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Joshi AR
P. G. student, Department of Entomology, C. P. College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Patel JR
Agro-forestry Research Station, SDAU, Sardarkrushinagar, Gujarat, India

Chaudhari SJ
P. G. student, Department of Entomology, C. P. College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Joshi MJ
P. G. student, Department of Entomology, C. P. College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Correspondence
Joshi AR
P. G. student, Department of Entomology, C. P. College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Field efficacy of newer molecules against stem borer, *Chilo partellus* (Swinhoe) infesting maize

Joshi AR, Patel JR, Chaudhari SJ and Joshi MJ

Abstract
The investigations were carried out at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif*, 2017 on field efficacy of newer insecticides against stem borer, *Chilo partellus* (Swinhoe) infesting maize under field condition.
Among all seed treatment and application of insecticides, leaf whorl application of Carbofuran 3G @ 10 kg/ha at 20 and 35 days after sowing found superior as, it recorded only 15.80 per cent damaged plant which was found at par with seed treated with thiamethoxam 30 FS @ 8 ml/kg seed + foliar spray of spinosad 45 SC @ 0.0054 per cent at (18.21 %) and seed treated with imidacloprid 600 FS @ 10 ml/kg seed + foliar spray of spinosad 45 SC @ 0.0054 per cent recorded 20.29 per cent damaged plant by *C. partellus*. On other hand, higher per cent damaged plant due to *C. partellus* was noticed in untreated plot (33.77 %). Leaf whorl application of Carbofuran 3G @ 10 kg/ha, recorded only 1.96 leaf injury scale which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.1) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent recorded 2.37 leaf injury scale recorded at 15 day after second spray. Lowest (1.60 %) stem tunneling was observed in the plots treated with leaf whorl application of carbofuran 3 G @ 10 kg/ha and it was at par with treatment thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.02 %) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.03 %). On the other hand, control plots harboured highest (4.00 %) stem tunneling percentage. Significantly the lowest (0.64 %) dead heart was observed in the plots treated with leaf whorl application of carbofuran 3G @ 10 kg/ha and it was followed by thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.28 %) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.28 %). Whorl and spray applications of insecticides were superior over untreated plot as well as seed treatment in reducing per cent dead heart.

Keywords: *Chilo partellus*, insecicides, maize, leaf injury, dead heart

Introduction
Maize (*Zea mays* Linnaeus) is a major cereal crop belonging to family Poaceae. It is originated from South America, from where it was taken to all parts of the world. It is mainly cultivated for food, fodder and as raw material for many industries. Maize grow throughout the world over a wide range of Agro-climatic conditions due to its wider adaptability than wheat or rice. However, with respect to duration, yield and suitability in a multiple cropping programme, it ranks first amongst the high yielding crops. Being the highest yielding cereal crop in the world is of significant importance for countries like India, where rapidly increasing population already out stripped the available food supplies.
Maize is attacked by about 140 species of insect pests causing varying degree of damage from sowing till storage (Arabjafari and Jalali, 2007) [1]. However, only a few insect pests viz., stem borer [*Chilo partellus* (Swinhoe), *Diatraea* spp. and *Sesamia inferens* (Walker.)], army worm [*Mythimna separate* (Walker.)], bark beetle [*Anthracophora crucifera* (Olivier)], blister beetle [*Cylindrothorax audouini* (Hag-Rutenberg.)], grasshopper [*Epacromia dorsalis* (Thunberg) and *Hieroglyphus banian* (Fabricius)], aphid [*Rhopalosiphum maidis* (Fitch)], surface grasshopper [*Chrotogonus* sp.], white grub [*Holotrichia consanguinea* (Blanchard)], cob borer [*Helicoverpa armigera* (Hubner) Hardwick], leaf eating caterpillar [*Spodoptera litura* (Fabricius)] and white ants [*Odontotermes* sp. and *Microterms* sp.] cause economic loss and are more common over the large area (Patel and Patel, 1970 and Atwal and Dhaliwal, 2002) [6, 2].
Among these, maize stem borer, *C. partellus* (Crambidae; Lepidoptera) is one of the most important pest in Asian and African countries (Arabjafari and Jalali, 2007) [1]. Larvae of *C. partellus* after hatching feed on soft surface of the leaves and then enter in to the stem through

whorl and feeding on pith of the stem. The growth of the plants becomes stunted and results into dead hearts when attacked by *C. partellus* at their initial stages. The larvae also enter in to the stem through lower nodes by making the holes. Yield losses of 24 to 75 per cent have been reported by the attack of this pest alone (Khan, 1983) [5]. Sharma and Gautam (2010) [9] reported that yield loss due to this pest is about 28 per cent.

This being an internal borer, it is difficult to control with single method of pest control practices. To minimize the use of insecticides leading to environmentally safe, economically feasible and socially acceptable as a tactic of pest management.. The present study was conducted to evaluate different insecticides against maize stem borer in field conditions.

Materials & Methods

The field experiment was laid out in Randomized Block Design during *Rabi* 2016-17 at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar. Maize cultivar GAYMH-1 was sown in plots of size 2.4 x 4.0 m at a spacing 60 cm between two rows with 10 treatments (Table 2) replicated thrice. The seeds were treated as per the respective dosage 12 hours before sowing in respective treatments. The spray and leaf whorl application of insecticides were applied as per method of application indicated in treatment details. The first application of insecticides was given at 20 days after sowing and second application of insecticides at 35 days after sowing. From each plot, 15 plants were selected randomly from middle rows of each plots for recording the observations on number of damaged plants and leaf injury scale. The leaf injury was recorded by following visual rating scale (1 to 9) given by Tefera *et al.* (2013) [10] as mentioned in Table 1. The observations recorded before, 7 and 15 days after each spray. Number of dead heart was recorded from middle two rows. The effect of different treatment on per cent stem tunneling was also studied as per the methodology described under. The per cent stem tunneling was worked out by the formula (Dindor, 2016) [4].

$$\text{Per cent stem tunneling} = \frac{\text{Total length of stem tunnel by } \textit{C. partellus} \text{ in 10 plants}}{\text{Total stem length of 10 plants}}$$

Table 1: Stem borer leaf damage assessment using the 1-9 visual rating scale

Scale (1-9)	Description
1	No visible leaf feeding damage
2	Few pin holes on older leaves
3	Several shot-holes injury on a few leaves
4	Several shot-holes injury common on several leaves or small lesions
5	Elongated lesions (> 2 cm long) on a few leaves
6	Elongated lesions on several leaves
7	Several leaves with elongated lesions or tattering
8	Most leaves with elongated lesions or severe tattering
9	Plant dying as a result of foliar damage

Result and Discussion

Based on per cent damaged plant

Before spray

The results presented in Table 2 revealed that before spray there was significant difference among the treatment as far as per cent damaged plant is concerned which ranged from 4.87 to 11.60 per cent among different treatments. The lowest (4.87 %) plant damage was observed in seed treated with thiamethoxam 30 FS @ 8 ml/kg seed and imidacloprid 600 FS @ 10 ml/kg seed treatment. However, higher (11.60 %) damaged plant due to *C. partellus* was noticed in control (untreated) plot, spinosad 45 SC @ 0.0054 per cent (11.55 %) and chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent (11.55 %). Whereas, only 9.31 per cent damaged plant was observed in imidacloprid 600 FS @ 10 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent, carbofuran 3G @ 10 kg/ha treatment.

First spray

All the treatments were significantly superior over control in reducing the damage plant per cent caused by *C. partellus* at seven days after spray (Table 2). The damaged plant ranged from 7.12 to 20.33 per cent among different treatments. The lowest (7.12 %) plant damage was observed in thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent, thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent, treatment, which was statistically at par with carbofuran 3G @ 10 kg/ha treatment which recorded 9.31 per cent plant damage caused by *C. partellus*. However, higher per cent damage plant due to *C. partellus* was noticed in untreated treatment (20.33 %).

While, 13.76, 15.95 and 18.25 per cent damaged plant observed in treatment of chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent, thiamethoxam 30 FS @ 8 ml/kg seed and imidacloprid 600 FS @ 10 ml/kg seed respectively. Foliar spray application of spinosad 45 SC @ 0.0054 per cent, seed treatment of imidacloprid 600 FS @ 10 ml/kg seed + foliar spray application of chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 recorded 11.54 and 11.56 per cent damaged plants respectively.

After 15 days the damage plant ranged from 11.50 to 24.86 per cent among different treatments (Table 2). Significantly minimum (11.50 %) damage plant was observed in carbofuran 3G @ 10 kg/ha which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (13.54 %) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (13.54 %) followed by thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent recorded 15.56 per cent damaged plants caused by *C. partellus*. However, highest per cent damaged plants due to *C. partellus* was noticed in untreated treatment (24.86 %).

Second spray

All the treatments found significantly superior over control at seven days after second spray except imidacloprid 600 FS @ 10 ml/kg seed (Table 2). The damage plant ranged from 13.40 to 29.31 per cent among different treatments. The lower (13.40 %) plant damage was observed in carbofuran 3G @ 10 kg/ha which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (13.53 %), imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (15.95 %) followed by thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent recorded 18.18 per cent damaged plant caused by *C. partellus*. However, highest per cent damage plant due to *C. partellus* was noticed in untreated treatment (29.31 %) which was found at par with imidacloprid

600 FS @ 10 ml/kg seed recorded 27.13 per cent damaged plants.

The results presented 15 days after second spray in Table 2 revealed that damaged plant due to *C. partellus* ranged from 15.80 to 33.77 per cent among different treatments. Carbofuran 3G @ 10 kg/ha treatment found superior as it recorded only 15.80 per cent damaged plant, which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (18.21 %) followed by imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent recorded 20.29 per cent damage plant caused by *C. partellus*. However, highest per cent damage plant due to *C. partellus* was noticed in untreated plot (33.77 %).

Overall at fifteen days after second application of insecticides carbofuran 3G @, 10 kg/ha thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent and 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent were found superior on reducing damaged plants caused by *C. partellus.*

Based on leaf injury scale

Before spray

The results presented in Table 3 revealed that before spray the leaf injury due to *C. partellus* ranged from 1.0 to 1.43 among different treatments. The lower (1.0) leaf injury scale was observed in thiamethoxam 30 FS @ 8 ml/kg seed and thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent which was found at par with imidacloprid 600 FS @ 10 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent (1.03), imidacloprid 600 FS @ 10 ml/kg seed (1.13), imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.16), carbofuran 3G 10 kg/ha (1.16) and thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent (1.19) treatment. However, higher leaf injury due to *C. partellus* was noticed in untreated plot (1.43). First spray

All the treatments were significantly superior over control in reducing the leaf injury per cent caused by *C. partellus* at seven days after spray. The leaf injury ranged from 1.13 to 2.1 among different treatments (Table 3). The lowest (1.13 %) plant damage was observed in thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent which was at par with imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.33) and carbofuran 3G @ 10 kg/ha (1.35). It was followed by thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent treatment which recorded 1.47 per cent plant damage caused by *C. partellus*. However, higher (2.1) leaf injury due to *C. partellus* was noticed in untreated plot.

After 15 days the leaf injury ranged from 1.60 to 2.56 among different treatments (Table 3). Significantly minimum (1.60) leaf injury was observed carbofuran 3G @ 10 kg/ha which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.63) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.73), thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent (1.76) and imidacloprid 600 FS @ 10 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 (2.16). However, higher leaf injury due to *C. partellus* was noticed in untreated plot (2.56).

Second spray

All the treatments found significantly superior over control at seven days after second spray. The leaf injury ranged from 1.86 to 3.0 among different treatments. The lower (1.86) leaf injury was observed in thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent which was found at par with carbofuran 3G @ 10 kg/ha (1.93), imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.03) and imidacloprid 600 FS @ 10 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 (2.16). However, higher per cent leaf injury due to *C. partellus* was noticed in untreated plot (3.0).

The results presented in Table 3 revealed that 15 days after spray the leaf injury due to *C. partellus* ranged from 1.96 to 3.26 among different treatments. Carbofuran 3G @ 10 kg/ha treatment found superior as it recorded only 1.96 leaf injury scale which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.1) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.37). However, higher leaf injury due to *C. partellus* was noticed in untreated treatment (3.26).

Based on per cent dead heart

The data on per cent dead heart was recorded are presented in Table 4. All the treatments were significantly superior over control in reducing the per cent dead heart caused by *C. partellus*. The dead heart ranged from 0.64 to 4.48 per cent among different treatments. Significantly the lowest (0.64 %) dead heart was observed in the plots treated with leaf whorl application of carbofuran 3G @ 10 kg/ha and it was followed by thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.28 %) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.28 %) followed by thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent and imidacloprid 600 FS @ 10 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent recorded 2.15 and 2.23 respectively. The highest (4.48 %) per cent dead heart was recorded in the untreated plot.

Based on per cent stem tunneling

The data on per cent stem tunneling recorded at harvest are presented in Table 4. All the treatments were significantly superior over control in reducing the per cent stem tunneling caused by *C. partellus*. The stem tunneling ranged from 1.60 to 4.00 per cent among different treatments. Significantly the lowest (1.60 %) stem tunneling was observed in the plots treated with leaf whorl application of carbofuran 3G @ 10 kg/ha and it was at par with treatment thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.02 %) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.03 %) followed by thiamethoxam 30 FS @ 8 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent and imidacloprid 600 FS @ 10 ml/kg seed + chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent recorded 2.15 and 2.23 respectively.

The highest stem tunneling (4.00 %) was recorded in the untreated plot. The per cent stem tunneling in treatments of spinosad 45 SC @ 0.0054 per cent, thiamethoxam 30 FS @ 8 ml/kg seed, chlorpyriphos 50 per cent + cypermethrin 5 per cent EC @ 0.11 per cent and imidacloprid 600 FS @ 10 ml/kg seed were significantly superior over control and recorded 2.31, 3.11, 3.17 and 3.33 per cent, respectively. Bamaiyi and Joan (2011) [3] reported that the tunnel length caused by *C. partellus* was relatively lower in carbofuran 3G treated plots which are in accordance with the present findings.

Table 2: Efficacy of various insecticides on *C. partellus* in maize (per cent damaged plant)

Tr. No.	Treatments	Damage plant (%)				
		Before spray	First spray		Second Spray	
			7 DAS	15DAS	7DAS	15DAS
T_1	Thiamethoxam 30 FS @ 8 ml/kg seed	12.75 (4.87)	23.54 (15.95)	26.89 (20.46)	29.94 (24.91)	31.38 (27.11)
T_2	Imidacloprid 600 FS @ 10 ml/kg seed	12.75 (4.87)	25.29 (18.25)	28.38(22.59)	31.39 (27.13)	34.18 (31.56)
T_3	Spinosad 45 SC @ 0.0054 %	19.87(11.55)	19.86(11.54)	25.25(18.20)	26.86 (20.41)	29.91 (24.86)
T_4	Chlorpyriphos 50 % + Cypermethrin 5 % EC @ 0.11 %	19.87(11.55)	21.77(13.76)	26.8620.41)	28.32 (22.51)	32.77 (29.30)
T_5	$T_1 + T_3$	15.48(7.12)	15.48(7.12)	21.59(13.54)	21.58 (13.53)	25.26 (18.21)
T_6	$T_1 + T_4$	15.48(7.12)	15.48 (7.12)	23.53(15.94)	25.24 (18.18)	28.25 (22.40)
T_7	$T_2 + T_3$	15.51(7.15)	15.48(7.12)	21.59(13.54)	23.54 (15.95)	26.77 (20.29)
T_8	$T_2 + T_4$	17.77(9.31)	19.88(11.56)	25.22(18.16)	27.05(20.68)	28.24 (22.39)
T_9	Carbofuran 3G @ 10 kg/ha	17.77(9.31)	17.67(9.31)	19.82(11.50)	21.47 (13.40)	23.42 (15.80)
T_{10}	Control (Untreated)	19.91 (11.60)	26.80(20.33)	29.91(24.86)	32.78 (29.31)	35.53 (33.77)
S.Em.±		0.95	1.23	1.48	1.68	2.01
C.D. at 5 %		2.83	3.65	4.41	4.99	5.97
C.V. %		9.87	10.58	10.32	10.86	11.77

*Figures inside parenthesis are indicates retransformed values of arc sin transformation.
DAS: Day(s) after spray.

Table 3: Efficacy of various insecticides on *C. partellus* in maize (Leaf injury scale)

Tr. No.	Treatments	Leaf injury scale				
		Before spray	First spray		Second Spray	
			7 DAS	15DAS	7DAS	15DAS
T_1	Thiamethoxam 30 FS @ 8 ml/kg seed	1.00	1.70	2.23	2.33	2.43
T_2	Imidacloprid 600 FS @ 10 ml/kg seed	1.13	1.83	2.40	2.43	2.67
T_3	Spinosad 45 SC @ 0.0054 %	1.25	1.57	2.20	2.37	2.40
T_4	Chlorpyriphos 50 % + Cypermethrin 5 % EC @ 0.11 %	1.23	1.73	2.26	2.57	2.47
T_5	$T_1 + T_3$	1.00	1.13	1.63	1.86	2.10
T_6	$T_1 + T_4$	1.19	1.47	1.76	2.06	2.33
T_7	$T_2 + T_3$	1.16	1.33	1.73	2.03	2.20
T_8	$T_2 + T_4$	1.03	1.50	1.80	2.16	2.37
T_9	Carbofuran 3G @ 10 kg/ha	1.16	1.35	1.60	1.93	1.96
T_{10}	Control (Untreated)	1.43	2.10	2.56	3.00	3.26
S.Em.±		0.07	0.09	0.12	0.14	0.16
C.D. at 5 %		0.22	0.28	0.35	0.43	0.47
C.V. %		10.97	10.68	10.2	11.01	11.44

Table 4: Efficacy of various insecticides on *C. partellus* in maize (per cent dead heart and per cent stem tunneling)

Tr. No.	Treatments	Dead heart (%)	Stem tunneling (%)
T_1	Thiamethoxam 30 FS @ 8 ml/kg seed	3.20	3.11
T_2	Imidacloprid 600 FS @ 10 ml/kg seed	3.84	3.33
T_3	Spinosad 45 SC @ 0.0054 %	2.66	2.31
T_4	Chlorpyriphos 50 % +Cypermethrin 5 % EC @ 0.11 %	3.20	3.17
T_5	$T_1 + T_3$	1.28	2.02
T_6	$T_1 + T_4$	1.92	2.15
T_7	$T_2 + T_3$	1.28	2.03
T_8	$T_2 + T_4$	2.66	2.23
T_9	Carbofuran 3G @ 10 kg/ha	0.64	1.60
T_{10}	Control (Untreated)	4.48	4.00
S.Em.±		0.15	0.15
C.D. at 5 %		0.44	0.45
C.V. %		10.3	10.25

Conclusion

Among all seed treatment and application of insecticides, leaf whorl application of Carbofuran 3G @ 10 kg/ha treatment at 20 and 35 days after sowing found superior as, it recorded only 15.80 per cent damage plant which was found at par with seed treated with thiamethoxam 30 FS @ 8 ml/kg seed + foliar spray spinosad 45 SC @ 0.0054 per cent (18.21 %) followed by seed treated with imidacloprid 600 FS @ 10 ml/kg seed + foliar spray of spinosad 45 SC @ 0.0054 per cent (20.29 per cent) damage plant caused by *C. partellus*. On other hand, higher per cent damage plant (33.77%) due to *C. partellus* was noticed in untreated plot. Leaf whorl application of Carbofuran 3G @ 10 kg/ha, recorded only 1.96 leaf injury scale which was found at par with thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.1) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.37) at 15 day after second spray. However, higher leaf injury scale due to *C. partellus* was noticed in untreated plot (3.26). Based on stem tunneling, all the treatments were found significantly superior over control. The stem tunneling ranged from 1.60 to 4.00 per cent among different treatments. Lowest (1.60 %) stem tunneling was observed in the plots treated with leaf whorl application of carbofuran 3 G @ 10 kg/ha and it was at par with treatment thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.02 %) and imidacloprid 600 FS @ 10

ml/kg seed + spinosad 45 SC @ 0.0054 per cent (2.03 %). On the other hand, control plots harboured highest (4.00 %) stem tunneling percentage. The dead heart ranged from 0.64 to 4.48 per cent among different treatments. Significantly the lowest (0.64 %) dead heart was observed in the plots treated with leaf whorl application of carbofuran 3G @ 10 kg/ha and it was followed by thiamethoxam 30 FS @ 8 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.28 %) and imidacloprid 600 FS @ 10 ml/kg seed + spinosad 45 SC @ 0.0054 per cent (1.28 %). The highest (4.48 %) per cent dead heart was recorded in the untreated plot. Whorl and spray applications of insecticides were superior over untreated plot as well as seed treatment in reducing per cent dead heart.

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