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EVALUATION OF SOME IGRS ALONE AND IN COMBINATION WITH SEED TREATMENTS AGAINST *CHILO PARTELLUS* SWINHOE (PYRALIDAE: LEPIDOPTERA) AND *ATHERIGONA SOCCATA* RODANI (MUSCIDAE: DIPTERA) ON FIELD MAIZE

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ABSTRACT

The present studies were conducted to evaluate efficacy of three IGRs, Viper® (Buprofezin), Match® (Lufenuron) and Priority® (Pyriproxyfen) alone and in combination with two insecticides used for seed treatment [Confidor® (Imidacloprid) and Contest® (Thiamethoxam)] at their field recommended dose rate against *Chilo partellus* Swinhoe (Pyralidae: Lepidoptera) and *Atherigona soccata* Rodani (Muscidae: Diptera). Confidor® as seed treatment alone kept the *C. partellus* and *A. soccata* infestation below their ETL (10%) for 30 days; whereas, Contest® for 15 days only. Mortality of *C. partellus* larvae and *A. soccata* maggots increased upto 21 DAT and 14 DAT in Confidor® and Contest® treated plants, respectively. Match® and Priority® alone or in combination with seed treatments exhibited 80-100% reduction in *C. partellus* infestation and 65.3-100% larval mortality upto 15 DAT. Viper® alone did not performed, however, its performance in combination with Confidor® increased for *C. partellus*. Against *A. soccata,* all evaluated IGRs, alone or in combination with seed treatment, exhibited 80-100% reduction in infestation and 75-100% maggots' mortality upto 15DAT. The results reveal that Match® and Priority® in combination with Confidor® seed treatment can be better alternate to granular insecticide application for the biorational management of *C. partellus* and *A. soccata* on maize.

Keywords: Biorational management, IGRs, stem borer, shoot fly, seed treatment

INTRODUCTION

Agriculture being the backbone of Pakistan's economy employs 50% of the total labor force at national level, contributing 25 and 85% to GDP and export earnings, respectively. Maize (*Zea mays* L.) is a popular food, feed and fodder crop in Pakistan. Its yield in Pakistan is only 3.0 t ha^{-1} compared to USA 8.92 t ha^{-1}, Canada 7.82 t ha^{-1}, France 7.14 t ha^{-1} and China 4.85 t ha^{-1} (Anonymous, 2003). Maize (*Zea mays* L.) is the third most important cereal crop in Pakistan after wheat and rice and is produced in most countries of the world. Maize accounts for 4.8% of the total cropped area and 3.5% of the value of agricultural output (Govt. of Pakistan, 2008). It contributes about 4% of the total food grain production in the country. Maize is also used in industries for manufacturing of corn sugar, corn oil, corn protein, corn-flacks and corn syrup etc. (MINFAL, 2009).

In Pakistan, per hectare yield of maize has not increased despite the introduction of high yielding varieties. The major obstacle in achieving this goal is the attack/infestation by insect pests. The notable insect pests are maize and Jawar stem borer (*C. partellus*) and shoot fly (*A. soccata),* the infestation of which ultimately results in total failure of autumn and spring crops, respectively (Singh and Sharma, 1984; Rao and Panwar, 1996; Lisowicz, 2000; Ahmed *et al*., 2002; Ahmed *et al*., 2003; Naz *et al.,* 2003). The grain losses range from 10-15% in the grains due to insect pests alone (Jaipal and Dass, 1993). The total loss due to shoot fly is sometimes as high as 60 percent (Atwal, 1976); whereas maize stem bore, most destructive pest of maize crop, causes

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losses up to 75%. Its infestation at seedling stage may cause total failure of crop (Sekhon and Kanta, 1992; Songa *et al.,* 2001). Kumar (2002) has reported an estimated loss of 24-75%, by maize borer alone. In order to prevent infestation of maize crop by maize stem borer and shoot fly, insecticides particularly granular formulations are recommended as soil and/or whorl application at 25 and 45 days after sowing (Khan *et al.,* 2004), but very early stage, application of granules is quite difficult and possess stress on growth of maize crop.

Insect growth regulators (IGRs) include compounds that affect moulting and metamorphosis by mimicking juvenile hormone (JH agonists) or usually antagonizing JH activity (Ecdysteroid agonists) or by interfering with cuticle formation (Chitin synthesis inhibitors) (Smet *et al.*, 1990; Oberlander *et al.*, 1991, 1997). Insect growth regulators degrade rapidly in the environment (Staal, 1975; Zurfleuh, 1976) and generally have low mammalian toxicity to non-target species (Staal, 1975; Oberlander *et al.*, 1997). Some IGRs have a very high biological activity (Slama, 1971, Slama *et al.,*1974) and can potentially be integrated in other insect pest management techniques such as biological control (Wright and Spades, 1972). IGRs are considered as safe insecticides to insect parasitoids (Sohrabi *et al*., 2012). Insect growth regulators like, hexaflumuron, bifenthrin, fenoxycarb, lufenuron, pyriproxyfen have been reported as strong molecules against different insect pests, but they have not been evaluated against *C. partellus* and shoot fly of maize crop (Singla and Singh, 1998; Mishra, 1999; Singh and Singh, 2001, 2002, 2003; Ahmed *et al*., 2006; Smith, 1995; DeWael *et al*., 1995).

Seed treatments are also an effective strategy to minimize above-ground exposures and environmental loadings of pesticides (Lange, 1959; Jeffs, 1986; Martin, 1988). According to Mashwani *et al*. (2011), seed treatment with confidor caused 97.3% reduction in maize borer infestation. Seed treatment with Carbofuron and Endosulfan has also been reported as useful against the pest (Sekhon and Kanta, 1992). Seed treatment protect the maize crop from initial attack of shoot fly and maize borer at quick early (4-5 leaf stage) for at least one month (Suhail *et al*., 2000; Mashwani *et al*., 2011).

Keeping in view the above importance of maize Stem borer and shoot fly, the study was conducted to evaluate the efficacy of different insecticides as seed treatment and various IGRs as cover spray against maize stem borer and shoot fly.

MATERIALS AND METHODS

Insecticides

Confidor® (immidacloprid) 70% WS (Bayer Crop Sciences, Pakistan), Contest® (thiamethoxam) 70 WS (Kanzo AG, EVYOL Group, Pakistan), Viper® (buprofezin) 25 WP (Agritop Pvt. Ltd. Pakistan), Match® (lufenuron) 5% EC (SYNGENTA, Pakistan Ltd.), Priority® 10.8 EC @ 250 ml/acre (pyriproxyfen) (Kanzo AG, EVYOL Group, Pakistan) were evaluated for the control of maize stem bore and shoot fly. Confidor® and Contest® were used for seed treatment @ 5 g/kg seeds; whereas, Viper®, Match® and Priority® were used for cover spray.

Experimental layout

A hybrid maize variety AAS-9732 (Pioneer Seed Company) was sown on July 15, 2011 in the experimental area of Agricultural Entomology, Youngwala, University of Agriculture Faisalabad by using dibbler method under randomized complete block design. The experimental area consisted of 36 experimental units which were separated into three blocks each having 12 experimental units. Each block was separated by a path of three feet width; whereas, each experimental unit was separated from each other by a path of 1.5 feet width. The twelve treatments were completely randomized in each block. The recommended agronomic practices were done before sowing and during the growing season the crop uniformly in all the experimental units. Thinning was done 10 days after germination to main the healthy plant population at plant to plant distance of 20 cm.

Treatments

Experiment consisted of twelve treatments. These treatments included control treatment (T_1) where only water was sprayed, seed treatment with Confidor® (T_2), seed treatment with Contest® (T_3), seed treatment with Confidor® alongwith cover spray of Viper® (T_4), seed treatment with Confidor® alongwith cover spray of Match® (T_5), seed treatment with Confidor® alongwith cover spray of Priority® (T_6), seed treatment with Contest® alongwith cover spray of Viper® (T_7), seed treatment with Contest® alongwith cover spray of Match® (T_8), seed treatment with Contest® alongwith cover spray of Priority® (T_9), cover spray of Viper® (T_{10}), cover spray of Match® (T_{11}) and cover spray of Priority® (T_{12}).

Viper®, Match® and Priority®

Seed treatments

Seed treatment was done once during experimental period. For seed treatment, a solution of each of Confidor® and Contest® was prepared in water by dissolving 5 g of insecticide in 1000 ml of distilled water. The prepared solution was used to treat 1 kg of seeds. The seeds of weight 1 kg were put in the seed treatment machine and half of the solution was poured on the seeds. The machine was manually revolved for 5 minutes to mix the solution with the grains. After 5 minutes other half solution was poured on the grains and seed treatment machine was revolved manually for another 5 minutes till the seed grains were uniformly treated with the insecticides. The treated seeds were taken out of the machine and dried under shade for 30 minutes. The treated seeds were then sown in the field.

Application of cover spray of IGRs

Cover spray of three IGRs i.e., Viper®, Match® and Priority® was applied twice. First and second application of IGRs as cover sprayer in respective treatments was exercised 10 and 20 days after germination, respectively. Calibration was done to determine the quantity of water required for each experimental unit. The IGRs, after tank-mixing with water at

their field recommended doses, were applied by knapsack sprayer (19.15 L knapsack sprayer (PB-20; Cross Mark Sprayers, Johor, West Malaysia). Hollow-cone nozzle was used in knapsack sprayer and pressure was maintained inside the sprayer. Spray of IGRs was applied along the rows and inside the whorl.

Data collection

The data regarding infestation or dead heart intensity, larvae or maggots per plant and tunnel-length (in case of stem borer only) were recorded 3, 7, 14, 21 and 30 days post treatment in plots receiving seed treatment and 3, 7 and 15 days post treatment in plots receiving cover spray of IGRs. A stick of length 2 m was dropped randomly at three places in each experimental unit along the row and total as well as infested plants in the range of stick were counted. Percent infestation was calculated by the following formula:

$$\text{Percent infestation} = \frac{\text{Number of infested plants}}{\text{Total plants}} \times 100$$

From the plots receiving cover spray of IGRs, infestation data as described above was collected 24 hours before treatment application. Then change in percent infestation/population (percent infestation reduction) (increased or decreased) was calculated by the modified Abbot's formula (Flemings and Ratnakaran, 1985) given below:

$$\text{\% Population change} = \left\{ 1 - \frac{\text{Post treatment population in treatment}}{\text{Pre treatment population in treatment}} \times \frac{\text{Pre treatment population in treatment}}{\text{Post treatment population in treatment}} \right\} \times 100$$

The infested plants were uprooted, brought in the laboratory and dissected with a sharp knife. The dead as well as alive larvae and maggots of stem borer and shoot fly, respectively, were counted.

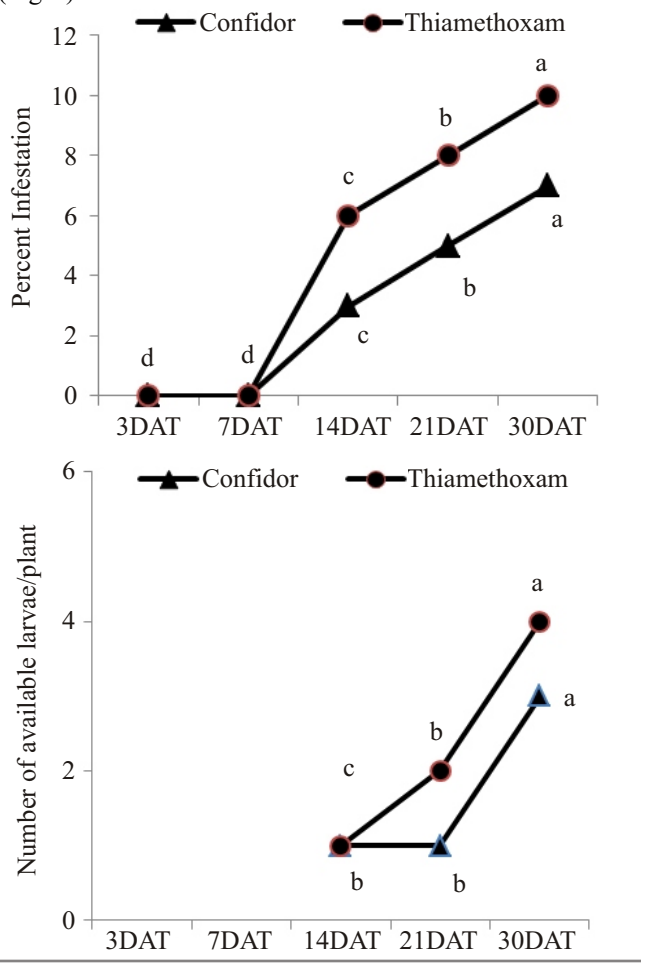
STATISTICAL ANALYSIS

The data collected was subjected to ANOVA technique for the determination of level of significance of treatments (Tabachnick and Fidell, 2001); whereas Tukey HSD test was used for the comparison of means, if treatment shows significant results.

RESULTS

Comparison of seed treatment with Confidor® and thiamethoxam against *C. partellus*

Seed treatment, post treatment intervals and their interaction had highly significant effect on percent infestation, number of alive and dead larvae/plant and tunnel length of *C. partelllus* (Table 1). No infestation of *C. partelllus* was recorded upto 7 days after seed treatment with both Confidor® (imidacloprid) and thiamethoxam. However, infestation of *C. partelllus* started to appear 7 DAT and increased persistently upto 30 DAT; but infestation remained below ETL (10%) upto 30 and 21 DAT in plots which were treated with Confidor® and thiamethoxam, respectively. These results indicated that Confidor® was more effective than thiamethoxam as the former suppressed the infestation of *C. partelllus* below its ETL for longer period as compared to later. As infestation stared 7 DAT, the numbers of larvae dead and alive were counted at three intervals (14, 21 and 30 DAT). The density of larvae alive was less (1 per plant for both Confidor® and thiamethoxam) and that of dead (4-5/plant) were more for 14 DAT. In case of Confidor®, number of larvae alive sustained at 1 alive larva/plant upto 21 DAT and then increased to 3 alive larvae/plant; unlikely, the density of dead larvae/plant increased to 5 larvae/plant for 21 DAT and then a decline was observed. These results indicate that Confidor® remained effective for 21 DAT and its application should be repeated or alternated after an interval of 21 days against *C. partellus*. In case of thiamethoxam, density of alive and dead larvae/plant consistently increased and decreased, respectively. Maximum density of dead larvae/plant was observed for 14 DAT of thiamethoxam. These results indicate that thiamethoxam stayed effective for 14 days only and should be repeated or alternated after 14 days of interval against *C. partellus*. No tunnel length was observed upto 7 DAT. However, tunnel length significantly varied among post treatment intervals as well as between Confidor® and thiamethoxam, being significantly higher in thiamethoxam as well as for longer post treatment interval and lower in Confidor® as well as for shorter post treatment interval. In both treatments, tunnel length increased with an increase in post treatment interval (Fig. 1).



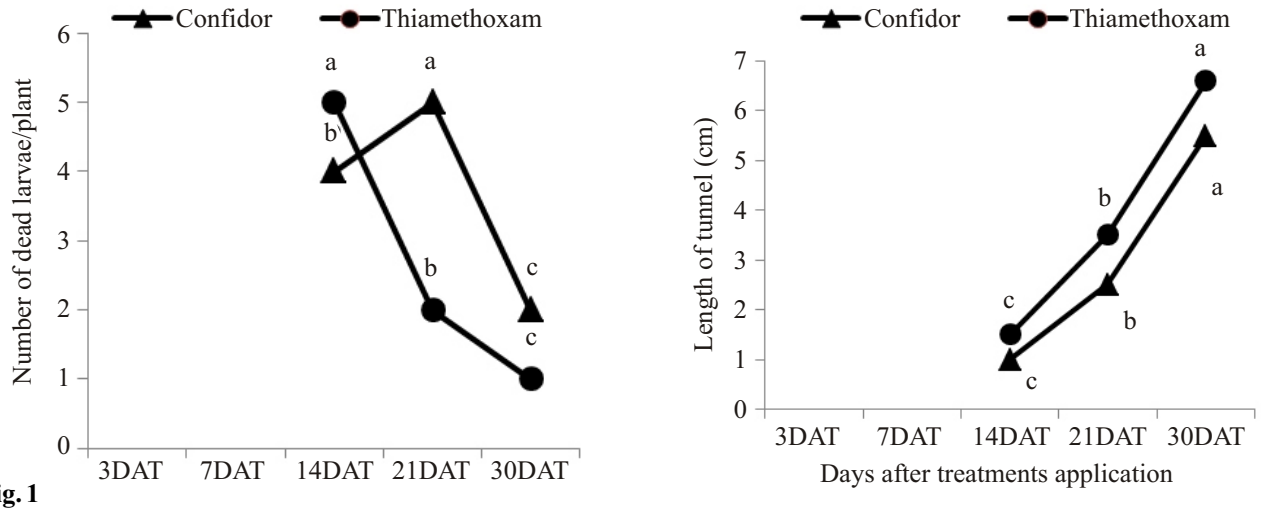


Fig. 1
Percent infestation, number of alive and dead larvae per plant and tunnel length (cm) of *C. partellus* 3, 7, 14, 21 and 30 days after application of seed treatment with imidacloprid (Confidor®) and thiamethoxam (means sharing similar letters on each line of graph are not significantly different from each other at P = 0.05)

Table 1
ANOVA parameters for main effect of different treatments (Thiamethoxam and Confidor) on the percent infestation, number of alive and dead larvae per plant and length of tunnel of *C. partellus* 3, 7, 14, 21 and 30 days after treatment (DAT) application (total *d.f.* = 29; replications = 3)

Source of variation	*d.f.* (V^a/E^b)	*Chilo partellus*							
		Infestation (%)		Alive larvae (n)		Dead larvae (n)		Tunnel length (cm)	
		F	P	F	P	F	P	F	P
Treatments (T)	1/20	18.75^{**}	<0.0001	6.0^{*}	0.02	13.5^{**}	0.002	1014.0^{**}	<0.0001
DAT	4/22	262.5^{**}	<0.0001	62.3^{**}	<0.0001	125.3^{**}	<0.0001	19460.3^{**}	<0.0001
T x DAT	4/22	30.0^{**}	<0.0001	2.3^{ns}	0.100	17.3^{**}	<0.0001	207.8^{**}	<0.0001

Comparison of seed treatment with Confidor® and thiamethoxam against *A. soccata*

A significant variation in percent infestation and dead and alive maggots/plants of *A. soccata* was observed for treatments, post treatment interval and their interactions (Table 2). No infestation was recorded for 3 and 7 DAT. Infestation of *A. soccata* was recorded 14 DAT and it then consistently increased with increasing post treatment interval for both Confidor® and thiamethoxam. Infestation of *A. soccata* persisted below 5% upto 21 DAT for both Confidor® and thiamethoxam; however it was higher in thiamethoxam ad lower in Confidor®. After 21 DAT, infestation was more than 5% and increased more promptly in case of thiamethoxam as compared to Confidor®. The density of alive maggots/plants increased with increasing post treatment interval but increase was steeper in case of thiamethoxam than Confidor®. Less numbers of alive maggots/plant were observed in case of Confidor®. The density of dead maggots/plant increased with same steepness upto 21 DAT and it then declines quickly from 5-6 to 3 dead maggots/plant for both Confidor® and thiamethoxam. However, more density of dead maggots/plant was observed in case of Confidor® than thiamethoxam (Fig. 2). These results directed that Confidor®, explaining less infestation and more density of dead maggots/plants of *A. soccata*, sustained its effectiveness for longer period of time (upto 21 days) and was more effective than thiamethoxam. Thiamethoxam was also effective but for 14 days only. For *A. soccata*, Confidor® and thiamethoxam should be used for seed treatment but application of cover spray with alternative insecticides should be ensured after 21 and 14 days in case of Confidor® and thiamethoxam, respectively.

Table 2
ANOVA parameters for main effect of different treatments (Thiamethoxam and Confidor) on the percent infestation and number of alive and dead larvae per plant of *A. soccata* 3, 7, 14, 21 and 30 days after treatment (DAT) application (total *d.f.* = 29; replications = 3)

Source of variation	*d.f.* (V^a/E^b)	*A. soccata*					
		Infestation (%)		Alive maggots (n)		Dead maggots (n)	
		F	P	F	P	F	P
Treatments (T)	1/20	73.5^{**}	<0.0001	37.5^{*}	<0.0001	26.0^{**}	0.004
DAT	4/22	587.3^{**}	<0.0001	136.5^{**}	<0.0001	170.3^{**}	<0.0001
T x DAT	4/22	32.3^{**}	<0.0001	7.5^{**}	0.001	21.3^{**}	<0.001

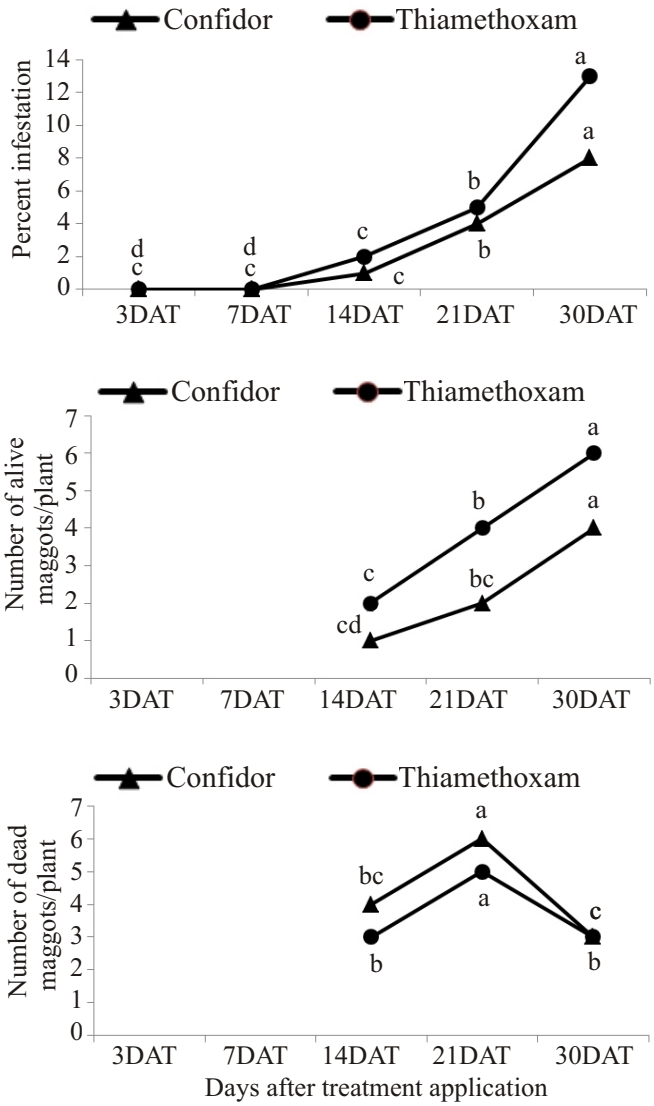


Fig. 2
Percent infestation and number of alive and dead maggots per plant of *A. soccata* 3, 7, 14, 21 and 30 days after application of seed treatment with imidacloprid (Confidor®) and thiamethoxam (means sharing similar letters on each line of graph are not significantly different from each other at P = 0.05)

Effects of seed treatment and IGR's application, alone or in various combinations, on the infestation reduction and larval mortality of *C. partellus*

A significant variation in percent infestation reduction and larval mortality in *C. partellus* was recorded for different treatments, DAT and their interactions (Table 3). The plots treated with Confidor® and thiamethoxam alone as seed treatments exhibited an enhanced reduction in infestation from 89.5 to 100% and 83.4 to 100% for 3 and 7 DAT, respectively; whereas, at 15 DAT, infestation reduction declined to 64.4% and 58.5%, respectively (Fig. 3). Similarly, 2% larvae of *C. partellus* were recorded dead at 7 DAT in infested plants experiencing seed treatment with Confidor® and thiamethoxam. Under the same treatments, 50 and 48.5% larvae were observed dead, respectively at 15 DAT. Cover spray of lufenuron and pyriproxyfen explained 84% reduction in infestation of *C. partellus* that increased to 100% at 15 DAT in case of both IGRs. Cover spray of buprofezin, at 3 DAT, induced 40.8% reduction in infestation that increased to 62.6% at 7 DAT and then decreased to 35.3%. This reveals that application of buprofezin as cover spray remained effective for 7 days (Fig. 3). An enhanced larval mortality was observed from 7 DAT to 15 DAT in case of cover spray of all three IGRs. At 15 DAT, 75.5, 65.3 and 62.6% later instar larvae of *C. partellus* were observed dead in plants treated with cover spray of lufenuron, pyriproxyfen and buprofezin, respectively; whereas, only 1st instar larvae were found alive in these treatments. Treatments involving different combinations of seed treatments with both Confidor® and thiamethoxam and cover spray of three IGRs (lufenuron and buprofezin) caused 80 to 92% reduction in infestation at 3 DAT that reached to 100% at 7 DAT and sustained at this level even at 15 DAT. Treatment combination of cover spray of pyriproxyfen with both Confidor® and thiamethoxam brought 74.6 and 82.6% reduction in infestation of *C. partellus* that increased to 100% at 7 DAT and 15 DAT in case of a combination of pyriproxyfen (as cover spray) with Confidor® and thiamethoxam (as seed treatment), respectively. Lufeneuron in combination with Confidor® and thiamethoxam explained maximum larval mortality of 60 and 55.6% at 7 DAT, whereas 100 and 95.4% at 15 DAT. Pyriproxyfen in combination with Confidor® and thiamethoxam brought 45.5 and 45.8% larval mortality at 7 DAT, whereas 88.8 and 71.0% at 15 DAT. While, buprofezin in combination with Confidor® and thiamethoxam induced least larval mortality of 20 and 28.6% at 7 DAT, whereas 40.0

Table 3
ANOVA parameters for main effect of different treatments on the percent infestation reduction (total *d.f.* = 107; replications = 3) and percent larval mortality (total *d.f.* = 71; replications = 3) of *C. partellus* and *A. soccata* at different post treatment intervals

Source of variation	*d.f.* (V^a/E^b)	Infestation reduction (%) *C. partellus*		*A. soccata*		*d.f.* (V^a/E^b)	Larval mortality (%) *C. partellus*		*A. soccata*	
		F	P	F	P		F	P	F	P
Treatments (T)	11/72	112378.5	<0.0001	2332800.3	<0.0001	11/48	25705.5	<0.0001	1351335.7	<0.0001
DAT	2/72	20762.8	<0.0001	1080289.0	<0.0001	1/48	133109.2	<0.0001	502608.7	<0.0001
T x DAT	22/72	4038.9	<0.0001	35199.2	<0.0001	11/48	2162.1	<0.0001	13532.9	<0.0001

** Highly significant at P = 0.01, * Significant at P = 0.05, [a] degree of freedom of Variable, [b] degree of freedom of Error

and 61.3% at 15 DAT. In control treatment, percent infestation increased from 2.6 at 3 DAT to 6.6 and 8.9% at 7 and 15 DAT, respectively.

Effects of seed treatment and IGR's application, alone or in various combinations, on the infestation reduction and maggot mortality of *A. soccata*

Percent infestation reduction and larval mortality of *A. soccata* varied significantly for different treatments, DAT and their interactions (Table 3). Percent reduction in infestation and maggot mortality of *A. soccata* for all treatments increased significantly with increasing DAT, being significantly lower at less and higher at more DAT. Confidor® and thiamethoxam alone as seed treatments exhibited 55.7-79.5 and 57.9-80.1% reduction in infestation and 50.3-60.0 and 49.5-62.6% mortality of *A. soccata* maggots, respectively, being significantly lower at less and higher at more DAT (Fig. 4). Cover spray of buprofezin, lufenuron and pyriproxyfen explained 75.5-88.3, 82.2-95.4 and 74.3-91.2% reduction in infestation and 56.4-61.3, 75.0-82.0 and 65.3-78.2% maggot martality of *A. soccata*, being significantly lower at less and higher at more DAT (Fig. 4); whereas, only 1st instar larvae were found alive in these treatments. Cover spray of buprofezin, lufenuron and pyriproxyfen integrated with Confidor® caused 60.5-92.3, 81.4-100 and 71.7-100% reduction in infestation and 75.7-82.3, 95.4-100 and 82.5-100% mortality of *A. soccata* maggots, respectively, being significantly lower at less and higher at more DAT (Fig. 4).

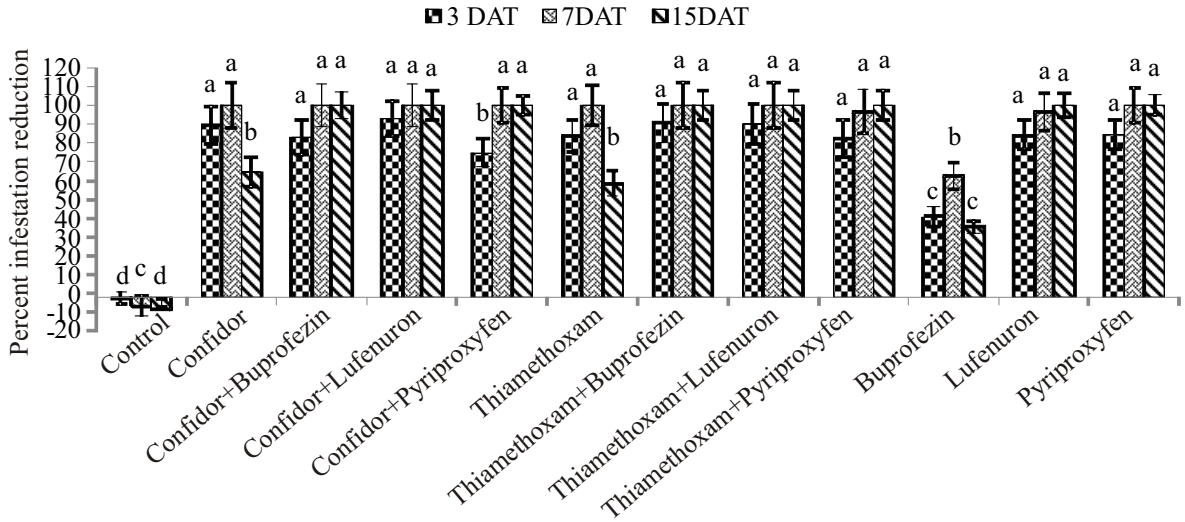


Fig. 3
Percent reduction in infestation of *C. partellus* 3, 7 and 15 days after application of different insecticides, used for seed treatment (Confidor® and thiamethoxam) and cover spray (buprofezin, lufenuron and pyriproxyfen), alone and in various combinations (means sharing similar letters in each cluster of histogram are not significantly different from each other at P = 0.05; Error bars indicate ±SE)

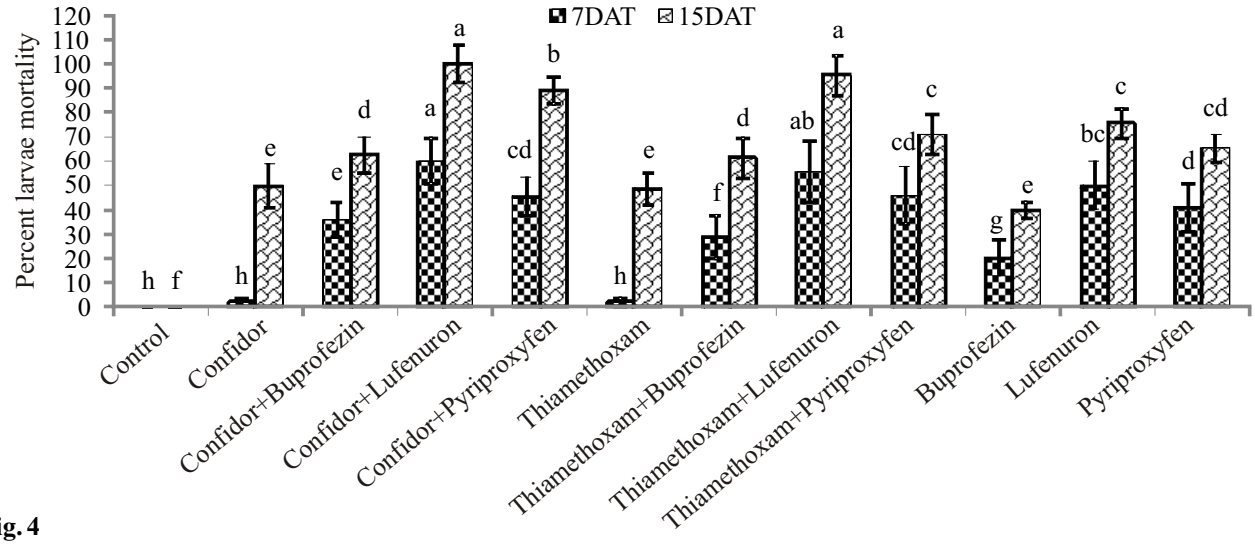


Fig. 4
Percent larval mortaity of *C. partellus* 7 and 15 days after application of different insecticides, used for seed treatment (Confidor® and thiamethoxam) and cover spray (buprofezin, lufenuron and pyriproxyfen), alone and in various combinations (means sharing similar letters in each cluster of histogram are not significantly different from each other at P = 0.05; Error bars indicate ±SE)

Likely, a cover spray of buprofezin, lufenuron and pyriproxyfen integrated with Confidor® induced 65.5-88.9, 85.5-100 and 75.4-98.4% reduction in infestation and 72.3-83.8, 92.6-100 and 79.9-97.8% mortality of *A. soccata* maggots, respectively, being significantly lower at less and higher at more DAT. In control treatment, percent infestation increased from 3.5 at 3 DAT to 7.5 and 12.8% at 7 and 15 DAT, respectively.

DISCUSSION

The objectives of the present study were to evaluate efficacy of three IGRs, Viper®, Match®and Priority® alone and in combination with two insecticides used for seed treatment (Confidor® and Contest®) at their field recommended dose rate against *C. partellus* and *A. soccata*. Confidor® as seed treatment alone kept the *C. partellus* and *A. soccata* infestation below their ETL (10%) for 30 days; whereas, Contest® for 15 days only. Mortality of *C. partellus* larvae and *A. soccata* maggots increased upto 21 DAT and 14 DAT in Confidor® and Contest® treated plants, respectively. Match® and Priority® alone or in combination with seed treatments exhibited 80-100% reduction in *C. partellus* infestation and 65.3-100% larval mortality upto 15 DAT. Viper® alone did not performed, however, its performance in combination with Confidor® increased for *C. Partellus*. Against *A. soccata,* all evaluated IGRs, alone or in combination with seed treatment, exhibited 80-100% reduction in infestation and 75-100%

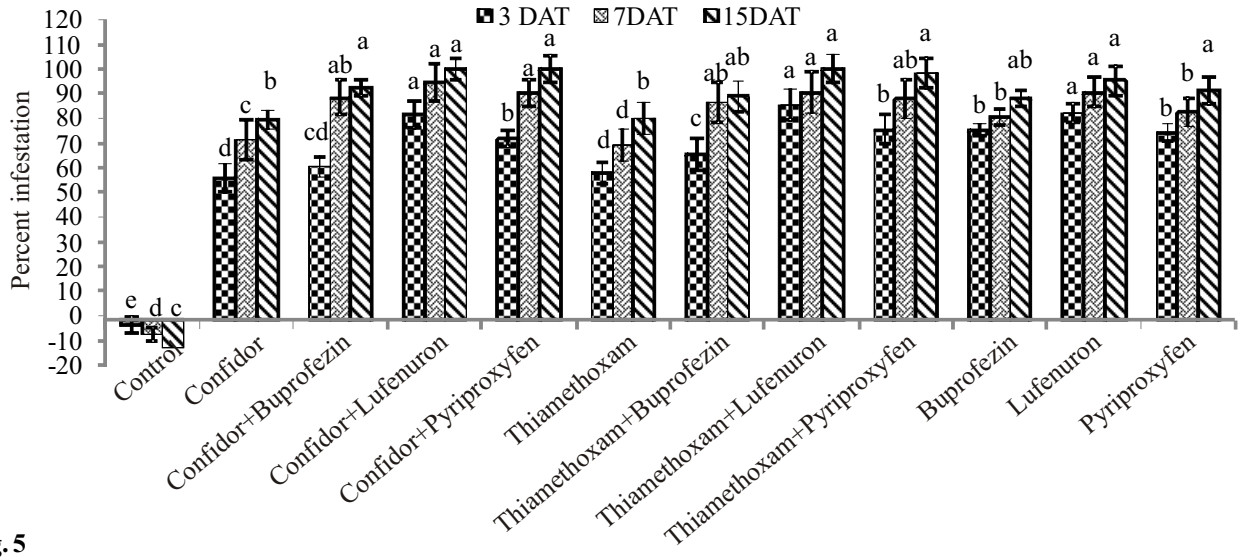


Fig. 5
Percent reduction in infestation of *A. soccata* 3, 7 and 15 days after application of different insecticides, used for seed treatment (Confidor® and thiamethoxam) and cover spray (buprofezin, lufenuron and pyriproxyfen), alone and in various combinations (means sharing similar letters in each cluster of histogram are not significantly different from each other at P = 0.05; Error bars indicate ±SE)

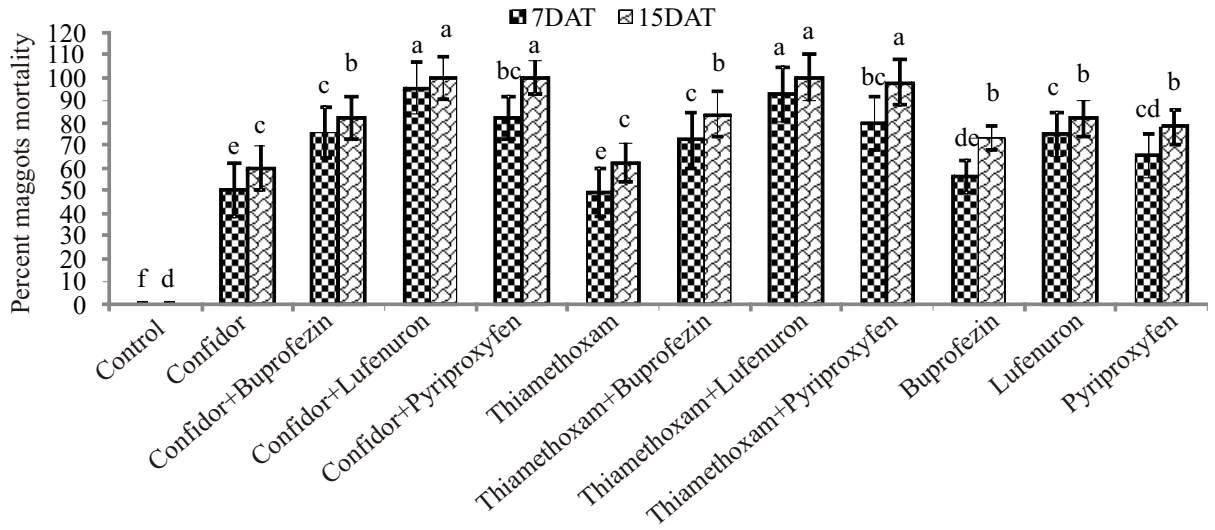


Fig. 6
Percent maggot mortality of *A. soccata* 7 and 15 days after application of different insecticides, used for seed treatment (Confidor® and thiamethoxam) and cover spray (buprofezin, lufenuron and pyriproxyfen), alone and in various combinations (means sharing similar letters in each cluster of histogram are not significantly different from each other at P = 0.05; Error bars indicate ±SE)

maggots' mortality upto 15DAT. These findings are in accordance with those of Suhail *et al*. (2000), Pons and Albages (2002); Kamatar *et al*. (2002); Ahmad *et al.* (2003); Koch *et al*. (2005); Naveed *et al*. (2010), Mashwani *et al*. (2011) who documented no initial incidence of shoot fly and maize stem borer due to the seed treatments with confidor® and thiamethoxam. Variation in the performance of confidor® and thiamethoxam for 30 and 21 DAT, respectively is attributed to more residual persistency of confidor® than that of thiamethoxam. The tunnel length was least for 7 DAT in case of both seed treatments but increased with an increase in post treatment interval. These results indicate a decline in performance of both of the seed dressers. Treatments involving different combinations of seed treatments with both Confidor® and thiamethoxam and cover spray of two IGRs (Match® and Priority®) explained better results for longer period. These results proves that seed treatment integrated with cover spray of IGRs serve as two sided sward for suppression of maize stem borer and shoot fly at initial and later growth stages of maize. The results of present study regarding performance of IGRs alone or in combination with seed treatment cannot be compared or contradicted as no information on these aspects are available in literature cited against maize stem borer and shoot fly. In conclusion, Match® and Priority® in combination with Confidor® seed treatment can be better alternate to granular insecticide application for the biorational management of *C. partellus* and *A. soccata* on maize.

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