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# Efficacy of novel insecticidal seed treatments on mortality of rice weevil [*Sitophilus oryzae* (Linnaeus)]

**A Padmasri, C Srinivas, K Vijaya Lakshmi, T Pradeep and B Anil**

**A Padmasri**
Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

**C Srinivas**
Department of Entomology, College of Agriculture, Rajendranagar, Hyderabad, Telangana, India

**K Vijaya Lakshmi**
Department of Entomology, College of Agriculture, Palem, Nagarkurnool, Telangana, India

**T Pradeep**
Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

**B Anil**
Department of Environmental Science & Technology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

**Correspondence**
**A Padmasri**
Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

**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 residual toxicity of insecticides on mortality of rice weevil was assessed immediately after seed treatment and at every three months interval upto nine months of storage and similarly, seed damage (per cent), weight loss (per cent) and adult emergence were also recorded. The results revealed that Spinosad (Tracer 45 SC) @ 2 ppm $kg^{-1}$ seed found to be significantly superior among the treatments as it resulted hundred per cent mortality within three days after release of adult *Sitophilus oryzae* (L), lowest infestation (0.33 per cent), weight loss (0.05 per cent) and adult emergence (1.00) at the end of nine months of storage.

**Keywords:** Novel insecticidal seed treatment, residual toxicity, *Sitophilus oryzae* (L.) mortality, quantitative losses

## 1. Introduction
The three major cereals *viz*., rice, wheat and maize constitute about 85 per cent of total global cereal production. Maize or Corn (*Zea mays* L.), a cereal crop originated in Central Mexico is a versatile crop grown over a range of agro climatic zones. Maize like other food grains is infested by a number of insect pests. More than 37 species of arthropod pests are associated with maize seeds in storage (Abraham, 1991) [1]. *Sitophilus oryzae* causes enormous losses upto 100 per cent in stored maize in India and other countries (Irabagon, 1959[6] and Singh *et al*., 1974) [14]. 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 seed is drastically reduced and affects subsequent planting (Tefera, 2012) [17].
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.

## 2. 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 residual toxicity of novel insecticides against *Sitophilus oryzae*, seed damage (per cent), weight loss (percent), and adult emegence was recorded upto nine months of treatment imposition. Data were analyzed statistically as per Panse and Sukhatame, 1985 [10].

### 2.1 Residual toxicity against rice weevil
100g of treated seeds were taken in a plastic container and 10 adult weevils were released. Mortality of insects was recorded at 1, 3, 7 and 15 days after treatment at every three months interval upto nine months of storage,

### 2.2 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.

### 2.3 Weight loss (per cent)
The count and weight method was used to determine seed weight loss using the formula:

$$W(\%) = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

Where,
W =Weight loss (%),
Wu = Weight of undamaged seed
Nu =Number of undamaged seeds
Wd = Weight of damaged seed
Nd = Number of damaged seeds.

### 2.4 Presence/absence of insect (live and dead)
Numbers of live/dead weevils were counted in all the treatments by taking out 400 seeds.

## 3. Results and Discussion
### 3.1 Residual Toxicity
Observations on the adult mortality of *S. oryzae* were recorded at 1, 3, 7 and 15 days after release of ten adult weevils into treated seeds at immediately after seed treatment and at every three months interval upto nine months of storage (Tables1 and 2). The results revealed significant differences among the treatments throughout the storage period.

#### 3.1.1 Immediately after seed treatment
The mortality was significantly highest in spinosad 45 SC @ 2 ppm (98.33 per cent) at first day followed by emamectin benzoate 5 SG @ 2 ppm and chlorfenapyr 10 EC @ 2 ppm (93.33 per cent) which were on par with each other and by third day cent per cent mortality was observed in spinosad 45 SC @ 2 ppm and chlorfenapyr 10 EC @ 2 ppm. The mortality recorded in rhynaxypyr 20 EC, profenophos 50 EC, thiomethoxam 350 FS and deltamethrin 2.8 EC at first day were 26.66, 81.66, 86.67 and 86.67 per cent, respectively and all these insecticidal seed treatments recorded 100 per cent mortality by seventh day. While, novaluron 10 EC and untreated control resulted in 100 per cent and 25 per cent mortality, respectively by fifteenth day.

#### 3.1.2 At three months after seed treatment
The results obtained at one day after three months of treatment imposition revealed that spinosad 45 @ 2 ppm recorded significantly highest adult mortality of 81.67 per cent at first day and by third day it resulted in 100 per cent mortality. The adult mortality recorded in emamectin benzoate 5 SG @2 ppm, rhynaxypyr 20 EC @2 ppm, chlorfenapyr 10 EC @ 2 ppm, profenophos 50 EC @ 2 ppm, thiomethoxam 350 FS and deltamethrin 2.8 EC @ 1 ppm at first day were 73.33, 11.67, 71.67, 63.33, 71.67 and 45.00 per cent, respectively and by fifteenth day 100 per cent mortality was recorded in emamectin benzoate 5 SG @ 2 ppm, rhynaxypyr 20 EC @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm, profenophos 50 EC @ 2 ppm, thiomethoxam 350 FS, whereas in deltamethrin 2.8 EC @ 1 ppm it was attained by seventh day. While, the mortality recorded in novaluron 10 EC @ 5 ppm and untreated seeds was 93.33 and 13.33 per cent, respectively at fifteenth day.

#### 3.1.3 At six months after seed treatment
Observations recorded at first day after six months of treatment imposition revealed significant differences among the treatments. Spinosad 45 SC recorded significantly highest mean mortality (78.33 per cent) and by third day 100 per cent mortality was observed. The mortality registered in emamectin benzoate 5 SG @2ppm, chlorfenapyr 10 EC @ 2 ppm, profenophos 50 EC @ 2 ppm, thiomethoxam 350 EC and deltamehrin 2.8 EC @ 1 ppm were 43.33, 41.67, 31.67, 40.00 and 33.33 per cent, respectively and by fifteenth day all these insecticides resulted 100 per cent mortality except profenophos 50 EC, which resulted in 61.67 per cent mortality. While, zero per cent mortality was recorded in rhynaxypyr 20 EC @ 2 ppm, novaluron 10 EC @ 2 ppm and untreated control at first day and by fifteenth day 100.00, 51.67 and 3.3 per cent was recorded, respectively.

#### 3.1.4 At nine months after seed treatment
Observations recorded at first day after release of adults at nine months of treatment imposition revealed significant differences among the treatments. Spinosad 45 SC found to be superior in the performance, resulting in 60 per cent mortality and attained 100 per cent by third day. The mortality recorded in emamectin benzoate 5SG @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm, thiomethoxam 350 FS and deltamethrin @ 1 ppm at first day were 13.33, 10.00, 11.67 and 10.00 per cent, respectively all these insecticidal seed treatments resulted in 100 per cent mortality of test insects by fifteenth day while, no mortality was observed in rynaxypyr 20 EC @ 2 ppm, profenophos 50 EC @ 2ppm, noveluron 10 EC @ 2 ppm and untreated control at first day and by fifteenth day 100.00, 53.33, 21.67 and 10.00 per cent, respectively were observed.
Spinosad which is based on the metabolites from the actinomycetes, *Saccharpolyspora* spinosad Mertz and Yao (Bacteria: Actino bacteridae) appeared to be one of the most promising new seed protectant (Thompson *et al*., 1997) [18]. Spinosad has low mammalian toxicity and act on insects nervous system by ingestion or contact (Sparkes *et al*., 2001 [15], Subramanyam, 2006) [16].
The efficacy of spinosad in the present investigation was in tune with the findings of Subramanyam *et al.* (2006) [16] who reported mortality of more than 98 per cent within 12 days, when seed was treated with spinosad @ 1 or 2 mg/kg. Yousefnezhad and Aasghar (2007) [19] conducted bioassay studies with Spinosad on *T. castaneum* and *S. oryzae* and reported that spinosad was most effective against *T. castaneum* than *S. oryzae*. Sadeghi *et al*. (2011) [11] reported $LC_{50}$ value of spinosad in 72 hours after exposure to *S. oryzae* as 279 ppm. So far spinosad has proved to be very effective against a wide range of stored product pests and can retain its

efficacy for a long time after application (Fang *et al*., 2002 [5]; Daglish and Nayak, 2006 [3]; Maier *et al*., 2006 [9]) found that in stored maize, spinosad remained stable for a period of two years.

Spinosad is effective against *Sitophilus oryzae* which is in accordance with the results published by above researchers.

### 3.2 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 3).

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) [5] 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) [13] 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) [7] reported that per cent seed damage and loss in weight increased with increase in storage period.

### 3.3 Effect of novel insecticidal seed treatments on weight loss (per cent) due to *S. oryzae*

The results pertaining to weight loss of maize seed due to *S.oryzae* are presented in Table 3 reveals that at three months after treatment, the seed treatments that gave complete protection without any weight loss were spinosad 45 SC @ 2 ppm, emamectin benzoate 5 SG @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm and thiomethoxam 350 FS. Next best treatment was deltamethrin 2.8 EC @ 1 ppm (0.24 per cent). All the insecticidal seed treatments were significantly superior over the untreated control (1.16 per cent).

At six months after treatment no weight loss was observed in spinosad 45 SC @ 2 ppm, but weight loss in emamectin benzoate 5 SG @ 2 ppm (0.27 per cent), chlorfenapyr 10 EC @ 2 ppm (0.33 per cent) was observed and they were on par with each other. Untreated control (2.5 per cent) was significantly inferior to the rest of the treatments.

At nine months after seed treatment, minimum per cent weight loss of seeds was observed in spinosad 45 SC @ 2 ppm (0.05 per cent) which was significantly superior over all other treatments. The highest per cent weight was recorded in untreated control (4.53 per cent).

Weight loss might be due to increase in adult population as well as humidity that caused fungus proliferation and dry matter loss. Christensen and Meronuck (1989) [2] also confirmed that the weight loss in corn could be due to the invasion of molds, being accentuated with the increase of humidity, the storage period and the number of insects inside the kernel might have also influenced the dry matter loss.

In stored maize, heavy infestation of *S. zeamais* has resulted in a weight loss of 30-40 per cent (Sclar, 1994) [12]. After a period of three months, weight loss of 1.16 per cent was recorded, which was in support of the findings of Derera *et al*. (2001) [4], who reported that, there was a loss in grain weight ranging from 0.85 to 8.45 per cent, after 70 days of infestation. Lakwah and Latif (1998) [8] also reported that weight loss in maize seed was positively correlated to insect population and storage period.

### 3.4 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 3. 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) [1] 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.

**Table 1:** Residual toxicity of novel insecticidal seed treatments on adult mortality of *S. oryzae* (immediately after seed treatment and three months after seed treatment)

| Treatments | Per cent mortality | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Storage duration | | | | | | | |
| | Immediately after seed treatment | | | | 3 months after seed treatment | | | |
| | 1 DAR | 3 DAR | 7 DAR | 15 DAR | 1 DAR | 3 DAR | 7 DAR | 15 DAR |
| $T_1$-Emamectin benzoate 5SG @ 2 ppm | 93.33 (75.24) | 98.33 (82.99) | 100.00 (85.95) | 100.00 (85.95) | 73.33 (58.93) | 81.67 (64.69) | 93.33 (75.24) | 100 (85.95) |
| $T_2$-Spinosad 45SC @ 2 ppm | 98.33 (82.99) | 100.00 (85.95) | 100.00 (85.95) | 100.00 (85.95) | 81.67 (64.69) | 100.00 (85.95) | 100.00 (85.95) | 100.00 (85.95) |
| $T_3$-Rynaxypyr 20EC@ 2 ppm | 26.66 (31.07) | 53.33 (46.91) | 100.00 (85.95) | 100.00 (85.95) | 11.67 (19.89) | 23.33 (28.86) | 81.67 (64.69) | 100.00 (85.95) |
| $T_4$-Chlorfenapyr 10EC @ 2 ppm | 93.33 (75.24) | 100.00 (85.95) | 100.00 (85.95) | 100.00 (85.95) | 71.67 (57.86) | 86.67 (68.66) | 91.67 (73.40) | 100.00 (85.95) |
| $T_5$-Profenophos 50 EC @ 2ppm | 81.66 (64.69) | 86.67 (68.66) | 100.00 (85.95) | 100.00 (85.95) | 63.33 (52.74) | 66.67 (54.75) | 73.33 (58.93) | 100.00 (85.95) |
| $T_6$-Novaluron 10EC @ 5ppm | 0.00 (4.05) | 51.67 (45.96) | 71.67 (57.86) | 100.00 (85.95) | 0.00 (4.05) | 30.00 (33.00) | 38.33 (38.24) | 93.33 (76.36) |
| $T_7$-Thiomethoxam 350 FS | 86.67 (68.66) | 96.67 (80.03) | 100.00 (85.95) | 100.00 (85.95) | 71.67 (57.86) | 71.67 (57.86) | 81.67 (64.69) | 100.00 (85.95) |
| $T_8$-Deltamethrin 2.8EC @ 1ppm | 86.67 (68.66) | 95.00 (77.08) | 100.00 (85.95) | 100.00 (85.95) | 45.00 (42.12) | 63.33 (52.74) | 100.00 (85.95) | 100.00 (85.95) |
| $T_9$-Untreated | 0.00 (4.05) | 0.00 (4.05) | 10.00 (18.43) | 25.00 (29.93 | 0.00 (4.05) | 0.00 (4.05) | 0.00 (4.05) | 13.33 (21.14) |
| SEm± | 1.58 | 1.54 | 0.36 | 0.64 | 1.09 | 1.55 | 1.16 | 1.84 |
| CD (P=0.05) | 4.69 | 4.59 | 1.06 | 1.91 | 3.27 | 4.6 | 3.44 | 5.45 |
| CV (%) | 5.19 | 4.16 | 0.82 | 1.33 | 4.73 | 5.35 | 3.27 | 4.09 |

Figures in the parentheses are angular transformed values
DAR: Days after release of test insect

**Table 2:** Residual toxicity of novel insecticidal seed treatments on adult mortality of *S. oryzae* (six to nine months after seed treatment)

| Treatments | Per cent mortality | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Storage duration | | | | | | | |
| | 6 months after treatment | | | | 9 months after treatment | | | |
| | 1 DAR | 3 DAR | 7 DAR | 15 DAR | 1 DAR | 3 DAR | 7 DAR | 15 DAR |
| $T_1$-Emamectin benzoate 5SG @ 2 ppm | 43.33 (41.16) | 51.67 (45.96) | 73.33 (59.00) | 100 (85.95) | 13.33 (21.34) | 20.00 (26.57) | 51.67 (45.96) | 100.00 (85.95) |
| $T_2$-Spinosad 45SC @ 2 ppm | 78.33 (62.29) | 100 (85.95) | 100 (85.95) | 100 (85.95) | 60 (50.77) | 100.00 (85.95) | 100.00 (85.95) | 100.00 (85.95) |
| $T_3$-Rynaxypyr 20EC @ 2 ppm | 0.00 (4.05) | 13.33 (21.14) | 41.67 (40.20) | 100 (85.95) | 0.00 (4.05) | 6.67 (14.76) | 10.00 (18.43) | 100.00 (85.95) |
| $T_4$-Chlorfenapyr 10EC @ 2 ppm | 41.67 (40.20) | 51.67 (45.96) | 71.67 (57.86) | 100 (85.95) | 10.00 (18.43) | 20.00 (26.57) | 36.67 (37.26) | 100.00 (85.95) |
| $T_5$-ProfenophosEC @ 2 ppm | 31.67 (34.23) | 43.33 (41.16) | 53.33 (46.91) | 61.67 (51.76) | 0.00 (4.05) | 10.00 (18.43) | 31.67 (34.23) | 53.33 (46.91) |
| $T_6$-Novaluron 10EC @ 5 ppm | 0.00 (4.05) | 11.67 (19.89) | 26.67 (31.07) | 51.67 (45.96) | 0.00 (4.05) | 0.00 (4.05) | 11.67 (19.89) | 21.67 (27.71) |
| $T_7$-Thiomethoxam 350 FS | 40.00 (39.21) | 53.33 (46.91) | 60.00 (50.77) | 100 (85.95) | 11.67 (19.89) | 16.67 (24.05) | 31.67 (34.23) | 100.00 (85.95) |
| $T_8$-Deltamethrin 2.8EC @ 1 ppm | 33.33 (35.25) | 35.00 (36.24) | 83.33 (66.14) | 100 (85.95) | 10 (18.43) | 16.67 (24.05) | 30.00 (33.21) | 100.00 (85.95) |
| $T_9$-Untreated | 0.00 (4.05) | 3.33 (8.85) | 3.33 (8.85) | 3.33 (8.85) | 0.00 (4.05) | 0.00 (4.05) | 10.00 (18.43) | 10.00 (18.43) |
| SEm± | 0.95 | 2.09 | 2.09 | 1.67 | 0.683 | 0.853 | 0.82 | 0.49 |
| CD (P=0.05) | 2.82 | 6.19 | 6.21 | 4.94 | 2.031 | 2.53 | 2.44 | 1.48 |
| CV (%) | 5.6 | 9.23 | 7.298 | 4.94 | 7.347 | 5.382 | 3.91 | 1.27 |

Figures in the parentheses are angular transformed values
DAR: Days after release of test insect

**Table 3:** Effect of novel insecticidal seed treatments on seed damage, weight loss and adult emergence (*S. oryzae)*

| Treatments | Storage duration | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Seed damage (per cent) | | | Weight loss (per cent) | | | Adult emergence | | |
| | 3 Mast | 6 Mast | 9 Mast | 3 Mast | 6 Mast | 9 Mast | 3 Mast | 6 Mast | 9 Mast |
| $T_1$-Emamectin benzoate 5 SG @ 2 ppm | 00.00 (4.06) | 00.73 (4.91) | 2.07 (8.27) | 00.00 (4.06) | 00.27 (4.06) | 00.68 (4.71) | 0.00 (0.71) | 0.67 (1.1 ) | 1.67 (1.46) |
| $T_2$-Spinosad 45SC @ 2 ppm | 00.00 (4.06) | 00.00 (4.06) | 00.33 (4.06) | 00.00 (4.06) | 00.00 (4.06) | 0.05 (4.06) | 0.00 (0.71) | 0.00 (0.71) | 1.00 (1.23) |
| $T_3$-Rynaxypyr 20 SC @ 2 ppm | 2.09 (8.31) | 3.44 (10.69) | 5.44 (13.49) | 00.55 (4.26) | 1.04 (5.85) | 1.58 (7.21) | 2.00 (1.58) | 4.67 (2.27) | 9.00 (3.08) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $T_4$-Chlorfenapyr 10 EC @ 2 ppm | 00.00 (4.06) | 1.05 (5.73) | 2.38 (8.84) | 00.00 (4.06) | 0.33 (4.06) | 0.68 (4.75) | 0.00 (0.71) | 1.33 (1.34) | 2.67 (1.77) |
| $T_5$-Profenofos 50 EC @ 2 ppm | 1.93 (7.98) | 2.76 (9.52) | 4.16 (11.77) | 00.5 (4.13) | 00.77 (5.03) | 1.16 (6.17) | 1.67 (1.46) | 4.67 (2.27) | 7.33 (2.79) |
| $T_6$-Novaluron 10 EC @ 5 ppm | 2.22 (8.56) | 3.66 (11.02) | 6.40 (14.66) | 00.90 (5.44) | 1.21 (6.30) | 2.51 (9.12) | 3.00 (1.86) | 7.00 (2.74) | 11.33 (3.44) |
| $T_7$-Thiamethoxam 350 FS | 00.00 (4.06) | 1.07 (5.94) | 2.48 (9.06) | 00.00 (4.06) | 00.47 (4.13) | 0.78 (5.06) | 0.00 (0.71) | 2.00 (1.56) | 3.67 (2.04) |
| $T_8$-Deltamethrin 2. 8 EC @ 1.0 ppm | 1.00 (5.75) | 1.84 (7.79) | 3.17 (10.23) | 0.24 (4.06) | 00.49 (4.45) | 0.57 (4.36) | 0.33 (0.88) | 2.33 (1.68) | 3.67 (2.04) |
| $T_9$-Untreated control | 2.39 (8.88) | 6.23 (14.44) | 13.66 (21.69) | 1.16 (6.17) | 2.5 (9.10) | 4.53 (12.28) | 10.67 (3.34) | 26.33 (5.18) | 52 (7.24) |
| SEm± | 0.13 | 0.42 | 0.29 | 0.07 | 0.17 | 0.12 | 0.10 | 0.11 | 0.08 |
| CD (P=0.05) | 0.39 | 1.26 | 0.88 | 0.2 | 0.51 | 0.36 | 0.27 | 0.33 | 0.25 |
| CV (%) | 3.7 | 8.93 | 4.52 | 2.65 | 5.74 | 3.24 | 12.14 | 9.48 | 5.33 |

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

## 4. Conclusion

Studies conducted with novel insecticides as seed treatments revealed superior performance of spinosad 45 SC @ 2 ppm in which hundred per cent mortality was observed within three days after release of *Sitophilus oryzae* adults and also it maintained seed damage below permissible limit upto nine months of storage.

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