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Impact of newer pesticides and botanicals on sucking pest management in cotton under high density planting system (HDPS) in India

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Abstract
In the present study, different insecticides were evaluated on cotton insect pests under high density planting system (HDPS) on research plots at Central Institute for Cotton Research, Nagpur during *kharif* 2012-13. Efficacy of Buprofezin, fipronil, imidacloprid, diafenthiuron, spiromesifen, flonicamid and acephate were among the synthetic insecticides whereas, biopesticides and botanicals included NSKE, *Verticillium lecanii*, mealy kill, mealy quit, bacterial formulation, neem oil was tested against cotton insect pests. Flonicamid 50% WG and Acephate, 75% SP were the most effective treatments which were significantly superior to all the other treatments was 2.19 Jassid nymphs/ 3 leaves/ plant and 2.59 nymphs/ 3 leaves/ plant respectively. The lowest whitefly population was recorded in the flonicamid 50% WG (0.42 whitefly/ 3 leaves/ plant), *Verticillium lecanii* (0.50 whitefly/ 3 leaves/ plant) and Spiromesifen (0.64 whitefly/ 3 leaves/ plant) as compared to other treatments. Further, these insecticides were found to be eco friendly and safe to the natural enemies.

Keywords: HDPS, sucking pests, cotton, management and pesticides

1. Introduction
Increasing plant density in cotton is a potential alternate route to maximize cotton yield and net profits [19]. Considerable research efforts have been going on for over a century to determine the optimum plant population for maximum yield and quality in upland cotton. Cotton (*Gossypium spp*.) major commercial crop of global significance unanimously designated as "King of Fibres" is grown for its lint and seed in more than 70 countries of the world [14]. India takes the privilege of growing all the four species of cotton on commercial scale. India is the largest cotton growing country in the world with area of more than 118.81 lakh hectares with a production of 352.00 lakh bales. However the productivity with 503 kg/ha against world approximate average of 766 kg lint/ha [1]. In cotton about 184 insect pests have been recorded on cotton in India, causing a 30–80% loss to yield, and among them the bollworm complex serves as major menace in cotton production system [10].
So far these insecticides are considered less toxic to the predators of sucking insect pests. Though laboratory or semi-field trials have demonstrated this property against whitefly, jassid and thrips [4, 11] but a few studies have addressed side effects of neonicotinoids under the field conditions [13]. However, field studies under natural conditions are proposed in the recent literature [18]. The toxicity of conventional insecticides to the natural enemies present in various agro-ecosystems has been demonstrated in laboratory tests and most of them were harmful to the different parasites and predators [3, 22, 20]. To overcome this problem discovery of novel substances with different biochemical targets are needed. Novel molecules are effective at low doses and have less exposure in the environment. These insecticides are also effective against all sucking pests that appeared in cotton at different stages of crop growth [16, 17, 23, 24].
Keeping this view, present investigation was conducted to evaluate the efficacy of different insecticides against sucking pests infesting on non *Bt* cotton and their impact on natural enemies.

2. Materials and Methods
The present experiments were conducted in experimental farm at Central Institute for Cotton research (CICR), Nagpur on Suraj non Bt.

The crop was sown on 20th June 2012-13 at a spacing of 45×10 cm with help of tractor sowing @ 8 kg of seeds/acres square meter plots and was maintained well by adapting standard agronomic practices as per the recommendations. There were 14 treatments (including control) comprising of Buprofezin, Fipronil, NSKE, *Verticillium lecanii.* Mealy Kill, Mealy Quit, Bacterial formulation, Imidacloprid, Neem oil, Diafenthiuron, Spiromesfin, Flonicamid and Acephate (Table 1). All the treatments were replicated thrice in randomized block design RBD. The insecticides were sprayed at 15 days interval as foliar application using knapsack sprayer.

2.1 Experimental layout: The experiment was laid out with three replications and fourteen treatments in randomized block design (RBD) with the spacing of 45 cm between rows and 10 cm between plants of Suraj variety at Research farm, ICAR-CICR.

2.2 Treatments given: The intensity of sucking pests was observed at 40 days after the insecticides were sprayed as per the recommitted dose; the insecticides were taken in 10 liter plastic container missing with properly and added in knapsack sprayer. The spraying was done with three time at 40, 55 and 70 days with interval of 15 days as foliar application using knapsack sprayer.

2.3 Pests and predators sampling

The sucking pests sampled were recorded from three leaves, one each from top, middle and bottom part of the canopy. Number of individuals per leaf was counted for plant leafhopper (Amrasca *biguttula biguttula*), whitefly (*Bemisia tabaci*), aphids (*Aphis gossypii*) and thrips (*Thrips tabaci*). The whole plant incidence were recorded in major predators sampled included spiders, lady bird beetles (coccinellids) and chrysopa. In each plot, data was recorded from six pre-tagged plants by counting the number of insects prior to and after each spray of applications. Seed cotton yield was harvested on plot basis excluding border lines and expressed as q/ha.

2.4 Data analysis

The data obtained for sucking insect pests and natural enemies were analyzed by adopting square root transformation before statistical analysis following [8] data analysis was performed by ANOVA and means were separated using LSD test at 5% level of significance.

3. Results and Discussion

In first spray, the foliar application of flonicamid @ 50 WG (2.19 per 3 leaves/plant) and acephate (2.59 per 3 leaves/plant) recorded significantly lowest number of leafhopper population followed by fipronil 5SC (3.2 per 3 leaves). The maximum number of leaf hoppers were recorded in *verticillium lecanii* applied plots (6.08 per 3 leaves), which was significantly higher than the control (4.72 per 3 leaves). In second spray, lowest population was observed in flonicamid 50WG (2.45 per 3 leaves) followed by buprofezin 25SC (2.67 per 3 leaves) (Table 2 & 4).

In first spray, minimum number of whiteflies were recorded in flonicamid 50WG (0.42 per 3 leaves) followed by *verticilium lecanii* (0.5 per 3 leaves). The second spray had experienced relatively large number of whiteflies. At these populations, buprofezin 25SC was found effective in reducing the whitefly population with mean number of white flies, 2.11 per 3 leaves. The second lowest population was observed in flonicamid 50WG (2.5 per 3 leaves).

The populations of tested predatory arthropods (Coccinelid, spiders and chrysopids) were significantly different between two sprays. Interestingly, the first spray recorded positive growth of tested predatory populations when compared to control. On the other hand, the second spray data showed negative impact of some tested chemicals. In the first spray, peak population of Coccinelid was observed in mealy quit (0.58) and buprofezin 25SC (0.56). Whereas, in second spray diafenthiuron 50WP recorded highest population. Little negative effect on Coccinelid was observed in spiromesifen 22.9SC with recorded lowest population (0.16) (Table 3 & 5).

The data on spider population revealed significantly high levels in fipronil 5 SC (0.89 spider /plant) followed by neem oil (0.75) in first spray. Whereas, the second spray data recorded highest populations in acephate 75SP (1.05) and bacterial formulation (0.97). NSKE and buprofezin 25SC recorded little negative impact on spider populations in second spray.

The chrysopid populations were significantly different between two sprays. In first spray highest population was recorded in NSKE (0.3) followed by mealy kill. The second spray had experienced a very residual population of chrysopidis, irrespective of the treatments.

The present study is in agreement with the [7] that flonicamid 0.02 per cent was found more effective against major sucking pests in cotton. According to [12] flonicamid found very active against wide range of aphid species and also effective against some other species of sucking insects. The maximum per cent reduction in jassids and whitefly population was recorded in difenthiuron 50 WP during both the years, and it was statistically at par with flonicamid 50 WP @ 100g a.i. [9] and studies conducted by [6] proved that acetamiprid 20 SP @ 0.004 per cent effective in lowering down the whitefly population (0.99 whiteflies/leaf), which was closely followed by flonicamid 50 WG @ 0.02 per cent (1.10 whiteflies/leaf). As per the report of [5] flonicamid @ 75 g a.i. ha^{-1} provided up to 73.4 per cent reduction in whitefly population. In the present investigation acephate also proved best insecticide for controlling leaf hopper follows the results of [21] acephate was the best in reducing A. devastans populations. In the same corner, according to [1] these modern insecticides, relatively safer to the natural beneficial fauna, commonly available and used by the farmers, *viz.*, buprofezin, Flonicamid, spintoram, pyriproxyfen, diafenthiuron, acetamiprid, spirotetramid so that these could be included in effective IPM of whitefly.

Conclusion

The present study concluded that, flonicamid 50WG found most effective in controlling both leaf hopper as well as whitefly population in high density planted cotton crop in the same manner the modern insecticides relatively safer to the natural beneficial fauna.

Table 1: Details of insecticides used in the study

Treatments	Insecticide	Dose (g ai/ha)	group	WHO Toxicity rating	IOBP Toxicity rating
T_1	Buprofezin 25% SC	100	Growth regulator	III	U
T_2	Fipronil 5% SC	40	Phenylpyrazoles (Fiproles)	II	
T_3	NSKE 1 %	10 ml/10 l	Botanical	-	
T_4	*Verticillium lecanii*	10 g / l	Entomopathogenic fungi	-	-
T_5	Mealy Kill	10 ml / l	Botanical	-	-
T_6	Mealy Quit	10 ml / l	Botanical	-	-
T_7	Bacterial formulation	2lit/10 lit	Entomopathogenic bacteria	-	-
T_8	Imidacloprid 17.8% SL	20	Neonecotinoids	II	II
T_9	Neem oil	5ml/l	Azadirachtin	-	-
T_{10}	Diafenthiuron 50% WP	300	Diafenthiuron)	III	U
T_{11}	Spiromesifine 22.9 % SC	40	spirocyclic phenyl-substituted tetronic acids	-	-
T_{12}	Flonicamide 50% WG	50	Flonicamid	-	-
T_{13}	Acephate 75 % SP	562.5	Organo phosphorous	II	III
T_{14}	Control				

Table 2: Effect of Newer Insecticides against sucking pests of Cotton under HDPS (first spray)

Treatments	Number 3 leaves /Plant					
	Jassids			White fly		
	3DAT	10DAT	Mean	3DAT	10DAT	Mean
T1	2.61 (1.61)	4.00 (2.110)	3.31 (1.816)bcd	0.72 (1.104)	0.61 (1.023)	0.66 (1.075)bcde
T2	2.89 (1.69)	3.50 (1.983)	3.20 (1.781)cd	1.17 (1.285)	0.83 (1.156)	1.00 (1.227)bc
T3	5.83 (2.37)	4.17 (2.130)	5.00 (2.238)ab	1.16 (1.283)	1.11 (1.260)	1.14 (1.272)b
T4	5.67 (2.303)	6.50 (2.614)	6.08 (2.445)a	0.55 (1.024)	0.44 (0.963)	0.50 (0.995)de
T5	5.33 (2.209)	5.22 (2.379)	5.28 (2.253)ab	0.89 (1.167)	0.77 (1.122)	0.83 (1.143)bcde
T6	6.00 (2.447)	3.78 (2.062)	4.89 (2.202)abc	0.72 (1.101)	0.72 (1.104)	0.72 (1.106)bcde
T7	5.22 (2.238)	2.22 (1.611)	3.72 (1.912)bcd	0.78 (1.087)	0.72 (1.104)	0.75 (1.107)bcde
T8	5.72 (2.371)	3.72 (2.011)	4.72 (2.173)abc	1 (1.211)	0.94 (1.193)	0.97 (1.204)bcd
T9	5.61 (2.348)	4.45 (2.208)	5.03 (2.227)abc	0.94 (1.209)	0.9 (1.183)	0.92 (1.192)bcd
T10	4.50 (2.025)	4.89 (2.317)	4.69 (2.141)abc	0.89 (1.175)	0.77 (1.122)	0.83 (1.156)bcde
T11	5.22 (2.270)	4.17 (2.154)	4.70 (2.152)abc	0.72 (1.089)	0.55 (1.024)	0.64 (1.050)cde
T12	2.05 (1.426)	2.33 (1.674)	2.19 (1.486)d	0.55 (1.005)	0.29 (0.889)	0.42 (0.947)e
T13	3.17 (1.765)	2.00 (1.485)	2.59 (1.603)d	0.83 (1.110)	0.77 (1.122)	0.80 (1.125)bcde
T14	7.28 (2.682)	2.17 (1.517)	4.72 (2.147)abc	2.06 (1.594)	2.89 (1.833)	2.47 (1.726)a
SEm	0.173	0.179	0.075	0.048	0.011	0.015
CD(P=0.05)	0.698	NS	0.449	NS	0.0.219	0.222

Table 3: Effect of Newer Insecticides against natural enemies of Cotton under HDPS (first spray)

Treatments	Number /Plant								
	Coccinellids			Spiders			Chrysopids		
	3DAT	10DAT	Mean	3DAT	10DAT	Mean	3DAT	10DAT	Mean
T1	0.5 (0.987)	0.55 (1.026)	0.53 (1.008)	0.66 (0.814)	0.72 (1.101)	0.69 (0.832)	0.11 (0.770)	0.48 (0.972)	0.30 (0.885)a
T2	0.55 (0.993)	0.5 (0.971)	0.53 (0.983)	0.44 (0.657)	0.77 (1.128)	0.61 (0.772)	0.16 (0.811)	0.11 (0.770)	0.14 (0.792)bc
T3	0.55 (1.002)	0.39 (0.928)	0.47 (0.967)	0.55 (0.738)	0.72 (1.104)	0.64 (0.792)	0.11 (0.770)	0.05 (0.742)	0.08 (0.760)c
T4	0.49 (0.962)	0.33 (0.899)	0.41 (0.932)	0.61 (0.770)	1.17 (1.288)	0.89 (0.932)	0.11 (0.770)	0.16 (0.811)	0.14 (0.792)bc
T5	0.55 (1.024)	0.33 (0.899)	0.44 (0.967)	0.55 (0.738)	0.83 (1.145)	0.69 (0.820)	0.11 (0.770)	0.16 (0.811)	0.14 (0.792)bc
T6	0.44 (0.946)	0.67 (1.067)	0.56 (1.018)	0.61 (0.769)	0.67 (1.067)	0.64 (0.780)	0.11 (0.773)	0.05 (0.742)	0.08 (0.763)c
T7	0.77 (1.116)	0.38 (0.934)	0.58 (1.029)	0.61 (0.765)	0.67 (1.079)	0.64 (0.780)	0.11 (0.773)	0.11 (0.770)	0.11 (0.772)bc
T8	0.44 (0.923)	0.33 (0.903)	0.39 (0.925)	0.5 (0.651)	0.72 (1.094)	0.61 (0.753)	0.39 (0.928)	0.11 (0.770)	0.25 (0.859)ab
T9	0.44 (0.948)	0.33 (0.893)	0.39 (0.929)	0.5 (0.677)	1 (1.201)	0.75 (0.827)	0.05 (0.742)	0.22 (0.838)	0.14 (0.792)bc
T10	0.33 (0.876)	0.5 (0.971)	0.42 (0.928)	0.55 (0.738)	0.83 (1.146)	0.69 (0.817)	0.05 (0.742)	0.05 (0.742)	0.05 (0.742)c
T11	0.44 (0.946)	0.16 (0.811)	0.30 (0.889)	0.55 (0.738)	0.5 (0.997)	0.53 (0.711)	0.16 (0.811)	0.11 (0.770)	0.14 (0.792)bc
T12	0.66 (1.064)	0.39 (0.928)	0.53 (1.004)	0.55 (0.738)	0.77 (1.116)	0.66 (0.791)	0.05 (0.742)	0.05 (0.742)	0.05 (0.742)c

T13	0.44 (0.948)	0 (0.701)	0.22 (0.840)	0.61 (0.770)	0.44 (0.957)	0.53 (0.727)	0.05 (0.742)	0.05 (0.742)	0.05 (0.744)c
T14	0.22 (0.838)	0.17 (0.807)	0.19 (0.820)	0.5 (0.686)	0.33 (0.893)	0.41 (0.642)	0.05 (0.742)	0.00 (0.701)	0.03 (0.722)c
SEm	0.014	0.010	0.003	0.009	0.025	0.010	0.001	0.008	0.006
CD(P=0.05)	NS	NS	NS	NS	NS	NS	0.098	NS	0.089

Table 4: Effect of Newer Insecticides against sucking pests of Cotton under HDPS (second spray).

Treatments	Number 3 leaves /Plant					
	Jassids			White fly		
	3DAT	10DAT	Mean	3DAT	10DAT	Mean
T1	3.39 (1.837)	2.61 (1.589)	2.67 (1.632)fg	1.67 (1.383)	1.56 (1.213)	2.11 (1.436)
T2	3.44 (1.847)	2.33 (1.499)	2.89 (1.687)efg	2.11 (1.593)	2.89 (1.690)	3.50 (1.813)
T3	4.50 (2.115)	3.06 (1.738)	3.78 (1.934)bcd	2.28 (1.662)	3.11 (1.752)	3.64 (1.861)
T4	4.67 (2.160)	4.00 (1.998)	4.33 (2.089)bc	2.17 (1.634)	3.72 (1.925)	3.92 (1.954)
T5	5.11 (2.258)	3.33 (1.816)	4.22 (2.050)bc	2.44 (1.669)	2.56 (1.584)	3.55 (1.796)
T6	4.89 (2.190)	4.44 (2.106)	4.67 (2.150)ab	2.22 (1.641)	3.50 (1.857)	3.61 (1.893)
T7	3.33 (1.823)	3.17 (1.769)	3.25 (1.805)def	2.16 (1.595)	2.78 (1.657)	3.61 (1.810)
T8	3.89 (1.963)	3.05 (1.746)	3.47 (1.858)cdef	2.28 (1.662)	2.11 (1.399)	3.28 (1.711)
T9	5.22 (2.284)	3.17 (1.769)	4.19 (2.040)bc	2.22 (1.649)	2.89 (1.666)	3.58 (1.832)
T10	4.28 (2.058)	2.83 (1.676)	3.56 (1.884)cde	2.72 (1.779)	2.44 (1.548)	3.61 (1.834)
T11	4.28 (2.063)	3.67 (1.914)	3.97 (1.990)bcd	2.55 (1.732)	5.28 (2.276)	5.30 (2.244)
T12	3.00 (1.729)	2.45 (1.567)	2.45 (1.566)g	2.00 (1.578)	1.94 (1.384)	2.50 (1.576)
T13	3.89 (1.965)	2.61 (1.579)	3.25 (1.808)def	2.28 (1.661)	3.95 (1.945)	4.53 (2.033)
T14	5.61 (2.367)	3.44 (1.850)	5.64 (2.374)a	2.44 (1.693)	3.56 (1.875)	3.94 (1.957)
SEm	0.035	0.038	0.014	0.079	0.097	0.060
CD(P=0.05)	0.319	0.325	0.227	NS	0.526	NS

Table 5: Effect of Newer Insecticides against natural enemies of Cotton under HDPS (second spray).

Treatments	Number /Plant								
	Coccinellids			Spiders			Chrysopids		
	3DAT	10DAT	Mean	3DAT	10DAT	Mean	3DAT	10DAT	Mean
T1	0.27 (0.865)	0.11 (0.773)	0.19 (0.409)	0.72 (0.842)	0.83 (0.875)	0.77 (0.878)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T2	0.55 (1.026)	0.22 (8.842)	0.39 (0.616)	0.94 (0.973)	0.94 (0.959)	0.94 (0.968)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T3	0.33 (0.910)	0.11 (0.773)	0.22 (0.477)	0.83 (0.908)	1.05 (1.017)	0.94 (0.970)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T4	0.33 (0.908)	0.27 (0.879)	0.30 (0.548)	0.94 (0.954)	0.94 (0.973)	0.94 (0.969)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T5	0.11 (0.773)	0.22 (0.840)	0.16 (0.393)	0.77 (0.871)	0.83 (0.903)	0.80 (0.893)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T6	0.33 (0.908)	0.16 (0.814)	0.25 (0.494)	0.88 (0.920)	0.66 (0.814)	0.77 (0.879)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T7	0.16 (0.811)	0.22 0.842	0.19 (0.426)	0.89 (0.904)	0.83 (0.908)	0.86 (0.920)	0.00 (0.701)	0.11 (0.773)	0.05 (0.744)
T8	0.27 (0.879)	0.16 (0.814)	0.22 (0.451)	0.72 (0.842)	0.94 (0.973)	0.83 (0.910)	0.00 (0.701)	0.05 (0.742)	0.03 (0.722)
T9	0.22 (0.842)	0.16 (0.811)	0.19 (0.410)	1.11 (1.050)	0.78 (0.877)	0.94 (0.969)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T10	0.38 (0.934)	0.28 (0.877)	0.33 (0.536)	0.89 (0.946)	1.06 (1.022)	0.97 (0.983)	0.00 (0.701)	0.05 (0.742)	0.03 (0.722)
T11	0.22 (0.838)	0.22 (0.842)	0.22 (0.462)	0.89 (0.946)	0.72 (0.840)	0.80 (0.890)	0.00 (0.701)	0.05 (0.742)	0.03 (0.722)
T12	0.22 (0.842)	0.22 (0.840)	0.22 (0.477)	0.89 (0.928)	1.22 (1.093)	1.05 (1.014)	0.00 (0.701)	0.11 (0.770)	0.06 (0.742)
T13	0.33 (0.908)	0.33 (0.906)	0.33 (0.565)	0.83 (0.908)	1.00 (0.971)	0.92 (0.944)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
T14	0.16 (0.811)	0.44 (0.973)	0.30 (0.546)	1.00 (0.995)	0.78 (0.851)	0.89 (0.947)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
SEm	0.018	0.007	0.013	0.029	0.024	0.012		0.009	0.005
CD(P=0.05)	NS	NS	NS	NS	NS	NS		NS	NS

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