mechanism and also helps to minimize predisposition to stalk rot (caused by *Fusarium moniliforne* Sheld.) in sorghum. Pedgaonkar and Mayec (1990) also discussed the role of stalk rot potential in relation to charcoal rot development in sorghum. Rosenow (1980) and Pande et al. (1989) found negative correlations between plant lodging and non-senescence. In the present study, the correlation and regression analyses clearly indicated that different senescent levels have positive correlations with disease development. The stay-green character means plants are not disposed the disease, and hence increase in stay-green level is an important factor in charcoal rot resistance. It is therefore possible that high-yielding non-senescent, charcoal rot-resistant offsprings could result from a crossing program involving B 35 or QL 41 (non-senescent) with high-yielding genotypes.

References

Duncan, R.R. 1984. The association of plant senescence with root and stalk diseases in sorghum. Pages 99 100 *in* Sorghum root and stalk rots—a critical review. Proceedings of the Consultative Group Discussion on Research Needs and Strategies for Control of Sorghum Root and Stalk Rot Diseases. Bcllagio, Italy, 27 Nov-2 Dec 1983. (Mughogho, L.K. and Rosenberg, G., eds.). Pantancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Pande, S., Mughogho, L.K., Seetharama, N., and Karunkumar, R.L. 1989. Effects of nitrogen, plant density, moisture stress and artificial inoculation with *Macrophomina phaseolina* on charcoal rot incidence in grain sorghum. Journal of Phytopathology 126: 343-352.

Pedgaonkar, S.M., and Mayee, C.D. 1990. Stalk water potential in relation to charcoal rot of sorghum. Indian Phytopathology 43(2): 192-196.

Rosenow, D.T. 1980. Stalk rot resistance breeding in Texas. Pages 306-314 *in* Sorghum diseases—a world review. Proceedings of the International Workshop on Sorghum Diseases, 11 15 December 1978, Patancheru 502 324, Andhra Pradesh, India. (Williams, R.J., Frediksen, R.A., Mughogho, L.K., and Bengston, G.D., eds.). Pantancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Effects of Crop Season, Storage Conditions, Cultivars, and Fungicide on Postharvest Mold Fungi Infecting Sorghum Grain

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Introduction

Field fungi often invade grains before harvest in the field and affect the quality of grain. The damage caused by fungi is often neglected until it reaches an advanced stage. In addition to direct losses some of these fungi produce mycotoxins that contaminate food and feed, and thus create health hazard for humans and cattle. The association of *Fusarium* spp. and *Aspergillus* spp. with grain has been a major cause of concern because of their ability to produce toxins (Bhat et al. 2000). Little information is available on frequency of fungi associated with postharvest sorghum grains and their management. We report here the fungal frequency recorded in grain samples collected from various storage systems, cultivars, seasons, and fungicide-treated grains, and suggest strategies to protect postharvested grain from mold fungi infestations.

Materials and methods

A total of 26 sorghum grain samples of hybrids, varieties and local cultivars were collected during surveys in 1997 in rural areas in the Indian states of Andhra Pradesh, Karnataka, and Maharashtra. The samples were drawn from sorghum grain stored by fanners for food in five different types of storage. Fifteen samples were collected from the 1996 rainy-season crop and 11 from the 1996/97 postrainy-season crop from gunny bags, mud-lined baskets (MB), polypropylene bags (PB), open storage in the corner of a room, and a mixture of MB and PB.

Using compartment probes (80 cm long x 2.5 cm diameter and 27 cm long x 1.5 cm diameter) 5-kg grain samples were drawn from each lot. Each grain sample was assessed for its fungal profile in a representative sample of 800 grains that were equally distributed in four

treatments: 1. grains surface-sterilized in 1% sodium hypochlorite (NaOCl), and not treated with benomyl, 2. grains surface-sterilized and treated with benomyl (0.05%), 3. grains not surface-sterilized, but treated with benomyl, and 4. control, no surface-sterilization and no benomyl treatment. The treated grains were transferred to pre-sterilized petridish humid chambers (25 grains petridish^{-1}) and were incubated at 28±1°C with a 12-h light/dark cycle for 5 d. Individual grain in all the four treatments were examined and the identity of the fungi were confirmed (Navi et al. 1999). The frequency offungi found was determined using a Statistical Analysis System (SAS) procedure.

Results and discussion

The major fungi observed with mean fungal frequency of >5% in various storages, cultivars, seasons, and treatments were—*Alternaria alternata* (Fr.) Keissler; *Aspergillus flavus* Link; *A. niger* van Tieghem; *Bipolaris australiensis* (M.B. Ellis) Tsuda & Ueyama; *Curvularia lunata* (Wakker) Boedijn; *C. lunata* var *aeria* (Bat., Lima, & Vasconcelos) M.B. Ellis; *Fusarium moniliforme* J. Sheld. *Lisea fujikuroi* Sawada, *Penicillium citrinum* Thorn; *Phoma sorghina* (Sacc.) Boerema, Dorenbosch, & van Kesteren; and *Rhizopus stolonifer* (Ehrenb:Fr.) Lindner. 39 other fungi (Navi et al. 1999) with <5% mean frequencies recorded in the study are not reported.

Effect of season. In 15 samples collected during the rainy season the mean grain germination was only 52% compared to 99% in 11 postrainy-season samples (Table 1). In addition, the frequency of the potentially toxin-producing fungus *F. moniliforme* was higher (15%) in the rainy season samples than in the postrainy samples (9%). The frequencies for *A. flavus* were 3% in the rainy and 2% in the postrainy season samples. Similarly, the spectrum of other major fungi varied depending on the season during which grain samples were drawn. The fungi with high frequencies were *A. alternata, C. lunata, C. lunata* var. *aeria,* and *F. moniliforme.*

Effect of storage types. Storage types also influenced the grain germination and fungal frequency (Table 2). Higher grain germination (86-92%) was recorded from gunny bags and MB-stored grain than from that stored in in other containers (21-43%). Grain stored in the corner of a room, had 0.1% *A. alternata* compared with 12-16% in

Table 1. Effect of season on frequency of mold fungi in sorghum grain samples

Haravesting season	Samples	Germination (%)	Major fungal[1] frequency (%)[2]									
			AA	AF	AN	BA	CL	CLA	FM	PC	PS	RS
Rainy	15	52	13	3	6	5	19	16	15	0.3	5	6
Postrainy	11	99	16	2	3	4	12	10	9	2	3	11
SE (M)i.		23.5	1.5	0.5	1.5	0.5	3.5	3.0	3.0	0.9	1.0	2.5

1. AA = *Alternaria alternata,* AF = *Aspergillus flavus,* AN = *A. niger,* BA - *Bipolaris australiensis,* CL = *Curvularia lunata,* CLA = *C. lunata* var *aeria,* FM = *Fusarium moniliforme,* PC = *Penicillium citrinum,* PS = *Phoma sorghina,* and RS = *Rhizopus stolonifer*
2. Across treatments, cultivars, and storage conditions

Table 2. Effect of storage type on frequency of mold fungi in sorghum grain samples

Storage type	Samples	Germination (%)	Major fungal[1] frequency (%)[2]									
			AA	AF	AN	BA	CL	CLA	FM	PC	PS	RS
Corner of a room	1	21	0.1	0.2	7	0	16	1	25	0	2	6
Gunny bag	14	92	16	3	7	4	6	5	6	2	2	9
Mud-lined baskets (MB)	7	86	12	3	3	8	16	22	15	1	6	9
Polypropylene bags (PB)	3	37	16	4	4	1	29	9	14	0.2	2	7
PB/MB	1	43	13	0	1	4	20	42	24	0	13	7
SE (M)±		14.5	2.9	0.8	1.2	1.4	3.7	7.4	3.5	0.4	2.1	0.6

1. A A = *Alternaria alternata,* AF = *Aspergillus flavus,* AN = *A. niger,* BA = *Bipo laris australiensis,* CL = *Curvul aria lunata,* CLA = C. *lunata* var *aeria,* FM = *Fusarium moniliforme,* PC = *Penicillium citrinum,* PS = *Phoma sorghina,* and RS - *Rhizop us stolonifer*
2. Across treatments, cultivars, and storage conditions

Table 3. Effect of sorghum cultivars on frequency of mold fungi in sorghum grain samples

Genotypes	Samples	Germination (%)	Major fimgal[1] frequency (%)[2]									
			AA	AF	AN	BA	CL	CLA	FM	PC	PS	RS
CSH 9	6	60	24	1	1	5	37	19	17	0.1	6	3
Dagri local	1	100	10	0	6	5	6	1	8	0	0.1	23
JK 22	2	44	1	4	4	7	4	16	13	0	3	20
Local	1	91	1	3	0.2	0	3	0	10	0	22	6
Maldandi/ Dagri local	1	93	12	1	6	2	8	6	3	9	0	16
Maldandi	11	98	16	3	5	4	3	4	7	3	2	10
MSH 51	3	54	4	8	14	4	8	18	17	0.1	2	6
SPH 468	1	68	12	2	7	6	15	37	16	0	2	0
SE(M)±		7.8	2.8	0.9	1.5	0.8	4.0	4.4	1.8	1.1	2.6	2.9

1. AA = *Alternaria alternata,* AF = *Aspergillus flavus,* AN = *A. niger,* BA = *Bipolaris austral tensis,* CL = *Cunwlaria lunula,* CLA = *C. lunata* var *aeria,* FM = *Fusahum moniliforme,* PC = *Penicillium citrinum,* PS = *Phoma sorghina,* and RS = *Rhizopus stolonifer*
2. Across treatments, cultivars, and storage conditions

Table 4. Effect of seed treatment with benomyl on frequency of mold fungi in sorghum grain samples

Grain treatment	Germination (%)	Major fungal[1] frequency (%)[2]									
		AA	AF	AN	BA	CL	CLA	FM	PC	PS	RS
1.. Surface-sterilized not treated with benomyl	79	13	1	2	4	11	8	17	0.1	5	0.4
2. Surface-sterilized and treated with benomyl	81	15	1	1	4	11	11	1	0	1	1
3. No surface-sterilization but treated with benomyl	79	17	0.2	1	6	13	18	1	0	2	11
4. Control, no sterilization or benomyl	76	12	10	17	4	17	9	27	6	7	23
SE(M)±	1.0	1.1	2.3	3.9	0.5	1.4	2.3	6.4	1.5	1.4	5.3

1. AA = *Alternaria alternata,* AF = *Aspergillus flavus.* AN = *A. niger,* BA = *Bipolaris australiensis,* CL = *Curvularia lunata,* CLA = *C. lunata* var *aeria,* FM = *Fusarium moniliforme,* PC = *Penicillium citrinum,* PS = *Phoma sorghina,* and RS = *Rhizopus stolonifer*
2. Across treatments, cultivars, and storage conditions

other types of storage. Similarly, the frequencies of other fungi differed with types of storage. The major fungi were the same four reported above.

Effect of sorghum cultivars. Among the eight sorghum cultivars, higher grain germination was observed in local cultivars (91-100%) than in hybrids (44-68%) (Table 3). On the contrary, CSH 9 had highest frequency of *C. lunata* (37%), followed by *A. alternata* (24%), *C. lunata* var *aeria* (19%) and *F. moniliforme* (17%). The frequency of *F. moniliforme* was higher in the hybrids (13-17%) than in Maldandi and local cultivars (3-10%). While the frequency of *A. flavus* in MSH 51 was 8% and that of *P. citrinum* in Maldandi/Dagri local was 9%. However, the frequency of other major fungi varied between hybrids and local cultivars.

Effect of benomyl seed treatment. Of the four treatments, the highest grain germination (81%) was recorded from grains surface-sterilized with NaOCl and treated with benomyl compared with the control (76%) (Table 4). However, surface-sterilization of grains with NaOCl did not eliminate all the fungi, indicating that most of the major fungi were internally seedborne. Grains treated with benomyl with or without surface sterilization considerably reduced the frequency of *A. flavus, F. moniliforme* and *P. citrinum.* Benomyl treatment (0.05%) greatly reduced the frequency of *F. moniliforme* from 27% in the control to 1% in treated grains. Besides *F moniliforme,* benomyl was also effective against *A. flavus, A. niger, P. citrinum,* and *P. sorghina,* but it was not effective against *Alternaria, Bipolaris,* and *Curvularia* spp.

Conclusion

In storage, fungi can develop if grains are stored without sufficient drying, if grain is damaged during harvest, handling, threshing, and drying, and if the moisture content of grains increases during storage. In this study it was observed that, most of the fungi appeared to have come from field infestation. *A. flavus,* and *P. citrinum* have also been recorded in storage. Based on the results of this study, it is suggested that grain is stored either in gunny bags or jute bags rather than in other containers mainly to minimize the damage from *Fusarium* spp., or that mold-tolerant/resistant genotypes are grown during the rainy season. Benomyl-treated grains could be used as seed for the next season's crop.

Acknowledgments

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the developing countries. The views expressed are not necessarily those of DFID (R 6767, Crop Post-Harvest Programme).

References

Bhat R.V., Shetty, H.P.K. and Vasanthi, S. 2000. Human and animal health significance of mycotoxins in sorghum with special reference to Fumonisins. Pages 107 -115 *in* Technical and Institutional options for sorghum grain mold management: Proceedings of an international consultation, 18-19 May 2000, ICRISAT, Patancheru, India (Chandrashekar, A., Bandyopadhyay, R., and Hall, A.J., eds). Patancheru, 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Navi, S. S., Bandy opadhy ay, R., Hall, A. J ., and Bramel-Cox, P. 1999. A pictorial guide for the identification of mold fungi on sorghum grain. Information Bulletin no 59 (in En, Fr). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 118 pp.
http://www.icrisat.org/text/research/grep/homepagc/sorghum/sfm/homepage.htm

An Outbreak of Sorghum Ergot in Parts of Andhra Pradesh, India

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Introduction

Ergot (*Claviceps sorghi* P. Kulkarni et al. and *C. qfricana* Frederickson, Mantle, and de Milliano) of sorghum (*Sorghum bicolor* (L.) Moench) is a serious limiting factor in hybrid seed production, particularly if seed set in male-sterile lines is delayed due to lack of viable pollen caused by non-synchronous flowering in male-sterile and restorer lines. Further, environmental conditions favorable for disease development are not congenial to rapid seed set, thus making spikelets more vulnerable to ergot attack (Bandy opadhy ay 1992). In this paper we report the occurrence of ergot in epidemic form in Maachinenipalli village towards the end of the rainy season (1-8 October 1999) and its further spread in 12 administrative zones of Mahbubnagar and two zones of Ranga Reddy districts in Andhra Pradesh from a survey conducted in 2000.

Materials and methods

A total of 28 farms were surveyed in Andhra Pradesh during an ergot epidemic in the rainy season 2000. The areas represent the major sorghum-growing belt of Mahbubnagar district where sorghum was grown on over 130,000 ha (Source: Associate Director of Research, Regional Agricultural Research Station (RARS), Palem 509 215, Mahbubnagar District). Most of the farmers sow local Yellow Jowar, local White Jowar and ICSV 745 as dual-purpose sorghums during the rainy seasons, and SSG 777 and SSG 878 are exclusively grown for fodder in areas of Kalwakurthy administrative zone all year round.

The incidence and severities of ergot was recorded from each field in an area of approximately 12-m^2 in each of three randomly selected subplots. Based on the number of infected plants and the total plants the incidence (%)