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Evaluation of Combination of Botanicals and Insecticides against Population Builds up of Cotton Whitefly (*Bemisia tabaci*, Gennadius) and Its Natural Enemies

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A B S T R A C T

To manage the population of cotton whitefly (*Bemisia tabaci*), an experiment was laid out in randomised block design (RBD) with nine treatments including untreated control and each treatment was replicated thrice. The study revealed that among nine treatments T_8 (Neem Baan 1500 ppm @ 1.0 l/acre + thiamethoxam 25 WG @ 40 g/acre + Neem Baan 1500 ppm @ 1.0 l/acre) was better against whitefly, where the minimum population of adult whiteflies were found during 3rd DAS (1.89 adults/leaf), 5th DAS (1.78 adults/leaf) and 7th DAS (2.11 adults/leaf) but T_1 was found safest to the natural enemies with 1.89 per plant natural enemies population and had highest BC ratio (1.17).

Introduction

Cotton (*Gossypium* spp.) belongs to the family "*Malvaceae*" and genus "*Gossypium*" popularly known as "White Gold" and "Natural Fiber" is a commercial crop of paramount importance. It is considered as the landmark achievement of any civilization as it provides clothing to human beings and gainful employment to millions of people in the field of agriculture and industry (Singhal, 2003).

In India cotton is cultivated on 11.87 million hectare with a production of 484 million bales of seed cotton (Anonymous, 2015). The average productivity of cotton in India is 537 kilogram lint per hectare which is low when compared to world average of 760 kilogram lint per hectare. India occupies 37.20 per cent of global cotton area contributing 25.58 per cent of world production. Thus India ranks first in area and production on global basis. Despite the large area, the productivity in India is very low (Patel *et al.*, 2016). In Haryana, cotton crop is grown in five major districts viz., Hisar, Fatehabad, Jind, Bhiwani and Sirsa. The year 2015-16 was not congenial for cotton as both abiotic and biotic stresses pulled down the production as well as productivity in these areas. The total area under cotton was 6.03 lakh hectares and production was 15.00 lakh bales with

productivity of 423 kilogram per hectare (Anonymous, 2015).

Amongst the cotton insect-pests, whitefly a sucking insect-pest has been reported as a major pest during mid to late cotton growing season causing 50 per cent damage due to loss of sap which ultimately reduces plant vigour.

The excessive and indiscriminate use of insecticides for the control of sucking pests has resulted in development of insecticide resistance to cypermethrin, acephate, chlorpyriphos, dimethoate, monocrotophos, oxydemeton methyl and quinalphos (Kumar and Grewal, 2014).

The management of *Bemisia tabaci* is challenging task as well as having ill-effects to human health and environment in the present day scenario upon using the insecticides for the control of the pest. Thus keeping in view the devastating effect of whitefly during 2015 in Punjab and Haryana the cotton growing states of North India, the present studies were undertaken with an aim to determine the best combination of safer pesticides to manage whitefly without harming the NEs.

Materials and Methods

The experiment was conducted during *kharif* season of 2016 at Research Area of Department of Entomology, CCS Haryana Agricultural University, Hisar. Experiment was laid out in randomised block design (RBD) with nine treatments including untreated control and each treatment was replicated three times (made into blocks) and denoted as B1, B2 and B3.

The American cotton variety H-1117 was used for the experiment which was sown on 7th may 2016. The crop was sown by maintaining a spacing of 67.5 cm x 30 cm in a plot size of 5 m x 4 m with a block border of 1 m between replications and 30 cm bund between the plots. The experimental field was maintained according to the recommendation of "Package of Practices of *Kharif* crops" of CCS Haryana Agricultural University, Hisar (Anonymous, 2005). When the whitefly population reached economic threshold (ET) *i.e.* 6-8 adults per leaf, the crop was treated with the following treatments of bio rational pesticides thrice at 10 days intervals of each spray. Sprayings were done by employing a knapsack sprayer using hollow cone nozzle and the latter were held 0.3-0.5 meter above the cotton plants while spraying (Wu *et al.,* 2002).

The crop was sprayed with an application rate of 200 litre water per acre. There were nine treatments including control, each of them consisted of different insecticides with their dosages as per the recommendation of the package of practices (Table 1).

Population of whitefly was recorded as per the method adopted under objective number one. Post treatment observations were recorded 1, 3, 5 and 7 days after treatment. Then the observations were compared to conclude which is the most effective insecticide against whitefly and safest for their natural enemies.

Results and Discussion

Effects of insecticides against adult whitefly population build up

In each treatment three sprays were done at ten days interval and the data was taken one day before and on the 1st, 3rd, 5th and 7th DAS (days after spray). The "T_9" was taken as control having no insecticide treatment. The data in the Table 2 revealed that all the insecticides evaluated against the whitefly adults; less number of adult whiteflies was recorded as compared to control. There was no significant difference in the population of whitefly before applying the insecticides.

Observation after first spray recorded on 1st DAS (days after spray) revealed that minimum population of whitefly adults *i.e.* 1.11 per leaf was in treatment T_5 followed by T_4 (1.22 adults/leaf). The minimum whitefly population found on 3rd DAS *i.e.* 3 per leaf was in treatment T_4, which was found at par with the T_3. Observation recorded on 5th DAS revealed that minimum population of whitefly adults *i.e.* 4.78 per leaf was in treatment T_5.

On the 7th DAS observation of whitefly population was found minimum in T_4 *i.e.* 7.67 per leaf. All the treatments had less population of whitefly than T_9.

In the second spray there was change in sequence (as mentioned above) of the application of insecticides *i.e.* in T_5, T_6, T_7 and T_8. Observations on 1st DAS revealed the minimum population in the T_8 (0.22 adults/leaf) that was followed by T_6 (0.33 adults/leaf). The same trend of population build up was there in following days, where there was minimum population of adults found in T_8 *i.e.* 3rd DAS (1.89 adults/leaf), 5th DAS (2.67 adults/leaf), 7th DAS (7.55 adults/leaf). All the treatments had less population of whitefly than T_9. In the third spray there was again change in the insecticide sequence *i.e.* in T_5, T_6, T_7 and T_8. Observations on 1st DAS revealed the minimum population in the T_8 (0.67 adults/leaf) that was followed by T_6 (0.89 adults/leaf). The same trend of population build up was there in following days, where there was minimum population of adults found in T_8 *i.e.* 3rd DAS (1.89 adults/leaf), 5th DAS (1.78 adults/leaf), 7th DAS (2.11 adults/leaf). There was effective control of whitefly adults in T_8.

Effects of insecticides against natural enemies' population of whitefly

The data in Figure 1 indicate that up to some extent the natural enemies' population of whitefly especially the predators like lady bird beetles and their grubs, *chrysoperla carnea* grub and the spider are affected by all the chemical treatments applied against whitefly management. The natural enemies' population before insecticide spray was found to be differ numerically but not significantly. Among them the T_1 was found safest to the natural enemie's population which was followed by T_5 and the harmful one was T_4 which even destroyed the natural enemies' population completely.

Table.1 Different chemical treatments for management of whitefly on cotton

	TREATMENTS:
T1	Nimbecidine 300 ppm @ 1.0 l/acre
T2	Neem Baan 1500 ppm @ 1.0 l/acre
T3	Thiamethoxam 25 WG @ 40 g /acre
T4	Triazophos 40EC @ 600 ml/acre
T5	Nimbecidine 300 ppm @ 1.0 l/acre + Nimbecidine 300 ppm @ 1.0 l/acre +
	Thiamethoxam25 WG @ 40 g /acre
T6	Nimbecidine 300 ppm @ 1.0 l/acre + Thiamethoxam 25 WG @ 40 g /acre +
	Nimbecidine 300 ppm@ 1.0 l/acre
T7	Neem Baan 1500 ppm @ 1.0 l/acre + Neem Baan 1500 ppm @ 1.0 l/acre +
	Thiamethoxam 25 WG @ 40 g /acre
T8	Neem Baan 1500 ppm @ 1.0 l/acre + Thiamethoxam 25 WG @ 40 g /acre + Neem
	Baan 1500 ppm @ 1.0 l/acre
T9	Control

Table.2 Mean population of whitefly adults after spraying different insecticides at 10 days interval during *khraif* 2016 season

Treatments	Before spray (24th August)	Whitefly adults population per leaf after 3 sprays at 10 days interval											
		1st spray				2nd spray				3rd spray			
		1st DAS	3rd DAS	5th DAS	7th DAS	1st DAS	3rd DAS	5th DAS	7th DAS	1st DAS	3rd DAS	5th DAS	7th DAS
T_1	7	1.33	3.33	5.11	9.89	2.44	4	5.89	9.67	2.67	3.67	6.56	6.89
	(2.825)	(1.525)	(2.081)	(2.471)	(3.298)	(1.855)	(2.235)	(2.625)	(3.265)	(1.914)	(2.157)	(2.748)	(2.809)
T_2	7.45	2.33	4.22	6.45	10.11	1.89	3.22	5	9	2.22	3.33	5.11	5.67
	(2.905)	(1.824)	(2.284)	(2.728)	(3.330)	(1.698)	(2.054)	(2.449)	(3.162)	(1.792)	(2.081)	(2.472)	(2.581)
T_3	7.22	3.33	3	6.22	10.78	3.33	3.11	6.11	11.11	3.44	2.78	6.89	7.44
	(2.862)	(2.081)	(1.995)	(2.687)	(3.431)	(2.081)	(2.027)	(2.666)	(3.480)	(2.108)	(1.938)	(2.809)	(2.906)
T_4	6.89	1.22	3	5.22	7.67	1.22	3.22	6.33	10.11	2.11	3.55	6.22	5.33
	(2.803)	(1.489)	(1.999)	(2.493)	(2.943)	(1.489)	(2.054)	(2.708)	(3.332)	(1.753)	(2.133)	(2.687)	(2.516)
T_5	7.22	1.11	3.11	4.78	9.67	2.33	4.33	5.89	9.56	1.89	2.22	3	4.33
	(2.865)	(1.452)	(2.027)	(2.401)	(3.265)	(1.824)	(2.309)	(2.625)	(3.246)	(1.692)	(1.794)	(1.999)	(2.309)
T_6	8.11	1.25	3.45	5	9.89	0.33	2.11	3.56	8.11	0.89	2.11	2.89	3.11
	(3.014)	(1.493)	(2.107)	(2.449)	(3.299)	(1.149)	(1.761)	(2.132)	(3.018)	(1.365)	(1.761)	(1.972)	(2.026)
T_7	7.33	2.33	4.11	6.33	10.33	1.44	3.44	4.11	9.11	1.33	2.33	3.44	4.78
	(2.885)	(1.824)	(2.259)	(2.449)	(3.366)	(1.551)	(2.108)	(2.260)	(3.178)	(1.525)	(1.824)	(2.106)	(2.404)
T_8	7.22	2.22	4.33	6.56	10.22	0.22	1.89	2.67	7.55	0.67	1.89	1.78	2.11
	(2.866)	(1.794)	(2.309)	(2.748)	(3.350)	(1.102)	(1.694)	(1.911)	(2.923)	(1.276)	(1.699)	(1.664)	(1.761)
T_9	7.22	7.11	7.67	8.33	12.22	7.22	7.89	8.56	11.45	7.44	7.89	8.56	7.33
	(2.862)	(2.845)	(2.943)	(3.054)	(3.636)	(2.866)	(2.980)	(3.091)	(3.527)	(2.905)	(2.980)	(3.091)	(2.884)
SE(m)±	(0.104)	(0.051)	(0.049)	(0.055)	(0.065)	(0.073)	(0.050)	(0.050)	(0.061)	(0.088)	(0.067)	(0.049)	(0.041)
CD (P=0.05)	(N.S)	(0.155)	(0.147)	(0.166)	(0.197)	(0.222)	(0.152)	(0.152)	(0.184)	(0.266)	(0.202)	(0.149)	(0.124)

Fig.1 Population of whitefly natural enemies/plant after spray of different insecticide

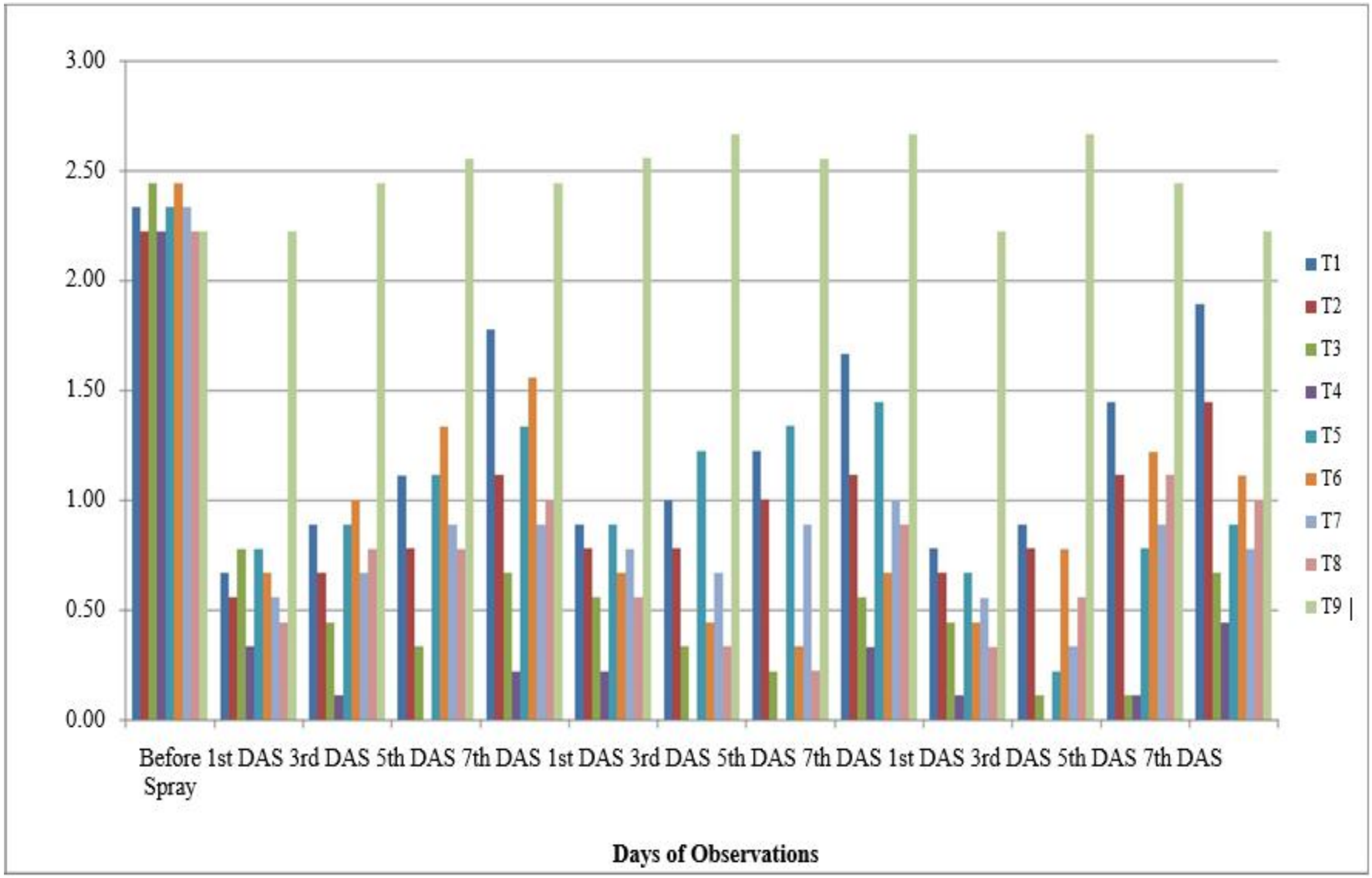

Table.3 Benefit cost ratio of cotton after whitefly management by various treatments

Input		**Cost**
Nimbecidine 300 ppm (2.5 l/ha)		Rs. 280/l
Neem Baan 1500 ppm (2.5 l/ha)		Rs. 383/l
Thiamethoxam 25 WG	(0.1 Kg/ha)	Rs. 1510/Kg
Triazophos 40 EC (1.5 l/ha)		Rs. 390/l
Labour charge		Rs. 350/one man day
Market Price of Cotton		Rs. 5000/q
Price of by products		Rs. 188/q of cotton
Harvesting Charge		Rs. 850/q of cotton

Treatment	Yield q/ha	Variablecost	Totalcost	Gross Returns	*ROVC	*ROTC	B:C ratio cost over variable	B:C ratio over total cost
T_1	20.12	53183	89570	104375	51193	14805	1.96	1.17
T_2	20.23	54083	90650	104875	50793	14225	1.94	1.16
T_3	18.45	49910	85643	96000	46090	10358	1.92	1.12
T_4	18.87	52135	88315	98125	45990	9810	1.88	1.11
T_5	19	51568	87633	98750	47183	11118	1.91	1.13
T_6	19.23	51775	87883	99875	48100	11993	1.93	1.14
T_7	19.12	52220	88418	99375	74155	10958	1.90	1.12
T_8	19.45	52523	88778	101000	48478	12223	1.92	1.14
T_9	16.77	46715	81808	87633	40918	5825	1.88	1.07

*ROVC - Returns over Variable cost *ROTC - Returns over Total cost

Among the various treatments the maximum BC ratio (1.17) was obtained from T_1 (nimbecidine 300 ppm @ 1l/acre, three sprays at 10 days intervals) which was followed by (1.16) in T_2 (Neem Baan 1500 ppm @ 1l/acre, three sprays at 10 days intervals) and (1.14) in T_8 (Neem Baan 1500 ppm @ 1.0 l/acre + thiamethoxam 25 WG @ 40 g/acre + Neem Baan 1500 ppm @ 1.0 l/acre) (Table 3). The present findings revealed that according to population reduction aspect the control of both nymphs and adults of whitefly were better in case of T_8 (Neem Baan 1500 ppm @ 1.0 l/acre + thiamethoxam 25 WG @ 40 g/acre + Neem Baan 1500 ppm @ 1.0 l/acre) as compare to other treatments. However, the maximum yield was obtained in nimbecidine 300 ppm @ 1l/acre treated plots hence, the

BC ratio. The results are similar to that of Saini (2014) who reported that spray of NSKE 5 per cent alternated with ethion and novaluron were the most effective treatments combination in controlling whitefly adult population on mungbean crop. However, the maximum yield was obtained in nimbecidine (5ml/l) treated plots followed by two times NSKE 5 per cent treated plots. The results are in confirmation with Naik *et al.,* (2009) who indicated that besides recording higher fruit yield, thiamethoxam @ 0.005% and combination treatments of thiamethoxam @ 0.0025% + novaluron @ 0.05% and thiamethoxam @ 0.0025% + azadirachtin @ 0.15% were highly effective in reducing the population of *Bemisia tabaci* and *Amrasca biguttula biguttula* on brinjal.

The present study revealed that the T_1 (nimbecidine 300 ppm @ 1l/acre) and T_2 (Neem Baan 1500 ppm @ 1l/acre) are safest for the natural enemies of whitefly, which was followed by T_8 (Neem Baan 1500 ppm @ 1.0 l/acre + thiamethoxam 25 WG @ 40 g/acre + Neem Baan 1500 ppm @ 1.0 l/acre). The findings are similar with Kharche *et al.,* (2015) who revealed that the soil application of carbofuran 3G @ 5 kg/ha (T1), soil application of thiamethoxam 75SG @75 g a.i./ha (T2), soil application of imidacloprid 70WS @ 110 g a.i./ha (T3) proved significantly safer treatments which recorded 1.53, 1.27, 1.06 and 1.06 number of lady bird beetle/plant, respectively than all other insecticidal treatments.

The result inferred that few selective eco-friendly insecticides are safer to the natural enemies of whitefly as compared to other conventional insecticides.

Under whitefly management trial, the better result was found in case of T_8 (Neem Baan 1500 ppm @ 1.0 l/acre + thiamethoxam 25 WG @ 40 g/acre + Neem Baan 1500 ppm @ 1.0 l/acre), so this combination of pesticide can be utilized for management of whitefly in cotton.

Maximum BC ratio (1.17) was obtained from T_1 (nimbecidine 300 ppm @ 1l/acre, and that was found safer to the NEs.

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