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# Factors affecting development of covered kernel and long smut diseases and yield losses of grain sorghum

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Grain sorghum, Smuts, Inoculum, Cultivars, Yield Losses, Dates.

## Abstract

Sorghum plants (*Sorghum bicolor* linn. Moench) is the important grains crop for human being and animals in Upper Egypt, grain sorghum are attacked by certain smut diseases causing considerable losses in the grain yield. Covered kernel smut (CKS) caused by *Sporisorium sorghi* and long smut (LS) caused by *Sporisorium ehrenbergii* are one of the most significant diseases in sorghum production especially where untreated seed is planted. Results of this study showed that the high rates of inoculum of *S. sorghi* and *S. ehrenbergii* teliospores playing a great factor to increasing the infection with CKS and LS diseases and yield losses, while they reduced the yield of grains. Sorghum cultivars Giza-15 and Dorado differed in their ability to infection with these two types of CKS and LS respectively. Results revealed that due to infection by CKS disease Giza-15 (highly susceptible) recorded the lowest yield and highest yield losses (2.30 kg and 51.78%, respectively) and (2.25 kg and 52.22%, respectively) in both 2014 and 2015 seasons, respectively. While Shandweel-305 cv. (highly resistant) recorded the highest yield and lowest yield losses (3.11 kg and 12.39%, respectively) and (3.15 kg and 11.26%, respectively) in both 2014 1nd 2015 seasons, respectively. Also, due to infection by LS disease, Dorado cv. (highly susceptible) recorded the lowest yield and highest yield losses (2.53 kg and 29.72%, respectively) and (2.56 kg and 30.99%, respectively) in both 2014 1nd 2015 seasons, respectively. While Shandweel-305 cv. (moderately resistant) recorded the highest yield and lowest yield losses (3.35 kg and 6.42%, respectively) and (3.33 kg and 3.47%, respectively) in both 2014 1nd 2015 seasons, respectively. Different planting dates (1$^{st}$ May, 1$^{st}$ June and 1$^{st}$ July of the early, optimal and late planting, respectively) also affected on the response of grain sorghum to infection by both smut diseases and yield losses. Therefore, adjustments to time of sowing often make it possible for sorghum to escape from smut diseases by ensuring that the crop is not in the most disease susceptible stage when smut inoculum is abundant and the weather favorable for infection and disease spread.

## Introduction

In Egypt, Grain Sorghum (*Sorghum bicolor* L. Moench) is ranked fourth in importance among cereal crops in the world after wheat, rice, and corn, it is one of the world's major food cereal crops**.** Global production of the small grain is estimated to be 40 million hectares **(F.A.O., 2012).** Sorghum is particularly important in areas of high tempe-ratures and low rainfall as the crop is drought tolerant **(Hayden, 2002)**. It is grown in more than 100 countries all over the world. In 2014, Egypt planted 353850 feddans of grain sorghum with an average yield of 843844 tons of grain (**Anonymous, 2012**). More than 80% of the area devoted to sorghum lies within El Fayoum, Assiut, Sohag and Qena governorates of middle and Upper Egypt. In the areas where sorghum is traditionally grown, plants may be attacked by different smut diseases (**Moharam *et al*, 2015**). Three types of smuts are generally recognized. These are covered kernel smut, long smut and head smut. In Egypt, the first record of covered kernel smut (CKS) of sorghum caused by *Sporisorium sorghi* (syn. *Sphacelotheca sorghi* (Link) Clinton) was by **Briton-Jones (1922 and 1925).** The disease was found in Assiut, Aswan and Cairo governorates **(Melchers, 1931).** Later, it was found in all governorates of Upper Egypt **(Abd El - Hak and Abd El-Rehim, 1950).** Long smut caused by *Sporisorium ehrenbergii* Vánky (syn. *Tolyposporium ehrenbergii* (Kühn) Pat.) is a limiting factor in sorghum productivity in several African and Asian countries (**Kumar and Nath, 1991; Kollo and Frederiksen, 1998; Botros *et al*, 1999; Marley and Aba, 1999; Ngugi *et al*, 2002; Prom *et al*, 2007**). Smuts are one of the most important diseases of sorghum especially where untreated seed is planted. Damage is confined almost entirely to the head or panicles, thus the reduction in yield is conspicuous and direct. The quality of the remaining yield is drastically reduced by the presence of the black smut spores on the surface of healthy kernels. Smut fungi seldom kill their hosts (biotrophs), but in some cases infected plants may be severely stunted (**Agrios, 1997**). As covered and long smut affecting dramatically yield production of grain sorghum in Egypt, present study dealt with these two diseases to the benefit of the crop. The specific objectives of this study were to study factors such as sorghum cultivars, inoculum density and planting date affecting the grain sorghum yield and yield losses in relation to smut infection.

## Material and Methods

### 1-Survey of covered kernel and long smut diseases of sorghum in Qena and Sohag governorates:

A field survey of covered kernel and long smut diseases on sorghum was conducted in the summer growing season 2012 in 12 counties (Abu-Tesht, Nakada, Qeft, Qus, Deshna and Bndr Qena) and (Al-Margha, Al-Osyrat, Al-Baliana, Gerga, Dar El-Salam and Tahta) of Qena and Sohag governorates, respectively that listed in (Table 1). Three villages from each county and five sorghum fields' from each village were randomly chosen. The fields were only assessed if the sorghum crop was in the milk stage or later at maturity stage. Approximately, 500 plants were randomly selected from each field using a W-pattern of zigzag method described by **Ngugi *et al*. (2002)**.

Heads of growing plants were examined for covered kernel and long smut infections, and then the percent of infected plants (infection) was calculated. In case of covered kernel smut the disease severity (DS) was calculated using five class scales, where 1= few flower smutted, 2= 0.25-0.50 flowers smutted, 3= 0.50-0.75 flowers smutted, 4= few healthy, 5= all head smutted according to the method described by **McKinney (1923)**. The average number of sori per infected plant was also calculated in case of long smut.

**2- Isolates collection and identification of the causal pathogens of covered kernel and long smut diseases:**

Smutted panicles of sorghum plants infected with covered kernel and long smut diseases of each county of the 12 counties surveyed were collected in paper bags and sampled through the summer growing season 2012. Sori of smutted panicles were crushed to collect the teliospores. The resultant smut masses (teliospores) were passed through a sieve (100- mesh screen) to eliminate plant debris and stored at ambient temperature in the laboratory for further studies. Identification of collected isolates of *S. sorghi* and *S. ehrenbergii*, the causal pathogens of covered kernel and long smut diseases, respectively was carried out according to the morphological characteristics of teliospores and their germination on water agar as described previously by **Tarr (1962), Longdon and Fullerton (1978), Sing (1982), Gazar (1985), Ingold (1986) and Frederiksen and Odvody (2000).**

**3-Pathogenisty tests:**

Sorghum plants were inoculated with teliospores of 12 isolates each of *S. sorghi* and *S. ehrenbergii*) through 2013 growing season at the Experimental Farm of El-Mattana Agric. Res. Station, Luxor governorate. The sowing date was 1$^{st}$ of June.

Sorghum grains of Giza-15 cultivar were surface sterilized with 70% ethanol for 2 minutes, and soaked in sterile tap water for 6 hours, air dried and then thoroughly dusted with teliospores of each isolate of *S. sorghi* individually at the rate of 3g/kg of grains **(Moharam, 2010**). Disinfected grains treated with sterile distilled water (SDW) were served as control. Four grains were sown at a distance of 20 cm in two rows (60 cm a part) in plots of 2.0 × 3.5 m in a randomized complete block design with three replicates. After three weeks from sowing, the plants were thinned to two. The common cultural practices of sorghum at the field were followed.

On other hand, grains of Dorado cv. were also disinfected, soaked in sterile tap water, air dried and then thoroughly planted in the plots as described before. Teliospores suspension containing $1\times10^{6}$ spores/ml SDW of each isolate of *S. ehrenbergii* in was prepared using Hemocytometer (**Tzeng and De vay, 1989**).

The suspension was filtered through a double-layered muslin cloth after incubation at room temperature for 20 hour (Prom *et al*., 2007). For inoculation of the plants at boot stage, 5.0 ml of spore suspension of each isolate was placed between the flag leaves and the panicles using a syringe. Inoculated boots and the bases of flag leaves were immediately covered with sterilized paper bags after inoculation (**Ragab and Mahdi, 1966**). Inoculated plants with SDW were served as control. Following full appearance of panicles, the bags were removed.

At end of the season, any plant exhibiting sori of covered kernel and long smut was scored as infected. The percentage of infection and disease severity and sori number per infected plant were calculated as described before. The results were analyzed according to the statistical procedures described by **Gomez and Gomez (1984)**.

**4-Factors affecting development of covered kernel and long smut diseases and yield losses of sorghum:**

**4-1- Inoculum density:**

The sorghum plants were inoculated with teliospores of isolate No.2 of *S. sorghi* and isolate No.4 of *S. ehrenbergii*. The experiment was carried out in 2014 and 2015 growing seasons at the Experimental Farm of El-Mattana Agric. Res. Station, Luxor governorate. The sowing date was 1$^{st}$ of June.

Sorghum grains of Giza-15 cv were surface sterilized, soaked in sterile tap water for 6 hours, air dried and then thoroughly dusted with teliospores of *S. sorghi* at the rate of 1, 2, 3, 4 and 5 g per 1 kg of grains as above mentioned. Disinfected grains treated with SDW were served as control. Grains were sown in plots of 2.0 × 3.5 m in a randomized complete block design with three replicates as mentioned before. Twenty-one days after sowing the plants were thinned to 2 per hill and all common agricultural practices were followed.

On other hand, grains of Dorado cv. were also disinfected, soaked in sterile tap water, air dried and then thoroughly planted in the plots as described before. Twenty-one days after sowing the plants were thinned to 2 per hill and all common agricultural practices were followed.

Teliospore suspensions of *S. ehrenbergii* containing $1\times10^6$, $1\times10^8$ and $1\times10^{10}$ spores/ml of SDW were prepared. The suspensions were then filtered after incubation at room temperature for 20 hour as mentioned before. At boot stage, 5.0 ml of each spore suspension was placed between the flag leaves and the panicles using a syringe for inoculation of the plants as mentioned before. Inoculated plants with SDW were served as control. Inoculated boots were immediately covered with paper bags as mentioned before. Following full appearance of panicles, the bags were removed. After the symptoms development, the percentage of infection and disease severity of both diseases and sori number per infected plant by LS disease were calculated as described before. Following full maturity, total 40 sorghum plants of each plot were harvested and left in the field to dry for a week. Then panicles of sorghum plants were threshed and grains yield (kg) per plot was determined. Yield loss (%) of sorghum per plot was also calculated. The results obtained were statistically analyzed as described before.

**4-2- Sorghum varietal sensitivity: Reaction of certain sorghum cultivars and hybrids to infection by *S. sorghi* and *S. ehrenbergii*.**

These experiments were carried out in 2014 and 2015 growing seasons at the Experimental Farm of El-Mattana Agric. Res. Station, Luxor governorate to evaluate some sorghum cultivars and hybrids for susceptibility to *S. sorghi* and *S. ehrenbergii* the casual pathogens of covered kernel and long smut diseases, respectively. The sowing date was 1st of June. The sorghum cultivars and hybrids used were Giza-15, Dorado, Shandweel-305 and Shandweel-306. Grains of tested cultivars and hybrids were surface disinfested with 70% ethanol and artificially inoculated with teliospores isolate No.2 of *S. sorghi* at the rate 5g/kg of grains as mentioned before. Non inoculated grains were served as control. Then grains were sown in plots of 2.0 × 3.5 m in a randomized complete block design with three replicates as mentioned before. Twenty-one days after sowing the plants were thinned to 2 per hill and all common agricultural practices were followed. On the other hand, grains of tested cultivars and hybrids were also disinfected, soaked in sterile tap water, air dried and then thoroughly planted in the plots as described before. Twenty-one days after sowing the plants were thinned to 2 per hill and all common agricultural practices were followed. At boot stage, 5.0 ml of spore suspension containing $1\times10^{10}$ spores/ml of *S. ehrenbergii* isolate No. 4 was placed between the flag leaves and the panicles using a syringe for inoculation of the plants as mentioned before. Inoculated plants with SDW were served as control. Inoculated boots were immediately covered with paper bags as mentioned before. Following full appearance of panicles, the bags were removed. At end of the season, the percentage of infection and disease severity of both diseases and sori number per infected plant by long smut disease were calculated as described before. Following full maturity, sorghum plants were harvested and left in the field to dry under the sun for 4 days. Then panicles of sorghum plants were threshed and grains yield (kg) per plot was determined. Yield loss (%) of sorghum per plot was also calculated.

**4-3- Planting date:**

The effect of three sowing dates 1st of May, 1st of June and 1st of July of sorghum as early, optimal and late dates, respectively on development of CKS and LS diseases was studied during 2014 and 2015 seasons. Sorghum grains of Giza-15 cv were surface sterilized, soaked in sterile tap water for 6 hours, air dried and then thoroughly dusted with teliospores of *S. sorghi* isolate No.2 at the rate of 5 g per 1 kg of grains as mentioned before. Disinfected grains treated with SDW were served as control. Grains were sown in plots of 2.0 × 3.5 m in a randomized complete block design with three replicates as mentioned before. On other hand, grains of Dorado cv were also disinfected, soaked in sterile tap water, air dried and then thoroughly planted in the plots as described before. At boot stage, 5.0 ml of each spore suspension ($1\times10^{10}$ spores/ml) of *S. ehrenbergii* isolate No.4 was placed between the flag leaves and the panicles using a syringe for inoculation of the plants as mentioned before. Inoculated plants with SDW were served as control. At end of the season, the percentage of infection and disease severity of both diseases and sori number per infected plant by LS disease were calculated as described before. Grains yield (kg) per plot was determined and yield loss (%) per plot was also calculated as described before.

**Statistical analysis**

Data were subjected to statistical analysis of variance. The experimental design (s) of all studies was a randomized complete block design with three replicates. Analysis of variance of the data was performed with the MSTAT-C statistical package (A) micro-computer program for the design, management, and analysis of agronomic research experiments. Michigan State Univ., USA. Least significant difference (LSD) was used to compare treatment means (**Gomes and Gomes, 1984**).

## Experimental Results

**1-Survey of covered kernel and long smut diseases of sorghum in Qena and Sohag governorates:**

A field survey for the occurrence of covered kernel and long smut diseases of sorghum was conducted during the growing summer season 2012 in 12 counties of Qena and Sohag governorates. Data in Table (1) and Figure (1) indicate that sorghum was infected with covered kernel and long smut diseases with various degrees of infection. Covered kernel smut disease recorded (3.09% and 2.67%) with disease severity of (0.96% and 0.94%) in Qena and Sohag governorates, respectively. Long smut disease recorded (3.87% and 3.71%) with sori number per infected plant of (2.1 and 7.93) in Qena and Sohag governorates, respectively. The highest incidence of covered kernel and long smut diseases were observed in Naqada and Qeft counties, Qena governorate of 5.97% and 5.86%, respectively. While the lowest incidence of both diseases were observed in Al-Margha and Deshna counties, Sohag and Qena governorates of 1.44% and 3.27%, respectively. The highest disease severity (1.44%) of covered kernel smut was observed in Qeft county, Qena governorate and Al-Baliana and Gerga counties, Sohag governorate. While the lowest disease severity (0.59%) was recorded in Al-Margha county, Sohag governorate. The highest sori number (9.77) per infected plant with long smut disease was recorded in Al-Baliana county, Sohag governorate. While the lowest sori number (1.55) per infected plant was recorded in Bndr Qena county, Qena governorate.

A B

Fig. 1: Symptoms of covered kernel smut (A) and long smut (B) diseases of sorghum caused by *S. sorghi* and *S. ehrenbergii*, respectively in the field.

**Table 1**: Incidence of covered kernel and long smut diseases of sorghum assessed in 12 counties of Qena and Sohag governorates during survey performed in season 2012.

| Governorate | County | Village | Covered kernel smut | | Long smut | |
|---|---|---|---|---|---|---|
| | | | Infection (%) | DS (%) | Infection (%) | Sori/plant |
| Qena | Abu-Tesht | Samhod | 1.40* | 0.89 | 3.33 | 2.14 |
| | | Abu-Shosha | 3.33 | 0.75 | 3.67 | 1.50 |
| | | Al-Qara | 3.16 | 0.61 | 3.16 | 2.00 |
| | | **Mean** | **2.63** | **0.75** | **3.39** | **1.88** |
| | Nakada | Al-Zawaida | 7.88 | 2.11 | 3.50 | 1.00 |
| | | Tokh | 5.80 | 1.16 | 2.48 | 2.63 |
| | | Al-Khatara | 4.23 | 1.05 | 4.50 | 2.50 |
| | | **Mean** | **5.97** | **1.44** | **3.49** | **2.56** |
| | Qeft | Al-Brahma | 4.00 | 1.22 | 6.33 | 2.00 |
| | | Al-Shikhia | 3.16 | 1.13 | 5.50 | 2.33 |
| | | Al-Klahen | 1.50 | 0.68 | 5.76 | 3.17 |
| | | **Mean** | **2.89** | **1.01** | **5.86** | **2.50** |
| | Qus | El-Meqrabia | 2.40 | 0.91 | 4.16 | 2.50 |
| | | Hagza Qebli | 3.16 | 0.97 | 3.50 | 3.00 |
| | | Khozam | 2.50 | 0.94 | 3.33 | 2.16 |
| | | **Mean** | **2.69** | **0.94** | **3.66** | **2.55** |
| | Deshna | El-Sabryat | 1.83 | 0.81 | 2.50 | 2.50 |
| | | Fao Qebly | 1.44 | 0.77 | 4.16 | 1.33 |
| | | El-Samtaa Bhry | 1.25 | 0.63 | 3.16 | 2.40 |
| | | **Mean** | **1.51** | **0.74** | **3.27** | **2.08** |
| | Bndr Qena | El-Mahrosa | 3.66 | 1.14 | 3.11 | 1.50 |
| | | El-Manaa | 1.83 | 0.50 | 4.16 | 2.00 |
| | | El-Deer Bahry | 3.16 | 1.12 | 3.50 | 1.16 |
| | | **Mean** | **2.88** | **0.92** | **3.59** | **1.55** |
| **Mean** | | | **3.09** | **0.96** | **3.87** | **2.10** |
| Sohag | Al-Margha | Bani Helal | 1.05 | 0.77 | 3.20 | 2.70 |
| | | Shandaweel | 1.12 | 0.89 | 3.50 | 9.50 |
| | | Al-Heridia | 1.25 | 0.13 | 3.53 | 4.50 |
| | | **Mean** | **1.14** | **0.59** | **3.41** | **5.57** |
| | Al-Osyrat | Al-Masaied | 2.70 | 0.44 | 4.08 | 9.80 |
| | | Al-Rashaida | 3.50 | 1.15 | 4.33 | 7.00 |
| | | Al-Gazera | 2.67 | 0.95 | 3.05 | 4.60 |
| | | **Mean** | **2.96** | **0.85** | **3.82** | **7.13** |
| | Al-Baliana | Bani Hemail | 3.50 | 1.20 | 2.44 | 8.80 |
| | | Pardis | 4.16 | 1.66 | 4.83 | 9.80 |
| | | Barkhel | 3.22 | 0.55 | 4.50 | 10.70 |
| | | **Mean** | **3.63** | **1.14** | **3.92** | **9.77** |
| | Gerga | El-Toad | 1.88 | 1.11 | 4.11 | 8.14 |
| | | El-Khlfya | 2.50 | 1.08 | 4.16 | 8.50 |
| | | El-Berba | 2.33 | 1.23 | 3.50 | 6.67 |
| | | **Mean** | **2.24** | **1.14** | **3.92** | **7.77** |
| | Dar El-Salam | El-Blabesh | 2.67 | 0.97 | 3.16 | 6.00 |
| | | El-Haraga | 3.16 | 1.05 | 3.67 | 7.11 |
| | | El-Nagamesh | 3.67 | 1.04 | 3.50 | 7.00 |
| | | **Mean** | **3.17** | **1.02** | **3.44** | **6.70** |
| | Tahta | Shatora | 3.50 | 1.02 | 3.33 | 6.50 |
| | | El-Sawalem | 2.83 | 0.89 | 3.60 | 6.23 |
| | | Banho | 2.50 | 0.87 | 4.33 | 9.16 |
| | | **Mean** | **2.94** | **093** | **3.75** | **7.29** |
| **Mean** | | | **2.67** | **0.94** | **3.71** | **7.37** |
| **General Mean** | | | **2.88** | **0.95** | **3.79** | **4.74** |

* Values are means of five fields per each village.

**2- Identification of collected isolates of covered kernel and long smut pathogens:**

Total 24 isolates were obtained from diseased sorghum plants showing typical covered kernel smut disease (12 isolate) and long smut disease (12 isolate) collected from 12 counties of Sohag and Qena governorates in 2012 season. Teliospores of each smut disease were examined microscopically according to their morphological characteristics and germination on water agar. The casual pathogen of covered kernel smut disease was identified as *Sporisorium sorghi* (syn. *Sphacelotheca sorghi* Lin. Clint.). Also, the casual pathogen of long smut disease was identified as *Sporisorium ehrenbergii* Vànky (syn. *Tolyposporium ehrenbergii* (Kühn) Pat.). The teliospores of *S. sorghi* are round or slightly oval, dark brown in masse, but brownish olive when single and the spore size is within the range of 4-9 µm in diameters. After germination of teliospores on water agar, promycelium bearing lateral sporidia was predominant. The teliospores of *S. ehrenbergii* are in spore balls which are dark brown, subglobose to oblong or irregular and 40-150 µm long. Outer spores are dark brown, varicose on the free surface and the inner spores are pale yellowish brown, thin-walled and smooth. Spore germination on water agar resulted in 3-6 cells predominant promycelium bearing laterally and terminally spindle sporidia.

**3- Pathogenicity tests:**

The pathogenic capabilities of *S. sorghi* and *S. ehrenbergii* isolates were tested on sorghum Giza 15 and Dorado cvs, respectively. Data in Table (2) indicated that all tested isolates of *S. sorghi* and *S. ehrenbergii* were pathogenic to sorghum plants. Isolate No.2 of *S. sorghi* was the highest pathogenic one (47.67% infection and 17.53% disease severity), whereas isolate No.1, No. 7 and No.12 were the least pathogenic ones (22.53% and 4.11%) and (20.66% and 3.83%), respectively. In case of *S. ehrenbergii*, isolate No.4 was the highest pathogenic one (83.50% infection and 45.22 sori per infected plant), whereas isolate No.7, No.10, No.11 and No.12 were the least pathogenic ones (73.23% and 42.50), (72.33% and 42), (72.83% and 42.16) and (72.75% and 42), respectively.

**Table 2:** Pathogenicity of *S. sorghi* and *S. ehrenbergii* isolates on Giza 15 and Dorado cultivars, respectively performed under field conditions in 2013 growing season.

| Isolate | | *S. sorghi* on Giza 15 cv. | | *S. ehrenbergii* on Dorado cv. | |
|---|---|---|---|---|---|
| No. | Source | Infection (%) | DS (%) | Infection (%) | Sori/plant |
| 1 | Abu-Tesht | 22.53 | 4.11 | 78.33 | 43.33 |
| 2 | Nakada | 47.67 | 17.53 | 75.16 | 44.16 |
| 3 | Qeft | 29.16 | 4.50 | 79.50 | 44.22 |
| 4 | Qus | 28.14 | 5.16 | 83.50 | 45.22 |
| 5 | Deshna | 26.50 | 5.11 | 77.67 | 43.16 |
| 6 | Bndr Qena | 34.83 | 10.16 | 78.33 | 43.23 |
| 7 | Al-Margha | 24.40 | 3.49 | 73.23 | 42.50 |
| 8 | Al-Osyrat | 26.33 | 3.83 | 74.50 | 42.53 |
| 9 | Al-Baliana | 32.50 | 10.08 | 74.15 | 42.63 |
| 10 | Gerga | 29.45 | 4.83 | 72.33 | 42.00 |
| 11 | Dar El-Salam | 35.16 | 12.19 | 72.83 | 42.16 |
| 12 | Tahta | 20.66 | 3.83 | 72.55 | 42.00 |
| Control, sterile distilled water (SDW) | | 0.0 | 0.0 | 0.0 | 0.0 |
| L.S.D. $_{at\ 0.05}$ | | 2.42 | 1.27 | 1.94 | 1.55 |

**4-Factors affecting development of covered kernel and long smut diseases and yield losses of sorghum:**

**4-1- Inoculum density:**

Data presented in (Table 3 and 4) and (Figure 2 and 3 ) indicate that inoculum density of teliospores of *S. sorghi* varied significantly in their effect on infection with covered kernel smut, yield and yield losses of sorghum Giza-15 cv in both 2014 and 2015 seasons. Inoculation with 5g teliospores per kg sorghum grains resulted in the highest percentage of infection, disease severity and yield losses (75.55%, 20.25% and 48.66%, respectively in 2014 season) and (72.16%, 19.25% and 51.04%, respectively in 2015 season) and caused the lowest grain yield 2.50 and 2.35 kg in 2014 and 2015 seasons, respectively. While 1g teliospores per kg of grains gave the lowest percentage of infection, disease severity and yield losses (30.53%, 2.22% and 33.05%, respectively in 2014 season) and (27.22%, 2.07% and 34.79%, respectively in 2015 season) and recorded grain yield 3.26 and 3.13 kg in 2014 and 2015 seasons, respectively.

Data presented in (Table 5 and 6) indicate that inoculum density of teliospores of *S. ehrenbergii* varied significantly in their effect on infection with long smut, yield and yield losses of sorghum Dorado cv in both 2014 and 2015 seasons. Boot inoculation with concentration $1\times10^{10}$ spores/ml of SDW resulted in the highest infection %, sori per plant and yield losses % (93.33%, 51.13 and 35.6%, respectively in 2014 season) and (94.21%, 57.33 and 40.75%, respectively in

2015 season) and caused the lowest grain yield 1.61 and 1.57 kg in 2014 and 2015 seasons, respectively. While conc. $1\times10^6$ spores/ml of SDW gave the lowest infection %, sori per plant and yield losses % (56.77%, 43.53 and 20%, respectively in 2014 season) and (67.14%, 48.45 and 25.66%, respectively in 2015 season) and recorded grain yield 2.0 and 1.97 kg in 2014 and 2015 seasons, respectively (Figure 4 and 5).

**Table 3:** Effect of inoculum density of *S. sorghi* on incidence of covered kernel smut, and yield losses of sorghum Giza-15 cv in season 2014.

| Inoculum density(g) | Infection (%) | DS (%) | Yield (kg)/plot | Yield losses (%) |
|---|---|---|---|---|
| 1 | 27.22 | 2.07 | 3.13 | 34.79 |
| 2 | 39.53 | 3.50 | 3.04 | 36.66 |
| 3 | 46.83 | 9.11 | 2.80 | 41.66 |
| 4 | 55.67 | 13.23 | 2.71 | 43.54 |
| 5 | 72.16 | 19.25 | 2.35 | 51.04 |
| Control, SDW | 0.00 | 0.00 | 4.80 | 0.00 |
| **Mean** | **40.23** | **7.86** | **3.13** | **34.61** |
| L.S.D. at $_{0.05}$ | 4.61 | 1.39 | 0.07 | 1.25 |

**Table 4:** Effect of inoculum density of *S. sorghi* on incidence of covered kernel smut, and yield losses of sorghum Giza-15 cv in season 2015.

| Inoculum density (spores/ml) | Infection (%) | Sori/plant | Yield (kg)/plot | Yield losses (%) |
|---|---|---|---|---|
| $1\times10^6$ | 60.14 | 48.45 | 2.97 | 18.63 |
| $1\times10^8$ | 90.50 | 54.50 | 2.73 | 25.20 |
| $1\times10^{10}$ | 94.21 | 57.33 | 2.57 | 29.58 |
| Control, SDW | 00.00 | 00.00 | 3.65 | 00.00 |
| **Mean** | **61.21** | **40.07** | **2.98** | **18.35** |
| L.S.D. at $_{0.05}$ | 3.93 | 2.32 | 0.12 | 4.10 |

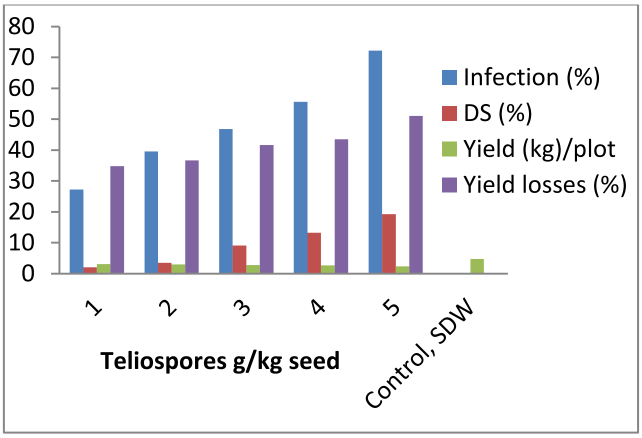


Fig. 2: Effect of inoculum density of *S. sorghi* on incidence of covered kernel smut, and yield losses of sorghum Giza-15 cv. in season 2014.

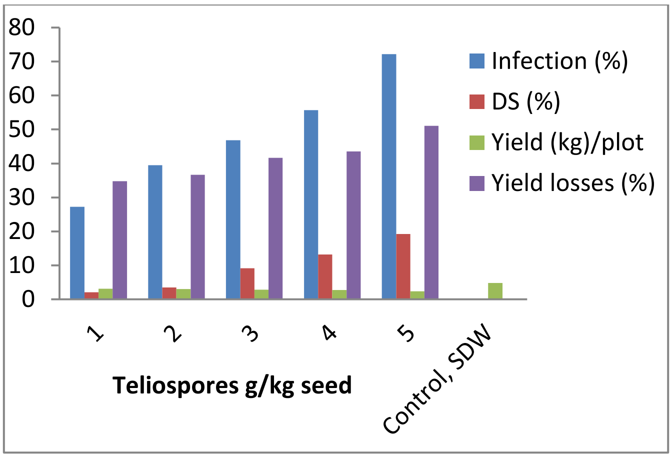


Fig. 3: Effect of inoculum density of *S. sorghi* on incidence of covered kernel smut, and yield losses of sorghum Giza-15 cv. in season 2015.

**Table 5**: Effect of inoculum density of *S. ehrenbergii* on incidence of long smut, and yield losses of sorghum Dorado cv. in season 2014.

| Inoculum density (spores/ml) | Infection (%) | Sori/plant | Yield (kg)/plot | Yield losses (%) |
|---|---|---|---|---|
| $1\times10^{6}$ | 56.97 | 43.53 | 3.00 | 14.28 |
| $1\times10^{8}$ | 89.33 | 49.50 | 2.77 | 20.85 |
| $1\times10^{10}$ | 93.33 | 51.13 | 2.61 | 25.42 |
| Control, SDW | 00.00 | 00.00 | 3.50 | 00.00 |
| **Mean** | **59.51** | **36.04** | **2.97** | **15.13** |
| L.S.D. at $_{0.05}$ | 3.13 | 1.82 | 0.11 | 3.23 |

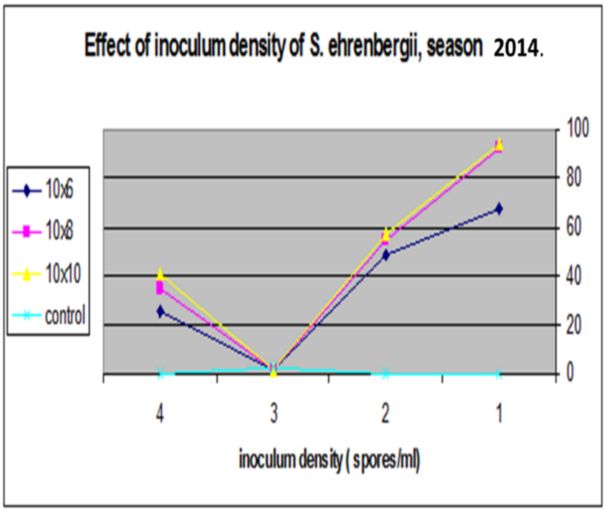


Fig. 4: Effect of inoculum density of *S. ehrenbergii* on incidence of long smut, and yield losses of sorghum Dorado cv. in season 2014.

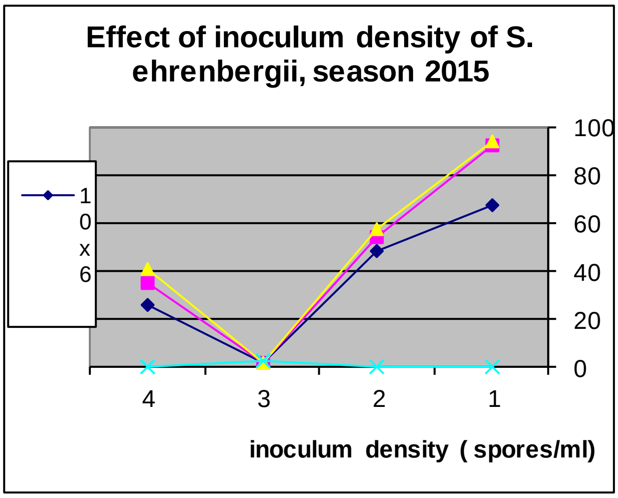


Fig. 5: Effect of inoculum density of *S. ehrenbergii* on incidence of long smut, and yield losses of sorghum Dorado cv. in season 2015.

**4-2- Sorghum varietal sensitivity: Reaction of certain sorghum cultivars and hybrids to infection by *S. sorghi* and *S. ehrenbergii*.**

Four sorghum cultivars and hybrids were evaluated for susceptibility to infection by *S. sorghi* and *S. ehrenbergii* in field trails through the 2014 and 2015 growing seasons. Data in Tables (7 and 8) show that sorghum cultivars and hybrids tested varied significantly in the response to infection by *S. sorghi*. Giza-15 cultivar (highly susceptible) showed the highest percentage of infection and disease severity (93.25% and 22.93%, respectively) and (91.50% and 24.50%, respectively) in both 2014 and 2015 seasons, respectively followed by Dorado cultivar (susceptible) (48.33% and 11.50%, respectively) and (50.33% and 13.33%, respectively) in both 2014 and 2015 seasons, respectively. Hybrid Shandweel-305 (resistant) exhibited the lowest infection percentage and disease severity (12.58% and 2.33%, respectively) and (12.16% and 2.45%, respectively) in both 2014 and 2015 seasons, respectively followed by Shandweel-306 (moderately resistant) (17.50% and 3.67%, respectively) and (18.33% and 3.83%, respectively) in both 2014 and 2015 seasons, respectively. Results also revealed that due to infection by covered kernel smut disease Giza-15 recorded the lowest yield and highest yield losses (2.30 kg and 38.99%, respectively) and (2.25 kg and 40.41%, respectively) in both 2014 and 2015 seasons, respectively. While Shandweel-305 recorded the highest yield and lowest yield losses (3.11 kg and 12.39%, respectively) and (3.15 kg and 11.26%, respectively) in both 2014 1nd 2015 seasons, respectively.

**Table 6**: Effect of inoculum density of *S. ehrenbergii* on incidence of long smut, and yield losses of sorghum Dorado cv. in season 2015.

| **Sorghum cultivars and hybrids** | | **Infection (%)** | **Sori/ plant** | **Reaction** | **Yield (kg)/plot** | **Yield losses (%)** |
|---|---|---|---|---|---|---|
| Giza-15 | Inoculated | 51.50 | 11.66 | S | 3.00 | 9.09 |
| | Non-inoculated | 0.00 | 0.00 | | 3.30 | 0.00 |
| Dorado | Inoculated | 92.16 | 51.50 | HS | 2.56 | 31.00 |
| | Non-inoculated | 0.00 | 0.00 | | 3.71 | 0.00 |
| Shandweel-305 | Inoculated | 33.00 | 7.67 | MR | 3.38 | 7.65 |
| | Non-inoculated | 0.00 | 0.00 | | 3.66 | 0.00 |
| Shandweel-306 | Inoculated | 28.83 | 7.50 | MR | 3.33 | 3.47 |
| | Non-inoculated | 0.00 | 0.00 | | 3.45 | 0.00 |
| L.S.D. at $_{0.05}$ | | 4.02 | 1.52 | - | 0.93 | 1.10 |

**Table 7:** Susceptibility of certain sorghum cultivars and hybrids to covered kernel smut infection and yield losses under field condition in 2014 season.

Resistant (R) = 0.0 -15.0% infection (**Abera and Alemayehu, 2012**)

| Sorghum cultivars and hybrids | | Infection (%) | DS (%) | Reaction | Yield (kg)/plot | Yield losses (%) |
|---|---|---|---|---|---|---|
| Giza-15 | Inoculated | 93.25 | 22.83 | HS | 2.30 | 51.28 |
| | Non-inoculated | 0.00 | 0.00 | | 4.77 | 0.00 |
| Dorado | Inoculated | 48.33 | 11.50 | S | 2.47 | 31.76 |
| | Non-inoculated | 0.00 | 0.00 | | 3.62 | 0.00 |
| Shandweel-305 | Inoculated | 12.58 | 2.33 | R | 3.33 | 10.72 |
| | Non-inoculated | 0.00 | 0.00 | | 3.73 | 0.00 |
| Shandweel-306 | Inoculated | 17.50 | 3.67 | MR | 3.00 | 16.66 |
| | Non-inoculated | 0.00 | 0.00 | | 3.60 | 0.00 |
| L.S.D. at $_{0.05}$ | | 4.02 | 1.29 | - | 0.04 | 4.10 |

Moderately resistant (MR) = 15.1-30.0% infection
Susceptible (S) = 30.1-60.0% infection
Highly susceptible (HS) = 60.1-100% infection

**Table 8:** Susceptibility of certain sorghum cultivars and hybrids to covered kernel smut infection and yield losses under field condition in 2015 season.

Resistant (R) = 0.0 -15.0% infection (**Abera and Alemayehu, 2012**)

| Sorghum cultivars and hybrids | | Infection (%) | DS (%) | Reaction | Yield (kg)/plot | Yield losses (%) |
|---|---|---|---|---|---|---|
| Giza-15 | Inoculated | 91.50 | 24.50 | HS | 2.25 | 51.61 |
| | Non-inoculated | 0.00 | 0.00 | | 4.65 | 0.00 |
| Dorado | Inoculated | 50.33 | 13.33 | S | 2.42 | 32.77 |
| | Non-inoculated | 0.00 | 0.00 | | 3.60 | 0.00 |
| Shandweel-305 | Inoculated | 12.16 | 2.45 | R | 3.29 | 11.79 |
| | Non-inoculated | 0.00 | 0.00 | | 3.73 | 0.00 |
| Shandweel-306 | Inoculated | 18.33 | 3.83 | MR | 3.05 | 17.34 |
| | Non-inoculated | 0.00 | 0.00 | | 3.69 | 0.00 |
| L.S.D. at $_{0.05}$ | | 3.98 | 1.33 | - | 0.28 | 4.73 |

Moderately resistant (MR) = 15.1-30.0% infection
Susceptible (S) = 30.1-60.0% infection
Highly susceptible (HS) = 60.1-100% infection

Data in Tables (9 and 10) show that sorghum cultivars and hybrids tested varied significantly in the response to infection by *S. ehrenbergii*. Dorado cv. (highly susceptible) showed the highest infection % and sori per plant (91.33% and 54.16, respectively) and (92.16% and 54.50, respectively) in both 2014 and 2015 seasons, respectively followed by

Giza-15 cultivar (susceptible) (50.66% and 12.50, respectively) and (51.50% and 11.66, respectively) in both 2014 and 2015 seasons, respectively. Hybrid Shand-306 (moderately resistant) exhibited the lowest infection % and sori per plant (30.25% and 2.33%, respectively) and (28.33% and 7.5, respectively) in both 2014 and 2015 seasons, respectively followed by Shandweel-305 (moderately resistant) (33.33% and 8.5, respectively) and (33.00% and 7.67, respectively) in both 2014 and 2015 seasons, respectively. Results also revealed that due to infection by long smut disease Dorado recorded the lowest yield and highest yield losses (1.53 kg and 41.15%, respectively) and (1.56 kg and 42.45%, respectively) in both 2014 1nd 2015 seasons, respectively. While Shandweel-306 recorded the highest yield and lowest yield losses (3.35 kg and 6.42%, respectively) and (3.33 kg and 3.47%, respectively) in both 2014 1nd 2015 seasons, respectively.

**Table 9**: Susceptibility of certain sorghum cultivars and hybrids to long smut infection and yield losses under field condition in 2014 season.

Highly resistant (HR) = 0.0-10.0% infection (**Moharam *et al*, 2015**)
Resistant (R) = 10.1-20.0% infection

| Sorghum cultivars and hybrids | | Infection (%) | Sori/ plant | Reaction | Yield (kg)/plot | Yield losses (%) |
|---|---|---|---|---|---|---|
| Giza-15 | Inoculated | 50.66 | 12.50 | S | 3.11 | 13.13 |
| | Non-inoculated | 0.00 | 0.00 | | 3.35 | 0.00 |
| Dorado | Inoculated | 91.33 | 54.16 | HS | 2.53 | 29.91 |
| | Non-inoculated | 0.00 | 0.00 | | 3.61 | 0.00 |
| Shandweel-305 | Inoculated | 33.33 | 8.50 | MR | 3.30 | 7.04 |
| | Non-inoculated | 0.00 | 0.00 | | 3.55 | 0.00 |
| Shandweel-306 | Inoculated | 30.25 | 7.67 | MR | 3.35 | 6.42 |
| | Non-inoculated | 0.00 | 0.00 | | 3.58 | 0.00 |
| L.S.D. at $_{0.05}$ | | 4.02 | 1.52 | - | 0.93 | 1.10 |

Moderately resistant (MR) = 20.1-40.0% infection
Susceptible (S) = 40.1-60.0% infection
Highly susceptible (HS) = 60.1-100% infection

**Table 10**: Susceptibility of certain sorghum cultivars and hybrids to long smut infection and yield losses under field condition in 2015 season.

| **Sorghum cultivars and hybrids** | | **Infection (%)** | **Sori/ plant** | **Reaction** | **Yield (kg)/plot** | **Yield losses (%)** |
|---|---|---|---|---|---|---|
| Giza-15 | Inoculated | 51.50 | 11.66 | S | 3.00 | 9.09 |
| | Non-inoculated | 0.00 | 0.00 | | 3.30 | 0.00 |
| Dorado | Inoculated | 92.16 | 51.50 | HS | 2.56 | 31.00 |
| | Non-inoculated | 0.00 | 0.00 | | 3.71 | 0.00 |
| Shandweel-305 | Inoculated | 33.00 | 7.67 | MR | 3.38 | 7.65 |
| | Non-inoculated | 0.00 | 0.00 | | 3.66 | 0.00 |
| Shandweel-306 | Inoculated | 28.83 | 7.50 | MR | 3.33 | 3.47 |
| | Non-inoculated | 0.00 | 0.00 | | 3.45 | 0.00 |
| L.S.D. at $_{0.05}$ | | 4.02 | 1.52 | - | 0.93 | 1.10 |

Highly resistant (HR) = 0.0-10.0% infection (**Moharam *et al*, 2015**)
Resistant (R) = 10.1-20.0% infection
Moderately resistant (MR) = 20.1-40.0% infection
Susceptible (S) = 40.1-60.0% infection
Highly susceptible (HS) = 60.1-100% infection

**4-3- Planting date:**

Data, Table (11. Figure 6) illustrate the relation of date of planting and inoculum concentration on infection of tested cultivar Giza-15 with covered kernel smut in 2014 and 2015. Results indicated that all planting dates significantly caused high infection (%.), disease severity (D.S.) and reduction in yield compared to the control. It was observed that the late planting date (1st July) gave the highest degrees of infection (93.67 %), the yield losses was recorded ( 40,57%) at the optimum planting date (1st June) compared with the early date of planting (1st May) and the late date (1st July) comparable to the control at the two growing seasons 2014 and 2015. Data in Table (12) and Figure (7) indicated that long smut disease was observed at the three tested planting dates. The early date (1st May ) gave the highest percentage of infection, sori/ head (92.16, %, 25.33% ), while the yield losses was recorded ( 30.78 %, 28.11% ) at the optimum planting date (1st June) during seasons 2014 and 2015 respectively, compared with the early date, late date and control .

**Table 11**: Effect of planting date on incidence of covered kernel smut, yield and yield losses of sorghum Giza-15 cv in 2014 and 2015 seasons.

| Planting date | | 2014 season | | | | 2015 season | | | | Mean | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Infection (%) | DS (%) | Yield (kg)/plot | Yield losses (%) | Infection (%) | DS (%) | Yield (kg)/plot | Yield losses (%) | Infection (%) | DS (%) | Yield (kg)/plot | Yield losses (%) |
| **1st May** | Inoculated | 48.83 | 19.17 | 3.14 | 14.67 | 47.50 | 18.83 | 3.10 | 15.30 | 48.16 | 19.00 | 3.32 | 14.95 |
| | Non-inoculated | 0.00 | 0.00 | 3.68 | 0.00 | 0.00 | 0.00 | 3.66 | 0.00 | 0.00 | 0.00 | 3.67 | 0.00 |
| **1st June** | Inoculated | 88.50 | 31.45 | 2.90 | 40.57 | 87.16 | 30.16 | 2.88 | 40.61 | 87.83 | 30.80 | 2.91 | 40.59 |
| | Non-inoculated | 0.00 | 0.00 | 4.88 | 0.00 | 0.00 | 0.00 | 4.85 | 0.00 | 0.00 | 0.00 | 4.86 | 0.00 |
| **1st July** | Inoculated | 93.67 | 35.25 | 2.55 | 20.31 | 93.50 | 34.50 | 2.52 | 21.98 | 93.58 | 34.87 | 2.53 | 21.14 |
| | Non-inoculated | 0.00 | 0.00 | 3.20 | 0.00 | 0.00 | 0.00 | 3.23 | 0.00 | 0.00 | 0.00 | 3.21 | 0.00 |
| $LSD_{at\ 0.05}$ | | 3.55 | 1.97 | 0.08 | 1.08 | 2.17 | 1.69 | 0.11 | 0.93 | 2.10 | 1.75 | 0.09 | 0.97 |

**Table 12:** Effect of planting date on incidence of long smut, sori per plant and yield losses of sorghum Dorado *cv* in 2014 and 2015 seasons.

| Planting date | | 2014 season | | | | 2015 season | | | | Mean | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Infection (%)** | **Sori/plant** | **Yield (kg)/plot** | **Yield losses (%)** | **Infection (%)** | **Sori/plant** | **Yield (kg)/plot** | **Yield losses (%)** | **Infection (%)** | **Sori/plant** | **Yield (kg)/plot** | **Yield losses (%)** |
| **1st May** | Inoculated | 92.16 | 25.33 | 1.96 | 27.76 | 90.33 | 22.50 | 2.00 | 25.92 | 91.25 | 23.91 | 1.98 | 26.79 |
| | Non-inoculated | 0.00 | 0.00 | 2.71 | 0.00 | 0.00 | 0.00 | 2.70 | 0.00 | 0.00 | 0.00 | 2.70 | 0.00 |
| **1st June** | Inoculated | 80.25 | 17.16 | 2.63 | 30.78 | 77.50 | 10.33 | 2.71 | 28.11 | 78.87 | 16.74 | 2.67 | 29.44 |
| | Non-inoculated | 0.00 | 00.00 | 3.80 | 0.00 | 0.00 | 0.00 | 3.77 | 0.00 | 0.00 | 0.00 | 3.78 | 0.00 |
| **1st July** | Inoculated | 58.16 | 05.25 | 2.57 | 08.27 | 57.50 | 5.00 | 2.25 | 8.93 | 57.83 | 5.12 | 3.56 | 8.56 |
| | Non-inoculated | 0.00 | 0.00 | 2.80 | 0.00 | 0.00 | 0.00 | 2.80 | 0.00 | 0.00 | 0.00 | 2.80 | 0.00 |
| L.S.D. $_{at\ 0.05}$ | | 4.02 | 0.17 | 0.08 | 1.11 | 2.08 | 0.22 | 0.05 | 0.95 | 3.99 | 0.20 | 0.06 | 0.98 |

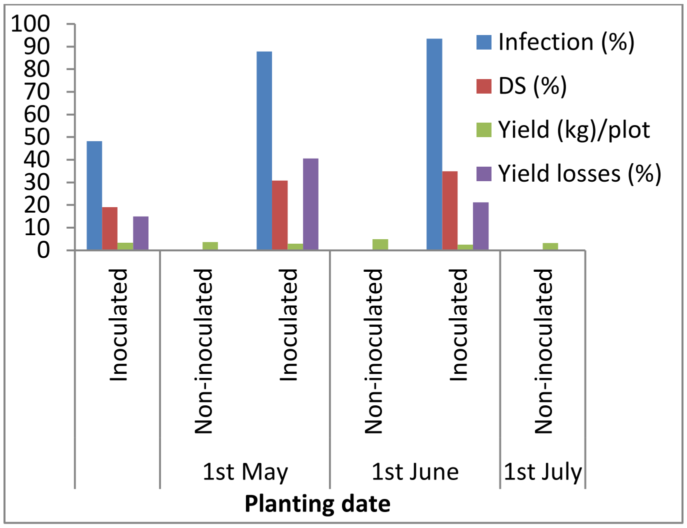


**Fig. 6:** Effect of planting date on incidence of covered kernel smut, yield and yield losses of sorghum Giza-15 cv. in 2014 and 2015 seasons (mean).

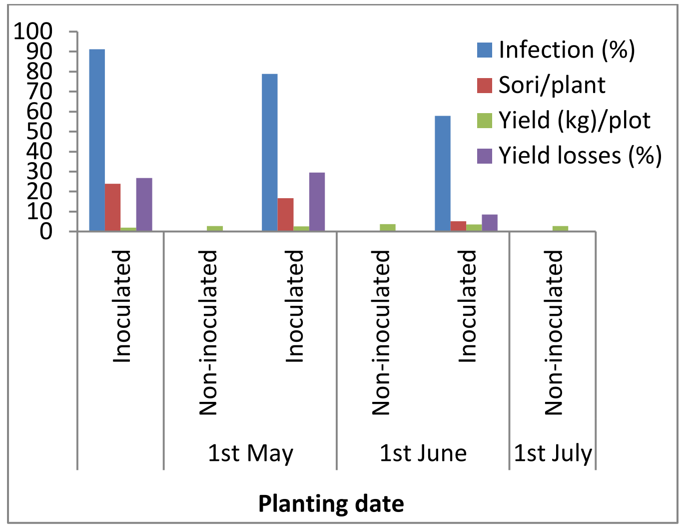


**Fig.7:** Effect of planting date on incidence of long smut, sori per plant and yield losses of sorghum Dorado cv in 2014 and 2015 seasons (mean).

## Discussion

Sorghum plants (*Sorghum bicolor* linn. Moench) the important grains crop for human being and animals in Upper Egypt are attacked by certain smut diseases causing considerable losses in the grain yield **(Botros, 1993).** Seed borne diseases are the main problems that affect sorghum plants because seed are the economic and edible part of the crop. In Egypt, seed are used as feed and food crop, especially at south Egypt. For this reason, current study threw the light on the importance of getting grains free from smut diseases to the benefit of man and animal. Like other crops, grain sorghum is subject to various infectious diseases which limit grain yield production in the agriculture sector **(Vinceli and Hershman, 2011).** These unusual diseases and the wide range of environments in which the crop is exposed to challenges of up to three smuts which are commonly namely, the covered kernel smut, loose kernel smut and head smut (**Frederiksen and Odvody, 2000**). Field trials were done to find out the effect of these smuts on different varieties and hybrids and findings revealed that the open pollinated varieties were more susceptible to infection than the newly produced hybrids. This finding could be explained as follows: The open pollinated varieties were produced by selecting the best candidates within the cultivated local population yielding the high grain production regardless their potential to be resistant to infection with smuts. But, hybrids are produced through the breeding program, hence, the produced hybrids are evaluated starting from their inbred linens against several steps for several years to assure that they have the potential to have the high yield and yield components, in addition to be highly resistant to infection with major diseases of the crop. Results indicated that infection percent with grain smut was obviously higher in planting the crop late in the season comparable with planting early (**Gazar, 1985; Kollo and Frederiksen, 1998**). This is may be due to the soil temperature that affects the efficiency of teliospores to attack the juvenile plant roots. Sorghum planted in warm (<30C) soil had the greatest incidence of covered kernel smutted panicles (**Ramundo *et al*. 2000).** Infection percent in turn decreased the yield production and increased the yield losses. Yield reduction due to infection with the major diseases is well known in other cereal crops. Late wilt of, for instance reduced yield productivity of maize, estimated as 35 % **(Lin-Jian *et al.*, 2001).** Yield losses of sorghum due to anthracnose might reach values higher than 70% **(Costa *et al.*, 2009).** Long smut caused significant decrease in the produced yield as compared with the uninfected plants, which in turn caused an obvious increase in yield losses. High rates of *S. sorghi* and *S. ehrenbergii* teliospores playing great factor to increasing the two smuts diseases infection and yield losses, while it was reduced the yield of grain for the tested cultivars and hybrids It was agreement with **Mukuru, 1993; Prom and Ndoye, 2007.** Different planting dates it also affected on the response of grain sorghum cultivars and hybrids to infection by smut diseases. Adjustments to time of sowing often make it possible for crops to escape from disease by ensuring that the crop is not in the most disease susceptible stage when pathogen inoculum is abundant and the weather favorable for infection and disease spread. This strategy has, however, received little attention in sorghum disease control. Choosing the time of sowing it should be taken into consideration that susceptible stage of the crop growth and soil conditions and other environments favorable for maximum activity of the pathogen does not fall at the same time.

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# العوامل التى تؤثر على تطور مرض تفحم الحبوب المغطى والتفحم الطويل والفقد فى محصول الذره الرفيعه

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## الملخص العربى

تعد الذرة الرفيعة احد اهم محاصيل الحبوب لتغذيه الإنسان والحيوان في صعيد مصر، وتتعرض ذرة الحبوب للهجوم من بعض مسببات الأمراض الخطيره والتي تسبب خسائر كبيرة في المحصول. ويعتبر مرضى تفحم الحبوب المغطى والتفحم الطويل من أهم الأمراض التى تؤثر على إنتاج الذرة الرفيعه خاصة عند زراعة البذور الغير معالجة. تحت ظروف العدوى الصناعيه فى الحقل, اختلفت اصناف الذره الرفيعه فى حساسيتها للإصابه بمرضى تفحم الحبوب المغطى والتفحم الطويل حيث كان الصنف جيزه 15 عالى الحساسيه وحساس لإصابه بمرضى تفحم الحبوب المغطى والتفحم الطويل, على التوالى. بينما كان الصنف دورادو حساس وعالى الحساسيه للاصابه بمرضى تفحم الحبوب المغطى والتفحم الطويل, على التوالى. وكان الصنف هجين شندويل 305 مقاوم ومتوسط المقاومه لمرضى تفحم الحبوب المغطى والتفحم الطويل, على التوالى. أظهرت نتائج الدراسه أن المعدلات العاليه لكميه لقاح الفطرين *سبوريسوريم سورجاى* و *سبوريسوريم إهرنبرجياى* من الجراثيم التيلتيه تمثل عامل كبير فى زياده الإصابه بمرضى التفحم وخسائر المحصول, حيث تسببت فى نقص محصول الحبوب للذره الرفيعه. مواعيد الزراعه المختلفه ايضا أثرت على مدى استجابه الذره الرفيعه للإصابه بمرضى التفحم والخساره العاليه فى كميه المحصول خاصه عند الزراعه المبكر والمتاخره عن الزراعه المثلى فى الأول من مايو.