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Compatibility and Bio-efficacy of Certain Insecticides in Combination with Zinc against Yellow Stem Borer, *Scirpophaga incertulas* (Walker) in Rice

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ABSTRACT

Eleven commonly used insecticides *viz.,* chlorpyriphos 20 EC, chlorpyriphos 50 EC, monocrotophos 36 SL, cartap hydrochloride 50 SP, profenophos 50 EC, acephate 75 SP, imidacloprid 200 SL, thiamethoxam 25 WG, lambda cyhalothrin 2.5 EC, flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC were tested for their physical compatibility with three zinc formulations *viz.,* zinc sulphate (zinc monohydrate 33%), chelated zinc (EDTA 12%) and zinc sulphate (21%). Further, the test chemicals at all the 33 possible combinations (insecticide + zinc formulation) and alone were tested for phytotoxicity during *rabi,* 2013-14 and evaluated for their bio-efficacy against yellow stem borer, *Scirpophaga incertulas* (Walker) during *rabi,* 2014-15. All the insecticide + zinc combinations tested were physically compatible and did not show phytotoxicity on rice crop. Among the insecticides sprayed alone, the stem borer incidence was significantly lower in chlorantraniliprole with 1.4% dead hearts followed by cartap hydrochloride (1.5% dead hearts), whereas highest dead heart damage was recorded in imidacloprid (7.2%) followed by thiamethoxam (6.9%). Stem borer incidence ranged from 6.8 to 8.2% dead hearts in plots treated with zinc formulations. Similar trend of stem borer damage was observed even when mixed with zinc formulations. None of the insecticide + zinc combinations had caused any negative effect on the bio-efficacy of insecticides against stem borer.

Keywords: *Bio-efficacy, Compatibility, Insecticides, Rice, Yellow stem borer and Zinc.*

Rice is an important food crop, providing staple food to majority of the people in India, where the crop is grown in an area of 439.9 lakh hectares with a production of 109.7 million tonnes and with a productivity of 2494 kg per hectare (Annual Report, DAC, 2018-19). In Telangana, rice is grown in an area of 10.46 lakh hectares, with a production of 30.47 lakh tonnes and productivity of 2913 kg per hectare (Telangana state at a glance, 2017). Rice productivity is often limited because of several biotic and abiotic stresses. Among the biotic stresses, insect pests are the main cause of low yields of rice in India (Behura *et al.* 2011). Rice crop is attacked by more than 100 species of insects, of which only, 20 species are of economic importance. Insect pests that can cause significant yield losses are stem borers, leafhoppers, plant hoppers, gall midge, defoliators and grain-sucking bugs. The yield loss estimates due to yellow stem borer, brown plant hopper and gall midge are 25-30, 10-70 and 15-60%, respectively. Leaf folder (10%) and other pests (25%) also cause yield losses. The incidence of insect pests and resultant yield losses vary depending upon the crop age. During the first 30 days after transplanting, significant yield losses are reported due to stem borer and gall midge in 10-15% of the locations tested under AICRIP. The crop growth period between 30-60 days after transplanting was most vulnerable resulting in major yield losses (20-68%) mainly due to stem borer, gall midge, leaf folder and brown plant hopper. Beyond sixty days after transplanting, the crop damage is inflicted by stem borer and leaf folder causing 10 to 48% damage (Krishnaiah and Varma, 2012). In Telangana, stem borer is the predominant insect pest during *rabi*.

Abiotic stresses like micronutrient deficiencies and their impact on crop yields are widely reported in various parts of the country (Singh, 2008). Zinc deficiency is the most widely recognized deficiency in India. In Telangana, zinc deficiency is quite often noticed during r*abi* season in rice, affecting seedlings in nursery stage, seedling establishment and early crop growth after transplantation.

Farmers resort to foliar application of zinc formulations to correct zinc deficiency and insecticidal application against insect pests separately. Tank mixing of both insecticide and zinc sulphate (zinc formulation), would save time and money for the farmers. However, there is no systematic study on the physical or chemical compatibility of newer insecticides and different zinc formulations on rice yellow stem borer. It is imperative to generate information on the phytotoxicity and bio-efficacy of insecticide + zinc combinations. Hence, the present experiment was conducted to identify most compatible combinations in rice, so that farmers can save on plant protection costs.

MATERIAL AND METHODS

The present experiment was conducted at Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Warangal, Telangana. Eleven commonly used insecticides *viz.*, chlorpyriphos 20 EC, chlorpyriphos 50 EC, monocrotophos 36 SL, cartap hydrochloride 50 SP, profenophos 50 EC, acephate 75 SP, imidacloprid

200 SL, thiamethoxam 25 WG, lambda cyhalothrin 2.5 EC, flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC were tested for their compatibility, phytotoxicity and bio-efficacy with three zinc formulations *viz.,* zinc sulphate (zinc monohydrate 33%), chelated zinc (EDTA 12%) and zinc sulphate (21%) (Table 1) during *rabi*, 2013-14 and *rabi,* 2014-15. All insecticide + zinc formulation combinations were studied for their physical compatibility and phytotoxicity at recommended dosages during *rabi,* 2013-14 followed by bio-efficacy studies against rice yellow stem borer during *rabi,* 2014-15.

Physical compatibility

Physical compatibility of the insecticides with zinc formulations was tested using Jar test method. A clear glass jar with lid of 250 ml capacity was taken, in which 100 ml of water was taken. The test chemicals were added to the jar depending on the recommended dilution factor/dose of the chemical. Order of mixing of the chemicals for compatibility was WP, WG, SC, SP and SL. The mixture in the jars was stirred gently after each addition by closing the jars tightly. Contents were mixed thoroughly by turning the jars 10 times. Later, the jars were kept aside for 30 minutes and checked for incompatible phenomena like non homogeneity, layer suspension, precipitation, change in viscosity, aggregation, flocculation, clump formation and gelatinization of the mixture, which cause clogging of nozzle and uneven spray distribution in the field.

Phytotoxicity studies

Preliminary small scale field test was carried during *rabi* 2013-14, to know phytotoxicity of the mixtures on rice crop. For this study, insecticides and zinc formulations alone and in combination were sprayed, 40 days after transplanting in MTU-1010 rice variety. Observations of phytotoxicity symptoms such as leaf tips and surface injury, vein clearing were recorded using 0-9 scale at 1, 3, 5, 7 and 10 days after spraying and score was given for the phytotoxicity parameters based on per cent phytotoxicity (Table 2).

Bio-efficacy studies

During *rabi* 2014-15, insecticide + zinc combinations that were physically compatible and non-phytotoxic were tested for their bio-efficacy along with individual insecticides and zinc formulations in a field experiment with the variety MTU -1010, laid out in a Randomised block design consisting of 47 treatments (Table 5) and 3 replications. Transplanting was done on 30-12-2014 at a spacing of 15x15 cm and the crop was grown by following all the recommended agronomic practices except plant protection measures and foliar nutrient application.

Insecticides and zinc formulations alone and in combination were sprayed in standing crop at 38 DAT using knapsack sprayer with spray fluid of 500 l/ha. As zinc deficiency is generally observed during the early stage of the rice crop, and stem borer is an important pest during *rabi* season, data on per cent dead hearts was taken to study the efficacy of chemicals. Data on per cent dead hearts were recorded at 15 days after spraying on 10 randomly selected hills per plot and mean was calculated which was then analysed using ANOVA.

RESULTS AND DISCUSSION

The test insecticides *viz.,* chlorpyriphos 20 EC, chlorpyriphos 50 EC, monocrotophos 36 SL, cartap hydrochloride 50 SP, profenophos 50 EC, acephate 75 SP, imidacloprid 200 SL, thiamethoxam 25 WG, lambda cyhalothrin 2.5 EC, flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC were found to be physically compatible with zinc sulphate (33%), chelated zinc (EDTA 12%) and zinc sulphate (21%), at their respective recommended doses (Table 3) and none of insecticide + zinc formulation combinations involving these had shown phytotoxicity symptoms on rice crop (Table 4). Physical compatibility study showed that, when the insecticides were mixed with zinc formulations, the spray solution was homogeneous, smooth mixture, and did not show any flocculation or sedimentation. Foliar spraying of individual insecticide, zinc formulation and their combinations did not show any phytotoxicity symptoms like injury to leaf tips, leaf surface injury and vein clearing on rice crop. It shows that the above zinc formulations can be safely used along with these insecticides.

The information on compatibility of zinc formulations with insecticides in rice is meagre. Mehta *et al*., (2011) reported that, zinc application as seed treatment in combination with conventional seed treatments - biofertilizer, insecticide and fungicide was found feasible. Among the different seed treatment combinations, zinc was found more compatible with biofertilizer and insecticide than fungicide.

The data pertaining to bio-efficacy of insecticides alone and in all possible combinations is presented in Table 5. During the period under report, only stem borer incidence was recorded. It is evident from perusal of the data that, the incidence of stem borer in terms of dead hearts ranged from 1.1% to 8.2% in the experimental plot. Among the insecticides sprayed alone, the stem borer incidence was significantly lowest in chlorantraniliprole (1.4%) followed by cartap hydrochloride (1.5%), whereas highest stem borer damage was recorded in plots treated with imidacloprid (7.2%) followed by thiamethoxam (6.9%). Stem borer incidence was in

Table1. Insecticides and zinc formulations used and their dosage

S. No.	Test Agro- chemical	Dose
Insecticides		
1	Chlorpyriphos 20 EC	2.5 ml/l
2	Chlorpyriphos 50 EC	2.0 ml/l
3	Monocrotophos 36 SL	1.6 ml/l
4	Cartap hydrochloride 50 SP	2.0 g/l
5	Profenophos 50 EC	2.0 ml/l
6	Acephate 75 SP	1.5 g/l
7	Imidacloprid 200 SL	0.25 ml/l
8	Thiamethoxam 25 WG	0.2 g/l
9	Lambda cyhalothrin 2.5 EC	1.0 ml/l
10	Flubendiamide 39.35 SC	0.2 ml/l
11	Chlorantraniliprole 18.5 SC	0.4 ml/l
Zinc Formulations		
12	Zinc sulphate (Zinc monohydrate 33%)	2.5 g/l
13	Chelated zinc (EDTA 12%)	1.0 g/l
14	Zinc sulphate (21%)	2.5 g/l

Table 2. Rating Scale for Phytotoxicity

Score	Per cent Phytotoxicity
0	No phytotoxicity
1	0-10
2	20-Nov
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

Table 3. Physical compatability of certain insecticides with zinc formulations

Insecticide \ Zinc formulation	Zinc sulphate (Zinc monohydrate 33%)	Chelated zinc (EDTA 12%)	Zinc sulphate (21%)
Chlorpyriphos 20 EC	C	C	C
Chlorpyriphos 50 EC	C	C	C
Monocrotophos 36 SL	C	C	C
Cartap hydrochloride 50 SP	C	C	C
Profenophos 50 EC	C	C	C
Acephate 75 SP	C	C	C
Imidacloprid 200 SL	C	C	C
Thiamethoxam 25 WG	C	C	C
Lambda cyhalothrin 2.5 EC	C	C	C
Flubendiamide 39.35 SC	C	C	C
Chlorantraniliprole 18.5 SC	C	C	C

C – Compatible; IC - Incompatible

Table 4. Phytotoxicity of certain insecticides in combination with zinc formulations on Rice

Tr. No.	Insecticide/ Zn product or combination	Dosage	Score
1	Chlorpyriphos 20 EC	2.5 ml/l	0
2	Chlorpyriphos 50 EC	2.0 ml/l	0
3	Monocrotophos 36 SL	1.6 ml/l	0
4	Cartap hydrochloride 50 SP	2.0g/l	0
5	Profenophos 50 EC	2.0 ml/l	0
6	Acephate 75 SP	1.5 g/l	0
7	Imidacloprid 200 SL	0.25 ml/l	0
8	Thiamethoxam 25 WG	0.2 g/l	0
9	Lambda cyhalothrin 2.5 EC	1.0 ml/l	0
10	Flubendiamide 39.35 SC	0.2 ml/l	0
11	Chlorantraniliprole 18.5 SC	0.4 ml/l	0
12	Zinc sulphate (zinc monohydrate 33%)	2.5 g/l	0
13	Chelated zinc (EDTA 12%)	1.0 g/l	0
14	Zinc sulphate (21%)	2.5g/l	0
15	Chlorpyriphos 20 EC + Zinc sulphate (Zinc monohydrate 33%)	2.5 ml/l +2.5 g/l	0
16	Chlorpyriphos 20 EC+ Chelated zinc (EDTA 12%)	2.5 ml/l+1.0 g/l	0
17	Chlorpyriphos 20 EC + Zinc sulphate (21%)	2.5 ml/l + 2.5g/l	0
18	Chlorpyriphos 50 EC + Zinc sulphate (Zinc monohydrate 33%)	2.0 ml/l +2.5 g/l	0
19	Chlorpyriphos 50 EC + Chelated zinc (EDTA 12%)	2.0ml/l+1.0 g/l	0
20	Chlorpyriphos 50 EC + Zinc sulphate (21%)	2.0 ml/l+2.5 g/l	0
21	Monocrotophos 36 SL + Zinc sulphate (Zinc monohydrate 33%)	1.6 ml/l+2.5 g/l	0
22	Monocrotophos 36 SL + Chelated zinc (EDTA 12%)	1.6 ml/l + 1.0 g/l	0
23	Monocrotophos 36 SL + Zinc sulphate (21%)	1.6 ml/l + 2.5g/l	0
24	Cartap hydrochloride 50 SP + Zinc sulphate (Zinc monohydrate 33%)	2.0 g/l +2.5 g/l	0
25	Cartap hydrochloride 50 SP + Chelated zinc (EDTA 12%)	2.0 g/l +1.0 g/l	0
26	Cartap hydrochloride 50 SP + Zinc sulphate (21%)	2.0 g/l + 2.5 g/l	0
27	Profenophos 50 EC + Zinc sulphate (Zinc monohydrate 33%)	2.0 ml/l + 2.5g/l	0
28	Profenophos 50 EC + Chelated zinc (EDTA 12%)	2.0 ml/l + 1.0 g/l	0
29	Profenophos 50 EC + Zinc sulphate (21%)	2.0 ml/l +2.5 g/l	0
30	Acephate 75 SP + Zinc sulphate (Zinc monohydrate 33%)	1.5 g/l + 2.5 g/l	0
31	Acephate 75 SP + Chelated zinc (EDTA 12%)	1.5 g/l +1.0 g/l	0
32	Acephate 75 SP + Zinc sulphate (21%)	1.5 g/l + 2.5 g/l	0
33	Imidacloprid 200 SL + Zinc sulphate (Zinc monohydrate 33%)	0.25 ml/l + 2.5g/l	0
34	Imidacloprid 200 SL + Chelated zinc (EDTA 12%)	0.25 ml/l + 1.0 g/l	0
35	Imidacloprid 200 SL + Zinc sulphate (21%)	0.25ml/l + 2.5 g/l	0
36	Thiamethoxam 25 WG + Zinc sulphate (Zinc monohydrate 33%)	0.2 g/l + 2.5 g/l	0
37	Thiamethoxam 25 WG + Chelated zinc (EDTA 12%)	0.2 g/l + 1.0 g/l	0
38	Thiamethoxam 25 WG + Zinc sulphate (21%)	0.2 g/l + 2.5 g/l	0
39	Lambda cyhalothrin 2.5 EC + Zinc sulphate (Zinc monohydrate 33%)	1.0ml/l + 2.5g/l	0
40	Lambda cyhalothrin 2.5 EC + Chelated zinc (EDTA 12%)	1.0 ml/l +1.0 g/l	0
41	Lambdacyhalothrin 2.5 EC + Zinc sulphate (21%)	1.0 ml/l + 2.5g/l	0
42	Flubendiamide 39.35 SC + Zinc sulphate (Zinc monohydrate 33%)	0.2ml/l + 2.5g/l	0
43	Flubendiamide 39.35 SC + Chelated zinc (EDTA 12%)	0.2 ml/l +1.0 g/l	0
44	Flubendiamide 39.35 SC + Zinc sulphate (21%)	0.2 ml/l +2.5g/l	0
45	Chlorantraniliprole 18.5 SC + Zinc sulphate (Zinc monohydrate 33%)	0.4ml/l +2.5g/l	0
46	Chlorantraniliprole 18.5 SC + Chelated zinc (EDTA 12%)	0.4ml/l +1.0 g/l	0
47	Chlorantraniliprole 18.5 SC + Zinc sulphate (21%)	0.4ml/l +2.5g/l	0

Table 5. Bio-efficacy of certain insecticides alone and in combination with zinc formulations against yellow stem borer during *Rabi*, 2014-15 at RARS, Warangal

Tr. No.	Treatments	Dosage	Per cent dead hearts
1	Chlorpyriphos 20 EC	2.5 ml/l	2.50
2	Chlorpyriphos 50 EC	2.0 ml/l	2.00
3	Monocrotophos 36 SL	1.6 ml/l	3.50
4	Cartap hydrochloride 50 SP	2.0 g/l	1.50
5	Profenophos 50 EC	2.0 ml/l	4.80
6	Acephate 75 SP	1.5 g/l	3.20
7	Imidacloprid 200 SL	0.25 ml/l	7.20
8	Thiamethoxam 25 WG	0.2 g/l	6.90
9	Lambda cyhalothrin 2.5 EC	1.0 ml/l	2.80
10	Flubendiamide 39.35 SC	0.2 ml/l	5.30
11	Chlorantraniliprole 18.5 SC	0.4 ml/l	1.40
12	Zinc sulphate (zinc monohydrate 33%)	2.5 g/l	7.10
13	Chelated zinc (EDTA 12%)	1.0 g/l	6.80
14	Zinc sulphate (21%)	2.5g/l	8.20
15	Chlorpyriphos 20 EC + Zinc sulphate (Zinc monohydrate 33%)	2.5 ml/l +2.5 g/l	2.30
16	Chlorpyriphos 20 EC+ Chelated zinc (EDTA 12%)	2.5 ml/l +1.0 g/l	2.00
17	Chlorpyriphos 20 EC + Zinc sulphate (21%)	2.5 ml/l + 2.5g/l	2.50
18	Chlorpyriphos 50 EC + Zinc sulphate (Zinc monohydrate 33%)	2.0 ml/l +2.5 g/l	2.10
19	Chlorpyriphos 50 EC + Chelated zinc (EDTA 12%)	2.0ml/l +1.0 g/l	2.30
20	Chlorpyriphos 50 EC + Zinc sulphate (21%)	2.0 ml/l +2.5 g/l	2.20
21	Monocrotophos 36 SL + Zinc sulphate (Zinc monohydrate 33%)	1.6 ml/l+2.5 g/l	3.00
22	Monocrotophos 36 SL + Chelated zinc (EDTA 12%)	1.6 ml/l + 1.0 g/l	3.50
23	Monocrotophos 36 SL + Zinc sulphate (21%)	1.6 ml/l + 2.5g/l	3.30
24	Cartap hydrochloride 50 SP + Zinc sulphate (Zinc monohydrate 33%)	2.0 g/l +2.5 g/l	1.80
25	Cartap hydrochloride 50 SP + Chelated zinc (EDTA 12%)	2.0 g/l +1.0 g/l	2.00
26	Cartap hydrochloride 50 SP + Zinc sulphate (21%)	2.0 g/l + 2.5 g/l	1.10
27	Profenophos 50 EC + Zinc sulphate (Zinc monohydrate 33%)	2.0 ml/l + 2.5g/l	5.10
28	Profenophos 50 EC + Chelated zinc (EDTA 12%)	2.0 ml/l + 1.0 g/l	4.50
29	Profenophos 50 EC + Zinc sulphate (21%)	2.0 ml/l +2.5 g/l	4.80
30	Acephate 75 SP + Zinc sulphate (Zinc monohydrate 33%)	1.5 g/l + 2.5 g/l	3.50
31	Acephate 75 SP + Chelated zinc (EDTA 12%)	1.5 g/l +1.0 g/l	3.00
32	Acephate 75 SP + Zinc sulphate (21%)	1.5 g/l + 2.5 g/l	3.20
33	Imidacloprid 200 SL + Zinc sulphate (Zinc monohydrate 33%)	0.25 ml/l + 2.5g/l	7.50
34	Imidacloprid 200 SL + Chelated zinc (EDTA 12%)	0.25 ml/l + 1.0	6.90
35	Imidacloprid 200 SL + Zinc sulphate (21%)	0.25ml/l + 2.5 g/l	7.00
36	Thiamethoxam 25 WG + Zinc sulphate (Zinc monohydrate 33%)	0.2 g/l + 2.5 g/l	7.30
37	Thiamethoxam 25 WG + Chelated zinc (EDTA 12%)	0.2 g/l + 1.0 g/l	8.00
38	Thiamethoxam 25 WG + Zinc sulphate (21%)	0.2 g/l + 2.5 g/l	7.50
39	Lambda cyhalothrin 2.5 EC + Zinc sulphate (Zinc monohydrate 33%)	1.0ml/l + 2.5g/l	3.00
40	Lambda cyhalothrin 2.5 EC + Chelated zinc (EDTA 12%)	1.0 ml/l +1.0 g/l	2.60
41	Lambdacyhalothrin 2.5 EC + Zinc sulphate (21%)	1.0 ml/l + 2.5g/l	2.50
42	Flubendiamide 39.35 SC + Zinc sulphate (Zinc monohydrate 33%)	0.2ml/l + 2.5g/l	5.40
43	Flubendiamide 39.35 SC + Chelated zinc (EDTA 12%)	0.2 ml/l +1.0 g/l	4.90
44	Flubendiamide 39.35 SC + Zinc sulphate (21%)	0.2 ml/l +2.5g/l	5.10
45	Chlorantraniliprole 18.5 SC + Zinc sulphate (Zinc monohydrate 33%)	0.4ml/l +2.5g/l	1.40
46	Chlorantraniliprole 18.5 SC + Chelated zinc (EDTA 12%)	0.4ml/l +1.0 g/l	1.70
47	Chlorantraniliprole 18.5 SC + Zinc sulphate (21%)	0.4ml/l +2.5g/l	1.10
	C.D. (5%)		1.4
	S.Em ±		0.32

the range of 6.8 to 8.2% dead hearts in plots treated with different zinc formulations sprayed alone.

The present results on bio-efficacy are in conformity with Sachan *et al*., (2018), who reported that application of chlorantraniliprole 18.5 SC @ 150 ml/ha was the most effective treatment in reducing the stem borer infestation in Basmati rice followed by chlorantraniliprole 0.4 % GR @ 10 kg/ha. Similarly, Kumud Singh (2018) reported that, rynaxypyr (Coragen) 20 SC @ 150 ml/ha was found best to control stem borer in rice. Similar findings were reported by Omprakash *et al*., (2017) who found that, chlorantraniliprole 0.4 G @ 10 kg/hectare followed by chlorantraniliprole 18.5 SC @ 150 ml/ hectare were the best chemicals against stem borer with an average of 1.9 and 2.5 per cent dead hearts and 0.7 and 1.0 per cent white ears damage, respectively, in rice. Mishra *et al*., (2012) reported superiority of fipronil 5 SC @ 50 g *a.i.*ha^{-1} against yellow stem borer followed by cartap hydrochloride 50 SP @ 300g *a.i.*ha^{-1} and cartap hydrochloride 4G @ 750 g *a.i.*ha^{-1}.

However, among the combinations, significantly lowest per cent dead hearts of 1.1 per cent were recorded in combination of zinc sulphate (21%) with cartap hydrochloride or chlorantraniliprole followed by other zinc combinations with chlorantraniliprole or cartap hydrochloride, whereas, significantly higher per cent dead hearts were recorded in plots treated with imidacloprid + zinc formulations and thiamethoxam + zinc formulations. The trend of efficacy against stem borer when insecticide + zinc formulation combinations are sprayed is similar to that of insecticides when sprayed alone. Further, there is no significant variation in per cent dead heart incidence among an insecticide sprayed alone and the insecticide in combination with any of the three zinc formulations. Thus, none of the combinations have caused any negative effect on bio-efficacy of insecticides against stem borer.

CONCLUSION

The insecticides *viz*., chlorpyriphos 20 EC, chlorpyriphos 50 EC, monocrotophos 36 SL, cartap hydrochloride 50 SP, profenophos 50 EC, acephate 75 SP, imidacloprid 200 SL, thiamethoxam 25 WG, lambda cyhalothrin 2.5 EC, flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC were physically compatible with the zinc formulations - zinc sulphate (zinc monohydrate 33%), chelated zinc (EDTA 12%) and zinc sulphate (21%) at their respective recommended doses and were not phytotoxic to rice crop. Spray mixture of insecticides with zinc formulations did not cause any significant change in their bio-efficacy against stem borer. The most effective insecticides *viz.,* chlorantraniliprole or cartap hydrochloride can be used against stem borer and can be tank mixed with zinc formulations, particularly during *rabi* to save on the spraying costs.

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