Contributions of Bt-transgenic cotton to the Israeli Insecticide Resistance Management (IRM) strategy

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ABSTRACT

Laboratory bioassays and field trials of Bt-transgenic cotton (Bt-cotton) were conducted in Israel during the 1998-2000 cotton growing seasons to examine effectiveness against the main lepidopteran cotton pests. The transgenic NuCOTN 33B was compared with DP 5415 and the local Acala 'Sivon' against Helicoverpa armigera, Earias insulana, Spodoptera littoralis *and* Pectinophora gossypiella *(pink bollworm). In laboratory bioassays, leaves, flower buds ("squares") or bolls collected periodically during the cotton season were exposed for 48h or 96h to neonates or third/fourth instars of the examined pest. In experimental small-plots with the same varieties, damage to bolls caused by* E. insulana *and* P. gossypiella *was estimated. In large-scale field trials, the efficacy of Bt-cotton was compared with the local cotton variety by weekly samplings of pest populations and cotton bolls. Leaves of Bt-cotton were collected during the early and mid season, caused high mortality (90-100%) of* H. armigera *and* E. insulana *neonates. In late season, the efficacy of the Bt-cotton leaves to* H. armigera *significantly declined. In flower buds, substantial bud damage was found; however, Bt-cotton decreased larval weight and penetration to bolls. Both leaves and bolls of Bt-cotton did not affect* S. littoralis *larvae. In all the experiments, Bt-cotton considerably protected the cotton bolls from* P. gossypiella *damage, as compared with the other cultivars (controls). According to field samples, there was less* E. insulana *damage to bolls in the Bt-cotton plots than the non-transgenic cotton, and almost no damage to cotton bolls resulted from pink bollworms. Large-scale field trials have shown that the moderate protection of Bt-cotton that had been found under laboratory conditions was sufficient in preventing economic damage to cotton fibers from* H. armigera *and* E. insulana. *The reduced level of insect pests in the Bt-transgenic cotton fields resulted in decreased applications of insecticides, supporting thereby the Israeli IRM strategy.*

Introduction

The Israeli Insecticide Resistance management (IRM) strategy was established in 1987 to combat resistance to insecticides within the complex of cotton pests, of which the most important are the whitefly, *Bemisia tabaci* and the pink bollworm, *Pectinophora gossypiella* (Horowitz *et al*., 1995). During 15 years of resistance monitoring, according to the IRM strategy, a slow and gradual increase in resistance was observed, but until now whiteflies have been successfully controlled with either insect growth regulators (IGRs) (in areas without resistance problems) or neonicotinoids (Horowitz *et al.*, 2002).

One of the problems of the Israeli strategy arises from the obligatory use of non-selective insecticides for controlling the pink bollworm and the spiny bollworm, *Earias insulana* in midsummer. These insecticides interfere with the ecological balance; they are harmful to beneficial arthropods and may cause a build up of earlier attacks by other pests (such as *B. tabaci*). Therefore, a strategy incorporating Bt transgenic cotton (Bt-cotton) plants may successfully suppress bollworm populations without harming natural enemies and could be useful to the Israeli IPM-IRM strategy.

In this paper, we present our evaluation of the Bt transgenic cotton against the main lepidopteran cotton pests under laboratory and field conditions, and its contribution to the IRM Israeli cotton strategy.

Experimental procedures

Laboratory bioassays and field trials of Bt-cotton were conducted in Israel during the 1998-2000 cotton growing seasons to examine effectiveness against the main lepidopteran cotton pests: the pink bollworm, *P. gossypiella*, the cotton bollworm, *Helicoverpa armigera*, the spiny bollworm, *E. insulana* and the Egyptian leaf worm, *Spodoptera littoralis*. The transgenic NuCOTN 33B (Bt-cotton) was compared with the non-Bt cultivars DP 5415 and the local Acala 'Sivon'. In laboratory bioassays, leaves, flower buds ("squares") or bolls were collected periodically during the cotton season and exposed for 48 h, 72 h or 96 h to neonates or third instars of the examined pest. In experimental small-plots with the same varieties, damage to bolls caused by *E. insulana* and *P. gossypiella* was estimated. In large-scale field trials, the efficacy of Bt-cotton was compared with the local cotton variety by weekly samplings of pest populations and cotton bolls.

The effect of Bt-cotton leaves on *H. armigera* neonates was determined under laboratory conditions. Leaves from the cotton cultivars NuCOTN 33B (Bt-cotton) and DP 5415 (control) were randomly collected on 26/5, 2/6 and 1/10/1998 from experimental field plots at Bet Dagan Israel. The leaves were exposed to neonates of *H. armigera* for 72 h and mortality then was determined. Performance of Bt-cotton against *E. insulana* was tested under field conditions at Bet Dagan 1999. One hundred cotton bolls were sampled randomly on two dates in each of three cotton cultivars: NuCOTN 33B (BT); DP 5415 (DP) and Sivon (IL). All the collected bolls were examined for damage due to

E. insulana (see Figure 2).

The effect of Bt-cotton bolls on pink bollworm, *P. gossypiella* was determined under laboratory conditions. Young bolls from the cotton cultivars NuCOTN 33B (Bt-cotton), DP 5415 (non-Bt), and Sivon (non-Bt) were randomly collected on 19/7, 22/7 and 3/8/1998 from experimental field plots at Bet Dagan Israel. Each boll was exposed to 10 eggs of *P. gossypiella* and maintained under laboratory conditions for 12 days, and then penetration of pink bollworm larvae to bolls was determined.

Results

Leaves of Bt-cotton collected during the early and mid-season caused high mortality (90-100%) of *H. armigera* (Figure 1) and *E. insulana* neonates. In late season, the efficacy of the Bt-cotton leaves to *H. armigera* significantly declined. In flower buds, substantial bud damage was found due to both pests; however, Bt-cotton affected larval weight and penetration into bolls. Under field conditions, little damage to bolls due to *E. insulana* was observed in Bt-cotton (Figure 2). Both leaves and bolls of Bt-cotton did not affect *S. littoralis* larvae. In all the experiments, Bt-cotton bolls had less *P. gossypiella* damage, as compared with the other cultivars (controls) (Figure 3).

According to the experimental field samples, there was less *E. insulana* damage to bolls in the Bt-cotton plots than the non-transgenic cotton, and almost no damage to cotton bolls from pink bollworms was recorded. Large-scale field trials have proved that the moderate protection of Bt-cotton that had been found under laboratory conditions was sufficient in preventing economic damage to cotton fibers from *P. gossypiella*, *H. armigera* and *E. insulana;* this resulted in application of fewer broad spectrum insecticides.

Conclusions

From our laboratory evaluating assays, experimental plot, and semi-field trials, we can conclude that Bt-cotton effectively protects against pink bollworm, *P. gossypiella*. Leaves of Bt-cotton protected against damage caused by *H. armigera* and *E. insulana* larvae better than fruit organs, but no treatment may be needed under field conditions in Israel. Bt-cotton is not effective against *S. littoralis* larvae but in Bt-cotton plots, they were less widespread. The effective control of pink bollworm resulted in delays of treatments against whiteflies. However, relatively high levels of leafhoppers were observed, especially in the semi-field trials; hence, this pest would increase its levels on Bt-Cotton. It seems that one of the advantages of Bt-cotton is the reduced numbers of insecticide applications necessary under field conditions.

Acknowledgements

The authors acknowledge with thanks the Israeli Cotton Board and the Chief Scientist of the Ministry of Agriculture for their partial support of this study.

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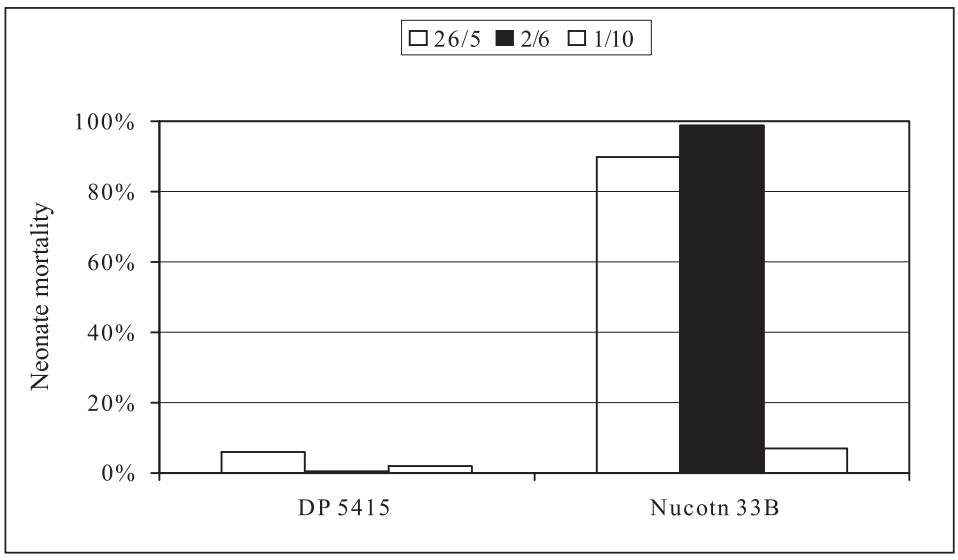

Figure 1. *Effect of Bt-cotton leaves on* Helicoverpa armigera *neonates under laboratory conditions.*

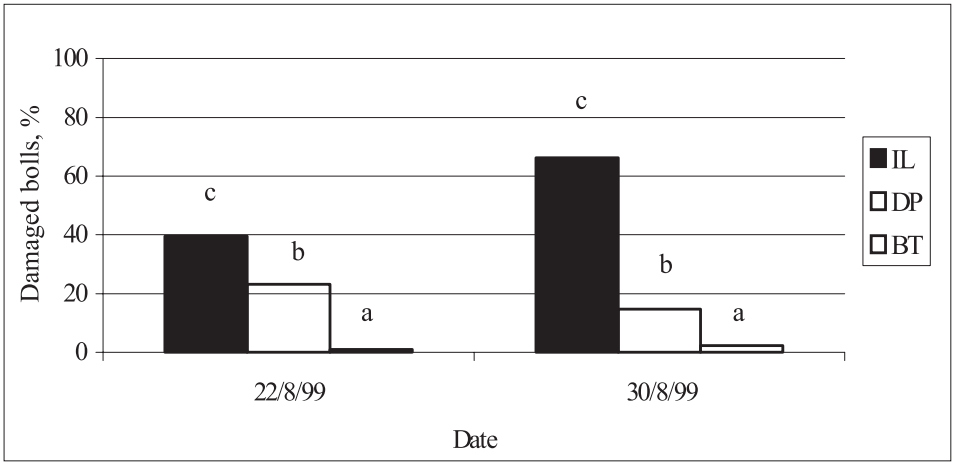

Figure 2. *Performance of Bt-cotton against* Earias insulana *under field conditions, Bet Dagan 1999.*

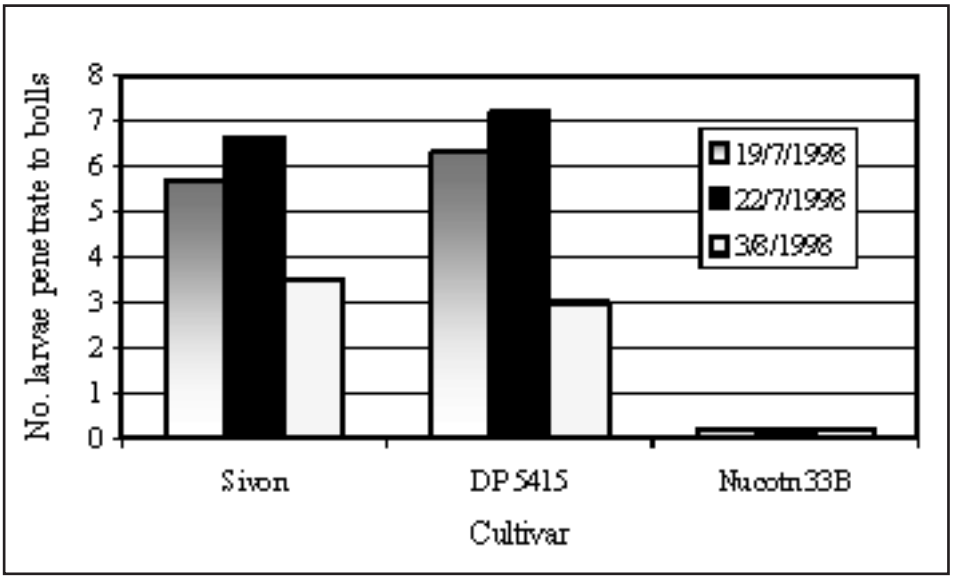

Figure 3. *Effect of Bt-cotton bolls on pink bollworm,* Pectinophora gossypiella *under laboratory conditions.*