Effect of *Bt*-Corn Hybrids (MON 810) on Plants Characteristics and their Productivity, in Egypt

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ABSTRACT

Three corn hybrids (XL214, MSA852, CRN3505) expressing the gene *Cry 1 Ab* in the form of the MON810 genetic event were tested against their sprayed (diazinon) and unsprayed non-transgenic counterparts as well as Pioneer3062, to evaluate the effects of the insecticidal gene (active against Lepidopteran larvae) and planting dates on agronomic characteristics and, ultimately, on yield. XL214 was evaluated in 2002 and 2003, while MSA852 and CRN3505 were studied in 2004; tests took place in Kaha, Kaliobia governorate, Egypt. The presence of the *Bt* gene showed no negative agronomic influence on corn hybrids. In fact, in every comparison with untreated and diazinon-treated non-*Bt* hybrids, *Bt* hybrids showed significant increases in grain yield, regardless planting dates. . The presence of the *Bt* gene corn resulted in an increase of grain yield increase from 20 to 41 percent over untreated non-*Bt* checks and from 17 to 41 percent over diazinon-treated non-Bt plants, depending upon planting date. Similarly, *Bt* hybrids yielded 9 to 41 percent more grain, and 9 to 27 percent more grain than those of untreated and diazinon-treated versions, respectively, of the popular local hybrid Pioneer3062. Results of this 3-year study suggest that *Cry 1 Ab*-expressing corn hybrids would provide a great value as a component of corn IPM, in Egypt.

INTRODUCTION

Corn is a major food and feed source worldwide and is also processed into a extremely broad range of food and non-food products (NCGA, 2000). Corn is palatable, readily digested by humans as well as by monogastric and ruminant animals, and is one of the best grain sources of easily metabolized energy (Wright, 1988).

Insect damage to corn includes leaf feeding; stalk tunneling; leaf sheath, collar feeding and ear damage (Dicke and Guthrie, 1988). Economic control of stalk tunneling lepidopteran larvae (corn borers) with the conventional chemicals is difficult, one of the reasons being that insect control is not completely efficient, since insecticide timing applications are hard to predict in order to protect the crop across the entire egg laying period (Tollefson and Calvin 1994). In the U.S., yield losses due to *Ostrinia*

nubilalis damage are estimated to be 3 to 7% per borer per plant, leading to annual losses from $37 to $172 per hectare of corn (Sanders *et al.*, 1998).

Bt transgenic corn is corn that has been modified to express the *Cry1 Ab* gene from the soil bacterium, *Bacillus thuringiensis*. The gene allows the bacterium to produce a protein (*Cry1 Ab*) that upon ingestion by insects, this crystalline inclusion is solubilized in the midgut, releasing proteins that called 6-endotoxins which are activated by the midgut proteases. The activated toxin interacts with the larval midgut epithelium causing a disruption in membrane integrity, leading to the death of the insect (Gill *et al.*, 1992). *Cry1 Ab* has been used as the active ingredient in *Bt* insecticides for many years (Flexner et al., 1986). In addition, the *Cry1 Ab* protein produced in *Bt* corn is rapidly degraded in soil and has no effect on soil microbial populations nor non target organisms (Marchetti *et al.*, 2007; Dubelman, et al., 2005; Head, 2007; Birch et al., 2007; Sanvido et al., 2006; Romeis et al., 2006; Eizaguirre et al., 2006; EPA-BRAD, 2001; Palm *et al.*, 1994; Sims and Holden, 1996; Yu *et al.*, 1997).

The *Cry1 Ab* protein is only biological active against lepidopteran insects. This specificity is directly attributable to the presence of *Cry1A*-specific receptors in the midguts of target insects (Hofmann *et al.*, 1988a; Van Rie *et al.*, 1990). There are no receptors for the protein delta-endotoxins of *Bacillus thuringiensis* subspecies on the surface of mammalian intestinal cells. Humans and other mammals are consequently not susceptible to these proteins (Sacchi *et al.*, 1986; Hofmann *et al.*, 1988b; Noteborn *et al.*, 1995). The forage and grain of *Bt* corn plants are as safe and nutritious as conventional corn varieties.

Bt-corn hybrids (MON 810) reduce insect damage in corn plants and the *Cry1 Ab* protein levels are sufficient to provide effective protection from the feeding damage of the corn borers throughout the growing season (Massoud, 2005). Corn borer tunneling is one of the main pathways by which, *Fusarium moniliforme* mold infects grain (Munkvold *et al.*, 1997). *Fusarium* produces fumonisin, a class of mycotoxins hazardous to animals and humans that can cause equine leukoencephalomalacia and porcine pulmonary edema syndrome and has been linked to esophageal cancer in humans (Sobek and Munkvold, 1999). *Bt*-corn hybrids have proven to decrease occurrence of fungal mycotoxins, associated with adverse health effects in humans and animals (CAST, 2003), as a result of lowering damage to maize plants by lepidopteran pests (Masoero *et al.*, 1999;

Bakan *et al.*, 2002; Hammond *et al.*, 2003; Magg *et al.*, 2003; de la Campa *et al.*, 2005; Munkvold, 2003).

Out of 91.00 million hectars planted in 2006, 11.10 million hectares were planted with Bt maize crop (James, 2006). This can be attributed to a variety of factors, not the least of which is the ability of growers to protect crop yield. The estimate of increased yield for transgenic corn has been reported to be as high as 26% depending on region (ERS 1999).

This study aims to evaluate the efficacy of different *Bt* corn hybrids (Mon 810) on the yield performance in relation to insecticide treatment of appropriate controls in Egypt.

MATERIALS AND METHODS

This research was carried out during the growing seasons of 2002, 2003 and 2004, in Kaha, Kaliobia governorate, Egypt.

In 2002, XL214 with MON810 event (*Cry 1 Ab*), and XL214 as a conventional hybrid, were planted. In 2003, XL214 with MON810 event, as well as the conventional versions of XL214, and Pioneer3062 were planted. In 2004, MON810-containing MSA852 and CRN3505 were raised, as well as the conventional versions of both. The conventional hybrid plots were either untreated or treated with the insecticide diazinon (Diazinox® 5%G). Diazinon was applied in the plant whorl twice during the growing season at recommended rates by the Egyptian Ministry of Agriculture (MOA). The 1st application was carried out at 21 days after sowing (the same day of the 1st irrigation) and the second application after 36-40 days of sowing. No additional insecticides or herbicides were applied to the studied plants throughout the period of the test.

The trial was arranged in a randomized complete block design (RCBD), with four replicates. Each replicate plot was five rows (0.6m apart and ten meters long). In each year, sequential sowing dates with a one month interval were conducted. In 2002, there were three planting dates, with the first on 27th of April . In 2003, there were five, with the first on March the 27th, and in 2004, there were three, with the first on May the 27th. The plants were sown with 2-3 kernels/hill, 17 hills/row; about 1.5kg seeds were used for each *Bt* hybrid. The seeds were supplied by Fine Seeds International Co. (Giza, Egypt).

A site border consisting of four rows of the conventional hybrid plants and a buffer strip (without plants) of 6m, was maintained around the tested plants at every site. At flowering stage, the *Bt* plants were de-tasseled at the beginning of tassel emergence and prior to pollen dispension. So, each trial was visited regularly every 2 days over a 2 week period. After recording the data, all plants of the *Bt* and conventional hybrids were chopped and plowed into the soil. No plant materials were removed from the plots.

Recorded agronomic parameters:

1) Plant characteristics:
   a) No. of plants/plot at 8-leaf stage,
   b) Plant height (cm) and
   c) No. of plants/plot at harvest stage.
2) Ear characteristics:
   a) Ear height (cm),
   b) Ear position % = (ear height/plant height) x 100
   c) No. of ears/plot
   d) Prolificacy = (no. of ears/plant)
3) Yield performance:
   a) Field weight (kg) = average yield/plant
      or = average weight of cobs with grains/plant.
   b) Shelling % = (grain weight/ear weight) x 100.
   c) Moisture % = moisture% in grains at harvesting day.
   d) Moisture factor = (100 – moisture %) /84.5.
   e) Drying factor = W_2/W_1
      Where: W_1= sample of 5kg grains at harvesting day
      W_2= sample weight after 15 days.
   f) Experimental factor = shelling % x moisture factor x drying factor
   g) Adjusted yield at 15.5% moisture (kg) = experimental factor x field weight

Data were analyzed using an ANOVA followed by Tukey's Studentized Range (HSD) multiple comparisons test (SAS, 1990).

RESULTS

1- Season 2002

The agronomic characteristics and yield performance of corn hybrids are shown in Table (1). The plant height and the ear position percent were not affected significantly in the *Bt*-XL214 compared to the non–*Bt* XL214 (diazinon treated or untreated) controls among the three planting dates. Meanwhile, the plant height decreased gradually across all treatments as planting date was delayed. Overall, ear position percent increased slightly, but insignificantly, with the delay of planting date. The highest ear position percent (62.5%) was recorded in the *Bt*-XL214 plants planted on 27th of June.

Ear prolificacy was significantly (at $p \leq 0.05$) higher in *Bt*-XL214 than in the treated non-*Bt* XL214 or the untreated non-*Bt* XL214 for the sowing dates in April, May and June, respectively. The increase of prolificacy of *Bt*-XL214 was significant over the untreated non-*Bt* XL214 for all planting dates, and over treated non-*Bt* XL214 only in plants sown in May (Table 1).

There was a clear and significant positive effect regarding *Bt* plots on field weight and adjusted grain yield of corn plants (at $p \leq 0.05$). The field weight increased significantly in *Bt*-XL214 over the diazinon–treated XL214 and the untreated XL214 for April, May and June, respectively. Similarly, the adjusted grain yield significantly increased in the *Bt*-XL214 hybrid giving 0.18, 0.16 and 0.12 kg/plant in plants sown in April, May and June, respectively, versus 0.14, 0.13 and 0.09 kg/plant for diazinon-treated XL214 and 0.15, 0.12 and 0.09 kg/plant for untreated check, respectively. Overall, field weight and adjusted grain yield decreased as planting date was delayed. Mote (1986) stated that in Indian sorghum, the greatest stalk tunneling damage occurred in late planted fields. Data were analyzed using an ANOVA followed by Tukey's Studentized Range (HSD) multiple comparisons test)

If the *Bt* hybrid yield gain is expressed as a percentage increase over the non-*Bt* hybrids, the yield benefits were 20%, 25%, and 33% over the untreated conventional hybrid, and 29%, 23%, and 33% over the diazinon-treated hybrid for April, May, and June plantings, respectively (Table 1).

2- Season 2003

Results in Table (2) showed the influence of the *Bt* gene in the XL214 hybrid compared with non-*Bt* XL214 and the conventional hybrid (Pioneer 3062) on yield for the five planting dates in 2003.

There were no significant differences in plant height due to the *Bt* gene; the only significant height difference occurred between the untreated conventional XL214 and the untreated Pioneer 3062 plants sown in March (at $p \leq 0.05$). Generally, plant height decreased as the planting dates were delayed; the exception was the slight rise in plant height for the latest planting of July. The plant height ranged from 173 to 233 cm in *Bt* plants, from 185 to 231 cm in diazinon-treated XL214 plants, and from 183 to 248 cm in the untreated XL214 plants across the five planting dates. Plant height ranged between 175 and 246 cm and between 188 and 255 cm in the diazinon-treated and the untreated Pioneer3062 plants, in respect (Table 2).

Ear position percent increased slightly with planting date delays. It ranged from 51.9 to 60.0% depending on the planting date. The prolificacy (ears/plant) was not influenced by the *Bt* gene or the planting date; it ranged between 0.93 and 1.08 across all the planting dates (Table 2).

The ulmost influence of the *Bt* gene in corn plants was reflected on maize yield that expressed in both the field yield weight and the adjusted grain yield. The *Bt* hybrid had the highest field weight and grain yields for every planting date; the Pioneer hybrid was statistically similar to the Bt hybrid only for the earliest planting date. The greatest adjusted grain yield (0.202 kg/plant) for *Bt*-XL214 was seen in plants cultivated in April, while for Pioneer 3062, elevated yields (0.187 kg/plant) were observed in March-sown plants.

The percent increase in grain yield for the *Bt*-XL214 represented 30 to 40% more than the untreated XL214 and 17 to 40% more than the diazinon-treated XL214 across the planting dates. Moreover, *Bt*-XL214 yielded more than the diazinon-treated Pioneer3062 by 9-27% depending on planting date.

3- Season 2004

As listed in Table (3), there were significant differences between MSA852 and CRN3505 in plant height. The plants of *Bt*-MSA 852 were

significantly taller than those of *Bt*-CRN 3505, but within each hybrid, the presence of the *Bt* gene had no effect on plant height.

Ear position percent was not affected by both hybrid and *Bt* gene. Prolificacy (ears/plant), differed among treatments only in June-planted corn. *Bt* versions had significantly more ears/plant than non-*Bt* versions, and *Bt*-MSA852 had more ears/plant than *Bt*-CRN3505 (1.6 vs. 1.4).

As in previous years, yield performance characteristics were significantly affected by the presence of the *Cry1 Ab* gene. Within each hybrid, the *Bt* version had higher field weight and grain yield than either the diazinon-treated or the untreated versions. Except for, May-planted corn, where field weight was equivalent to *Bt*-MSA852 and *Bt*-CRN3505, *Bt*-MSA852 that always had higher field weight and adjusted grain yield than those of *Bt*-CRN3505. Yield percentage increased in all planting dates for the *Bt*-MSA852 which ranged from 24 to 35% over the untreated MSA852 and 19: 29% over the corresponding percentages of the diazinon-treated MSA852. *Bt*-CRN3505 yielded 37: 41% more grain than its untreated conventional version and 30: 41% more than its diazinon-treated conventional version, depending upon planting date.

DISCUSSION

A prior study (Massoud 2005) has shown that the pesticide treatment couldn't efficiently protect non *Bt* maize plants from *S. cretica* infestation at the preharvest stage. The infestations of *C. agamemnon* and *O. nubilalis* were significantly higher on the diazinon-treated controls than on *Bt*-plants and didn't differ significantly from those of the untreated controls for all sowing dates. The infestations of *S. cretica, C. agamemnon* and *O. nubilalis* were negligible or completely prevented in *Bt* plants (XL214, MSA852 and CRN3505) throughout the whole season for all sowing dates.

In general, across the three studied seasons, the plant height and the ear position percent appeared to be slightly influenced by planting date, but not by variety type (Tables 1-3).

Prolificacy (ears/plant) appeared to be affected by the presence of the *Bt* gene only four times among the 11 planting dates studied across the three years. In 2002 *Bt*-XL214 produced significantly more ears/plant than the untreated conventional version for all three planting dates. In June-

planted corn in 2004, both *Bt* hybrids (*Bt*-MSA852; *Bt*-CRN3505) had more ears/plant than either their untreated or diazinon-treated versions.

The main influence of encoding *Bt* gene in corn plants was reflected on yield as expressed in the field weight and adjusted grain yield. The field weight and the adjusted grain yield increased significantly in *Bt*-versions over non-*Bt* versions (diazinon-treated or untreated) across all planting dates over the three studied seasons. These results could be owing to the efficacy of encoding *Bt* gene in protecting plants against the corn borers attack. Massoud (2005) found that the maximum reductions of *S. cretica, C. agamemnon* and *O. nubilalis* infestations that been induced by diazinon were 69.86, 51.85, and 53.70%, successively, suggesting that the efficacy of diazinon against these corn borers was not suffecient. The infestations of *S. cretica, C. agamemnon* and *O. nubilalis* were negligible or completely prevented in *Bt* plants (XL214, MSA852 and CRN3505) throughout the whole season for all sowing dates. The infestation reduction ranged from 90.48 to 100% for *Bt* hybrids.

This study cleared that incorporating the *Bt* gene (MON810 event) into the corn hybrids of XL214, MSA852 and CRN3505 could protect plants season-long against stalk boring lepidopteran borers, regardless the planting date. Result of insect protection had significantly increased yields, even over insecticide-treated conventional hybrids, with little or no effect of the *Bt* gene on other agronomic characteristics measures of plant height, ear position percentage and prolificacy. It is proposed here that corn germplasm containing the MON810 event could be considered as a good management tool for corn borers, which deserve a place a forefront rank in initiating IPM programme for corn in Egypt.

However, the benefits of planting insect-protected corn include: (1) a reliable means to control these corn pests; (2) control of target insects, while maintaining beneficial species; (3) reduced use of chemical insecticides; 4) reduced applicator exposure to chemical pesticides; (5) fit with integrated pest management (IPM) and sustainable agricultural systems; (6) reduced fumonisin mycotoxin levels in corn kernels; and (7) free from additional labor or machinery requirements, allowing both large and small growers to maximize hybrid yields and profits (Masoero *et al.*, 1999; Munkvold *et al.*, 1999; Rice and Pilcher, 1999).

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Table (1) Effect of XL214 hybrid (MON810 event) on maize yield during three sowing dates in 2002.

Planting Date	Hybrid & Treatment	Plant Height (cm)	Position (%)	Ear Prolificacy	Maize yield		% *Bt* increase	
					Field weight kg/plant	Adjusted grain yield kg/plant	than untreated	than Diazinon
27th of April	*Bt*-XL214	223	99.6	1.01 a	0.20 a	0.18 a		
	Non-*Bt*- XL214 (Diazinon)	225	56.7	0.93 ab	0.16 b	0.14 b		28.57
	Non *Bt* XL214 (untreated)	223	55.6	0.91b	0.15 b	0.15 b	20.0	
	LSD 5%	ns	ns	0.08	0.02	0.02		
27th of May	*Bt*-XL214	209	59.9	1.00 a	0.18 a	0.16 a		
	Non-*Bt*- XL214 (Diazinon)	213	58.0	0.95 b	0.15 b	0.13 b		23.07
	Non *Bt* XL214 (untreated)	193	60.4	0.93 b	0.14 b	0.12 b	25.0	
	LSD 5%	ns	ns	0.04	0.02	0.02		
27th of June	*Bt*-XL214	179	62.5	0.96 a	0.15 a	0.12 a		
	Non-*Bt*- XL214 (Diazinon)	184	59.3	0.89 ab	0.11 b	0.09 b		33.33
	Non *Bt* XL214 (untreated)	181	59.6	0.86 b	0.11 b	0.09 b	33.33	
	LSD 5%	ns	ns	0.08	0.02	0.02		

* ns : not significantly differed
* In each column, means followed by the same letter are not significantly different at the 5% level by Tukey's Studentized Range (HSD) multiple comparisons test.

Table (2) Effect of XL214 hybrid (MON810 event) on maize yield during five sowing dates in 2003.

Planting Date	Hybrid & Treatment	Plant Height (cm)	Ear Position (%)	Prolificacy	Maize yield		% *Bt* increase	
					Field weight kg/ plant	Adjusted grain yield kg/plant	than untreated	than Diazinon
27th of March	*Bt*-XL214	233	53.9	0.99	0.31 a	0.20 a	33.55	23.78
	Non *Bt*-XL214 (Diazinon)	230	53.8	0.94	0.25 bc	0.16 bcd		
	Non *Bt*-XL214 (untreated)	243	51.9	0.93	0.23 c	0.15 d		
	Pioneer 3062 (Diazinon)	246	52.3	1.08	0.29 ab	0.19 ab	9.14	8.56
	Pioneer 3062 (untreated)	255	54.4	1.20	0.28 abc	0.19 ab		
27th of April	*Bt*-XL214	218	58.5	0.97	0.30 a	0.20 a	40.27	40.27
	Non-*Bt*-XL214 (Diazinon)	231	59.8	1.02	0.22 b	0.14 b		
	Non *Bt*-XL214 (untreated)	248	52.4	0.96	0.22 b	0.14 b		
	Pioneer 3062 (Diazinon)	219	54.3	1.01	0.23 b	0.16 b	41.26	23.93
	Pioneer 3062 (untreated)	210	56.7	1.02	0.22 b	0.14 b		
27th of May	*Bt*-XL214	195	59.6	0.98	0.28 a	0.18 a	30.43	19.21
	Non *Bt*-XL214 (Diazinon)	224	54.2	0.98	0.24 b	0.15 bc		
	Non *Bt*-XL214 (untreated)	209	55.6	0.98	0.23 b	0.14 c		
	Pioneer 3062 (Diazinon)	216	56.1	1.03	0.24 b	0.16 b	25.00	13.21
	Pioneer 3062 (untreated)	216	59.6	0.98	0.23 b	0.14 c		
27th of June	*Bt*-XL214	173	60	0.99	0.20 a	0.12 a	35.96	32.97
	Non *Bt*-XL214 (Diazinon)	185	54	1.02	0.16 b	0.09 b		
	Non *Bt*-XL214 (untreated)	183	54	1.00	0.14 b	0.09 b		
	Pioneer 3062 (Diazinon)	175	56	1.06	0.15 b	0.10 b	24.74	27.37
	Pioneer 3062 (untreated)	188	55	1.08	0.15 b	0.10 b		
27th of July	*Bt*-XL214	205	56.7	0.98	0.13 a	0.08 a	35.71	16.92
	Non *Bt*-XL214 (Diazinon)	210	55.6	0.98	0.10 b	0.07 bc		
	Non *Bt*-XL214 (untreated)	203	58.6	0.93	0.09 b	0.06 c		
	Pioneer 3062 (Diazinon)	213	56.9	1.03	0.10 b	0.07 bc	40.74	15.15
	Pioneer 3062 (untreated)	216	54.4	1.03	0.09 b	0.05 c		

* ns: not significantly differed

* In each column, means followed by the same letter are not significantly different at the 5% level by Tukey's Studentized Range (HSD) multiple comparisons test.

Table (3) Effect of MSA852 and CRN3505 hybrid (MON810 event) on the maize yield during three sowing dates in 2004.

Planting Date	Hybrid & Treatment	Plant height (cm)	Ear Position (%)	Prolificacy	Maize yield		% *Bt* increase	
					Field weight kg/plant	Adjusted grain yield kg/plant	than untreated	than Diazinon
27th of May	*Bt*-MSA852	250 a	65.1	1.45	0.48 a	0.31 a		
	Non-*Bt*-MSA852 (Diazinon)	235 a	63.9	1.40	0.37 b	0.24 b		29.17
	Non *Bt* MSA852 (untreated)	240 a	63.0	1.2	0.34 b	0.23 b	34.78	
	Bt-CRN3505	220 b	61.4	1.09	0.47 a	0.26 b		
	Non *Bt*-CRN (Diazinon)	222 b	61.2	1.03	0.28 c	0.19 c		36.84
	Non *Bt*-CRN (untreated)	228 b	61.5	1.0	0.26 c	0.19 c	36.84	
27th of June	*Bt*-MSA	229 a	66.1	1.6 a	0.47 a	0.32 a		
	Non *Bt*-MSA (Diazinon)	215 ab	63.3	1.2 c	0.38 b	0.25 b		28.0
	Non *Bt*-MSA (untreated)	215 ab	64.5	1.4 b	0.39 b	0.25 b	28.0	
	Bt-CRN	181 b	62.2	1.4 b	0.39 b	0.24 b		
	Non *Bt*-CRN (Diazinon)	200 ab	64.3	1.2 c	0.28 c	0.17 c		41.18
	Non *Bt*-CRN (untreated)	194 b	60.6	1.2 c	0.29 c	0.17 c	41.18	
27th of July	*Bt*-MSA	240 a	66.1	1.4	0.45 a	0.31 a		
	Non *Bt*-MSA (Diazinon)	227 ab	62.3	1.32	0.36 b	0.26 b		19.23
	Non *Bt*-MSA (untreated)	229 ab	62.6	1.26	0.35 b	0.25 b	24.0	
	Bt-CRN	218 b	62.9	1.52	0.40ab	0.26 b		
	Non *Bt*-CRN (Diazinon)	217 b	64.4	1.35	0.34bc	0.20 c		30.0
	Non *Bt*-CRN (untreated)	212 b	63.9	1.29	0.31 c	0.19 c	36.84	

* ns : not significantly differed

* In each column, means followed by the same letter are not significantly different at the 5% level by Tukey's Studentized Range (HSD) multiple comparisons test.

الملخص العربي

تأثير هجن الذرة المحتوية على جين *Bt* (MON 810) على خصائص النباتات و انتاجيتها في مصر

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تم تقييم تأثيرعدة هجن ذرة معدلة وراثيا (XL214, MSA852, CRN3505) المحتوية على جين مقاوم ليرقات حرشفية الأجنحة على خصائص المحصول و انتاجيته، و مقارنتها بمثيلاتها من الهجن غير المعدلة وراثيا بالإضافة الى الهجين المحلي بيونير 3062 سواء كانت معاملة أو غير معاملة بمبيد ديازينون. حيث تم تقييم الهجين XL214 في موسمي 2002 و 2003 بينما تم تقييم كل من MSA852, CRN3505 في موسم 2004 وذلك في مدينة قها بمحافظة القليوبية.

أوضحت النتائج أن وجود الجين *Bt* لم يكن له تأثير سلبي على خصائص محصول الذرة. و أظهرت النتائج زيادة معنوية للمحصول في الهجن المحتوية على جين ال *Bt* مقارنة مع كل الهجن التقليدية غير المعدلة وراثيا سواء كانت معاملة أو غير معاملة بمبيد ديازينون و بغض النظر عن ميعاد الزراعة. كما تراوحت الزيادة في انتاجية الحبوب من 20 الى 41% عن مثيلاتها من الهجن التقليدية غير المعاملة بالمبيد، و من 17 الى 41% عن مثيلاتها التقليدية المعاملة بمبيد ديازينون و ذلك تبعا لميعاد الزراعة.

كذلك كانت هناك زيادة في انتاجية الحبوب في الهجن المحتبرة حيث تراوحت من 9 الى 41% عند مقارنتها بهجين الذرة المحلي بيونير 3062 غير المعامل بالمبيد أو من 9 الى 27% اذا كان الهجين بيونير معامل بالمبيد.

لناء على ما تقدم تشير هذه الدراسة التي تمت على مدار 3 سنوات الى القيمة الكبيرة للهجن المعدلة وراثيا و التي تحتوي على جين *Bt* المقاوم للحشرات في برامج المكافحة المتكاملة لثاقبات الذرة في مصر.