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Field evaluation of biological compatibility of selected agrochemicals against cotton leafhopper, *Amrasca biguttula biguttula* (Ishida)

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Abstract
A field trial was conducted to evaluate the bioefficacy of combinations of insecticides with fungicides / fertilizer / growth regulator, as foliar application on Bt cotton against cotton leafhopper. The lowest population of leafhopper was recorded in diafenthiuron 50 WP @ 0.6 g + carbendazim 50 WP @ 1.0 g (2.87 / 3 leaves) followed by diafenthiuron 50 WP @ 0.6 g alone (2.99 / 3 leaves) with 74.30, 73.21 high per cent reduction over control. Sequentially in the efficacy, treatments *i.e.*, spinetoram 12 SC followed by acetamiprid 20 SP, nimbecidine, thiamethoxam 25 WG were alone and its combinations found effective in reducing the leafhopper population in 60 days cotton old crop.

Keywords: Bioefficacy, Combinations, Diafenthiuron 50 WP, Leafhopper, Cotton

Introduction
Cotton (*Gossypium hirsutum* L.), popularly known as "the white gold", is an important commercial fibre crop grown under diverse agro-climatic conditions around the world. It provides fibre, an important raw material for textile industry which is supposed to be a number one enterprise in the country and consumes nearly 70 per cent of total fibre produced in India. Second generation of Bt cotton has given solution to the bollworm complex to the larger extent but at the same time they are susceptible to most of the sucking pests. Among them leaf hopper is most destructive sucking pest (Amin *et al*., 2008) [1]. It sucks the cell sap and injects the toxic saliva inside veins during feeding. The first symptom of its attack is leaves turned yellowish due to sucking and latter on turned to reddish coloration of the margin of leaves followed by dryness.

Some time due to heavy attack at early stage reduced plant growth, cause the abortion of the first fruiting branch and increase shedding of squares and young bolls by affecting the photosynthesis (Patel and Patel, 1998; Rafique and Shah, 1998; Sudahkar *et al*., 1998) [8, 9, 10]. Combinations of pesticides spray are economical and convenient to apply a mixture of two or more pesticides when wide ranges of pests are to be controlled. Incompatibility may cause loss of effectiveness, poor application and also phytotoxicity. Chemical incompatibility occurs when the materials breaks down in to different compounds or when the products chemically combine to produce another which involves deactivation and may result in complete or partial failure. Combination of insecticide with fungicide and nutrients may save time energy and labour in case of complex field problems (Jasmine *et al.,* 2007) [6]. The present study was undertaken in field to evaluate the biological compatibility of selected insecticides with other agrochemicals against cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) and presented in this chapter.

Material and Methods
A field trial was conducted to evaluate the bioefficacy of combinations of insecticides with fungicides / fertilizer / growth regulator, as foliar application on Bt cotton. The experiment was laid out in a Randomized Block Design (RBD) at MARS, Dharwad during *kharif*, 2014-15 season (Plate 2). The experiment consisted of 35 treatments replicated twice (Table 1). A cotton hybrid, RCH-2 Bt susceptible to insect pests and diseases was choosen and raised in plots of 5.40 x 2.70 metre with 90 x 60 cm row to row and plant to plant spacing. Crop was raised by following package of practices. For the experiment two sprayings were carried out using hand operated pneumatic knapsack sprayer with 500 litres of spray fluid/ha at 60 and 90 days after sowing. The population of nymphs and adults of leaf hopper were recorded from ten randomly selected and tagged plants in each replication. In each plant, three leaves from top, middle and bottom were selected for observation. The observations were made prior to

spraying, 3, 7 and 14 days after spraying (DAS). The data obtained from field experiments was analysed in randomized block design (RBD) (Gomez and Gomez, 1984). The mean values were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1951) [4].

Results and Discussion

The results of the present investigation revealed that the lowest population of leafhopper was recorded in diafenthiuron 50 WP @ 0.6 g + carbendazim 50 WP @ 1.0 g (2.87 / 3 leaves) followed by diafenthiuron 50 WP @ 0.6 g alone (2.99 / 3 leaves), diafenthiuron 50 WP @ 0.6 g + copper oxychloride 50 WP @ 2 g (3.57 / 3 leaves), diafenthiuron 50 WP @ 0.6 g + NAA @ 20 ppm (3.59 / 3 leaves) and diafenthiuron 50 WP @ 0.6 g + $MgSO_4$ @ 10 g (3.74 / 3 leaves) with 74.30, 73.21, 67.99, 67.84 and 66.46 per cent reduction over untreated check respectively. These treatments were significantly superior over remaining treatments.

Similar trend was followed in other treatments *i.e.*, spinetoram 12 SC alone and its combinations (3.37 to 3.97 hoppers / 3 leaves with 67.81 to 64.42% reduction over control) followed by acetamiprid 20 SP alone and its combinations (3.54 to 4.26 hoppers / 3 leaves with 64.54 to 61.82% reduction over control); nimbecidine alone and its combinations (4.85 to 6.07 hoppers / 3 leaves with 52.76 to 45.62 reduction over control); thiamethoxam 25 WG alone and its combinations (3.73 to 5.01 hoppers / 3 leaves with 66.64 to 55.14 reduction over control).

The non insecticidal treatments like $MgSO_4$ @ 10 g, NAA 20 ppm, copper oxychloride 50 WP @ 2 g and carbendazim 50 WP @ 1.0 g recorded higher hopper population (9.94 to 8.81 hoppers / 3 leaves) with less than 22 per cent reduction over untreated check. Similarly, profenofos 50 EC alone and its combination treatments registered higher number of hoppers (6.37 to 5.78 hoppers / 3 leaves with 42.95 to 51.37 per cent reduction over untreated check (Table 1). Similar trend was observed with respect to efficacy of different treatments during second spray also. The results are in agreement with the findings of Bharpoda *et al.* (2014) [3] who noticed that difenthiuron 50 WP @ 0.05% recorded significant lower population of the leafhopper (1.66/ leaf) compared to all other treatments. Muhammad Afzal *et al.* (2014) [7] reported that diafenthiuron gave maximum mortality of leaf hoppers during first spray (88.56%) after 72 h of application respectively. The findings of the present study are in line with the findings of Bhamare and Wadnerkar (2013) [2] revealed that acetamiprid 20 g a.i. /ha was found superior for minimizing leafhopper population in cotton.

The insecticides *viz.*, thiamethoxam 25 WG, acetamiprid 20 SP, spinetoram 12 SC, diafenthiuron 50 WP, profenofos 50 EC and nimbecidine when sprayed in combination with carbendazim 50 WP were found more effective against leafhoppers with higher pest reduction values over control than when used alone or their combinations with copper oxychloride, NAA and $MgSO_4$. The combinations having carbendazim have shown synergistic action whereas, copper oxychloride, NAA and $MgSO_4$ exhibited additive action (slight increase in the toxicity) when combined with all the insecticides. Diafenthiuron 50 WP and its combinations followed by spinetoram 12 SC and its combinations were found quite effective against leafhoppers with high per cent reduction over untreated check, the combinations being statistically superior over the rest of the treatments. The results proved that all the test treatments were biologically compatible with each other against cotton leafhopper.

Table 1: Effect of combination of agrochemicals against cotton leaf hoppers

Treatments	Trt. no.	Number of leaf hoppers /3 leaves											
		1st spray (60 DAS)*						2nd spray (90 DAS)*					
		1 DBS	3 DAS	7 DAS	14 DAS	Mean	PRC	1 DBS	3 DAS	7 DAS	14 DAS	Mean	PRC
Thiamethoxam 25 WG	T_1	9.60 (3.18)^{a}	5.50 (2.45)$^{a-d}$	3.03 (1.88)$^{a-f}$	4.08 (2.14)$^{a-d}$	4.20 (2.17)^{a}	62.37	10.20 (3.27)^{a}	6.50 (2.65)^{abc}	4.05 (2.13)^{abc}	4.95 (2.33)$^{a-h}$	5.17 (2.38)^{abc}	54.48
Thiamethoxam 25 WG + Carbendazim 50 WP	T_2	9.51 (3.16)^{a}	5.05 (2.36)^{ab}	2.58 (1.75)$^{a-e}$	3.55 (2.01)$^{a-d}$	3.73 (2.06)^{a}	66.64	10.20 (3.27)^{a}	6.00 (2.55)^{abc}	3.65 (2.04)^{abc}	4.54 (2.24)$^{a-g}$	4.73 (2.29)^{ab}	58.33
Thiamethoxam 25 WG + Copper oxychloride 50 WP	T_3	9.41 (3.15)^{a}	5.90 (2.53)$^{a-d}$	3.63 (2.03)$^{a-f}$	4.45 (2.22)$^{a-d}$	4.66 (2.27)^{a}	58.28	10.21 (3.27)^{a}	7.00 (2.74)^{abc}	4.83 (2.31)$^{a-f}$	5.30 (2.41)$^{a-h}$	5.71 (2.49)^{abc}	49.71
Thiamethoxam 25WG + NAA	T_4	9.49 (3.16)^{a}	5.95 (2.54)$^{a-d}$	3.80 (2.07)$^{a-f}$	4.53 (2.24)$^{a-d}$	4.76 (2.29)^{ab}	57.38	10.22 (3.27)^{a}	7.00 (2.74)^{abc}	4.90 (2.32)$^{a-f}$	5.75 (2.50)$^{b-h}$	5.88 (2.53)^{abc}	48.16
Thiamethoxam 25 WG + $MgSO_4$	T_5	9.40 (3.15)^{a}	6.45 (2.64)$^{a-d}$	3.50 (2.00)$^{a-f}$	5.08 (2.36)$^{c-f}$	5.01 (2.35)^{abc}	55.14	10.22 (3.27)^{a}	7.50 (2.83)^{abc}	4.60 (2.26)$^{a-e}$	6.15 (2.58)$^{c-h}$	6.08 (2.57)^{abc}	46.40
Profenofos 50 EC	T_6	9.60 (3.18)^{a}	6.55 (2.66)$^{a-d}$	4.97 (2.34)^{def}	5.82 (2.51)^{cde}	5.78 (2.51)$^{a-d}$	48.23	10.20 (3.27)^{a}	8.00 (2.92)$^{a-d}$	6.05 (2.56)$^{a-f}$	6.95 (2.73)$^{d-h}$	7.00 (2.74)$^{a-d}$	38.33
Profenofos 50 EC + Carbendazim 50 WP	T_7	9.31 (3.13)^{a}	6.15 (2.58)$^{a-d}$	4.78 (2.30)$^{c-g}$	5.36 (2.42)$^{c-f}$	5.43 (2.44)^{ac}	51.37	10.23 (3.27)^{a}	7.90 (2.90)$^{a-d}$	5.85 (2.52)$^{a-f}$	6.60 (2.66)$^{c-h}$	6.78 (2.70)$^{a-d}$	40.23
Profenofos 50 EC + Copper oxychloride 50 WP	T_8	9.53 (3.17)^{a}	6.55 (2.66)$^{a-d}$	5.13 (2.37)^{cef}	6.33 (2.61)$^{c-f}$	6.00 (2.55)$^{a-d}$	46.26	10.21 (3.27)^{a}	8.25 (2.96)$^{a-d}$	6.30 (2.61)$^{b-f}$	7.20 (2.77)$^{e-h}$	7.25 (2.78)$^{a-d}$	36.12
Profenofos 50 EC + NAA	T_9	9.52 (3.16)^{a}	7.05 (2.75)$^{a-d}$	5.30 (2.41)^{ef}	6.25 (2.60)$^{c-f}$	6.20 (2.59)$^{a-d}$	44.47	10.21 (3.27)^{a}	8.50 (3.00)$^{a-d}$	6.50 (2.65)$^{c-f}$	7.25 (2.78)^{fgh}	7.42 (2.81)$^{a-d}$	34.65
Profenofos 50 EC + $MgSO_4$	T_{10}	9.59 (3.18)^{a}	7.60 (2.85)$^{a-d}$	5.43 (2.43)^{f}	6.08 (2.57)$^{c-f}$	6.37 (2.62)$^{a-d}$	42.95	10.22 (3.27)^{a}	8.70 (3.03)$^{a-d}$	6.70 (2.68)$^{c-f}$	7.20 (2.77)$^{e-h}$	7.53 (2.83)$^{a-d}$	33.63
Spinetoram 12 SC	T_{11}	9.42 (3.15)^{a}	5.35 (2.42)^{abc}	2.23 (1.65)^{abc}	3.20 (1.92)$^{a-d}$	3.59 (2.02)^{a}	67.81	10.21 (3.27)^{a}	6.50 (2.65)^{abc}	3.00 (1.87)^{abc}	3.98 (2.12)^{abc}	4.49 (2.23)^{a}	60.43
Spinetoram 12 SC + Carbendazim 50 WP	T_{12}	9.68 (3.19)^{a}	4.95 (2.33)^{ab}	2.08 (1.60)^{ab}	3.09 (1.89)^{abd}	3.37 (1.97)^{a}	69.80	10.22 (3.27)^{a}	6.00 (2.55)^{abc}	2.75 (1.80)^{ab}	3.85 (2.09)^{abc}	4.20 (2.17)^{a}	63.00
Spinetoram 12 SC + Copper oxychloride 50 WP	T_{13}	9.58 (3.17)^{a}	5.56 (2.46)$^{a-d}$	2.90 (1.84)$^{a-f}$	3.28 (1.94)$^{a-d}$	3.91 (2.10)^{a}	64.98	10.20 (3.27)^{a}	6.20 (2.59)^{abc}	3.55 (2.01)^{abc}	4.15 (2.16)$^{a-d}$	4.63 (2.27)^{a}	59.18
Spinetoram 12 SC + NAA	T_{14}	9.40 (3.15)^{a}	5.50 (2.45)$^{a-d}$	3.13 (1.90)$^{a-f}$	3.29 (1.95)$^{a-d}$	3.97 (2.11)^{a}	64.42	10.22 (3.27)^{a}	6.25 (2.60)^{abc}	4.00 (2.12)^{abc}	4.35 (2.20)$^{a-f}$	4.87 (2.32)^{ab}	57.12
Spinetoram 12 SC + $MgSO_4$	T_{15}	9.49	5.40	2.84	3.24	3.83	65.73	10.21	6.40	4.25	4.30	4.98	56.09

		(3.16)^{a}	(2.43)$^{a-d}$	(1.83)$^{a-f}$	(1.93)$^{a-d}$	(2.08)^{a}		(3.27)^{a}	(2.63)^{abc}	(2.18)^{abc}	(2.19)$^{a-e}$	(2.34)^{abc}	
Diafenthiuron 50 WP	T_{16}	9.59 (3.18)^{a}	4.60 (2.26)^{a}	2.04 (1.59)^{ab}	2.33 (1.68)^{ab}	2.99 (1.87)^{a}	73.21	10.21 (3.27)^{a}	5.50 (2.45)^{a}	2.70 (1.79)^{a}	3.40 (1.97)^{ab}	3.87 (2.09)^{a}	65.93
Diafenthiuron 50 WP + Carbendazim 50 WP	T_{17}	9.48 (3.16)^{a}	4.70 (2.28)^{a}	1.83 (1.53)^{a}	2.08 (1.60)^{a}	2.87 (1.84)^{a}	74.30	10.22 (3.27)^{a}	5.60 (2.47)^{ab}	2.55 (1.75)^{a}	3.15 (1.91)^{a}	3.77 (2.07)^{a}	66.81
Diafenthiuron 50 WP + Copper oxychloride 50 WP	T_{18}	9.59 (3.18)^{a}	4.90 (2.32)^{a}	2.43 (1.71)$^{a-d}$	3.39 (1.97)$^{a-d}$	3.57 (2.02)^{a}	67.99	10.21 (3.27)^{a}	5.80 (2.51)^{abc}	3.57 (2.02)^{abc}	4.45 (2.22)$^{a-g}$	4.61 (2.26)^{a}	59.43
Diafenthiuron 50 WP + NAA	T_{19}	9.53 (3.17)^{a}	4.95 (2.33)^{a}	2.60 (1.76)$^{a-e}$	3.23 (1.93)$^{a-d}$	3.59 (2.02)^{a}	67.84	10.21 (3.27)^{a}	5.95 (2.54)^{abc}	3.65 (2.04)^{abc}	4.35 (2.20)$^{a-f}$	4.65 (2.27)^{a}	59.03
Diafenthiuron 50 WP + $MgSO_4$	T_{20}	9.59 (3.18)^{a}	5.45 (2.44)^{ab}	2.65 (1.78)$^{a-f}$	3.13 (1.91)$^{a-d}$	3.74 (2.06)^{a}	66.46	10.21 (3.27)^{a}	7.00 (2.74)^{abc}	3.80 (2.07)^{abc}	4.15 (2.16)$^{a-d}$	4.98 (2.34)^{abc}	56.09
Acetamiprid 20 SP	T_{21}	9.55 (3.17)^{a}	5.25 (2.40)$^{a-d}$	3.13 (1.90)$^{a-f}$	3.50 (2.00)$^{a-d}$	3.96 (2.11)^{a}	64.54	10.2 (3.27)^{a}	6.20 (2.59)^{abc}	3.95 (2.11)^{abc}	4.55 (2.25)$^{a-g}$	4.90 (2.32)^{ab}	56.83
Acetamiprid 20 SP + Carbendazim 50 WP	T_{22}	9.68 (3.19)^{a}	4.85 (2.31)^{a}	2.61 (1.76)$^{a-e}$	3.16 (1.91)$^{a-d}$	3.54 (2.01)^{a}	68.31	10.22 (3.27)^{a}	6.13 (2.57)^{abc}	3.65 (2.04)^{abc}	4.05 (2.13)^{abc}	4.61 (2.26)^{a}	59.40
Acetamiprid 20 SP + Copper oxychloride 50 WP	T_{23}	9.62 (3.18)^{a}	5.10 (2.37)^{ab}	3.29 (1.95)$^{a-f}$	3.85 (2.09)$^{a-d}$	4.08 (2.14)^{a}	63.45	10.20 (3.27)^{a}	6.20 (2.59)^{abc}	4.25 (2.18)^{abc}	5.25 (2.40)$^{a-h}$	5.23 (2.39)^{abc}	53.89
Acetamiprid 20 SP + NAA	T_{24}	9.33 (3.14)^{a}	5.10 (2.37)^{a}	3.59 (2.02)$^{a-f}$	4.15 (2.16)$^{a-d}$	4.28 (2.19)^{a}	61.65	10.21 (3.27)^{a}	6.20 (2.59)^{abc}	4.40 (2.21)^{abc}	5.65 (2.48)$^{a-h}$	5.42 (2.43)^{abc}	52.28
Acetamiprid 20 SP + $MgSO_4$	T_{25}	9.67 (3.19)^{a}	5.20 (2.39)^{abc}	3.30 (1.95)^{bcd}	4.29 (2.19)$^{a-d}$	4.26 (2.18)^{a}	61.82	10.22 (3.27)^{a}	6.25 (2.60)^{abc}	4.55 (2.25)$^{a-d}$	5.90 (2.53)$^{-h}$	5.57 (2.46)^{abc}	50.95
Nimbecidine	T_{26}	9.53 (3.17)^{a}	5.65 (2.48)$^{a-d}$	4.32 (2.20)$^{b-g}$	5.85 (2.52)^{cde}	5.27 (2.40)^{abc}	52.76	10.20 (3.27)^{a}	6.60 (2.66)^{abc}	5.05 (2.36)$^{a-f}$	7.00 (2.74)$^{c-h}$	6.22 (2.59)^{abc}	45.23
Nimbecidine + Carbendazim 50 WP	T_{27}	9.24 (3.12)^{a}	5.25 (2.40)^{abc}	4.06 (2.14)$^{a-f}$	5.23 (2.39)$^{a-d}$	4.85 (2.31)^{ab}	56.57	10.22 (3.27)^{a}	7.30 (2.79)^{abc}	4.85 (2.31)$^{a-f}$	6.65 (2.67)$^{c-h}$	6.27 (2.60)^{abc}	44.79
Nimbecidine + Copper oxychloride 50 WP	T_{28}	9.34 (3.14)^{a}	6.11 (2.57)$^{a-d}$	4.62 (2.26)$^{c-f}$	6.58 (2.66)$^{c-f}$	5.77 (2.50)$^{a-d}$	48.35	10.21 (3.27)^{a}	7.75 (2.87)$^{a-d}$	5.50 (2.45)$^{a-f}$	7.35 (2.80)^{gh}	6.87 (2.71)$^{a-d}$	39.50
Nimbecidine + NAA	T_{29}	9.24 (3.12)^{a}	6.28 (2.60)$^{a-d}$	4.67 (2.27)$^{c-f}$	6.85 (2.71)^{def}	5.93 (2.54)$^{a-d}$	46.86	10.21 (3.27)^{a}	7.85 (2.89)$^{a-d}$	5.80 (2.51)$^{a-f}$	7.70 (2.86)^{hi}	7.12 (2.76)$^{a-d}$	37.30
Nimbecidine + $MgSO_4$	T_{30}	9.29 (3.13)^{a}	6.59 (2.66)$^{a-d}$	4.83 (2.31)$^{c-f}$	6.80 (2.70)^{def}	6.07 (2.56)$^{a-d}$	45.62	10.22 (3.27)^{a}	7.80 (2.88)$^{a-d}$	6.00 (2.55)$^{a-f}$	7.85 (2.89)^{hi}	7.22 (2.78)$^{a-d}$	36.42
Carbendazim 50 WP	T_{31}	9.62 (3.18)^{a}	7.59 (2.84)$^{a-d}$	8.86 (3.06)^{g}	9.98 (3.24)^{efg}	8.81 (3.05)$^{a-d}$	21.09	10.21 (3.27)^{a}	8.23 (2.95)$^{a-d}$	8.55 (3.01)$^{d-g}$	10.90 (3.38)^{ij}	9.23 (3.12)^{bcd}	18.72
Copper oxychloride 50 WP	T_{32}	9.60 (3.18)^{a}	8.01 (2.92)$^{a-d}$	9.03 (3.09)^{g}	10.30 (3.29)^{fg}	9.11 (3.10)^{cde}	18.37	10.21 (3.27)^{a}	8.88 (3.06)^{cd}	8.80 (3.05)^{efg}	10.80 (3.36)^{ij}	9.49 (3.16)^{cd}	16.37
NAA	T_{33}	9.53 (3.17)^{a}	8.58 (3.01)^{de}	9.55 (3.17)^{g}	11.58 (3.47)^{g}	9.90 (3.23)^{de}	11.31	10.21 (3.27)^{a}	9.00 (3.08)^{cd}	8.85 (3.06)^{fg}	10.75 (3.35)^{ij}	9.53 (3.17)^{cd}	16.01
$MgSO_4$	T_{34}	9.64 (3.18)^{a}	8.36 (2.98)^{cde}	9.83 (3.21)^{g}	11.63 (3.48)^{g}	9.94 (3.23)^{de}	11.00	10.22 (3.27)^{a}	8.75 (3.04)^{bcd}	8.80 (3.05)^{efg}	11.00 (3.39)^{ij}	9.52 (3.16)^{cd}	16.15
Untreated check	T_{35}	9.53 (3.17)^{a}	11.04 (3.40)^{e}	10.49 (3.31)^{g}	11.97 (3.53)^{g}	11.16 (3.42)^{e}	0.00	10.22 (3.27)^{a}	11.25 (3.43)^{d}	11.30 (3.44)^{g}	11.50 (3.46)^{j}	11.35 (3.44)^{d}	0.00
S. Em±		0.22	0.17	0.19	0.23	0.22		0.21	0.17	0.23	0.17	0.24	
CD (0.05)		NS	0.49	0.54	0.66	0.65		NS	0.48	0.67	0.49	0.69	
CV (%)		9.75	9.36	12.43	13.75	13.42		9.28	8.49	13.93	9.33	13.22	

PRC = Per cent Reduction Over Control;
DBS = Day Before Spray;
DAS = Days After Spray;
*DAS = Days After Sowing;
NS = Non Significant;
Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values. Means followed by same letter do not differ significantly by DMRT (P = 0.05).

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