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The effect of seed treatment of some grain sorghum genotypes with pesticides on *Spodoptera frugiperda* infestation, grain yield and grain yield components

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Abstract

The experiment was carried out in Shandaweel Agricultural Research Station, Sohag Governorate, in two successive seasons of 2022 and 2023 to study the effect of seed treatment of three sorghum genotypes with some insecticides, *i.e.*, Trigard, Gaucho, Match, and Fortenza on *S. frugiperda* infestation after 14, 21, 28, and 35 days after emergence (DAE). The results showed that fortenza treatment recorded the lowest mean number of infested plants. However, the control recorded the highest mean number of infested plants. Dorado variety was the most infested genotype by *S. frugiperda* followed significantly by Shandaweel-1 hybrid in both seasons. The data showed significant differences between seasons for plant height and pests. Also, highly significant differences were found between seed treatments and among genotypes for all the studied traits. The first shortest period till days to 50 % flowering was obtained by application of Fortenza to the sorghum genotypes under study. Untreated seed (control) shortens plant height significantly. Sorghum genotype H-306 surpassed the other sorghum genotypes under study in plant height (195.00 and 198.33 cm) in 2022 and 2023 seasons respectively, with significantly affect. Untreated seeds (control) reduce the 1000 grain weight significantly. H-306 recorded the least loss of yield compared with the other genotypes. No. of Pests /Plant had negative and highly significant correlation with plant height, 1000-grain weight and grain yield/plant. But, No. of Pests /Plant had positive and highly significant correlation with Days to 50% flowering.

Keywords: Sorghum, *Spodoptera frugiperda*, seed treatment, genotypes, yield components and correlation coefficient.

INTRODUCTION

Grain Sorghum (*Sorghum bicolor* (L.) Moench) is commonly grown in arid and semi-arid regions around the world. (Youssef, 2013). Sorghum is one of the important food crops in the world. It is cultivated in many parts of Asia and Africa, where its grains are used to make flat breads that form the staple food of many cultures. Sorghum ranks fifth among cereal crops after wheat, rice, maize, and barley in terms of production and use. In Egypt, sorghum crop is the fourth cereal crop after wheat, corn, and rice. In 2018 the grown area of sorghum was about 42 million hectares yielded about 6.18 million metric ton grains in the world (FAO, 2023). The cultivated area of sorghum in Egypt about 360000 feddan, produce an average of 16.5 ardeb/feddan (5.5 Tons per hectare) (Mourad *et al.,* 2022). Some agricultural measures, such as host resistance varieties, cultivation dates, and others have taken into account the impact of insect pest infestation on many important crops (Dent, 1991). Suhail *et al.,* (2000) reported that treating corn seeds with insecticides before Planting protects seeds from soil pests and early season infestations on seedlings for a period of plant life depending on the pesticides used on seed treatment. Sorghum crop affected by a big number of insect pests one of these pests is the fall armyworm (FAW), *Spodoptera frugiperda* which was recorded for the first time in Egypt in 2019 on maize plants. Youssef, (2021) noticed *S. frugiperda* on sorghum plants in 2020 in Egypt at Sohag Governorate. The invasion and massive spread of *S. frugiperda* are real barriers to food security and livelihoods of millions of maize and sorghum growing communities in Sub-Saharan Africa and Sahel regions (Mohamed *et al.*, 2021). The use of pesticides by spraying to control the fall armyworm is the most effective method but, It leads to the drift of pesticides to undesirable places and is also diluted by rain, especially when spraying in inappropriate weather conditions (Zheng *et al.*, 2006; Ranabhat and Wang, 2020). The effectiveness of the pesticide is also affected by the behavior of the larva, as the larva tends to enter the whorl of the plant, which hinders the access of the pesticide to it (Muraro *et al.,* 2020). In addition, the excessive use of pesticides in the control of this pest in Africa, especially internationally banned pesticides, leads to the rapid emergence of resistance in addition to environmental pollution. It also increases costs and affects the health of farmers who do not have sufficient knowledge of the dangers of pesticides and it makes harmful impact on beneficial organisms (Odeyemi *et al.,* 2020). Also, spraying pesticides needs more labors, which increases the cost of the control. In general, treating the seed with pesticides reduces the amount of pesticides used compared to spraying pesticides and reduces the harmful effects of pesticides on the environment and beneficial organisms (Schemeer *et al.,* 1990; Nault *et al.*, 2004). (Triboni1 *et al.*, 2019) recommended seed treatment with pesticides as one of the means of integrated pest management, as it leads to reducing the use of pesticides and preserving the environment and beneficial organisms, as well as regulating the population density of many pests. Therefore, the aim of this study is to evaluate the effectiveness of some pesticides as seed treatment of some sorghum genotypes on (FAW). Also to evaluate the effect of the treatment of sorghum genotypes seeds with pesticides on the yield and its components, and to evaluate the phenotypic correlation between yield and its components.

MATERIALS AND METHODS

The experiment was conducted in 2022 and 2023 at Shandaweel Agricultural Research Station, Sohag Governorate, Egypt during two consecutive planting seasons. The genotypes used in the experiment, namely Dorado, Shandaweel 1 (Sh-1) and, Hybrid 306 (H-306), were obtained from the Sorghum Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt. The insecticides were obtained from the following companies: Match (Lufenuron 5%), Fortenza Duo (Cyantraniliprole 60%) and Trigard (cyromazine 75%), Syngenta; Gaucho® 600 (Imidacloprid), Bayer. The grains of the three genotypes were placed in plastic pots. Then, treated with Trigad, Gaucho, Match, and

Fortenza at the following rates: 20 g, 10 g, 10 cm^3, and 3 cm^3 per kg of seeds, respectively, mixed for minutes until completely homogeneous, and then left to dry in the open air. The seeds of the previously mentioned genotypes were sown during the fourth week of June in the 2022 and 2023 seasons after seed treatment with the mentioned insecticides and untreated seeds were sown as a control. It was planted in experimental plots of 1/100 feddan in three replicates. Each experimental plot consisted of 12 rows and a 60 cm distance between the rows at a rate of 2 seeds/ hill, the distance between the hills is 15 cm. All recommended agricultural procedures have been carried out except insecticides spraying. 20 plants were examined in each plot at 14, 21, 28, and 35 days after emergence (DAE) and the mean number of infested plants with FAW were recorded. Also, the following parameters were recorded: Days from sowing date to 50% flowering, plant height (cm.), 1000- grain weight (g), grain yield/plant (g) for the three genotypes treated with insecticides as well as without insecticides treatment. A split plot design with three replicates was used, the main plots were randomly arranged to the genotypes (H- 306, Sh-1 and Dorado) and five seed treatments (control, Trigard, Gaucho, Match, and Fortenza) were applied to the sub plots.

Statistical analysis:

Data were statistically analyzed according to Gomez and Gomez (1984), using the computer MSTAT-C statistical analysis package (Freed *et al.,* 1989).Duncan's Multiple Range Test (MRT) by Duncan, 1955 and the least significant difference (L.S.D) 0.05 were used for comparison between means of the treatments.

Phenotypic correlation:

Phenotypic correlation among studied traits were estimated according to Steel and Torrie (1980).

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \times \sum y^2}}$$

RESULTS AND DISCUSSIONS

The effect of seed treatment of three sorghum genotypes with some insecticides, *i.e.*, Trigard, Gaucho, Match, and Fortenza compared with untreated seeds (control) on *S. frugiperda* infestation after 14, 21, 28, and 35 DAE was studied in 2022 and 2023 seasons. In case of Dorado variety at season 2022 (Fig. 1), the number of infested plants with *S. frugiperda* at 14 DAE differed significantly between treatments. Control and Gaucho treatments recorded the highest mean number of infested plants. However, Fortenza treatment recorded the lowest mean number of infested plants with insignificant differences with Trigard and Match treatments. Also, significant differences between treatments were found at 21 DAE. The highest mean number of infested plants was recorded with control. However, the lowest mean number with recorded when seeds treated with Fortenza insecticide. After 28 DAE, the highest mean number of infested plants was recorded in control differed significantly than the other treatments. Fortenza treatment recorded the lowest mean number of infested plants. On the other hand, there were insignificant differences between Trigard, Gaucho, and Match treatments. After 35 DAE, significant differences between the treatments were recorded. The highest mean number of infested plants was recorded with untreated seeds (control) and seeds treated with Gaucho. However, the lowest mean number of infested plants was recorded when seeds treated with Fortenza and Trigard.

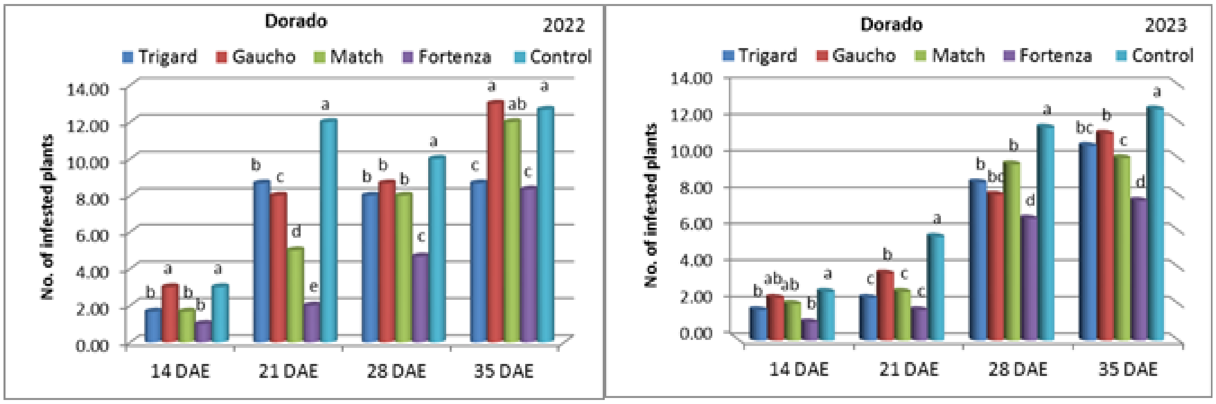

Fig. 1 Effect of seed treatment with insecticides on Dorado variety infestation by *S. frugiperda* after 14, 21, 28, and 35 DAE in season 2022 and 2023**.**

In case of Dorado variety at season 2023 (Fig. 1), there were a significant differences between treatments after 14 DAE. The highest mean number of infested plants was recorded with control. However, the lowest mean number was recorded when seeds treated with Fortenza with no significant differences with Trigard treatment. Also, there were significant differences between treatments after 21 DAE. The highest mean number of infested plants was recorded with control. However, the lowest mean number of infested plants was recorded when seeds treated with Fortenza with insignificant differences between Fortenza, Trigard, and Match treatments. After 28 DAE and 35 DAE the highest mean number of infested plants was recorded in control differed significantly about the other treatments. Fortenza treatment recorded the lowest mean number of infested plants. In case of Sh-1 hybrid at season 2022 (Fig. 2), there were a significant differences between untreated seeds (control) and other treatments in the mean number of infested plants with *S. frugiperda* at 14 DAE. Fortenza treatment recorded the lowest mean number of infested plants with insignificant differences between Fortenza and other three insecticides. At 21 DAE, there were significant differences between untreated seeds (control) and other treatments in the mean number of infested plants with *S. frugiperda.* The lowest mean number of plants infested with *S. frugiperda* was recorded when seeds treated with Fortenza followed by Match with no significant differences.

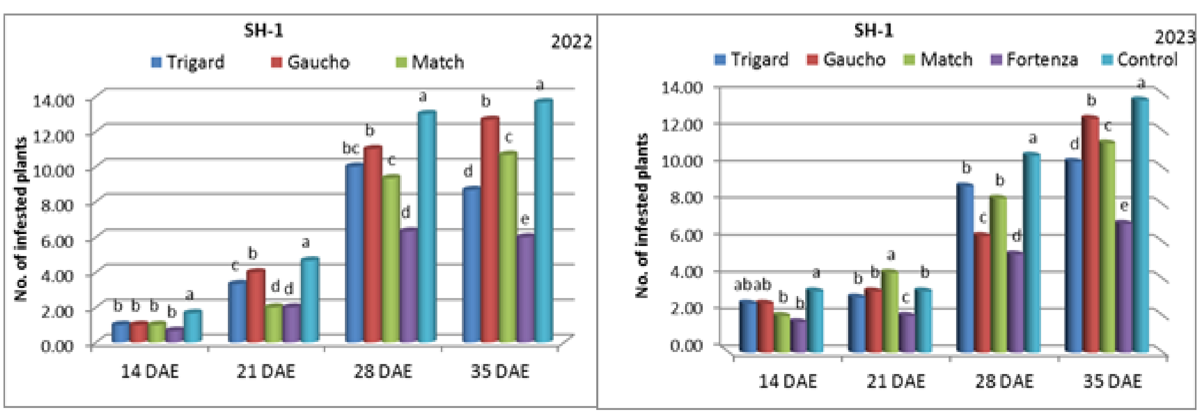

Fig. 2 Effect of seed treatment with insecticides on Sh-1 hybrid infestation by *S. frugiperda* after 14, 21, 28, and 35 DAE in season 2022 and 2023.

After 28 DAE, the control recorded the highest mean number of infested plants with *S. frugiperda* with significant differences between control and the other treatments. Seeds treated with Fortenza recorded the lowest mean number of infested plants. At 35 DAE, control and Gaucho treatments recorded the highest mean numbers of infested plants with no significant differences between each other. Seeds treated with Fortenza recorded the lowest mean number of infested plants with significant differences between Fortenza and the other treatments.In case of Sh-1 at season 2023 (Fig. 2), there were a significant differences between untreated seeds (control) and other treatments in the mean number of infested plants with *S. frugiperda* at 14 DAE. Fortenza treatment recorded the lowest mean number of infested plants with insignificant differences between Fortenza and Match treatments. At 21 DAE, the highest mean number of infested plants with *S. frugiperda* was recorded with Match treatment. The lowest mean number of infested plants was recorded when seeds treated with Fortenza. The highest mean number of infested plants with *S. frugiperda* at 35 DAE was recorded with untreated seeds (control) with significant differences between control and other treatments. Seeds treated with Fortenza recorded the lowest mean number of infested plants. At 35 DAE the highest mean number of infested plants was recorded with the control and the lowest mean number of infested plant was recorded when seeds treated with Fortenza with a significant differences between Fortenza and other treatments. In case of H-306 hybrid at season 2022 (Fig. 3), a significant differences were found between the treatments in the mean number of infested plants by *S. frugiperda* at 14 DAE. The highest mean number of infested plants was recorded in the control followed by Trigard with insignificant differences between each other. The lowest mean number of infested plants was recorded when seeds treated with Fortenza followed by Match. While after 21 DAE, the control recorded the highest mean number of infested plants differed significantly with the other treatments. Trigard, Gaucho, and Match recorded average infestation with no significant differences between each other. Fortenza was the most effective insecticide with average number of infested plants, significantly lower than the other treatments.

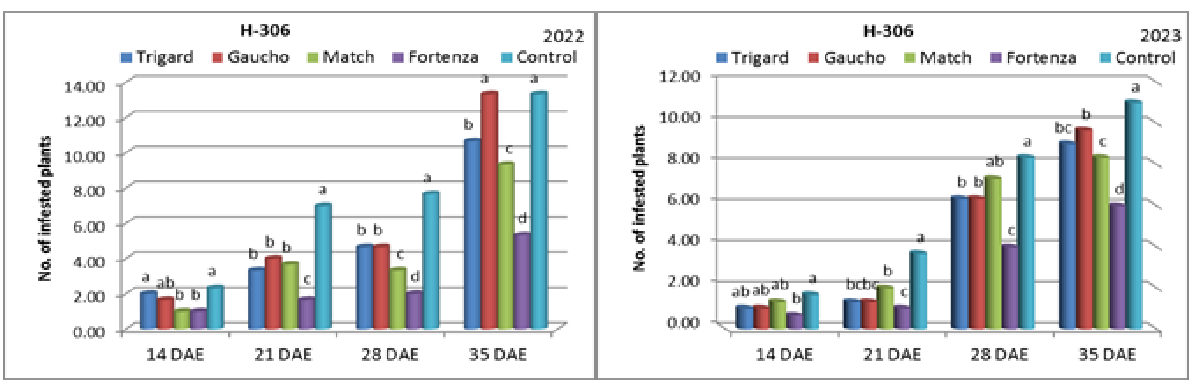

Fig. 3 Effect of seed treatment with insecticides on H-306 hybrid infestation by *S. frugiperda* after 14, 21, 28, and 35 DAE in season 2022 and 2023.

The highest mean number of infested plants by *S. frugiperda* at 28 DAE was recorded in control. However, the lowest mean number of infested plants was recorded when seeds treated with Fortenza. Trigard and Gaucho were in-between with no significant differences between each other. After 35 DAE the highest mean number of infested plants by *S. frugiperda* was recorded with control and Gaucho treatment and no significant differences was recorded between each other. Fortenza recorded the lowest mean number of infested plants with significant differences between Fortenza and the other treatments. In case of H-306 hybrid at season 2023 (Fig. 3), the highest mean number of infested plants by *S. frugiperda* after 14 DAE was recorded in the control. The lowest mean number of infested plants was recorded when seeds treated with Fortenza. Trigard, Gaucho, and Match were in-between with no significant between the three treatments. There were a significant differences between the treatments in the mean number of infested plants by *S. frugiperda* at 21 DAE. The highest mean number of infested plants was recorded with untreated seeds (control). However, the lowest mean number of infested plants was recorded when seeds treated with Fortenza. After 28 DAE, there were significant differences between the treatments. The control recorded the highest mean number of infested plants. However, Fortenza treatment recorded the lowest mean number of infested plants by *S. frugiperda*. Trigard and Gaucho were in-between and no significant differences were found between the two treatments. Also, there were significant differences between the treatments after 35 DAE in the mean number of infested plants by *S. frugiperda*. The control recorded the highest mean number of infested plants. Comes after that Trigard followed by Gaucho and Match. However, Fortenza treatment recorded the lowest mean number of infested plants. Our results in agreement with Triboni *et al.*, 2019, who illustrated that pesticides from the diamide group (chlorantraniliprole and cyantraniliprole) have a high effect as a seed treatment on *S. frugiperda*, reducing the damage of the pest. Seed treatment is considered a successful alternative to traditional methods of controlling the pest in the early stages of the plant, when the behavior of the insect is to cut off the seedlings and when feeding on the leaves. Dobariya and Sisodiya, (2022) studied the effect of some insecticides as seed treatment on maize against *S. frugiperda*. They demonstrated that cyantraniliprole 19.8+ thiamethoxam 19.8 FS was the most effective treatment in reducing *S. frugiperda* numbers, recording the lowest percentage of damaged plants. Also, cyantraniliprole 19.8+ thiamethoxam 19.8 FS treatment recorded the highest yield. Oliveira *et al.*, 2022 stated that *S. frugiperda*, in the early stages of the plant, can feed on different parts of plant such as the stem and leaf whorl, using systemic pesticides as seed treatment can reduce armyworm damage. Behera and Muralimohan, (2024) stated that the effect of cyantraniliprole and chlorantraniliprole as a seed treatment against *S. frugiperda* on maize continued about a month after planting. The effect of sorghum genotypes on *S. frugiperda* infestation in season 2022 and 2023 (Fig. 3). Dorado variety was the most infested genotype by *S. frugiperda* followed significantly by Sh-1 hybrid in both seasons. H-306 hybrid was least infested genotype by *S. frugiperda*.in both seasons. Oliveira *et al.*, 2019 evaluated the feeding preference of fall army worm to some sorghum genotypes. They demonstrated that the Agromen 50A40 genotype was least preferred genotype for S. *frugiperda* between the tested sorghum genotypes.

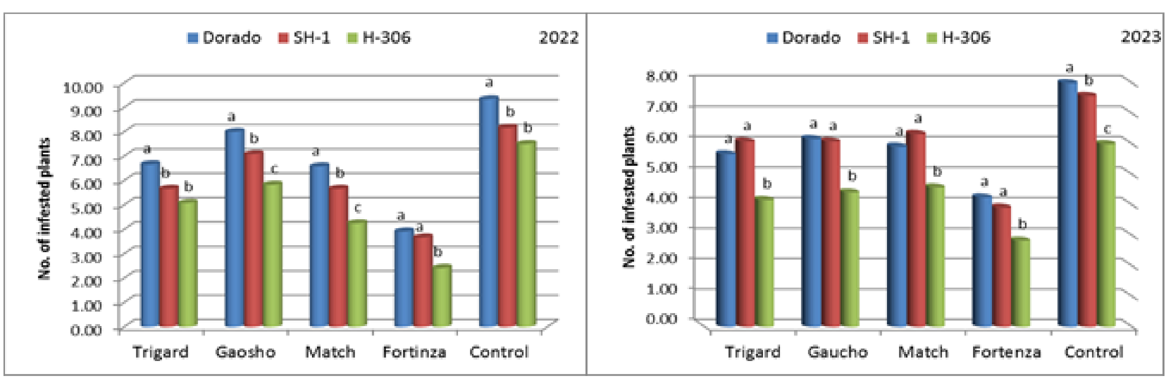

Fig. 4 The effect of sorghum genotypes on *S. frugiperda* infestation with seed treatment and without (control) in season 2022 and 2023.

Analysis of Variance

The combined analysis of variance across the two seasons is presented in Table (1). The data showed significant differences between seasons for plant height and pests reflecting the sensitivity of genotypes to fluctuation of climatic factors. Also, highly significant differences were found between seed treatments and among genotypes for all the studied traits. But, the interaction between years × seed treatments showed significance for only pests. Moreover, the interactions between genotypes × seed treatments were highly significant for all the studied traits indicating that genotypes responded differently to the quantity of treatments applied.

Table 1. Mean squares values of combined analysis across two seasons and five levels of treatments for studied traits.

SOV	D.f.	Days to 50% flowering	Plant height	1000 grain weight	Grain yield per plant	No. of infested plants
Years (Y)	1	10.68	124.84**	1.93	17.42	6.27**
REP./Y(Ea)	4	4.79	23.78	2.09	8.85	0.08
Treatments (T)	4	181.21**	4332.89**	428.91**	5131.09**	42.62**
Y×T	4	3.10	14.51	3.65	4.80	2.66**
Error (b)	16	4.03	10.96	2.13	4.94	0.61
Genotypes (G)	2	144.63**	20305.08**	377.34**	5567.37**	24.81**
G × Y	2	44.81**	305.41**	35.60**	180.32**	1.35**
G×T	8	19.31**	267.40**	33.76**	191.24**	0.14*
G×Y×T	8	2.85	5.62	8.03**	8.51*	0.23**
Error	40	1.36	22.09	1.96	3.77	0.06

*, ** significant at 0.5 and 0.01 probability levels, respectively.

Also, the interactions between years × treatments × genotypes were highly significant for 1000 grain weight, grain yield per plant and pests.

Days to 50% flowering

From (Table 2 and 3), it could be seen that the difference between genotypes (Dorado, Sh-1 and H-306) was significant on the days to 50% flowering under five seed treatments. While the differences between the five seed treatments (Control, Trigard, Gaucho, Match and Fortenza) were significant, whereas, the control delayed plant flowering significantly as a result of the harmful effect of the fall armyworm, it causes a prolonged season for sorghum plants. Sorghum infestation by *S. frugiperda* can reduce plant height, delay plant maturity, and increase the number of tillers and panicles per plant (McMillian and Starks 1967, Starks and Burton, 1979). It is clear from (Table 2 and 3) that the first shortest time for the days to 50 % flowering was obtained by application of Fortenza to the sorghum genotypes under study. In the first season the shortest times (67.00 and 67.33 days) were obtained by application of Fortenza to sorghum hybrids Sh-1 and H-306, respectively. Whereas, the second season the shortest times (64.67 days) were obtained by application of Fortenza to sorghum hybrid H-306. Seed treatment (Fortenza) provided protection for sorghum plants for the first 25 days from the beginning of planting. Buntin, 2012, showed that seed dressing with systemic pesticides, such as Gaucho™ and Cruiser™, can give protection to the plants tell 25 days after planting. Also, It is clear from the combined data in (table 2 and 3) that the first, second, third, fourth and five shortest time for the days to 50 % flowering were obtained by application of Fortenza , Trigard, Match, Gaucho, and Control treatments respectively, to the sorghum genotypes under two seasons study.

Table 2. Effect of seed dressing with insecticides on Days to 50% flowering, plant height, 1000 grain weight and Grain yield/plant for three Sorghum genotypes during 2022 season.

Var (A)	Treatments (B)					Mean
	Control	Trigard	Gaucho	Match	Fortenza	
Days to 50% Flowering						
Dorado	78.67	71.33	76.67	71.00	68.00	73.13
Sh-1	74.67	68.33	72.67	69.00	67.00	70.33
H-306	73.33	70.00	70.33	72.67	67.33	70.73
Mean	75.56	69.89	73.22	70.89	67.44	71.40
$LSD_{0.05}$ for A	**0.48**					
$LSD_{0.05}$ for B	**1.62**					
$LSD_{0.05}$ for AB	**2.81**					
Plant Height						
Dorado	105.00	132.67	117.67	130.67	134.67	124.14
Sh-1	135.00	162.67	150.33	151.67	174.00	154.73
H-306	145.00	178.00	173.67	155.00	195.00	169.33
Mean	128.33	157.78	147.22	145.78	167.89	149.40
$LSD_{0.05}$ for A	**6.24**					
$LSD_{0.05}$ for B	**3.93**					
$LSD_{0.05}$ for AB	**6.81**					
1000 Grain Weight						
Dorado	8.50	20.27	12.93	20.70	23.20	19.28
Sh-1	16.50	25.77	20.13	25.40	28.37	24.92
H-306	18.83	27.07	24.47	21.70	30.37	25.90
Mean	14.61	17.67	26.42	22.30	27.31	29.37
$LSD_{0.05}$ for A	**1.80**					
$LSD_{0.05}$ for B	**1.48**					
$LSD_{0.05}$ for AB	**2.57**					
Grain Yield/Plant						
Dorado	20.97	61.80	41.50	57.27	68.27	49.96
Sh-1	31.27	76.67	71.23	75.03	83.80	67.60
H-306	61.50	88.37	72.57	82.33	93.50	79.65
Mean	37.91	75.61	61.77	71.543	81.86	65.74
$LSD_{0.05}$ for A	**1.46**					
$LSD_{0.05}$ for B	**1.92**					
$LSD_{0.05}$ for AB	**3.33**					

Plant height (cm.)

It might be seen that the difference between genotypes (Dorado, Sh-1 and H-306) was significant on the plant height cm under four seed treatments and control. While the differences between the five treatments (Control, Trigard, Gaucho, Match and Fortenza) were significant, whereas, the control shortens plant height significantly as a result of the damaging effect of the fall armyworm.

Table 3. Effect of seed dressing with insecticides on Days to 50% flowering, plant height, 1000 grain weight and Grain yield/plant for three Sorghum genotypes during 2023 season.

Var (A)	Treatments (B)					Mean
	Control	Trigard	Gaucho	Match	Fortenza	
Days to 50% Flowering						
Dorado	81.33	72.67	79.33	73.00	70.00	75.27
Sh-1	75.67	71.00	71.67	74.00	68.67	72.20
H-306	72.00	67.00	68.67	72.00	64.67	68.87
Mean	76.33	70.22	73.22	73.00	67.78	72.11
$LSD_{0.05}$ for A	**0.73**					
$LSD_{0.05}$ for B	**1.39**					
$LSD_{0.05}$ for AB	**2.41**					
Plant Height						
Dorado	93.67	127.00	109.67	121.33	130.00	116.33
Sh-1	130.00	159.33	146.33	148.33	170.00	150.80
H-306	145.00	184.67	179.33	162.67	198.33	174.00
Mean	122.89	157.00	145.11	144.11	166.11	147.04
$LSD_{0.05}$ for A	**7.12**					
$LSD_{0.05}$ for B	**3.54**					
$LSD_{0.05}$ for AB	**6.13**					
1000 Grain Weight						
Dorado	7.50	22.27	15.13	23.57	26.13	18.92
Sh-1	15.67	22.93	22.13	18.57	25.67	20.99
H-306	20.30	28.20	25.27	23.33	31.30	25.68
Mean	14.49	24.47	20.84	21.82	27.70	21.86
$LSD_{0.05}$ for A	**1.46**					
$LSD_{0.05}$ for B	**1.19**					
$LSD_{0.05}$ for AB	**2.06**					
Grain Yield/Plant						
Dorado	25.67	66.67	52.43	60.80	73.20	55.75
Sh-1	28.87	74.40	66.00	69.17	79.50	63.59
H-306	63.93	86.10	73.63	83.93	94.97	80.51
Mean	39.49	75.72	64.02	71.30	82.56	66.62
$LSD_{0.05}$ for A	**2.08**					
$LSD_{0.05}$ for B	**2.09**					
$LSD_{0.05}$ for AB	**3.62**					

It was observed from (Table 2 and 3) that sorghum genotype H-306 surpassed sorghum genotypes under study (195.00 and 198.33 cm) in 2022 and 2023 seasons respectively, with significantly affect. This may be due to some genetic factors. Concerning the effect of seed treatments, the obtained results in (Table 2 and 3) showed that (Trigard, Gaucho, Match and Fortenza) treatments respectively, obtained taller plants than those obtained from control in the two studied seasons. The positive effect of seed treatments may be due to decrease the damaging influence of fall armyworm infestation, similar results obtained by Chamberlin and All, 1991 they concluded that Control of fall armyworm and corn earworm with chlorpyrifos increased yield in the second planting 106% relative to nontreated plots. Fall armyworm control with methomyl increased plant height 6.8% in the second planting relative to nontreated plots. Yield losses were significantly correlated with corn earworm density in the first planting and fall armyworm damage in the second. Fall armyworm injury in sorghum can reduce plant height, delay plant maturity, and increase the number of tillers and panicles per plant (McMillian and Starks, 1967; Starks and Burton, 1979).

1000 Grain weight (g.)

It may perhaps be seen that the difference between genotypes (Dorado, Sh-1 and H-306) was significant on the days to 1000 grain weight g under five seed treatments. While the differences between the five seed treatments (Without, Trigard, Gaucho, Match and Fortenza) were significant, whereas, untreated seeds (control) reduce the 1000 grain weight g significantly as a result of the harmful effect of the fall armyworm. Statistical analysis in (Table 2 and 3) showed that the effects of sorghum genotypes under study on 1000- grain weight were significant in both 2022 and 2023 seasons. Results revealed also that application of seed treatments increased 1000 grain weight. The highest values of 1000- grain weight were obtained at Fortenza treatment (30.37 and 31.30g.) in 2022 and 2023 seasons, respectively. On other hand, the lowest values of 1000- grain weight were obtained at without treatment (8.50 and 7.50 g) in 2022 and 2023 seasons, respectively. Fall armyworm infestations in the whorl stage (from five leaves to boot stage) can reduce grain yields of susceptible sorghum lines by 55–80% (Andrews, 1988). The combined data clear that the first, the second, third , fourth and the fifth treatments that had the more effect on the 1000-grain weight were, Fortenza, Gaucho, Match, Trigard and without respectively, under two studied seasons.

Grain yield/plant (g.)

It could be seen that the difference between genotypes (Dorado, Sh-1 and H-306) on the grain yield g (Control, Trigard, Gaucho, Match and Fortenza) were significant ,whereas, application of without seed treatments decrease grain yield g significantly as a result of the harmful effect of the fall armyworm. Buntin, 2012 found that fall armyworm; *S. frugiperda* is the most common caterpillar feeding in the whorls of sorghum. Results presented in (Table 2 and 3) revealed that sorghum hybrid 306 had a more pronounced and positive effect on grain yield as compared by sorghum hybrid Sh-1 and Dorado with values 93.50, 83.80, and 68.27 g/plant under Fortenza treatment in 2022 season, the same trend was found in 2023 season with values 94.97, 79.50, and 73.20 g/plan under Fortenza treatment. The combined data, also, showed that application of Fortenza, Trigard, Match and Gaucho obtained higher grain yield more than those obtained by control in 2022 and 2023 seasons, respectively. These results were in harmony with Utono and Adamu, (2023) they found that Fall Armyworm, *S. frugiperda* infestation in Nigeria has reduced the yield of maize by over 40%, especially when pest control operations are not carried out appropriately. The larvae's feeding behavior inside the leaf whorl, which makes it hidden, making it difficult to control it with pesticides. This requires an increase in the volume of the spray solution, which increases the exposure of the larva to the pesticide. This increases the selection pressure, which increases the insect’s resistance to the pesticide. Therefore, we resorted to one of the new strategies to combat the pest, which is treating the seed with pesticides, followed by foliar spraying with pesticides. Treatment with imidacloprid or thiamethoxam as a seed treatment, followed by spraying with Ampligo pesticide 4 weeks after planting, resulted in the lowest number of larvae and the highest yield as the yield increased by 15% in comparison with the untreated. Saxena *et al.,* 2023 found that the highest germination rate (94.93%), maximum grain yield (23.67q-ha-1), and most avoidable loss (64.93%) were observed by the seed treatment with Thiamethoxam + Cyantraniliprole. Seed treated with Thiamethoxam 30 FS, Fipronil 5 SC and Chlorantraniliprole 18.5 SC also recorded better germination and yield compare to control. Worku *et al.,* (2024) studied the effect of insecticides on *S. frugiperda* infestation on sorghum. They illustrated that using insecticides reduced the number of larvae and effected positively on the grain yield. The three genotypes (H-306, Sh-1 and Dorado) were significant different in the untreated plots (control). H-306 recorded the least loss of yield compared with the other genotypes. So, H-306 was more tolerant to fall armyworm infestation than the genotypes Sh-1 and Dorado, that may returns two the fact that Dorado variety is one of the parents of the genotype SH-1.

Table 4. Phenotypic correlation coefficients among five studied traits for all genotypes across two seasons under five pesticide applications.

Genotype	No. of Pests /Plant	Plant Height	1000 Grain Weight	Days to 50% Flowering
Plant Height	-0.73**			
1000 Grain Weight	-0.85**	0.83**		
Days to 50% Flowering	0.76**	-0.79**	-0.89**	
Grain Yield/Plant	-0.86**	0.83**	0.90**	-0.78**

*, ** significant at 0.5 and 0.01 probability levels, respectively

Phenotypic correlation coefficients among the five studied traits for all genotypes across two seasons in Table 4. Results indicated that No. of Pests /Plant had negative and highly significant correlation with plant height, 1000-grain weight and grain yield/plant. But, No. of Pests /Plant had positive and highly significant ($P \leq 0.01$) correlation with Days to 50% flowering. Plant height had positive and highly significant correlation with each of 1000-grain weight/plant and grain yield/plant. However, it had negative and highly significant correlation with Days to 50% flowering. Moreover, 1000 grain weight had positive and highly significant ($P \leq 0.01$) correlation with Grain Yield/plant. Then again, 1000 Grain weight had negative and highly significant correlation with Days to 50% flowering. Finally, the correlation between grain yield/plant with each of plant height, 1000-grain weight/plant was positive and highly significant. On the other hand, it had Negative and highly significant correlation with No. of Pests /Plant and Days to 50% flowering. El-Sagheer *et al.,* 2020 found that the correlation between grain yield/plant with each of plant height, 1000-grain weigh/plant was positive and highly significant.

CONCLUSION

In conclusion, this study revealed that the grain sorghum genotype H-306 recorded the least loss of yield compared with the other genotypes. Dorado variety was the most infested genotype by *S. frugiperda.* Also applying the insecticide fortenza seed treatment before planting recorded the lowest mean number of infested plants. Pesticides from the diamide group (Cyantraniliprole 60%) could have a high effect as a seed treatment on reducing the damage of the fall armyworm pest. Seed treatment could be considered a successful alternative of the traditional methods of controlling the pest in the early vegetative stages of sorghum plant, when the behavior of the insect is to cut off the seedlings and when feeding on the leaves.

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