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Compatibility and bioefficacy studies of different agrochemicals in cotton

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Abstract
Five commonly used insecticides (contact and systemic), two fungicides, one chemical and two fertilizers in forty combinations were tested at their recommended doses for its physical, chemical compatibility, phytotoxicity and bio efficacy on cotton crop at Regional Agricultural Research Station, Nandyal during Kharif, 2017-18. All the agro chemicals tested were physically and chemically compatible. In all the 40 combinations, phytotoxicity symptoms such as leaf epinasty, leaf hyponasty, necrosis and scorching were not observed. Among the combinations, Flonicamid + acephate, Flonicamid + thiamethoxam, monocrotophos + flonicamid and flonicamid + imidacloprid reduced the leafhoppers population by 69.57, 68.09, 66.38 and 65.26% after one week after the spray.

Keywords: cotton, leafhoppers, compatibility, insecticides, fertilizers

Introduction
Cotton (*Gossypium hirsutum* L.), popularly known as "white gold" is an important fibre and cash crop of India having global significance. Cotton being a long duration and succulent crop, it is infested by a number of insect pests throughout its growth period. In India, about 162 insect pest species attack cotton crop from sowing to harvesting and causes yield loss up to 50-60 per cent [1]. The insect pests of cotton can be primarily divided into two groups as sucking pests and bollworms. Aphid (*Aphis gossypii* Glover), jassids (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Lind.) and whitefly (*Bemisia tabaci* Genn.) are the major sucking pests of cotton. These sucking pests are noticed at all the stages of crop growth and responsible for direct and indirect yield losses. A reduction of 22.85 per cent in seed cotton yield due to sucking pests has been reported by [2, 3]. According to [4], Bt cotton succumb to yield loss due to sucking pests such as leafhoppers, aphids, thrips and whitefly, etc. At the same time various diseases are also casuing economical loses in cotton cultivation. For effective management of the insect pests and diseases requires frequent applications of chemcial sprays which increases the cost of cultirvation. In general farmers apply insecticides and fungicides together for the control of insect pests and diseases to reduce the cost of plant protection. Mixture of two pesticides may produce greater insecticidal action than the sum of the individual components by synergism [5]. It has been proposed that pesticide mixtures may delay the onset of resistance developing in pest populations [6]. The numbers of chemicals involved in plant protection are too many and the information on compatibility of individual chemical is scanty. Common growers facing difficulty in ascertaining the compatibility of agro-chemicals. Hence, based on experience, [7] prepared a chart showing compatibility of some insecticides and fungicides. Later several charts were developed or updated by [8, 9] for the chemicals in use with additional information regarding compatibility in different crops, season, aging of mixtures and many other factors.

It has been reported that Diafenthiuron in combination with carbendazim and copper oxychloride were found to be more effective in reducing the sucking pest population and foliar diseases incidence in cotton [10]. It is a common practice of farmers to use pesticides and their mixtures most frequently without consideration of compatibility and efficacy. The information available on novel insecticides in combination with fungicides that are commonly used by farmers against insect pests and diseases is very scare. If compatible insecticides and fungicides mixture is used in combination it may prove cheaper and such combination become useful for the control of both insect pests and diseases without losing their efficacy individually. Keeping this in mind present study was carried out to evaluate compatibility of different pesticides against sucking pests viz; leafhoppers and whiteflies of cotton and to find out most cost effective pesticidal treatment.

Material and Methods

The experiment was conducted at Regional agricultural Research Station, Nandyal in *Kharif*, 2016-17 by taking RCH 2 BGII cotton hybrid as test hybrid and the crop was raised following all the recommended package of practices except plant protection. Agrochemicals (5 insecticides, *viz*., Monocrotophos, Imidacloprid , flonicamid, thiamethoxam and acephate; two fungicides v*iz*., (copper oxy chloride and propiconazole), one chemical (Cobalt chloride) and fertilizers (KNO_3 and Urea) were tested at recommended doses and arrived at a total of 40 combinations which were tested for their physical and chemical compatibility following standard procedures**.** For testing physical compatibility, clear glass jars with lids (250 ml capacity) were taken with 100 ml water and to this added the test insecticides/ fungicides (undiluted chemical as per dilution factor) in the order of WP-WG-SC-SP- SL. The mixtures were stirred after each addition and capped the jars tightly with lids and turn the jars 10 times and left aside for 5 Minutes. Finally observed for incompatible phenomena (flakes/precipitate/gel/slurry/layering, etc.). Among the combinations, physically compatible combinations were tested for their phytotoxicity at field level at flowering stage of the crop and recorded the phytotoxicity score using 0-9 scale.

Phytotoxicity scale

Observations on phytotoxity were recorded at a day before and 7 days after spray. Observation for the specific parameters like leaf tip & surface injury, hyponasty and epinasty and scorching were recorded by using following scale. Safe combinations with zero phytotoxicity ratings were studied for bio-efficacy against the leafhoppers of cotton Observations on the incidence of leafhoppers were made as per the standard protocols (on three leaves, one each from top, middle and bottom canopy of the plant) at a day before and at one week after spraying. The reduction over pre-treatment count was calculated and expressed as per centage.

Results

Compatibility

All the treatment combinations were tested for their physical and chemical compatibility and all the treatments were found compatible both physically and chemically without any flocculation, sedimants, leaf epinasty, leaf hyponasty, necrosis and phytotoxicity. (Table 2).

Bioefficacy

The per cent reduction over control of different combinations was presented in table 3. The per cent reduction over pre-treatment count ranged from 43.24 to 69.57%. The treatment combinations imidacloprid + thiamethoxam, acephate alone, imidacloprid + acephate, monocrotophos + acephate, flonicamid alone and its combinations with copper oxy chloride, KNO_3, propiconazole, urea, cobalt chloride, imidacloprid, and monocrotophos have given more than 50% reduction of leafhoppers i.e., 55.00, 55.32, 55.88, 56.18, 63.55, 60.00, 61.98, 62.22, 63.44, 63.81, 65.26 and 66.38 per cent reduction of leafhoppers, respectively (Table 3). The list of best and effective combinations against leafhoppers in cotton was given in Table 4.

Phytotoxicity rating scale

S. No	Crop Response / Crop injury	Rating
1	0-00	0
2	1-10%	1
3	11-20%	2
4	21-30%	3
5	31-40%	4
6	41-50%	5
7	51-60%	6
8	61-70%	7
9	71-80%	8
10	81-90%	9
11	91-100%	10

Discussion

The results of the present investigation i.e., flonicamid +copper oxychloride, imdiadacloprid + acephate which gave 60.00 and 55.88% reduction of leafhoppers were in agreement with [11] who also reported the excellent efficacy of the same combinations against leafhoppers in cotton. The investigations of [12] also supports the results of present investigation that flonicamid alone and in combination with other chemicals gave good reduction of leafhoppers in cotton. Moreover, the earlier workers [10] reported that diafenthiuron 50% WP when sprayed in combination with copper oxychloride 50 WP exhibited additive action, and was very effective against cotton leafhoppers. Similarly, [14] reported an enhanced action of combination of spiromesifen and fipronil against leafhoppers in cotton. Reports of [15] revealed that diafenthiuron and its combination with other pesticides was effective against whiteflies in cotton.

Table 1: Compatibility chart for Insecticides Vs Fungicides Vs fertilizers

Agrochemicals	Monocrotophos	Imidacloprid	Flonicamid	Thiamethoxam	Acephate	Copper oxychloride	Propiconazole	Cobalt Chloride	K NO3	Urea
Monocrotophos	C	C	C	C	C	C	C	C	C	C
Imidacloprid		C	C	C	C	C	C	C	C	C
Flonicamid			C	C	C	C	C	C	C	C
Thiamethoxam				C	C	C	C	C	C	C
Acephate					C	C	C	C	C	C
Copper oxychloride						C	C	C	C	C
Propiconazole							C	C	C	C
Cobalt Chloride								C	C	C
K NO3									C	C
Urea										C

Table 2: Combinations of insecticides, fungicides and fertilizers used on cotton for their phytotoxicity studies

Tr. No.	Treatment combination	Leaf epinasty	Leaf hyponasty	Necrosis	Scorching
T1	Monocrotophos	Not found	Not found	Not found	Not found
T2	Monocrotophos +flonicamid	Not found	Not found	Not found	Not found
T3	Monocrotophos+imidacloprid	Not found	Not found	Not found	Not found
T4	Monocrotophos +thiamethoxam	Not found	Not found	Not found	Not found
T5	Monocrotophos+COC	Not found	Not found	Not found	Not found
T6	Monocrotophos+Acephate	Not found	Not found	Not found	Not found
T7	Monocrotophos+propiconazole	Not found	Not found	Not found	Not found
T8	Monocrotophos+Urea	Not found	Not found	Not found	Not found
T9	Monocrotophos+KNO_3	Not found	Not found	Not found	Not found
T10	Monocrotophos+cobalt chloride	Not found	Not found	Not found	Not found
T11	Flonicamid	Not found	Not found	Not found	Not found
T12	Flonicamid +imidacloprid	Not found	Not found	Not found	Not found
T13	Flonicamid +thiamethoxam	Not found	Not found	Not found	Not found
T14	Flonicamid +Copper oxychloride	Not found	Not found	Not found	Not found
T15	Flonicamid +Acephate	Not found	Not found	Not found	Not found
T16	Flonicamid +propiconazole	Not found	Not found	Not found	Not found
T17	Flonicamid +Urea	Not found	Not found	Not found	Not found
T18	Flonicamid +KNO_3	Not found	Not found	Not found	Not found
T19	Flonicamid +cobalt chloride	Not found	Not found	Not found	Not found
T20	Imidacloprid	Not found	Not found	Not found	Not found
T21	Imidacloprid +thiamethoxam	Not found	Not found	Not found	Not found
T22	Imidacloprid +Copper oxychloride	Not found	Not found	Not found	Not found
T23	Imidacloprid +Acephate	Not found	Not found	Not found	Not found
T24	Imidacloprid +propiconazole	Not found	Not found	Not found	Not found
T25	Imidacloprid +Urea	Not found	Not found	Not found	Not found
T26	Imidacloprid +KNO_3	Not found	Not found	Not found	Not found
T27	Imidacloprid +cobalt chloride	Not found	Not found	Not found	Not found
T28	Thiamethoxam	Not found	Not found	Not found	Not found
T29	Thiamethoxam +COC	Not found	Not found	Not found	Not found
T30	Thiamethoxam +Acephate	Not found	Not found	Not found	Not found
T31	Thiamethoxam +propiconazole	Not found	Not found	Not found	Not found
T32	Thiamethoxam +Urea	Not found	Not found	Not found	Not found
T33	Thiamethoxam+KNO_3	Not found	Not found	Not found	Not found
T34	Thiamethoxam+cobalt chloride	Not found	Not found	Not found	Not found
T35	Acephate	Not found	Not found	Not found	Not found
T36	Acephate+propiconazole	Not found	Not found	Not found	Not found
T37	Acephate + Urea	Not found	Not found	Not found	Not found
T38	Acephate + KNO3	Not found	Not found	Not found	Not found
T39	Acephate + cobalt chloride	Not found	Not found	Not found	Not found
T40	Acephate + Copper oxychloride	Not found	Not found	Not found	Not found

Table 3: Efficacy of different treatment combinations against leafhoppers of cotton

S. No	Combination	Pre count	Post count	% ROC
1	Monocrotophos	10.60	5.10	51.89
2	Monocrotophos +flonicamid	11.60	3.90	66.38
3	Monocrotophos+imidacloprid	9.50	4.30	54.74
4	Monocrotophos +thiamethoxam	8.60	4.00	53.49
5	Monocrotophos +Copper oxychloride	10.30	5.00	51.46
6	Monocrotophos+Acephate	8.90	3.90	56.18
7	Monocrotophos+propiconazole	9.80	4.80	51.02
8	Monocrotophos+Urea	9.25	4.60	50.27
9	Monocrotophos+KNO_3	8.90	4.20	52.81
10	Monocrotophos+cobalt chloride	10.00	4.90	51.00
11	Flonicamid	10.70	3.90	63.55
12	Flonicamid +imidacloprid	9.50	3.30	65.26
13	Flonicamid +thiamethoxam	9.40	3.00	68.09
14	Flonicamid +Copper oxychloride	10.00	4.00	60.00
15	Flonicamid +Acephate	11.50	3.50	69.57
16	Flonicamid +propiconazole	9.00	3.40	62.22
17	Flonicamid +Urea	9.30	3.40	63.44
18	Flonicamid +KNO_3	12.10	4.60	61.98
19	Flonicamid +cobalt chloride	10.50	3.80	63.81
20	Imidacloprid	10.10	4.70	53.47
21	Imidacloprid +thiamethoxam	10.00	4.50	55.00
22	Imidacloprid +Copper oxychloride	9.00	4.20	53.33

23	Imidacloprid +Acephate	10.20	4.50	55.88
24	Imidacloprid +propiconazole	9.10	4.30	52.75
25	Imidacloprid +Urea	9.40	4.40	53.19
26	Imidacloprid +KNO_3	11.50	5.50	52.17
27	Imidacloprid +cobalt chloride	10.20	5.00	50.98
28	Thiamethoxam	9.40	4.80	48.94
29	Thiamethoxam +Copper oxychloride	9.80	5.20	46.94
30	Thiamethoxam +Acephate	9.30	4.70	49.46
31	Thiamethoxam +propiconazole	7.80	4.10	47.44
32	Thiamethoxam +Urea	7.20	3.80	47.22
33	Thiamethoxam +KNO_3	7.40	4.20	43.24
34	Thiamethoxam+cobalt chloride	6.40	3.40	46.88
35	Acephate	9.40	4.20	55.32
36	Acephate+propiconazole	6.90	3.25	52.90
37	Acephate+Urea	8.30	4.00	51.81
38	Acephate+KNO_3	8.40	4.10	51.19
39	Acephate+cobalt chloride	7.50	3.70	50.67
40	Acephate+Copper oxychloride	6.90	3.50	49.28

Table 4: List of best combinations of insecticides, fungicides and fertilizers

S. No.	Best combination	% ROC
1	Imidacloprid +thiamethoxam	55.00
2	Acephate	55.32
3	Imidacloprid +Acephate	55.88
4	Monocrotophos+Acephate	56.18
5	Flonicamid +Copper oxychloride	60.00
6	Flonicamid +KNO_3	61.98
7	Flonicamid +propiconazole	62.22
8	Flonicamid +Urea	63.44
9	Flonicamid	63.55
10	Flonicamid +cobalt chloride	63.81
11	Flonicamid +imidacloprid	65.26
12	Monocrotophos +flonicamid	66.38
13	Flonicamid +thiamethoxam	68.09
14	Flonicamid +Acephate	69.57

Conclusion

Among the 40 combinations tested on cotton, all the combinations were physically as well as chemically compatible. The bio efficacy studies of all compatible agrochemical combinations in cotton against leafhoppers indicated that, the combinations of Flonicamid+Acephate, Flonicamid+thiamethoxam and Monocrotophos +flonicamid were effective against leafhoppers in cotton.

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