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Comparative Efficacy of some Synthetic Insecticides against Leafhopper, *Amrasca biguttula biguttula* (Ishida) and Whitefly, *Bemisia tabaci* (Genn.) on *Bt* Cotton

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ABSTRACT

Studies were conducted to evaluate some insecticide molecules *viz*., monocrotophos 36 SL (360 g a.i./ha), acephate 75 SP (562.5 g a.i./ha), imidacloprid 17.8 SL (35.6 g a.i./ha), diafenthiuron 50 WP (300 g a.i./ha), fipronil 5 SC (50 g a.i./ha), dinotefuran 20 SG (40 g a.i./ha), flonicamid 10 WG (15 g a.i./ha) and bifenthrin 10 EC (75 g a.i./ha) as foliar application for their bioefficacy against leafhopper, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Genn.) on Bt cotton during 2013-14. Among the insecticides evaluated, flonicamid 10 WG had shown greater efficacy against leafhoppers as well as whiteflies up to seven days after spray. Dinotefuran 20 SG and monocrotophos 36 SL were found to be effective in control of leafhoppers after flonicamid 10 WG, while diafenthiuron 50 WP (300 g a.i./ha) and bifenthrin 10 EC which were at par with flonicamid 10 WG in reducing whitefly population. Among all the treatments, highest number of bolls and seed cotton yield was observed in flonicamid 10 WG treated plot which had shown significantly better performance over all other treatments in reducing the pest population.

Key words: *Cotton, flonicamid,insecticide evaluation, leafhopper, whitefly.*

Cotton, known as "White Gold", is the premier commercial crop in India. Due to assured protection of bollworms in Bt cotton hybrids, the area under Bt cotton is increasing day by day but at the same time sucking pests has emerged as major threat for cotton growers causing heavy yield losses. Among the sucking pests, leafhopper, *Amrasca biguttula biguttula* (Ishida); thrips, *Thrips tabaci* (Linn); aphids, *Aphis gossypii* (Glovar) and whiteflies, *Bemisia tabaci* (Genn.) are the important pests from seedling stage and cause heavy losses in tune of 21.20 to 22.86 per cent (Kulkarani *et al*., 2003).

Among the sucking pests attacking cotton in early stages of crop growth, leafhoppers constitute as one of the important sap feeders. The desaping by the leafhoppers cause specking symptoms, crinkling, distortion of leaves and reddening all along the sides of leaves and such type of symptom is called "Hopper burn" which lead to drying of leaves affecting the growth and reduction in square number and ultimately become one of limiting factor in the productivity of the crop. The losses in yield due to this pest have been reported to be 1.19 q per hectare (Dhawan *et al.,*1988). Whitefly causes great damage to the cotton crop, by sucking the cell sap from under surface of leaves, it secrets the honey dew, as a result sooty mold grows which reduces the photosynthetic area of leaves and as a vector whitefly transmits the viral diseases to cotton crop (Khan & Ahmad, 2005). To combat these sucking pests, cotton growers in India rely mainly on synthetic pesticides. Now a days, numbers of new insecticide molecules are introduced in the market and those are not only effective but also cost effective and less toxic to the existing natural enemies of the pests. Therefore, the present investigation was conducted to evaluate the efficacy of different insecticides against leafhoppers and whiteflies infesting *Bt* cotton.

MATERIAL AND METHODS

Evaluation of insecticides: The experiment to evaluate the insecticides to manage leafhoppers and whiteflies on cotton crop was conducted at Regional Agricultural Research Station, Lam farm, Guntur, Andhra Pradesh during *kharif* season in the year

2013-14. The experiment was laid out in Randomized Block Design with eight insecticides monocrotophos 36 SL (360 g a.i./ha), acephate 75 SP (562.5 g a.i./ha), imidacloprid 17.8 SL (35.6 g a.i./ha), diafenthiuron 50 WP (300 g a.i./ha), fipronil 5 SC (50 g a.i./ha), dinotefuran 20 SG (40 g a.i./ ha), flonicamid 10 WG (15 g a.i./ha), bifenthrin 10 EC (75 g a.i./ha) for foliar application and a control treatment which were replicated thrice. RCH 2 *Bt* cotton hybrid was selected for this purpose with the spacing of 105×60 cm with each plot size of 25 sq.m. Standard agronomic practices were adopted to raise a good cotton crop.

Preparation of spray fluid for foliar application:

A measured quantity of insecticidal solution /powder was mixed with a little quantity of water and stirred well, after which the remaining quantity of water was added to obtain the required concentration of spray fluid.

Foliar application of treatments:

Sprayings were given by using a hand compression knapsack high volume sprayer, during morning hours. The plot in each treatment was sprayed with respective insecticides ensuring uniform coverage of insecticide. The first spraying was given at 50 days after sowing when the incidence of pest population was sufficiently built up in the experimental plots. A total of four sprays were given during the course of season at 10 days interval.

Recording observations:

Pest count of leafhoppers and whiteflies on three leaves of top, middle and bottom per plant were recorded with the help of 4X magnifying lens on 5 randomly selected plants per each treatment at third and seventh day after treatment (DAT). Number of bolls per each plant and the kapas yield from each plot were recorded separately in kg/plot for two pickings and converted into q/ha.

RESULTS AND DISCUSSION

Efficacy of insecticides against leafhoppers and whiteflies on cotton after first application:

The data after three days of first application (Table 1) revealed that all the treatments had shown significant differences over control. Flonicamid 10 WG treated plot recorded the least population of leafhoppers (2.53/3 leaves/plant), followed by dinotefuran 20 SG (3.07/3 leaves/plant) and monocrotophos 36 SL (3.47/3 leaves/plant) where as imidacloprid 17.8 SL (6.13/3 leaves/plant) and bifenthrin 10 EC (6.40/ 3 leaves/plant) recorded the highest leafhopper population. Similar trend was observed at 7 days after treatment, where flonicamid 10 WG, dinotefuran 20 SG and monocrotophos 36 SL which were on par with each other recorded less leafhopper population of 2.93, 3.67 and 4.13/ 3 leaves/plant respectively (Table 1). The next best insecticides were diafenthiuron 50 WP, fipronil 5 SC and acephate 75 SP which recorded significant lower (4.93, 5.87 and 6.13/ 3 leaves/plant respectively) population. Significantly higher leafhopper population was observed in the plots treated with imidacloprid 17.8 SL (7.27/ 3 leaves/ plant) and bifenthrin 10 EC (7.67/ 3 leaves/plant). The data recorded for whiteflies at 3 DAT and 7 DAT of the first spray was non significant due to less population of whiteflies in the experimental plot at that time (Table 2).

Efficacy of insecticides against leafhoppers and whiteflies on cotton after second application:

The population data of leafhoppers after three days of second application (Table 1) revealed that flonicamid 10 WG recorded less population (3.07/3 leaves/plant), followed by dinotefuran SG (3.93/3 leaves/plant) which were at par with each other. Similar trend in controlling leafhopper population was found by the remaining insecticides as observed in the 3 DAT and 7 DAT of first spray. Though the leafhopper population recorded by all the insecticides tested was significantly lower than the untreated control plot (15.80/3 leaves/plant), the highest leaf hopper population was recorded in imidacloprid 17.8 SL (9.07/ 3 leaves/plant) and bifenthrin 10 EC (9.47/ 3 leaves/plant) at 7 DAT. Whitefly population in the experimental plot was slightly increased at the time of second spray (Table 2). Among the insecticides tested flonicamid 10 WG treated plot recorded reduced whitefly population of 1.40/ 3 leaves/plant where the population in control plot was 2.87/ 3 leaves/plant at 7 DAT after second spray.

Efficacy of insecticides against leafhoppers and whiteflies on cotton after third application:

The chemicals which could control the pest population in the first and second foliar application had shown the same pattern of results in the third foliar application. Flonicamid 10 WG treated plot recorded less population (3.73/3 leaves/plant) of leafhopper while bifenthrin 10 EC (9.47/3 leaves/

Table 1. Efficacy of insecticides against leafhoppers on cotton

Treatments	Number of leafhoppers/3leaves/plant									
	Before Spray	First spray		Second spray		Third spray		Fourth spray		Cumulative efficacy of four sprays at 7 DAT
		3 DAT	7 DAT	3 DAT	7 DAT	3 DAT	7 DAT	3 DAT	7 DAT	
T1:Monocrotophos 36 SL	8.27	3.47	4.13	4.53	5.20	4.73	5.87	3.80	3.60	4.70
	(2.88)	(1.86)^{b}	(2.03)^{ab}	(2.13)^{bc}	(2.28)^{bc}	(2.18)^{bc}	(2.42)^{bc}	(1.95)^{bc}	(1.90)^{bc}	(2.17)^{c}
T2:Acephate 75 SP	7.87	5.27	6.13	7.00	7.53	6.60	8.40	5.40	4.73	6.70
	(2.80)	(2.29)^{cd}	(2.48)^{cd}	(2.65)^{def}	(2.74)^{de}	(2.57)^{de}	(2.90)^{de}	(2.32)^{de}	(2.18)^{cd}	(2.59)^{e}
T3:Imidacloprid 17.8 SL	7.67	6.13	7.27	7.87	9.07	7.47	9.07	6.53	5.53	7.73
	(2.77)	(2.48)^{cd}	(2.70)^{d}	(2.80)^{ef}	(3.01)^{ef}	(2.73)^{e}	(3.01)^{e}	(2.56)^{ef}	(2.35)^{d}	(2.78)^{f}
T4:Diafenthiuron 50 WP	8.20	4.00	4.93	5.67	6.53	5.27	6.80	4.53	4.07	5.58
	(2.86)	(2.00)^{b}	(2.22)^{bc}	(2.38)^{cd}	(2.56)^{cd}	(2.29)^{bcd}	(2.61)^{cd}	(2.13)^{cd}	(2.02)^{c}	(2.36)^{d}
T5:Fipronil 5 SC	7.60	5.00	5.87	6.40	7.27	6.13	7.67	5.20	4.60	6.35
	(2.76)	(2.24)^{bc}	(2.42)^{cd}	(2.53)^{de}	(2.70)^{de}	(2.48)^{cde}	(2.77)^{de}	(2.28)^{de}	(2.14)^{cd}	(2.52)^{e}
T6:Dinotefuran 20 SG	7.67	3.07	3.67	3.93	4.47	3.80	4.80	3.27	2.93	3.97
	(2.77)	(1.75)^{ab}	(1.91)^{ab}	(1.98)^{ab}	(2.11)^{ab}	(1.95)^{ab}	(2.19)^{ab}	(1.81)^{ab}	(1.71)^{ab}	(1.99)^{b}
T7:Flonicamid 10 WG	8.07	2.53	2.93	3.07	3.53	2.87	3.73	2.60	2.47	3.17
	(2.84)	(1.59)^{a}	(1.71)^{a}	(1.75)^{a}	(1.88)^{a}	(1.69)^{a}	(1.93)^{a}	(1.61)^{a}	(1.57)^{a}	(1.78)^{a}
T8:Bifenthrin 10 EC	7.80	6.40	7.67	8.20	9.47	8.07	9.47	7.13	5.87	8.12
	(2.79)	(2.53)^{d}	(2.77)^{d}	(2.86)^{f}	(3.08)^{f}	(2.84)^{e}	(3.08)^{e}	(2.67)^{f}	(2.42)^{d}	(2.85)^{f}
T9:Control	7.87	9.07	10.27	13.20	15.80	19.07	21.47	18.53	16.20	15.93
	(2.80)	(3.01)^{e}	(3.20)^{e}	(3.63)^{g}	(3.97)^{g}	(4.37)^{f}	(4.63)^{f}	(4.31)^{g}	(4.02)^{e}	(3.99)^{g}
F-test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEm±	0.11	0.09	0.12	0.10	0.11	0.12	0.11	0.10	0.09	0.05
CD (P=0.05)	0.33	0.25	0.35	0.30	0.33	0.36	0.34	0.28	0.28	0.14
CV(%)	6.80	6.79	8.58	6.92	7.17	8.14	6.97	6.89	7.24	3.17

Figures in parentheses are square root transformed values. NS: Non Significant, Sig: Significant

Table 2. Efficacy of insecticides against whitefly on cotton

Treatments	Number of leafhoppers/3leaves/plant									
	Before Spray	First spray		Second spray		Third spray		Fourth spray		Cumulative efficacy of four sprays at 7 DAT
		3 DAT	7 DAT	3 DAT	7 DAT	3 DAT	7 DAT	3 DAT	7 DAT	
T1:Monocrotophos 36 SL	1.40	1.20	1.27	1.67	2.20	3.07	4.07	3.47	4.27	2.95
	(1.18)	(1.10)	(1.15)	(1.29)^{b}	(1.48)^{bcd}	(1.75)^{cde}	(2.02)^{cde}	(1.86)^{cd}	(2.07)^{cde}	(1.72)^{cd}
T2:Acephate 75 SP	1.33	1.13	1 .20	1.53	1.93	2.67	3.47	3.07	3.73	2.58
	(1.15)	(1.06)	(0.89)	(1.24)^{ab}	(1.39)^{abc}	(1.63)^{bcd}	(1.86)^{abc}	(1.75)^{bc}	(1.93)^{bcd}	(1.61)^{bc}
T3:Imidacloprid 17.8 SL	1.27	1.27	1.20	1.73	2.47	3.67	4.67	4.07	5.07	3.35
	(1.13)	(1.13)	(1.18)	(1.32)^{bc}	(1.57)^{cd}	(1.91)^{de}	(2.16)^{de}	(2.02)^{d}	(2.25)^{de}	(1.83)^{de}
T4:Diafenthiuron 50 WP	1.33	1.00	1.07	1.27	1.60	1.93	2.60	2.47	2.93	2.05
	(1.15)	(1.00)	(1.24)	(1.13)^{ab}	(1.26)^{ab}	(1.39)^{ab}	(1.61)^{ab}	(1.57)^{ab}	(1.71)^{ab}	(1.43)^{a}
T5:Fipronil 5 SC	1.27	1.27	1.27	1.73	2.53	3.93	5.13	4.40	5.67	3.65
	(1.13)	(1.13)	(0.97)	(1.32)^{bc}	(1.59)^{cd}	(1.98)^{e}	(2.27)^{e}	(2.10)^{d}	(2.38)^{e}	(1.91)^{e}
T6:Dinotefuran 20 SG	1.20	1.20	1.27	1.60	2.20	3.00	3.73	3.40	4.00	2.80
	(1.10)	(1.10)	(1.00)	(1.26)^{ab}	(1.48)^{bcd}	(1.73)^{cde}	(1.93)^{bcd}	(1.84)^{c}	(2.00)^{bcd}	(1.67)^{bcd}
T7:Flonicamid 10 WG	1.40	0.93	1.00	1.13	1.40	1.67	2.27	2.07	2.47	1.78
	(1.18)	(0.97)	(1.06)	(1.06)^{a}	(1.18)^{a}	(1.29)^{a}	(1.51)^{a}	(1.44)^{a}	(1.57)^{a}	(1.34)^{a}
T8:Bifenthrin 10 EC	1.27	1.07	1.07	1.27	1.73	2.13	2.93	2.67	3.33	2.27
	(1.13)	(1.03)	(1.18)	(1.13)^{ab}	(1.32)^{abc}	(1.46)^{abc}	(1.71)^{abc}	(1.63)^{abc}	(1.83)^{abc}	(1.51)^{ab}
T9:Control	1.40	1.60	1.73	2.27	2.87	5.60	7.73	10.27	12.20	6.13
	(1.18)	(1.26)	(1.29)	(1.51)^{c}	(1.69)^{d}	(2.37)^{f}	(2.78)^{f}	(3.20)^{e}	(3.49)^{f}	(2.48)^{f}
F-test	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEm±	0.05	0.07	0.07	0.07	0.10	0.11	0.13	0.08	0.12	0.06
CD (P=0.05)	0.16	NS	NS	0.21	0.29	0.33	0.37	0.25	0.34	0.17
CV(%)	8.08	10.88	10.25	9.88	12.00	11.27	11.09	7.50	9.43	5.81

Figures in parentheses are square root transformed values. NS: Non Significant, Sig: Significant, DAT: Days after treatment.

Table 3: Influence of insecticides on number of bolls / plant and seed cotton yield

Treatment No.	Treatments	Dosage	Number of bolls/plant	Seed cotton yield (Q ha^{-1})
T_1	Monocrotophos 36 SL	360 g a.i./ha	46.89 ^{bc}	20.96 ^{bc}
T_2	Acephate 75 SP	562.5 g a.i./ha	37.11 ^{d}	15.14 ^{e}
T_3	Imidacloprid 17.8 SL	35.6 g a.i./ha	29.00 ^{e}	14.51 ^{ef}
T_4	Diafenthiuron 50 WP	300 g a.i./ha	45.67 ^{c}	19.15 ^{cd}
T_5	Fipronil 5 SC	50 g a.i./ha	39.33 ^{d}	18.45 ^{d}
T_6	Dinotefuran 20 SG	40 g a.i./ha	54.00 ^{b}	21.97 ^{ab}
T_7	Flonicamid 10 WG	15 g a.i./ha	59.33 ^{a}	23.45 ^{a}
T_8	Bifenthrin 10 EC	75 g a.i./ha	26.89 ^{e}	12.63 ^{f}
T_9	Control		22.56 ^{f}	11.15 ^{f}
F-test			Sig.	Sig.
SEm			0.90	0.78
CD (P=0.05)			2.67	2.32
CV (%)			4.76	9.49

Sig. : Significant

plant) recorded higher leafhopper population but less than the control plot (21.47/3 leaves/plant) after seven days of third spray (Table 1). Due to the presence of heavy leafhopper population on the cotton plants of untreated control plot, hopper burn symptom was observed. With regard to whitefly population at 7 DAT of third spray, untreated control plot had shown highest population (7.73/3 leaves/plant) over the insecticide sprayed plots (Table 2). Flonicamid 10 WG, diafenthiuron 50 WP and bifenthrin 10 EC had shown reduced whitefly population (2.27, 2.60 and 2.93/3 leaves/plant respectively) over other insecticides, while fipronil 5 SC recorded higher population (5.13/3 leaves/plant).

Efficacy of insecticides against leafhoppers and whiteflies on cotton after fourth application:

The data after three days and seven days of fourth application followed the same trend of chemical control of leafhopper population by the insecticides as observed in the previous sprays (Table 1). Flonicamid 10 WG recorded the lowest population (2.60/3 leaves/plant) while bifenthrin 10 EC was found to be the least effective (7.13/3 leaves/plant) but better than untreated control plot (18.53/3 leaves/plant) at 3 DAT of fourth spray. Same trend of pest control had shown by the insecticides at 7 DAT. In case of whitefly population, minimum number of pest was recorded in the flonicamid 10 WG, diafenthiuron 50 WP and bifenthrin 10 EC treated plots (2.47, 2.93 and 3.33/3 leaves/plant) while maximum number of pest was recorded on the fipronil 5 SC treated plot (5.67/3 leaves/plant), which was found to be less effective among the insecticides evaluated but significantly reduced the pest population over untreated control plot (12.20/3 leaves/plant).

Cumulative efficacy of four sprays at 7 DAT against leafhoppers and whiteflies on cotton:

The cumulative efficacy of all the four sprays of different insecticides against leafhoppers at seven days after spray had shown that the treatment flonicamid 10 WG recorded the lowest population of leafhoppers (3.17/3 leaves/plant) in all the sprayings and was significantly superior to all the other treatments including untreated check (Table 1). The next best treatment was dinotefuran 20 SG with reduced pest population (3.97/3 leaves/plant) and these present findings on the efficacy of flonicamid 10 WG and dinotefuran 20 SG are confirming with those of earlier workers Kumar and Dhawan (2011) and Gaurkhede *et al*. (2015) who noticed the lowest population of leafhopper in the treated plots of flonicamid 50 WG @ 0.02 per cent and dinotefuran 20 SG @ 0.008 per cent. The next promising insecticide in controlling leafhopper population was monocrotophos 36 SL (4.70/3 leaves/plant) which was followed by the remaining insecticides *viz*., diafenthiuron 50 WP (5.58/3 leaves/plant) fipronil 5 SC (6.35/3 leaves/plant) and

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acephate 75 SP (6.70/3 leaves/plant). Similar observations were also recorded by Sathyan *et al.* (2016) who stated that diafenthiuron 50 WP, fipronil 5 SC and monocrotophos 36 SL were able to reduce the leafhopper population by more than 50 per cent in cotton over untreated check. Imidacloprid 17.8 SL and bifenthrin 10 EC which were on par with each other reported higher leafhopper population and found to be the least effective, when compared with the remaining insecticides. The efficacy of all the treatments decreased after 7 DAT leading to slight build up of population.

The data regarding the cumulative efficacy of all the four sprays of different insecticides against whiteflies at 7 DAT had shown that the treatment flonicamid 10 WG and diafenthiuron 50 WP registered the lowest population (1.78 and 2.05/3 leaves/plant respectively). The present findings are in agreement with Ghelani *et al.* (2014) who reported that effective control of whiteflies was observed with application of flonicamid 0.02 per cent, and Barrania and Taleb, 2014 reported that diafenthiuron 50 WP had higher efficacy against whiteflies. Though the insecticide bifenthrin 10 EC was found to be less effective against leafhopper, it was found to be promising in reducing whitefly population (2.57/3 leaves/plant). This is in confirmation with the results of Muhammad Aslam *et al.* (2004) who reported that one day after the spray, maximum decrease in whitefly population was observed in bifenthrin 10 EC treated plots. The next best treatments were acephate 75 SP, dinotefuran 20 SG and monocrotophos 36 SL with the population of 2.58, 2.80 and 2.95/3 leaves/plant. Among the insecticides evaluated imidacloprid 17.8 SL and fipronil 5 SC were found to be least effective in reducing the pest population. The present findings are in agreement with the work of Bharpoda *et al.* (2014) who reported that acephate 75 SP and diafenthiuron 50 WP were effective against whitefly while fipronil 5 SC was least effective.

Influence of insecticides on number of bolls / plant and cotton yield:

Number of bolls per each plant and the kapas yield from each plot were recorded separately in kg/plot for two pickings and converted into q/ha (Table 3). The data showed that flonicamid 10 WG which was effective against leafhoppers and whiteflies recorded the highest number of bolls per plant (59.33) and yield (23.45 q/ha). Dinotefuran 20 SG which was on par with flonicamid 10 WG recorded 54 bolls per plant and yield of 21.97 q/ha. Monocrotophos 36 SL and diafenthiuron 50 WP were on par with each other and recorded 46.89,45.67 bolls per plant and 20.96, 19.15 Q/ha respectively. Less number of bolls (26.89) and yield (12.63 q/ha) was observed in bifenthrin 10 EC. Untreated control plot recorded the least number of bolls (22.56/plant) and yield (11.15 q/ha). The present findings are in agreement with Rohini *et al.* (2011) who evaluated different insecticides for their efficacy against sucking pests of cotton and reported that the insecticides which were found to be more effective in controlling the sucking pest resulted in higher number of bolls and yield than the less effective insecticides.

CONCLUSIONS

Among the insecticides tested, flonicamid 10 WG was found to be highly effective against leafhoppers which was followed by dinotefuran 20 SG, monocrotophos 36 SL and diafenthiuron 50 WP. The remaining insecticides fipronil 5 SC, acephate 75 SP, imidacloprid 17.8 SL and bifenthrin 10 EC were very less effective when compared with flonicamid 10 WG. Whitefly population was effectively controlled by flonicamid 10 WG and diafenthiuron 50 WP. Highest number of bolls (59.33/ plant) and seed cotton yield (23.45 q/ha) was observed in flonicamid 10 WG treated plot which had shown significantly better performance over all other treatments. Flonicamid is very effective against sucking pest in cotton. It rapidly inhibits the feeding behavior of leafhoppers and whiteflies and provides long-lasting control. Previous workers reported that flonicamid shows no cross-resistance to conventional insecticides and exhibits excellent systemic and translaminar activity. It has no negative impact on beneficial insects and mites. Furthermore, it has a favourable toxicological, environmental and ecotoxicological profile. These characteristics make flonicamid well suited for resistant management strategies and integrated pest-management programs. Apart from the flonicamid, the above tested chemicals which are effective would be helpful in mitigating sucking pest problem, which are alarming in the present situation and could be included in IPM of either *Bt* cotton or conventional cotton as a promising component.

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