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In Vitro Studies on Physical and Chemical Compatibility of Some Insecticides and Fungicides

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ABSTRACT

A Lab experiment was conducted in the Department of Entomology, Agricultural College, Bapatla to know the physical and chemical compatibility of some insecticides and fungicides. Physical compatibility tests like Emulsion stability test and specific gravity test, chemical compatibility test like E.C and pH were followed. The results showed that there was no incompatibility found between the test combinations in both physical and chemical compatible tests. All the tests were carried out using distilled water, normal tap water and standard hard water (342 ppm).

Key words: *Compatibility, Emulsion stability, E.C, pH, Specific gravity*

Among various constraints of grain production, the insect pests and diseases are of prime importance and are the limiting factors in getting higher yield. Pests and diseases occur simultaneously in crop growth period and estimated to cause yield losses to the tune of 30 to 40 per cent. A significant correlation between insect pests, diseases and yield loss of crops was observed (Biswas, 2012). Multiple pest damage usually had additive effects on yield loss. Major factors that have contributed towards changes in the pest scenario are extensive cultivation of high yielding varieties, intensified rice cultivation throughout the year, imbalanced use of fertilizers, non-judicious use of insecticides resulting in pest resistance to insecticides, resurgence of pests and outbreak of minor pests (Prakash *et al.,* 2014).

Therefore, there is a dire need to discover newer and safer pest control methods for effective management of pests and diseases. For example, insect-pests of rice like stem borer, leaf folder, diseases like blast and sheath blight coexist in rice ecosystem which, farmers have to manage simultaneously. Considering these factors, a novel method called development of pesticide mixture has emerged (Siddegowda, 2009). In this method, compatible and effective insecticide and fungicide combinations were formulated and applied as a single tank mix which saves time, labour, energy, equipment cost to the farmers and prevents ecological problems like enhanced phytotoxicity, resurgence *etc*.

The chemicals involved in plant protection are too many and the information on compatibility of individual chemicals, efficacy of insecticides and fungicides as a tank mix application in rice is scanty in the literature (Lakshmanan, 1992). Common growers find difficulty in ascertaining the compatibility of agrochemicals. Keeping these problems in view, the In vitro study was carried out to test the physical and chemical compatibility of some insecticides and fungicides as a pesticide mixture

MATERIAL AND METHODS

The experiment was carried out during *Kharif*, 2014 at Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh. Four insecticides *viz.,* chlorpyriphos, cartap hydrochloride, chlorantraniliprole, phosphamidon and four fungicides *i.e.,* carbendazim, hexaconazole, tricyclazole and isoprothiolane were selected to test their physical and chemical compatibility. (Table. 1)

Physical Compatibility

Physical compatibility of spray solutions of insecticides, fungicides alone and in combination were tested by conducting emulsion stability test and specific gravity test.

Emulsion stability test

Emulsion stability test was carried out with distilled water, normal tap water and standard hard water (342 ppm) as prescribed by Indian Standard Institution specifications (ISI 1973). Standard hard water was prepared by dissolving 0.302 g of anhydrous calcium chloride ($Ca Cl_2$) and 0.139 g of hexahydrate magnesium chloride ($Mg Cl_2$) in one litre of distilled water which gives standard hard water with hardness of 324 ppm of calcium carbonate. Individual pesticide solutions (30 ml each) were prepared by utilizing hard water in a beaker. For testing the emulsion stability of the combinations, each insecticide (30 ml) and fungicide (30 ml) solutions were poured into a beaker. The contents of the beaker was stirred with a glass

Table 1. Particulars of dosage of insecticides, fungicides alone and their combination used in physical and chemical compatibility test

S. No.	Treatments (Trade name)	Recommended Concentration (ml or g l^{-1})
1	Chlorpyriphos 20% EC (Classic)	2.5
2	Cartaphydrachloride 50% SP (Caldan)	2
3	Chlorantraniliprole 18.5% SC (Coragen)	0.3
4	Phosphamidon 25% EC (Sumidan)	2
5	Carbendazim 50% WP (Bavistin)	1
6	Hexaconazole 5% SC (Contaf)	2
7	Tricyclazole 75% WP (Baan)	0.6
8	Isoprothiolane 40% EC (Fuzi-one)	1.5
9	Chlorpyriphos 20% EC + carbendazim 50% WP	2.5 + 1.0
10	Chlorpyriphos 20% EC + hexaconazole 5% SC	2.5 + 2.0
11	Chlorpyriphos 20% EC + tricyclazole 75% WP	2.5 + 0.6
12	Chlorpyriphos 20% EC + isoprothiolane 40% EC	2.5 + 1.5
13	Cartap hydrochloride 50% SP + carbendazim 50% WP	2.0 + 1.0
14	Cartap hydrochloride 50% SP + hexaconazole 5% SC	2.0 + 2.0
15	Cartap hydrochloride 50% SP + tricyclazole 75% WP	2.0 + 0.6
16	Cartap hydrochloride 50% SP + isoprothiolane 40% EC	2.0 + 1.5
17	Chlorantraniliprole 18.5% SC + carbendazim 50% WP	0.3 + 1.0
18	Chlorantraniliprole 18.5% SC + hexaconazole 5% SC	0.3 + 2.0
19	Chlorantraniliprole 18.5% SC + tricyclazole 75% WP	0.3 + 0.6
20	Chlorantraniliprole 18.5% SC + isoprothiolane 40% EC	0.3 + 1.5
21	Phosphamidon 40% EC+ carbendazim 50% WP	2.0 + 1.0
22	Phosphamidon 40% EC + hexaconazole 5% SC	2.0 + 2.0
23	Phosphamidon 40% EC + tricyclazole 75% WP	2.0 + 0.6
24	Phosphamidon 40% EC + isoprothiolane 40% EC	2.0 + 1.5
25	Untreated control	-

rod at the rate of four revolutions per second during the addition of pesticides after that the diluted emulsion was made upto 100 ml with standard hard water and transferred immediately to a clean and graduated cylinder. The cylinder with its contents was kept at a temperature of 30 ± 1 ^{0}C for one hour without any disturbance. The experiment was replicated thrice. After a specified time *i.e.,* on 1st, 6th and 24th hr of the experiment, the volume of the creamy matter at the top and or the sediment if any at the bottom were observed. For stable emulsion, the creamy matter or the sediment if any should not exceed 2.0 ml (ISI). The same test was repeated with normal tap water and distilled water.

Specific gravity test

Specific gravity bottles of 25 ml capacity were taken and the weight of clean and dry specific gravity bottle was recorded as W_1. The bottle was filled with distilled water and closed with stopper and the excess water adhering to the outer surface of the bottle was wiped out with blotting paper. The weight of the bottle along with distilled water was recorded as W_2. A known quantity of recommended concentration of pesticide formulation was prepared as detailed earlier for calculating the specific gravity. The bottle with distilled water was emptied and filled with the liquid formulation of pesticide. Weight of the bottle along with pesticide solution was recorded as W_3. The specific gravity test of the insecticides, fungicides were worked out by using the following formula

Specific gravity of pesticide =

$$\frac{\text{Weight of the known volume of the insecticide}}{\text{Weight of the equal volume of the water}}$$

$$\text{Specific gravity of pesticide} = \frac{(W_3 - W_1)}{(W_2 - W_1)}$$

Table 2. Emulsion stability of insecticides and fungicides alone and in combination using standard hard water

S. No	Treatments	Recommended Concentration	Creamy top layer in ml (<)			Bottom sediment ml (<)		
		(g or ml l^{-1})	1 h	6 h	24 h	1 h	6 h	24 h
1	Chlorpyriphos 20% EC	2.5	0	0	0	0	0	0
2	Cartap hydrochloride 50% SP	2	0	0	0	0	0	0
3	Chlorantraniliprole 18.5% SC	0.3	0	0	0	0	0	0
4	Phosphamidon 25% EC	2	0	0	0	0	0	0
5	Carbendazim 50% WP	1	0	0	0	0	0	0
6	Hexaconazole 5% SC	2	0	0	0	0	0	0
7	Tricyclazole 75% WP	0.6	0	0	0	0	0	0
8	Isoprothiolane 40% EC	1.5	0	0	0	0	0	0
9	Chlorpyriphos 20% EC + Carbendazim 50% WP	2.5 +1.0	0	1	1	0.5	1	1
10	Chlorpyriphos 20% EC + Hexaconazole 5% SC	2.5 +2.0	0.5	1	0	0	0	0
11	Chlorpyriphos 20% EC + Tricyclazole 75% WP	2.5 +0.6	0.1*	0.5*	0.5*	0	0	0
12	Chlorpyriphos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	0	1	1	0	0	0.5
13	Cartap hydrochloride 50% SP + Carbendazim 50% WP	2.0 +1.0	0	0	0	0.1	0.5	0.5
14	Cartap hydrochloride 50% SP + Hexaconazole 5% SC	2.0 +2.0	0	1	1	0	0	0
15	Cartap hydrochloride 50% SP + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
16	Cartap hydrochloride 50% SP + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
17	Chlorantraniliprole 18.5% SC + Carbendazim 50% WP	0.3 +1.0	0	0	0	0	0.5	0.5
18	Chlorantraniliprole 18.5% SC + Hexaconazole 5% SC	0.3 +2.0	0	0	0	0	0	0
19	Chlorantraniliprole 18.5% SC + Tricyclazole 75% WP	0.3 +0.6	0	0	0	0	0	0
20	Chlorantraniliprole 18.5% SC + Isoprothiolane 40% EC	0.3 +1.5	0	0	0	0	0	0
21	Phosphamidon 40% EC+ Carbendazim 50% WP	2.0 +1.0	0	0	0	0	0	1
22	Phosphamidon 40% EC + Hexaconazole 5% SC	2.0 +2.0	0.5	0.5	0.5	0	0	0
23	Phosphamidon 40% EC + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
24	Phosphamidon 40% EC + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
25	Untreated control	-	0	0	0	0	0	0

***Oily emulsion**

Table 3. Emulsion stability of insecticides and fungicides alone and in combination using tap water

S. No.	Treatments	Recommended Concentration	Creamy top layer in ml (<)			Bottom sediment ml (<)		
		(g or ml l^{-1})	1 h	6 h	24 h	1 h	6 h	24 h
1	Chlorpyriphos 20% EC	2.5	0	0	0	0	0	0
2	Cartap hydrochloride 50% SP	2	0	0	0	0	0	0
3	Chlorantraniliprole 18.5% SC	0.3	0	0	0	0	0	0
4	Phosphamidon 25% EC	2	0	0	0	0	0	0
5	Carbendazim 50% WP	1	0	0	0	0	0	0
6	Hexaconazole 5% SC	2	0	0	0	0	0	0
7	Tricyclazole 75% WP	0.6	0	0	0	0	0	0
8	Isoprothiolane 40% EC	1.5	0	0	0	0	0	0
9	Chlorpyriphos 20% EC + Carbendazim 50% WP	2.5 +1.0	0	1	1	1	1	1
10	Chlorpyriphos 20% EC + Hexaconazole 5% SC	2.5 +2.0	0.5	1	0	0	0	0
11	Chlorpyriphos 20% EC + Tricyclazole 75% WP	2.5 +0.6	0.1*	0.5*	0.5*	0	0	0
12	Chlorpyriphos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	0	1	1	0	0	0.5
13	Cartap hydrochloride 50% SP + Carbendazim 50% WP	2.0 +1.0	0	0	0	0	1	0.5
14	Cartap hydrochloride 50% SP + Hexaconazole 5% SC	2.0 +2.0	0	1	1	0	0	0
15	Cartap hydrochloride 50% SP + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
16	Cartap hydrochloride 50% SP + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
17	Chlorantraniliprole 18.5% SC + Carbendazim 50% WP	0.3 +1.0	0	0	0	0	1	0.5
18	Chlorantraniliprole 18.5% SC + Hexaconazole 5% SC	0.3 +2.0	0	0	0	0	0	0
19	Chlorantraniliprole 18.5% SC + Tricyclazole 75% WP	0.3 +0.6	0	0	0	0	0	0
20	Chlorantraniliprole 18.5% SC + Isoprothiolane 40% EC	0.3 +1.5	0	0	0	0	0	0
21	Phosphamidon 40% EC+ Carbendazim 50% WP	2.0 +1.0	0	0	0	0	0	1
22	Phosphamidon 40% EC + Hexaconazole 5% SC	2.0 +2.0	0.5	0.5	0.5	0	0	0
23	Phosphamidon 40% EC + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
24	Phosphamidon 40% EC + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
25	Untreated control	-	0	0	0	0	0	0

***Oily emulsion**

Table 4. Specific gravity (g) of insecticides and fungicides alone and in combination using distilled water

	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Tricyclazole	1.001	1.001	1.000	0.999	0.997
Hexaconazole	1.000	1.001	1.000	1.001	0.901
Carbendazim	1.001	1.002	1.000	0.999	1.000
Isoprothiolane	1.000	1.000	1.000	0.999	0.999
Alone	0.995	1.000	0.999	1.000	

Table 5. Specific gravity (g) of insecticides and fungicides alone and in combination using tap water

	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Tricyclazole	1.003	1.002	1.001	1.002	1.005
Hexaconazole	1.007	1.006	1.002	1.002	1.007
Carbendazim	1.003	1.003	1.011	1.005	1.008
Isoprothiolane	1.004	1.005	1.004	1.001	1.004
Alone	1.002	1.015	1.006	1.001	

Table 6. Specific gravity (g) of insecticides and fungicides alone and in combination using standard hard water

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantra-niliprole	Phospha-midon	Alone
Tricyclazole	1.003	1.002	1.002	1.001	1.002
Hexaconazole	1.005	1.004	1.002	1.000	1.005
Carbendazim	1.003	1.004	1.008	1.003	1.007
Isoprothiolane	1.002	1.005	1.004	1.001	1.006
Alone	1.000	1.009	1.007	1.000	

Table 7. pH of insecticides, fungicides alone and in combination in distilled water

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantra-niliprole	Phosphamidon	Alone
Carbendazim	6.2	6.0	6.7	5.9	6.6
Hexaconazole	6.4	6.0	6.6	5.8	6.8
Tricyclazole	6.3	6.2	6.5	5.8	6.6
Isoprothiolane	6.2	5.9	6.7	6.0	6.7
Alone	6.7	6.0	6.8	6.2	

Table 8. pH of insecticides, fungicides alone and in combination in tap water

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Carbendazim	7.8	7.0	7.7	7.2	7.7
Hexaconazole	7.0	7.0	7.5	7.5	7.4
Tricyclazole	6.9	6.9	7.8	7.2	7.6
Isoprothiolane	6.9	7.0	7.5	7.4	7.4
Alone	7.4	6.8	7.7	7.3	

Table 9. pH of insecticides, fungicides alone and in combination in Standard hard water

Chemical	Chlorpyriphos	Cartap Hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Tricyclazole	7.2	6.6	7.3	6.7	7.3
Hexaconazole	6.6	6.7	7.2	7.1	7.2
Carbendazim	6.6	6.5	7.1	6.9	7.5
Isoprothiolane	6.4	6.7	7.3	7.2	7.2
Alone	7.1	6.8	7.4	7.1	

Table 10. EC (dSm^{-1}) of insecticides, fungicides alone and in combination in distilled water

Chemical	Chlorpyriphos	Cartap Hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Carbendazim	0.08	1.53	0.08	0.10	0.05
Hexaconazole	0.09	1.36	0.02	0.07	0.06
Tricyclazole	0.08	1.63	0.08	0.93	0.22
Isoprothiolane	0.04	1.63	0.02	0.08	0.05
Alone	0.04	1.77	0.06	0.09	

Table 11. EC (dSm^{-1}) of insecticides, fungicides alone and in combination in tap water

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Carbendazim	2.67	3.64	2.64	2.67	2.64
Hexaconazole	2.88	3.62	2.91	2.92	2.92
Tricyclazole	2.94	3.77	2.93	2.64	2.63
Isoprothiolane	2.9	3.7	2.95	2.94	2.94
Alone	2.91	4.48	2.94	2.88	

Table 12. EC (dSm^{-1}) of insecticides, fungicides alone and in combination in standard hard water

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Tricyclazole	1.92	2.86	2.06	1.90	1.86
Hexaconazole	1.85	2.51	2.21	2.22	2.27
Carbendazim	1.98	2.92	2.16	2.02	1.98
Isoprothiolane	2.20	2.98	2.21	2.38	2.46
Alone	1.95	3.85	2.18	2.25	

The test was conducted by using normal tap water, standard hard water and distilled water in three replications to find out the differences in their specific gravity, if any.

Chemical Compatibility

Chemical compatibility of spray solutions of insecticides, fungicides alone and in combination was tested by conducting pH and EC analysis using pH and EC meter, respectively.

pH and EC analysis

A known quantity of solution was taken in a beaker from the solutions prepared for emulsion stability test individually for all the treatments mentioned in the table and the pH and EC measuring electrodes were dipped into the individual beaker and the values were noted. All the treatments were replicated thrice and the tests were conducted with normal distilled water, tap water and standard hard water.

RESULTS AND DISCUSSION

Emulsion stability test

The results obtained from emulsion stability test revealed that when the insecticides and fungicides were mixed in distilled water, tap water and standard hard water (324 ppm), there was no sedimentation at the bottom and creamy layer at the top of the measuring cylinder in distilled water whereas it was observed up to one ml in standard hard water and tap water. Further there was no formation of clumps, clods, emulsions and separation of mixtures when they were mixed. Since there was no formation of sediment or creamy layer (> 2 ml) in all the three types of water it is proved that all the insecticides and fungicides combinations tested are physically compatible and stable. (Table 2 & 3)

Specific gravity test

The results obtained for all the insecticides and fungicides alone and in combination with distilled water are presented in the Table 4. From the table, it was evident that the specific gravity of the test insecticides, fungicides alone and in combination did not vary much in distilled water. The specific gravity values of the insecticides alone ranged from 0.995 g (chlorpyriphos) to 1.000 g (cartap hydrochloride and phosphamidon) whereas the specific gravity values of fungicides alone in distilled water ranged from 0.901 g (hexaconazole) to 1.000 g (carbendazim). However, the specific gravity values of the insecticide and fungicide combinations in distilled water ranged from 0.999 g (all fungicide combinations with phosphamidon except hexaconazole) to 1.002 g (catap hydrochloride + carbendazim). The small differences in the combinations may be attributed to the higher or lower densities of the respective insecticide and fungicide in their combination.

The results obtained for all the insecticides and fungicides alone and in combination with tap water are presented in the Table 5. From the table, it is evident that there was no much variation in the specific gravity of the test insecticides, fungicides alone and in combination in tap water. The specific gravity values of the insecticides alone ranged from 1.001 g (phosphamidon) to 1.015 g (cartap hydrochloride) whereas the specific gravity values of fungicides alone in tap water ranged from 1.004 g (isoprothiolane) to 1.008 g (carbendazim). However the specific gravity values of the insecticide and fungicide combinations in tap water ranged from 1.001 g (chlorantraniliprole + tricyclazole and phosphamidon + isoprothiolane) to 1.011 g (chlorantraniliprole + carbendazim). The small differences in the combinations may be due to the higher or lower densities of the respective insecticide and fungicide in their combination.

The results obtained for all the insecticides and fungicides alone and in combination with standard hard water are presented in the Table 6. From the table, it was evident that the specific gravity of the test insecticides, fungicides alone and in combination did not vary much in standard hard water. The specific gravity values of the insecticides alone ranged from 1.000 g (chlorpyriphos and phosphamidon) to 1.009 g (cartap hydrochloride) whereas the specific gravity values of fungicides alone in tap water ranged from 1.002 g (tricyclazole) to 1.007 g (carbendazim). However, the specific gravity values of the insecticide and fungicide combinations in standard hard water ranged from 1.000 g (phosphamidon + hexaconazole) to 1.008 g (chlorantraniliprole + carbendazim). The small differences in the combinations may be due to the higher or lower densities of the respective insecticide and fungicide in their combination.

Chemical Compatibility

In chemical compatibility, the parameters like pH (Hydrogen ion concentration) and EC (Electrical conductivity) of the insecticides, fungicides alone and their combinations were measured. From the results obtained, it was clear that there was no much difference in the values of pH, EC when the insecticides and fungicides were combined compared to individual treatments. The insecticides, fungicides alone and in combination were slightly alkaline in nature.

pH

The results obtained for all the insecticides and fungicides alone and in combination with distilled water are presented in the Table 7. The pH values of insecticides alone ranged from 6.0 (cartap hydrochloride) to 6.8 (chlorantraniliprole) whereas the pH values of fungicides alone in distilled water ranged from 6.6 (tricyclazole and carbendazim) to 6.8 (hexaconazole). However, the pH values of the insecticide and fungicide combinations in distilled water ranged from 5.8 (phosphamidon + tricyclazole and phosphamidon + hexaconazole) to 6.7 (chlorantraniliprole + carbendazim and chlorantraniliprole + isoprothiolane).

The pH values obtained for all the insecticides and fungicides alone and in combination with tap water are presented in the Table 8. The pH values of insecticides alone ranged from 6.8 (cartap hydrochloride) to 7.7 (chlorantraniliprole) whereas the pH values of fungicides alone in distilled water ranged from 7.4 (hexaconazole and isoprothiolane) to 7.7 (carbendazim). However, the pH values of the insecticide and fungicide combinations in distilled water ranged from 6.9 (cartap hydrochloride + tricyclazole, chlorpyriphos + tricyclazole and chlorpyriphos + isoprothiolane) to 7.8 (chlorpyriphos + carbendazim and chlorantraniliprole + tricyclazole).

The results pertaining to all the insecticides and fungicides alone and in combination with standard hard water are presented in the table 9. The pH values of insecticides alone ranged from 6.8 (cartap hydrochloride) to 7.4 (chlorantraniliprole) whereas the pH values of fungicides alone in standard hard water ranged from 7.2 (hexaconazole and isoprothiolane) to 7.5 (carbendazim). However, the pH values of the insecticide and fungicide combinations in standard water ranged from 6.4 (chlorpyriphos + isoprothiolane) to 7.3 (chlorantraniliprole + tricyclazole and chlorantraniliprole + isoprothiolane).

EC

The results pertaining to Electrical Conductivity (E.C) of all the insecticides and fungicides alone and in combination with distilled water are presented in the Table 10. The EC values of insecticides alone ranged from 0.04 dSm^{-1} (chlorpyriphos) to 1.77 dSm^{-1} (cartap hydrochloride) whereas the EC values of fungicides alone in distilled water ranged from 0.05 dSm^{-1} (carbendazim and isoprothiolane) to 0.22 dSm^{-1} (tricyclazole). However, the EC values of the insecticide and fungicide combinations in distilled water ranged from 0.02 dSm^{-1} (chlorantraniliprole + hexaconazole and chlorantraniliprole + isoprothiolane) to 1.63 dSm^{-1} (cartap hydrochloride + tricyclazole and cartap hydrochloride + isoprothiolane).

The results of E.C when tested with tap water for all the insecticides and fungicides alone and in combination are presented in the Table 11. The EC values of insecticides alone ranged from 2.91 dSm^{-1} (chlorpyriphos) to 4.48 dSm^{-1} (cartap hydrochloride) whereas the EC values of fungicides alone in tap water ranged from 2.63 dSm^{-1} (tricyclazole) to 2.94 dSm^{-1} (isoprothiolane). However, the EC values of the insecticide and fungicide combinations in tap water ranged from 2.64 dSm^{-1} (chlorantraniliprole + carbendazim and phosphamidon + tricyclazole) to 3.77 dSm^{-1} (cartap hydrochloride + tricyclazole).

The results obtained for all the insecticides and fungicides alone and in combination with standard hard water are presented in the Table 12. The EC values of insecticides alone ranged from 1.95 dSm^{-1} (chlorpyriphos) to 3.85 dSm^{-1} (cartap hydrochloride) whereas the EC values of fungicides alone in tap water ranged from 1.86 dSm^{-1} (tricyclazole) to 2.46 dSm^{-1} (isoprothiolane). However, the EC values of the insecticide and fungicide combinations in standard hard water ranged from 1.85 dSm^{-1} (chlorpyriphos + hexaconazole) to 2.98 dSm^{-1} (cartap hydrochloride + isoprothiolane).

The results pertaining to physical and chemical compatibility test revealed that there were no incompatible combinations physically and chemically and all the insecticides and fungicides alone and in combinations are safe to use in the field. The present findings are in conformity with the Koushika *et al*. (2014) who reported that chlorantraniliprole 4.3% + abamectin 1.7% SC with other agrochemicals did not produce creamy matter or sediment at the top or bottom of the 100 ml cylinder. Govindan *et al.* (2013) reported that emamectin benzoate 5% SG at 11 g a.i. ha^{-1} was physically compatible with endosulfan, carbendazim and urea which did not produce any sedimentation at bottom and creamy layer at top of the cylinder. The findings of Kubendran *et al.* (2009) also revealed that physical compatibility of flubendiamide + thiocloprid 480% SC with other agrochemicals in terms of emulsion stability test which showed that flubendiamide + thiocloprid 480 SC @ 25 ml ha^{-1} with diammonium phosohate (2%), quinalfos (0.05%) and copper oxychloride (0.25%) combination did not produce creamy matter or sediment at the top or bottom of the 100 ml cylinder.

CONCLUSION

Compatibility of the pesticides is the basic and most important one to be considered by the farmer as the incompatible combinations may cause him a huge loss. So proper knowledge on compatibility is a must and they should be proved scientifically before applying in the field. In our study the results pertaining to physical and chemical compatibility test revealed that there were no incompatible combinations physically and chemically and all the insecticides and fungicides alone and in combinations are safe to use in the field.

LITERATURE CITED

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