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# Frequency of pink bollworm *Pectinophora gossypiella* (Saunders) on different events of *Bt* cotton hybrids

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**ABSTRACT :** A field study was conducted during *kharif*, of 2007-2008 and 2008-2009 seasons at Regional Agricultural Research Station, Lam, Guntur. Four *Bt* cotton hybrids *viz.,* RCH *2 Bt,* JK Durga *Bt*, Nath baba *Bt* and RCH 2 BGII *Bt* representing Mon 531event, JK Cry 1Ac event, GFM event and Mon 15985 event and their respectively non *Bt* versions *viz.,* RCH 2 non *Bt,* JK Durga non *Bt* and Nath baba non *Bt* were selected for the experiment. The incidence of *Pectinophora gossypiella* (Saunders) was negligible in *Bt* hybrids compared to their non *Bt* versions. Mon 15985 event *Bt* hybrid (RCH 2 BG II) was completely free from *P.gossypiella*. The per cent locule damage of *P.gossypiella* was also negligible in *Bt* hybrids compared to their non *Bt* counter parts and it was nil in Mon 15985 event of *Bt* hybrid (RCH 2 BGII). The Cry protein content was highest at 60 DAS, with decline at 90 DAS and 120 DAS, and reached to negligible levels by 150 DAS different events of *Bt* cotton during both the seasons.

**Key words :** *Bt* cotton, *Bt* events, pink bollworm, temporal, transgenic

In India the bollworms commonly encountered in cotton cultivation were Spotted bollworm, *Earias vittella* (Fabricius), American bollworm, *Helicoverpa armigera* (Hubner), Tobacco cutworm, *Spodoptera litura* (Fabricius) and the pink bollworm *Pectinophora gossypiella* (Saunders) since the induction of hybrids. Among the bollworms, the pink bollworm assumed major pest status in recent past. World over, Pink bollworm, *Pectinophora gossypiella* (Saunders) has become economically the most destructive pest of cotton and has known to cause 2.8 to 61.9 per cent loss in seed cotton yield, 2.1 to 47.10 per cent loss in oil content and 10.70 to 59.20 per cent loss in normal opening of bolls (Patil, 2003). *Bt* cotton (Bollgard®) offered high level of resistance against cotton bollworm complex *i.e.*, *Helicoverpa armigera* (Hubner), *Earias vittella* (Fabricius) and *Pectinophora gossypiella* (Saunders) both under laboratory as well as field conditions (Kranthi and Kranthi., 2004). In 2009, the Genetic Engineering Approval Committee (GEAC) approved 248 new *Bt* cotton hybrids for commercial cultivation in the 2009 season, in addition to the 274 *Bt* cotton hybrids approved for sale in 2008, for a total of 522 hybrids. Recently the *Bt* gene does not allow the development of bollworm population because of its inherent toxicity of the *Bt* cotton against bollworms.

The expression of Cry protein in different plant parts at a given point of time and different growth stages is not uniform. Stacked *Bt* cotton and *Bt* cotton cultivars control the bollworms upto 110 days only and thereafter the toxin expression level decreases as the plant age advances. Laboratory studies have shown that the addition of second *Bt* protein (2Ab) to *Bt* cotton may reduce the survival of bollworms relative to *Bt* cotton with only one protein. *Bt* gene does not allow the development of bollworm population because of the inherent toxicity of the *Bt* cotton against bollworms. This leads to minimum usage of insecticides and is considered as one of the best tools of Integrated Pest Management against bollworm complex. It has been proved eco-friendly in the management of bollworm complex (Romeis *et al.,*, 2006). Hence, it fits very well in Integrated Pest Management programme of bollworm

complex.

## MATERIALS AND METHODS

A field was conducted during *kharif*, 2007-2008 and 2008-2009 seasons at Regional Agricultural Research Station, Lam, Guntur. Four *Bt* cotton hybrids *viz.,* RCH *2 Bt,* JK Durga *Bt*, Nath baba *Bt* and RCH 2 BGII *Bt* representing Mon 531event, JK Cry 1Ac event, GFM event and Mon 15985 event and their respectively non *Bt* versions *viz.,* RCH 2 non *Bt,* JK Durga non *Bt* and Nath baba non *Bt* were selected for the study. The experiment was laid out in a randomized block design with seven treatments replicated thrice with plot size of 7.2 x 6 m during both the seasons. The cultivars were grown completely under unsprayed conditions from sowing to harvest. The observations were recorded from five randomly selected plants from each plot at 15 days interval throughout the cropping season. The incidence of pink bollworm larvae was recorded by destructive sampling of the green bolls at of 100, 115, 130, 145, 160, 175 and 190 days of sowing 10 to 15 days old bolls. From each of the test hybrid eight of all the treatments, 10 bolls/replication were collected randomly and were cut open to observe the number of larvae/boll and locule damage for both the season during the season at different intervals. The larval incidence and percentage damage were subjected to square root and angular transformations, respectively. The transformed data was subjected to ANOVA using MSTATC software package.

## RESULTS AND DISCUSSION

The incidence of pink boll worm *Pectinophora gossypiella* (Saunders) during *kharif* 2007-2008 started from 100 DAS and recorded up to 190 DAS. The incidence of pink bollworm was nil on RCH 2 *Bt*, JK Durga *Bt* and RCH 2 BG II hybrids at 100 DAS (Table1). the expression of Cry proteins levels were estimated during the season at different intervals at *Bt* referral laboratory CICR, Nagpur. The toxin expression was significantly highest at 60 DAS in all the plant parts and declined gradually to very low levels by 150 DAS in different events of transgenic *Bt* cotton. Sesha Mahalakshmi and Prasad (2013) reported that the Cry1AC toxins expression was fond to be variable among the hybrid and among the plants parts over the plant age. The incidence of pink bollworm larvae was very less in RCH 2 *Bt*, JK Durga *Bt* and Nath baba *Bt* events but it was significantly superior over their corresponding non *Bt* hybrids with high larval incidence of pink bollworm. The present findings are in concurrence with the observations of Surulivelu *et al.,* (2004), Bambawale *et al.,* (2004), Lavekar *et al.,* (2004) and Soujanya (2008) who reported very low incidence of pink bollworm larvae in *Bt* cotton cultivars.

The Nath baba *Bt* with 0.33 larvae/10 bolls was statistically *on par* with other *Bt* hybrids at 100 DAS. In general the non *Bt* hybrids recorded more number of larvae/10 bolls compared to *Bt* hybrids. The pink boll worm incidence reached its peak levels at 160 DAS and thereafter it declined gradually. At 160 DAS, the maximum larval population was recorded on RCH 2 non *Bt* (17.66 larva/10 bolls) followed by Nath baba non *Bt* (17.26 larva/10 bolls) and JK Durga non *Bt* (17 larvae/10 bolls) hybrids and are statistically *on par* with each other and significantly different from other *Bt* hybrids. At peak levels of population at 160 DAS the *Bt* hybrids recorded only 3.33, 3.26 and 2.86 larva/10 bolls on JK Durga *Bt*, Nath baba *Bt* and RCH 2 *Bt* hybrids, respectively.

The seasonal mean larval population on non *Bt* hybrids was maximum compared to *Bt* hybrids. These results were in conformity with the report of Sandhya *et al.,* (2010) who observed that the initiation of incidence of was early and intensity of damage was high on non *Bt* cotton compared to *Bt* cotton. The seasonal mean larval

**Table 1.** Incidence of *Pectinophora gossypiella* larvae during *kharif* 2007-2008

| Hybrids | Numbers of larvae / 10 bolls (Days after sowing) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 100 | 115 | 130 | 145 | 160 | 175 | 190 | **Mean** |
| RCH 2 *Bt* | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.93(1.19)[b] | 1.66(1.46)[b] | 2.86(1.83)[b] | 1.33(1.34)[b] | 0.73(1.11)[b] | **1.50(1.40)[b]** |
| RCH 2 non *Bt* | 1.66(1.46)[b] | 3.33(1.95)[b] | 7.00(2.73)[c] | 12.33(3.58)[d] | 17.66(4.26)[c] | 12.46(3.60)[c] | 7.13(2.76)[e] | **8.79(3.04)[c]** |
| JK Durga *Bt* | 0.00(0.70)[a] | 0.00(0.70)[a] | 1.66(1.46)[b] | 2.66(1.77)[c] | 3.33(1.95)[b] | 1.20(1.30)[b] | 0.90(1.18)[bc] | **1.95(1.54)[b]** |
| JK Durga non *Bt* | 2.00(1.58)[b] | 3.66(2.03)[b] | 6.33(2.61)[c] | 13.66(3.76)[b] | 17.00(4.18)[c] | 12.96(3.66)[c] | 7.00(2.73)[e] | **8.94(3.05)[c]** |
| Nath baba *Bt* | 0.33(0.88)[a] | 0.00(0.70)[a] | 2.00(1.58)[b] | 3.33(1.94)[c] | 3.26(1.94)[b] | 1.42(1.38)[b] | 1.03(1.23)[c] | **1.89(1.52)[b]** |
| Nath baba non *Bt* | 1.73(1.48)[b] | 3.00(1.85)[b] | 7.00(2.73)[c] | 14.00(3.80)[d] | 17.26(4.21)[c] | 12.96(3.66)[c] | 6.10(2.56)[d] | **8.86(3.04)[c]** |
| RCH 2 BGII | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | **0.00(0.70)[a]** |
| SEm+ | 0.09 | 0.07 | 0.06 | 0.09 | 0.05 | 0.05 | 0.03 | 0.11 |
| CD (p=0.05) | 0.28 | 0.23 | 0.20 | 0.30 | 0.18 | 0.15 | 0.10 | 0.33 |

Figures in parentheses are square root transformed values, Numbers followed by same superscript are not statistically different

population on non *Bt* hybrids like RCH2 non *Bt*, JK Durga non *Bt* and Nath Baba non *Bt* ranged from 8.79 to 8.94 larvae/10 bolls and all the non *Bt* hybrids are statistically *on par* with each other. In *Bt* hybrids the mean population ranged from 1.50 to 1.95 larvae/10 bolls and are statistically at par. The RCH 2 BG II was superior over all other *Bt* and non *Bt* hybrids with zero levels of larval population throughout the crop growth period.

In *kharif* 2008-2009 also the pink boll worm larval activity was recorded from 115 DAS to 190 DAS. There was no larval population on *Bt* cotton hybrids at 115 DAS. The RCH 2 BG II hybrid recorded nil population throughout the crop growth period (Table 2). the present findings are in conformity with Soujanya (2008) who reported that the larval incidence of pink bollworm was completely absent in stacked *Bt* hybrids. The Incidence of pink bollworm larvae was absent at Raichur and Coimbatore location on *Bt* hybrids. The peak levels of pink boll worm larval population were recorded at 175 DAS. The non *Bt* cotton hybrids recorded maximum larval population compared to *Bt* cotton hybrids. A maximum of 15.40, 14.20 and 14.00 larvae/10 bolls was recorded on Nath baba non *Bt*, JK Durga non *Bt* and RCH 2 non *Bt* hybrids, respectively at 175 DAS. There was no significant difference between other non *Bt* hybrids. Among *Bt* hybrids, RCH 2 *Bt* recorded maximum larval population *i.e.* 1.90 larva/10 bolls at 175 DAS followed by Nath baba *Bt* (1.73) and JK Durga *Bt* (1.43 larva/10 bolls). The differences between the peak incidences of pink bollworm larvae for the both seasons were weather factors influence.

The mean seasonal population of larvae was maximum on non *Bt* cotton hybrids with more than 9.00 larva/10 bolls and all the non *Bt* cotton hybrids are statistically *on par* with each other and significantly different from the *Bt* cotton hybrids. All the *Bt* hybrids except RCH 2 BG II are statistically *on par* with 1.02 to 1.03 larva/10 bolls. During *kharif* 2008-2009 also RCH 2 BG

**Table 2 :** Incidence of *Pectinophora gossypiella* larvae during *kharif* 2008-2009

| Hybrids | Number of larvae/10 bolls (Days after sowing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 115 | 130 | 145 | 160 | 175 | 190 | **Mean** |
| RCH 2 *Bt* | 0.00(0.70)[a] | 0.10(0.77)[b] | 0.96(1.21)[b] | 1.30(1.33)[b] | 1.90(1.54)[b] | 0.90(1.18)[b] | **1.03(1.24)[b]** |
| RCH 2 non *Bt* | 1.10(1.26)[b] | 6.13(2.57)[de] | 8.0(2.91)[c] | 13.13(3.69)[c] | 14.00(3.80)[c] | 12.06(3.54)[c] | **9.07(4.30)[d]** |
| JK Durga *Bt* | 0.00(0.70)[a] | 0.20(0.83)[c] | 1.13(1.27)[b] | 1.60(1.44)[b] | 1.43(1.38)[b] | 0.76(1.12)[b] | **1.02(1.23)[b]** |
| JK Durga non *Bt* | 1.16(1.29)[b] | 6.00(2.54)[d] | 9.00(3.08)[d] | 13.62(3.75)[c] | 14.20(3.83)[c] | 12.13(3.55)[c] | **9.35(3.13)[c]** |
| Nath baba *Bt* | 0.00(0.70)[a] | 0.16(0.81)[c] | 1.10(1.26)[b] | 1.33(1.35)[b] | 1.73(1.48)[b] | 0.83(1.15)[b] | **1.03(1.24)[b]** |
| Nath baba non *Bt* | 1.33(1.35)[c] | 6.20(2.58)[e] | 8.26(2.96)[c] | 13.73(3.77)[c] | 15.40(3.98)[c] | 11.86(3.51)[c] | **9.46(3.14)[c]** |
| RCH 2 BGII | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | 0.00(0.70)[a] | **0.00(0.00)[a]** |
| SEm+ | 0.01 | 0.01 | 0.02 | 0.05 | 0.06 | 0.04 | **0.08** |
| CD (p=0.05) | 0.04 | 0.03 | 0.06 | 0.15 | 0.18 | 0.14 | **0.24** |

II was absolutely free from incidence and found superior over all other cotton hybrids tested.

Locule damage due to pink bollworm, were noticed on cotton hybrids from 115 DAS and recorded up to 190 DAS during *kharif* 2007-2008 (Table 3). The locules damage were recorded on green bolls for every fifteen days using distractive sampling method but open locules damage at harvest stage were not reported. There was no locule damage on all the *Bt* cotton hybrids at 115 DAS. The toxin expression was significantly highest at 60 DAS in all the plant parts and declined gradually to very low levels by 150 DAS in different events of transgenic *Bt* cotton. The present findings are in agreement with Kranthi *et al.,* (2005) Wan *et al.,* (2005), and Soujanya (2008) who reported high toxin content at early stages compared to later stages of crop growth.

RCH 2BG II hybrid was free from the pink boll worm damage during the *kharif* 2007-2008. During the both seasons the per cent locule damage was nil in RCH 2 BG II hybrids and found significantly superior over the other *Bt* events. The present findings are in close agreement with Jeughal *et al.,* (2007) and Soujanya (2008) who observed stacked *Bt* hybrids free from locule damage. The per cent locule damage was low in *Bt* events compared to non *Bt* hybrids. These findings derive support from the work done by Vennila *et al.,* (2004) and Bhosle *et al.,* (2004), who reported low the locule damage in *Bt* cotton compared to non *Bt* hybridsIn all other cotton hybrids the locule damage reached its peak levels at 160 DAS. The maximum locule damage was recorded on Nath baba non *Bt* (36.42%) followed by JK Durga non *Bt* (36.20%) and RCH 2 non *Bt* (36.13%) during 160 DAS. All these non *Bt* hybrids are statistically *on par* and significantly different from other *Bt* hybrids. Among the *Bt* hybrids, Nath Baba *Bt* recorded maximum locule damage (3.25%) followed by JK Durga *Bt* (3.02%) and RCH 2 *Bt* (2.06%) hybrid at 160 DAS and are statistically *on par* with each other. There was no significant difference in locule damage among the non *Bt* cotton hybrids. The mean per cent locule damage was more on non *Bt* hybrids with 20.74, 20.70 and 19.53 per cent on Nath baba non *Bt*, JK Durga non *Bt* and RCH 2 non *Bt* hybrids, respectively. RCH 2 BG II hybrid was superior over other *Bt* and non *Bt* hybrids.

The locule damage during *kharif* 2008-2009 was similar to the results obtained in *kharif* 2007-2008. The initial damage at 115 DAS was nil on *Bt* cotton hybrids compared to non *Bt* hybrids (Table: 4). Gradual increase in locule damage was recorded from 115 DAS to 160 DAS and thereafter the damage declined upto 190 DAS.The Cry 1AC protein content declined as the plant grew and was found to drop below its lethal level (Nadaf and Goud 2007). In *kharif* 2008-2009 also the RCH 2 BG II hybrid recorded nil damage throughout the crop growth period. The present

**Table 3:** Per cent locule damage by *Pectinophora gossypiella* during *kharif* 2007-2008

| Hybrids | Days after sowing | | | | | | |
|---|---|---|---|---|---|---|---|
| | 115 | 130 | 145 | 160 | 175 | 190 | **Mean** |
| RCH 2 *Bt* | 0.00(0.00)$^{a}$ | 1.00(5.73)$^{b}$ | 1.36(6.69)$^{b}$ | 2.06(8.26)$^{b}$ | 1.90(7.92)$^{b}$ | 1.00(5.74)$^{c}$ | **1.46(6.80)$^{b}$** |
| RCH 2 non *Bt* | 4.78(12.63)$^{b}$ | 13.04(21.16)$^{d}$ | 23.51(29.00)$^{d}$ | 36.13(36.95)$^{d}$ | 21.96(27.94)$^{c}$ | 17.78(24.93)$^{d}$ | **19.53(20.16)$^{c}$** |
| JK Durga *Bt* | 0.00(0.00)$^{a}$ | 1.08(5.96)$^{b}$ | 2.06(8.26)$^{c}$ | 3.02(10.01)$^{c}$ | 1.80(7.70)$^{b}$ | 0.39(3.05)$^{b}$ | **1.67(7.09)$^{b}$** |
| JK Durga non *Bt* | 5.76(13.89)$^{b}$ | 14.20(22.13)$^{d}$ | 26.66(31.08)$^{e}$ | 36.20(36.99)$^{d}$ | 23.00(28.65)$^{d}$ | 18.38(25.38)$^{d}$ | **20.70(27.05)$^{c}$** |
| Nath baba *Bt* | 0.00(0.00)$^{a}$ | 1.58(7.20)$^{c}$ | 2.13(8.39)$^{c}$ | 3.25(10.38)$^{c}$ | 1.70(7.49)$^{b}$ | 1.10(6.03)$^{c}$ | **1.72(7.38)$^{b}$** |
| Nath baba non *Bt* | 4.86(12.73)$^{b}$ | 14.65(22.50)$^{d}$ | 26.80(31.16)$^{e}$ | 36.42(37.12)$^{d}$ | 23.62(29.08)$^{d}$ | 18.09(25.17)$^{d}$ | **20.74(27.07)$^{c}$** |
| RCH 2 BGII | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | **0.00(0.00)$^{a}$** |
| SEm+ | 0.04 | 0.22 | 0.41 | 0.24 | 0.22 | 0.59 | **2.32** |
| CD (p=0.05) | 0.12 | 0.68 | 1.26 | 0.76 | 0.69 | 1.84 | **7.15** |

Figures in parentheses are square root transformed values, Numbers followed by same superscript are not statistically different

**Table 4.** Per cent locule damage by *Pectinophora gossypiella* during *kharif* 2008-2009

| Hybrids | Per cent locule damage (Days after sowing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 115 | 130 | 145 | 160 | 175 | 190 | **Mean** |
| RCH 2 *Bt* | 0.00(0.00)$^{a}$ | 1.03(5.81)$^{b}$ | 1.80(7.67)$^{b}$ | 2.93(9.85)$^{b}$ | 1.60(7.25)$^{b}$ | 0.73(4.90)$^{b}$ | **1.61(7.26)$^{b}$** |
| RCH 2 non *Bt* | 2.23(8.59)$^{b}$ | 8.80(17.25)$^{d}$ | 15.86(23.47)$^{c}$ | 22.53(28.32)$^{c}$ | 18.76(25.67)$^{c}$ | 9.60(18.04)$^{c}$ | **12.96(21.05)$^{c}$** |
| JK Durga *Bt* | 0.00(0.00)$^{a}$ | 1.400(6.69)$^{bc}$ | 1.93(7.91)$^{b}$ | 2.96(9.91)$^{b}$ | 1.26(6.39)$^{b}$ | 0.80(5.13)$^{b}$ | **1.67(7.35)$^{b}$** |
| JK Durga non *Bt* | 2.86(9.73)$^{c}$ | 8.83(17.27)$^{d}$ | 16.72(24.13)$^{c}$ | 23.16(28.76)$^{c}$ | 19.90(26.49)$^{c}$ | 11.06(19.42)$^{d}$ | **13.75(21.72)$^{c}$** |
| Nath baba *Bt* | 0.00(0.00)$^{a}$ | 1.70(7.44)$^{c}$ | 2.26(8.65)$^{b}$ | 3.00(9.97)$^{b}$ | 1.13(6.07)$^{b}$ | 0.76(5.00)$^{b}$ | **1.77(7.56)$^{b}$** |
| Nath baba non *Bt* | 3.13(10.18)$^{c}$ | 8.70(17.14)$^{d}$ | 16.73(24.13)$^{c}$ | 22.36(28.20)$^{c}$ | 19.23(26.00)$^{c}$ | 9.56(18.01)$^{c}$ | **13.28(21.33)$^{c}$** |
| RCH 2 BGII | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | 0.00(0.00)$^{a}$ | **0.00(0.00)$^{a}$** |
| SEm+ | 0.18 | 0.50 | 0.36 | 0.53 | 0.393 | 0.32 | **0.45** |
| CD (p=0.05) | 0.56 | 1.56 | 1.13 | 1.64 | 1.212 | 1.00 | **1.38** |

Figures in parentheses are angular transformed values, Numbers followed by same superscript are not statistically different

findings are in conformity with Soujanya (2008) who reported that the larval incidence of pink bollworm was completely absent in stacked *Bt* hybrids. The pink bollworm larvae was absent at Raichur and Coimbatore on *Bt* hybrids. At 160 DAS, the non *Bt* hybrids *viz.,,* JK Durga non *Bt*, RCH 2 non *Bt* and Nath Baba non *Bt* recorded 23.16, 22.53 and 22.36 per cent locule damage, respectively. All these non *Bt* hybrids are statistically *on par* with each other. At peak levels of incidence at 160 DAS, the *Bt* hybrids recorded 3.0, 2.96 and 2.93 per cent locule damage on Nath baba *Bt*, JK Durga *Bt* and RCH 2 *Bt* hybrid, respectively. There was no significant difference between the *Bt* hybrids. Similarly among the non *Bt* hybrids the incidence levels were statistically *on par*. The mean per cent locule damage was more in non *Bt* hybrids and it ranged from 12.96 to 13.75 per cent and there was no significant difference between the non *Bt* hybrids. The *Bt* cotton hybrids *viz.,* Nath baba B, JK Durga *Bt* and RCH 2 *Bt* recorded less mean locule damage with 1.77, 1.67 and 1.61 per cent respectively. Channakeshava and Patil (2009) reported that MECH 184 *Bt* cotton recorded significantly lower larval population of *H.armigera* on cotton The RCH 2 BG II was superior over all other hybrids with nil damage. Because of BG-II hybrids contains Cry1AC+2Ab genes. Kambrekar *et al.,* (2008) reported *Bt* cotton (Cry1AC) had greater influence of management of bollworm of cotton.

## REFERENCES

**Bambawale, O. M., Singh, A., Sharma, O. P., Bhosle, B. B., Lavekar, R. C., Dhandapani, A., Kanwar, V., Tanwar, R. K., Rathod, K. S, Patange, N. R and Pawar, V. M. 2004.** Performance of *Bt* cotton (MECH 162) under IPM in farmers participatory field trial in Nanded district, Central India. *Curr. Sci.* **86** : 1628-33.

**Bhosle, B. B., Rathod, C. S., and Patange, N. R. 2004.** Transgenic *Bt* cotton: A sustainable way of bollworm management. Proceedings of National symposium on *"Strategies for Sustainable Cotton Production Global Vision"* 23-25, November, 2004, UAS, Dharwad. 146-48.

**Channakeshva, R. and Patil, B. V. 2009.** Seasonal incidence of and management of bollworm complex in *Bt* cotton under irrigated ecosystem. *Ann. Pl. Protec. Sci.* **17** : 275-78.

**Jeughale, G. S., Kakade, S. U. and Kadam, S. R 2007.** Effect of *Bt* cotton hybrids as one of the components of IPM on pink bollworm incidence under rainfed situation. *Crop Research* **34** : 206-09.

**Kambrekar, D. N., Kulkarni, K. A. and Giraddi, R. S. 2008.** Influence of *Bt* Cotton on HaNPV isolates . *Ann.Pl.Protec.Sci.* **16 :** 95-101

**Kranthi, K. R., Dhawad, C. S., Naidu, S., Mate, K., Patil, E and Kranthi, S. 2005.** *Bt* cotton

seed as a source of *Bacillus thuringiensis* insecticidal Cry 1Ac toxin for bioassays to detect and monitor bollworm resistance to *Bt* cotton. *Curr. Sci.* **88 :** 796-800.

**Kranthi, K. R. and Kranthi, N. R., 2004**, Modelling adaptability of the cotton bollworm, *Helicoverpa armigera* (Hubner) to *Bt* cotton in India. *Curr. Sci.* **87**: 1096-1107.

**Lavekar, R.C., Telang, S. M., Sharma, O. P and Rathod, K. S 2004**. Efficacy of pesticides against field insect pests of *Bt* cotton. *Ann. Plant Prot. Sci.* **12** : 428-431.

**Nadaf, A. R. M. and Goud, K. B. 2007.**Effect of *Bt* cotton on pink bollworm investigation . *Ann. Plant Prot. Sci.* **15 :** 61-67.

**Patil, S. B., 2003,** Studies on management of cotton pink bollworm *Pectionophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae). *Ph. D. Thesis,* UAS, Dharwad.

**Romeis, J., Meissle, M and Bigler, F 2006.** Transgenic crops expressing *Bacillus thuringiensis* toxins and biological control. *Nature Biotechnology* **24** : 63-71.

**Sandhya Rani B, Prasad,N.V.V.S.D., Arjuna Rao, P. and Srinivasa Rao, V. 2010.** Seasonal progression and incidence of Pectinophora gossypiella (Saunders) on cotton. *Ann. Pl. Protec. Sci.* **18** : 323-26

**Sesha Mahalakshmi, M. and Prasad, N.V.V.S.D. 2013.** Seasonal expression of Cry1AC toxin in different plant parts of two *Bt* cotton hybrids. *Ann. Pl. Protec. Sci.* **21** : 62-64

**Soujanya, P. L 2008.** Effect of *Bt* toxions (Cry 1Ac and Cry 1Ac + 2 Ab) on the development and management of bollworm complex with special references to (*Pectinophora gossypiella* Saunders) and (*Spodoptera litura* Fabricius) on cotton. *Ph.D. Thesis* ANGRAU, Hyderabad.

**Surilivelu, T., Sumathi, E., Mathiarjan,G and Rajendran, T. P. 2004.** Temporal distribution of pink bollworm in *Bt* cotton hybrids. Proceedings of National Symposium on *"Strategies for Sustainable Cotton Production. A global vision"* 23-25, November, 2004, UAS, Dharwad pp 86-88.

**Vennila, S., Biradar, V. K., Gadpayle, J. G., Panchbhai, P. ., Ramteke, M. S., Deole, S. A and Karanjkar, P. P 2004**. Field evaluation of *Bt* transgenic cotton hybrids against sucking pests and bollworms. *Indian Jour. Plant Prot.* **32** : 1-10.

**Wan, P., Zhang Y, Wu K and Huang M 2005.** Seasonal expression profiles of insecticidal protein and control efficacy against *Helicoverpa armigera* for *Bt* cotton in the Yangtze river valley of China. *Jour. Eco. Ent.* **98** : 195-201.

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