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Reaction of Sorghum Differentials to Grain Mold Infection in Puerto Rico

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Abstract

Grain mold, associated with many fungi, is the most important disease of sorghum, causing both yield and quality losses. In this study, 23 sorghum differentials used in pathotype characterization of anthracnose and head smut pathogens were evaluated for grain mold resistance under favorable conditions in Isabela, Puerto Rico. Lines BTx643 and IS18760 exhibited the lowest grain mold severity, indicating that these two may possess genes for grain mold resistance. These two lines also recorded the highest germination rates 94.7% and 97.6%, respectively, and their seed weight was among the heaviest. In conclusion, these two lines can be utilized in breeding programs to develop grain mold-resistant hybrid lines.

Keywords

Sorghum, Grain Mold, Fungi, Resistance, Sorghum Differentials, Seed Germination, Seed Weight

1. Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is a versatile crop in terms of its uses and adaptability to diverse environments playing a critical role in subsistence farming and supplying the daily calorie needs of hundreds of millions of people, especially in the drier tropics [1] [2] [3] [4]. However, sorghum is vulnerable to many fungal diseases, including grain mold, a complex disease associated with numerous fungi species [1] [5] [6] [7] [8].

Globally, grain mold significantly impacts sorghum yield, especially if mature grains are not harvested on time and are exposed to wet and humid weather conditions, which is a common occurrence in regions such as Puerto Rico later in the growing season [5] [9]. Many fungal species, including *Fusarium thapsinum*, *Fusarium semitectum*, *Curvularia lunata*, *Alternaria alternata*, *Colletotrichum sublineola*, and *Phoma sorghina* are reported to be associated with grain mold [9] [10] [11]. Grain mold on sorghum affects both the quality and quantity of the grain; however, on susceptible cultivars, losses in grain yield can reach 100% [12]. In addition, several fungi associated with grain mold are mycotoxigenic, further limiting the use of the grain as food and feed [13] [14] [15].

Management strategies for grain mold may involve different options such as planting of sorghum cultivars that mature during dry weather conditions, sorghum cultivars with high levels of tannins, or planting resistant cultivars [6] [7] [16] [17] [18] [19]. Desai *et al.* [20] reported that three applications of propiconazole and hexaconazole lowered the incidence of grain mold on sorghum. However, the utilization of genetically resistant lines offers the best means of controlling this disease complex [2] [7] [19] [21]. Previous studies have shown that resistant lines for some diseases are more likely to have resistance to other diseases [22]. Therefore, in this communication, sorghum differentials for anthracnose and head smut pathotype characterization were evaluated for grain mold resistance under field infection in Isabela, Puerto Rico.

2. Materials and Methods

2.1. Field Trial

The sorghum differentials, RTx2536, SC748-5, Martin (BTx398), TAM428, BTx430, Brandes, SC112-14, Theis, BTx378, SC326-6, SC283, BTx623, SC328C, SC414-12E, PI570841, PI570726, PI569979, and IS18760 used for anthracnose and BTx635, BTx643, SC170-6-17, SC414-12E, RTx7078, and SA281 used for head smut pathotype characterizations [23] [24] were evaluated for resistance to grain mold during the 2019 and 2020 seasons in Isabela, Puerto Rico. Using a randomized complete block design, seeds were planted in 1.8 m rows with 0.9 m row spacing. Each line was replicated three times. Standard field practices were employed, and weeds were controlled with occasional hand hoeing. At maturity, three panicles from each replication were harvested and threshed. Severity was based on a scale of 1 to 5 where, 1 = no mold observed on the seeds; 2 = 1% to 9%, 3 = 10% to 24%, 4 = 25% to 49% and 5 = 50% or more of the seeds molded [5] [25]. Kernel weight was based on weight in grams of 100 randomly selected seeds from each panicle. Germination rates were based on the number of seeds that germinated in 7 days out of 100 seeds placed on Anchor seed germination paper (Anchor Paper CO, St. Paul, MN).

2.2. Statistical Analysis

Data for grain mold severity, seed weight, and percent germination rate were analyzed using the command PROC GLM (SAS Institute, SAS version 9.4, Cary, NC). Differences in means among the lines were determined at the 5% probability level based on LS-Means.

3. Results

The main effect of line was highly significant ($P < 0.01$). Among the 23 lines tested, BTx643 (2.0 g) exhibited the lowest infection while SC326 (4.3 g) recorded the highest grain mold severity. The level of diseases severity on BTx643 was significantly lower than the levels found in 12 of the lines evaluated (**Table 1**). Line PI570726 recorded 2.82 g per 100 seed weight, followed by IS18760 (2.55 g), BTx378 (2.51 g), and SC112-14 (2.24 g). Out of the 23 lines evaluated, 16 had seed weight below 2.00 g (**Table 1**). IS18760 recorded the highest germination rate of 97.6% while the lowest 14.4% was noted on RTx7078 (**Table 1**). The rest of the lines had germination rates ranging from 94.7% (BTx643) to 26.2% (SC112-14).

Table 1. Reaction of the sorghum differentials to grain mold severity, seed weight, and percent germination rate.

Line	GM[1]	Seedwt[2]	Germ[3]
SC326-6	4.3a[4]	1.13f	38.3cde
SC328C	4.2ab	1.50def	27.0de
BTx635	4.0ab	1.67cdef	42.6cde
RTx7078	4.0ab	1.65cdef	14.4e
QL3	3.8abc	1.84bcde	53.2bcd
Theis	3.7abcd	1.81cdef	83.5ab
BTx623	3.7abcd	1.63cdef	38.2cde
RTx2536	3.7abcd	1.45def	53.8bcd
SC414-12E	3.7abcd	1.84def	38.3cde
SC748-5	3.7abcd	1.78cdef	71.2abc
SA281	3.5abcde	1.92bcd	70.8abc
Brandes	3.5abcde	1.64cdef	87.8a
TAM428	3.3abcdef	1.75cdef	54.5bcd
SC170-6-17	3.2abcdef	1.16ef	29.2de
Martin	3.2bcdef	1.81cdef	28.3de
PI570841	3.2bcdef	1.89bcde	82.0ab
SC112-14	2.8cdef	2.24abc	26.2de
BTx378	2.8cdef	2.51ab	33.0de
PI569979	2.8cdef	2.20abc	41.6cde
PI570726	2.7def	2.82a	82.3ab
SC283	2.5ef	2.06bcd	46.3cde
IS18760	2.4ef	2.55ab	97.6a
BTx643	2.0f	2.17abcd	94.7a

[1]GM = grain mold severity based on a scale of 1 to 5 [5] [25]. [2]Seedwt = seed weight based on weight in grams of 100 randomly selected seeds. [3]Germ = germination rate based on the number of seeds that germinated in 7 days out of 100 seeds. [4]Means within a column with the same letter(s) are not significantly different at the 5% probability level based on pairwise comparisons of least-square means with *t*-tests.

4. Discussion

Grain mold on sorghum is one of the most devastating diseases, resulting in both losses in grain yield and quality [6] [10] [26]. Several fungi associated with this disease are mycotoxigenic [13] [14] [15], complicating the ability to estimate the economic losses due to grain mold on a global basis [26]. The annual monetary loss due to grain mold globally of over $130 million put forth by Das *et al.* [11] is an underestimation. Management of grain mold can be challenging due to the number of fungi involved and the effect of weather conditions later in the growing season, if the mature grains are not harvested on time [7] [9] [11]. However, the use of resistant cultivars can mitigate grain mold losses.

In this study, the response of 23 sorghum lines used for anthracnose and head smut pathotype characterization was evaluated for grain mold resistance. Lines BTx643 and IS18760 exhibited the lowest grain mold severity, indicating that these two may possess genes for grain mold resistance. In addition, these two lines also recorded the highest germination rates 94.7% and 97.6%, respectively (**Table 1**). Nevertheless, BTx643 was reported to be highly susceptible to head smut [23], and IS18760 had been noted to be susceptible to several pathotypes of *Colletotrichum sublineola*, causal agent of sorghum anthracnose [24]. Over the years, grain mold-resistant sources were identified either under field environment, inoculation with one fungal species or mixture of fungi associated with the disease [6] [7] [17] [18] [19] [20] [27]. In India, Kumar *et al.* [27] reported several sorghum hybrids with resistance to grain mold. Accessions from Burkina Faso evaluated against *F. thapsinum*, *F. semitectum* and *C. lunata* in Isabela, Puerto Rico, identified several lines, including PI586182, PI647705, and PI647710 that exhibit high levels of grain mold resistance [22]. At the Texas A&M AgriLife Research Farm, Texas, accessions inoculated with a mixture of *F. thapsinum* and *C. lunata*, note that four accessions PI534101, PI534127, PI534050, and PI534145 exhibited a moderate resistant to resistant response to grain mold [6]. Also, Cuevas *et al.* [7] reported high number of accessions from Senegal that may possess genes for grain mold resistance. Although there are many reports of grain mold-resistant sources, the question remains how stable these resistance responses are across locations. Studies have shown that the frequency and recovery of fungi associated with grain mold on sorghum vary from location to location, and in some sorghum production areas, the frequency of isolation of the primary fungal species such as *F. thapsinum* and *C. lunata* is either low or non-existent [28] [29]. Navi *et al.* [30] noted that the duration of wetness will influence the infection and the frequency of infection by the grain mold fungi may vary, indicating that there is different window for grain mold infection during the grain development stages. The set of anthracnose sorghum differentials in this study was evaluated for panicle and leave diseases in two agroecological zones, Tillabéri and Maradi in Niger, West Africa. All 18 lines were infected with leaf blight, caused by *Exserohilum turcicum*; however, PI570726, an accession from Sudan was free of all other diseases observed in both locations [31].

Future research in grain mold studies would require planting sorghum lines in multiple geographic locations to identify stable resistant lines.

5. Conclusion

This study identified that the sorghum differentials BTx643 and IS18760 can be used in grain mold resistance breeding programs because they exhibited low infection, heavy seed weight and high germination rates.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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