*J. Cotton Res. Dev.* **31** (1) 128-132 (January, 2017)

# Crop loss estimation due to mealybug, *Phenacoccus solenopsis* Tinsley in *Bt* cotton

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**ABSTRACT**: Crop loss estimation was worked out at Main Agricultural Research Station, Raichur. Field experiment was conducted with six damage levels to assess the crop loss. Crop loss estimation due to mealybug damage indicated that cotton plants did not survive at all the damage levels at 60 days after sowing. At 90 days after sowing cotton yield was severely affected due to different levels of mealybug damage. Seed cotton yield differed significantly in all the damage levels at 120 and 150 days after sowing and yield reduction was more than 14 to 50 per cent in different levels.

**Key words :** Cotton, crop loss estimation, mealybug, *Phenacoccus solenopsis*

Cotton *(Gossypium* spp) occupies an enviable place amongst the commercial crops of India. Introduction of transgenic *Bt* cotton for commercial cultivation in India during 2002 has become boon to the cotton growing farmers and have harvested good yields with maximum returns. *Bt* cotton clearly appears to have been playing a key role in production and productivity. Second generation *Bt* cotton has given solution to the bollworm complex to the larger extent but at the same time they are susceptible to most of the sucking pests *viz.*, thrips, *Thrips tabaci* (Linnman), leaf hoppers, *Amrasca biguttula biguttula* (Ishida) aphids, *Aphis gossypii* (Glover), whitefly, *Bemisia tabaci* (Gennadius) and dusky cotton bug, *Oxycarenus hyalinipennis* (Costa).Recently mirid bug and mealybug have been reported as severe pests on cotton from different parts of the country. In the current decade, the trend of increased build up of various mealybug species in crop plants and in the wild is observed mainly due to certain biotic changes in climate and environment. Mealybug species *viz., Phenacoccus solenopsis* Tinsley, *Phenacoccus solani* Ferris and *Maconellicoccus hirsutus* (Green) have been recorded on cotton in India. Among them *P. solenopsis* is a major and wide spread species in the country (Nagrare *et al.*,, 2009).

Severe economic damage to *G. hirsutum* was reported in 2007 in 4 major cotton growing districts of Punjab, 2 districts of Haryana, and low to moderate damage in parts of Maharashtra, Tamil Nadu and Andhra Pradesh (Dharajyoti *et al.,* 2008 and Dhawan, *et al.,* 2008). Nearly 2000 ac of cotton destroyed by mealybug and over 100 acres of infested cotton was uprooted in Bhatinda and estimated loss ranged from US$ 400000 to 500000 in north India alone. In Karnataka, mealybug appeared in isolated patches of cotton growing districts during 2006. Later it was found in the cotton growing districts of Raichur, Bellary, Gulbarga, Haveri, Dharwad and Belguam during 2007-2008. Mealybug incidence was more in the Tungabhadra project (TBP) and Uupper Krishna Project (UKP) areas which comprises major irrigated cotton (Hanchinal *et al.*, 2009).

## MATERIALS AND METHODS

Field experiment was conducted during

2013 and 2014 seasons to estimate the crop loss due to *P. solenopsis* on *Bt* cotton at Main Agricultural Research Station, UAS, Raichur. Crop loss estimation due to *P. solenopsis* damage on *Bt* cotton was undertaken by following the concept of comparing the yield from healthy plants with that of infested ones. To know the extent of loss caused by mealybug, pot and field experiments were conducted on NCS 145 *Bt* during cropping seasons.

Totally 5 treatments *viz.,* 50, 100, 150, 200 and 250 females/plant with 4 replications were released on potted cotton plants Female mealybugs were released at 60, 90, 120 and 150 days after sowing in different caged plants. Field experiment was conducted with six damage levels ($D_0$ to $D_5$) /treatments *viz.,* control ($D_0$) 50 ($D_1$), 100($D_2$), 150($D_3$), 200($D_4$) and 250($D_5$) female mealybugs/plant with 4 replications. Six plants were caged for each replication before releasing mealybugs.

Care was taken to remove all the insect pests including mealybugs if any from plants before enclosing in cages. Observations were recorded on population build up *i.e.* mealybugs/ 10 cm shoot length, growth parameters like good opened bolls (GOB),bad opened bolls (BOB) and seed cotton yield/plant. Quality parameters were also recorded by analyzing the cotton lint by CIRCOT Regional Office, Dharwad Farm, UAS, Dharwad. Oil estimation of cotton seeds was done at Main Agricultural Research Station, Raichur. Correlation studies were made to know the impact of mealybug damage on plant height, yield parameters and lint quality.

**Table 1.** Impact of mealybug population during early stages of crop growth on yield parameters and seed cotton yield

| Mealybugs released/ plant | Days after sowing (DAS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | 90 | | | | |
| | Mealybugs/ 10 cm apical shoot | Plant height (cm) | GOB/ plant | BOB/ plant | Yield (g/ plant) | Mealybugs/ 10 cm apical shoot | Plant height (cm) | GOB/ plant | BOB/ plant | Yield (g/ plant) |
| Control ($D_0$) | 0 (0.71)$^a$ | 112.42 (10.62)$^a$ | 25.42 (5.09)$^a$ | 4.15 (2.15)$^b$ | 122.10$^a$ | 0 (0.71)$^a$ | 115.16 (10.74)$^a$ | 27.32 (5.27)$^a$ | 3.25 (1.93)$^a$ | 141.16$^a$ |
| 50 ($D_1$) | 122.52 (11.08)$^b$ | 91.51 (9.59)$^b$ | 0 (0.71)$^b$ | 0 (0.71)$^a$ | 0.00$^b$ | 118.22 (10.89)$^b$ | 98.22 (9.93)$^b$ | 4.33 (2.20)$^b$ | 3.73 (2.06)$^b$ | 21.14$^b$ |
| 100 ($D_2$) | 172.52 (13.15)$^c$ | 85.25 (9.25)$^c$ | 0 (0.71)$^b$ | 0 (0.71)$^a$ | 0.00$^b$ | 130.16 (11.42)$^b$ | 92.56 (9.64)$^c$ | 4.09 (2.14)$^b$ | 4.27 (2.18)$^{bc}$ | 19.57$^b$ |
| 150 ($D_3$) | 184.22 (13.58)$^c$ | 84.22 (9.20)$^c$ | 0 (0.71)$^b$ | 0 (0.71)$^a$ | 0.00$^b$ | 152.25 (12.35)$^c$ | 92.2 (9.62)$^c$ | 3.34 (1.96)$^{bc}$ | 4.64 (2.27)$^c$ | 16.76$^{bc}$ |
| 200 ($D_4$) | 188.25 (13.74)$^c$ | 80.15 (8.98)$^c$ | 0 (0.71)$^b$ | 0 (0.71)$^a$ | 0.00$^b$ | 164.24 (12.83)$^{cd}$ | 90.18 (9.52)$^c$ | 3.1 (1.90)$^c$ | 4.93 (2.33)$^c$ | 15.37$^c$ |
| 250 ($D_5$) | 178.25 (13.36)$^c$ | 78.42 (8.88)$^c$ | 0 (0.71)$^b$ | 0 (0.71)$^a$ | 0.00$^b$ | 170.42 (13.06)$^d$ | 88.25 (9.41)$^d$ | 1.87 (1.54)$^d$ | 6.73 (2.69)$^d$ | 9.08$^d$ |
| S.Em + | 0.21 | 0.21 | 0.05 | 0.02 | 1.69 | 0.2 | 0.05 | 0.06 | 0.04 | 1.24 |
| CD (p=0.05) | 0.65 | 0.63 | 0.16 | 0.06 | 5.08 | 0.61 | 0.15 | 0.2 | 0.12 | 3.72 |

DAS : Days after sowing, GOB: Good opened bolls,BOB: Bad opened bolls

In vertical columns means followed by similar letters are not different significantly (P = 0.05) by DMRT.

Figures in the parentheses are " (x+1) values

## RESULTS AND DISCUSSION

The crop loss estimation studies revealed that the mealybug population ranged from 122.52 to 188.25/10 cm shoot length in the damage levels $D_1$ to $D_5$ at 60 DAS. The plant height ranged from 78.42 cm to 112.42 cm and was maximum at damage level $D_0$ (112.42 cm) which was superior and highly significant to $D_1$ (91.51 cm). Plant height significantly reduced in $D_2$ to $D_5$. Because of high density of mealybugs and severe damage, plants withered and yield was nil in $D_1$ to $D_5$ levels. However, control ($D_0$) level recorded cotton yield of 122.10 g/plant.

Similarly at 90 DAS, maximum plant height of 115.16 cm was recorded in the control plant ($D_0$) while at $D_5$ it was 88.25 cm which significantly differed from damage level $D_1$ to $D_5$. Maximum seed cotton yield of 141.16 g/plant was recorded in $D_0$ level which was significantly superior over other levels. However, at lower damage level $D_1$ recorded 21.14 g/plant which was *on par* with $D_2$, $D_3$ and $D_4$ levels of damage (Table 1).

At 120 DAS, minimum population of 132.53 mealybugs/10 cm apical shoot was recorded in $D_1$ which was significantly lower than other levels of damage. In $D_2$ to $D_5$ mealybug population ranged between 158.15 to 194.24 / 10 cm apical shoot which were *on par* with each other. Plant height significantly differed from damage levels $D_0$ (128.28 cm) to $D_5$ (118.44) indicating impact of mealybug population on growth of the plant.

The highest seed cotton yield of 128.22 g/plant was recorded in control plant ($D_0$) while at the highest damage level ($D_5$), minimum cotton yield (30.28 g/plant) was recorded. Per cent reduction of seed cotton yield ranged from 45.06 ($D_1$) to 76.38 ($D_5$). Similarly at 150 DAS, maximum seed cotton yield of 160.24 g/plant was recorded in the control plant ($D_0$) and minimum seed cotton yield of 66.22 g/plant was recorded in highest damage level ($D_5$) and per cent

**Table 2.** Impact of mealybug population during early season of crop growth on yield parameters and seed cotton yield

| Mealybugs released/ plant | Days after sowing (DAS) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | | 90 | | | | | |
| | Mealy-bugs/ 10 cm apical shoot | Plant height (cm) | GOB/ plant | BOB/ plant | Yield (g/ plant) | Per cent* reduction/ over control | Mealy-bugs/ 10 cm apical shoot | Plant height (cm) | GOB/ plant | BOB/ plant | Yield (g/ plant) | Per cent* reduction/ over control |
| Control ($D_0$) | 0 | 128.28 | 26.31 | 4.22 | 128.22$^{a}$ | 0 | 0 | 130.44 | 28.44 | 5.22 | 160.24$^{a}$ | 0 |
| | (0.71)$^{a}$ | (11.34)$^{a}$ | (5.17)$^{a}$ | (2.17)$^{a}$ | | (0.00)$^{a}$ | (0.71)$^{a}$ | (11.43)$^{a}$ | (5.37)$^{a}$ | (2.39)$^{a}$ | | (0.00)$^{a}$ |
| 50 ($D_1$) | 132.53 | 122.52 | 14.44 | 12.42 | 70.45$^{b}$ | 45.06 | 75.22 | 104.22 | 18.45 | 9.12 | 92.66$^{b}$ | 42.17 |
| | (8.96)$^{b}$ | (8.65)$^{b}$ | (3.86)$^{b}$ | (3.59)$^{b}$ | | (42.16)$^{b}$ | (8.70)$^{b}$ | (10.23)$^{b}$ | (4.35)$^{b}$ | (3.10)$^{b}$ | | (40.49)$^{b*}$ |
| 100 ($D_2$) | 158.15 | 121.22 | 13.62 | 14.22 | 65.24$^{c}$ | 49.12 | 115.45 | 107.1 | 17.27 | 9.23 | 90.04$^{b}$ | 43.81 |
| | (12.59)$^{c}$ | (11.03)$^{c}$ | (3.76)$^{b}$ | (3.83)$^{c}$ | | (44.49)$^{b}$ | (10.76)$^{c}$ | (10.37)$^{b}$ | (4.21)$^{b}$ | (3.12)$^{b}$ | | (41.44)$^{b}$ |
| 150 ($D_3$) | 162.25 | 120.43 | 11.12 | 15.45 | 55.88$^{d}$ | 56.42 | 164.12 | 98.22 | 17.12 | 10.24 | 88.11$^{b}$ | 45.01 |
| | (12.75)$^{c}$ | (10.99)$^{c}$ | (3.41)$^{c}$ | (3.99)$^{cd}$ | | (48.70)$^{c}$ | (12.82)$^{d}$ | (9.93)$^{b}$ | (4.20)$^{b}$ | (3.28)$^{b}$ | | (42.13)$^{b}$ |
| 200 ($D_4$) | 168.25 | 118.56 | 10.32 | 16.42 | 51.24$^{d}$ | 60.04 | 172.24 | 95.62 | 15.42 | 10.26 | 72.45$^{c}$ | 54.79 |
| | (12.99)$^{c}$ | (10.91)$^{c}$ | (3.29)$^{c}$ | (4.11)$^{d}$ | | (50.80)$^{c}$ | (13.14)$^{d}$ | (9.80)$^{b}$ | (3.99)$^{bc}$ | (3.28)$^{b}$ | | (47.75)$^{c}$ |
| 250 ($D_5$) | 194.24 | 118.44 | 6.24 | 22.44 | 30.28$^{e}$ | 76.38 | 186.45 | 95.1 | 15.2 | 12.45 | 66.22$^{d}$ | 58.67 |
| | (13.95)$^{c}$ | (10.90)$^{c}$ | (2.59)$^{d}$ | (4.79)$^{e}$ | | (61.08)$^{d}$ | (13.66)$^{e}$ | (9.77)$^{b}$ | (3.96)$^{c}$ | (3.60)$^{c}$ | | (50.01)$^{c}$ |
| S.Em + | 0.79 | 0.06 | 0.08 | 0.07 | 1.67 | 1.22 | 0.19 | 0.22 | 0.07 | 0.06 | 1.89 | 0.95 |
| CD (P= 0.05) | 2.39 | 0.18 | 0.25 | 0.22 | 5.01 | 3.69 | 0.59 | 0.68 | 0.21 | 0.18 | 5.67 | 2.86 |

DAS : Days after sowing, GOB: Good opened bolls,BOB: Bad opened bolls, Figures in the parentheses are " (x+1) values
In vertical columns means followed by similar letters are not different significantly (P = 0.05) by DMRT

**Table 3.** Quality parameters of cotton lint due to mealybug damage at different days after sowing

| Days after sowing (DAS) | Mealybugs released/ plant | Hundred seed weight (g) | Oil (%) | 2. 5 per cent SL (mm) | Uniformity ratio (%) | Micronaire value | Maturity ratio | Tenacity (g/t) | Elongation (%) |
|---|---|---|---|---|---|---|---|---|---|
| 90 | Control ($D_0$) | 9.30 | 12.5 | 34.3 | 46 | 3.5 | 0.92 | 25.6 | 6.0 |
| | 50 ($D_1$) | 7.65 | 11.0 | 32.4 | 41 | 1.8 | 0.58 | 20.6 | 5.8 |
| | 100 ($D_2$) | 7.48 | 11.0 | 32.3 | 41 | 1.9 | 0.61 | 20.8 | 5.8 |
| | 150 ($D_3$) | 7.38 | 10.8 | 31.9 | 42 | 1.9 | 0.62 | 21.5 | 5.8 |
| | 200 ($D_4$) | 7.33 | 10.6 | 30.9 | 42 | 2.3 | 0.62 | 22.4 | 5.8 |
| | 250 ($D_5$) | 6.48 | 10.3 | 30.9 | 42 | 2.4 | 0.63 | 22.5 | 5.8 |
| 120 | 50 ($D_1$) | 8.18 | 11.5 | 33.1 | 43 | 3.1 | 0.63 | 22.5 | 5.9 |
| | 100 ($D_2$) | 8.14 | 11.5 | 32.9 | 43 | 3.0 | 0.63 | 22.8 | 5.9 |
| | 150 ($D_3$) | 8.14 | 11.4 | 32.8 | 44 | 3.0 | 0.64 | 22.9 | 5.9 |
| | 200 ($D_4$) | 8.12 | 11.4 | 32.6 | 44 | 2.5 | 0.64 | 23.3 | 5.9 |
| | 250 ($D_5$) | 8.08 | 11.2 | 32.5 | 44 | 2.4 | 0.64 | 23.6 | 6.0 |
| 150 | 50 ($D_1$) | 8.67 | 11.8 | 33.8 | 44 | 3.5 | 0.64 | 24.5 | 6.0 |
| | 100 ($D_2$) | 8.66 | 11.8 | 33.7 | 44 | 3.2 | 0.64 | 24.6 | 6.0 |
| | 150 ($D_3$) | 8.66 | 11.7 | 33.5 | 45 | 3.2 | 0.66 | 25.4 | 6.0 |
| | 200 ($D_4$) | 8.58 | 11.6 | 33.2 | 45 | 3.2 | 0.66 | 25.5 | 6.0 |
| | 250 ($D_5$) | 8.48 | 11.6 | 33.1 | 45 | 3.1 | 0.67 | 25.6 | 6.0 |

reduction of cotton yield ranged from 42.17 ($D_1$) to 58.67 ($D_5$)/plant (Table 2).

Quality analysis of cotton lint at 90 DAS indicated that 100 g seed weight varied from 6.48 to 7.65 g, oil percentage varied from 10.3 to 11 and staple length varied from 30.9 to 32.4 mm in different damage levels. At 120 and 150 DAS, there was no much variation in 100 seed weight, oil percentage, staple length, tenacity and elongation percentage. However micronaire value was affected at 120 and 150 DAS which varied from 2.4 to 3.1 and 3.1 to 3.5, respectively. This indicates that fiber quality was affected at all the levels of damage from $D(_0)$ to $D(_5)$ (Table 3). The correlation coefficient indicated negative relationship with all the quality

**Table 4.** Correlation between mealybug population and quality parameters of cotton lint

| | Mealybugs released/ plant | Hundred seed weight (g) | Oil (%) | 2. 5 per cent SL (mm) | Uniformity ratio (%) | Micronaire value | Maturity ratio | Tenacity (g/t) | Elongation (%) |
|---|---|---|---|---|---|---|---|---|---|
| Mealybugs released /plant | 1 | -0.876* | -0.865* | -0.932** | -0.459 | -0.336 | -0.556 | -0.275 | -0.655 |
| Hundred seed weight (g) | | 1 | 0.983** | 0.936* | 0.797* | 0.693 | 0.847* | 0.666 | 0.898* |
| Oil (%) | | | 1 | 0.968** | 0.832* | 0.744 | 0.894** | 0.706 | 0.938** |
| 2. 5 per cent SL (mm) | | | | 1 | 0.707 | 0.594 | 0.790* | 0.545 | 0.852* |
| Uniformity ratio (%) | | | | | 1 | 0.963** | 0.985** | 0.972** | 0.965** |
| Micronaire value | | | | | | 1 | 0.955** | 0.990** | 0.925** |
| Maturity ratio | | | | | | | 1 | 0.942** | 0.991** |
| Tenacity(g/t) | | | | | | | | 1 | 0.903** |
| Elongation (%) | | | | | | | | | 1 |

* Differs significantly (P = 0.05), * Differs significantly (P = 0.01) DAS : Days after sowing

parameters *viz.,* 100 seed weight, oil percentage, staple length, micronaire, uniformity ratio, maturity ratio, tenacity and elongation (Table 4).

The quantitative estimation of yield loss in cotton due to mealybug damage is very much lacking and hence, could not be compared with earlier reports. However Dhawan *et al.,* (2007) reported that, 4800 ha of cotton crop in Sirsa district, Punjab was affected due to mealybug and 0.9 to1.2 per cent plants were found to be affected by mealybug. In severely infested plants, the size of the bolls was reduced and resulted in low yield. Cotton lint was found covered with sooty mould. Similarly Dhawan *et al.*, (2007) also reported that, mealybug caused 30 to 40 per cent loss to cotton yield in Punjab. Similar report was also made by Acharya *et al.*, (2008), who briefly noted that, mealybug affected cotton plants become distorted, stunted, bunchy top symptoms and reduction in boll number, boll size and seed cotton yields. In another study, Jhala and Bharpoda (2008) reported that, mealybug *P. solenopsis* infesting cotton has reduced 50 per cent yield of cotton in Gujarat.

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**Received for publication : January 15, 2016**
**Accepted for publication : July 19, 2016**