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Mycoflora Compositions of Sorghum (*Sorghum bicolor* L. Moench) Grains from Eastern Region of Kenya

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Sorghum is an important cereal crop produced as staple food in Eastern region of Kenya prone to fungal infection. Mycological examination on farm surveyed 150 sorghum grains samples (each weighing 250 g) of improved variety (Gadam-greyish grains) and a landrace (reddish grains) from farmers at Machakos, Makueni, Kibwezi East and West which are semi arid low lands. Mycoflora culturing on grains was by direct plating method on potato dextrose agar (PDA) for *Aspergillus* and *Penicillium* spp. while malachite green agar 2.5 (MGA 2.5) for *Fusarium* spp. Sorghum grains were infected with mycoflora composition of *Aspergillus*, *Fusarium* and *Penicillium* genera. *Aspergillus* and *Fusarium* species had a high percentage frequency and relative frequency of fungi isolates from improved varieties and a few in landraces. *Penicillium* species had a lowest percentage and relative frequencies isolates on both the improved and landraces sorghum varieties. Significant difference was observed between the frequency of fungi isolates from the improved and landraces of sorghum grains. These results indicate possible health hazards for humans and animals consumption of such infected food grain with a composition of mycoflora.

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Keywords: Percentage frequency; relative frequency; improved; landrace; mycoflora.

1. INTRODUCTION

Sorghum is the fifth most economically important cereal crops with an annual production of 60 million tones. Besides being an important food, feed and forage crop, it also provides raw material for the production of starch, fiber, dextrose syrup, biofuels and alcohol among other products [1]. More than half of the world's sorghum is grown in semi-arid tropics of India and Africa, where it is a staple food for millions of poor people [1]. The increasing worldwide concern about food and nutrition insecurity has enhanced interest in fungal contamination and subsequent production of mycotoxins in food products. In this regard, attention is continuously focused on sorghum because it is an important dietary staple food and feedstuffs in different regions of the world [1]. Mycotoxigenic fungi are significant constraints to the realization of food and nutritional security in sub-Saharan Africa (SSA) is grain yield loss caused by Insect pests and diseases. Many diseases are caused by fungi, are the most important diseases of sorghum [2]. The fungi produce toxic substances, known as mycotoxins, including aflatoxins, which cause various diseases in humans and animals. It is estimated that about 25% and 50% of grain losses in SSA are due to these toxic substances [3]. Sorghum grains are often contaminated by moulds as they are ideal substrates for mould growth when poorly dried and stored and are a serious biotic constraint in sorghum production areas [4]. Fungal species associated with sorghum belong to the genera *Fusarium*, *Aspergillus* and *Penicillium*, which produce mycotoxins that cause mycotoxicosis in animals and humans. Studies have shown fungi and their mycotoxins in sorghum grains [2,5]. Mycotoxins are produced by fungal at pre and post harvest activities of sorghum grains [6]. Mycotoxins are carcinogenic, teratogenic, mutagenic, immunosuppressive, hemorrhagic, and hepatotoxic [7]. Mycotoxin attracts attention consumer of agricultural produce and products worldwide because of the significant economic losses associated with their impact on human health animal productivity and trade [8]. There is a lack of accurate data on the frequency and relative percentage of mycotoxigenic fungi isolated from sorghum grains produced semi arid low and in Eastern Kenya. This has made not to be possible to develop effective management strategies to prevent mycoflora infection and bio-deterioration of sorghum grains. This study was undertaken to identify the distribution, frequency and a relative percentage of mycoflora in sorghum grains produced semi arid low land in Eastern Kenya.

2. MATERIALS AND METHODS

2.1 Collection of Sorghum Samples

A farm surveys was carried out in the semi arid low land of sorghum growing areas, Machakos, Makueni, Kibwezi East and West which are in Eastern Kenya. The region experiences an average annual rainfall of between 250 and 500 mm [9]. The long rains start at the mainly in mid of March and last until May while the short rains start in October to December. The minimum and maximum temperatures in this region range from 23 to 35℃ [10]. Sorghum samples were collected a month after harvest in each of the two main seasons of March to July 2015 and October 2015 to February 2016 in the respective areas of study. Snowball random sampling of farmers was done at each of the seasons of August 2015 and March 2016. Samples were separately put in khaki bags, transported in a cool box to the laboratory and stored at 4℃ until all the samples were subjected to mycological analysis. During the second season, repeated sampling was undertaken in the same areas as the first one. In total of 300 sorghum samples were collected during both season each weighing two hundred and fifty grams. This was done taking into consideration that home grown maize was a major source of contamination compared to the one purchased hence the exclusion during sampling [11].

2.2 Preparation of the Culturing Media

The media was prepared according to the manufacturer's manual by suspending 39 g of the potato dextrose agar powder (PDA) in one litre of distilled water. It was heated for the powder to completely dissolve. The medium was sterilized by autoclaving (WACS-1100) at 121℃ for 15 minutes and was allowed to cool to about 45℃. The cooled media was aseptically poured into petri-dishes in a laminar flow (model LCB-0153B-A2) and allowed to solidify.

2.2.1 Isolation and identification of mycoflora compositions

Isolation of fungi from the sorghum grains from the farm surveys were carried out as described

by [8]. after surface sterilization of grains in 2% NaOCl. Fifteen grains were randomly picked from the khaki bags and they were introduced into a conical flask containing NaOCl, swirled gently for two minute. Afterwards, they were removed and rinsed thrice in sterile distilled water. Sorghum grains were plated on potato dextrose agar (PDA) medium by agar direct plating method [12]. Five grains were plated at about 2.5 cm apart on petri dishes (90 mm diameter × 15 mm height) containing Czapek Agar amended with 50 mg each of streptomycin sulphate and penicillin per litre of medium. The set up was replicated thrice for each sample in a complete randomized design. All the culture plates were incubated in a growth chamber (PIN30 (201)) at 26±2℃ for 7 days. Malachite green agar 2.5 medium was used for the isolation of *Fusarium* species from the natural sources of sorghum grains [13]. Fungi species were isolated from colonies in petri dishes then sub-cultured in potato dextrose agar and incubated as above. Upon fungi maturation, they were classified based on cultural and morphological features such as colony diameter, colony colour on agar, front and reverse and colony texture [14]. Slide culture was then prepared and incubation in moist chambers at 26±2℃ for 4 days before observation under a light microscope (labomed, model CxL). Mycological keys and manuals were used for macro and microscopic features that are commonly used identification of fungi, which were conidiophores, conidial shape, phialides and metulae, presence and shape of vesicles [15,14,12]. The frequency of fungi and relative percentage of particular species with in a genus of fungi was calculated using the formula [16].

$$Frequency\ (\%) = \frac{Number\ of\ samples\ infected\ with\ fungi}{Total\ number\ of\ samples\ analysed} \times 100$$

$$Relative\ percentage(\%) = \frac{Number\ of\ fungal\ species\ isolated}{Total\ number\ of\ fungi\ isolated} \times 100$$

2.3 Screening for the *Aspergillus* species

Toxin producing ability of the fungi was tested following the ammonium hydroxide (NH4OH) vapour test [17]. A single fungal colony was grown in the centre of a Petri dish containing yeast extract-sucrose medium for 5 days at 27℃. Then 2 drops of concentrated (28%) NH4OH solution were added to the inverted lid of the Petri dish and allowed (30 min) to react. Toxin production (positive test) was evidenced by formation of a pink to plum-red colour on the underside of the fungal colony while negative tests had no observable colour changes [18].

2.4 Data Analysis

The data on the abundance of the fungi in each study region were represented as a percentage of score total count. Analysis of variance was performed to determine whether the distribution of the *Aspergillus, Fusarium and Penicillium* isolates in the four study sites were significantly different. Student t-test was performed to determine whether the distribution of the species between the two seasons was statistically significant. Cluster analysis was performed with the software package SPSS 20.0 (version 20.0) cross tabulation was used in the analysis of data.

3. RESULTS

In the present investigation, mycological examination of 150 sorghum samples revealed the occurrence of 13 fungal genera such as *Fusarium, Aspergillus and Penicillium* species. The most dominant fungal genera were *F. moniliforme* and *A. flavus* with a high frequency of 95.0 and 81.7% with a relative percentage of 28.2 and 21.7%, respectively. The other fungal genera such as *P. frequentans* (34.3%) were also isolated with the different level of frequency and relative percentage (Tables 1,2 and 3). Six species of *Aspergillus species,* the predominant being were *A. flavus* (81.7%), *A. niger* (77.0%) and *A. parasiticus* (68.3%) with the relative percentage of 21.7, 20.5% and 18.6% respectively. The three *Aspergillus* species such as *A. niveus* and *A. clavatus* were recorded with a frequency of 60.0 and 57.7%. A low frequency of *A. terreus* (31.7%) was recorded. An important observation made in the present investigation is that *A. flavus* was isolated from all the samples with high frequency and relative density (Table 1). The study showed the presence of six *Fusarium* species. A high frequency of *F. moniliforme* (95.0%), *F. dimerum* (93.0%), *F. colmorum* (65.0%) and *F. laterium* (36.0%) recorded on from sorghum grain samples. A low frequency of *F. nivale* and *F. poae* (31.0 and 18.3%) recorded on sorghum grain samples, respectively. An important observation made in the present investigation is that *F. moniliforme* was isolated from almost all the samples with high frequency and relative density (Table 2) *Penicillium frequentans* was the only isolate (Table 3).

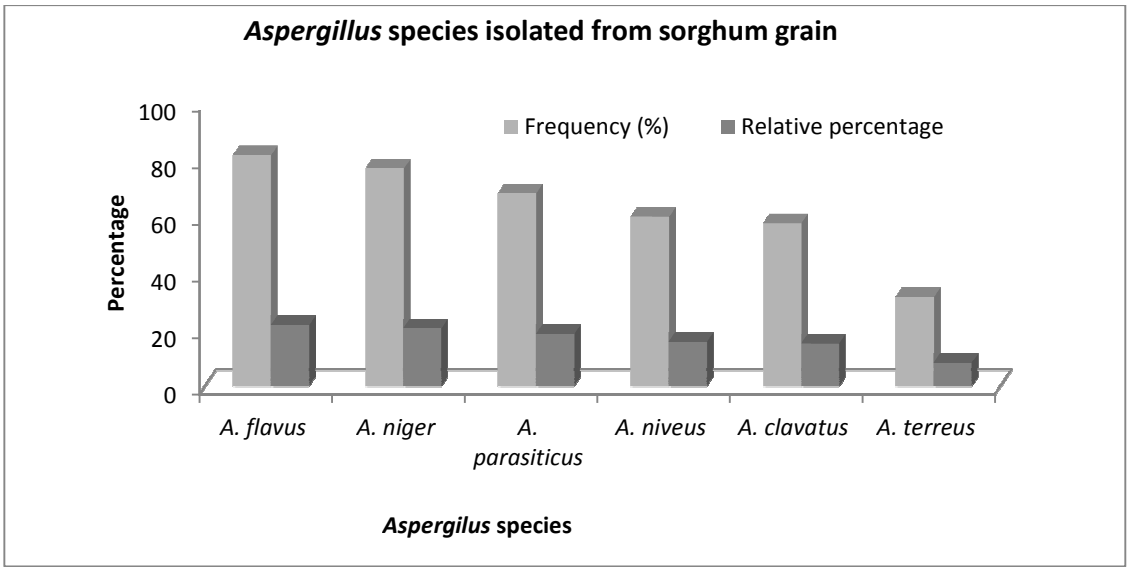

Fig. 1. *Aspergillus* species from sorghum grains

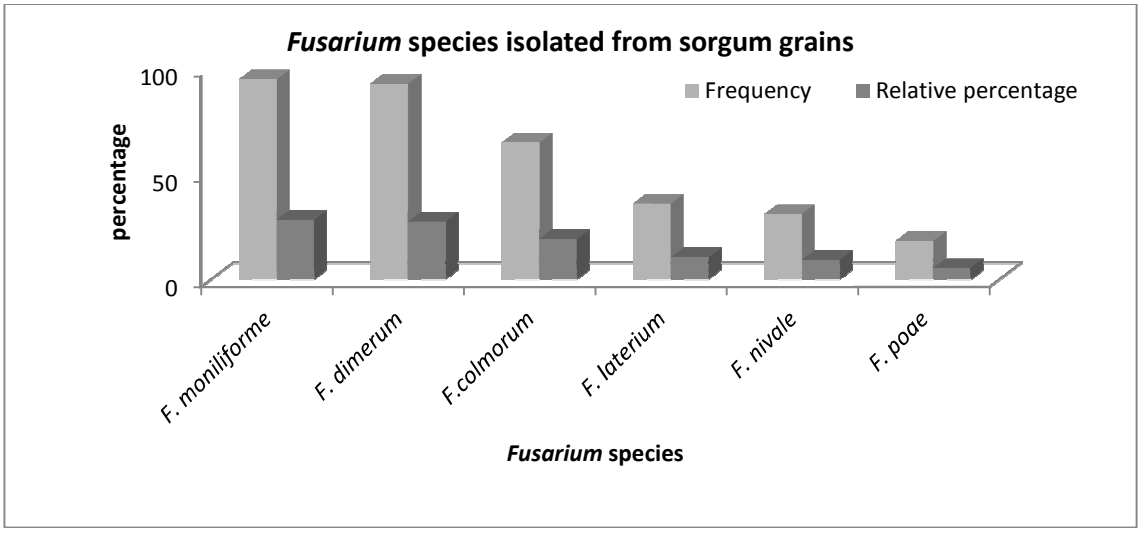

Fig. 2. *Fusarium* species from sorghum grains

Table 1. *Aspergillus* species isolated from sorghum grain samples

Sample no.	Name of fungus	Total no. of isolates	Frequency (%)	Relative percentage
1	*A. flavus*	435	81.7	21.7
2	*A. niger*	231	77.0	20.5
3	*A. parasiticus*	205	68.3	18.6
4	*A. niveus*	180	60.0	15.9
5	*A. clavatus*	173	57.7	15.3
6	*A. terreus*	95	31.7	8.4

Due to the sampling procedure that was followed and the choice of only analyzing the farmers who planted sorghum crop and excluding those who stored their produce to the subsequent season whose samples were collected for this study. It was not possible to

reliably compare the study sites in Eastern Kenya region and respective two seasons but rather consider the entire region as a block. This could partly explain why there were some observable differences in distribution of fungi in the two sampling seasons but they did not appear significant. In general, there were *Aspergillus, Fusarium* and *Penicillium* species isolated from sorghum samples in the two seasons. This was consistent in each of the location (Tables 4, 5 and 6).

There was a general percentage incidence and distribution of *Aspergillus, Fusarium and Penicillium* species across the four study sites isolated from sorghum grains except for *A. terreus* in Makueni (0.00%) and *F. moniliforme* (0.00%) in Kibwezi East (Table 7).

3.1 Isolates of Mycoflora Compositions from Sorghum Grains

The morphological and cultural features of the *Aspergillus, Fusarium and Peniccillium* isolates are presented in Table 8. In total (from both seasons), 324 isolates were obtained from sorghum grains samples. The identification process resulted into 6 *Aspergillus* 6 *Fusarium and* 5 *Peniccillium* species (Table 8 and Plate 1).

4. DISCUSSION

The results of this study indicated that the type of fungal contamination of sorghum grains, at Eastern Kenyan region, was qualitatively comparable to that found in other sorghum producing countries such as the African countries [2]., United States [19]., Switzerland [20], United Arab Emirates [5] and India [21].

The key potential impacts of climate change, food safety and food security have received relatively less attention. Agriculture is profoundly affected by the main climatic factors that may change significantly in the near future: Temperature, precipitation, drought, and atmospheric carbon dioxide. A number of agricultural entities could be affected by these climatic factors, including soil quality, crop yields, and the biological environment of crops such as the abundance of pests and plant pathogens. Mycoflora are among the food-borne risks that are dependent upon climatic conditions. Indeed, the ability of fungi to produce mycoflora is largely

Table 2. *Fusarium* species isolated from sorghum grain samples

Sample no.	Name of fungus	Total no. of isolates	Frequency (%)	Relative percentage
1	*F. moniliforme*	285	95.0	28.2
2	*F. dimerum*	278	93.0	27.4
3	*F. colmorum*	195	65.0	19.2
4	*F. laterium*	108	36.0	10.6
5	*F. nivale*	93	31.0	9.4
6	*F. poae*	55	18.3	5.4

Table 3. *Penicillium* species isolated from sorghum grain samples

Sample no.	Name of fungus	Total no. of isolates	Frequency (%)	Relative percentage
1	*P. frequentans*	103	34.3	1.0

Table 4. Distribution of *Aspergillus* sp. in the two planting seasons

Aspergillus species	Season				
	I		II		Total
	Count	%	Count	%	Count
A. flavus	240	25.29	217	22.53	417
A. niger	198	19.92	223	23.16	421
A. parasiticus	176	18.54	194	20.15	370
A. niveus	143	16.07	133	13.81	276
A. clavatus	121	12.75	109	12.11	230
A. terreus	71	7.48	87	9.03	158

influenced by temperature, relative humidity, insect attack, and stress conditions of the plants [22]. Therefore studies on frequency and their relative percentage of mycotoxigenic fungi are highly useful and required for further studies on toxin producing fungi and their epidemiological significance in sorghum crop. Several genera and species of filamentous fungi significant agricultural, epidemiological and economic impact. *Aspergillus*, *Fusarium*, and *Penicillium* genera are mycotoxigenic fungi responsible for the majority of agricultural mycotoxin contamination. These fungi are common components of the microbial flora associated with many agronomic crops, including sorghum [23]. Many previous studies have reported cereal grain during ripening as well as grape development represent food ecosystems that are colonized by mycotoxigenic fungi, which are influenced by abiotic factors such as prevailing temperature, relative humidity, especially at a microclimate level and storage conditions in many regions around the world [24]. Previous studies identified genus *Fusarium*, *Aspergillus* and *Penicillium* as mycotoxigenic fungi were isolated from in all the sorghum grain samples in this study. It was report as a natural contaminant in sorghum crops and also in many other agricultural commodities [25]. It seems that traditional methods of handling grains during harvesting in the field, drying, threshing and process in relevant country lead to mechanical damage of grains, broken and ground grains are more vulnerable to fungal attack than whole grains [26]. Insects and rodents may also contribute to deterioration of grains rapidly and increasing mycoflora during long term storage [27]. The use of good agricultural practices that would discourage fungal growth and mycoflora production would be necessary to reduce mycotoxin levels in the grain and grain products. Contact of the grains with the soil should be avoided during harvest and drying to avoid contamination with the fungal inocula present in the soil. Drying of grain to safe moisture levels of 12% below on mats and polythene sheets to avoid contact with soil surface and cleaning of stores at the end of each season would reduce chances of infection and mould growth [28].

Table 5. Distribution of *Fusarium* sp. in the two planting seasons

***Fusarium* species**	**Season**				
	I		**II**		**Total**
	Count	**%**	**Count**	**%**	**Count**
F. moniliforme	265	26.89	246	24.28	511
F. dimerum	237	29.31	255	25.17	492
F. colmorum	217	22.01	209	20.63	426
F. laterium	107	10.85	119	11.75	226
F. nivale	91	9.23	103	10.17	194
F. poae	69	7.00	81	8.00	150

Table 6. Distribution of *Penicillium* sp. in the two planting seasons

***Penicillium* species**	**Season**				
	I		**II**		**Total**
	Count	**%**	**Count**	**%**	**Count**
P. frequentans	207	1	186	1	393

Table 7. The incidence (%) and distribution of *Aspergillus, Fusarium and Penicillium* species across the four study sites (30>N<40)

***Aspergillus* species**	**Sites**			
	Machakos (N=38)	**Makueni (N=37)**	**Kibwezi East (N=39)**	**Kibwezi West (N=36)**
A. flavus	25.29	30.15	28.50	36.78
A. niger	19.92	23.56	27.78	21.64
A. parasiticus	18.54	17.30	15.40	12.80
A. niveus	16.07	13.40	17.60	12.20
A. clavatus	12.75	11.30	9.02	5.50
A. terreus	7.48	0.00	3.40	6.50
F. moniliforme	26.89	30.10	28.90	0.00
F. dimerum	29.31	35.50	30.12	25.04
F. colmorum	22.01	25.08	18.70	25.35
F. laterium	10.85	9.08	11.49	8.72
F. nivale	9.23	8.43	10.37	12.20
F. poae	7.00	5.07	8.95	10.45
P. frequentans	11.24	15.08	20.40	13.60

Table 8. Cultural, morphological and microscopic features of the identified *Aspergillus*, *Fusarium* and *Penicillium* species

Fungi species	Cultural and morphological features on PDA			Microscopic features			Conidiophores
	Colony diameter (mm)	Surface colour	Reverse colour	Vesicle shape	Conidial head	Colony seration	
A. flavus	37±2	Deep green/olive green conidia with white margin Presence of white mycelia	Cream to brown reverse with a smooth texture	Globose	Columnar	Biseriate	Colourless, relatively short roughened conidiophores
A. niger	58±2	Dark brown to black densely matted conidia, rare white mycelia with cream margin	Yellow to dull brown reverse with a wrinkled texture	Globose	Radiate	Biseriate	Brownish, relatively long conidiophores with smooth surfaces
A. parasiticus	Almost full plate	Coniferous green conidia with white mycelia white margin	Cream reverse with slightly wrinkled centre	Globose	Columnar	Uniseriate	Colourless short and finely roughened
A. niveus	23±2	Dull orange-white conidia with white mycelia	Yellow-gold reverse with star-shaped striations and concentric ring patterns	Columnar	Radiate	Biseriate	Colourless, short and finely roughened
A. clavatus	34±2	Blue-green conidia, white mycelia with a white margin	Brown centre with alternating yellow and brown concentric rings	Clavate	Radiate	Uniseriate	Brownish, short and finely roughened
A. terreus	25±2	Brownish-orange conidia with white aerial mycelia	Yellow to gold reverse with star-shaped striations and concentric ring patterns	Sub-globose	Columnar	Biseriate	Colourless short smooth-walled conidiophores
F. moniliforme	26±2	White aerial mycelium tinged purple	Tinged purple to colourless	Globose	Radiate	Biserate	brown conidia on of conidiophores
F. dimerum	28±2	Whitish aerial mycelia with orange margin	Whitish to orange reverse with concentric rings	Sub-globose	Columnar	Biserate	Colourless, short and finely roughened
F. colmorum	25±2	White aerial mycelia	Whitish to orange reverse with alternating whitish and brown concentric rings	Globose	Radiate	Uniseriate	Colourless short and finely roughened

Fungi species	Cultural and morphological features on PDA			Microscopic features			Conidiophores
	Colony diameter (mm)	Surface colour	Reverse colour	Vesicle shape	Conidial head	Colony seration	
F. laterium	33±2	White to pink aerial mycelia	Pinkish to pinkish reverse with concentric ring	Sub-globose	Radiate	Uniseriate	Colourless, short and finely roughened conidiophores
F. nivale	29±2	White to pink aerial mycelia with orange margin	Pinkish to orange with slightly wrinkled centre	Globose	Radiate	Uniseriate	Colourless, short and finely roughened conidiophores
F. poae	27±2	Densely aerial mycelia that are white to pink in colur	Carmine red with smooth texture	Glopbose	Radiate	Unisarate	Long conidiophores with smooth surfaces
P. frequentans	27±2	Green to dark green colony	Pale yellow with a smooth texture	Globose	Columnar	Uniseriate	Long conodiophores with smooth surface

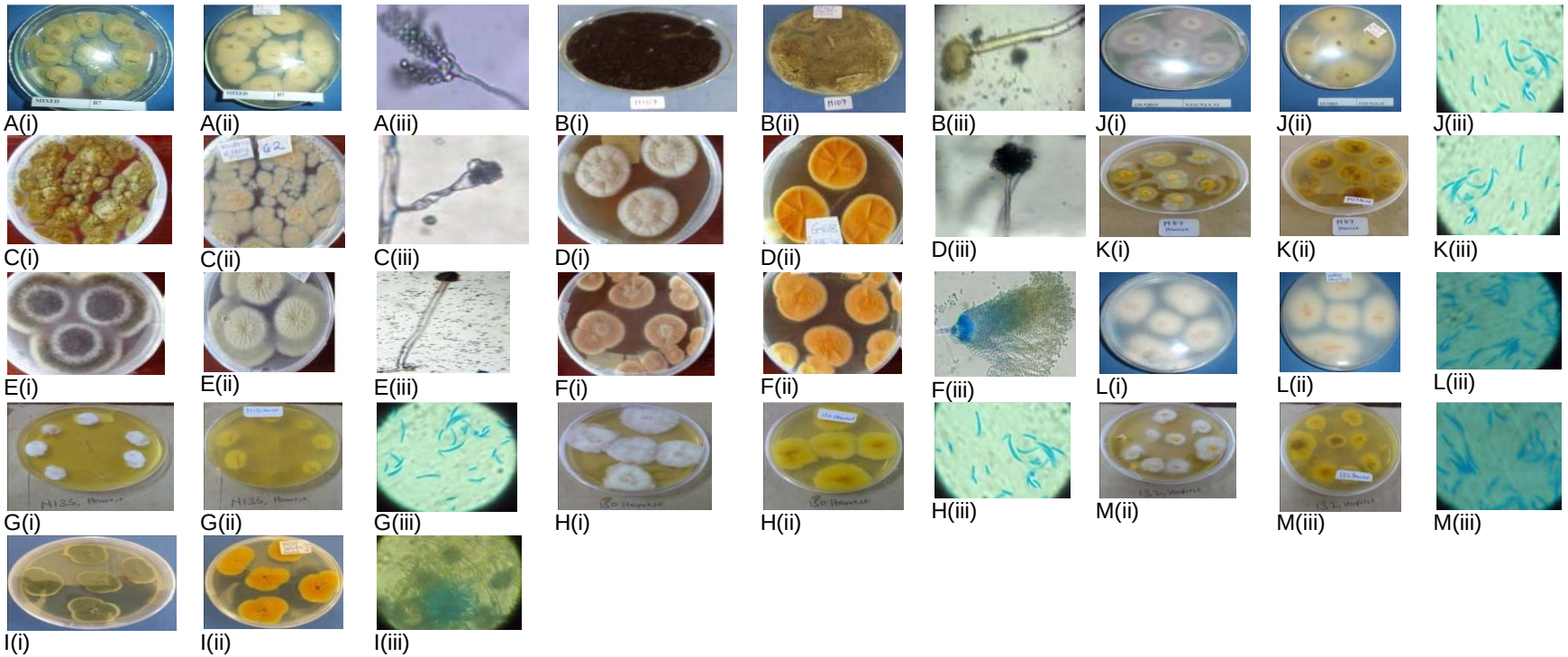

Plate 1. Cultural and morphological features of fungi species growing after 7 days of incubation observed under the microscope (Mg=400×). A(i) *A. flavus* surface, A(ii) *A. flavus* reverse and A(iii) biseriate conidial head with a globose vesicle; B(i) *A. niger* surface, B(ii) *A. niger* reverse and B(iii) A globose vesicle; C(i) *A. parasiticus* surface, C(ii) *A. parasiticus* reverse and C(iii) clavate vesicle; D(i) *A. niveus* surface, D(ii) *A. niveus* reverse and D(iii) short, finely roughened; E(i) *A. clavatus* surface, E(ii) *A. clavatus* reverse and E(iii) brownish, relatively long and smooth conidiophore; F(i) *A. terreus* surface, F(ii) *A. terrus* reverse and F(iii) columnar conidial ornamentation; G(i) *F. colmorum* surface, G(ii) *F. colmorum* reverse and G(iii) curved macro and micro conidia observed under the microscope. H(i) *F. laterium* surface, H(ii) *F. laterium* reverse and H(iii) short stipe of curved conidia under the microscope; I(i) *P. frequentans* surface, I(ii) *P. frequentans* reverse and I(iii) conidial head with a globose vesicle, J(i) *F. dimerum* surface and J(ii) *F. dimerum* reverse and J(iii) slightly curved conidia (Mg=×1000); K(i) *F. moniliforme* surface, K(ii) *F. moniliforme* reverse and K(iii) stripe of curved conidia, L(i) *F. poae* surface, L(ii) reverse and L(iii) curved macro and micro conidia observed under the microscope, M (i) *F. nivale* surface, L(ii) *F. nivale* reverse and L(iii) long curved septate conidia observed under the microscope

Eastern Kenyan region has a biennial rainfall pattern with a varied agro-climatic condition that produces a wide range of crop in the seasons. The use of non-scientific method of agricultural practices, poor storage facilities and unfavourable environmental conditions during pre and postharvest handling of the crop produce are responsible for contamination, infection and colonization by mycoflora producing fungi [29]. Fungi grow on a cereal; which reduces the germination, loss of carbohydrate, protein and oil content, the increase of moisture content, free fatty acids and thus reduces dry matter content [30].

Fungal growth also causes discolouration of grain, heating, mustiness and production of secondary metabolites like mycotoxins that are potentially dangerous to humans and animals [31]. Studies on frequency and their relative percentage are useful and necessary for further studies on toxin producing fungi and epidemiological significance in cereal crops grown in eastern Kenyan region and other regions.

In this study, mycological examination of sorghum samples exposed the occurrence of fungal genera such as *Fusarium, Aspergillus and Penicillium* species. This concurred with a study [16] that occurrence *of Fusarium, Aspergillus and Penicillium* species was predominant incidence of fungal species on various cereals crops.

The findings of the present study reports six *Aspergillus* spp. (*A. flavus, A. niger, A. parasiticus, A. niveus, A. clavatus,* and *A. terreus*) were isolated where *A. flavus,* was predominant this concurs with the study of [28], in his study of two consecutive years, 2008-2009, [32] reported that *A. flavus* as being the most abundant in the same region of study. Moreover, [28] reported seven species (*A. flavus, A. niger, A. ochraceus, A. terreus, A. clavatus, A. versicolor* and *A. fumigatus*). In this study six fungi species (*A. flavus, A. niger, A. parasiticus, A. niveus, A. clavatus* and *A. terreus*), four of which matched an earlier study of [28] except for *A. parasiticus* and *A. niveus* which were isolated in this study and are known to be toxigenic while three were not isolated in this study, *A. ochraceus*, *A. versicolor* and *A. fumigates.* The differences in the fungi species could be due to varying time in sample collection [33], sampling strategy [34] and the season of sample collection which could lead to species overlap as seasons change. In a study by [32] who did his sample collection two weeks after harvest for his work while in this study it was a month. This could possibly explain the changes in fungal community during storage with the natural selection favouring adaption of the fungi species. The sampling time for this study was chosen based on the general observation of toxin build up mostly in store at a month of post-harvest. In India, [35], mould occurrence and mycotoxin contamination in freshly harvested cereal grain samples and the fungal isolates were *Fusarium*, *Aspergillus* and *Penicillium* species were identified and determined and *A. flavus* was predominant species which concurs with this study. In the current study, six putatively toxigenic species *A. flavus, A. niger, A. parasiticus, A. niveus, A. clavatus,* and *A. terreus* were reported. This is similar to an earlier study of aflatoxin production by *Aspergillus,* and *A. parasiticus* [36]; *A. niveus* has been reported to produce fumonisins [37]. In a similar study by [38] of surveys conducted worldwide noted the occurrence of *A. flavus* and *A. niger* that had frequently contaminated peanuts and produced aflatoxins.m It was also noted that *A. flavus* contamination and aflatoxin production in sorghum was serious problem in sorghum-producing countries in crops that are grown under rain fed conditions [39].

The *Fusarium* species was the dominant fungi in this study. This is similar to a study by [40] who reported *Fusarium* species as a natural contaminant in cereals. *Fusarium* is an economically important genus of fungi causing many diseases on a wide variety of plants and plant products [41]. The widespread distribution of *Fusarium* species may be attributed to its ability to grow on a wide range of substrates and their efficient mechanism of spore dispersal [42]. Considering the importance of the genus *Fusarium*, all the isolates of *Fusarium* species were identified up to the species level. The results of this study are similar to those obtained by [43]. showing that *Fusarium* is the most dominant species isolated from cereals like maize and sorghum grains. [44] in their studies in Zimbambwe evaluated the distribution of *Fusarium* species in cereals and oilseeds and they found out that on maize and sorghum were most contaminated cereals compared to oilseeds. Similarly in Brazil, [45]. found out 98.7% incidence of *Fusarium* species on corn, in the same region, *F. moniliforme* was the most frequently isolated fungal species. The survey conducted worldwide also showed that, *F. moniliforme*, was the most frequently isolated

species in sorghum that produce fumonisin [46]. The National Institute of Nutrition, Hyderabad (India) conducted an epidemiological survey of fumonisins a class of fusarial toxins in a number of the villages in the districts of Andhra Pradesh, it was found out that high levels of fumonisins were detected in sorghum grain samples [47].

5. CONCLUSION

The data on the frequency and relative percentage of fungi on sorghum grains would be of immense significance for predicting the extent of postharvest infection, colonization, subsequent deterioration of sorghum grains and grain loss.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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