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ORIGINAL ARTICLE

Effect of Refuge Cotton Crops on Yield of Bollgard II in Allahabad

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ABSTRACT

The results presented in this article compare Bollgard II (BG-II) yield when non-Bt cotton as refuge was sown either as border rows (1 or 2 rows) or within the BG-II field (10-50%). When nBt cotton was sown within the BG-II field significant difference was observed in yield parameters such as lint, number of bolls/plant, number of seeds/plant and seed index. However when nBt was sown as border row(s) the difference in lint yield was non significant while the number of seeds/plant and seed index were found significant. Further nBt sown as border rows gave a greater cotton yield when compared to nBt within the BG-II field trial. Total cotton yield for 1 row nBt (11.7% nBt) was 322.305kg/ha whilefor field trial with 10% nBt within the field trial was 278.16 kg/ha. A high positive physical correlation coefficient for lint with bolls/plant and with seed index was obtained from 1 row nBt BG-11 field trial (0.835 and 0.809 respectively) than when compared to 10% nBT within the BG-II field trial (0.132 and 0.083 respectively).

Key words: Bollgard II, correlation coefficient, lint, seed cotton, yield

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INTRODUCTION

Low investment and high profit is the main criteria for selecting a crop for farming. Cotton crop fulfils this criteria due to its economic value. It is one of the major non-food cash crop which gives significant boost to the economy of farmers [1]. China and India are the significant cotton cultivating countries, with 6.8 and 2.3 million producers, respectively [2].The major concern in cultivation of this crop which limits its productivity around the world is damage to the plant and fibre due to insects and pests[3]. In 2002 Indian government approved Monsanto along with Mahyco to introduce the Bollgard varities of cotton for commercial cultivation. The Cry1Ac gene incorporated in Bollgard cotton variety gives resistance to bollworm [4]. It's been more than two decades since the introduction of Bollgard in India and it has shown promising results for the economic growth of the farmers because of the higher yield compared to conventional or hybrid varieties of cotton [5].

Bt cotton hybrids have exhibited significant control of bollworm and lowered the use of insecticides [5]The addition of other Cry proteins stacked with Cry1Ac as in Bollgard II has improved the efficiency of plant resistance against various insects [6]. Bollgard expressing single Bt-Cry gene skill a narrow set of target pests, which gives high possibility of development of insect resistance to the cry protein. To lower this risk, varieties with multiple Cry genes and other insecticidal proteins are expressed to delay or suppress the risk of insect resistance development to the incorporated insecticidal proteins[7].Planting refuge crop along with Bt. Cotton is also one of the strategy for insect resistance management. The refuge crop is a target of large numbers of susceptible target insects within the Bt cotton field. Any resistant insects emerging from the Bt cotton are likely to mate with susceptible insects from the refuge. Thus resulting in minimizing the risk of resistance development to the insecticidal protein [8].

MATERIAL AND METHODS

The small scale field trials for Bollgard II (BG) was at the central farm of the Sam Higginbottom University of Agriculture Technology and Sciences, Naini, Allahabad in April 2017. The field was ploughed with a tractor and prepared for sowing using furrows. Before sowing the field received an organic source of field yard manure (1.25g/m2). The experiment was a completely randomised design arranged in 10 rows and 5 columns per treatment using Bollgard II (KCH14K59) Jadoo seeds obtained from the market. BG-II and the commercially provided refuge non Bt cotton seeds were sown at 0.65m x 0.65m spacing. The first treatment contained one row of non-Bt (11.7% of total seeds sown) on either side of the BG trial field. The second treatment contained two rows of refuge non-Bt cotton seeds (37% of total seeds sown) on either side of the BG-II field trial. And the third treatment was BG field trial without any non-Bt cotton seeds. No pesticide was used through out the trial and irrigation was done at 15/20 day intervals, de weeding was done manually when required. Similarly in brief for the field trials containing 10%, 25% and 50% nBt within the field the field was prepared as above using BG-II (KCH14K59) [9].Cotton bolls were harvested in 4/5 pickings depending on the yield of the crop. Plant height, number of monopodia, number of sympodia, number of seeds per ball, lint weight, seed cotton weight were recorded. Seed index (SI) and lint index were calculated[10]where

Lint index = (seed index x lint %)/ (lint% - 100)

And lint % = (weight of lint/weight of seed cotton) x 100

Statistical analysis: For the data collected from the field trials using row nBt,5 randomly selected were used for 1 way ANOVA analysis using the WASP software package [11]. The calculated F value was compared to the F value at 5% level probability. Where the treatment means were found significantly different the critical difference, the coefficient of variance and mean standard error were recorded. The same protocol above but using 9 randomly selected crops was used for the comparison of data from the field trials containing n Bt at 10%, 25% and 50% dispersed within the field and with the 2 row nBt border crops [9].

Correlation Coefficient: Phenotypic correlation coefficient were calculated from the corresponding variance and covariance [12] using the following equation:

$$rpxy = \sigma pxy / \mathrm{sqrt}(\sigma px \times \sigma py),$$

where, rpxy: phenotypic correlation coefficient between X and Y; σpxy the covariance for X and Y and σpx and σpy the variance for X and Y respectively.

RESULTS AND DISCUSSION

Comparison of means for border nBt crops in BG-II field trials: The comparison of means of various parameters such as lint (gm), number of bolls/plant, number of seeds/plant, seed index (gm), plant height (cm) including number of sympodia was performed using the WASP software as described in materials and methods. Comparison was done of three treatments, fields with 1 row nBt, 2 rows nBt cotton as border crops and a third treatment with no nBt border crops. The results show that mean difference for lint or cotton fibre, number of seeds/plant, plant height and number of sympodia for the three treatments are non significant (Table 1). While the mean difference for number of bolls/plant and seed index were shown to be significant (Table 1).

The lint or cotton fibre obtained per plant for 1 row nBt refuge crops was found higher than with 2 row nBt refuge crops (12.08gm/plant) and for field trials without nBt (14.9gm/plant) (Table 1). The critical difference observed at 5% probability was non significant with a coefficient of variance of 19.483 and a mean S.E of 0.193. (Table 1).

Similarly the number of bolls/plant was found higher for 1 row nBt (23.8/plant) than for than with 2 row nBt (17.6/plant) and for field trials without nBt (22.4/plant) (Table 1). The critical difference observed at 5% probability was significant with a coefficient of variance of 15.666 and a mean S.E of 0.229. (Table 1).

The number of seeds/plant was found higher for 1 row nBt (452/plant) than for 2 row nBt refuge crops (349.4/plant) and for field trials without nBt (440.2/plant) (Table 1). The critical difference observed at 5% probability was non significant with a coefficient of variance of 15.956 and a mean S.E of 4.556. (Table 1).

The seed index for 1 row nBt was 31.78gm which was higher than for 2 row nBt refuge crops (24.4gm) but lower for field trials without nBt (33.48gm) (Table 1). The critical difference observed at 5% probability was significant with a coefficient of variance of 15 and a mean S.E of 0.309. (Table 1).

Similar to the seed index the plant height for 1 row nBt was 137.4cm which was higher than for 2 row nBt refuge crops (135.6cm) but lower for field trials without nBt (140.2cm) (Table 1). The critical difference observed at 5% probability was non significant with a coefficient of variance of 6.892 and a mean S.E of 0.655. (Table 1).

Similar to the seed index and plant height the number of sympodia/plant was found higher for 1 row nBt (14.2/plant) than for 2 row nBt refuge crops (13.2/plant) and lower for field trials without nBt (14.6/plant) (Table 1).The critical difference observed at 5% probability was non significant with a coefficient of variance at 15.54 and a mean S.E of 0.06. (Table 1).

Comparison of means for nBt crops within the BG-II field trial: Comparison of means was done of three treatments, fields with 50%nBt, 25% nBt and 10% nBt cotton within the trial field as described [9] and a fourth treatment with 2 row nBt border crops as described [9]. The results obtained are shown in Table II. The results show that the difference in means for lint or cotton fibre, number of seeds/plant, and plant height were significant (Table 2). However the difference in means for the number of sympodia/plant for the four treatments was non significant (Table 2).

The lint or cotton fibre obtained per plant for 50% nBt refuge crops was 11.037gm/plant while for 25% nBt was 14.675gm/plant and with 10% nBt was 10.13gm/plant. For the fourth treatment of 2 row nBt was 12.431gm/plant (Table 2). The critical difference observed at 5% probability was significant with a coefficient of variance of 13.959 and a mean S.E of 0.045. (Table 2)

The number of bolls obtained per plant for 50% nBt refuge crops was 20.11/plant while for 25% nBt was 23.556/plant and with 10% nBt was 18.111/plant. For the fourth treatment of 2 row nBt the number of bolls/plant was 19.778 (Table 2). The critical difference observed at 5% probability was significant with a coefficient of variance of 9.637 and a mean S.E of 0.055. (Table 2)

The number of seeds/plant for 50% nBt refuge crops was 356.444/plant while for 25% nBt was 407.222/plant and with 10% nBt was 308.333/plant. For the fourth treatment of 2 row nBt the number of bolls/plant was 340.444 (Table 2). The critical difference observed at 5% probability was significant with a coefficient of variance of 17.053 and a mean S.E of 1.696. (Table 2).

The seed index for 50% nBt refuge crops was 8.139gm/plant while for 25% nBt was 8.173gm/plant and with 10% nBt was 7.202gm/plant. For the fourth treatment of 2 row nBt the seed index was 7.276 (Table 2). The critical difference observed at 5% probability was significant with a coefficient of variance of 8.738 and a mean S.E of 0.018. (Table 2).

The plant height for 50% nBt refuge crops was 117.444cm/plant while for 25% nBt was 101.222cm/plant and with 10% nBt was 128.556cm/plant. For the fourth treatment of 2 row nBt the plant height was 133.444cm/plant (Table 2). The critical difference observed at 5% probability was significant with a coefficient of variance of 7.484 and a mean S.E of 0.253. (Table 2).

The number of sympodia for 50% nBt refuge crops was 11.889/plant while for 25% nBt was 12.667/plant and with 10% nBt was 12.333/plant. For the fourth treatment of 2 row nBt the number of sympodia/plant was 10.333 (Table 2). The critical difference observed at 5% probability was non significant with a coefficient of variance of 19.689 and a mean S.E of 0.065. (Table 2).

Comparison of cotton yield/ha by varying nBt crops: nBt as Border crops: In the first set of 3 treatments of no nBt, 1 row nBt and 2 row nBt the Bt cotton yield/ha and the total cotton (Bt+nBt) yield/ha were calculated as shown in Table 3. The results show the mean Bt cotton yield/plant and Bt cotton yield/ha across these three treatments was highest for 2 row nBt at 15.448gm/plant and 429.11kg/ha respectively. The total cotton yield of the field (Bt + nBt) was higher for the 2 row nBt (382.004kg/ha) than the 1 row nBt (322.305kg/ha) (Table 3).

nBt within the Bt trial field: For these 4 treatments of 50%, 25% and 10% nBt within the field and 2 row nBt, the results show the mean Bt cotton yield/plant and Bt cotton yield/ha across these four treatments was highest for 25% nBt at 14.675 gm/plant and 407.63 kg/ha respectively. The total cotton yield (Bt + nBt) was higher for the 25% nBt (375.027 kg/ha) than the remaining three treatments (Table III).

The comparison across the seven treatments shown in Table III indicate that border refuge crops gave a higher total cotton yield than when nBt is sown within BG-II trial fields. Further 10% nBt being the standard norm of refuge crops used to prevent the development of insect resistance to the insecticidal proteins in the Bt crops.It is observed that 1 row nBt (11.7% nBt) gave a higher total cotton yield of 322.305kg/ha when compared to 10% nBt within the BG-II trial field of 278.16kg/ha (Table III).

Comparison of phenotypic correlation coefficient for 10% nBt within the field and 1 row nBt crops: For the 1 row nBt field trial: The pheotypic correlation coefficient was calculated as described in materials and methods. Lint was found positively correlated with number of bolls/plant (0.835), seed index (0.809),plant height (0.751) and number of sympodia/plant (0.516) (Table IV). The number of bolls was found positively correlated with the seed index (0.802), and number of sympodia/plant (0.663) (Table

IV). The number of bolls was found negatively correlated with the plant height (-0.494) (Table IV). The seed index was found positively correlated with number of sympodia/plant (0.368) (Table IV) while the seed index was found negatively correlated with the plant height (-0.517) (Table IV). The plant height was found negatively correlated with the number of sympodia (-0.833) (Table IV).

For the 10% nBt within the field trial: Lint was found positively correlated with number of bolls/plant (0.132), and seed index (0.083) (Table IV). Lint was found negatively correlated with plant height (-0.229) and number of sympodia/plant (-0.688) (Table IV). The number of bolls was found positively correlated with the seed index (0.709), and number of sympodia/plant (0.531) (Table IV). The number of bolls was found negatively correlated with the plant height (-0.423) (Table IV). The seed index was found positively correlated with number of sympodia/plant (0.453) (Table IV) while the seed index was found negatively correlated with the plant height (-0.812) (Table IV). The plant height was found positively correlated with the number of sympodia (0.014) (Table IV).

Table 1: Comparison of means from small scale field plots using nBt refuge cotton as border crops where CD indicate critical difference at 5% probability; NS: non significance, CV: coefficient of variance; and S.E: mean standard error**.**

	Lint (gm)	No of bolls/plant	No of seeds/plant	Seed index (gm)	Plant height (cm)	No of sympodia
1 row nBt	15.448	23.8	452	31.78	137.4	14.2
2 row nBt	12.08	17.6	349.4	24.4	135.6	13.2
no nBt	14.959	22.4	440.2	33.48	140.2	14.6
CD (0.05)	NS	4.591	NS	6.178	NS	NS
CV(%)	19.483	15.666	15.956	15	6.892	15.54
mean S.E.	0.193	0.229	4.556	0.309	0.655	0.06

Table 2: Comparison of means from small scale field plots using nBt refuge cotton at 10%, 25% and 50% within the trial fieldwhere CD indicate critical difference at 5% probability; NS: nonsignificance; CV: coefficient of variance and; S.E: mean standard error.

	Lint (gm)	No of bolls/plant	No of seeds/plant	Seed index (gm)	Plant height (cm)	No of sympodia
50% nBt	11.037	20.111	356.444	8.139	117.444	11.889
25% nBt	14.675	23.556	407.222	8.173	101.222	12.667
10% nBt	10.13	18.111	308.333	7.202	128.556	12.333
2 row nBt	12.431	19.778	340.444	7.276	133.444	10.333
CD (0.05)	1.618	1.887	57.822	0.646	8.636	NS
CV(%)	13.959	9.637	17.053	8.738	7.484	19.689
mean S.E.	0.045	0.055	1.696	0.018	0.253	0.065

Table 3: Comparison of yield in kg/ha forsmall scale field plots using nBt refuge cotton as border crops with small scale field plots using nBt refuge cotton at 10%, 25% and 50% within the trial field [9]. Sowing for border crops were done in June 2017* while for nBt within the small scale filed trial ** was in April 2016.

Border nBt				
	Mean Bt cotton yield/ plant (gm)	**Bt cotton yield (kg/ha)**	**Mean nBt cotton yield/ plant (gm)**	**Total cotton yield (Bt+nBt) (kg/ha)**
no nBt	14.959	415.52	0	415.52
1 row nBt	12.08	335.55	8.014	322.305
2 row nBt	15.448	429.11	7.377	382.004
nBt within the field **				
10% nBt	10.13	281.38	8.97	278.16
25% nBt	14.675	407.63	9.98	375.027
50% nBt	11.037	306.58	9.6	286.61
2 row nBt	12.431	345.3	9	310.97

Table 4: Comparison of the phenotypic corelation coefficient for field plots using 1 row nBt refuge cotton as border crops with small scale field plots using nBt refuge cotton at 10% within the trial field.

1 row border nBt (11.7% nBt)					
	Lint (gm)	Bolls/plant	Seed Index (gm)	Plant Height	number of sympodia
Lint (gm)	-	0.835	0.809	0.751	0.516
Bolls/plant		-	0.802	-0.494	0.663
Seed Index (gm)			-	-0.517	0.368
Plant Height(cm)				-	-0.833
number of sympodia					-
10% nBt in the BG-II trial field					
	Lint (gm)	Bolls/plant	Seed Index (gm)	Plant Height	number of sympodia
Lint (gm)	-	0.132	0.083	-0.229	-0.688
Bolls/plant		-	0.709	-0.423	0.531
Seed Index (gm)			-	-0.812	0.453
Plant Height(cm)				-	0.014
number of sympodia					-

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