

Original Research Article

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Evaluation of Novel Insecticides as Seed Treatments to Control Rice Weevil [*Sitophilus oryzae* (Linnaeus)] on Maize Seeds

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ABSTRACT

A study was conducted to evaluate the effectiveness of some newer insecticidal molecules viz., Emamectin benzoate (Proclaim 5 SG) @ 2 ppm, Spinosad (Tracer 45 SC) @ 2 ppm, Indoxacarb (Avaunt 14.5 SC) @ 2 ppm, Rynaxypyr (Coragen 20 SC) @ 2ppm, Chlorfenapyr (Intrepid 10 EC) @ 2 ppm, Profenofos (Curacron 50 EC) @ 2 ppm, Novaluron (Rimon 10 EC) @ 5 ppm, Deltamethrin 2.8 EC @ 1 ppm along with untreated control against rice weevil and to assess the storability of treated seed. All the nine treatments were replicated thrice and statistically analyzed by using completely randomized design. The data on germination percentage, seedling vigour index, moisture content (per cent), seed damage (per cent) and adult emergence at every three months interval upto nine months of storage were recorded. The results revealed that Spinosad (Tracer 45 SC) @ 2 ppm kg⁻¹ seed had recorded highest germination percentage (93.67), seedling vigour index (3113), less moisture per cent (11.33), lowest infestation (0.33 per cent) and adult emergence (1.00) at the end of nine

Keywords

Management, *Sitophilus oryzae* (L.), insecticidal seed treatment, Maize

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Introduction

Maize (*Zea mays*. L) is one of most versatile emerging crop having wider adoptability under varied agro climatic conditions. Maize hybrids and varieties are reported to be highly

susceptible to insect pests both in the field and storage (Gimma *et al.*, 2008). Hence, farmers are not as such beneficiaries of this increased production and productivity potential of new varieties. More than 37 species of arthropod pests are associated with maize grain in

storage (Abraham, 1991). *Sitophilus oryzae* causes enormous losses upto 100 per cent in stored maize in India and other countries (Irabagon, 1959 and Singh *et al.*, 1974). This evidently indicates the importance of *S. oryzae* in the storage of maize seed.

Infested seed fetches lower market price due to reduced weight. Seed viability of the damaged grain is drastically reduced and affects subsequent planting (Tefera, 2012).

Storage insect pests are difficult to control due to their small size, feeding behaviour and ability to attack seed before harvest. Synthetic pesticides are the major tools for stored grain protection in developed countries. They are valued for their uniform and rapid effectiveness, ease of shipment, storage and application. Efforts have been made to identify novel insecticides which are safe to environment and economical to farmers.

Materials and Methods

A laboratory experiment was conducted at Seed Research and Technology Centre, Rajendranagar, Hyderabad during 2015-17 by using the Maize hybrid DHM 117. Freshly harvested certified seed with high germination percentage (> 99%) and low moisture content (< 12%). The study was carried out with nine treatments *viz.*, Emamectin benzoate (Proclaim 5 SG) @ 2 ppm (40.0 mg/kg seed), Spinosad (Tracer 45 SC) @ 2 ppm (4.4 ml/kg seed), Rynaxypyr (Coragen 20 SC) @2ppm (0.01ml/kg seed), Chlorfenapyr (Intrepid 10 EC) @ 2 ppm (0.02ml/kg seed), Novaluron (Rimon 10 EC) @2ppm (0.02ml/kg seed), Thiamethoxam 350 FS, Profenofos (Curacron 50 EC) @2ppm (0.004ml/kg seed) and Deltamethrin 2.8 EC @ 1.0 ppm (0.04 ml/kg seed) and untreated control with three replications Required quantity of insecticides was diluted in 5 ml of water to treat one kg of seed for proper coating. After drying in shade,

seeds were packed in 2 kg capacity gunny bags. Similarly, control was maintained without any treatment for comparison.

Observations on seed germination (%), seedling vigour index, seed moisture (%), seed damage (%) and Adult emergence were recorded at every three months interval up to nine months of experimental period. Data were analyzed statistically as per Panse and Sukhatame, 1985.

Germination percentage

It was determined by adopting the rolled paper towel method.

Germination percentage

$$= \frac{\text{No. of seeds germinated}}{\text{Total no. of seeds germinated}} \times 100$$

Seedling vigour index

Seedling vigour index = Germination (%) x Seedling length (cm).

Seed Moisture content (%)

The seeds were coarse ground and dried in an oven at 103±1°C for 17 hours, cooled in desiccators over silica gel.

The samples were weighed and the seed moisture content was calculated and expressed in percentage on wet weight basis by using following formula

Moisture content (%)

$$= \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M₁: Weight of the empty container

M₂: Weight of the container + seed sample (before drying)

M₃: Weight of container + seed sample (after drying)

Seed damage (per cent)

From each treatment, 400 seeds were selected randomly and number of weevil infected seeds were counted and expressed as percentage seed damage.

Presence/absence of insect (live and dead)

Numbers of live/dead weevils were counted in all the treatments by taking out 400 seeds.

Results and Discussion

Effect of novel insecticidal seed treatments on germination of maize seeds

Germination percentage of maize seeds gradually decreased with the progressive increase in the storage period. Initial germination percentage was 100 per cent at initial period and after nine months of storage period the germination percentage declined to 86.48. Observations after three months of treatment imposition revealed that the highest germination percentage (99.33) was recorded in spinosad 45 SC @ 2 ppm, which was on par with emamectin benzoate 5 SG @ 2 ppm (97.00, rhynaxypyr 20 EC @ 2 ppm, chlorfenapyr 20 EC @ 2 ppm (96.00) and thiomethoxam 350 FS (95.67), deltamethrin 2.8 EC @ 1.00 ppm (98.67) followed by profenophos 50 EC @ 2 ppm (94.33), novuloron 10 EC @ 5 ppm (92.67) and untreated control (90.67) were on par with each other.

After six months of storage the highest germination percentage was observed in spinosad 45 SC @ 2 ppm (94.33) and

emamectin benzoate 5SG @ 2 ppm (94.33), which were on par with chlorfenapyr 10 EC @ 2 ppm (93.67) and rhynaxypyr 20 SC @ 2 ppm (92.00) treated seeds while the lowest germination was recorded in untreated seeds (86.00).

After nine months of treatment, significantly highest germination percentage was found in spinosad 45 SC @ 2 ppm treated seeds (93.67) followed by emamectin benzoate 5 SG @ 2 ppm (90.33) treated seeds which were on par with chlorfenapyr 10 EC @ 2 ppm (90.00). The lowest germination was recorded in untreated control (66.33).

The germination per cent of maize seeds declined progressively with increase in the period of storage in all the treatment combinations, which may be attributed to the phenomenon of ageing and depletion of food reserves and decline in synthetic activity of seed.

The results indicated that among the insecticide molecules the lowest (82.67 per cent) germination was recorded in seeds treated with novaluron 10 EC @ 5 ppm which was inferior to all other treatments except untreated control (66.33 per cent). This might be due to infestation of *S. oryzae*. The rice weevil, *S. oryzae* being an internal feeder where internal infestation might have resulted in a progressive reduction of germination which was influenced by the infestation level and the storage period

Observations after three, six and nine months of treatments imposition revealed that highest germination of 99.33, 94.33 and 93.67 per cent, respectively was observed in seeds treated with spinosad 45 SC @ 2 ppm.

After nine months after treatment spinosad 45 SC @ 2 ppm and chlorfenapyr 10 EC @ 2 ppm were able to maintain germination above Indian Minimum Seed Certification Standards

(IMSCS) *i.e.*, 90.00 per cent (Table.1 and Fig.1).

Present findings also support the work done by Ramazan and Chahal (1989), Bhuiyah *et al.*, (1992), Guedes and Silva (1992) and Bhujbal *et al.*, (2001) who indicated no adverse effect of insecticides on germination of seed.

Effect of novel insecticidal seed treatments on seedling vigour index of maize seeds

Results on seedling vigour index of maize seed treated with insecticides (Table.1 and Fig.2) revealed that after three months of treatment imposition, the highest seedling vigour index was observed in spinosad 45 SC @ 2 ppm (3862) treated seeds which was on par with all other insecticidal treatment except novaluron 10 EC @ 5ppm (3321), while lowest seedling vigour index was recorded in untreated control (2301).

At six months after treatment imposition higher seedling vigour index was recorded in spinosad 45 SC @ 2 ppm (3243) which was on par with emamectin benzoate 5 SG @ 2ppm (3153), chlorfenapyr 10 EC @ 2 ppm (3112), rhynaxypyr 20 EC @ 2ppm (3054), deltamethrin 2.8 EC @ 1.00 ppm (3162) and thiomethoxam 350 FS (3067) except novaluron 10 EC @ 5 ppm (3013) and profenophos 50 EC @ 2 ppm (3041). Untreated control recorded lowest seedling vigour index (1896). At nine months after treatment similar trend was observed. The highest seedling vigour index was noticed in spinosad 45 SC @ 2 ppm (3113) which was on par emamectin benzoate 5SG @ 2 ppm (3025), chlorfenapyr 10 EC @ 2 ppm (3009), deltamethrin 2.8 EC @ 1.00 ppm (2990) and thiomethoxam 350 FS (2954). While, untreated control recorded lowest seedling vigour index (1628).

Among the insecticidal treatments spinosad 45 SC @ 2 ppm was found to be superior over

control and seedling vigour index observed was 3862, 3243 and 3113 at three, six and nine months, respectively as against 2301, 1896 and 1623 in untreated seeds at three, six and nine months, respectively. There was progressive reduction in vigour with the increase in adult emergence, weight loss, damaged seed and storage period. There was progressive reduction in vigour along with germination such decrease in vigour could be attributed to the internal and external infestation by *Sitophilus oryzae* which had contributed to the reduction in physiological and physical quality of maize seeds affecting the growth of the seedlings.

The present findings are in accordance with Bhogeesh *et al.*, (2014), who reported that at six and nine months after treatment imposition, the treatments deltamethrin 100 ppm and spinosad 100 ppm recorded highest mean vigour index (2099 and 2020, respectively).

Effect of novel insecticidal seed treatments on moisture content of maize seeds

Significant differences among the treatments were observed with respect to the moisture content of maize seed at three months after treatment imposition (Table 1 and Fig. 3).

However, the lowest moisture content (8.57 per cent) was observed in spinosad 45 SC @ 2 ppm and emamectin benzoate 5 SG @ 2 ppm and highest in novaluron 10 EC @ 5 ppm (8.83 per cent).

At six months after treatment imposition results revealed that the lowest moisture content (9.63 per cent) was in spinosad 45 SC @ 2 ppm.

However, it was on par with emamectin benzoate 5 SG @ 2 ppm (9.67 per cent), chlorfenapyr 10 EC @ 2 ppm (9.77 per cent), thiomethoxam 350 FS (9.87 per cent),

deltamethrin 2.8 EC @ 1 ppm (9.63 per cent) except rhytaxypyr 20 EC @ 2 ppm (10.17 per cent), novaluron 10 EC @ 5 ppm (10.10 per cent) and profenofos 50 EC (9.97 per cent) insecticidal seed treatment.

Table.1 Effect of novel insecticidal seed treatment on germination, seedling vigour index and moisture content of maize seeds

Treatments	Dosage kg ⁻¹ seed	Germination percentage			Seedling vigour index			Moisture content (per cent)		
		3 MAST	6 MAST	9 MAST	3 MAST	6 MAST	9 MAST	3 MAST	6 MAST	9 MAST
T₁-Emamectin benzoate 5 SG) @ 2 ppm (40.0 mg/kg seed)	40.0 mg	97.00 (80.12)	94.33 (76.31)	90.33 (71.89)	3854	3153	3025	8.57 (17.02)	9.67 (18.11)	11.33 (19.67)
T₂-Spinosad 45 SC @ 2 ppm	0.004 ml	99.33 (84.59)	94.33 (76.45)	93.67 (75.70)	3862	3243	3113	8.57 (17.02)	9.63 (18.08)	11.33 (19.67)
T₃-Rynaxypyr 20 SC @2ppm	0.01ml	95.67 (78.00)	92.00 (73.57)	89.33 (70.94)	3427	3054	2628	8.73 (17.19)	10.17 (18.59)	11.50 (19.82)
T₄- Chlorfenapyr 10 EC @2ppm	0.02ml	96.00 (79.33)	93.67 (75.61)	90.00 (71.58)	3798	3112	3009	8.63 (17.09)	9.77 (18.21)	11.37 (19.70)
T₅-Profenofos 50 EC @2ppm	0.004ml	94.33 (76.27)	90.33 (71.89)	88.67 (70.33)	3671	3041	2882	8.70 (17.15)	9.97 (18.40)	11.40 (19.73)
T₆- Novaluron 10 EC @ 5ppm	0.05ml	92.67 (74.40)	90.67 (72.23)	82.67 (65.40)	3321	3067	2491	8.83 (17.29)	10.10 (18.58)	11.50 (19.82)
T₇- Thiamethoxam 350 FS	3.00ml	95.67 (78.00)	90.67 (72.25)	89.33 (70.94)	3501	3013	2954	8.67 (17.12)	9.87 (18.31)	11.40 (19.73)
T₈-Deltamethrin 2. 8 EC @ 1.0 ppm	0.04 ml	98.67 (83.45)	90.67 (72.25)	88.00 (69.74)	3614	3162	2990	8.80 (17.26)	9.63 (18.08)	11.43 (19.76)
T₉-Untreated control		90.67 (72.23)	86.00 (68.04)	66.33 (54.54)	2301	1896	1628	8.70 (17.15)	9.73 (18.18)	11.50 (19.82)
SEm±		1.67	1.05	0.79	172.53	64.03	76.99	0.07	0.11	0.02
CD(P=0.05)		4.99	3.12	2.37	512.61	190.23	228.75	0.21	0.33	0.06
CV (%)		3.71	2.49	2.00	8.58	3.73	4.86	0.74	1.06	0.18

Figures in the parentheses are angular transformed values
MAST – Months after seed treatment

Table.2 Effect of novel insecticidal seed treatments on seed damage and adult emergence (*S. oryzae*)

Treatments	Dosage kg ⁻¹ seed	Storage duration					
		Seed damage (per cent)			Adult emergence		
		3 MAST	6 MAST	9 MAST	3 MAST	6 MAST	9 MAST
T₁-Emamectin benzoate 5 SG @ 2 ppm	40.0 mg	00.00 (4.06)	00.73 (4.91)	2.07 (8.27)	0.00 (0.71)	0.67 (1.1)	1.67 (1.46)
T₂-Spinosad 45SC @ 2 ppm	0.004 ml	00.00 (4.06)	00.00 (4.06)	00.33 (4.06)	0.00 (0.71)	0.00 (0.71)	1.00 (1.23)
T₃-Rynaxypyr 20 SC @ 2 ppm	0.01 ml	2.09 (8.31)	3.44 (10.69)	5.44 (13.49)	2.00 (1.58)	4.67 (2.27)	9.00 (3.08)
T₄-Chlorfenapyr 10 EC @ 2 ppm	0.02 ml	00.00 (4.06)	1.05 (5.73)	2.38 (8.84)	0.00 (0.71)	1.33 (1.34)	2.67 (1.77)
T₅-Profenofos 50 EC @ 2 ppm	0.004 ml	1.93 (7.98)	2.76 (9.52)	4.16 (11.77)	1.67 (1.46)	4.67 (2.27)	7.33 (2.79)
T₆-Novaluron 10 EC @ 5 ppm	0.05 ml	2.22 (8.56)	3.66 (11.02)	6.40 (14.66)	3.00 (1.86)	7.00 (2.74)	11.33 (3.44)
T₇-Thiamethoxam 350 FS	3.00 ml	00.00 (4.06)	1.07 (5.94)	2.48 (9.06)	0.00 (0.71)	2.00 (1.56)	3.67 (2.04)
T₈-Deltamethrin 2.8 EC @ 1.0 ppm	0.04 ml	1.00 (5.75)	1.84 (7.79)	3.17 (10.23)	0.33 (0.88)	2.33 (1.68)	3.67 (2.04)
T₉-Untreated control		2.39 (8.88)	6.23 (14.44)	13.66 (21.69)	10.67 (3.34)	26.33 (5.18)	52 (7.24)
SEm±		0.13	0.42	0.29	0.10	0.11	0.08
CD (P=0.05)		0.39	1.26	0.88	0.27	0.33	0.25
CV(%)		3.7	8.93	4.52	12.14	9.48	5.33

Figures in the parentheses are transformed values
MAST: Months after seed treatment

Fig.1 Effect of novel insecticidal seed treatments on germination of maize seeds

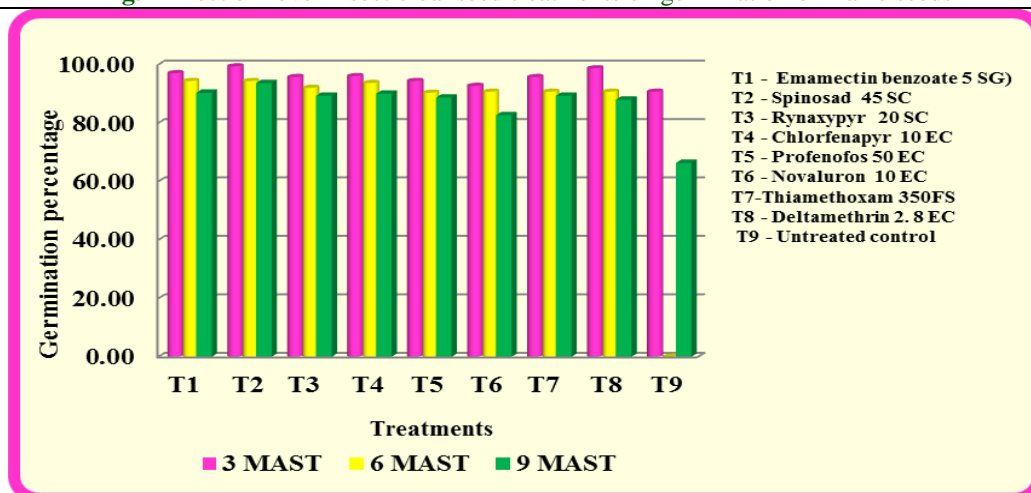


Fig.2 Effect of novel insecticidal seed treatments on seedling vigour index of maize seeds

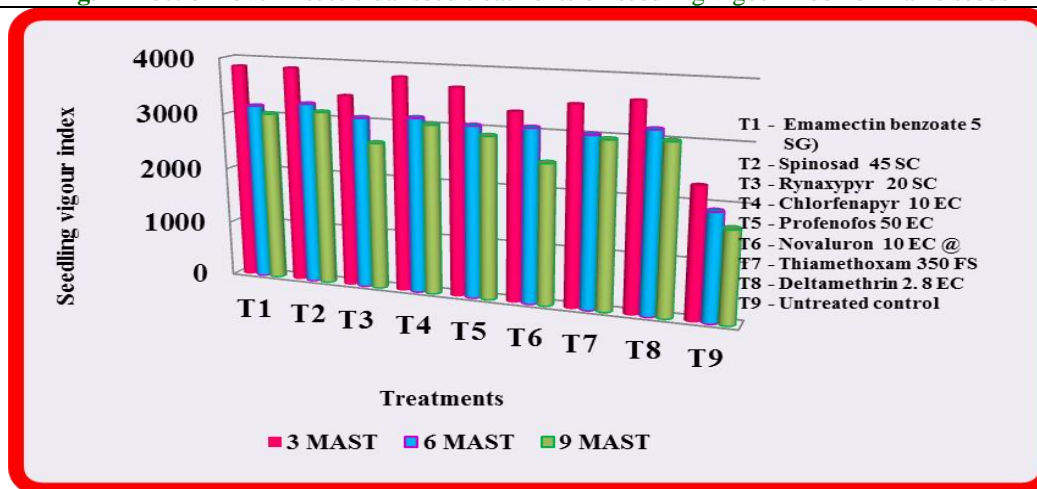
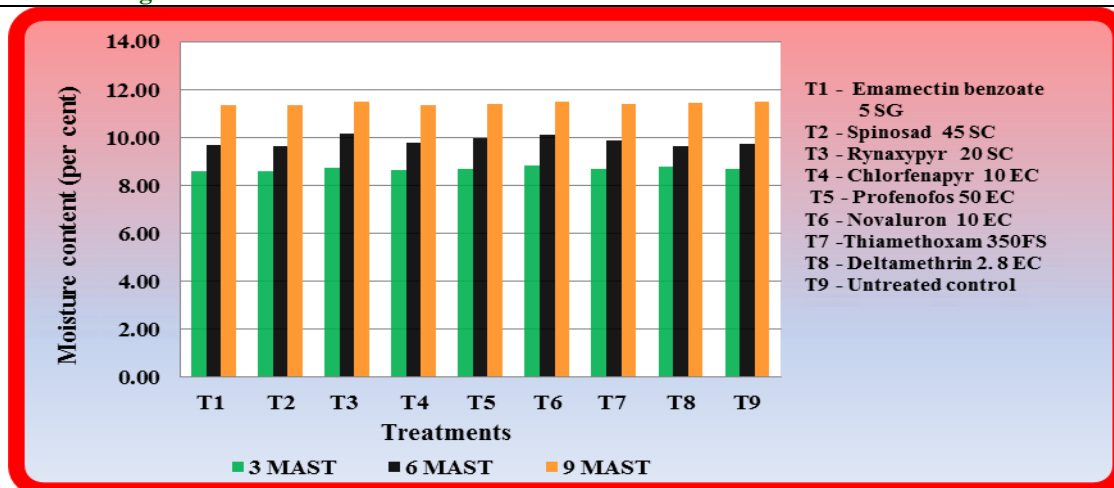


Fig.3 Effect of novel insecticidal seed treatments on moisture content of maize seeds



At nine months after treatment imposition, lowest moisture content of 11.33 per cent was observed in spinosad 45 SC and emamectin

benzoate 5 SG @ 2 ppm on par with chlorfenapyr 10 EC @ 2ppm (11.37 per cent). The moisture content in the rest of the

insecticidal treatments varied from 11.40 to 11.50 per cent. The highest moisture content (11.50 per cent) was observed in untreated seeds.

The present results are in consonance with Sinha and Sinha (1992) who reported a increase in moisture content of the grain as a result of infestation by *S. oryzae* in maize. Similarly, Malarkodi and Srimathi (2001) reported that the moisture absorption by the seed of maize was found to be in increasing order with advance in storage period.

Effect of novel insecticidal seed treatments on seed damage due to *S. oryzae*

Insecticidal seed treatments *viz.*, spinosad 45 SC @ 2 ppm, emamectin benzoate 5 SG @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm and thiomethoxam 350 FS gave complete protection to maize seed without any damage at three months after treatment.

However, maximum damage was observed in untreated check (2.39 per cent) (Table.2).

At six months after treatment imposition, per cent damage seeds were nil in spinosad 45 SC @2 ppm which was on par with emamectin benzoate 5 SG @ 2 ppm (0.73 per cent), chlorfenapyr 10 EC @ 2 ppm (1.05 per cent) and thiomethoxam 350 FS (1.05 per cent). All the treatments were found to be statistically superior over untreated control (6.25 per cent).

At nine months after treatment the significantly lowest damage was recorded in spinosad 45 SC @ 2 ppm (0.33 per cent) followed by emamectin benzoate 5 SG @ 2 ppm (2.07 per cent), chlorfenapyr 10 EC @ 2 ppm, (2.38 per cent) and thiomethoxam 350 FS (2.48 per cent), which were on par with each other. However, maximum damage was observed in untreated seed (13.66 per cent) and found significantly inferior over all other treatments.

The present results are in accordance with the findings of Fang *et al.*, (2002) who reported that spinosad was effective against *S. oryzae*, *O. surinamensis* and *T.castaneum* on wheat seeds at 1 mg kg⁻¹. Sharma and Michaelraj (2006) reported that complete mortality of *S. oryzae* adults was obtained with 1.0 and 2.0 mg a.i. spinosad per kg, whereas, 96.7 per cent mortality was obtained with 0.5 mg a.i. spinosad kg⁻¹ in maize seeds. Seed damage of 0.7 and 5.3 per cent and progeny production of 0.3 and 2.0 were recorded for 1.0 and 0.5 mg a.i. spinosad kg⁻¹ maize seed, respectively. Similar to the present results, Kurdikeri *et al.*, (1994) reported that per cent seed damage and loss in weight increased with increase in storage period.

Effect of novel insecticidal seed treatments on adult emergence of *S. oryzae*

The data on effect of insecticidal seed treatments on adult emergence of *Sitophilus oryzae* are presented in Table 2.

There was no emergence of adult rice weevils in emamectin benzoate 5 SG @ 2 ppm, spinosad 45 SC @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm and thiomethoxam 350 FS, followed by deltamethrin 2.8 EC @ 2 ppm (0.33) treated seeds after three months of treatment.

However, maximum number of adults emerged in untreated seeds (10.67), which was significantly inferior over all other treatments.

At six months after seed treatment there was no emergence of *Sitophilus oryzae* in spinosad 45 SC @ 2 ppm followed by emamectin benzoate 5 SG @ 2 ppm (0.67). All the insecticidal treatments were significantly superior over the control which recorded 26.33 adults.

At nine months after seed treatment similar trend was observed where least number of adults were emerged in spinosad 45 SC @ 2 ppm treated seeds (1.00) followed by

emamectin benzoate 5 SG @ 2 ppm (1.67). However, untreated control (5.2) was significantly inferior over all other insecticidal treatments. Similar observations were also made by Abraham (1991) who has indicated that the extent of damage during storage period depends on the number of adults emerged during each generation.

The high rate of adult emergence might be due to production of second generation resulting in total increase in number of adult emergence.

Studies conducted with novel insecticides as seed treatments revealed superior performance of spinosad 45 SC @ 2 ppm as it maintained seed damage below permissible limit and germination above > 90 per cent upto nine months of storage.

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