Research Article

Effects of Different Seed Dressers and Varietal Response of Maize Against Maize Stem Borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) Infestation

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Abstract | Maize (*Zea mays* L.) is a staple crop of significant agricultural importance worldwide. However, its productivity is severely threatened by the maize stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae), a destructive pest that affects maize at various growth stages. To mitigate the damage caused by this pest, the use of seed dressers has emerged as an effective pest management strategy. This study aimed to evaluate the efficacy of different seed dressers (imidacloprid, thiamethoxam, clothianidin) at their recommended field doses against maize stem borer infestation in two maize varieties. Field trials were carried out to assess the effectiveness of these three synthetic insecticides against maize stem borer on two maize varieties (Jalal and Iqbal) at ARI Tarnab, Peshawar during 2019. The experiments were laid out under Randomized Complete Block Design with split plot arrangement. The results showed that all insecticides had significantly reduced maize stem borer infestation; lowest mean percent infestation of maize stem borer was recorded by clothianidin in variety Jalal followed by plots treated with imidacloprid. While in variety Iqbal, imidacloprid performed better with lowest mean percent infestation (9.58%) as compared to Jalal variety, this was followed by plots treated with clothianidin. Data regarding the combined effect of seed dressers and varieties showed that imidacloprid and clothianidin appeared to be the most effective with minimum mean percent infestation, followed by thiamethoxam compared to control where maximum mean percent infestation was recorded. The study revealed that the Jalal variety, when treated with thiamethoxam, exhibited superior performance in terms of plant height, thousand grain weight, cob weight, and grain yield compared to other treatments. Similarly, the Iqbal variety treated with thiamethoxam also showed improved grain yield, plant height, and cob weight. Interestingly, treatments with clothianidin resulted in higher biological yield for both varieties, highlighting differences in response to seed dressers. These trends suggest that thiamethoxam is particularly effective in enhancing key yield parameters, while clothianidin excels in promoting overall plant biomass. The present study concluded that both imidacloprid and clothianidin proved the best seed dressers in maize variety Iqbal and hence can be used in the IPM of maize stem borer.

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Introduction

Maize (*Zea mays* L.) is an important cereal crop grown on large scale for both grains and fodder purposes. Maize is used in a lot of products and is considered an important constituent of the human diet. Besides, maize straw is used for livestock feeding and their grains are used for poultry food (Afzal *et al*., 2009). The maize crop is grown on an area of 184 M ha^{-1} with a total yield of 1016 MMT. Average production of maize crops is 5.52 T ha^{-1} globally (FAO, 2020). In Pakistan maize crop is grown on an area of 1,251.4 thousand hectares and their total yield across the country is 5901.6 thousand tons with an average production of 4716 kg/ha (MINFAL, 2019-20). The past few years, maize crop up ranked the paddy rice and wheat due to their high production globally (Huma *et al*., 2019; Salim *et al*., 2021). Maize crops become at high risk of injury when the crop is more susceptible and as a result, pests cause more damage. Nearly two hundred and fifty species of insects and mites pest infest the maize crops and cause minor damage to maize plants (Kumar *et al*., 2018). Among all these species, only half a dozen of them is having economic importance which damages and limits the productivity of the maize crop (Andow and Hilbeck, 2004). Among these insect pests, maize stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) is one of the serious insect pests of the maize crop and causes serious damage to the maize crop under favorable condition (Groote *et al*., 2011). Maize stem borer lays creamy white colour eggs, mainly oval in shape having 0.8 mm in length. The eggs are laid in clusters, one female lays up to 343 eggs (Ofomata *et al*., 2000). These eggs hatch in about 4-8 days. The larvae after hatching bore into the maize stem. Final instar larvae are 25-30 mm long having black spots on their body. Pupae are dark brown in colour having cylindrical shape. Size of male pupae is smaller than the pupae of the female. Pupation takes place inside the maize stem. The adult emerges after 5-12 days from pupae. Adults are pale brown in colour having 20-30 mm wingspan. The life span of maize stem borer adult is 5-8 days. Maize stem borer takes 30-40 days to complete its life cycle (Panchal and Kachole, 2013; Salim *et al*., 2016). Maize stem borer targets the leaf area for feeding and making tunnels inside the stem, as a result they block the nutrient supplying pathways and finally causing dead hearts and damage the plant. The damage is caused by larvae and maximum damage is caused by their 4th instar larva by consuming large amounts of food in short period of time (Yonow *et al*., 2017). The larvae make a small hole into the lower nodes of plant to get pass from one plant to another plant. Pupation takes place inside the stem of the host plant (Lella and Srivastav, 2013). As a result of the borer's infestation, dead hearts are produced that results in reduced translocation, ear damage, lodging, initial leaf senescence and in chronic condition, resulting in death of the host plant (Naz *et al*., 2003; Gupta *et al*., 2010).

To manage maize stem borer infestation, various control measures including cultural, physical, biological and chemical methods have been applied throughout the country for getting higher crops yield. Due to the quick action of insecticides against maize stem borer, the farmer community prefers to use these insecticides as compared to other control measures (Tende *et al*., 2010). Neonicotinoids are the new chemistry insecticides widely used worldwide against a large number of insect pests and are considered as a key component integrated pest management program. Besides, they don't require much labor work and are easy to use as compared to other chemicals (Zhang et al., 2016a; b) and are having long lasting effects. They are effective against many insect pests when used as seed dressers to crops like groundnut, cotton, and soyabean (Reisig et al., 2012; Zidan 2012; Nataraja et al., 2016; Salim *et al.*, 2023 a ; b). Seed dressers such as clothianidin and thiamethoxam are used for the control of different insect's pests in crops like barley, wheat, maize, sorghum, canola, and cotton. These insecticides are second generation neonicotinoids and their mode of action is stomach, contact, and systemic poison (Wilde *et al.*, 2001). The use of these insecticides as seed treatment in the maize crop and canola has given superior results against the major insect pests of concern to growers, like the maize stem borer, maize rootworm and European maize borer in maize crop and the flea beetle in canola (Hurley and Mitchell, 2014). Imidacloprid is another insecticide belonging to the chemical class of neonicotinoids which is systemic in nature and works against insect pest by blocking the microtinergic neural pathway of insects (Jemec *et al.*, 2007). Sucking insects are more effectively controlled by the imidacloprid due to their systemic nature up to 6 weeks (Kencharaddi, 2012; Kaleem *et al.*, 2022). Seed treatments are effective and are used in smaller amounts to control various in sect pests, including maize stemborer infestation in maize crops. Keeping in view the above facts, the current experiment was carried out to check the response of two verities integrated with three neonicotinoids used as seed dressers for the management of maize stem borer.

Materials and Methods

The research experiment was conducted at Agricultural Research Institute Tarnab during Kharif season, 2019. Maize seeds of two commonly cultivated varieties, namely Jalal and Iqbal were collected from CCRI (Cereal Crops Research Institute) Pirsabaq, District Nowshera and seed dressers namely imidacloprid, clothianidin and thiamethoxam were purchased from the local market at Peshawar.

Seed dressers application

Each seed dresser was applied to both maize varieties as per the recommended dose (5.00 g/cc per kg of maize seed). Each seed variety weighed 250g was put in a 500ml plastic pot already consisting of 250cc water and 1.25gm/cc of each seed dresser and were fully mixed through common plastic stirrer. For each variety and seed dresser, a separate plastic pot of the same size was used. Six plastic pots were used for three different seed dressers to mix with the two varieties separately. To avoid any poisonous effect of seed dressers, rubber gloves were used in the mixing of seed dressers (Ding *et al.*, 2018).

Field layout/land preparation

The experiment was laid out under RCBD having split plot arrangements with three replicates. Both the selected varieties of maize (Jalal and Iqbal) were sown in three rows in such a way that all sub plots in each replicate received both the varieties. There were three rows of Jalal and three rows of Iqbal with a row to row and plant to plant wise distance of 75cm and 20cm, respectively. All agronomic practices including fertilizers (NPK) application were equally done to the field from seed sowing to crop maturation.

Treatments application

After an overnight socking, both the maize seed varieties were put on six separate paper sheets for complete dryness. When the seed becomes ready for sowing, the field was fully prepared where all the standard agronomic practices were done.

Data recording

Data was recorded at weekly intervals on the basis of the number of infested plants, leaf injury and plant infestation. To check maize stem borer infestations, all plant parts in rows were checked thoroughly for damage produced by the maize stem borer in both the varieties. Plant height data of both the varieties were measured by selecting one plant from all rows in each treatment through measuring tape. Data regarding thousand grains weight was recorded by counting the actual number of 1000 grains from each plot at random and then was weighed with electronic balance. Biological and grain yield (kg/ha) was calculated as following formula (Ali *et al.*, 2014).

$$Yield\ kg/ha = \frac{Weight\ of\ grain\ in\ (kg)}{Net\ area\ harvested\ (m^2)} \times 10{,}000$$

Statistical analysis

The data taken in the field was subjected to ANOVA under RCBD split plot arrangements. Means were separated through LSD at 0.05% level of probability. Statistical software STATISTIX 8.1 was used for data analysis.

Results and Discussion

Efficacy of different seed dressers against maize stem borer infestation in selected maize varieties

The results regarding the efficacy of different seed dressers (Thiamethoxam, Imidacloprid, Clothianidin and Control) on the mean percent infestation of maize stem borer across two maize varieties (Jalal and Iqbal) over eight weeks is presented in Table 1. The results reveal that maize stem borer infestation recorded at weekly intervals showed significant differences among the various weeks ($P \leq 0.05$). A significantly lower mean percent infestation of maize stem borer (2.91%) was recorded during the 1st week of August, thereafter a gradual increase over time in the mean percent infestation of maize stem borer was observed and reach to the maximum (22.50%) during the 1st week of September and again a decline in the mean percent infestation was observed at the crop maturity stage.

Further, the data revealed that interaction between seed dressers and varieties was also significant. The results show that a significantly lower mean percent infestation of maize stem borer (5.00%) was recorded in maize variety Jalal treated with clothianidin, this was followed by plot of maize variety Jalal treated with Imidacloprid (7.08%) and Thiamethoxam with (11.25 %) infestation. A significantly higher infestation (32.91%) of maize stem borer was observed in the control plot of maize variety Iqbal. The results also showed that all seed treatments were found effective with no infestation from 1st week of August as compared to control (10.00%). The results further show that in maize variety Jalal, a reduced mean percent infestation was recorded in plots treated with clothianidin (6.67%), followed by Imidacloprid (13.33%) and thiamethoxam (26.67%) while in control (33.33%) during 6th week (10th September) respectively. Similarly, in maize variety Iqbal, also similar trend in the mean percent infestation of maize stem borer was observed with a reduced mean percent infestation in plots treated with clothianidin (12.00%), followed by imidacloprid (16.67%) and thiamethoxam (28.00%) while the control plot of maize variety Iqbal shows a higher mean percent infestation (34.67%) during 6th week after sowing (10th September). The results regarding the varietal response in Table 1 further show that maize variety Jalal exhibited a lower mean percent infestation of maize stem borer than the maize variety Iqbal in most weeks. Overall mean data show that minimum mean percent infestation was shown by maize variety Jalal (12.39%) as compared to maize variety Iqbal (17.92%). The present findings are in conformity with the work of Iqbal *et al*. (2017) who reported minimum maize stem borer infestation by imidacloprid and fipronil (1DAT = 27.78%, 27.78%) respectively. Our results are further in line with the work of Udikeri *et al*. (2007) who reported maximum seed cotton yield (11.23 q/ha) in plots treated with clothianidin 600 FS @ 9 ml/kg, followed by imidacloprid 70 WS @ 10 g/kg seeds with (10.53 q/ha) when used as a seed treatment. Our results further authenticate the finding of Khan *et al*. (2006) who reported that imidacloprid when used as a seed dresser was found effective against aphid density. Similar results were also reported by Mashwani *et al*. (2011)

Table 1: *Combine effect of different seed dressers and maize varieties against maize stem borer (%) infestation during 2019.*

Varieties (V)	Treatment (T)	Time Interval (Weeks)								VxT (Mean)
		2nd Aug Week 1	9th Aug Week 2	16th Aug Week3	23rd Aug Week 4	30th Aug Week 5	7th Sept Week 6	14th Sept Week 7	21st Sept Week 8	
Jalal	Thiamethoxam	0.00	3.33	10.00	13.33	13.33	26.67	16.67	10.00	11.25d
	Imidacloprid	0.00	0.00	0.00	6.67	6.67	13.33	16.67	6.67	7.08e
	Clothianidin	0.00	0.00	6.67	6.67	10.00	6.67	3.33	6.67	5.00f
	Control	10.00	16.67	28.00	30.33	31.70	33.33	30.00	20.00	26.25b
Iqbal	Thiamethoxam	3.33	6.67	16.67	16.67	23.33	28.00	14.33	13.33	16.67c
	Imidacloprid	0.00	3.33	6.67	16.67	10.00	16.67	13.33	10.00	9.58e
	Clothianidisn	0.00	0.00	3.33	8.07	9.50	10.30	12.00	13.33	12.50d
	Control	10.00	23.33	26.67	27.67	32.33	34.67	33.50	30.75	29.91a
Jalal		2.50g	5.00ef	11.67d	15.00c	16.67c	20.00 b	16.67c	12.50d	12.39b
Iqbal		3.33fg	8.33e	15.00c	20.00b	21.67a	25.00a	20.00b	17.50c	17.92a
Mean		2.91d	6.67cd	13.33bcd	17.50abc	19.17ab	22.50a	18.335ab	15.00bc	-

Means in the same row and columns followed by different letters are significantly different based on the confidence intervals of the differences between treatments using LSD test.

Table 2: *Effect of different seed dressers on plant height, biological yield, cob weight thousand grain weight and grain yield in maize varieties.*

Varieties	Treatments	Plant height(cm)	Biological yield(kg)	Cob weight(g)	1000 grain weight(g)	Grain yield(kg/ha)
Jalal	Thiamethoxam	170.67	2.23	81.00a	230.67a	2847.00a
	Imidacloprid	161	3.50	72.33b	224.33c	2784.00b
	Clothianidin	164.67	3.73	68.67c	227.33b	2807.00b
	Control	156.67	1.97	59.67e	222.00d	2713.00c
Iqbal	Thiamethoxam	152.67	1.87	71.00b	228.33b	2801.00b
	Imidacloprid	141.67	2.70	59.67e	224.00c	2769.70c
	Clothianidin	147	2.80	62.67d	225.00c	2726.00c
	Control	139.33	1.90	57.00f	219e	2501.00d
Jalal		163.25a	2.86a	70.42a	226.08a	2791.20 a
Iqbal		145.16b	2.32b	62.58 b	224.07b	2438.40 b

Means in the same row and columns followed by different letters are significantly different based on the confidence intervals of the differences between treatments using LSD test.

and Ishtiyaq *et al*. (2012) who evaluated different insecticides against maize stem borer, among all insecticides imidacloprid (seed dresser) was found effective against maize stem borer in early days of data recording.

Effect of different seed dressers on yield and yield components of selected maize varieties

The data regarding plant height for different varieties treated with different seed dressers showed non-significant differences among the treatments. The results in Table 2 show that maximum plant height (170.67 cm) was noted in maize variety Jalal treated with thiamethoxam, followed by plot treated with Clothianidin and Imidacloprid (164.67 and161.00 cm) respectively, while minimum plant height (156.67cm) was noted in control plot of maize variety Jalal. In the same way, the maximum plot height (152.67cm) for maize variety Iqbal was noted in plots treated with thiamethoxam, this was followed by plots treated with clothianidin and imidacloprid (147.00 and 141.67 cm) respectively, while minimum plant height (139.33 cm) was noted in control plot. The results in Table 2 further show that that the mean maximum plant height (163.25 cm) was noted for maize variety Jalal, while the lowest plant height (145.17 cm) was recorded for maize variety Iqbal.

The data regarding biological yield of selected maize varieties and treatments was found non-significant. The data in Table 2 further showed that the maximum biological yield (3.73 kg) was recorded with clothianidin in maize variety Jalal, this was followed by plot treated with imidacloprid and thiamethoxam with (3.50 and 2.23 kg) respectively. The control plot (maize variety Iqbal) resulted in minimum biological yield (1.90 kg). The overall mean data show that the higher biological yield (2.86 kg) was noted in maize variety Jalal as compared to maize variety Iqbal with minimum biological yield (2.32 kg).

The mean cob weight results in Table 2 were found significantly different for varieties and seed dressers. The results in Table 2 further reveal that a significantly higher mean cob weight (81.00 g) was recorded in maize variety Jalal treated with thiamethoxam, this was followed by plots treated with imidacloprid (72.33 g). In the same way, maximum mean cob weight in maize variety Iqbal was noted in plot treated thiamethoxam (71.00 g), while significantly lowest mean cob weight (57.00 g) was observed in control plot of Iqbal variety. Table 2 further reveals that significantly higher mean cob weight (70.40 g) was noted in maize variety Jalal as compared to Iqbal variety where (62.60 g) mean cob weight was recorded.

The data regarding thousand grains weight in Table 2 was found significant for different treatments ($P \leq 0.05$). Further data in Table 2 show that the significantly highest mean thousand grains weight was noted in Jalal and Iqbal varieties treated with thiamethoxam (230.67 g and 228.33 g) respectively, while a significantly lower mean thousand grain weight (219 g) was noted in control plot of Iqbal variety. The data further illustrates maize variety Jalal recorded significantly higher mean thousand grains weight (226.33 g) as compared to) maize variety Iqbal (224.33 g).

The data regarding grain yield was also found significantly different for the different treatment and maize varieties ($P\leq0.05$). The grain yield data in Table 2 show that a significantly higher grain yield (2847 kg/ha) was recorded in maize variety Jalal treated with thiamethoxam, this was followed by plots treated with imidacloprid and clothianidin (2807 kg/ha and 2784 kg/ha), while in maize variety Iqbal maximum grain yield (2801 kg/ha) was recorded following Thiamethoxam treatment a seed dresser. The results further show that in terms of varieties evaluation, significantly highest mean grain yield was recorded in maize variety Jalal (2791.20 kg/ha), as compere to the maize variety Iqbal (2438.40 kg/ha).

Ding *et al*. (2018) also reported that imidacloprid, thiamethoxam, and clothianidin when used as seed treatments were effective against early season pests like aphids, foliage feeding insects, i.e. corn borers, and underground pests, i.e., wireworms, white grubs, and black cutworms. Similarly, Nemade et al. (2007) tested different insecticides and found imidacloprid effective with minimum leaf injury rating 2.09 (20 DAS) and 2.41 (40 DAS), followed by endosulfan 3.10 (20 DAS) and 3.29 (40 DAS) leaf injury rating respectively. El-Naggar (2006) also reported that both imidacloprid and thiamethoxam were effective in controlling thrips population for up to 7 weeks after cultivation. Similar results were also documented by El-Seady (2009) who discovered that imidacloprid was found successful against jassids and whiteflies for 42 to 49 days after cotton cultivation. El-Dewy (2006) assessed different insecticides against whitefly and reported that imidacloprid as effective than thiamethoxam against sap sucking pests due to highly systemic especially through the root system. While due to quick action and long residual effect against thrips and immature stages of whitefly imidacloprid and thiamethoxam were found effective support our findings. Further Aioub *et al*. (2002) also reported that imidacloprid for at least 70 days suppress sap sucking insects (whitefly and thrips) in cotton crop. Our findings are further in conformity with those of Dhandapani *et al*. (2002); Salim *et al*. 2025 who discovered that imidacloprid was effective for up to 8 weeks to suppress sucking pest population after sowing in cotton crops i.e. thrips and jassid. Similarly, Mashwani *et al*. (2011) found imidacloprid as an effective insecticide that reduced *C. partellus* infestation by 97.3 percent. The present finding also correlates to the work of Sharma and Gautam (2010) who reported higher yield in plot treated with chemicals due to less infestation of maize stem borer as compared to the control plots with reduced yield by 27.9 percent due to higher infestation. Imidacloprid, thiamethoxam and acetamiprid as seed dressers and foliar spray against sucking insect pests in cotton and other crops has been tested and were found effective by many researchers (Dhawan and Simwat, 2002; Salim *et al*., 2024). Similarly, Altaf *et al*. (2016) tested four inoculum levels of *Bipolaris maydis* on three maize varieties (Iqbal, Azam, and Jalal) and found maize variety Jalal as the most resistant variety with mean disease severity of 2.00, followed by Iqbal with 2.86 disease variety Also, they recorded maximum mean yield (5569.8 kg/ha) for maize variety Jalal, followed by Iqbal variety (5301.3 kg/ha. Our results are also similar to the findings of Khan *et al*. (2017) who tested different varieties with minimum thousand grains weight was recorded in PS-3 (265 g), Iqbal (270 g), such as lower grain yield was recorded in Iqbal (4128 kg/ha) and PS-3 (4202 kg/ha). Among tested maize varieties, minimum plant height was recorded in Iqbal (196.3 cm) respectively. The results obtained by Ali *et al*. (2011) support the present findings as they reported that imidacloprid was highly effective against wheat aphid among all the tested systemic insecticides. Correspondingly, Joshi and Sharma (2009) evaluated different treatment concentration of imidacloprid against wheat aphids at 24 hours, 2-, 7- and 14-days post spray interval. Imidacloprid treatment was found most effective against wheat aphids @ 400 ml/ha. Earlier it has been reported by Das (2013) who tested different insecticides concentration of imidacloprid against aphid *Myzus persicae,* spray effect was monitored after 24 hours to 10 days, after 24 hours of spray good knock down effect was observed. The present study revealed that both imidacloprid and clothianidin proved the best seed dressers in maize variety Iqbal and hence can be used in the IPM of maize stem borer.

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Novelty Statement

This study highlights the efficacy of new chemistry insecticides viz imidacloprid, thiamethoxam, clothianidin as seed dressers on two maize varieties (Jalal and Iqbal) against maize stem borer infestation. The results revealed that both imidacloprid and clothianidin proved the best seed dressers in maize variety Iqbal and hence can be used in the IPM of maize stem borer.

Author's Contribution

Muhammad Salim, **Ahmad-Ur-Rahman Saljoqi:** Conceptualization, methodology, formal analysis, investigation, writing.
Ali Qadar: Conceptualization, writing, data collection.
Amjad Usman, **Shahid Sattar Khan**, **Shah Alam Khan**, **Haroon Khan**, **Bashir Ahmad:** Formal analysis, methodology, and editing.
Ayhan Gokce: Conceptualization, writing, and editing.

Conflict of interest
The authors have declared no conflict of interest.

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