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Studies on the Effect of new Insecticidal Molecules as Seed Treatment for Management of Pulse Beetle *Collosobruchus maculates* (F) and Seed Viability of Cowpea Seeds During Storage under Ambient Conditions

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Abstract

An experiment was carried out to know the efficacy of new insecticidal molecules as seed treatment on storage insect pests and seed viability during storage under ambient conditions on cowpea from 2009-10 to 2011-12 at National Seed Project, University of Agricultural Sciences, Bangalore. Among the insecticides, seed treated with spinosad 45 SC @ 2 ppm recorded significantly highest germination at three months (95.33 %), six months (92.67 %) and nine months (90.67 per cent) after storage. The moisture content was significantly lowest (11.62 %) in spinosad 45 SC @ 2ppm at nine months after storage. The insect damage was significantly least in spinosad 45 SC @ 2 ppm at three months (0.09 per cent), six months (0.31 %) and nine months (0.83 %) after storage, closely followed by emamectin benzoate 5 SG @ 2 ppm and deltamethrin 2.8 EC @ 2 ppm. However, when considered cost benefit ratio, spinosad 45 SC @ 2ppm was recorded highest (1:23.85) followed by deltamethrin 2.8EC @ 2ppm (1:23.37).

Cowpea is one of the most important leguminous crop belonging to the family fabaceae grown in tropics. It has many uses as pulse, fodder, cover crop, green manure and tender green pods (vegetable), which provides cheap and easily digestable protein (4-5 %) for the vegetarian diet. India is one of the leading countries in pulse production with 23.7 million tonnes over an area of 34.62 million hectares at a productivity of 685 kg per ha (Singhal, 2003).

Pulses contain 20-30 per cent of protein of which lysine is of great importance and serves as the best means of solving malnutrition problems in the pure vegetarian Indian diet. As a result full yield potential of the cowpea crop is seldom realizes due to interaction of many factors of which post harvest insect infestation and consequent damage is one of the most important. The *Collosobruchus maculates* (F) is a serious cosmopolitan and polyphagous pest of stored pulses such as cowpea, chickpea and other legume crops. This pulse beetle can cause losses up to 30 per cent in a short period of time. These insects can damage 100 per cent of stored seeds causing weight losses of upto 60 per cent of the 25 species causing damage pulse beetles, bruchids assume greater importance since they damage final produce in the field and in storage (Prabhakar, 1979). Insecticides are one of the most effective weapons for disinfesting and protecting stored products from infestation. Along with the commonly used insecticides *viz.*,Deltamethrin, thiamethoxam and malathion (Malathion owing to its extremely low toxicity has been widely used in public health and for the control of stored pests), the new class of insecticides like emamectin benzoate and spinosad (Spinosad has low mammalian toxicity) are used against stored pests (Thompson *et al.,* 2000). Therefore, studies were undertaken to find out suitable new insecticide molecule for control of pulse beetle on stored cowpea seeds for better germination and good harvest of the crop.

Material and Methods

An experiment has been carried out in the Seed Technology Research Unit, Bangalore with eight treatments by adopting completely randomized design (CRD) in three replications during the years 2009-10 to 2011-12. The treatments were

T_1 = Flubendiamide (Fame 480 SC) @ 2ppm (4.2 mg/kg seed)

T_2 = Emamectin benzoate (Proclaim 5 SG) @ 2 ppm (40.0 mg/kg seed)

T_3 = Spinosad (Tracer 45 SC) @ 2 ppm (4.4 mg / kg seed)

T_4 = Thiodicarb (Larvin 75WP) @ 2ppm (2.7 mg / kg seed)

T_5 = Indoxacarb (Avaunt 14.5 SC) @ 2ppm (13.8 mg / kg seed)

T_6 = Lufenuron (Cigna 5 EC) @ 5 ppm (0.1 ml / kg seed)

T_7 = Deltamethrin 2.8 EC @ 1.0 ppm (0.04 ml / kg seed)

T_8 = Untreated control

One kg of freshly harvested certified seeds with higher germination (>95 %), least moisture content (>9 %) and free from insect damage were taken for each treatment. Recommended quantities of insecticides were diluted in 5 ml of water to treat one kg of seed for proper coating. After treatment, seeds were dried in shade and packed in 2 kg capacity gunny baglets and kept for storage under ambient condition. The observations were recorded at tri-monthly interval up to nine months or loss of minimum seed certification standard (MSCS).

For per cent seed damage, four hundred seeds were randomly drawn from each treatment and replication, number of damaged seeds were counted and expressed as per cent seed damage by using following formula.

$$\text{Per cent seed infestation} = \frac{\text{Number of seeds damaged}}{\text{Total number of seeds}} \times 100$$

The germination test was conducted by adopting between paper (BP) method as prescribed by the International Seed Testing Association (ISTA, 2010). The data was analyzed statistically. The germination test was conducted by between paper method by randomly selecting 100 cowpea seeds from each treatment and replication. Germination counts were recorded on 8th day after incubation in germination chamber maintained at 25^0 C with 85 per cent relative humidity. Ten randomly selected seedlings from germination test in each of the treatment and replication were used for measurement of root and shoot length and mean seedling length was calculated to find out vigour index-I by following formula.

Vigour Index-1 = Germination (%) × Mean seedling length (cm)

Same seedlings were dried in hot air oven maintained at 80 ± 2^{0}C for 24 hours, then dry weight was computed and vigour index-II was calculated by following formula

Vigour Index-II = Germination (%) × Mean dry weight of seedling (g)

Moisture content of seed was estimated by oven drying method by taking 5 grams of maize seeds from each replication and treatment. The seeds were grinded and kept in oven for17 hours and final weight was recorded. The moisture content of seed was calculated by using following formula.

$$\text{Moisture content(\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,as W_1 = weight of empty cup with lid (g)

W_2 = weight of cup with seed samples before drying (g)

W_3 = weight of cup with seed sample after drying (g)

Results and Discussion

The results on germination after three months of storage during 2009-10 and 2010-11 revealed no significant differences among the treatments. However, highest germination (92.00 %) was recorded in emamectin benzoate 5 SG @ 2 ppm during 2011-12, which was followed by spinosad 45 SC @ 2 ppm (90.33 per cent) and indoxacarb 14.5 SC @ 2 ppm (88.33 per cent) which were on par with each other and the first one differed significantly over all other treatments (Table I). The untreated control recorded lowest germination (80.67 %) and found to be significantly inferior to all other insecticidal treatments. The mean of three years after three months of storage revealed significant differences among the treatments. The highest germination (95.33 %) was in seeds treated with spinosad 45 SC @ 2 ppm followed by emamectin benzoate 5 SG @ 2 ppm (94.67 %) which were on par with each other and the first one differed significantly with all other treatments. The least germination was observed in untreated control (91.00 %) and was significantly inferior to all other treatments.

TABLE I

Effect of insecticides seed treatment on germination of stored cowpea

Treatments	Germination (%)											
	3 MAT				6 MAT				9 MAT			
	2009-10	2010-11	2011-12	Mean*	2009-10	2010-11	2011-12	Mean*	2009-10	2010-11	2011-12	Mean*
T_1 = Flubendiamide (Fame 480 SC) @ 2ppm	96.00	95.00	86.67	92.67	95.00	92.00	85.33	91.00	92.00	89.33	80.00	87.33
T_2 = Emamectin benzoate(Proclaim 5 SG) @ 2 ppm	96.00	95.33	92.00	94.67	95.33	92.67	88.33	92.11	90.00	88.00	88.00	88.67
T_3 = Spinosad (Tracer 45 SC) @ 2 ppm	98.33	97.00	90.33	95.33	94.67	94.00	89.00	92.67	91.33	91.67	88.33	90.67
T_4 = Thiodicarb (Larvin 75WP) @ 2ppm	98.00	94.33	86.00	93.89	94.00	93.33	84.00	90.67	91.33	91.33	82.00	88.33
T_5 = Indoxacarb (Avaunt 14.5 SC) @ 2ppm	96.33	95.33	88.33	92.11	95.67	94.00	84.67	91.33	89.00	88.33	81.67	86.33
T_6 = Lufenuron (Cigna 5 EC) @ 5 ppm	96.33	95.33	85.33	92.33	94.33	92.67	79.33	88.67	89.33	88.67	75.67	84.00
T_7 = Deltamethrin (2.8 EC) @ 1.0 ppm	97.00	96.00	86.67	93.33	95.00	93.33	85.33	91.33	91.00	90.33	81.00	87.44
T_8 = Untreated Control	96.67	96.00	80.67	91.00	95.33	90.00	38.67	74.67	85.33	81.67	7.00	58.00
SEm±	0.85	1.09	1.43	0.39	0.95	0.66	1.00	0.60	0.94	0.37	0.89	0.55
CV (%)	1.52	1.97	2.84	0.73	1.73	1.23	2.18	1.17	1.82	0.73	2.11	1.14
CD (P=0.05)	NS	NS	4.28	1.18	NS	1.97	3.00	1.80	2.83	1.12	2.67	1.65

*Mean of three Years MAT- Months after treatment NS- Non significant

At six months after storage, no significant differences were observed among the treatments during 2009-10. However, during 2010-11 the highest germination (94.00 % each) was in spinosad 45 SC @ 2 ppm and indoxacarb 75 WP @ 2 ppm which were on par with thiodicarb 75 WP @ 2 ppm and deltamethrin 2.8EC @ 1ppm (93.33 % each) and differed significantly with all other treatments. Whereas, during 2011-12 spinosad 45 SC @ 2 ppm recorded highest germination (89.00 %) followed by emamectin benzoate (88.33 %) which were on par with each other and both differed significantly with all other treatments. Untreated control recorded significantly least germination (90.00 and 38.67 %, respectively in each year). In the mean of three years during six months of storage, significantly highest germination (92.67 %) was observed in spinosad 45

SC @ 2 ppm which was on par with all other treatments and differed significantly over thiodicarb 75WP @ 2 ppm (90.67 %), lufenuron 5EC @ 5ppm (88.67 %) and the untreated control (74.67 %) which was significantly inferior to all other treatments.

The germination results after nine months of storage revealed significant results in all the years as well as mean of three years. During 2009-10 the highest (92.00 %) germination was observed in flubendiamide 480 SC @ 2 ppm, which was on par with all other treatments and differed significantly over indoxacarb 14.5 SC @ 2 ppm (89.00 %) and the untreated control recorded the least (85.33 %) germination. The seeds treated with spinosad 45 SC @ 2ppm recorded highest (91.67 %) germination which was on par with thiodicarb 25 WP @ 2 ppm (91.33 %) and the first one differed significantly with all other treatments during 2010-11. However, during 2011-12, the seeds treated with spinosad 45 SC @ 2ppm recorded highest (88.33 %) germination followed by emamectin benzoate 5 SG @ 2 ppm (80.00 %) which were on par and both differed significantly with other treatments. The least (81.67 and 7.00 %) germination was in untreated control during 2010-11 and 2011-12, respectively and found to be significantly inferior to all insecticidal treatments. However, in the mean of three years the highest germination (90.67 %) was found to be in spinosad 45 SC @ 2 ppm, followed by emamectin benzoate 45 SC @ 2 ppm (88.67 %) and thiodicarb 75 WP @ 2 ppm (88.33 %). The first one differed significantly over all other treatments and least was in untreated control (58.00 %) which was inferior to all other treatments. These findings were in confirmation with the results of Huang and Subramanyam (2007) on maize and Ghelani and Helal (2009) on different grain products.

The moisture content at three months of storage revealed non significant results in all the years and in the mean of three years. However, spinosad 45 SC @ 2 ppm during 2011-12 and 2009-10 was recorded the least moisture content (9.12 % and 9.31 per cent, respectively) (Table II). Further, flubendiamide 480 SC @ 2 ppm recorded least moisture content (9.51 %) in the mean of three years. Whereas, untreated control recorded highest moisture content (9.79 %).

The results of moisture content at six months revealed non significant results during the year 2009-10 and 2011-12. However, during 2010-11 deltamethrin 2.8EC @ 2 ppm recorded significantly least (10.25 per cent) moisture content and untreated control recorded highest (10.71 %) moisture content. The mean of three years, flubendiamide 480 SC @ 2ppm, spinosad 45 SC @ 2 ppm and deltamethrin 2.8 SC @ 1 ppm were recorded significantly least (10.60, 10.66 and 10.67 %, respectively) moisture content which were on par with each other. The untreated control recorded highest moisture content (11.01 %).

At nine months of storage non significant results were observed during 2009-10. Further, deltamethrin 2.8 EC @ 1 ppm and spinosad 45 SC @ 2 ppm during the year 2010-11 and 2011-12 recorded significantly lowest moisture content (11.15 and 12.07 % in each year, respectively). Whereas, untreated control recorded significantly highest moisture content (13.22 %) during the year 2011-12. In the mean of three years significantly least moisture content was recorded in thiodicarb 75WP @ 2 ppm, deltamethrin 2.8EC @ 1ppm, spinosad 45 SC @ 2 ppm and indoxcarb 14.5 SC @ 2 ppm, (11.53, 11.54, 11.62 and 11.70 %, respectively) which were on par with each other. Whereas, significantly highest (12.14 %) moisture content was observed in untreated control.

The insect damage per cent at three months of storage revealed no incidence of insect pests in most of the treatments and replications during 2009-10 and 2010-11(Table III). Whereas, in the year 2011-12 significantly least (0.25 %) insect damage was observed in flubendiamide 480 SC @ 2 ppm which was on par with all other treatments except lufenuron 5EC @ 2 ppm (0.75 %) and untreated control (1.08 %). In the mean of three years after three months of storage, significantly least insect damage was observed in flubendiamide 480SC @ 2 ppm (0.08 %), which was on par with all other treatments except lufenuron 5EC @ 2 ppm (0.28 %). Whereas, the highest insect damage (0.51 %) was recorded in untreated control.

The results of insect damage at six months after treatment imposition revealed significant differences among the treatments during all the years and mean of three years. Spinosad 45 SC @ 2 ppm and emamectin benzoate 5SG @ 2ppm recorded least (0.17 % each) insect damage which were on par with deltamethrin 2.8EC @ 1 ppm (0.83 %) and indoxacarb 75 WP @ 2 ppm (1.00 %) and the first two differed

TABLE II

Effect of insecticides seed treatment on moisture content of stored cowpea

Treatments	Moisture Content (%)											
	3 MAT				6 MAT				9 MAT			
	2009-10	2010-11	2011-12	Mean*	2009-10	2010-11	2011-12	Mean*	2009-10	2010-11	2011-12	Mean*
T_1 = Flubendiamide (Fame 480 SC) @ 2ppm	9.14	10.34	9.24	9.51	10.11	10.34	11.36	10.60	11.75	11.92	12.35	12.01
T_2 = Emamectin benzoate (Proclaim 5 SG) @ 2 ppm	9.34	10.36	9.26	9.65	10.13	10.51	11.74	10.79	11.41	11.85	12.74	12.00
T_3 = Spinosad (Tracer 45 SC) @ 2 ppm	9.31	10.33	9.12	9.59	10.08	10.48	11.40	10.66	11.12	11.68	12.07	11.62
T_4 = Thiodicarb (Larvin 75WP) @ 2ppm	9.37	10.38	9.27	9.68	10.36	10.52	11.55	10.81	10.93	11.22	12.43	11.53
T_5 = Indoxacarb (Avaunt 14.5 SC)@ 2ppm	9.36	10.35	9.33	9.61	10.41	10.51	11.74	10.89	11.18	11.50	12.42	11.70
T_6 = Lufenuron (Cigna 5 EC) @ 5 ppm	9.41	10.40	9.34	9.72	10.17	10.58	11.64	10.80	11.41	11.63	12.46	11.83
T_7 = Deltamethrin (2.8 EC)@ 1.0 ppm	9.17	10.18	9.39	9.58	10.25	10.25	11.50	10.67	11.18	11.15	12.28	11.54
T_8 = Untreated control	9.56	10.54	9.26	9.79	10.48	10.71	11.83	11.01	11.48	11.70	13.22	12.14
SEm±	0.17	0.07	0.15	0.06	0.15	0.01	0.15	0.06	0.19	0.01	0.05	0.07
CV (%)	3.23	1.16	2.75	1.06	2.46	0.16	2.29	0.99	2.96	0.19	0.66	0.98
CD (P=0.05)	NS	NS	NS	NS	NS	0.03	NS	0.18	NS	0.04	0.14	0.20

*Mean of three years MAT- Months after treatment NS- Non significant

significantly with remaining treatments during 2009-10. The highest (6.67 %) damage was in untreated control and significantly inferior to all other insecticidal treatments. During 2010-11, the least (0.08 %) damage was in spinosad 45 SC @ 2 ppm treated seeds, closely followed by emamectin benzoate 5SG @ 2 ppm and deltamethrin (0.17 % each) which were on par with each other and all differed significantly with remaining treatments. Untreated control recorded highest (5.42 per cent) damage and was significantly inferior to all treatments. However, during 2011-12, flubendiamide 480 SC @ 2 ppm treated seeds recorded least (0.50 per cent), closely followed by spinosad 45 SC @ 2 ppm (0.67 per cent), emamectin benzoate 5 SG @ 2 ppm and indoxacarb 14.5SC @ 2 ppm (0.83 per cent each) which were on par and the first one differed significantly with remaining treatments. The highest (36.08 %) damage was in untreated control. The mean of three years revealed least (0.31 %) damage in spinosad 45 SC @ 2 ppm treated seeds, which was on par with emamectin benzoate 5 SG @ 2 ppm (0.39 %) and deltamethrin 2.8 EC @ 2 ppm (0.69 %) and first two treatments differed significantly with other treatments. The highest (16.06 %) damage was in untreated control.

The insect damage at nine months after treatment imposition recorded significant differences among the treatments during all the years. The least insect damage (1.00, 0.35 and 5.40 %) was in spinosad 45 SC @ 2 ppm during 2009-10, 2010-11 and 2011-12, respectively, which was on par with

TABLE III

Effect of insecticide seed treatment on insect damage of stored cowpea

Treatments	Insect Damages (%)											
	3 MAT				6 MAT				9 MAT			
	2009-10	2010-11	2011-12	Mean*	2009-10	2010-11	2011-12	Mean*	2009-10	2010-11	2011-12	Mean*
T_1 = Flubendiamide (Fame 480 SC) @ 2ppm	-	-	0.25	0.08	1.58	1.33	0.50 (3.96)[a]	1.14	11.33	9.58	1.58 (7.19) [b]	7.50 (15.89) [a]
T_2 = Emamectin benzoate (Proclaim 5 SG) @ 2 ppm	-	-	0.33	0.12	0.17	0.17	0.83 (5.18) [ab]	0.39	1.50	0.83	1.33 (6.62) [ab]	1.22 (6.32) [a]
T_3 = Spinosad (Tracer 45 SC) @ 2 ppm	-	-	0.33	0.09	0.17	0.08	0.67 (4.61) [ab]	0.31	1.00	0.35	0.92 (5.40) [a]	0.83 (5.23) [a]
T_4 = Thiodicarb (Larvin 75WP) @ 2ppm	-	-	0.42	0.13	1.50	1.42	1.08 (5.91) [b]	1.44	10.17	8.50	1.42 (6.83) [b]	6.69 (14.99) [cd]
T_5 = Indoxacarb (Avaunt 14.5 SC) @ 2ppm	-	-	0.58	0.20	1.00	0.58	0.83 (5.22) [ab]	0.81	7.83	3.75	1.50 (7.02) [b]	4.36 (12.00) [b]
T_6 = Lufenuron (Cigna 5 EC) @ 5 ppm	-	-	0.75	0.28	2.00	1.58	1.33 (6.40) [b]	1.64	9.67	6.50	3.00 (9.96) [c]	6.39 (14.61) [c]
T_7 = Deltamethrin (2.8 EC) @ 1.0 ppm	-	-	0.50	0.19	0.83	0.17	1.08 (5.96) [b]	0.69	1.67	1.33	1.50 (7.02) [b]	1.50 (7.01) [a]
T_8 = Untreated control	0.5	0.75	1.08	0.51	6.67	5.42	36.08 (36.90)	16.06	18.67	19.25	85.42 (67.54) [d]	41.11 (39.86) [e]
SEm±	NA	NA	0.12	0.06	0.29	0.11	0.62	0.13	1.02	0.15	0.44	0.42
CV (%)			39.60	49.60	29.04	14.21	11.60	7.90	22.87	4.25	5.22	5.05
CD (P=0.05)			0.36	0.17	0.87	0.33	1.86	0.38	3.06	0.46	1.33	1.27

*Mean of three Years MAT- Months after treatment NA- Not analysed ** Values in the parenthesis are Arc sign transformed values

emamectin benzoate 5 SG (1.50 and 1.33 %) during 2009-10 and 2011-12, respectively differed significantly with all other treatments except deltamethrin 2.8 E @ 1 ppm (1.67 %) during 2009-10. In the mean of three years, significantly least (5.23 %) was recorded in spinosad 45 SC @ 2 ppm and on par with emamectin benzoate 5 SG @ 2 ppm (6.32 %). The highest insect damage (39.86 %) was in untreated control. These results were in conformity with the findings of Fang *et al*. (2002) on wheat, Srinath (2010) with respect to *S. Oryzae* in sorghum and *C. chinensis* in cowpea and Sharma and Micaelraj (2006) on maize.

The observations on vigour index were recorded to find out the effect of insecticides on stored cowpea during 2011-12 only. The results recorded significantly highest I was in spinosad 45 SC @ 2 ppm treated seeds at three, six and nine months after storage (2692, 2367 and 1886, respectively) (Table-IV). Similar trend was observed with respect to vigour index II, spinosad @ 45 SC @ 2 ppm recorded significantly highest Vigour Index-II (50.79, 38.14 & 28.02 %, respectively) (Table-IV) at three, six and nine months of storage and differed significantly with remaining treatments. No reviews were available with respect to effect of insecticides on vigour index of cowpea.

Cost benefit ratio was calculated to know the most beneficial insecticide to the farming community. The data revealed that (Table-V), the highest cost benefit ratio of 23.85 was in spinosad 45 SC @ 2 ppm treated seed, the next best in order was deltamethrin 2.8 EC @ 1.00 ppm (23.37).

Based on the results it can be concluded that the spinosad 45 SC @ 2 ppm may be recommended for management of storage insect pests of cowpea effectively up to nine months without affecting

TABLE IV

Effect of insecticides seed treatment on vigour index of stored cowpea during 2011-12

Treatments	Vigour Index - I			Vigour Index - II		
	3 MAT	6 MAT	9 MAT	3 MAT	6 MAT	9 MAT
T_1 = Flubendiamide (Fame 480 SC) @ 2ppm	2569 ^{c}	2184 ^{c}	1743 ^{c}	49.31 ^{bc}	33.68 ^{c}	25.20 ^{c}
T_2 = Emamectin benzoate (Proclaim 5 SG) @ 2 ppm	2653 ^{b}	2261 ^{b}	1790 ^{b}	49.65 ^{b}	35.28 ^{b}	26.50 ^{b}
T_3 = Spinosad (Tracer 45 SC) @ 2 ppm	2692 ^{a}	2367 ^{a}	1886 ^{a}	50.79 ^{a}	38.14 ^{a}	28.20 ^{a}
T_4 = Thiodicarb (Larvin 75WP) @ 2ppm	2566 ^{c}	2152 ^{d}	1686 ^{d}	48.61 ^{cd}	33.10 ^{d}	24.27 ^{d}
T_5 = Indoxacarb (Avaunt 14.5 SC)@ 2ppm	2553 ^{c}	2139 ^{d}	1682 ^{d}	47.85 ^{d}	32.24 ^{de}	23.36 ^{e}
T_6 = Lufenuron (Cigna 5 EC) @ 5 ppm	2551 ^{cd}	2165 ^{cd}	1547 ^{e}	47.89 ^{d}	31.57 ^{ef}	22.21 ^{f}
T_7 = Deltamethrin (2.8 EC) @ 1.0 ppm	2533 ^{d}	2100 ^{e}	1464 ^{f}	47.83 ^{d}	30.83 ^{f}	21.21 ^{g}
T_8 = Untreated control	2516 ^{e}	2017 ^{f}	1330 ^{g}	46.86 ^{e}	29.68 ^{g}	20.03 ^{h}
SEm±	5.79	9.87	7.04	0.32	0.29	0.21
CV (%)	0.39	0.79	0.74	1.14	1.51	1.57
CD (P=0.05)	17.36	29.60	21.09	0.96	0.86	0.65

MAT- Months after treatment

TABLE V

Cost Benfit ratio for seed treatment in cowpea

Chemicals	Dosage / kg	Qty. for 100 kg	Total cost for 100 kg (Rs)*	Damage (%) Mean of three years	Loss due to damage (Rs)	Total loss (Rs)	C : B
T_1 = Flubendiamide (Fame 480 SC) @ 2ppm	0.04ml	4ml	34.50	7.50	637.50	672.00	1:5.20
T_2 = Emamectin benzoate (Proclaim 5 SG) @ 2 ppm	40mg	40mg	360.00	1.22	103.70	464.00	1:7.53
T_3 = Spinosad (Tracer 45 SC) @ 2 ppm	0.04ml	4ml	76.00	0.83	70.55	146.50	1:23.85
T_4 = Thiodicarb (Larvin 75WP) @ 2ppm	2.70mg	2.7g	25.70	6.69	568.65	594.35	1:5.88
T_5 = Indoxacarb (Avaunt 14.5 SC) @ 2ppm	0.14ml	14ml	70.70	4.36	370.60	441.30	1:7.92
T_6 = Lufenuron (Cigna 5 EC) @ 5 ppm	0.10ml	10ml	150.00	3.39	543.15	693.15	1:5.04
T_7 = Deltamethrin (2.8 EC) @ 1.0 ppm	0.4ml	4ml	22.00	1.50	127.50	149.50	1:23.37
T_8 = Untreated control	-	-	-	41.11	3494.35	3494.35	-

* Cost of chemical including labour
* Cost of certified maize seed is Rs 8500/qtl

minimum seed certification standards.

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