 2012, 2013 and 2014 on cotton variety br-886. The crop was sown in bulk for seed purpose on an area of 0.57 ha. The plant to plant and row to row distance was 0.31 cm 0.76 cm, respectively. The observations were made on twenty five randomly selected plants started from 1st week of July to last week of November of each study year.

Population of RCB: The population of RCB was recorded weekly from 25 plants and then compiled average on weekly, month basis and yearly basis to observe its effect.

Data of unopened cotton bolls: The unopened bolls (UOB) were counted from 25 plants selected at random and were plucked. The bolls were brought to laboratory at entomological Research Sub Station (hot and cool chamber) Multan.

Percent Yellowish and Whitish Lint: The bolls were cut longitudinally and separated the yellowish and whitish lint on locules basis, separate the yellowish and whitish lint, count them separately and then calculate their percentage.

Meteorological Data: The data regarding abiotic factors like maximum and minimum temperature, relative humidity and rainfall for the experimental yeas were got from Cotton Research Station, Multan.

Statistical Analysis: At the end of experiment, the correlations and multivariate regression was calculated between population of RCB and weather factors data were determined by using Statistix. The data were processed for simple correlation with the objective to find the impact of these factors on the population fluctuation of the pest. All analysis was done using Statistix 9.0 software (Statistix9.0 Analytical software, 2008).

3. Results

Population of RCB versus weather factors during 2012: The results (Fig. 1) regarding population of RCB versus weather factors during 2012 showed that the population appeared on cotton crop during 1st week of September 2012 with 0.04 individuals per plant and this population increased subsequently and decreased during 2nd week of October. The population reached at peak of 2.40 /plant during 3rd week of October with maximum temperature of 30.30 °C, minimum of 18.60 °C and average RH of 81.80%. A decreasing trend was observed thereafter on the subsequent dates of observation and reached at minimum level of 0.77 during 3rd week of November, but during 4th week of November the population was increased up to 1.34 /plant.

Population of RCB versus weather factors during 2013: The results presented in Fig. 2 regarding population of RCB versus weather factors during 2013 showed that the population of RCB appeared on cotton crop during 2nd week of October with 0.73 individuals per plant. The population fluctuated up and down thereafter. The population reached to a peak of 1.65 /plant during 4th week of November with maximum temperature of 27.90 °C, minimum of 13.10 °C and RH 82.50%.

Population of RCB versus weather factors during 2014: The results depicted in Fig. 3 regarding population of RCB versus weather factors during 2014 showed that the population of RCB appeared on cotton crop on 3rd week of July 2014 with 1.17 individuals per plant and this population increase on subsequent date of observation and the pop reached to peak of 13.48 /plant on 1st week of August with max temp 38.40 °C mini 28.40 °C and average RH 73.00%. The decrease in trend was observed thereafter on the subsequent dates of observation and reached to mini of 0.00 on 4th week of Sept. But on 1st week of Oct the pop of RCB again appeared with 1.16/plant and go on increasing and its peak was observed on 2nd week of Nov with max temp 28.16 °C mini 11.83 °C and average RH 77.00%. The decreasing trend in pop was observed thereafter on subsequent dates of observation and reached to a mini of 0.73/-plant on 4th week of Nov.

Cumulative population of red cotton bug versus weather factors on an average basis of three year: The results (Fig. 4) regarding average population of RCB recorded per plant during 2012, 2013 and 2014 versus respective weather factors are shown in Fig. 4. It is clear from the graph that peaks of RCB were observed on average of
3 years data. In first peak the pop of RCB appeared on 3rd week of July i.e. 0.39 /plant and increased up to highest peak i.e. 4.51 /plant on 1st week of August with maximum temperature of 36.87 °C minimum of 27.47 °C and average RH 74.37%. A decreasing trend was observed thereafter on the subsequent dates of observation and reached to minimum of 0.00 during 4th week of August. The
2nd peak was appeared during 2nd week of September with pop of RCB 0.13/plant and then the population was increased and reached to its peak i.e., 2.80 /plant during 3rd week of October with maximum temperature of 32.23 °C, minimum of 19.50 °C at RH 76.13%. A decreasing trend in population was observed thereafter on subsequent dates of observation and reached to minimum of 1.24/-plant during 4th week of November with maximum temperature of 27.13 °C, minimum 10.87 °C and RH 82.93%.

Average population of red cotton bug versus weather factors during July, August, September, October and November during 2012: The results regarding average population of RCB versus weather factors. The results regarding average pop of RCB recorded per plant yearly of months July, August, September, October and November during 2012 versus weather factors are shown in Fig. 5. It is clear from the graph that peak of RCB was observed in the month of October i.e., 1.16 /plant with max temperature 33.10 °C minimum 19.20 °C and average RH 83.50% . More rainfall was recorded 175.50-mm in the month of September as compared to other months under study.

Average population of red cotton bug versus weather factors during July, August, September, October and November during 2013: The results regarding average population of RCB recorded per plant for of months of July, August, September, October and November during 2013 versus weather factors are shown in Fig. 6. It is clear from the graph that peak of RCB was observed in the month of November i.e., 1.15 /plant with max temperature 27.40 °C mini 13.30 °C and average RH 82.00% . More rainfall was recorded 96.50 mm in the month of August as compared with other months under study.

Average population of red cotton bug versus weather factors during July, August, September, October and November during 2014: The results regarding average pop of RCB recorded per plant yearly of months July, August, September, October and November during 2014 versus weather factors are shown in Fig. 7. It is clear from the graph that peak of RCB were observed in the month of August.
Average population of red cotton bug versus weather factors during 2012, 2013 and 2014: The results regarding average population of RCB recorded per plant during 2012, 2013 and 2014 versus weather factors are shown in Fig. 8. It is clear from the graph that peak of RCB was observed during 2014 i.e., 2.22 /plant during the year 2014 with maximum temperature of 34.60 °C, minimum 23.08 °C, RH 71.82% and 11.08-mm rainfall. The number of UOB were more i.e., 13.43% recorded during 2012 with YL 76.30 and WL 23.70 % when maximum temperature was 34.73 °C, minimum 22.83 °C, RH 77.43% and 9.95 mm rainfall. During 2013, the number of UOB were less i.e., 0.34 per plant with YL 1.48 and WL 99.53 per plant when average temp max 34.60, mini 23.37, RH 73.01 and 9.95 mm rainfall. During 2014 RCB population per plant was 3.22 with no UOB and YL was 0.00% and WL was 100% when average temp max 23.70, mini 23.18, RH 71.67 and 4.55 mm rainfall.

Role of weather factors in population fluctuation of red cotton bug. Simple correlations: A study was conducted to determine the role of weather in population fluctuation of red cotton bug. The data were processed for simple correlation with the objective to find the impact of these factors on the population fluctuation of the pest. The results are described under
The results presented in Table 1 reveal that during 2012, the weeks showed significant and positive correlation with population of red cotton bug. Among weather factor maximum and minimum temperature exerted significant effect on the population of red cotton bug whereas RH and rainfall showed non-significant influence in population fluctuation of RCB. During 2013, again the weeks had significant and positive correlation with population of RCB. The maximum and minimum temperature exerted significant effect on the population of red cotton bug whereas RH and rainfall had non-significant effect on population of RCB. During 2014 and on cumulative basis, the effect of weather factors on the population fluctuation of RCB was non-significant. Table 2.

**Simple correlation between weeks, weather factors and population of red cotton bug during 2012, 2013 and 2014.** The results presented in Table 1 showed that during 2012 the weeks have significant and positive correlation with population of red cotton bug. Among weather factor max and mini temperature has resulted significant effect on the population of red cotton bug whereas RH and rainfall has non-significant effect on population of RCB. In 2013 again the weeks has significant and positive correlation with population of red cotton bug. The max and min temperature has exerted significant effect on the population of red cotton bug whereas RH and rainfall has non-significant effect on population of RCB. In 2014 and cumulative data with weather factors have non-significant correlations with RCB population.

**Multiple regressions:** The results relating to Multiple Linear Regression Models along with coefficient of determination values between weather factors and population of red cotton bug during 2012, 2013, 2014 and on cumulative basis are given in Table. It is evident from the results that during 2012, maximum temperature showed 65.5% impact on the population fluctuation of red cotton bug. The effect of maximum and minimum temperature showed significant impact when computed together and contributed 1.1 percent role in the population fluctuation of the pest. The role become 3.1 percent when the effect of maximum temperature, minimum temperature and RH was computed together. Rainfall did not show any impact on the population fluctuation of the pest. During 2013, maximum temperature contributed 62.1% percent role in population fluctuation of the pest with significant impact. The role of maximum and minimum temperature reached up to 16.5 percent when the effect of both parameters was computed together. The combination of maximum temperature, minimum temperature and relative humidity showed 3.2 percent impact on the population fluctuation of the pest. Similarly, the effect of all the weather factors exerted zero percent role in population fluctuation of red cotton bug. During 2014, maximum temperature contributed 3.5% on population fluctuation of the pest with non-significant impact. The role maximum and minimum temperature contributed zero percent role in population fluctuation of the pest with non-significant impact. The role of maximum, minimum temperature and RH 0.7% with non-significant impact. Similarly, the effect of all the weather factors exerted 0.6 percent role in population fluctuation of red cotton bug. On cumulative basis, maximum temperature showed 12.2 percent impact non-significant impact .The role of maximum and minimum temperature have zero percent in population fluctuation of the pest. The impact was reached up to 1.7 percent when the effect of maximum

**Table 1**

| Years | r-values | Weather Factors |
|-------|----------|----------------|
|       |          | Temperature    |
|       |          | Max °C | Mini °C | R.H. (%) | Rainfall (mm) |
| 2012  | -0.81 (0.00) | -0.79 (0.00) | 0.43 (0.05) | -0.13 (0.57) |
| 2013  | -0.79 (0.00) | -0.88 (0.00) | 0.40 (0.08) | -0.26 (0.27) |
| 2014  | -0.15 (0.43) | -0.18 (0.46) | -0.13 (0.49) | -0.14 (0.57) |
| Cumulative | -0.35 (0.13) | -0.35 (0.14) | 0.32 (0.18) | -0.24 (0.30) |

Fig. 8. Year wise comparison of RCB pop/plant, UOB, YL, WL with abiotic factors.
temperature, minimum temperature and Relative humidity was computed together. Similarly, the effect of all the weather factors exerted 5.1 percent role in population fluctuation of red cotton bug.

4. Discussion

The results regarding the correlation between abiotic factors, population of Dysdercus koenigii and their impact on cotton lint quality and unopened cotton bolls of bt cotton 886. Our conclusion suggested that correlation between weather factors and population of red cotton bug indicated that max and mini temperature has positive and significant effect on the population of red cotton bug whereas percent RH and rainfall has non-significant effect on population of RCB. The results are in line with that of Butterfield and Coulson 1997 who highlighted the influence of climatic fluctuations and their impact on invertebrates. Moreover it has been mentioned that the timing of reproduction, nymphal development, migration and diapauses of Dysdercus species depend on the temperature, relative humidity, rainfall, photoperiod and food (Stadler et al., 1987; Arif and Mubashshera, 2005). The results are not in line with that of Berlinger et al. (1996) who reported that field temperature was negatively correlated while relative humidity was positively correlated with red cotton bug population. On the other hand, the field temperature and relative humidity were showed a combine non-significant effect on the population of red cotton bug on cotton varieties. Presented results support the findings of Gogoi et al. (2000), Murugan and Uthamasamy (2001) and Panicker and Patel (2001) reported that meteorological parameters play a key role in the population fluctuation of sucking insect pests.

During 2012, the cotton bolls were studied intensely and observed that the effected bolls were looking good outside but inside there was much different when bolls were opened transversely, seed rottening with discolored lint was seen. Diseased bolls were compact and failed to open properly. Rotted seeds exhibit hollow and dark discoloration. Further it was recorded that the population per plant of RCB during 2012 was almost same as during 2013, but the number of unopened bolls due to boll rot disease were more with more yellowish lint and less whitish lint. In 2013, a few numbers of unopened bolls were recorded with no yellowish lint and all the lint was whitish. Again in 2014, the populations of RCB was comparatively more as compared with 2012 and 2013, but no such bolls rot disease could be observed with yellowish lint. During these study years the only difference was of heavy rainfall in the month of September during 2012 which is considered as a reason of boll disease who changes whitish lint in to yellowish. The yellowish may be due to more rainfall as compared with 2013 and 2014 during bolls developmental stage. The results are in conformity to (Karar et al., 2013 unpublished data) who reported that red cotton bug is minor pest present in cotton long ago but rainfall is the only source of rotting boll disease, red cotton bug may act as vector of transmitting pathogen of disease. The results are not in conformity with the statement (Anonymous., 2014) who reported that the major cause of cotton staining is red cotton bug, Dysdercus koenigii F. Although red bugs feed on developing and mature cotton, Gossypium hirsutum (Linnaeus 1758) seed which decline seed weight, oil content and seed viability. But severe occurrences on bolls of two weeks old can kill developing seeds leading to boll shedding. Where feeding is less, though damaged bolls are retained and yield and quality of lint are also reduced as a secondary effect of feeding. The results are partially compatible with that of Wilson et al., 2008, who reported that yellow staining of the lint occurs as a consequence of watery faeces being deposited on the lint while bugs are feeding in the open bolls. The bugs transmit a fungal pathogen during feeding causing a reddening of the lint. Furthermore, it also acts as vector for transmitting the fungal pathogens in cotton (Kshemkalyani et al., 1989, Karimi et al., 2010). Further the reasons of boll rot disease can be confirmed by the installation of field cages by creating such conditions in standing crop in field.

Table 2

| Years | Regression Equation | D.F. | F-value | P-value | 100 R² | Impact (%) |
|-------|--------------------|-----|---------|---------|-------|------------|
| 2012  | Y = 2.83 - 0.0539 X1 | 18  | 34.11   | 0.00    | 65.5  | 65.5       |
|       | Y = 2.52 - 0.0358 X1 - 0.0142 X2 | 17  | 16.92   | 0.00    | 66.6  | 1.1        |
|       | Y = 4.15 - 0.0698 X1 + 0.0014 X2 - 0.0103 X3 | 16  | 12.25   | 0.00    | 69.7  | 3.1        |
|       | Y = 4.18 - 0.0680 X1 - 0.0002 X2 - 0.0109 X3 + 0.00032 X4 | 15  | 8.63    | 0.001   | 65.7  | 0          |
| 2013  | Y = 3.58 - 0.0934 X1 | 18  | 29.46   | 0.00    | 62.1  | 62.1       |
|       | Y = 1.16 - 0.0454 X1 - 0.102 X2 | 17  | 31.20   | 0.00    | 78.6  | 16.5       |
|       | Y = 2.87 - 0.0208 X1 - 0.0987 X2 - 0.0128 X3 | 16  | 23.92   | 0.00    | 81.8  | 3.2        |
|       | Y = 2.86 - 0.0208 X1 - 0.0986 X2 - 0.0127 X3 - 0.00005 X4 | 15  | 16.82   | 0.00    | 81.8  | 0          |
| 2014  | nsY = 3.65 - 0.0672 X1 | 18  | 0.66    | 0.427   | 3.5   | 3.5        |
|       | nsY = 3.52 - 0.061 X1 - 0.003 X2 | 17  | 0.31    | 0.735   | 3.5   | 0          |
|       | nsY = 1.64 - 0.043 X1 - 0.004 X2 + 0.0176 X3 | 16  | 0.23    | 0.872   | 4.2   | 0.7        |
|       | nsY = 1.75 - 0.094 X1 - 0.003 X2 + 0.0148 X3 - 0.0079 X4 | 15  | 0.19    | 0.941   | 4.8   | 0.6        |
| 2012 + 2013 + 2014 | nsY = 2.91 - 0.0475 X1 | 18  | 2.49    | 0.132   | 12.2  | 12.2       |
|       | nsY = 2.62 - 0.033 X1 - 0.0092 X2 | 17  | 1.18    | 0.33    | 12.2  | 0.00       |
|       | nsY = 0.04 + 0.026 X1 - 0.0343 X2 + 0.0149 X3 | 16  | 0.86    | 0.482   | 13.9  | 1.7        |
|       | nsY = 2.10 + 0.052 X1 - 0.0278 X2 + 0.0313 X3 - 0.0119 X4 | 15  | 0.86    | 0.498   | 19.0  | 5.1        |

Where X1 = Max. Temperature X2 = Mini. Temperature X3 = R.H percent X4 = Rainfall
R² = Coefficient of Determination
* = Significant at P ≤ 0.05.
** Significant at P ≤ 0.01.
pathogen of boll rot disease during heavy rainfall, but not itself causing disease.

Current studies were conducted at Cotton Research station Multan-Punjab Pakistan with the coordination of Cotton botanist, Multan, Government of the Punjab, Agricultural Department

Conflict of interest

There is no conflict of interest among authors.

Acknowledgement

The authors extend their appreciation to the Deanship of Scientific Research, King Khalid University for funding this work through research groups program under grant number R.G.P. 1/25/42.

References

Ahmad, I., Schaefer, C.W., 1987. Food plant and feeding biology of the pyrrhocoroidea (Heteropter); Phytophaga 1, 75–92.

Analytical software. 2008. Statistix 9.0. Available online with updates at http://www.statistix.com/freetrial.html

Anonymous, 2003. Cotton Production Plan. Div., Plann. Adv. Wing, Karachi-Pakistan, Government of Pakistan, Plann.

Anonymous. 2014. Cotton stainer- future threat to Pakistan. Pakistan observer, January 22, Islamabad

Arif, M., Mubahshera, A., 2005. Cannibalistic instincts in the red cotton bug Dysdercus cingulatus. J. Ecobiol. 17, 99–100.

Berlinger, M.J.N., Lehmannsigsu, Taylor, R.A.J., 1996. Survival of Bemisia tabaci (Genn.) under different climatic conditions. Entomol. Exp. Appl. 80, 511–519.

Butterfield, J.E.L. and J.C. Coulson. 1997. Terrestrial invertebrates and climatechange: Physiological and life-cycle adaptations. In: Past and future rapid environmental changes: The spatial and evolutionary responses of terrestrial biota (Eds.: B. Huntley, W. Cramer, A.V. Morgan, H.C. Prentice, J.R.M. Allen), Springer, Berlin: 401-424.

Freeman, P., 1947. A revision of genus Dysdercus Boisduval (Hemiptera; Pyrrhocoridae), excluding the American species. Trans. Royal Entomol. Soc. London 98, 373–424.

Ghosh, S.K., 2001 G.M. Crops: Rationally irresistible. Current Science 6, 655–660.

Gogoi, I., Dutta, B.C., 2000. Seasonal abundance of cotton jassid on okra. J. Agric. Sci. Society, North-East India 13, 22–26.

Khan, W.S. and A.G. Khan, 1995. Cotton situation in the Punjab, an overview, paper presented at National Seminar on “Strategies for increasing cotton production” held on April 26-27 at Agricultural house, 21–Agha Khan–III Road, Lahore–Pakistan

Kohno, K., Bui Thi, N., 2004. Effects of host plant species on the development of Dysdercus cingulatus (Heteroptera: Pyrrhocoridae). Applied Entomology and Zoology 39, 183–187.

Wilson, L., M. Khan and T. Farrell. 2008. Pale cotton stainers, Dysdercus cidea. On Farm Series: IPM

Maxwell-Lefroy H. 1908. The red cotton bug (Dysdercus cingulatus Fabr.). Memoirs of the Department of Agriculture in India (Entomological Series) 2:47–58.

Murugan, M., Uthamasamy, S., 2001. Dispersal behaviour of cotton whitely, Bemisia tabaci under cotton based garden land agro ecosystem of Coimbatore. Madras Agric. J. 88, 1–6,

Panicak, B.K., Patel, J.B., 2001. Population Dynamics of different species of thrips on chilli, cotton and pigeon pea. Indian J. Entomol. 63, 170–175.

Peter, K.L.N., Sivasothi, N., 1999. Animal diversity. A guide to the mangroves of Singapore. Singapore Science Centre, Singapore.

Singh, H.K., Singh, H.N., 1991. Some major pest incidence on certain late cultivators of pigeon pea, Cajanus cajan (L.) during half pod formation stage. Indian J. Entomol. 53, 298–303.

Singh, R.N., Singh, K., 1978. Influence of intercropping of succession and population build up of insect-pests in early variety of red gram, Cajanus cajan (L.) Millsp. Indian J. Entomol. 40, 361–375.

Singh, R.N., Singh, K., 2001. Population Dynamics of different species of thrips on chilli, cotton and pigeon pea. Indian J. Entomol. 53, 298–303.

Stadler, T., Mere, C., Cappozzo, H.L., 1987. La bionomia de Dysdercus albofasciatus Berg, (Hemiptera : Pyrrhocoridae), Plaga del algodon : Suciclo de vida, limentaction, estrategias adaptativas emeigos naturales. Bol. San. Veg. Plagas. 13, 143–159.

Tomás, D., Gajete, 2008. Okra Production. Open Academy for Philippine Agriculture. Yasuda, K., 1992. Cotton bug, in Insect pests of vegetables in the Tripics (T. Hindaka ed). Association for international cooperation of agriculture and forestry, pp 22–23 (in Japanese).

Further Reading

Balakrishnan, N., Vinothkumar, B., Sivasubramaian, P., 2010. Bioefficacy of kina dorgold against sucking pests of cotton. Madras Agric. J 97, 88–91.

David, B.V., Anantha Krishnan, T.N., 2004. General and applied entomology, Tata Mc Graw-Hill Publishing company Limited New Delhi, pp 1184. Mulberry Indian Silk 31 (2), 39–40.

Karihalo, J.L. and P.A. Kmar, 2009.Bt cotton in India-A status report (2nd Edn.). Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), New Delhi, India, p 56

Uthamasamy, S., Kannan, M., Mohan, S., 2004. Impact of insecticides on sucking pests and natural enemy complex of transgenic cotton in India. Current Science 86, 726–729.