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Evaluation of Weed Control Efficacy and Seed Cotton Yield in Transgenic Cotton

KEYWORDS: Transgenic cotton, Weed control efficacy, Seed cotton yield

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ABSTRACT *The research was conducted with transgenic cotton hybrid during winter irrigated season of 2009-10 and 2010-11 at the experimental site of Tamil Nadu Agricultural University, Coimbatore, with seven weed management methods viz., pendimethalin at 1.0 kg ha^{-1} + hand weeding, pendimethalin at 1.0 kg ha^{-1} + power weeder weeding, hand weeding on 25 and 45 DAS, power weeder weeding on 25 and 45 DAS, hand weeding on 25 + power weeder weeding 45 DAS,power weeder weeding on 25 + hand weeding 45 DAS and unweeded check. In both the years, higher seed cotton yield was recorded in hand weeding twice at 25 and 45 DAS and pendimethalin at 1.0 kg ha^{-1} + hand weeding also efficiently suppressed the weeds and recorded higher seed cotton yield in transgenic cotton.*

Introduction

Cotton is one of the important crop that has been genetically altered to address challenges with insect control. Transgenic Bt cotton technology has been widely accepted by Indian farmers across the country since its first commercialization in 2002. Apart from likelihood of reduction in insecticide usage by atleast 50 to 75 per cent in Bt cotton, it is also expected to ensure favourable ecological, economical and sociological returns in contrast to the harmful effects due to large scale use of insecticides (Kranti, 2002). Bt cotton has literally revolutionized cotton production in India. In a short span of eight years, 2002 to 2009, Bt cotton has generated economic benefits for farmers with halved insecticide requirements, contributed to the doubling of yield and transformed India from a cotton importer to a major exporter (Choudhary and Gaur, 2010).

Cotton hybrids are cultivated under wider plant spacing and heavily fertilized, which inturn invite multiple weed species infestation. Due to increased scarcity of labourers, manual weeding is not economical and the available pre - emergence herbicide has lesser weed control efficiency in controlling major problematic weeds.Mechanical weed control method was partially effective because most of the weeds growing in intra rows escaped weeding and incessant rains make the manual weeding impossible which resulted in an inefficient weed control situation and low seed cotton yield (Rajeswari and Charyulu, 1996).

With these in view, the study was conducted with integration of one or two methods for the effective control of weeds with better economic returns in transgenic cotton hybrids.

Materials and Methods

Experimental Site

The research was conducted with an experimental site of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The farm is situated in Western Agro climatic zone of Tamil Nadu with 11° N longitude, 77° E latitude and at an altitude of 426.7 m above mean sea level and the farm receives the normal total annual rainfall of 674.2 mm in 45.8 rainy days. Trial was conducted in soil with sandy clay loam type of soil and the soil was medium in organic carbon content and the available nutrient status was low in nitrogen, medium in phosphorus and high in potassium.

Experimental Design, Selection of Cultivar and Sowing

The experiment was laid out in randomized complete block design (RBD) with seven treatments and replicated thrice. The gross plot size adopted was 48.6 Sq. meter (9.0 m × 5.4 m). Transgenic cotton hybrid Bollgard II was used for the study. The cotton was sown manually keeping the distance of 90 × 90 cm at 2.5 kg·ha^{-1} of delinted seeds during winter irrigated season of Tamil Nadu.

Treatment Details

Treatments consisted of seven weed management methods viz., pendimethalin at 1.0 kg ha^{-1} + hand weeding (T_1), pendimethalin at 1.0 kg ha^{-1} + power weeder weeding (T_2), hand weeding on 25 and 45 DAS (T_3), power weeder weeding on 25 and 45 DAS (T_4), hand weeding on 25 + power weeder weeding 45 DAS (T_5), power weeder weeding on 25 + hand weeding 45 DAS (T_6) and unweeded check (T_7) in transgenic cotton. As per the treatment schedule pendimethalin was applied as pre-emergence. Hand operated knapsack sprayer fitted with a flat fan type nozzle (WFN 40) was used for spraying the herbicides adopting a spray volume of 500 litres ha^{-1}.

Observations on Weeds

Weed Density

The weed count was recorded species wise using 0.5 m × 0.5 m quadrat from four randomly fixed places in each plot and the weeds falling within the frames of the quadrat were counted and the mean values were expressed in number m^{-2}.

Weed Dry Weight

The weeds falling within the frames of the quadrat were collected, categorised into grasses, sedges and broad-leaved weeds, shade dried and later dried in hot-air oven at 80°C for 72 hrs.

Weed Control Efficiency

Weed control efficiency (WCE) was calculated as per the procedure given by Mani et al. (1973).

$$WCE\ \% = \frac{WD_c - WD_t}{WD_c} \times 100$$

Where,
WCE - weed control efficiency (per cent)
WD_c - weed biomass (g m^{-2}) in control plot.
WD_t- weed biomass (g m^{-2}) in treated plot.

Seed cotton yield

The seed cotton yield obtained from the net plot area at each picking was recorded and expressed in kg ha^{-1}.

Statistical Analysis

The data were statistically analysed following the procedure given by Gomez and Gomez (2010) for randomised block

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design. The data pertaining to weeds were transformed to square root scale of $\sqrt{(x+2)}$. Whenever significant difference existed, critical difference was constructed at five per cent probability level. Such of those treatments where the difference are not significant are denoted as NS.

Results and Discussion

Weed Control Efficacy

Cotton crop being slow in its initial growth and is grown with wider spacing, is always encountered with severe weed competition during early stage, which results in low yield. A broad spectrum of weeds with wider adaptability to extremities of climatic, edaphic and biotic stresses are infesting the cotton fields. Earlier, Buchanan et al. (1980) has shown that yield reduction in cotton is directly related to increasing weed density and duration of interference.

In transgenic cotton, pendimethalin at 1.0 kg ha^{-1} + HW (T_1), HW on 25 and 45 DAS (T_3) and PWW on 25 and HW 45 DAS (T_6)recorded lower weed density and higher weed control efficiency due to better control of weeds at critical stage of crop growth during winter 2009-10 and 2010-11 (Table 1 and 2). The findings are in concurrence with reports of Mahar et al. (2007), who had observed that hand weeding resulted in lower population of weeds or application of pendimethalin at high dose (5 L ha^{-1}) also showed similar performance with hand weeding.

Power weeder weeding on 25 and 45 DAS (T_4) resulted in higher weed density of 73.5 and 76.8 per cent over hand weeding twice (T_3) at 60 DAS. This treatment also recorded higher weed dry weight (21.25 and 22.99 g. m^{-2}) and lower weed control efficiency of 39.2 and 42.4 per cent at critical stage (60 DAS) of the cotton growth. Obviously, unweeded check (T_7) recorded higher weed density, dry weight and lower weed control efficiency. This might be due to highest weed infestation recorded in weedy check and the highest yield in hand weeded plot, which may be due to least weed density while the weeds were not controlled completely in other weed management treatments, as also observed by Khan et al. (1994).

Similar observation were made by Panwar et al. (2001) who had reported that application of pendimethalin at 1.0 kg ha^{-1} reduced the density and dry weight of weeds significantly over the unchecked weed growth. Pendimethalin in combination with inter-culturing + hand weeding gave 90 per cent broad leaf weeds and 89 per cent narrow leaf or grassy weeds control respectively (Ali et al., 2005).

Weed control efficiency (WCE) showed the maximum value of 90.7 and 92.3 under HW on 25 and 45 DAS (T_3) followed by pre-emergence application of pendimethalin at 1.0 kg ha^{-1} + HW (T_1) also registered higher WCE (84.3 and 84.5 per cent) at 60 DAS. The results of the present study indicated that hand weeding twice (T_3) and application of pendimethalin followed by hand weeding (T_1) produced higher WCE throughout the crop period which was comparable with that of PWW on 25 and HW 45 DAS (T_6). This was probably due to lesser weed competition by the weed management practices which favoured the growth and development of cotton, thereby higher weed control efficiency was obtained during early stages than other practices, conformity to the findings of Kumar, (2004).

Seed Cotton Yield

Higher seed cotton yield of transgenic cotton (69.2 and 72.0 per cent) was obtained with hand weeding on 25 and 45 DAS (T_3) compared to unweeded control (T_7) during both the years (Fig. 1), which was comparable with pendimethalin at 1.0 kg ha^{-1} + HW (T_1) which recorded 67.8 and 70.6 per cent increase than in unweeded check (T_7) weed competition. The reduction of weed density and weed biomass with higher weed control efficiency of 90.7, 92.3 % in hand weeding on 25 and 45 DAS (T_3) and 84.3, 84.5 % in pendimethalin at 1.0 kg ha^{-1} + HW (T_1) during critical stage (60 DAS) of the crop growth during winter 2009-10 and 2010-11, respectively, when compared to unweeded control (T_7) might have resulted in increased seed cotton yield. The results are in confirmation with the findings of Raskar and Bhoj (2002), who have recorded higher seed cotton yield with two hand weeding compared to other herbicidal methods of weed control.Maximum increase of 199.4 per cent in seed cotton yield was obtained with pendimethalin in combination with inter-culturing plus hand weeding as earlier reported by Ali et al. (2005).Similarly, application of herbicide pendimethalin, as pre-emergence spray was effective weed control method for cotton along with hand weeding as observed by Tunio et al. (2003).

Interculturing is normal practice to eradicate the weeds but, this practice is not applicable during rainy season due to wet condition in the soil which do not permit the mechanical weeding. Under such circumstances the chemical control measures are the alternate to control the weeds (Ansari et al., 2003). According to Zhang (2003) who has reported that, manual measures for crop weed control without herbicide application is the most labour intensive and impractical in modern agricultural production.

Unweeded control accounted for lower seed cotton yield during winter 2009-10 and 2010-11, due to heavy competition of weeds for nutrients, space and light. Bhoi et al. (2010) earlier reported the advantages of weed management methods recording significantly higher yield under weed free situation followed by pendimethalin @ 1.0 kg a.i ha^{-1} + HW at 50 DAS and hand weeding at 20 and 40 DAS, with lower yield registered under unweeded check.

4. Conclusion

From the results of the field experiments, it could be concluded that, hand weeding twice at 25 and 45 DAS or pre-emergence pendimethalin at 1.0 kg ha^{-1} on 3 DAS + hand weeding on 45 DAS for higher weed control efficiency and seed cotton yield of transgenic cotton with better economic returns. Power weeder weeding on 25 DAS + one hand weeding 45 DAS is a promising alternative weed management method for winter irrigated transgenic cotton with higher seed cotton yield and better economic returns.

Table 1. Effect of weed management methods on total weed density and total weed dry weight in transgenic cotton

Treatments	Total weed density (No. m^{-2})				Total weed dry weight (g. m^{-2})			
	Winter, 2009-10		Winter, 2010-11		Winter, 2009-10		Winter, 2010-11	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
T_1-PE Pendi. at 1.0 kg ha^{-1} + HW	5.86 (32.52)	7.45 (53.24)	6.35 (38.12)	7.32 (51.29)	2.72 (5.49)	3.63 (11.35)	2.85 (6.17)	3.62 (10.96)
T_2-PE Pendi. at 1.0 kg ha^{-1} + PWW	7.73 (57.41)	9.76 (92.82)	7.63 (55.98)	8.96 (78.54)	3.63 (10.97)	5.00 (23.23)	3.90 (13.37)	4.75 (20.66)
T_3 - HW on 25 & 45 DAS	5.13 (24.13)	5.57 (28.81)	4.96 (22.85)	6.12 (35.75)	2.27 (3.24)	2.78 (5.80)	2.23 (3.07)	3.00 (7.15)
T_4 - PWW on 25 & 45 DAS	9.66 (91.14)	10.17 (101.92)	10.04 (98.45)	10.66 (112.24)	4.80 (21.25)	5.15 (24.70)	5.02 (22.99)	5.42 (27.20)

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T_5 - HW on 25 & PWW 45 DAS	7.46 (53.50)	8.47 (69.53)	7.70 (57.44)	8.35 (68.19)	3.51 (10.45)	4.02 (14.33)	3.65 (11.23)	4.00 (14.20)
T_6 - PWW on 25 & HW 45 DAS	6.74 (43.16)	7.88 (59.82)	6.76 (43.60)	7.54 (55.01)	2.97 (6.88)	3.73 (11.8)	2.97 (6.92)	3.57 (10.91)
T_7- Unweeded check	10.85 (114.87)	10.72 (112.59)	11.56 (132.02)	11.27 (125.46)	6.06 (34.9)	6.16 (36.2)	6.45 (39.9)	6.50 (40.4)
SEd	0.87	1.15	0.95	1.02	0.43	0.60	0.57	0.66
CD (P=0.05)	1.70	2.32	1.84	2.00	0.83	1.14	1.10	1.28

Figures in the parenthesis are means of original values, DAS - Days After Sowing, PE – Pre-emergence, Pendi. - Pendimethalin, HW - Hand Weeding, PWW- Power weeder weeding

Table 2. Effect of different weed management methods on weed control efficiency (per cent) in transgenic cotton

Treatments	Weed control efficiency (%)							
	Winter, 2009-10				Winter, 2010-11			
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T_1-PE Pendi. at 1.0 kg ha^{-1} + HW	92.9	84.3	68.7	76.9	92.5	84.5	72.9	74.1
T_2-PE Pendi. at 1.0 kg ha^{-1} + PWW	90.7	68.6	35.8	54.7	89.8	66.5	48.8	52.9
T_3 - HW on 25 & 45 DAS	88.3	90.7	84.0	87.1	88.2	92.3	82.3	82.2
T_4 - PWW on 25 & 45 DAS	76.3	39.2	31.8	49.9	74.5	42.4	32.7	35.6
T_5 - HW on 25 & PWW 45 DAS	85.6	70.1	60.4	66.1	85.8	71.9	64.8	59.1
T_6 - PWW on 25 & HW 45 DAS	88.3	80.3	67.5	75.0	87.5	82.7	73.0	69.5
T_7- Unweeded check	-	-	-	-	-	-	-	-

Data not statistically analysed, DAS - Days After Sowing, PE - Pre-emergence, Pendi. - Pendimethalin, HW - Hand Weeding, PWW- Power weeder weeding

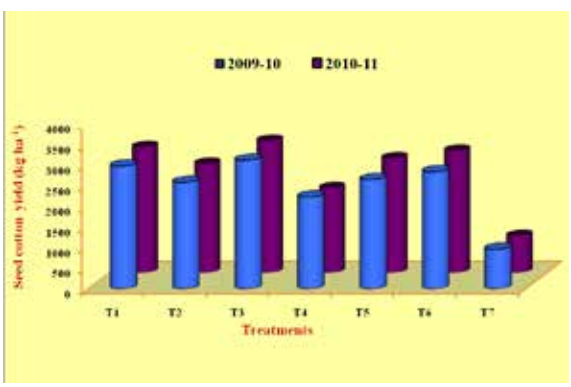

Fig.1. Weed management methods on seed cotton yield in transgenic cotton

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