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RESEARCH ARTICLE

Evaluation of second generation Bt cotton hybrids against sucking pests and bollworms

■ U.B. HOLE*, S.M. GANGURDE, N.D. SARODE AND R.W. BHARUD

Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA

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*Corresponding author:

ABSTRACT

The field trials were conducted at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2009 to 2011 to monitor the population of sucking pests as well as boll damage in commercially released second generation Bt cotton hybrids. The results revealed that second generation transgenic Bt cotton does not afford any protection against sucking pests of cotton and their tolerance or resistance is mainly dependent on the morphological or genetic base. Jassids and thrips population were above ETL both in Bt as well as non-Bt cotton hybrid. More than eight Bt cotton hybrids recorded higher population of sucking pests than non Bt cotton hybrid. The *Helicoverpa armigera* damage to square and green bolls was completely nil in almost all Bt cotton hybrids whereas non Bt hybrid Phule 492 recorded higher damage of 15.23 per cent and 10.90 per cent, respectively. The incidence of *Pectinophora gossypiella* on green bolls was also nil in all Bt cotton hybrids; while it was 14.29 per cent in non Bt cotton. In addition, Bt cotton hybrids recorded lower open boll and locule damage compared to non Bt cotton hybrid. The seed cotton yield of Bt cotton hybrids were more than that of non Bt cotton hybrid. This revealed the superiority of second generation Bt cotton hybrids in terms of pest resistance and yield.

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INTRODUCTION

Cotton is an important commercial crop in India playing a major role in agricultural economy. Before introduction of transgenic Bt cotton, farmers of Maharashtra witnessed instability in cotton production due to frequent crop failures because of outbreaks of insect pests. Among the problems, bollworms especially American bollworm, *Helicoverpa armigera* and pink bollworm , *Pectinophora gossypiella* cause considerable damage to cotton crop. *Helicoverpa* alone cause significant losses to the tune of Rs. 1000 crores in the country annually warranting insecticides application which many a times exceeds 20 sprays especially in epidemic years (Prasad *et al*., 2009).

In order to reduce dependence on chemical insecticides and resistant effect on non target organisms, tools of biotechnology have been applied to develop cotton that can withstand certain problematic and insecticide resistant pests more efficiently. Transgenic Bt cotton containing Cry1Ac gene which offers resistance to major bollworms was first commercially released in the world in 1996 and during 2002 in India. Since then transgenic Bt cotton has been adopted at an unprecedented pace in our country with the area crossing more than 90 per cent in last nine years of commercialization. The area under Bt cotton tripled over just one year *i.e.* between 2005-06 and 2006-07 (Jaykumar *et al*., 2008). There have been substantial gain in terms of lint yield and we have crossed the targets set for 11th Plan by many folds. Now Bt cotton comes with next generation technology called Bollgard II with increased efficacy for the control of bollworms. This technology provides a wider spectrum and season long control of bollworms and also provides convenient insect management

for cotton. Bollgard II contains two gene Cry1AC+Cry1Ab, double gene provides superior insect control, insects target are primary bollworms like American bollworm (*H. armigera*), spotted bollworm (*Earias* sp.), pink bollworm (*P. gossypiella*) as well as secondary Lepidopterans like tobacco caterpillar (*Spodoptera* sp.) and cotton semi-loopers. It provides superior control of pink bollworm. With this technology, the crop will be protected throughout the life period.

Though Bt cotton has been found successful in the management of bollworms, however, it has invited other insects pests especially sucking pests due to reduction on pesticide sprays at early stage because Bollgard II crops provided favourable environment to them. There is a need to monitor and take up control measures for the management of sucking pests in Bt cotton. Keeping this in view, these studies were taken up to monitor the population of sucking pests as well as boll damage in commercially released second generation Bt cotton entries.

MATERIALS AND METHODS

The field experiments were conducted during 2009 to 2011 at Cotton Improvement Project, MPKV, Rahuri under unprotected irrigated condition. Sixteen commercially released Bt cotton hybrids were selected for this study along with one non Bt cotton hybrid Phule-492. The experiment was laid out in a Randomized Block Design with seventeen treatments replicated thrice. Each plot measured 7.2 x 5.4 m in size. They were sown in *Kharif* 2009, 2010 and 2011 at a spacing of 90 x 90 cm and the regular agronomic practices were followed. All the test hybrids were raised under unprotected irrigated condition except one cover spray against sucking pests with imidacloprid at 70 days after sowing. The regular observations on sucking pests as well as boll damage were recorded at weekly intervals in all the hybrids from 10 randomly selected plants per plot. Sucking pests such as jassids, aphids, thrips and whitefly were recorded from three leaves; each one from top, middle and bottom canopies of the plant; while for the American bollworm per cent square damage was recorded from whole plant. The incidence of pink bollworm larvae was observed through destructive sampling of 20 randomly collected green bolls from each treatment and per cent damage in green bolls were recorded. The total number of bolls as well as damaged bolls was also counted to work out the per cent damaged bolls. The picking was done at the end of season and the seed cotton yield was calculated per hectare basis. Thus, the data obtained was subjected to statistical analysis after applying suitable transformations.

RESULTS AND DISCUSSION

The pooled data presented in the Table 1, revealed that among the sucking pests aphids, jassids, thrips and whiteflies were observed commonly in all cotton hybrids. The aphids and thrips population, in general, were found to be higher as compared to jassid and whitefly. The incidence of aphid ranged from 7.02 to 50.18 per three leaves among different hybrids. The Bt cotton hybrid PRCH-737, ZCH-501and non Bt cotton hybrid Phule-492 recorded lowest aphid incidence which were statistically at par and superior to rest of the Bt cotton hybrids. Tulsi-252, VBCH-1539, RJCN07-18, BAT HH-201, Solar-65 and Mallika Bt cotton hybrid recorded higher incidence of aphids indicating their susceptibility to aphids. The other major sucking pest infesting cotton, jassid ranged from 9.62 to 30.91 per three leaves among the hybrid evaluated. None of the genotypes recorded resistant reaction against jassids, almost all Bt cotton hybrids evaluated noted jassid population above ETL. However, the minimum of 9.62 jassids per three leaves was noted on VBCH-1539 and remained statistically at par with ZCH-201, PRCH-737 and Tulsi-252 Bt hybrids. The Ankur-651, MRC-7361and KSCH-212 hybrids were highly susceptible to jassids recorded population in the range of 27.22 to 30.91 per three leaves as compared to 18.49 jassids per three leaves on non Bt cotton Phule-492 hybrid. Amongst the all entries, KSCH-212 recorded maximum 48.64 thrips per three leaves followed by SP-7149; while minimum 12.98 to 14.16 thrips per three leaves were noted on KCH-100, VBCH-1539 and ZCH-501; which were statistically at par with each other. The incidence of other sucking pest whitefly occurs in the later stage of the crop growth and it ranged from 1.56 to 18.56 whiteflies per three leaves. Mallika, KCH-100 and Tulsi-252 showed tolerance in which 1.56 to 1.73 whitefly per three leaves were observed. Whereas other hybrids *viz*., RJCN07-018, VBCH-1539, RCH-2 and SP-7149 under evaluation are susceptible recorded 17.29 to 18.56 whitefly per three leaves.

In similar type of study Vennila *et al*. (2004) reported RCH 134 Bt showed tolerance to aphids and thrips. In general whitefly incidence was more in Bt cotton hybrids than that of non Bt cotton hybrid in current investigations. Cui and Xia (2000) also recorded 29.7 per cent more whitefly in Bt cotton as compared to that of the non Bt cotton control plants. Higher population of whitefly in Bt cotton as compared to non Bt cotton could be due to reduction in the spray of chemical insecticides or the negligible infestation of bollworms (Jaykumar *et al*., 2008). The non significant difference in population of sucking pests in Bt and non Bt was also reported by Lavekar *et al*. (2004). The results revealed that transgenic Bt cotton does not afford any protection against sucking pests of cotton and their relative tolerance or resistance is mainly dependent on the morphological or genetic base which is accordance with Reed *et al*. (2000) and Bambawale *et al*. (2004) who reported that the incidence of sucking pests was

Table 1: Incidence of sucking pests on second generation Bt cotton hybrids

Sr. No.	Bt cotton hybrids	Incidence of sucking pests/3leaves			
		Aphids	Jassids	Thrips	Whiteflies
1.	Tulsi-252	38.30 (6.23)	10.59 (3.33)	42.27 (6.54)	1.73 (1.49)
2.	ZCH-501	8.82 (3.05)	10.27 (3.28)	15.38 (3.98)	8.98 (3.08)
3.	RJCN07-018	49.13 (7.04)	18.51 (4.36)	36.13 (6.05)	17.29 (4.22)
4.	VBCH-1539	48.89 (7.03)	9.62 (3.18)	14.16 (3.83)	17.33 (4.22)
5.	MRC-7361	24.01 (4.95)	27.47 (5.29)	21.49 (4.69)	13.74 (3.77)
6.	KSCH-212	18.27 (4.33)	30.91 (5.60)	48.64 (7.01)	15.27 (3.97)
7.	Solar-65	49.76 (7.09)	18.67 (4.38)	19.47 (4.47)	3.93 (2.10)
8.	Ankur 651	29.72 (5.50)	27.22 (5.26)	35.80 (6.02)	9.00 (3.08)
9.	SP-7149	23.93 (4.94)	18.51 (4.36)	39.00 (6.28)	18.56 (4.37)
10.	NCS-857	22.67 (4.81)	21.00 (4.64)	42.30 (6.50)	14.18 (3.83)
11.	PRCH-737	7.02 (2.74)	10.31 (3.29)	42.16 (6.53)	12.13 (3.55)
12.	PCH-1412	29.27 (5.46)	18.76 (4.39)	24.51 (5.00)	12.13 (3.55)
13.	BAT HH-201	49.20 (7.05)	20.76 (4.61)	19.40 (4.46)	2.91 (1.85)
14.	RCH-2	17.82 (4.28)	20.93 (4.63)	25.60 (5.11)	18.44 (4.35)
15.	Mallika	50.18 (7.12)	18.84 (4.40)	31.69 (5.67)	1.56 (1.44)
16.	KCH-100	17.58 (4.25)	30.53 (5.57)	12.98 (3.67)	1.64 (1.46)
17.	Phule-492 (c) Non Bt hybrid (hxh)	7.33 (2.80)	18.49 (4.36)	31.60 (5.66)	9.11 (3.1)
	S.E.±	0.46	0.24	0.49	0.27
	C.D. at 5%LS	1.38	0.73	0.75	0.42
	C.V.	14.42	10.13	12.86	9.87

* Figures in parenthesis are √x+0.5 for numbers

Table 2: Incidence of bollworms on second generation Bt cotton hybrids

Sr. No.	Bt cotton hybrids	Infestation of *Helicoverpa armigera*		Infestation of *Pectinophora gossypiella*			Seed cotton yield (q/ha)
		Per cent square damage	Per cent green boll damage	Per cent green boll damage	Per cent open boll damage	Per cent locule damage in open bolls	
1.	Tulsi-252	0	0	0	4.44 (12.16)	2.34 (8.80)	15.36
2.	ZCH-501	0	0	0	10.33 (18.75)	5.34 (13.36)	18.29
3.	RJCN07-018	0	0	0	11.07 (19.43)	6.02 (14.20)	18.52
4.	VBCH-1539	0	0	0	6.54 (14.82)	3.88 (11.36)	17.68
5.	MRC-7361	0	0	0	6.54 (14.93)	4.29 (11.95)	18.05
6.	KSCH-212	0	0	0	3.64 (11.00)	2.35 (8.82)	17.93
7.	Solar-65	0	0	0	11.10 (19.46)	7.90 (16.32)	18.38
8.	Ankur 651	0	0	0	10.86 (19.24)	6.37 (14.62)	17.17
9.	SP-7149	0	0	0	8.81 (17.27)	5.95 (14.11)	22.88
10.	NCS-857	0	0	0	7.87 (16.29)	4.23 (11.87)	21.08
11.	PRCH-737	0	0	0	5.93 (14.09)	2.96 (9.91)	21.05
12.	PCH-1412	0	0	0	5.04 (12.97)	2.75 (9.55)	18.75
13.	BAT HH-201	0	0	0	3.46 (10.72)	2.01 (8.15)	18.83
14.	RCH-2	0	0	0	11.46 (19.79)	5.97 (14.14)	16.15
15.	Mallika	0	0	0	7.19 (15.58)	3.53 (10.35)	17.59
16.	KCH-100	0	0	0	6.67 (14.55)	3.16 (10.83)	22.01
17.	Phule-492(c) Non Bt (hxh)	15.23 (22.97)	10.90 (18.52)	14.29 (22.21)	20.68 (26.57)	13.23 (21.32)	11.99
	S.E.±	0.46	0.24	0.49	1.35	0.86	1.87
	C.D. at 5%	1.38	0.73	1.46	4.05	2.59	5.62
	C.V. %	14.42	10.13	12.86	9.20	11.64	10.68

* Figure in parenthesis is arcsin transformation values for per cent damage

more or less similar in both Bt and non Bt cotton hybrids. However, the present results contradict with the findings of Radhika *et al*. (2004) and Abro *et al*. (2004) who reported that the incidence of sucking pests was high in Bt hybrids than non Bt hybrids.

In contrast to the sucking pest populations, the American bollworm, *Helicoverpa armigera* damage in the current experiments revealed almost nil damage to the squares and green bolls in Bt cotton hybrids compared to non Bt cotton hybrid (Table 2). Highest square (15.23%) and green boll (10.90%) damage was recorded in non Bt cotton hybrid Phule-492. This shows the effectiveness of Bt protein expressed in the transgenic plant. The results clearly indicate that transgenic Bt cotton was highly effective against the most problematic pest in cotton which has developed many fold resistance to chemical insecticides. The present findings are in conformity with Krishnamurthy and Subramanian (2004) and Layton *et al.* (2000) who reported that fruiting body damage was very low in Bt cotton over non Bt cotton. Bhatade *et al.* (2006) reported 89 per cent reduction in square damage in Bt cotton over their non Bt hybrids due to *Helicoverpa*. The inbuilt resistance of transgenic Bt cotton to *Helicoverpa* was proved by many researchers by reporting very low larval population, low square and boll damage in Bt cotton hybrids than their non Bt counter parts and conventional cotton (Cui and Xia, 2000; Kranthi, 2002; Gore *et al.,* 2003; Vennila *et al.,* 2004).

Transgenic Bt cotton hybrids also offered protection against pink bollworm which is a late season pest in cotton. The incidence of *P.gossypiella* was also absent in all Bt cotton hybrids as no green boll damage was recorded followed by lower open boll and locule damage in Bt cotton hybrids compared to non Bt cotton hybrid. BAT HH-201 (3.46%, 2.01%), KSCH-212 (3.64%, 2.35%), Tulsi-252 (4.44%, 2.34%), PCH-1412 (5.04%, 2.75%) and PRCH-737 (5.93%, 2.96%) recorded lowest per cent open boll damage and locule damage, respectively. All these entries were statistically at par with each other and superior compared to non Bt hybrid Phule-492 in the experiment in which green boll damage, open boll damage and locule damage was 14.29 per cent, 20.68 per cent and 13.23 per cent, respectively. The results are in accordance with the findings of Hugar *et al*. (2006) who reported that fruiting damage to pink bollworm was 3.2 per cent in RCH 2Bt as against in NCH 145 non Bt cotton. Pink bollworm is not visible on the plant and completes most of the life cycle in the unopen boll itself and the damage in the form of stained and discoloured lint is seen only after bursting of the boll. Since the damage is not visible before boll opening it is very difficult to time the application of insecticides for taking control measures. Transgenic Bt cotton with Cry 1Ac + Cry1Ab toxin can able to control pink bollworm, as toxins are expressed in the plant parts itself and mostly prevents insecticide application and problems of decision making for control options. The resistance of Bt hybrids against pink bollworm was proved earlier by many scientist which are in accordance with the present results (Gianessi and Carpenter, 1999); Henneberry and Jech, 2000).

The seed cotton yield in Bt cotton hybrids were more than that of non Bt cotton hybrid. This reveals the superiority of Bt cotton hybrids in terms of yield. The same opinion of increased in yield in Bt cotton hybrids were also put forth by many earlier worker (Channakeshava and Patil, 2006; Kambhampati *et al.,* 2006).

From the present findings, it can be concluded that Bt cotton hybrids cannot control sucking pests of cotton and there was no difference in sucking pests incidence in Bt and non Bt cotton. The major bollworms *H.armigera* and *P.gossypiella* were effectively controlled in Bt cotton hybrids. Transgenic Bt cotton can play a major role in combating pest problem thereby reducing insecticide usage on cotton ecosystem and helps to maintain eco balance by conserving natural enemies.

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