Pakistan J. Zool., vol. 46(2), pp. 329-335, 2014.

The Cotton Stainer (*Dysdercus koenigii*): An Emerging Serious Threat for Cotton Crop in Pakistan

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Abstract.- The researchers and progressive farmers of cotton growers of Punjab, Pakistan had been worrying for six years from 2005 to 2010 for an obscure causing agent of the warts and internal lint damage (rotting) of cotton bolls. Consequently, a two years study was launched in 2010 and 2011 thoroughly aimed at investigating the actual causing insect pest of warts on the internal carpel wall of cotton bolls. The cotton stainer, *Dysdercus koenigii* F., (Hemiptera: Pyrrhocoridae), dusky cotton bug, *Oxycarenus* spp. (Hemiptera: Lygaeidae) and stink bug (Hemiptera: Pentatomidae) were considered as the suspected insect pests and were planned to be caged. A total of six observations were made with 7 days interval, with a total duration of 41 days for each of the experiments. In each observation, 10 bolls were observed in which the highest average of 4.8 warts boll^{-1} were recorded at the 5th observation while lowest average 0.8 warts boll^{-1} were observed at the 2nd observation. Whereas, in control and dusky cotton bug cages, there were no warts and no damage was recorded throughout the course of experiments.

Key Words: Cotton stainer, *Dysdercus koenigii*, dusky cotton bug, stink bug, warts, indentations, lesions, internal carpel wall, cotton boll.

INTRODUCTION

Agriculture is the backbone of Pakistan's economy and majority of the population is engaged in farming directly or indirectly through production, processing and distribution of major agricultural commodities. It contributes about 21% of our Gross Domestic Product (GDP), providing livelihood to almost 68% people living in rural areas and employing around 45% of the total national labor force (PBS, 2011). Cotton being among the major crops of the country, is an important cash crop which significantly contributes to the national economy by providing raw material to the local textile industry, such as cotton lint as an export item. It accounts for 7.8% of value added in agriculture and 1.6% of the GDP. During 2011-12, the crop was cultivated on an area of 2.835 million ha with a production of 13.6 million bales reported during the period of July-March, 2011-12 (PES, 2012).

However, one of the major obstacles hindering cotton cultivation is the attack of insect pests. Generally, the dusky cotton bug also called cotton seed bug and technically known as *Oxycarenus* spp. (Hemiptera: Lygaeidae) is one of the serious bugs of cotton seeds. Sometime, the bugs are crushed in the ginning process, staining the lint. Greater damage is done to the seeds by reducing quality, germination and oil content (Sweet, 2000). Both adults and nymphs of cotton seed bug feed on seeds. Feeding by large populations of the cotton seed bug can cause a significant decrease in cotton seed weight (up to 15%). The ability of seeds to germinate is also significantly reduced, potentially as much as 88% (Henry, 1983). In particular, the cotton stainer, *Dysdercus* spp. (Heteroptera: Pyrrhocoridae) has always been a source of serious damage to the crop by feeding on developing cotton bolls, and/or ripened cotton seeds (Ahmad and Khan 1980; Ahmad and Schaefer, 1987; Yasuda, 1992). According to Hill and Waller (1990), the developing fungus stains the lint.

Cotton stainer has been declared as one of the most destructive cotton pest in other parts of the world. Sprenkel (2000) is of the view that most of its nymphal stages as well as its adults feed on the seeds within the developing cotton bolls, leaving a stain on lint. Consequently, this feeding by puncturing the flower buds or the young cotton bolls usually causes reduction in size; or the fruiting body may abort and drop to the ground. Alternate hosts of *Dysdercus koenigii* include hollyhock (Kamble, 1971) and plants of family Bombacaceae (Kohno

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0030-9923/2014/0002-0329 $ 8.00/0

and Ngan, 2004).

A few years ago until 2010, red cotton bug was considered a minor pest in Pakistan, however, this boll-feeding insect with piercing sucking mouthparts has now become a more common pest of cotton. It is thought that major cause of cotton staining is *D. koenigii* (Anonymous, 2013). Cotton stainer or red cotton bug especially *D. koenigii* F. (Hemiptera: Pyrrhocoridae) has been found most destructive pests of cotton in the cotton zones of Pakistan during the 2011 (Jaleel *et al.*, 2013). Its population flared up during the last three years; as before 2011 they were reported very nominal.

A major reason for the increased population of cotton stainer is the wide adoption of transgenic cotton varieties in Pakistan, possessing *Bacillus thuringiensis* (*Bt*) insecticidal proteins, that has triggered reduced use of foliar insecticides; whereas before these transgenic varieties cotton stainer was not even considered a minor pest of cotton in Pakistan. From the year 2005 to 2010, the researchers and progressive farmers of cotton growers of Punjab, Pakistan were worried for the obscurely causing agent of the warts and internal lint rotting of cotton bolls. The pink bollworm *Pectinophora gossypiella* (Lepidoptera: Gelechiidae) was considered responsible for these damages in non-transgenic/conventional cotton; however, the same problems were even reported in the transgenic cotton as well. The infestation of *D. koenigii* was reported very low in cotton during the aforesaid period and consequently their damaging frequencies were reported to be very low as well. Cotton stainer has caused severe losses in the year of 2011 and onwards in major cotton growing areas of Pakistan. Heavily attacked bolls opened badly and the lint was reported stained. Nevertheless, very less attention was given to this *D. koenigii* in terms of research.

Keeping all this in view and focusing on the warts, an investigation on war footing basis was conducted to evaluate the actual causal organism for warts in cotton in Pakistan.

MATERIALS AND METHODS

A two years study was conducted in the Central Cotton Research Institute (CCRI), Multan for the investigation of actual warts causing insect pest. Three suspected insect pests including red cotton bug, dusky cotton bug and stink bug were planned to be caged. However, the stink bug was searched in both 2010 and 2011 during the peak season but it was not found in sufficient and required numbers. An 18 x 18 meter plot was selected and CIM-*Bt*-599 cotton variety was sown in April 2010 and 2011, having bed in furrow pattern. A cage of size 2.1 x 0.91 x 0.91 m was made by a thin muslin white cloth. Two plants were caged in each replication (cage), while experiment was repeated with three replications with control (check). All of agronomical practices were consulted to concerned sections.

All squares, flowers and small bolls were removed from caged plants, only mature bolls were left. Redeveloped squares were removed on each observation thoroughly. To avoid the chance of undesirable insect pests within the cages, crop were sprayed out on 25th July, 2010 and 23rd July, 2011 by application of Danadim progress (Dimethoate) 40%EC @ 33.2 ml/8.3 L of water (recommended dose 800ml/100 L of water). All cages were installed after three days of chemical spray, but before installation plants were washed thoroughly by tap water to disintegrate the residual toxicity of dimethoate. A total of 400 adults of red cotton bug (RCB) and 400 of dusky cotton bug (DCB) were released in the respective cages on August 10, 2010 and 2011. Six observations were totally made for each pest in each year with 7 days interval while the last observation was made with a single day interval. In each observation, 10 bolls were plucked, cut with sharp razor and its internal carpel wall for warts was observed in the laboratory. Few bolls were found open at the end of trial. Data were recorded for warts (out growth found on the inner carpel wall) and damage (lesions). Mostly, damage was found on one or on two locules of a boll, while rests of the locules of a boll were healthy.

Data analysis

As the pattern of the infestation (damages) of *D. koenigii* was similar, therefore, the data was averaged for two years and analyzed with one sample t-test.

Fig. 1. Field cages (top) and partially open damaged (lesions) bolls of cotton (bottom) from cages containing stainer.

Fig. 2. Crystal clear internal carpel wall (top) and lint from control cages (bottom).

RESULTS

Dysdercus koenigii

A significant effect of the pest was observed on the mature bolls. In released cages of the *D. koenigii*, a total of 59 bolls were counted with a mean of 9.8 bolls, the average of the two years study in 2010 and 2011 (Table I). The bolls were affected in two ways *i.e.* initially the pest pierced into the bolls and formed warts (Fig. 3) and when deep feeding inside the bolls occurred then the damage became visible (Fig. 1) and the lint was stained (Fig. 3). When compared with the control cages, where no releases were made, no wart or damage was recorded (Fig. 2).

As shown in Table I, no warts or damage were reported during the first observation in the released cages, while in the 2nd observation, an average of 1.2 warts boll^{-1} was observed but no damage reported. It is thus indicated that *D. koenigii* caused warts and then these warts led to the severe damage *i.e.* staining, lint lock and finally lesions (Fig. 1). At the 3rd observation, an average of 2.5 warts boll^{-1} and 0.4 damage boll^{-1} were observed. The highest average of 4.8 warts boll^{-1} were found in the 5th observation with average damage of 0.8, followed by the 6th (last) observation, where 4.6 warts boll^{-1} were recorded, however damage boll^{-1} was second highest *i.e.* 0.7 in the 4th observation.

Oxycarenus *spp.*

In the released cages of dusky cotton bug,

47.0 (7.83 mean) bolls were observed, which is the average of the two years of 2010 and 2011. No warts and damages were reported throughout the experiments. In the control cages, average number of mature bolls was 53.0 (Table II); however, all observed bolls were reported crystal clear.

Fig. 3. Prominent warts (out-growth on inside carpel wall) (top), stained and locked lint locules of cotton (bottom) from cages, where stainers were released.

DISCUSSION

D. koenigii has recently become an important insect pest of cotton crop in Pakistan having a key role in the facts and figures of the country's economy. These insects have caused substantial economic losses in cotton crop in the cotton growing areas of Pakistan. In the year 2011, warts on internal carpel wall of cotton boll, sever lint staining, lint lock and lesions followed by cotton stainer: an emerging serious threat for cotton production (CCRI, 2011).

In the present experiments, only warts were studied. However, various other experiments are in progress on qualitative and quantitative losses, while, some insecticides were successfully screened out against this destructive pest. It is confirmed that very limited this pest has been studied on all aspects except hematological studies.

Its mode of damage was very keenly observed during the course of these trials (inside the cages) in the years of 2010 and 2011. Both nymphs and adults of this insect have a very strong proboscis (stylet, a needle like protrusion from mouth). Elzinga (1997) has also reported that hemipteran pests have piercing-sucking type of mouth parts with the segmented beak arising from the anterior portion of the head, termed as the stylet. Moreover, Wilson *et al*. (2004), in his study, also mentioned *D. sidae*, one of the members of this genus, as having very strong piercing sucking mouth parts. As per our observations in the study, *D. koenigii* inserted its proboscis into the soft tissues of cotton bolls, produced an abnormal out-growth into the internal carpel wall of the boll, which eventually resulted into lesions on the respected locule lint (mostly cotton boll has four locules per boll). Therefore, the bolls of varying ages should be cut open to confirm and monitor for signs of damage. This kind of damage can only be observed if the bolls are cut, the locules are removed and the internal carpel walls are monitored (Wilson *et al*., 2004).

In light of the results, a significant effect of the pest was observed on the mature bolls. It is obvious from the study that the number of warts boll^{-1} and the damage boll^{-1} linearly increased with the passage of time after the release of the insect in to the cages. Looking at all the six observations, the number of warts after the first week of the insect release was zero and then after every seven days interval the no. of warts increased exponentially. The more time the insect is given to feed on the cotton bolls the more the warts are formed and consequently the more the damage is caused. Similarly, when compared to the control cages where there were no warts at all (Fig. 2), it became

Table I.- Average no. of bolls, warts boll^{-1} and damage (lesion) boll^{-1} of control and *Dysdercus koenigii* released cages in 2010 and 2011.

Obs. Date	Control cages			Released cages		
	Av. boll	Av. war./boll	Av. dam./boll.	Av. boll	War./boll	Dam./boll
18-08	10.0	0.0	0.0	10.0	0.0 ± 0.00	0.0 ± 0.00
26-08	10.0	0.0	0.0	10.0	1.2 ± 0.10	0.0 ± 0.00
03-09	10.0	0.0	0.0	10.0	2.5 ± 0.21	0.4 ± 0.13
11-09	10.0	0.0	0.0	10.0	3.0 ± 0.31	0.7 ± 0.26
19-09	10.0	0.0	0.0	10.0	4.8 ± 0.26	0.8 ± 0.20
20-09	3.0	0.0	0.0	9.0	4.6 ± 0.29	0.6 ± 0.20
Average	8.83	0.0	0.0	9.8	2.7	0.42

Obs, observations; Av, average; war, wart; dam, damage.

Table II.- Average number of bolls, warts boll^{-1} of control and *Oxycarenus* spp. released cages in 2010 and 2011.

Obs. Date	Control cage		Released cage	
	Av. boll	Av. war./ boll	Av. boll	Av. war./ boll
18-08	10.0	0.0	10.0	0.0
26-08	10.0	0.0	10.0	0.0
03-09	10.0	0.0	10.0	0.0
11-09	10.0	0.0	10.0	0.0
19-09	10.0	0.0	7.0	0.0
20-09	3.0	0.0	0.0	0.0
Average	8.83	0.0	7.83	0.0

For abbreviations, see Table I.

quite obvious that *D. koenigii* is responsible for the formation of warts, and then these warts led to the severe damage *i.e.* staining, lint lock and finally the lesions. The mechanism of action of the pest was that it initially pierced its stylet into the bolls and formed warts as obvious from the Figure 3. After continuous feeding inside the bolls the damage became visible as given in Figure 1.

Cauquil (1988) mentioned that *D. cingulatus* mainly feeds on the milky contents of seed kernels. A little damage is inflicted on the very young fruits but the perforation may cause bolls to fall down. In green bolls, less than 25 days old, the perforation induces a reaction which results in the formation of cankers (neoplasmic outgrowths) in the locules. The nature of damage caused by *D. koenigii* in the present study was quite similar to that found in citrus as reported by Hubbard (1885). In his evaluation, *D. siturellus* punctured and sucked the young bolls, preventing them from getting to maturity. *D. cingulatus* has also been a pest of oranges on occasions. In puncturing an orange, a cotton stainer often inserts its beak up to the full length with no visible wound.

It has also been confirmed from the literature study that other than the cotton stainer there are also a complex of stink bugs that cause warts in the internal carpel wall of cotton bolls similar to the damage caused by the cotton stainer. Wilson *et al*. (2004) conducted study on *D. sidae* (pale cotton stainer). They stated that pale cotton stainer caused damage to developing bolls which was similar to that of green vegetable bug. This includes a black spot on the outside of the boll, warty growths inside boll wall and brown colored lint. This green vegetable bug produced 20, while *D. sidae* produced 8 warts boll^{-1} in ten days old cotton boll. Cauquil (1988) affirmed that the same type of damage might be caused by other hemiptera such as *Nezara viridula*, *Calidae* spp., *Aspavia* spp., *Agonoscelis* spp., *Acrosternum* spp. or *Piezodorus* spp.

The plant bugs and their allies belong to the order Hemiptera, both have piercing-sucking type of mouthparts. There are two further sub orders known as Heteroptera and Homoptera. The plant-bugs are medium insects and important crop pests including the rice-bug, *Leptocorisa acuta* Thumb (Coreidae), the green potato-bug, *Nezara viridula* L. (Pentatomidae), the red cotton bug, *Dysdercus koenigii* F. (Pyrrhocoridae), the lace-bug, *Urentius sentis* Dist. (Tingidae) and the dusky cotton bug,

Oxycarenus. laetus Kirby (Lygacidae). All of these insects belong to the sub order Heteroptera (Atwal, 1976). Stink bugs primarily damage cotton bolls by piercing the fruit wall and feeding near or on immature seeds (Roberts *et al*., 2005). Plant bug pests pierce the boll wall with their piercing sucking mouth parts and feed on the developing seeds and surrounding tissues (Wene and Sheets, 1964).

Stink bugs (Heteroptera: Pentatomidae) are an important group of economic insect pests of many cultivated crops. Feeding by a complex of boll-feeding bugs, including the green stink bug, *A. hilare* (Say), southern green stink bug, *N. viridula* L., and brown stink bug, *Euschistus servus* (Say) cause severe economic losses to cotton crop (Cassidy and Barber, 1939; Toscano and Stern, 1976; Barbour *et al*., 1990; Greene *et al*., 1999; Turnipseed *et al.*, 2003). Boll feeding is evidenced through warty growths on the inner carpel (Wene and Sheets, 1964). A complex of stink bugs, including brown stink bug, *Euschistus servus* Say, southern green stink bug, *N. viridula* L. and green stink bug, *Acrosternum hilare* Say are most injurious to cotton during boll development stages (Wene and Sheets, 1964; Barbour *et al*., 1990; Greene *et al*., 1999; Willrich *et al*., 2004). Examining bolls for internal feeding symptoms the presence of wart-like callous tissue or punctures water-soaked lesions on the internal carpel wall, with or without stained lint has been an effective monitoring tool for complex of stink bugs (Greene and Herzog, 1999; Bundy *et al*., 2000).

ACKNOWLEDGEMENTS

The constant support of the field assistants Muhammad Akbar, Muhammad Aslam and Rashid in collection and other endeavors of the experiments are highly appreciated.

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(Received 4 October 2013, revised 15 November 2013)