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Studies on Microbial Succession Inhabiting the Phyllospheres of Local and Foreign Varieties of *Sorghum bicolor*

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: *Sorghum bicolor* has been identified as a prolific food producer, drought resistant and adapts well to other harsh environment. Its importance as a crop plant is being highlighted. This study investigates the isolation and succession of microorganisms inhabiting the phyllospheres (leaves, seeds, and stems) of four local varieties obtained from a market in Ado-Ekiti, Nigeria and two foreign varieties of sorghum obtained from Aberystwyth University, United Kingdom in order to scrutinize the disease-causing microorganisms that could inhabit the species of the plant and also to identify the varieties of sorghum that will adapt well to South West Nigerian soil.

Study Design: A piece of farmland with good soil was acquired from the management of Federal Polytechnic, Ado-Ekiti, Nigeria for plantation of sorghum.

Methodology: The six varieties of sorghum were planted and monitored for a succession of microorganisms on the leaves, stems, and seeds for 16 weeks.

Results: The fungal isolates include *Aspergillus flavus*, *Aspergillus glaucus*, *Aspergillus niger*, *Fusarium* spp., *Mucor* spp., *Penicillium chrysogenium*, *Penicillium notatum*, *Penicillium oxalicum*, *Rhizopus* spp., *Syncephalastrum* spp. and *Butrysporium* spp. The bacterial isolates were

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Staphylococcus aureus, *Mycobacterium smegmatis*, *Pseudomonas syringae*, *Escherichia coli* and *Bacillus subtilis*.

Discussion: The entire microorganisms were isolated from the local varieties except *for Butrysporium* spp. which was isolated from the foreign varieties. Some microorganisms were isolated early in the study but disappeared towards the end of the study. In the two foreign varieties of sorghum, the persistent bacterial isolates were *Mycobacterium segmatis* and *Pseudomonas syringes* while the fungal isolates were *Rhizopus stolonifer*, *Mucor* and *Aspergillus flavus*. In the four local varieties, the persistent bacterial isolates were *Staphlococcus aureus* and *Bacillus subtilis* while the persistent fungal isolates were *Mucor*, *Aspergillus niger*, *Aspergillus flavus* and *Rhizopus stolonifer*.

Conclusion: Irrespective of the microorganisms on the phyllospheres of both foreign and local varieties of sorghum, the plants thrived; therefore, sorghum can be planted to sustain food security in South West Nigeria.

Keywords: Food security; microbial succession; phyllospheres; Sorghum bicolor.

1. INTRODUCTION

There is a problem of food shortage all over Nigeria because of boarder closure to rice importation. The area mostly affected is south western Nigeria; consequently, a substitute for rice is required. Sorghum had been studied severally and has been discovered to be prolific food producer, resistant and adapts well to drought and another harsh environment [1]. Sorghum is crucially important in food security in Africa as it is uniquely drought resistant among cereals and can withstand periods of high temperature, grown in areas at risk of desertification, and can also withstand periods of waterlogging [2]. This plant remains a principal source of energy, protein, vitamins and minerals for some impoverished regions of the world. Indeed it is one of the indispensable crops required for the survival of humankind [3].

Unfortunately, the growth of sorghum is restricted to Northern part of Nigeria with only 1% contribution by the south-west. Southwestern Nigeria is a tropical rainforest region of high rainfall which makes the place to be humid and allows disease-causing microorganisms to thrive. As there is need to increase production of sorghum.in south west of Nigeria, it becomes expedient to carry out an investigation on the disease-causing microorganisms that could inhabit some species of the plant in the area. This study is important to select the variety that will adapt well to South West Nigeria soil with good yield.

Sorghum bicolor is a flowering plant in the grass family *Poaceae*, it is locally called guinea-corn in Nigeria and many other countries of the world [4]. It is one of the most important staple foods for millions of poor rural people in the semi-arid tropics of Asia and Africa [5]. Being a drought and heat tolerant crop, sorghum is produced on a variety of soils including harsh environment where other crops cannot grow well, it has high yield potential, comparable to rice, wheat and maize [6].

Sorghum is a plant with many species and subspecies, these include grain sorghums which are used in food industries, forage sorghums which are used in hay and silage production for livestock feeding, sweet sorghums used for the production of syrups and biomass sorghum which are used primarily for the production of bio energy [7]. The crop is also used for food and for the production of alcoholic beverages, in fruit canning and confection industries. It is the primary grain used in the production of Malta Guinness in Nigeria [7].

Pathogenic microorganisms causing sorghum diseases are fungi, bacteria and viruses [8]. Host plant resistance to diseases varies widely among hybrid, hybrid selection should be based on the diseases that occur in the local growing environment [9]. Hence, sorghum production can be achieved through growing varieties or hybrids with improved tolerance to drought, low soil fertility and resistance to pests and diseases [10].

2. MATERIALS AND METHODS

2.1 Sorghum Plantation

Four local varieties obtained from a market in Ado-Ekiti, Nigeria and two foreign varieties of sorghum obtained Aberystwyth University, United Kingdom were planted on the farmland in Federal Polytechnic Ado-Ekiti, they were demarcated in order to identify each variety. Variety 1, 2, 4 and 5 are local varieties of sorghum while variety 3 and 6 are foreign varieties of sorghum. The growths of the plants (height) were monitored on weekly basis for the period of sixteen (16) weeks. The leaves, stems, and seeds of these six varieties of sorghum were also monitored for a succession of microorganisms within the same period.

2.2 Isolation of Microorganisms

The leaves, stems and seeds of each variety were washed with distilled water into different sterile test tubes, properly labelled and taken to the laboratory for microbiological investigation. Isolation of microorganisms was carried out by using spread plates method according to Rakshit et al. [9]. The nutrient agar plates were incubated at 37°C for 24 hours while the Potato Dextrose Agar (PDA) plates were incubated at room temperature (25ºC) for five days. The culture plates were observed for the growth of microorganisms.

2.3 Identification of Microorganisms

The bacterial isolates were identified by using cultural, morphological and biochemical characteristics as described by Rajyalakshmi et al. [2], while the fungi isolates were identified according to the method used by Dillon et al. [4].

3. RESULTS AND DISCUSSION

Results from Tables 1 and 2 show the bacterial and fungal isolates on the stems, leaves and seeds of foreign and local varieties of sorghum. The bacterial isolates from the stems, leaves and seeds of the foreign varieties of sorghum were *S. aureus, M. smegmatis, P. syringe, E. coli and B. subtilis* while the fungi isolates were *Rhizopus* spp., *A. flavus, Fusarium* spp., *Mucor* spp., *P. ocalicum, P. chrysogenum, A. niger, A. glaucus, P. notatum* and *Botrysporium* spp.. The bacterial isolates from the local varieties were *S. aureus, M. smegmatis, P. syringe, E. coli and B. subtilis while* the fungal isolates were *R. stolonifer, A. flavus, Fusarium* spp., *Mucor* spp., *P. ocalicum, P. chrysogenum, A. niger, A. glaucus, P. notatum and Syncephalastrum spp*. This implies that the microorganisms that were isolated from the plant surfaces are pathogenic and potentially toxin-producing microorganisms which can lower the qualities of sorghum plants and can also be responsible for causing sorghum diseases. These isolates occupied the phyllosphere and as a result, they were found on sorghum plant surfaces, this result is in line with Berg and Smalla [11] where the authors discovered that microbes can be found both as epiphytes on the plant surfaces and as endophytes within plant tissues. Similar work by Hanna et al. [12] also revealed the isolation of *Pseudomonas* spp., *Bacillus* spp., *F. poae*, *P. terrestre* and *A. alternata* from the phyllosphere of *Hypericum perforatum*.

Aspergillus and *Mucor* were the most frequently isolated fungi, this might be due to the great influence in which the south western climate of Nigeria has on fungal growth while the frequently isolated bacteria were *S. aureus* and *E. coli*. The result from table 3 shows that only *Syncephalastrum* spp. was not isolated from foreign sorghum while *Botrysporium* spp. was not isolated from local varieties.

Figs. 1 and 2 showed that there was a reduction in the number of fungal and bacterial isolates as the growth rate increased; this implies that some microorganisms were initially isolated at the early stages of sorghum but disappeared as the sorghum plants increased in age. The microorganisms at the early stage of growth of sorghum may arrive at its phyllospheres through insects, atmosphere, seeds, animal-borne sources, rain splash as well as from contamination with soil [13]. The persistent isolates were the actual microorganisms that can be responsible for causing diseases in sorghum plants, in the two foreign varieties of sorghum planted, the persistent fungal isolates were *R. stolonifer*, *Mucor* spp. and *A. flavus* while the bacterial isolates were *M. smegatis* and *P. syragene*. In the four local varieties, the persistent fungal isolates were *Mucor*, *A. niger*, *A. flavus* and *Rhizopus* spp., while the persistent bacteria were *S. aureus* and *B. subtilis.* It was also observed that there were some microbes that were present in the local varieties but were absent in the foreign varieties and vice versa.

Figs. 5 and 6 showed that the seeds of both foreign and local varieties of sorghum were contaminated with fungi and bacterial pathogens, and as the seeds matured, the isolates reduced in number, this may be as a result of the moisture content or humid nature of the seeds at the early stage of development. This result corroborates with Abdulsalaam and Shenge [14], where the authors isolated *Fusarium* spp., *Aspergillus* and *Penicillium* spp. from *Sorghum bicolor.*

Fig. 7 shows the growth rate of the six varieties of sorghum over a period of 16 weeks, variety 1, 2, 4 and 5 showed increased in growth rate from week1 to week 16 with maximum height of 240, 520, 477 and 319 cm respectively while variety 3 and 6 attained their optimum growth rate at week 10 with maximum height of 179.0 cm and 186.0 cm respectively. The foreign varieties started fruiting earlier compared to local varieties and this may be as a result of the improved trait that has been introduced into it. The foreign varieties had robust seedlings, short height with thick stems, short fruiting and harvesting time while the local varieties had thin seedlings, long heights with thin stems, long fruiting and harvesting time.

Table 1. Biodiversity of Bacteria on the phyllosphere of foreign and local varieties of sorghum

Bacteria	Foreign varieties			Local varieties		
	Stems	Leaves	Seeds	Stems	Leaves	Seeds
Staphylococcus aureus	+	+	–	+	+	–
Mycobacterium smegmatis	+	–	–	+	+	+
Pseudomonas syringe	+	+	–	+	+	+
Escherichia coli	+	–	+	+	+	+
Bacillus subtilis	+	+	–	+	+	–

– negative, + positive

Table 2. Biodiversity of fungi on the phyllosphere of foreign and local varieties of sorghum

Fungi	Foreign varieties			Local varieties		
	Stems	Leaves	Seeds	Stems	Leaves	Seeds
Rhizopus stolonifer	+	+	–	+	+	–
Aspergilius flavus	+	+	+	+	+	+
Fusarium spp	+	+	+	+	+	+
Mucor	+	+	–	+	+	–
Penicillium ocalicum	+	+	–	+	+	–
Penicillium chrysogenum	+	+	+	+	+	+
Aspergillus niger	+	+	–	+	+	–
Aspergillus glaucus	+	+	+	+	+	+
Penicillum notatum	+	+	+	+	+	+
Syncephalastrum	–	–	–	+	+	+
Botrysporium	+	+	+	–	–	–

– negative, + positive

Table 3. Comparative incidence of microbial isolates from the six varieties of sorghum

Microorganisms	Foreign varieties	Local varieties
Staphylococcus aureus	+	+
Mycobacterium smegmatis	+	+
Pseudomonas syringe	+	+
Escherichia coli	+	+
Bacillus subtilis	+	+
Rhizopus stolonifer	+	+
Aspergilius flavus	+	+
Fusarium spp	+	+
Mucors	+	+
Penicillium ocalicum	+	+
Penicillium chrysogenum	+	+
Aspergillus niger	+	+
Aspergillus glaucus	+	+
Penicillum notatum	+	+
Syncephalastrum	_	+
Botrysporium	+	_

– negative, + positive

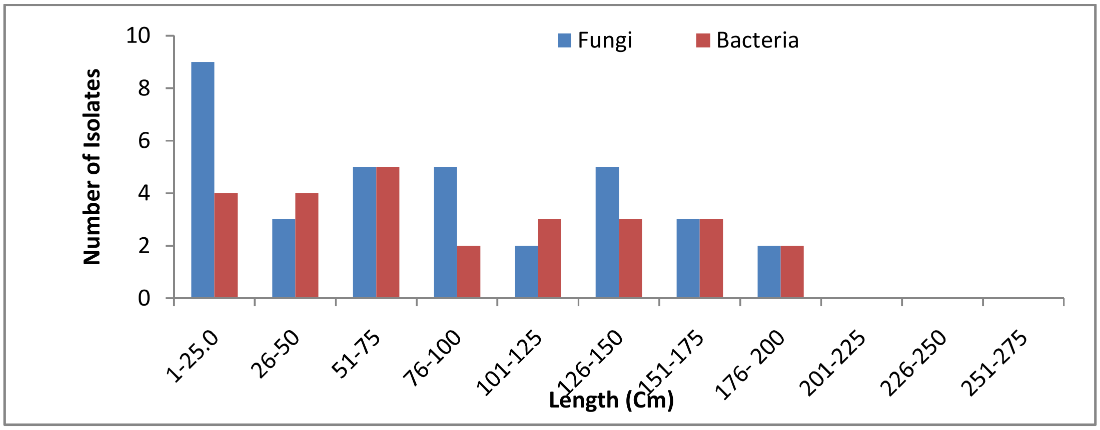

Fig. 1. Succession of microorganisms with height on the stems of foreign varieties of sorghum

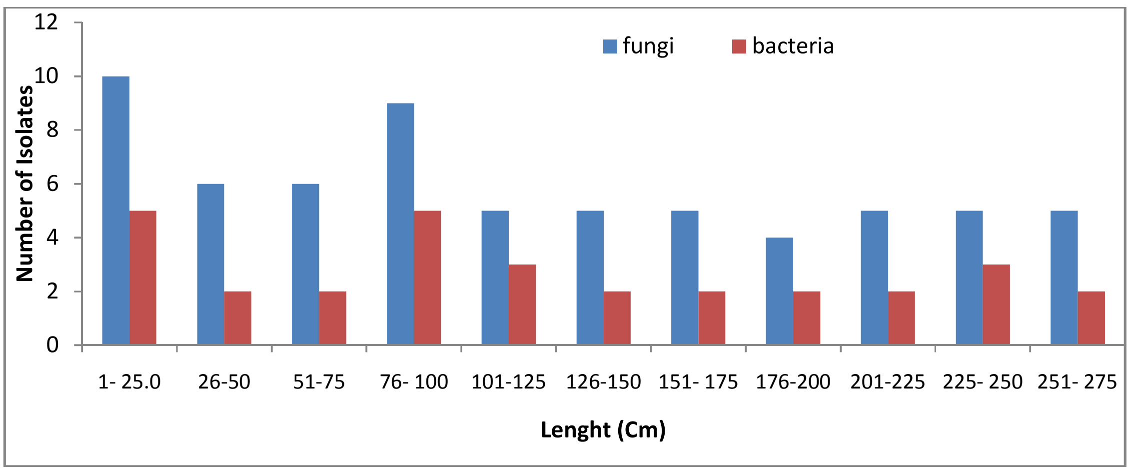

Fig. 2. Succession of microorganisms with height on stems of four local varieties sorghum

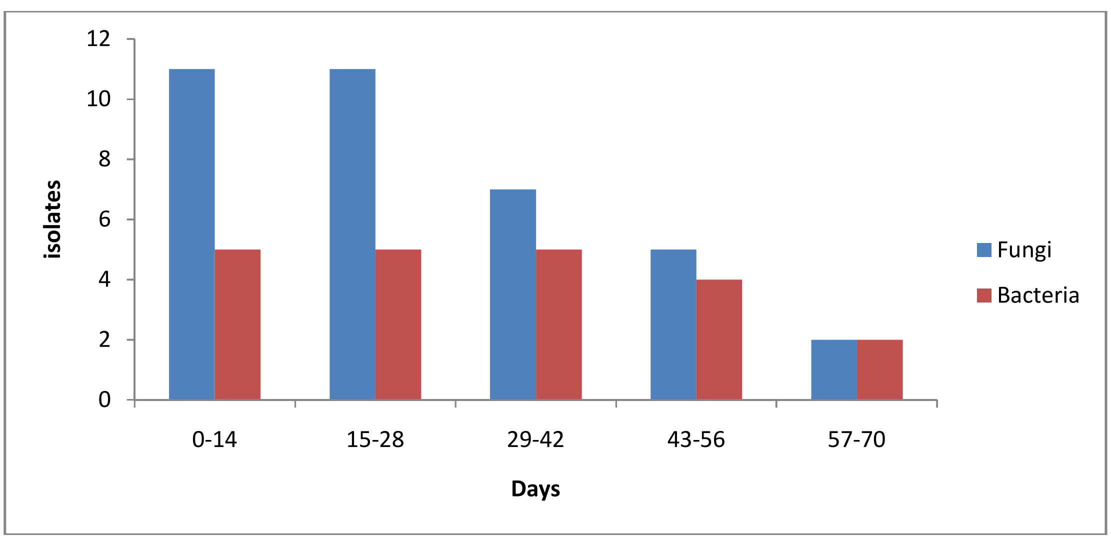

Fig. 3. Succession of microorganisms on leaves of foreign varieties of sorghum

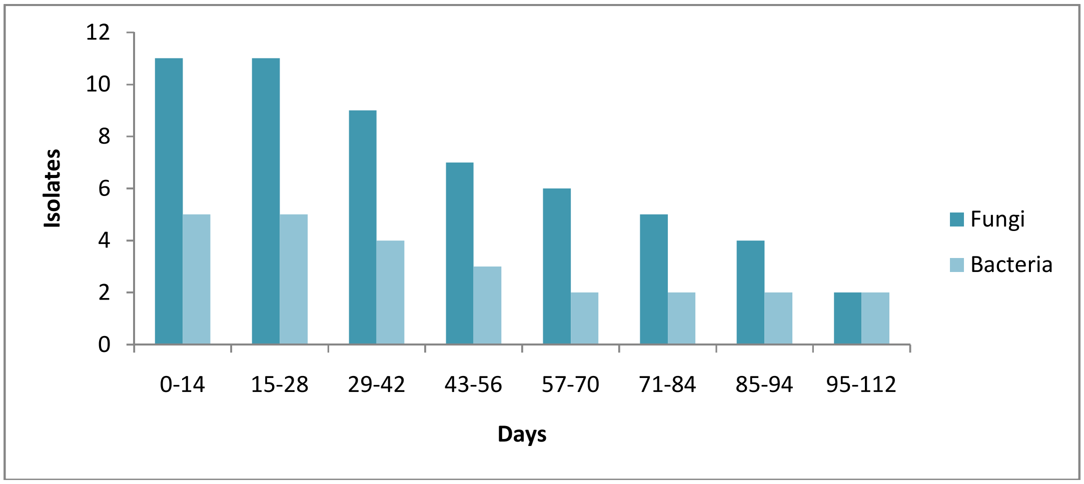

Fig. 4. Succession of microorganisms on the leaves of local varieties of sorghum

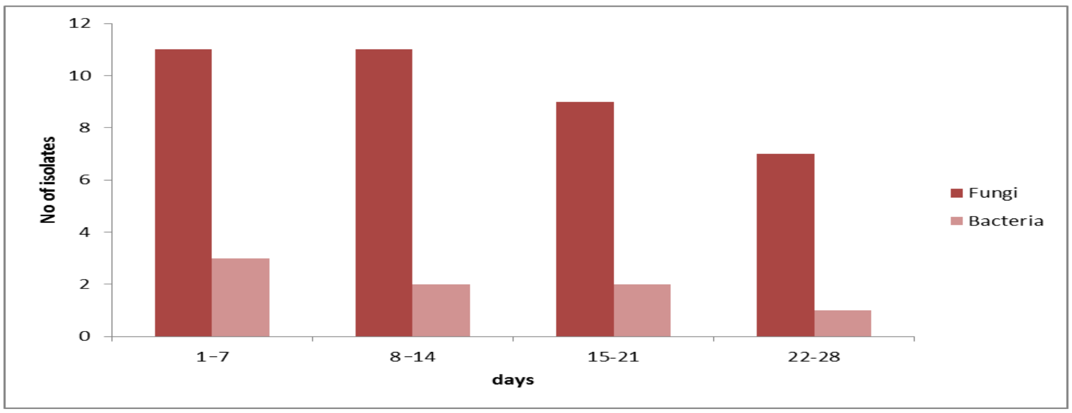

Fig. 5. Succession of microorganisms on the seeds of a foreign variety of sorghum

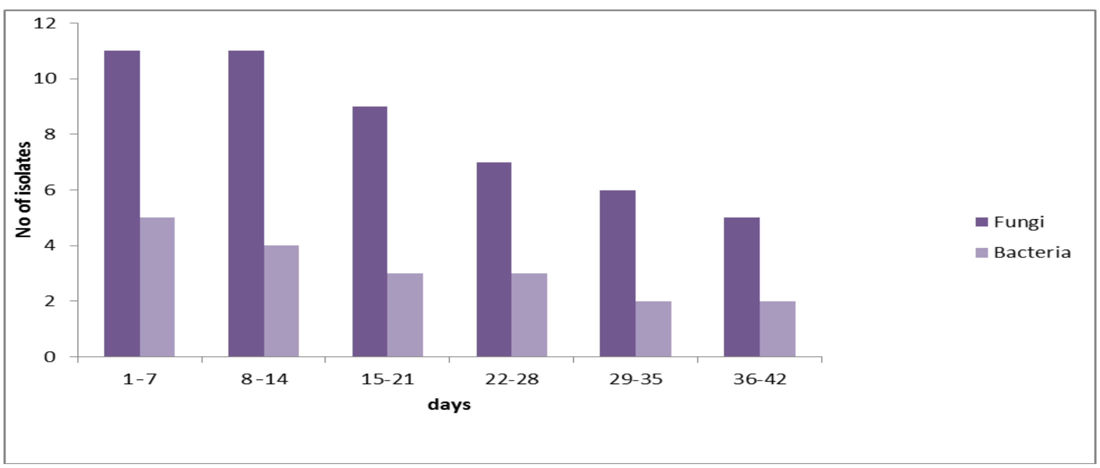

Fig. 6. Succession of microorganisms on the seeds of local varieties of sorghum

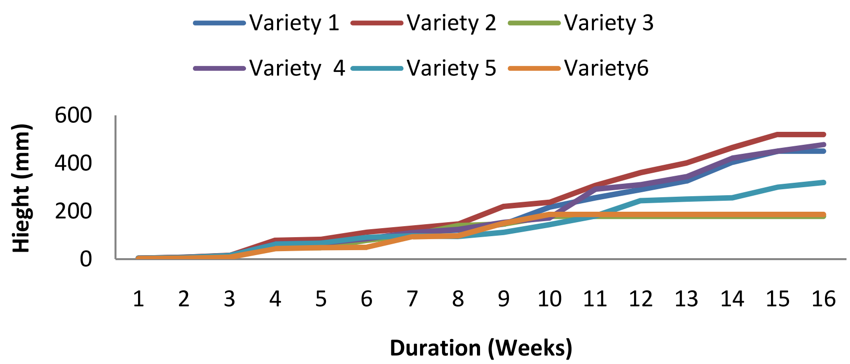

Fig. 7. Growth rate of six varieties of sorghum over a period of sixteen weeks
Note: varieties 1, 2 & 4 – Local varieties
varieties 3, 5 & 6 – Foreign varieties

4. CONCLUSION

The foreign varieties and the local varieties of sorghum planted adapted well to South West Nigerian soil with good yields and lesser microorganisms attack. Some microorganisms were isolated early in the study but disappeared towards the end of the study. Irrespective of the microorganisms on the phyllosphere of both foreign and local varieties of sorghum, the plants thrived; therefore, sorghum can be planted to sustain food security in South West Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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