Available online at http://www.sjbas.com.ng
Savanna Journal of Basic and Applied Sciences (December, 2024), 6(2): 191-195
P:ISSN 2705-3164 | E:ISSN 2695-2335

Fungi Associated with Postharvest Deterioration of Stored Onion Bulbs in North-Western Nigeria

[1]Shehu, K. *[2]Salau, I. A.; [1]Kasimu, S.M.

[1]Department of Biological Sciences, Federal University, Birnin-Kebbi, Kebbi State Nigeria

*[2]Department of Biological Sciences, Federal University Gusau, Zamfara State Nigeria

ABSTRACT

Postharvest deterioration of Onion bulbs is a major cause of onion losses in Nigeria and affectsthe quantity and quality of onions available for domestic use and export to international markets. In this study, fungi associated with postharvest deterioration of stored onion bulbs in the major onion producing areas of Nigeria were investigated using standard mycological techniques. Rotten and discoloured onion bulbs were sampled in One Hundred Onion stores and screened for fungal species. A total of ten fungal species belonging to six genera of fungi were recovered from the stored onion bulbs. These are *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Botrytis cinerea*, *Fusarium oxysporum*, *F. moniliforme*, *Alternaria porri*, *Penicillium citrinum*, *P. notatum* and *Rhizopus stolonifer*. All the isolated fungi were found to be pathogenic on healthy onion bulbs and have the potential to cause storage rots on onion bulbs under warm and humid environmental conditions. It is recommended that appropriate control measures involving proper handling practices at harvest, effective drying of bulbs before storing and the use of ventilated storage facilities could reduce postharvest losses of onion in Nigeria. There is need for improvement of existing local onion storage facilities to include ventilation system. Communication and education campaigns should be targeted to reduce onion losses at farm level and during storage.

Keywords: Postharvest loss, Onion bulbs, Fungi, Storage, Deterioration

INTRODUCTION

Onion (*Allium cepa* L.) is an important vegetable crop in Nigeria based on the level of consumption and economic value to farmers. Nigeria is the largest onion producing country in West Africa with a production of 2 million tons per annum and the 10th largest producer in the World (FAO, 2023). It exports Onions to Chad, Cameroun, Ghana, Benin, Niger, Mali, Burkina Faso and Senegal. The crop is grown mainly in Kebbi, Sokoto, Kaduna, Kano, Jigawa and Bauchi States (NBS, 2023). Postharvest losses are a major constraint to Onion production and trade in Nigeria as up to 50% of onions harvested are lost due to inadequate storage system in which the bulbs are bulked on the ground/raised platform in straw huts without adequate ventilation (Shehu *et al.* 2023). Storage rots induced by fungi are common causes of losses in agricultural commodities and reduce both the quality and quantity of the produce available for domestic use and export to international markets (Salisu *et al*. 2019). Other consequences often overlooked by the general public include the mycotoxin contamination of the contaminated commodities onions which when consumed are hazardous to humans (Shehu *et al*., 2020; Zakaria 2024).

Factors such as poor handling practices at harvest, lack of adequate drying before storage and inadequate storage facilities influence the magnitude of postharvest losses in onions (Nnadi and Carter, 2021). Our preventive goal therefore, should be the rapid identification of fungi associated with the storage rots of onions and conditions under which contamination occurs with a view to reducing the postharvest losses and improving onion production for domestic use, export promotion and improving economy of Nigeria. The aim of the present research was to determine the occurrence and incidence of fungal pathogens of stored onions in the major onion growing areas of Nigeria.

MATERIALS AND METHODS

Collection of Onion Samples

In Nigeria Onion is grown mainly in Kebbi, Sokoto, Kano, Kaduna, Jigawa and Bauchi States. In these states, a large proportion of Onion production and storage takes place annually. Average monthly temperature ranges from 21-40°C and is lowest in December and January. The area is characterized by a long dry season (November to April) and a short raining season (May to October). Five states namely Kebbi, Sokoto, Kano, Kaduna and Jigawa States located in North Western Nigeria were selected by purposive random sampling techniques for the present study. Onions stores from the selected states were identified through Local Government Departments of Agriculture and Traditional Authorities. Rotten and apparently healthy Onion bulbs were collected from the study areas for mycological analysis. Aseptic precautions were taken to prevent secondary contamination of the samples between sampling and analysis.

*Corresponding author. E-mail: kshehu67@yahoo.co.uk

Isolation of Fungi

Rotten and discoloured onion bulbs were collected from 100Onion stores located at Kebbi, Sokoto, Kano, Kaduna and Jigawa States in North-Western Nigeria. A total of 10,000 randomly selected rotten onion bulbs and 5000 healthy bulbs were collected from each store. The Bulbs were surface sterilized by dipping them in 90 percent ethyl alcohol for 1 minute and then rinsed in two changes of sterile distilled water. Small segment ($2cm^3$) of the tissues from the margins of the rotten onion bulbs were cut out with a sterile blade and plated in petri-dishes containing potato dextrose agar (PDA) and incubated at 27 ± 2ºC in an incubator for 7 days (Ikeh *et al.* 2023). The fungal cultures that appeared were identified using cultural and morphological features and by comparison with already identified stock cultures in the Mycology Laboratory of the Federal University Birnin Kebbi.

Pathogenicity of Isolated Fungi

Two hundred freshly harvested onion bulbs collected from the study sites were surface sterilized by dipping them into 90 percent ethyl alcohol for 1 min and then rinsed with three successive changes of distilled water. The bulbs were bored with 5mm diameter cork-borer, mycelial plug (9mm in diameter) from the pure cultures of the different fungi were singly inserted into the bulbs and the wounded areas sealed with petroleum jelly to prevent cross contamination. The inoculation was done in sterilized chambers. Three replications were prepared for each treatment. Control consisted of sterilized 3mm PDA disc placed in the holes of the healthy onion bulbs. Inoculated bulbs were incubated at 27 ± 2ºC for 7 days and observed for rot development. The fungi were re-isolated from the inoculated onions bulbs and compared with the original fungal isolates. The extent of rot in the inoculated onion bulbs were measured in millimetre and recorded for each fungal species.

Data Analysis

The data obtained from the study were statistically analysed using descriptive statistics.

RESULTS

The result on investigation of fungi associated with postharvest deterioration of stored onions are shown in Tables 1, 2 and 3. The conventional onion storage system in Nigeria are involves heaping of onion bulbs on the ground or raised platform in straw huts under ambient environmental conditions. The average fungal counts on the rotten onion bulbs are presented in Table 1. The counts were 1.1 x 10^3cfu/ml, 1.5 x 10^3cfu/ml, 1.6 x 10^3cfu/ml, 1.8 x 10^3cfu/ml and 2.2 x 10^3cfu/ml for the onion bulbs from Kebbi, Sokoto, Kano, Kaduna and Jigawa States respectively.

Table 1: Fungal load (cfu/g) of Stored Onions

S/N	States	Average fungal count (cfu/ml)
1.	Kebbi	1.6 x 10^3
2.	Sokoto	1.1 x 10^3
3.	Kano	1.8 x 10^3
4.	Kaduna	2.2 x 10^3
5.	Jigawa	1.5 x 10^3

A total of ten fungal species which include *Aspergillus niger*, A. *flavus*, A. *fumigatus*, *Alternaria porri*, *Rhizopus stolonifer*, *Fusarium oxysporum*, *Fusarium monilifome*, *Penicillium citrinum* and *Botrytis cinerea* were isolated from the stored onion bulbs obtained from 100 stores located in the study area (Table 2). The frequency of occurrence revealed that *Aspergillus niger* has the highest percentage of occurrence with 23.1%, followed by*A. Flavus* and *Alternaria porri* with 21.1% and 17.7% respectively. *Rhizopus stolonifer* and *Penicillium citrinum* have the lowest percentages of occurrences with 1.9% and 1.1% respectively.

The result of Pathogenicity test indicated that all the isolated fungi were found to be pathogenic to the Onion bulbs. However, *Aspergillus niger*, *Alternaria porri*, *Fusarium oxysporum* and *Botrytis cinerea* were found to be more pathogenic, while *Penicillium citrinum*, *Aspergillus fumigatus*, *Penicillium notatum* and *Rhizopus stolonifer* are the least pathogenic fungi contaminating stored onion (Table 3).The rot diameters were 40mm, 36mm, 33mm, 28mm, 26mm, 18mm, 16mm, 14mm, 10mm, 8mm and 8mm for *Aspergillus niger*, *Alternaria porri*, *Fusarium oxysporum*, *Botrytis cinerea*, *Fusarium monilifome*, *Aspergillus flavus*, *Rhizopus stolonifer*, *Penicillium citrinum*, *Penicillium notatum* and *Aspergillus fumigates* respectively.

Table 2: Frequency of Fungal occurrence on Stored Onion Bulbs

S/No.	Fungal Contaminant	Frequency	Percentage (%)
1.	*Aspergillus niger*	142	23.10
2.	*Aspergillus flavus*	130	21.10
3.	*Alternaria porri*	109	17.70
4.	*Fusarium oxysporum*	67	10.90
5.	*Botrytis cinerea*	59	9.60
6.	*Fusarium monilifome*	44	7.10
7.	*Penicilliumnotatum*	28	4.50
8.	*Aspergillus fumigatus*	19	3.00
9.	*Penicillium citrinum*	11	1.90
10.	*Rhizopus stolonifer*	07	1.10
	TOTAL	**616**	100

Table 3: Pathogenicity of the isolated fungi on onion bulbs

S/No.	Fungi	Rot Diameter (mm)
1.	*Aspergillus niger*	40
2.	*Alternaria porri*	36
3.	*Fusarium oxysporum*	33
4.	*Botrytis cinerea*	28
5.	*Fusarium monilifome*	26
6.	*Aspergillus flavus*	18
7.	*Rhizopus stolonifera*	14
8.	*Penicillium citrinum*	10
9.	*Penicillium notatum*	8
10.	*Aspergillus fumigatus*	8

DISCUSSION

The present study investigated the occurrence and significance of fungi in causing postharvest deterioration of onion bulbs stored under ambient environmental conditions in North Western Nigeria. The results from the study showed that storage rots induced by fungi are important causes of postharvest losses of onions in Nigeria. Farmers use rudimentary storage techniques and facilities which are inadequate to preserve onions for 4-6 months. The average fungal counts ranged from 1.1 $x10^3$cfu/ml to 2.2 $x10^3$cfu/ml. The samples from Kaduna state had the highest fungal count of 2.2 x 10^3cfu/ml while those from the Sokoto state had the lowest count of 1.1 x 10^3cfu/ml. *Aspergillus* spp. were found to be the dominant fungi on the onion samples and were able to cause rots on the onion samples as indicated by the Pathogenicity test. The results indicated that 10 species of fungi induced rotting on stored onion bulbs. *Aspergillus niger, Alternaria porri, Fusarium oxysporum and Botrytis cinaeria* were the most important pathogens on onions and caused the largest rot lesions on stored onion bulbs (Emeka, 2022). Their presence on onions may therefore pose a risk to storage of onions leading to high postharvest losses. *Penicillium notatum, Aspergillus fumigatus, Penicillium citrinum* and *Rhizopous stolonifer* were recovered at low rate, suggesting that the risk of storage rots developing from their inoculum transmitted at harvest or through infected stores is low. However, these isolated fungi are important upon contact with wounded bulbs under favourable conditions of temperature and relative humidity that prevail in storage environment. The variation in percentages of fungal occurrence could be attributed to the differences in inoculum density in the area or prevailing environmental conditions favouring the fungal growth (Samuel and Ifeanyi, 2015; Dorrigiv *et al.* 2021).

Fungi are important causes of postharvest losses in many agricultural commodities (Salau and Shehu, 2015; Uloma *et al*; 2024). *Aspergillus niger* cause black rot that occurs primarily on the bulbs surface that are wounded and maintained at high temperature (20-25°C), *Fusarium spp.* cause dry rot that mainly attack produce that are injured during harvest and stored under humid conditions. *Penicillium* spp. cause green and blue mold rots in stored onions, *Rhizopus* spp cause rots that become prevalent at high temperature (Shehu and Muhammad, 2011; Sunusi *et al.* 2024).

The findings in this study support those of Shehu *et al*. (2020) who isolated similar fungal taxa from stored maize grains. This demonstrates that when healthy produce was stored, fungal pathogens readily penetrated the produce through wounds. Propagules of fungi from infested produce may also be important sources of

inoculum for initiating rotting in stored onion bulbs. Similarly, mycelium of fungi can easily spread from infected bulbs to healthy ones thereby contaminating the stored onions.

The results suggest that the control of pathogenic fungi occurring on the onion bulbs or infested stores is important in reducing postharvest deterioration of onions and thus there is need for proper handling of onions at harvest to prevent field originating inoculum in getting to the store. Disinfestation of stores prior to each storage season can contribute to the management of fungal inoculum and reduce postharvest loss of onions induced by fungi during long-term storage. The results also showed that the level of deterioration as measured by the extent of rot lesion on the inoculated onion bulbs vary with the fungal species and ambient environmental conditions especially temperature and relative humidity indicating that inoculum capacity of pathogenic fungi varies among the species.

CONCLUSION

Postharvest losses of onions due to fungal infections are a major constraint to onion production and storage in Nigeria. The study found high incidence of fungal contamination and bulb rotting in stored onions in the major onion growing areas of Nigeria. Latent infection of onion bulbs may be the main factor contributing to postharvest deterioration during storage. Microbial infection of bulbs is often the result of poor handling practices at harvest and inadequate storage system. Healthy undamaged onion bulbs which have been cured properly could be stored in dried well-ventilated stores for a long period of time with minimal postharvest losses. It is recommended that appropriate control measures involving proper handling practices at harvest, effective drying of bulbs before storing and the use of ventilated storage facilities could reduce postharvest losses of onion in Nigeria. There is need for modern storage facilities or scale up of existing local onions stores to include ventilation system. Communication and education campaigns should be targeted to reduce onion losses at farm level and during storage.

Acknowledgements

We wish to express our sincere gratitude to Tertiary Education Trust Fund (TETfund), Abuja for providing the funding for this research (Institutional – Based Research) project. We also thank the management of Federal University Birnin-Kebbi for providing Laboratory facilities and technical assistance.

Conflict of Interest

The authors have declared that no competing interests exist.

REFERENCES

Dorrigiv M, Zareiyan, A. and Hosseinzadeh, H. (2021). Onion (*Allium cepa*) and its main constituents as antidotes or protective agents against natural or chemical toxicities: a comprehensive review. *Iranian Journal of Pharmaceutical Research*, 20(1): 3-26.

Emeka, C. P.O. (2022). Fungal diseases affecting onion (*Allium cepa* L.) grown under irrigation scheme in 2012 and 2013. Available on https://ssrn.com/abstract=3996257. Accessed on April 24, 2024.

FAO (2023). Food and Agriculture Statistical Year Book, 2023 FAO Websit (www.fao.org/publications)

Ikeh, M. I., Ishar, C.O., Eriobu, C.C. and Nnatuanya, I.O. (2023). Isolation and identification of fungi in onion bulbs obtained from markets in Awka metropolis, Anambra state, Nigeria. *Journal of Current Biomedical Research*, *3*(2): 957–965. https://doi.org/10.54117/jcbr.v3i2.12

National Bureau of Statistics (NBS, 2023). Foreign Trade in Goods Statistics Report.

Nnadi, N.E. and Carter, D. A. (2021). Climate change and the emergence of fungal pathogens. *PLoS Pathog*. 17(4):e1009503

Salau, I. A. and Shehu, K. (2015). An overview of the fungal diseases of vegetables in Sokoto State, Nigeria. *Global Advanced Research Journal of Agricultural Science, 4 (1):001-005*

Salisu, L H, Aliyu, M.S., Zaharau, U.I. (2019) Storage performance of modern onion storage structure facility Makani model. *International Journal of Agriculture, Environment and Bioresearch*, pp. 136-137.

Samuel, O. and Ifeanyi, O. (2015). Fungi Associated with the Deterioration of Post-harvest Onion Bulbs Sold in Some Markets in Awka, Nigeria. *Bioengineering and Bioscience*. **3**(5): 90-94. DOI: 10.13189/bb.030503.

Shehu, K., Salau, I. A. and Salisu, N. (2020). Fungal and Mycotoxin contamination of stored maize grains in Kebbi State, north-western Nigeria. *Journal. of Advanced Botany and Zoology*, 8(1).1-5. Article doi: https://doi.org/10.5281/zenodo. 4074249

Shehu, K; Salau, I. A; Kasimu, S.M. (2023). Enhancing Onion Preservation and Storage through Improved Storage System. *Journal of Applied Science and Environmental Management*, 27 (12) 2777-2781 DOI: https://dx.doi.org/10.4314/jasem.v27i12.15

Shehu, K. and Muhammad, S. (2011). Fungi Associated with Storage Rots of Onion Bulbs in Sokoto, Nigeria. *International Journal of Modern Botany***1** (1):3-6

Sunusi, B. B., Ahmad, I., Auwalu, A., Aliyu, U.M. and Labaran, B. U. (2024). Antifungal Activity of *M. indica* and *F. platyphylla* Leaf and Stem Bark Extracts against Onion Bulb Rot Fungi: A Comparative Study in North Western Nigeria. *Journal of Biotechnology Bioresources*, 5(2). 00061 DOI: 10.31031/JBB.2024.05.000610

Uloma E.O. Uzoamaka, O.G. and Ezinne, O.O. (2024). Isolation and Identification of potential mycotoxigenic fungi from some selected foods. *GSC Biological and Pharmaceutical Sciences* 28(02), 208-214.

Zakaria, L. (2024). An overview of Aspergillus Species Associated with Plant Diseases. *Pathogens*, 13, 813. https://doi.org/10.3390/pathogens13090813