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ORIGINAL PAPER

Effect of Harvest Time and Insect Control as Agriculture Practices on Maize Ear Rot Disease and Kernels Contamination by Some Mycotoxins

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ABSTRACT

Under field conditions, reaction of maize (*Zea mays*) genotypes against ear and kernels rot disease was studied under natural infection at two different harvest time and insect control at Sakha Agricultural Research Station, Egypt, seasons 2019 and 2020. In the field, split-plot design with three replicates was applied, maize hybrids were allocated in main plots, harvest time and insect control were assigned in sub plots. Results concluded that, hybrids of TWC353, SCs176 and 131 showed the highest mean ears rot infection and contamination with fumonisin (FB1) and aflatoxins, as well as the lowest yield weight. In reverse to, SCs10, 128 and 130 hybrids, they recorded the lowest response to disease infection and toxin contamination beside they gave the highest yield. Moreover, interaction between harvest time showed that, insect control by Pestban insecticide with normal harvest followed by early harvest led to yield enhancement and caused reduction on ear rot disease and its severity, FB1 and aflatoxins accumulation compared to normal harvest without controlling insects. Concerning of interaction between maize genotypes and insect control with normal harvest, it was found a reduction in grains contamination by toxins in most tested maize hybrids as a result to reduction of ear rot disease which affected by controlling of insect injury by Pestban insecticide, followed by interaction between early harvest and maize hybrids.

Key words: Maize, *Zea mays*, Ear rot disease, *Fusarium*, *Aspergillus*, mycotoxins, harvest time, insects.

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INTRODUCTION

Ear rot caused by *Fusarium verticillioides*, (Sacc.) Nirenberg (syn. *Fusarium moniliforme* J. Sheldon, Fusarium section *Liseola*), the anamorph of *Gibberella moniliformis* Wineland, is one of the most common diseases of maize, causing yield and quality reductions and contamination of grain by fumonisin and other mycotoxins, which are harmful to humans and animals (Morales *et al.*, 2019 and Parsons and Munkvold, 2012). This disease is the most imperative disease disturbing on maize crop inEgypt, which can affect yield fatalities up to 48% of the total production which caused by fungi *F. verticillioides*, *Aspergillus flavus, and A. niger* (Vigier *et al.*, 2001).

Application of agronomic suitable practices is a tool for modulating the effect of environmental conditions conductive for minimizing of fungal infection and risks of contamination by fumonisin accumulation in maize grains (Jouany, 2007 and Blandino *et al.*, 2009). An appropriate maize harvest dates may help in avoiding adverse conditions during critical periods, flowering and kernel drying earlier one presents lower fumonisin contamination by reducing the time that its accumulated in the field (Torelli *et al*., 2012 and Cao *et al.*, 2014). Early harvest has been advocated as means of reducing the incidence of seed borne pathogens of *F. moniliforme* and *Aspergillus sp*. and consequently reducing the levels of toxin production (Owolade *et al.*, 2005). Although, high infection by *F. verticillioides* leading to heavy levels mycotoxin contamination can be prevented by applying effective agriculture management practices in maize production (Ferrigo *et al.* 2016). Oldenburg *et al.* (2017) stated to keep maize from Fusarium toxin contamination, it should be harvested at the appropriate maturity stage. Good agriculture practices of resistant hybrids, insect control and harvesting time are needed to be considered (Blandino *et al.*, 2009 and Mohseni *et al.*, 2016). High level of visible ear rot and toxin of FB1 are consistently with late planting (Parsons and Munkvold, 2012). Mitigate abiotic stressors by good agricultural practices can decrease mycotoxin contamination, (Dohlan, 2003 and Jacobsen, 2014).

Many insects have been associated with fungal diseases frequently, visible mycelium grows around and from kernel wounds produced by insects, since their activity dispersed the fungus and provides routes of entry into ear and kernels (Dowd 1998 and Fandohan *et al.*, 2003). Additionally, pests of European corn borer (ECB) *Ostrinia nubilalis* and Mediterranean corn borer (MCB) *Sesamia nonagrioides* of maize have directly related with fumonisin accumulation (Blandino *et al.*, 2008 and Mazzoni *et al*., 2011) and nature ear damage by MCB is the most influential factor fumonisin contamination affecting in evaluation (Cao *et al.*, 2014). Resistant maize genotypes to ear damage could contribute to reduce fumonisin contamination in kernels than damage by borers (Santiago *et al.*, 2013). Ears damaged by caterpillars of ECB *Ostrinia nubilalis* and corn ear worm *Helicoverpa zea*, routinely exhibit higher levels of Fusarium ear rot and fumonisin concentrations compared to less damaged ears (Munkvold *et al.*, 1999; Sobek and Munkvold 1999; Dowd 2000 and Clements *et al.* 2003). Parsons and Munkvold (2010) showed that, insect activity was significantly correlated with disease severity and FB1 levels contamination, and the correlations were strongest for thrips, resistant hybrids and the insecticide-treated plots consistently had lower Fusarium ear rot severity and F B1 contamination. Insecticide treatments proposed to reduce fungal infection and fumonisin accumulation (Arino *et al.*, 2009 and Blandino *et al.*, 2008 and 2009). Exposed silks and insect-damaged kernels are the primary local infection sites upon which airborne *F. verticillioides* microconidia may land, germinate, colonize, (Munkvold, 2003). Insects provide entry for the fungus, distributing fungal propagules as they feed and create wounds for infection by microconidia or mycelia already on the ear tissues (Dowd, 1998 and Avantaggiato *et al.*, 2002) and serve as vector and create wounds that led to infection by *F. verticillioides* (Munkvold, 2003). However, in case of pest attack setting wounds by ECB larvae, risk for infection and toxin of Fusarium increased endangering quality of maize (Oldenburg *et al*, 2017). Insect controls reinforce the importance in management of FBs in maize (Munkvold *et al.*, 1999). Parsons and Munkvold (2012) stated majority of FB1 contamination and correlation with visible rot symptoms with high FBI can be found in visibly maize molded kernels. Madege *et al*. (2018 a,b) showed that, application of insecticide at anthesis and early harvesting (at physiological maturity) reduced significantly insect injury, fusarium ear rot and fumonisin contamination than harvested at later dates. Unfortunately, pre-harvest attacks by insects and fungal pathogens causes up to 40% of maize yield lost (Meissle *et al*., 2010).

This study aimed to investigate effect of different practices *i.e.,* harvest times and insects control or not on ears rot disease and contamination by fumonisin B1 on aflatoxins and yield of maize hybrids grains.

MATERIALS AND METHDOS

1- Field experiment:

Two field trails were carried out at the experimental farm of Sakha Agric. Res. Station farm during the 2019 and 2020 growing seasons.

The field experiments were executed in split-plot design with three replicates. The main-plots were dispersed to 13 maize hybrids (H), *i.e.,* single crosses (SC) *viz*. 10, 128, 130, 131, 162, 167, 168, 176 and three way crosses (TWC), *viz.* 321, 324, 352,353, 368. The sub-plots were allocated to three agricultural practice as follows: the first was early harvest date at 105 days from planting (d1) after complete physiological maturity and the second was normal harvest at 125 days as a comparison treatment (d2) without control of stem borers and ear worms insects in both above dates. The third was normal harvest at 125 days with insect protection (I) as follows: insecticides of Pestban, 48% EC. [Chloropyrifos (O, O-diethyl-O -3, 5 -6-trichlor -2-pyridyl phosphorothioate)]at recommended dose of 1 L / fed plus 200 cm of Match, were used to control insect injuries incited by European corn borer (*Ostrinia nubilalis*), Mediterranean corn borer (*Sesamiano nagrioides*) and corn ear worm (*Helicoverpa zea*). Plots receiving the insecticide application were sprayed three times. The first application was done at 50% of plants had silks (at 55 days from planting) and 10 days intervals between each one. Insecticide application on the foliage, stalk and ear tissue in each plot covered the zone extending from 0.60 m above to 0.60 m below the ear (Parsons and Munkvold, 2010). Maize hybrids and agricultural practices were randomized within blocks. Plot included two rows, 4 m long at 80 cm distance and sown with 2-3 grains/hill, thinned to one plant/hill after three weeks. The experiment was done under natural infection by ears rot disease and insect incidence of European corn borer (*Ostrinia nubilalis*), Mediterranean corn borer (*Sesamiano nagrioides*) and corn worm (*Helicoverpa zea*).

Disease assessment:

Ears rot disease was recorded after harvest directly in the field. Fungal maize ears rot incidence as percentage of ears displayed symptoms and severity were calculated. Disease severity of rotted ear was calculated following scale from (1-7) adopted by Raid *et al.* (1999) to quantify visible symptoms of diseases follows: 1= 0%, 2=1-3%, 3=4-10%, 4=11-25%, 5=26-50%, 6=51-75% and 7=>75%. Ears yield / plot (kg) was recorded in the two tested seasons. All cultural practices were done at proper time.

2-Toxins assessment:

All treatments were subjected to a toxicological contamination detection test. Randomized six ears were selected from each treatment and threshed, samples of 100 gm grains of each treatment were used to detect toxins contamination.

a-Extraction of aflatoxins:

The BF method was followed to extract and clean up aflatoxins from maize grains according to A.O.A.C (1990). Aflatoxins was separated and fractionated using Thin Layer Chromatography (TLC) technique. TLC aluminum sheets silica gel 60 (20 × 20 cm), without fluorescent indicator, were pre-coated with layer thickness of 0.25 mm (Merck Co.) then were used in separating all extracted samples from grains according to A.O.A.C (1980) method. Standard of aflatoxins B1, B2, G1and G2 (Sigma Chemical Co., Louis., Mo. U.S.A) were prepared by dissolving 1 mg of each in small volume of benzene-acetonitrile (98:2) and then completed to 100 ml with the same solvent mixture. Each prepared solution contained 10 µg/ml. Dried extract was dissolved in 200µl chloroform. Twenty µl of the extract were spotted on the TLC plate. The standard solution of B1, B2, G1 and G2 as well as their mixture were also spotted on the TLC plate 20 µl per each. Plates were developed in a jar 30 × 10 cm containing the running solvent system of chloroform: acetone: isopropanol: water (88:12:1.5:1 v/v) as described in A.O.A.C (1990) for approximately 20 min in darkness. Plates were then dried using a commercial hand hair drier and examined under U.V (365 nm). The intensity of fluorescence produced in samples patterns were compared with that of the standard patterns for aflatoxins spotted on the same plate. Aflatoxins B1, B2 were detected as blue fluorescence and G1 and G2 as yellow green fluorescence. As confirmation test, plates were lightly sprayed with 50% sulfuric acid. The fluorescence in samples will turn into yellow, indicating the presence of aflatoxins.

b-Extraction of fumonisin B1:

The extraction and cleanup of FB1were carried out according to Dupuy *et al.* (1993). TLC plates were dried and then sprayed with a developing solvent of 0.5% panizaldehyde in methanol. Plates were then heated for 5 min at 110°C, and visually inspected under U.V. (365 nm). FB1 appear as a reddish-purple spotting comparing with standard spot color and R*f* (0.25) according to Dupuy *et al.* (1993). FB1 standard was obtained from Sigma Chemical Co., St. Louis, Mo. USA, (approx. 98%). One mg of FB1 was dissolved in 1 ml of acetonitrile (ACN): water (1:1, v/v). The working standard solution was prepared by transferring 100µl, 50µl, 25µl & 10µl from the stock solution into vials, and final solutions of 100 µg/ml, 50 µg/ml, 25 µg/ml & 10 µg/ml were prepared by adding (ACN): H_2O (1:1, v/v).

c-Quantification of Aflatoxin and Fumonisin B1:

Determination of mycotoxin were performed according to A.O.A.C (1990) by scanning the TLC plates with a spectrophotodensitometer (No. CS930; Shimadzu Corp., Kyoto, Japan) set at 600 nm to identifying sample peak area comparing with the standard (Aflatoxins and /or Fumonisin B1) concentration area peaks. Sample concentrations were calculated by the following equation:

$$\mu g/kg = (B.Y.S.V)/(Z.X.W)$$

Whereas:

B= average area of peak in identified sample.
Y= concentration of (FB1and or Aflatoxins) standard (µg / ml).
S= µl spotted (FB1and or Aflatoxins).
V= final dilution of extracted sample (µl).
Z= average area of (FB1and or Aflatoxins) peaks in standard aliquots.
X = µl of spotted sample extract.
W= weight (g) sample represents final extract.

Statistical analysis:

The collected data of two seasons were subjected to proper statistical analysis of variance of split plot design according to Gomes and Gomes (1984). Means of treatments were compared using least significant difference at 5% of probably. Combined analysis of both seasons was done using the procedures out line of MSTATC by Freynd and Littell (1981).

RESULTS AND DISCUSSION

1- Effect of hybrids:

Data in Table (1) show that mean percentages of ear rot disease calculated throughout the two growing seasons (2019 and 2020) was significantly differed according to the tested maize hybrids, recorded a range from 4.52 to 15.92%. The highest infected hybrid was TWC353 *i.e.*, 15.92 %, ear rot and disease severity rate (DSR) reached 3.16, followed by SCs131, 176 and 168, which recorded 14.85, 14.30, 10.9 %ear rot incidence and DSR 3.5, 3.16, 3.83, respectively. In reverse, the lowest infected hybrids with ear rot disease were SC10, TWCs, 321, 352, 368, DSR ranged from 2.66% to 2.83%. The rest of the tested hybrids recorded disease incidence ranged between 6.89 and 8.63% and DSR from 2.83 to 3.16.

Regarding to yield, there were significantly differences between the tested maize hybrids. Mostly, high disease incidence led to decrease kernel yield (Table, 1). The highest yield was recorded from SC10, *i.e.*, 7.10 Kg, followed by SC 130, 128, 162. In the reverse, TWC353 was the lowest one in this respect *i.e.*, 4.84 kg followed by SC176 5.39 kg. Yield with other hybrids ranged from 5.4 - 5.81 Kg (Table,1). Amounts of fumonisin (FB1) toxin recorded from diseased grains were significantly differed between the tested maize hybrids (Table, 1). In most cases, high contamination of toxin was associated with high ear rot disease incidence. FB1 ranged from 1.88 - 20.46 µg/kg, and the most contaminated one was TWC353 followed by SC176, while the lowest hybrid was SC10 followed by SC 128 and TWC321, respectively (Table, 1).

Regarding to aflatoxins contamination in infected grains, results in Table (1) reveal that, hybrids were differed in levels of toxins accumulation. The highest accumulated ones were recorded from grains of TW C353 and SC 176 hybrids. In contrast grains of SC 10 and TWC 368 hybrids recorded the lowest accumulation levels. At all, aflatoxins contamination ranges were from 1.71 - 17.28 µg/kg. These results are in agreement with the work of Reid *et al*. (1999) who stated that infection by maize ear rot disease depended upon hybrids susceptibility to the disease, which led to different levels of infection degree reached 15.92% and DSR 3.83 beside different accumulation levels of FB1, and aflatoxins and decrease in grain yield.

Table (1): Under field natural infection, reaction of 13 maize hybrids against ear rot percentage, disease severity rating, yield and FB1 and aflatoxins accumulation in grains (Mean of the two tested seasons).

Hybrids	Ear rot %	Disease severity rating	Yield (Kg)	FB1µg/kg	Aflatoxins µg/kg
SC10	5.18	2.66	7.10	1.88	1.88
SC128	6.89	2.83	5.93	3.10	2.63
SC130	6.92	3.00	6.64	8.27	5.55
SC131	14.85	3.50	5.81	10.82	10.02
SC162	7.30	2.83	5.78	11.35	10.35
SC167	8.26	2.83	5.46	10.19	5.36
SC168	10.90	3.00	5.97	10.98	6.21
SC176	14.30	3.83	5.39	15.62	13.10
TWC321	5.01	2.66	5.78	2.93	5.91
TWC324	8.63	3.16	5.78	9.80	4.68
TWC352	4.52	2.83	5.52	5.70	2.74
TWC353	15.92	3.16	4.84	20.46	17.28
TWC368	5.96	2.83	5.53	4.36	1.71
LSD at 5%	0.337	0.707	0.038	0.294	0.197

2-Effect of agricultural practices:

Regarding to the effect of three agricultural practices on maize ear rot disease, data in Table (2) and Fig. (1) show that, significant differences between the three treatments were recorded. Whereas percentage of infection by ear rots in maize hybrids was decrease in treatment I (normal harvest after 125 days with insects management by Pestban insecticide) which showed the best ones in retarding of both infection percentage and DSR (4.26%, 2.65, respectively) on maize hybrids. The previously mentioned treatment also gave the lowest FB1 and Aflatoxins levels (4.7, 4.73 µg/kg, respectively) and the highest yield weight (6.4 kg/plot). Meanwhile, treatment d1 (early harvest after 105 days without insect management) recoded positive results in this respect and comes after (I) treatment, where infection % was 8.31 and DSR 2.9. This was accompanied with producing Aflatoxins (8.09 µg/kg) and FB1 (5.5 µg/kg) beside grain yielded 5.7 kg/plot. In contrary, treatment d2 (harvest at 125 days without insect management), recorded the highest incidence of ear rot disease (13.88 %) and DSR (3.46), beside toxin contaminations reached 13.87 µg/kg with FB1 and 9.95 µg/kg in case of aflatoxins. The previously mentioned treatment (d2) gave the lowest yield obtained (5.33 kg/plot).

Since stem borers and ear worm insects had a role in increasing of ear rot disease, controlling insects had a real role in decreasing damage in ears which led to raise the fungus invasion to kernels as results obtained in treatment (I) if compared with that not treated with insecticides. On the other hand, harvest at physiological maturity gave the lowest FB1 contamination than late harvest which gave higher FB1. Data of this study showed variation in toxins contaminations, suggesting that weather conditions in each season play critical role in toxins production. This is in agreement with work of Ferrigo *et al.* (2016) they found that maize infection with rots caused by *F. verticillioides*, consequently high toxins levels can be highly prevented by applied effective agriculture practices. Results obtained are in the same line of previous studies carried out by Torelli *et al.* (2012) and Cao *et al*. (2014), who observed avoiding adverse conditions by appreciate harvest date reducing the time to accumulate of FBs toxins in the field. Seasonality contamination by toxins in maize was reported by Parsons and Munkvold (2010). Also, results supported by the work of Owolade *et al.* (2005) showed reduction of toxins production by *F. verticillioides* and *Aspergillus* spp. resulted in decreasing of fungi incidence by early harvest. Moreover, early harvest has a great potential of decreasing of maize fusarium ear rot severity (DeCurtis *et al.*, 2011).

Table (2): Mean effect of agricultural practices on the incidence of ear rot, disease severity rating, yield and accumulation of fumonisin and aflatoxins in kernels.

Treatments	Ear rot %	disease severity rating	Yield/ Kg	FB1µg/kg	Aflatoxins µg/kg
d1*	8.31	2.9	5.70	8.09	5.50
d2	13.88	3.46	5.33	13.87	9.95
I	4.26	2.65	6.40	4.70	4.73
LSD at 5 %	0.126	0.250	0.027	0.259	0.174

* d1= early harvest at 105 days; d2= harvest at 125 days without insect control; I= harvest at 125 days with insect control and H = maize hybrids

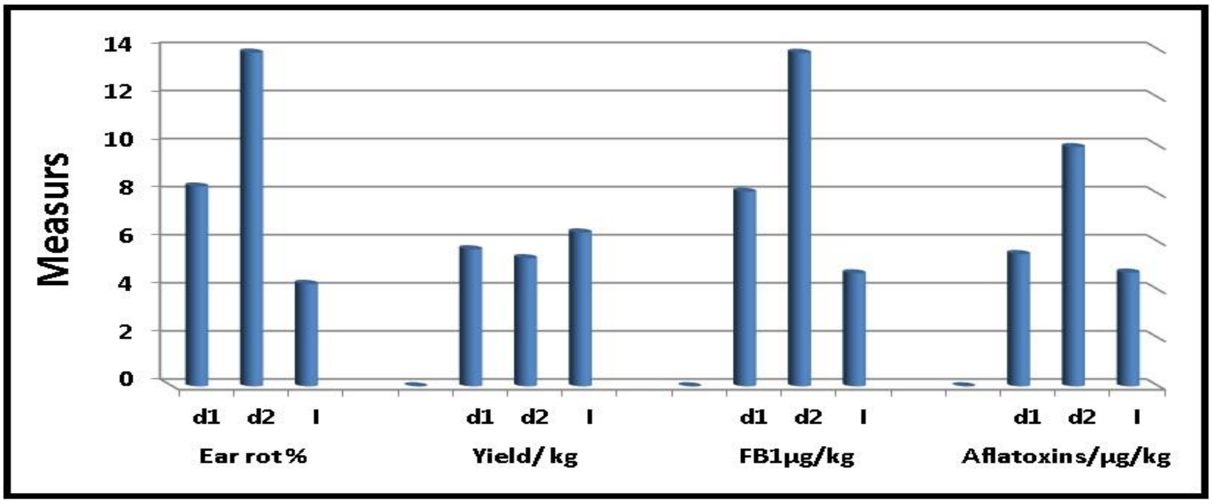

Fig. (1): The effect of three agricultural practices, *i.e.*, early harvest (d1), normal harvest (d2), normal harvest and insect control (I) on ear rot disease in addition of kernels contamination with fumonisin (FB1) and aflatoxins and yield.

3-Effect of interaction between hybrids, agricultural practices and insect control on incidence of maize ear rot:

The interaction between hybrids and agricultural practices and insect control on maize ear rot and yield were studied under natural field infection. Data in Table (3) and Fig. (2) show that interaction between hybrids and harvest after 125 days with insect management by Pestban (I × H) was superior in decreasing ear rots infection in most of maize hybrids, whereas ear rots disease was ranged between 1.57 - 8.25% and DSR from 2 - 3, followed by the interaction between hybrids and early harvest without insect control (d1 × H) which recorded infection percentage ranged between 3.64 - 17.94% and DSR 2.5 - 3.5 in maize hybrids. Meanwhile, harvest at 125 days without insect control (d2 × H) recorded highly infection in maize hybrids ranged between 5.85 - 25.50% and DSR 2.5 - 4.5. Also, data revealed that, SC131, TWC353 and SC176 hybrids were more susceptible to the disease under any interaction but they have a high infection degree in (d2 × H) interaction.

Regarding to the yield (Table, 3 and Fig.3) the decreasing in disease infection was accompanied with increasing in the yield obtained and the best treatment in this aspect was the interaction (I × H) which contained insect management. This treatment gave significant increase in kernel yield of the most tested maize hybrids where it ranged from 5.55 - 7.92 kg/plot. Whereas SCs10 and 130 were the most superior hybrids, while the least yielded hybrid was TWC353 in this interaction. The interaction of (d1 × H) showed an enhancement in yield comes after (I × H), as it was ranged between 4.66 - 7.05 kg/plot. Hybrid SC 10 was the highest one in kernel yielded in this interaction. The lowest kernel yield was gained from interaction between d2 × H (Table, 3 and Fig., 3).

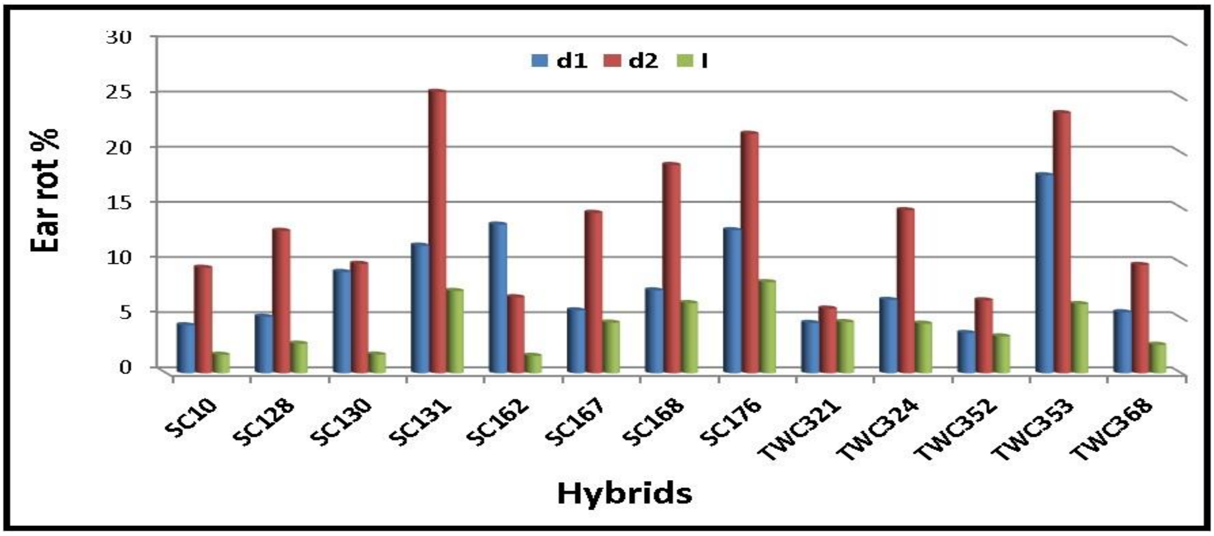

Figure (2): Effect of interaction between harvest time, insect control and maize hybrids on ear rot disease percentage (d1 × d2 × I × H).

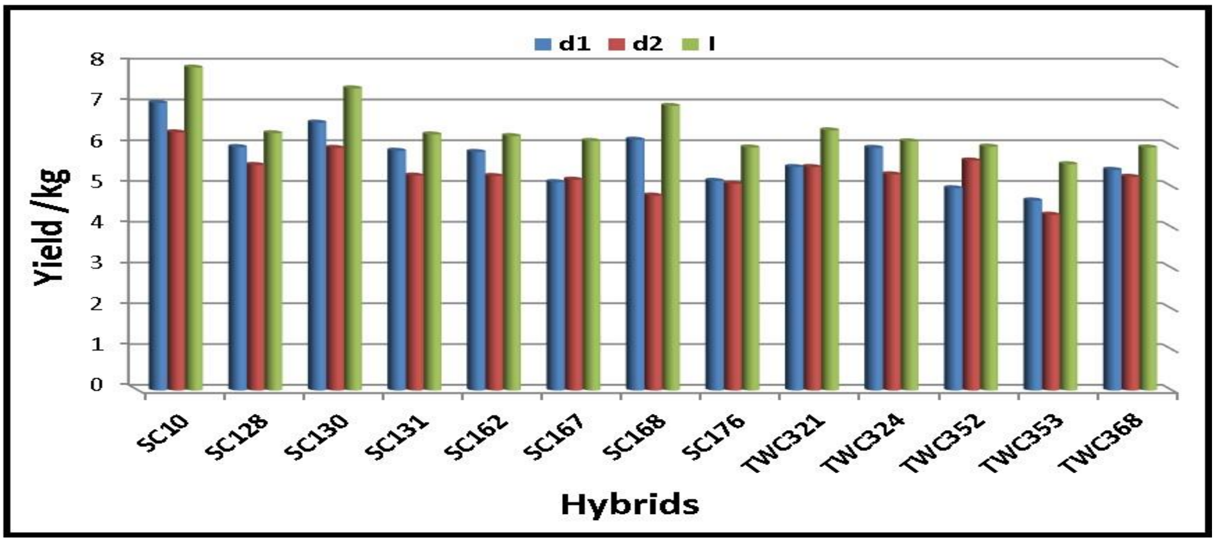

Figure (3): Effect of interaction between harvest time, insect control and maize hybrids on yield (d1 × d2 × I × H).

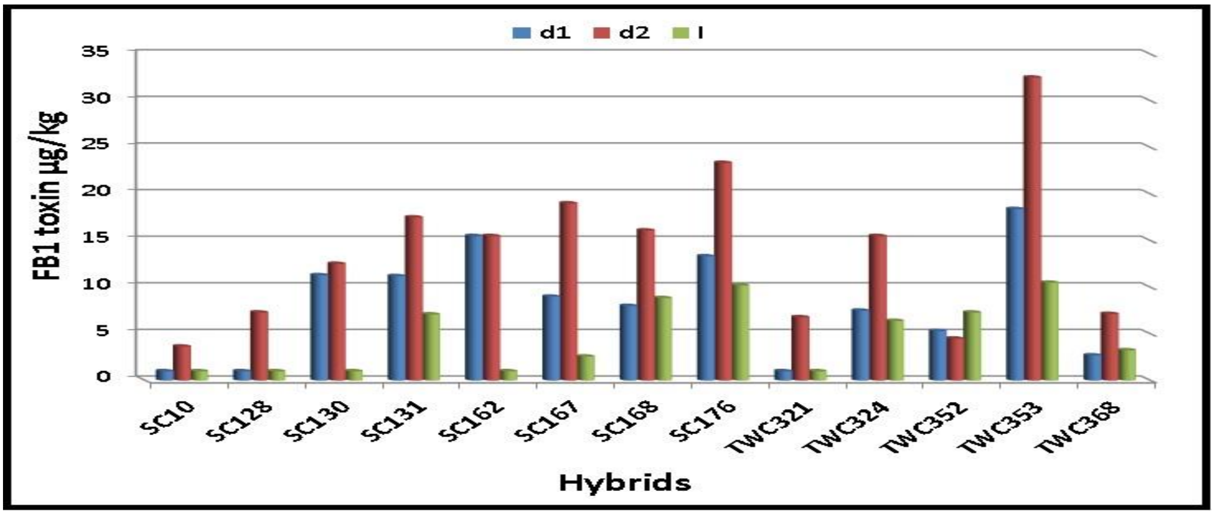

Figure (4): Effect of interaction between harvest time, insect control and maize hybrids on FB1 toxin accumulation (d1 × d2 × I × H).

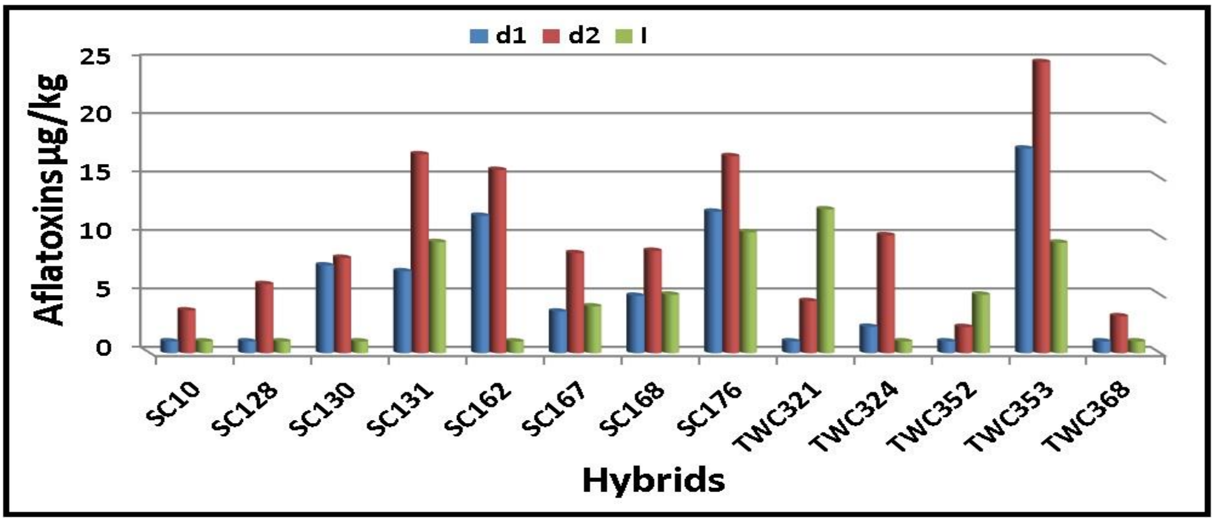

Figure (5): Effect of interaction between harvest time, insect control and maize hybrids on aflatoxins accumulation (d1 × d2 × I × H).

Table (3): Mean effect of interaction between harvest time, insect control and maize hybrids (H × d1 × d2 × I) on ear rot percentage, disease severity rating, yield and kernels FB1and aflatoxins accumulation.

Factors	Ear rot %			Disease severity rating			Yield (kg)			FB1µg/kg			Aflatoxins µg/kg		
Hybrids	d1*	d2	I	d1	d2	I	d1	d2	I	d1	d2	I	d1	d2	I
SC10	4.34	9.55	1.67	2.5	3.5	2.0	7.05	6.33	7.92	1.0	3.65	1.0	1.0	3.65	1.00
SC128	5.11	12.90	2.67	2.5	4.0	2.0	5.97	5.53	6.31	1.0	7.30	1.0	1.0	5.90	1.00
SC130	9.17	9.91	1.68	3.5	3.5	2.0	6.57	5.95	7.41	11.3	12.52	1.0	7.5	8.15	1.00
SC131	11.56	25.50	7.45	3.0	4.5	3.0	5.88	5.27	6.28	11.2	17.50	7.1	7.0	17.01	9.50
SC162	13.47	6.88	1.57	3.5	3.0	2.0	5.85	5.26	6.24	15.5	15.50	1.0	11.8	15.67	1.00
SC167	5.69	14.53	4.58	2.5	3.5	2.5	5.11	5.17	6.12	9.0	19.01	2.6	3.6	8.55	4.00
SC168	7.50	18.87	6.35	3.0	3.0	3.0	6.15	4.78	6.98	8.0	16.10	8.9	4.9	8.75	5.00
SC176	12.96	21.70	8.25	3.5	4.0	3.0	5.14	5.07	5.96	13.3	23.35	10.2	12.1	16.85	10.35
TWC321	4.55	5.85	4.63	2.5	2.5	3.0	5.48	5.48	6.38	1.0	6.79	1.0	1.0	4.45	12.30
TWC324	6.64	14.77	4.49	3.0	3.5	3.0	5.95	5.30	6.11	7.5	15.50	6.4	2.3	10.08	1.00
TWC352	3.64	6.60	3.33	2.5	3.0	3.0	4.96	5.64	5.98	5.3	4.50	7.3	1.0	2.23	5.00
TWC353	17.94	23.57	6.26	3.5	3.5	2.5	4.66	4.31	5.55	18.4	32.50	10.5	17.5	24.90	9.45
TWC368	5.52	9.81	2.57	2.5	3.5	2.5	5.41	5.24	5.96	2.7	7.15	3.3	1.0	3.15	1.00
LSD at 5%	3.495			0.906			1.304			0.553			0.224		

* d1= early harvest at 105 days; d2= harvest at 125 days without insect control; I= harvest at 125 days with insect control and H = maize hybrids

Concerning to mycotoxins contamination levels, data shown in Table (3) and illustrated in Fig. (4 and 5) clearly indicate that controlling insects by Pestban resulted in decreasing of ear rot infection in the most tested maize hybrids and this was associated with noticeable decrease in the amounts of fumonisin and aflatoxins, the interaction (I × H) followed by (d1 × H) gave lowest contaminated maize hybrids with mycotoxins tested. While the highest maize hybrids contamination with mycotoxins occurred from the interaction between (d2 × H). It was observed that hybrids TWC353, SCs176, 131 were the most contaminated hybrids with toxins.

From the results of interaction, it can be suggested that controlling insects of stem borers and ear worms by Pestban insecticide in maize hybrids harvest after 125 days (I × H) led to great reducing of ear rot disease, consequently, decrease of FB1 and aflatoxins levels. The obtained results are agreement with those obtained by Arino *et al.* (2009) they indicated that reducing of fungal infection and FBs contamination must be proposed insecticide treatments. Many insects served as vectors and created wounds to fungi as *F. verticillioides* (Dowd, 1998; Munkvold *et al.*, 1999 and Avantaggiato *et al.*, 2002). Present results supported by finding of Parsons and Munkvold (2010), who reported that, low *Fusarium* ear rot infection and FB1 contamination had concisely with plots treated by insecticide. Oldenburg (2017) stated that (ECB) attacks maize caused wounds by larvae raise risk for infection by *Fusarium* spp. and increased toxins contamination. On the other hand, insect activity dispersed fungi by providing routs to enter ear and kernels and association with disease (Dowd, 1998 and Fandohan *et al*. 2003).

Results in this study are in agreement with the work carried out by several investigators (Blandino *et al.*, 2009; DeCurtis *et al.*, 2011; Mohseni *et al.*, 2016 and Madege *et al.*, 2018a). They found that maize harvested at physiological mature had lowest FB1 contamination than that harvested at late dates after maturity and early harvest had a great potential reduction in fusarium ear rot of maize. Meanwhile, Insect control acts as reinforce in management of FB1of maize (Munkvold *et al.*, 1999).

Data in the present study showed that toxin contamination was correlated with insect injury of early harvest. This result is in accordance with results obtained by some investigators (Sobek and Munkvold, 1999; Blandino *et al.*, 2008 and Mazzoni *et al.*, 2011) who found that pests of ECB, MCB were related to implicated of *Fusarium* infection and FB1 accumulation. The results obtained in this investigation concerning with controlling insect injury with Pestban indicated noticeable decreases in ear rot incidence and disease severity. Furthermore, the fumonisin and aflatoxins amounts in maize kernels were greatly decreased by application of Pestban. Blandino *et al.* (2008) stated that spraying Pestban is an effective strategy to reduce ear rot severity of cob injuries due to larvae tunneling. This finding also conformed the results of previous studies on the efficacy of insecticide treatments on *Ostrinia nubilalis* and their influence on the mycotoxin contamination of maize kernels (Saladini *et al.*, 2008; De Curtis *et al.*, 2011; Jacobsen, 2014; Ferrigo *et al.*, 2016; Mohseni *et al.*, 2016; Oldenburg *et al.*, 2017 and Madege *et al.*, 2018a, b).

CONCLUSION

Finally, on the basis of the obtained findings, it could be concluded that, irrespective of maize hybrids, early harvest, controlling of stem bores and ear worms by Pestban insecticide had potential role in decreasing of ear rot disease, FB1 and aflatoxins contamination in maize kernels. Additionally, results showed that, the importance of agriculture practices (harvest date insects management) play an important role in reducing toxins contamination. Also, adaption of these practices was enhancing yield and safety reducing toxins contamination due to indirect control of ear rot by controlling of insects injury.

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CONFLICTS OF INTEREST:

The authors declare no conflict of interest exists.

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