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Efficacy of insecticide seed treatments against sucking pests and natural enemies in cowpea, *Vigna unguiculata* (Linn.) Walpers

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Abstract
A field experiment was conducted to test the efficacy of seed treatment chemicals against sucking pests *viz*., thrips, leafhopper and aphids infesting cowpea. In the experiment I and II, imidacloprid 60 FS, thiamethoxam 35 FS and carbosulfan 25 ST had equal population of thrips at 3rd, 4th and 5th weeks after germination. Seed treatment with thiamethoxam 35 FS was found to be the best in reducing the *E. kerri* population by 47.38 and 55.23 per cent in both the experiments I and II, respectively. The aphid injury grade was the least in the plants raised from imidacloprid 60 FS and thiamethoxam 35 FS treated seeds. Chlorpyriphos 20 EC (0.35) and dimethoate 30 EC (0.29) treated seeds harboured lesser number of coccinellid adults compared to the untreated control (0.62). All the seed treatments had reduced the spider population by more than 50 per cent compared to UTC in both the experiments.

Keywords: Insecticide seed treatment, sucking pests, natural enemies, cowpea

Introduction
Cowpea, *Vigna unguiculata* (Linn.) Walpers is one of the most important legume crop in the world. In India, the major constraint for cowpea grain production is insect pest damage (Ehlers and Hall, 1997) [3] resulting in lower production and productivity due to direct or indirect damage. As many as 21 insect pests of different groups have been recorded damaging the cowpea crop from germination to maturity stage (Patel *et al*., 2010; Sandeep *et al*., 2017) [16, 18]. The losses in grain or foliage of cowpea ranges from 20 to 100 per cent due to insect pests (Pandey *et al*., 1991; Alghali, 1992; Karungi *et al*., 2000) [15, 1, 7]. Cowpea is attacked by different species of insect pests, among them, sucking pests *viz*., flower thrips, *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae); leafhopper, *Empoasca kerri* Pruthi (Hemiptera: Cicadellidae); aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae) *etc*. are of the major importance.
In order to manage sucking pests, chemical insecticides are the most effective control measure against insect pests on cowpea (Jackai *et al*., 1985) [6]. However, some insecticides are expensive, toxic and when used extensively, may be harmful to human health and the environment (Isubikalu *et al*., 1999) [5]. Thus, there is a need to design alternate pest management options that have limited adverse effects on the environment and are effective against target insect pests. One such option is the seed treatment with systemic insecticides, which is an alternative, easy, economic and feasible method to manage insect pests during early stage of the crop growth without causing any harmful effect on natural enemies. It protects against insect pests and is an eco-friendly technique to bio-control agents like coccinellids and chrysopids under field condition (Satpute, 1999; Murugesan *et al*, 2002; Murugesan and Annakkodi, 2007) [19, 13 12]. Seed treatment with systemic insecticide is an integral part of integrated pest management practices, which is comparatively less pollutant to the environment, cost effective, selective and reported to maintain natural equilibrium (Taylor *et al*., 2001; Nault *et al*., 2004) [24, 14]. Hence, the present field experiment was conducted to study the effect of seed treatment chemicals against sucking pests of cowpea.

Materials and Methods
Two field experiments were conducted during 2018 and 2019 at Agricultural College and Research Institute, Killikulam of Tamil Nadu Agricultural University to test the efficacy of seed treatment chemicals against sucking pests *viz*., thrips, leafhopper and aphids infesting cowpea. The seeds of cowpea, Co (CP) 7 were taken in a polythene bag and required quantity of the seed treatment chemicals *viz*., imidacloprid 60 FS @ 10 ml / kg, thiamethoxam 35 FS @

10 ml / kg, carbosulfan 25 ST @ 20 g / kg, chlorpyriphos 20 EC @ 10 ml / kg, dimethoate 30 EC @ 5 ml / kg, fipronil 5 SC @ 10 ml / kg were added separately to respective polythene bags to get uniform coating of the chemical on the seeds and dried in shade before sowing. An untreated check was also maintained. The crops were grown in 5 x 4 m plot at a spacing of 45 x 15 cm. All the recommended agronomical practices except plant protection were followed to raise the crop. The experiment was laid out in Randomized Block Design (RBD) and replicated thrice with the following treatments.

The experiment was laid out in Randomized Block Design (RBD) and replicated thrice with the following treatments

Treatment	Dose (ml or g kg^{-1})
T1 - Imidacloprid 60 FS	10 ml
T2 - Thiamethoxam 35 FS	10 ml
T3 - Carbosulfan 25 ST	20 g
T4 - Chlorpyriphos 20 EC	10 ml
T5 - Dimethoate 30 EC	5 ml
T6 - Fipronil 5 SC	10 ml
T7 - Control	-

Observation on the incidence of sucking pests *viz*., thrips, leafhopper and aphids were made up to 5 weeks after germination in all treatments (Mishra, 2017) [8]. A total of 10 plants per treatment in each replication were selected and the number of thrips and leafhopper were recorded on three leaves from each plant and the mean population per leaf per plant was estimated. *A. craccivora* population was recorded on 10 randomly selected plants and the population of aphids was recorded through aphid infestation index (Swathi *et al*., 2015) [23]. The degree of infestation level was recorded and categorized into grades as 0, 1, 2, 3, and 4 according to visual and inspection counts. The aphid index is shown in table 1.

Table 1: Aphid Infestation Index

Damage Rating Scale	Criteria
0	No population of aphid on plant
1	One or two aphids observed on plant but no colony formation
2	Small colony of aphids observed with countable numbers on plant but no damage symptoms seen
3	Big colony of aphids is observed on plant; aphids can be counted and damage symptoms seen
4	Big colony of aphids observed on plant; aphids could not be counted; severe damage symptoms seen and plant withered

The number of coccinellid predators (adult) was also observed on cowpea aphids at weekly interval. Further, mean coccinellid population was worked out (Sandeep *et al*., 2017) [18].

Results and Discussion

Efficacy of insecticide seed treatments against thrips, *Megalothrips* spp.

The variability in thrips population due to seed treatment as well as periods of observation was noticed. The interaction effects were found to be significant in experiment I (Table 2), whereas in experiment II, they were not significant (Table 3). Overall treatment means ranged from 1.99 (imidacloprid 60 FS) to 3.13 (UTC) and 0.78 (imidacloprid 60 FS) to 1.88 (UTC) thrips/ 3 leaves in the experiment I and II, respectively. Overall reduction in thrips population exhibited by the treatments compared to UTC ranged from 36.42 (imidacloprid 60 FS) to 8.95 (dimethoate 30 EC) and 58.51 (imidacloprid 60 FS) to 18.62 per cent (dimethoate 30 EC) in experiment I and II, respectively. Overall mean population over the periods of observation shown that the thrips population was least on imidacloprid 60 FS treated plants and it reduce the population by 36.42 and 58.51 per cent in experiment I and II, respectively (Table 2).

In experiment I, thiamethoxam 35 FS (31.95 %) and carbosulfan 25 ST (28.75%) were found to be the next best treatments and were equal among themselves. Fipronil 5 SC (22.04%) was inferior to the former treatments but better than chlorpyriphos 20 EC (14.70%) and dimethoate 30 EC (8.95%). Similar was the trend at each periods of observation. However, imidacloprid 60 FS, thiamethoxam 35 FS and carbosulfan 25 ST had equal population of thrips at 3rd, 4th and 5th weeks after germination.

In experiment II, thiamethoxam 35 FS and carbosulfan 25 ST were the next best to imidacloprid 60 FS, they resulted in population reduction of 49.47 and 46.28 per cent, respectively. Fipronil 5 SC, chlorpyriphos 20 EC and dimethoate 30 EC were inferior to the former treatments resulting in a reduction of 36.17, 26.06 and 18.62 per cent in thrips population compared to UTC (Table 3).

Seed treatment with imidacloprid 60 FS showed lowest thrips population than other treatments in both the experiments. The present results are in accordance with the results of Shobharani *et al*. (2017) [20] who reported that imidacloprid 60 FS @ 10 ml / kg of seeds effectively reduced the sucking pest population in the blackgram field. Soundarajan and Chitra (2011) [22] reported that seed treatment with imidaclprid recorded the lowest incidence of the sucking pests in blackgram. Further, these results were almost similar to the findings of Mote *et al*. (1995) [9] and Patil *et al*. (2008) [17] who observed that imidacloprid as seed treating chemical reduced sucking pests population below the economic threshold level up to 40 days after sowing in cotton and 61 days after germination (Dandale *et al*., 2001; Murugan *et al*., 2003) [2, 10] in cotton.

Efficacy of insecticide seed treatments against leafhopper, *E. kerri*

The variability in leafhopper population due to seed treatment as well as periods of observation was noticed. The interaction effects were found to be significant in experiment I and II. Overall treatment means ranged from 1.11 to 2.07 and 0.77 to

1.72 leafhoppers / 3 leaves in the experiment I and II, respectively.

Overall treatment means in the 1st experiment, seed treatment with thiamethoxam 35 FS was found to be best in reducing the leafhopper population by 46.38 per cent and was followed by imidacloprid 60 FS, carbosulfan 25 ST, chlorpyriphos 20 EC, dimethoate 30 EC and fipronil 5 SC which resulted in a reduction of leafhopper population by 40.10, 35.27, 25.12, 14.49 and 5.80 per cent, respectively (Table 4).

Interaction effect shown that imidacloprid 60 FS and thiamethoxam 35 FS were equally and consistently effective during all periods of observation.

Overall treatment means of leaf hopper population in the second experiment brought out the most effectiveness of thiamethoxam 35 FS seed treatment in reducing the leaf hopper population by 55.23 per cent (Table 5). Imidacloprid 60 FS and carbosulfan 25 ST stood next with a reduction of 48.25 per cent and 44.19 per cent, respectively and they were equal among themselves. All other treatments *viz.*, chlorpyriphos 20 EC, dimethoate 30 EC, fipronil 5SC were found to be inferior against leaf hopper population; resulted in a reduction of 33.14, 22.67 and 11.04 per cent, respectively. Interaction effects brought out that imidacloprid 60 FS, thiamethoxam 35 FS were almost similar in effectiveness during all periods of observation.

The present findings are in agreement with Patil *et al*. (2008) [17] who confirmed efficacy of thiamethoxam 500 FS against the sucking pests. Further, they also opined that it could be a better option for the management of the sucking pests due to their safety to natural enemies and systemic action. Murugesan and Kavitha (2009) [11] reported that imidacloprid recorded the least mean population of leafhoppers in cotton. Galice *et al*. (2015) [4] reported that seed treatment with thiamethoxam 25 WG @ 3 g / kg of seed + spray with thiamethoxam 25 WG @ 0.4 g / lit was found to be effective against leafhopper in blackgram.

Efficacy of insecticide seed treatments against aphid, *A. craccivora*

The incidence of aphids could not be observed in the experiment I due to heavy rainfall during North East Monsoon in Tuticorin region of Tamil Nadu.

Data on the efficacy of seed treatments against the aphid damage collected during experiment II are presented in the table 6. Variability in aphid damage among treatments as well as periods of observation was noticed. Variability due to interaction effect was also evident. Considering weeks after germination aphid damage grade had a steady increase from 1st week to 5th week after germination with all the treatments except UTC. A decline in aphid population was observed after 4th week after germination on untreated plants. Overall treatment means shown that injury grade was the least in the plants raised from imidacloprid 60 FS (0.33) and thiamethoxam 35 FS (0.38) treated seeds. Fipronil 5 SC (0.46) was the next best treatment followed by dimethoate 30 EC (0.57). All these treatments brought out the reduction of more than 58.99 per cent in damage grade compared to the UTC. The other two inferior treatments *viz.*, carbosulfan 25 ST and chlorpyriphos 20 EC could bring out a reduction in damage grade by 47.48 and 27.33 per cent, respectively.

The present findings are in accordance with the results of Shobharani *et al*. (2017) [20] who reported that imidacloprid 60 FS (@ 10 ml / kg of seeds) effectively reduced the sucking pest population starting from sowing or germination up to 40-45 days old crop with highest grain yield and proved cost effective in the blackgram field. Imidacloprid effectively reduced aphids, whiteflies and thrips in cotton. Galice *et al*. (2015) [4] reported that seed treatment with thiamethoxam 25 WG @ 3 g / kg of seed + spray with thiamethoxam 25 WG @ 0.4 g / lit was found to be effective against *A. craccivora* in blackgram.

Efficacy of insecticide seed treatments against coccinellid adult

The coccinellids were not observed due to the absence aphid population in the experiment I.

Data on the population of coccinellid adult on the plants raised from treated seed are presented in table 7. The treatments as well as periods of observation exerted an influence on the coccinellid adult population. Interactions were also significant. Overall mean indicated that plants raised from untreated seeds had more coccinellid adults. Chlorpyriphos 20 EC (0.35) and dimethoate 30 EC (0.29) treated seeds harboured lesser number of coccinellid adults compared to the UTC (0.62), but more than that those on other treatments *viz.*, carbosulfan 25 ST (0.23), fipronil 5 SC (0.21), thiamethoxam 35 FS (0.16) and imidacloprid 60 FS (0.09). Similar was the trend at each periods of observation.

Chlorpyriphos 20 EC and dimethoate 30 EC were found to be comparatively safer to coccinellid adults. It may probably due to the systematic and translaminar entry of chlorpyriphos 20 EC and dimethoate 30 EC. Similarly persistent action of imidacloprid 60 FS, thiamethoxam 35 FS and carbosulfan 25 ST might did harm to the spiders, besides absence of prey insects on the plants raised from the insecticide treated plants.

Efficacy of insecticide seed treatments against spider

Statistical analysis revealed the influence of treatments and periods of observation on the variability in spider population (Table 8). Mean spider population ranged from 0.07 to 0.51 and 0.07 to 0.36 per plant in the first and second experiments, respectively. All the seed treatments except chlorpyriphos 20 EC had reduced the spider population by more than 50 percent compared to UTC in the both experiments. Overall mean indicated that plants raised from untreated seed harboured the greatest number of spider population in experiment I (0.51/plant) and experiment II (0.36/plant) (Table 8 & 9).

Among the seed treatments, chlorpyriphos 20 EC was found to be less harmful with a reduction of less than 50 per cent spider population. All other treatments *viz.*, dimethoate 30 EC (62.75 & 63.89%), Fipronil 5 SC (70.59 & 69.44%), carbosulfan 25 ST (76.47 &72.22%), thiamethoxam 35 FS (84.31 & 75.00%), imidacloprid 60 FS (86.27 & 80.56%) found to be the least safer insecticide in both experiments recording a reduction of more than 50 percent in spider population.

The present findings are in accordance with the results of Singh *et al*. (2008) [21] reported that the cartap hydrochloride 4 G and imidacloprid 17.8 SL adversely affected to the spider fauna in Basmati rice ecosystem.

Table 2: Efficacy of insecticide seed treatments against thrips, *Megalurothrips* spp. - Experiment I

Treatment	Dose / kg of seeds	No. of thrips / 3 leaves*						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.10	1.37	2.40	2.80	3.30	1.99	36.42
		(0.32) a	(1.17) a	(1.55) a	(1.67) a	(1.82) a	(1.30) a	
T2 - Thiamethoxam 35 FS	10 ml	0.17	1.47	2.57	2.97	3.47	2.13	31.95
		(0.40) ab	(1.21) a	(1.60) ab	(1.72) a	(1.86) a	(1.36) b	
T3 - Carbosulfan 25 ST	20 g	0.20	1.73	2.63	3.03	3.53	2.23	28.75
		(0.45) b	(1.32) b	(1.62) ab	(1.74) ab	(1.88) ab	(1.40) b	
T4 - Chlorpyriphos 20 EC	10 ml	(0.43	2.33	3.10	3.50	4.00	2.67	14.70
		(0.66) c	(1.53) cd	(1.76) cd	(1.87) cd	(2.00) cd	(1.56) d	
T5 - Dimethoate 30 EC	5 ml	0.47	2.50	3.33	3.73	4.23	2.85	08.95
		(0.68) c	(1.58) d	(1.83) d	(1.93) d	(2.06) d	(1.62) e	
T6 - Fipronil 5 SC	10 ml	0.23	2.13	2.87	3.20	3.77	2.44	22.04
		(0.48) b	(1.46) c	(1.69) bc	(1.79) bc	(1.94) bc	(1.47) c	
T7 - Untreated Control	--	0.83b	2.83	4.67	3.90	3.43	3.13	-
		(0.91) d	(1.68) e	(2.16) e	(1.97) a	(1.85) a	(1.72) f	
Mean (W)		0.35	2.05	3.08	3.30	3.68		
		(0.56) A	(1.42) C	(1.74) D	(1.81) B	(1.91) E		

*Mean of three replications.
Figures in parentheses are square root transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD)

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.04	0.03	0.09

Table 3: Efficacy insecticide seed treatments against thrips, *Megalurothrips* spp. - Experiment II

Treatment	Dose / kg of seeds	No. of thrips / 3 leaves*						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.30	0.60	1.00	1.30	0.70	0.78	58.51
		(0.54) a	(0.77) a	(1.00) a	(1.14) a	(0.84) a	(0.86) a	
T2 - Thiamethoxam 35 FS	10 ml	0.47	0.77	1.17	1.47	0.87	0.95	49.47
		(0.68) a	(0.87) a	(1.08) a	(1.21) a	(0.93) a	(0.95) b	
T3 - Carbosulfan 25 ST	20 g	0.53	0.83	1.23	1.53	0.93	1.01	46.28
		(0.73) a	(0.91) a	(1.11) a	(1.24) a	(0.96) a	(0.99) b	
T4 - Chlorpyriphos 20 EC	10 ml	0.77	1.30	1.47	2.00	1.40	1.39	26.06
		(0.88) a	(1.14) a	(1.21) a	(1.41) a	(1.18) a	(1.16) d	
T5 - Dimethoate 30 EC	5 ml	0.77	1.37	1.83	2.27	1.43	1.53	18.62
		(0.88) a	(1.17) a	(1.35) a	(1.51) a	(1.20) a	(1.22) e	
T6 - Fipronil 5 SC	10 ml	0.57	1.07	1.43	1.77	1.17	1.20	36.17
		(0.73) a	(1.03) a	(1.20) a	(1.33) a	(1.08) a	(1.07) c	
T7 - Untreated Control	--	1.10	1.83	1.93	2.60	1.93	1.88	-
		(1.05) a	(1.35) a	(1.39) a	(1.61) a	(1.39) a	(1.36) f	
Mean (W)		0.64	1.11	1.44	1.85	1.20		
		(0.78) A	(1.04) B	(1.19) D	(1.35) E	(1.08) C		

*Mean of three replications.
Figures in parentheses are square root transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD)

	T	W	T x W
Significance	0.01	0.01	NS
CD (p = 0.05)	0.05	0.04	-

Table 4: Efficacy of insecticide seed treatments against leafhopper, *Emposca kerri* - Experiment I

Treatment	Dose / kg of seeds	No. of leafhopper / 3 leaves *						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.13	0.57	1.37	1.67	2.47	1.24	40.10
		(0.36) a	(0.75) a	(1.17) ab	(1.29) a	(1.57) a	(1.03) b	
T2 - Thiamethoxam 35 FS	10 ml	0.10	0.47	1.20	1.50	2.30	1.11	46.38
		(0.32) a	(0.68) a	(1.09) a	(1.22) ab	(1.52) a	(0.97) a	
T3 - Carbosulfan 25 ST	20 g	0.17	0.83	1.43	1.73	2.53	1.34	35.27
		(0.40) a	(0.91) b	(1.20) b	(1.32) b	(1.59) ab	(1.08) c	
T4 - Chlorpyriphos 20 EC	10 ml	0.17	1.13	1.67	2.00	2.77	1.55	25.12
		(0.40) a	(1.06) c	(1.29) c	(1.41) c	(1.66) bc	(1.17) d	
T5 - Dimethoate 30 EC	5 ml	0.33	1.33	1.90	2.30	3.00	1.77	14.49
		(0.58) b	(1.15) d	(1.38) d	(1.52) d	(1.73) cd	(1.27) e	
T6 - Fipronil 5 SC	10 ml	0.37	1.47	2.13	2.53	3.23	1.95	5.80
		(0.60) b	(1.21) d	(1.46) e	(1.59) de	(1.80) d	(1.33) f	
T7 - Untreated Control	--	0.63	1.90	2.63	2.67	2.50	2.07	-
		(0.80) c	(1.38) e	(1.62) f	(1.63) e	(1.58) a	(1.40) g	
Mean (W)		0.27	1.10	1.76	2.06	2.69		
		(0.49) A	(1.02) B	(1.32) C	(1.43) D	(1.64) E		

*Mean of three replications.
Figures in parentheses are square root transformed values
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD)

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.04	0.03	0.08

Table 5: Efficacy of insecticide seed treatments against leafhopper, *E. kerri* - Experiment II

Treatment	Dose / kg of seeds	No. of leafhopper / 3 leaves *						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.20	0.37	0.87	1.37	1.67	0.89	48.25
		(0.45) a	(0.60) ab	(0.93) ab	(1.17) ab	(1.29) a	(0.89) b	
T2 - Thiamethoxam 35 FS	10 ml	0.17	0.27)	0.70	1.20	1.50	0.77	55.23
		(0.40) b	(0.50) a	(0.84) a	(1.09) a	(1.22) a	(0.81) a	
T3 - Carbosulfan 25 ST	20 g	0.27	0.43	0.93	1.43	1.73	0.96	44.19
		(0.51) b	(0.66) b	(0.96) b	(1.20) bc	(1.32) ab	(0.93) b	
T4 - Chlorpyriphos 20 EC	10 ml	0.30	0.67	1.17	1.67	1.97	1.15	33.14
		(0.54) b	(0.82) c	(1.08) c	(1.29) cd	(1.40) bc	(1.03) c	
T5 - Dimethoate 30 EC	5 ml	0.43	0.80	1.40	1.80	2.20	1.33	22.67
		(0.65) c	(0.89) c	(1.18) cd	(1.34) d	(1.48) cd	(1.11) d	
T6 - Fipronil 5 SC	10 ml	0.47	1.03	1.63	2.10	2.43	1.53	11.04
		(0.68) c	(1.02) d	(1.28) de	(1.45) e	(1.56) d	(1.20) e	
T7 - Untreated Control	--	0.73	1.37	1.87	2.27	2.37	1.72	-
		(0.86) d	(1.17) e	(1.37) e	(1.51) e	(1.54) d	(1.29) f	
Mean (W)		0.37	0.70	1.22	1.69	1.98		
		(0.59) A	(0.81) B	(1.09) C	(1.29) D	(1.40) E		

*Mean of three replications.
Figures in parentheses are square root transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD)

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.04	0.04	0.10

Table 6: Efficacy of insecticide seed treatment against aphid, *A. craccivora* - Experiment II

Treatment	Dose / kg of seeds	Aphid Injury Grade *						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.10 a	0.10 a	0.17 a	0.43 a	0.83 a	0.33 a	76.26
T2 - Thiamethoxam 35 FS	10 ml	0.10 a	0.10 a	0.20 a	0.53 a	0.97 a	0.38 a	72.66
T3 - Carbosulfan	20 g	0.10 a	0.30 b	0.73 b	1.27 c	1.23 b	0.73 d	47.48
T4 - Chlorpyriphos 20 EC	10 ml	0.17 a	0.53 c	0.90 b	1.73 d	1.70 c	1.01 e	27.33
T5 - Dimethoate 30 EC	5 ml	0.10 a	0.17 ab	0.33 a	1.13 c	1.13 b	0.57 c	58.99
T6 - Fipronil 5 SC	10 ml	0.10 a	0.13 ab	0.27 a	0.87 b	0.93 a	0.46 b	66.91
T7 - Untreated Control	--	1.17 a	1.37 d	1.40 c	1.73 d	1.30 b	1.39 f	-
Mean (W)		0.26 A	0.39 B	0.57 C	1.10 D	1.16 D		

*Mean of three replications.
Figures in parentheses are √(X+0.5) transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD)

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.07	0.06	0.17

Table 7: Efficacy of insecticide seed treatments against coccinellid adult - Experiment II

Treatment	Dose / kg of seeds	No. of adults / plant *						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.00	0.03	0.10	0.10	0.23	0.09	85.48
		(0.71) c	(0.73) d	(0.77) f	(0.77) f	(0.86) e	(0.77) e	
T2 - Thiamethoxam 35 FS	10 ml	0.00	0.07	0.13	0.20	0.40	0.16	74.19
		(0.71) c	(0.75) d	(0.80) ef	(0.84) e	(0.95) d	(0.81) d	
T3 - Carbosulfan 25 ST	20 g	0.00	0.10	0.23	0.37	0.47	0.23	62.90
		(0.71) c	(0.77) cd	(0.86) cd	(0.93) cd	(0.98) cd	(0.85) c	
T4 - Chlorpyriphos 20 EC	10 ml	0.07	0.17	0.33	0.53	0.63	0.35	43.55
		(0.75) bc	(0.82) b	(0.91) b	(1.02) b	(1.06) b	(0.91) b	
T5 - Dimethoate 30 EC	5 ml	0.10	0.13	0.27	0.43	0.53	0.29	53.25
		(0.77) b	(0.80) bc	(0.88) bc	(0.97) c	(1.02) bc	(0.89) b	
T6 - Fipronil 5 SC	10 ml	0.00	0.10	0.17	0.33	0.43	0.21	66.13
		(0.71) c	(0.77) cd	(0.82) de	(0.91) d	(0.97) d	(0.84) c	
T7 - Untreated Control	--	0.23	0.33	0.60	0.87	1.07	0.62	-
		(0.86) a	(0.91) a	(1.05) a	(1.17) a	(1.25) a	(1.05) a	
Mean (W)		0.06	0.13	0.26	0.40	0.54		
		(0.74) A	(0.79) B	(0.87) C	(0.94) D	(1.01) E		

*Mean of three replications.
Figures in parentheses are √(X+0.5) transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD).

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.02	0.02	0.04

Table 8: Effect of insecticide seed treatments on spider - Experiment I

Treatment	Dose / kg of seeds	No. of adults / plant *						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.00	0.00	0.07	0.13	0.13	0.07	86.27
		(0.71) b	(0.71) b	(0.75) d	(0.80) e	(0.80) f	(0.75) f	
T2 - Thiamethoxam 35 FS	10 ml	0.00	0.00	0.10	0.13	0.17	0.08	84.31
		(0.71) b	(0.71) b	(0.77) d	(0.80) e	(0.82) ef	(0.76) e	
T3 - Carbosulfan 25 ST	20 g	0.00	0.00	0.17	0.20	0.23	0.12	76.47
		(0.71) b	(0.71) b	(0.82) c	(0.84) de	(0.86) e	(0.78) dc	
T4 - Chlorpyriphos 20 EC	10 ml	0.00	0.00	0.27	0.43	0.57	0.26	49.02
		(0.71) b	(0.71) b	(0.88) b	(0.97) b	(1.03) b	(0.86) b	
T5 - Dimethoate 30 EC	5 ml	0.00	0.00	0.20	0.33	0.43	0.19	62.75
		(0.71) b	(0.71) b	(0.84) bc	(0.91) c	(0.97) c	(0.83) c	
T6 - Fipronil 5 SC	10 ml	0.00	0.00	0.20	0.23	0.33	0.15	70.59
		(0.71) b	(0.71) b	(0.84) bc	(0.86) d	(0.91) d	(0.80) d	
T7 - Untreated Control	--	0.10	0.13	0.57	0.80	0.97	0.51	-
		(0.77) a	(0.80) a	(1.03) a	(1.14) a	(1.21) a	(0.99) a	
Mean (W)		0.01	0.02	0.22	0.32	0.40		
		(0.72) A	(0.72) A	(0.85) B	(0.90) C	(0.94) D		

*Mean of three replications.
Figures in parentheses are √(X+0.5) transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD).

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.02	0.01	0.04

Table 9: Efficacy of insecticide seed treatments on spider - Experiment II

Treatment	Dose / kg of seeds	No. of adults / plant *						Reduction over control (%)
		1st week	2nd week	3rd week	4th week	5th week	Mean (T)	
T1 - Imidacloprid 60 FS	10 ml	0.00	0.00	0.10	0.10	0.17	0.07	80.56
		(0.71) a	(0.71) b	(0.77) c	(0.77) d	(0.82) d	(0.76) d	
T2 - Thiamethoxam 35 FS	10 ml	0.00	0.00	0.10	0.13	0.20	0.09	75.00
		(0.71) a	(0.71) b	(0.77) c	(0.80) cd	(0.84) cd	(0.76) d	
T3 - Carbosulfan 25 ST	20 g	0.00	0.00	0.13	0.13	0.23	0.10	72.22
		(0.71) a	(0.71) b	(0.80) bc	(0.80) cd	(0.86) cd	(0.77) d	
T4 - Chlorpyriphos 20 EC	10 ml	0.00	0.00	0.17	0.23	0.50	0.19	47.22
		(0.71) a	(0.71) b	(0.82) b	(0.86) b	(1.00) b	(0.82) b	
T5 - Dimethoate 30 EC	5 ml	0.00	0.00	0.17	0.17	0.30	0.13	63.89
		(0.71) a	(0.71) b	(0.82) b	(0.82) bc	(0.89) b	(0.79) c	
T6 - Fipronil 5 SC	10 ml	0.00	0.00	0.13	0.17	0.27	0.11	69.44
		(0.71) a	(0.71) b	(0.80) b	(0.82) bc	(0.88) bc	(0.78) cd	
T7 - Untreated Control	--	0.07	0.10	0.43	0.53	0.67	0.36	-
		(0.75) a	(0.77) b	(0.97) a	(1.02) a	(1.08) a	(0.92) a	
Mean (W)		0.01	0.01	0.18	0.21	0.33		
		(0.71) A	(0.72) A	(0.82) B	(0.84) B	(0.91) C		

*Mean of three replications.
Figures in parentheses are $\sqrt{(X+0.5)}$ transformed values.
In a column / row, means followed by a common letter are not significantly different at 5% level (LSD).

	T	W	T x W
Significance	0.01	0.01	0.01
CD (p = 0.05)	0.02	0.02	0.04

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