

Seed-Borne Fungi Associated with Pepper (*Capsicum* Species) in Some States in Nigeria

Otusanya, M. O.

ABSTRACT

Capsicum (Pepper: common name) species fruits are ground and utilized either fresh or dried as an essential ingredient of sauce/soup in every region of Nigeria. Seed health tests were carried out on thirty-one seed cultivars of *Capsicum* that is *Capsicum frutescens* L. and *Capsicum annuum* L. from Kaduna, Benue and Oyo States in Nigeria in this study. An initial mini-greenhouse project with some of the cultivars resulted in Curly-top Virus symptoms disease. The latter disease which had not been hitherto reported in Nigerian *Capsicum* cultivars necessitated the grouping of the seeds into two sets of Nigerian/Indigenous Cultivars (in group one) and Exotic plus less exotic cultivars in a second group. The Nigerian set made up of eight cultivars was examined with and without surface-sterilization for mycoflora. The design was completely randomized comprising five (5), replicates per cultivar and 50 seeds in a cultivar replicate. The working sample was 250 seeds per cultivar set up under an alternating cycle of 12hours Near ultra-violet light (NUV light) and 12hours darkness in an incubating room of $27 \pm 2^{\circ}\text{C}$ temperature. Incubation for viability counts and associated fungi was for seven days. The Exotic plus less exotic set had twenty-three cultivars, which were tested as the Nigerian Cultivars, without surface-sterilization. Viability was over 30.00% only in eleven of the twenty-three Exotic plus less exotic Cultivars, whereas there was none (over 30%) in the indigenous or Nigerian Cultivar set. Three reasons adduced for the low turn-out in germination are period of seed storage of six months or over, lack of seed treatment and mixed infections possibly with viruses or nematodes. The genera *Phoma*, *Chaetomium*, *Penicillium*, *Rhizopus* and *Cladosporium* with the former two associated with all eight cultivars, were isolated from the un-sterilized indigenous/Nigerian set and are considered to be surface contaminants. Twenty fungi namely *Aspergillus flavus*, *A. niger*, *A. ochraceus*, *A. wentii*, *Cercospora* sp., *Chaetomium* sp., *Colletotrichum* sp., *Curvalaria lunata*, *C. pallescens*, *Fusarium equiseti*, *F. moniliforme*, *F. solani*, *Graphuina* sp., *Macrophomina* sp., *Penicillium* sp., *Phoma* sp., *Rhizopus* sp., *Spegazzima* sp., *Stemphylium* sp. and *Verticillium* sp. were isolated from the un-sterillized Exotic plus less exotic cultivars set. Among the twenty, *Aspergillus flavus*, *Fusarium moniliforme* and *Phoma* sp. were dominant as they were associated with 22, 21 and 19 of the twenty-three cultivars respectively. Overall mean infection of 13.55%, 8.06% and 5.23% were highest by *A. flavus*, *Colletotrichum* sp. and *Rhizopus* sp. respectively and the three highest cultivar replicate infections were 55.60%, 32.80% and 23.20% also by *Aspergillus flavus*, *Rhizopus* sp. and *Colletotrichum* sp. in that order respectively. Seed-borne saprophytes are reported to be economically important as they effect seed rot, seed weight loss or seed germination reduction and ought to be excluded by adequate seed treatment. Twelve fungi were associated and isolated from the eight surface-sterilized Indigenous/Nigerian cultivar set. They are *Aspergillus flavus*, *A. niger*, *A. tamari*, *Cochliobolus lunatus*, *Colletotrichum capsici*, *Corynespora casiicola*,

Curunlaria pallescens, *Fusarium moniliforme*, *F. pallidroseum*, *Macrophomina phaseolina*, *Pithomyces chartarum* and *Thielavia terricola*. *Aspergillus flavus*, *Fusarium moniliforme* and *Aspergillus niger* were the three most frequently occurring/dominant fungi as they were isolated from all eight, seven and six cultivars respectively. However, overall mean infection was highest by *Aspergillus flavus* 11.80%, second is *Colletotrichum capsici* 6.60% and third is *Fusarium moniliforme* 3.20%. The two highest infections in any cultivar replicate also were 55.60% by *Aspergillus flavus* and 23.20% by *Colletotrichum capsici*, and in third place is 15.20% by *Aspergillus niger*. *Colletotrichum capsici* and two other *Colletotrichum* species *gloeosporioides* and *acutatum* are known to be the most important economic fungal pathogens of *Capsicum* species in Nigeria and globally causing ripe fruit rot and stem die-back. Seed-borne *Fusarium* species namely *moniliforme*, *solani* and *oxysporum* and *Verticillium* species also contribute to high pre-harvest losses (by damping-off of seedlings and wilting of field plants) on Pepper globally. The Aspergilli cause moulds on above-ground portions of pepper plants and *Macrophomina* is known to be parasitic on leaves. *Pithomyces chartarum* and *Thielavia terricola* have not been reported on *Capsicum* species and are therefore new records on *Capsicum* seeds in Nigeria. Seed storage for planting without adequate/appropriate seed treatment is to be discouraged in Nigeria; because of low viability as in this study, and seedling failure/field epidemics/crop failure. Fundings and extensive trials with Plant extracts, Oils and Biocontrol microbes should also be underscored as necessary for seed treatment in place of fungicides for health and environmental safety. Improved Seeds should also be sought for as priority from approved Agencies/Seed Companies by farmers.

INTRODUCTION

Capsicum frutescens L. and *Capsicum annum* L, (Pepper – common name) is traditionally important as a main component of soup/stew/sauce in every region/ethnic group in Nigeria. It is mixed with legume or cereal grains locally to preserve from spoilage/ward off insects and is also medicinal.

Seed samples of thirty-one cultivars of Pepper were collected from Inst. Of Agric Res., Ahmadu Bello University, Samaru Zaria (In Kaduna State, Nigeria), Yandev, Gboko (in Benue State, Nigeria) and Teaching and Research Farms in University of Ibadan, Ibadan (in Oyo State, Nigeria). Several cultivars were sown and then transplanted. Many of the Screen house potted plants had yellowing symptoms and marked curling of the leaves, identified as the Curly-top Virus disease at the Int. Inst. of Tropical Agric, Ibadan through Prof. Ekpo (personal communication). Curly-top virus disease was reported on Mexican tomato as well as wild and cultivated Mexican peppers namely *Capsicum annum* L., *C. chacoense* Hunz, *C. chinese* Jacq. and *C. frutescens* L. from Southern New Mexico (Bosland, 2000). The disease has also been reported on Coastal tomato and pepper from Monterey and San Benito Counties in California (Koike and Gilbertson, 2010). The cultivars were therefore separated into two sets of Indigenous/Nigerian in one set and Exotic plus less exotic in a second set. The twenty-three cultivars which may be said to be foreign or Exotic plus less exotic were examined for seed-borne fungi with the blotter technique, without surface-sterilization. Seven cultivars of pepper grown in the states where the seeds were sourced, and one foreign/exotic cultivar namely Cherry Sweet which has been adopted by Nigerian pepper growers were put in the Indigenous/Nigerian cultivars set. They were examined for seed-borne fungi using the blotter technique with and without surface-sterilization.

MATERIALS AND METHODS

Source of Seeds

Thirty-one Cultivars of Pepper, *Capsicum* species seeds were collected from the Inst. Of Agric. Res., Ahmadu Bello University (Samaru), Zaria in Kaduna State of Nigeria, Yandev and Gboko in Benue State of Nigeria, the National Inst. of Hort. Res., Ibadan in Oyo State and Teaching and Res. Farms, University of Ibadan, also in Oyo State of Nigeria.

Preparation of Surface-sterilized Seeds

Seeds were surface-sterilized with 10% Sodium hypochlorite solution, and washed in three changes of sterile distilled water. The Blotter technique was used to prepare the seeds for Incubation and Examination (ISTA 1993). Four (4) layers of Whatman number 4 filter paper were laid in sterile plastic 9 centimeter (9cm) petri-dishes. The dishes were flooded with sterile distilled water and excess decanted. With a pair of sterile forceps, five surface-sterilized seeds were placed in a row along the diameter of a petri-dish. Another set of seeds were placed in another row at right angles to the first one, and so on until there were a total of 25 seeds placed equidistant from one another in a petri-dish. The experiment was completely randomized design. Selection of the seeds was random. Two plates each with 25 seeds represented a cultivar replicate. Each cultivar had 5 replicates and a total of 250 seeds. Surface sterilization and loading of petri-dishes was in a Lamina-hood. Petri-dishes were covered and placed under a gadget supplying an alternating cycle of 12hours near ultraviolet light (NUV light) and 12 hours darkness, in an incubating room with temperature of $27 \pm 2^{\circ}\text{C}$. Incubation period was seven (7) days.

Record of Surface Contaminants and Germination Count.

Loading of petri-dishes with unsterilized seeds was the same as for the sterilized seeds. Incubation for the two sets of petri-dishes was 7 days. Germination count was taken on the 8th day. Germination was the number of seeds that had germinated as a percentage of the total of 50 seeds in a replicate, and the final cultivar percentage germination was the total number of seeds that were viable/germinated in a total of the 5 replicates of a cultivar. Surface contaminants were recorded from the seeds that were not surface-sterilized.

Examination of Seeds

After a 7-day incubation period, seeds were examined with a Wild M5 Stereo-binocular Microscope and a Compound binocular Microscope. Culturing of fungi from seeds as necessary was done for confirmation of fungal identity by slide preparations and use of potato dextrose agar. Identification was based on morphology/growth habit, reproductive structures such as sexual spores and asexual spores (e.g. conidia) and special structures such as sclerotia, sterile mycelia, etc, and with Identification guides namely the Illustrated Genera of Imperfect Fungi by Barnett and Hunter (1998) and FUNGI by Vashista and Sinha (1998). Some of the fungal identities were confirmed at the International Mycological Institute in Kew, Surrey England and bear numbers between the range IMI 321688 to IMI 321718.

Estimates of Infection

Infection by a fungus was firstly taken as a Percentage of a cultivar replicate, and then as a percentage of the total of 5 replicates in a cultivar, and also as a total of the cultivars examined.

Record of infection for a fungus:

$$\% \text{ Infection on a cultivar replicate} = \frac{\text{Number of seeds on which fungus was detected}}{50} \times \frac{100}{1}$$

$$\% \text{ Infection of fungus on a Cultivar} = \frac{\Sigma \% \text{ Infection on 5 replicates of a Cultivar}}{5}$$

$$\% \text{ Infection of fungus} = \frac{\Sigma \% \text{ Infection on total number of Cultivars}}{\text{Total number of Cultivars}}$$

Range of % Infection of fungus = a% to b% OR a% - b%

Where a is lowest % infection on the cultivars on which it is isolated

And b is the highest % infection on the cultivars on which it is isolated.

RESULTS**Seed Source, Storage and Surface Contaminants**

The eight Nigerian/Indigenous cultivars of *Capsicum* species and their sources, storage period before the seed test and seed treatment in storage are shown in Table 1. Also in Table 1 is germination percentage for each cultivator as well as fungi associated with the seeds that were not surface-sterilized before the seven days incubation. Viability of the cultivars was low. The lowest was 0.00% (no germination) recorded for cultivars Sakarho (SBEC) and Tattasai Ex-Hunkuyi from Kaduna State, with three and four surface contaminants associated with them respectively (Table 1). Viability of the six remaining cultivars is also considered low. In Tattasai L2289, it is 1.20%, Danmeyere (SBEC) 2.80%, Cherry Sweet 3.20%, Pepper 1 6.00%, Rodo 1 13.20% and Atarugu 23.60% as shown in Table 1. The fungi *Phoma* sp., *Chaetomium* sp., *Penicillium* sp., *Rhizopus stolonifer* and *Cladosporium* sp. were isolated from the unsterilized seeds of the Nigerian cultivars. The highest overall mean Infection of 13.20% was by *Phoma* sp., followed by 11.20% by *Chaetomium* sp.. *Phoma* and *Chaetomium* were also isolated from all eight cultivars. Third in overall mean Infection are *Penicillium* and *Rhizopus stolonifer* each with the value 4.00% (Table 1). The highest Cultivar replicate infection was 22.00% by *Chaetomium*. Second is 18.00% by *Phoma* and third is 14.00% also by *Phoma* sp.. *Cladosporium* sp. was isolated from two cultivars only.

Fungi isolated from the surface-sterilized seeds of the eight Nigerian/Indigenous cultivars

Twelve (12) fungi from the nine genera *Aspergillus*, *Cochliobolus*, *Colletotrichum*, *Corynespora*, *Curvularia*, *Fusarium*, *Macrophomina*, *Pithomyces* and *Thielevia* were isolated from the surface-sterilized seeds of the eight Nigerian cultivars (Table 2). *Aspergillus flavus*, *Fusarium moniliforme* and *Aspergillus niger* were the three dominant fungi as they were isolated from 8, 7, and 6 cultivars respectively (Table 2). The highest overall mean Infection was 11.80% by *Aspergillus flavus*, second highest is 6.60% by *Colletotrichum* sp. and third 3.20% by *Fusarium moniliforme* as shown in Table 2. Also the highest infection in any one cultivar replicate was 55.60% by *A. flavus*, followed by 23.20% by *Colletotrichum* sp. and 15.20% by *A. niger* (Table 2). Three fungi namely *Corynespora casicola*, *Pithomyces chartarum* and *Thielavia terricola* were the least dominant as they were associated with only one cultivar each (Table 2).

Exotic and less exotic Cultivar source and Viability

The twenty-three (23) Exotic and less exotic cultivars were sourced from Benue and Kaduna States of Nigeria (Table 3). Seven of the Cultivars did not germinate (0.00%) after 7 days of incubation (Table 3). Four cultivars had low viability of between 0.40% and 12.80% (Table 3).

Germination percent of eight cultivars are in the range 20.00% to 50.00% (Table 3). Only four cultivars had over 50% viability i.e. 50.80% to 76.00% (Table 3).

Fungi associated with seeds of the Exotic and less exotic Cultivars

Aspergillus flavus, *Fusarium moniliforme* and *Phoma* sp. were the three dominant fungi on the Exotic and less exotic cultivars as they were associated with 22, 21 and 19 cultivars respectively (Table 4). *Chaetomium*, *Curvularia lunata* and *Aspergillus niger* follow in dominance being associated with 17, 16 and 15 cultivars respectively (Table 4). *Collectotrichum*, *Aspergillus wentii*, *Curvularia pallescens*, *Penicillium* and *Rhizopus* were associated with 7, 9, 10 and 12 cultivars respectively (Table 4). *Cercospora*, *Fusarium equiseti*, *Stemphylium* and *Graphium* were associated with 2 and 3 cultivars (Table 4). The five fungi *Aspergillus ochraceus*, *Fusarium solani*, *Macrophomina* sp., *Spegazzinia* sp., and *Verticillium* sp., were found only on one cultivar each (Table 4). Highest overall mean infection in the Exotic cultivars was by *Aspergillus flavus* (13.55%), and next is *Colletotrichum* sp. (8.06%) and *Rhizopus* sp. (5.23%) (Table 4). The three highest infections on the cultivar replicates are 55.60% by *A. flavus*, 32.80% by *Rhizopus* and 23.20% by *Colletotrichum* sp.

Table 1: Nigerian/Indigenous Pepper Cultivars, Source, Storage Period, Germination and Mycoflora on Seeds Not Surface – Sterilized, after 7 days incubation

Pepper Cultivar and Source	Storage Period before Seed Test	Seed Treatment during Storage	Germination (%) after 7 days incubation	MYCOFLORA on Un-sterilized Pepper Seeds. Overall Mean and (Range) of percent (%) Infection				
				<i>Phoma</i> sp.	<i>Chaetomium</i> sp.	<i>Penicillium</i> sp.	<i>Rhizopus stolonifer</i>	<i>Cladosporium</i> spp.
ATARUGU IAR, ABU	< One year	No treatment	23.60	1.20 (0.00 – 2.00)	1.20 (0.00 – 4.00)	-	-	-
CHERRY SWEET IAR, ABU	> One year	No treatment	3.20	13.20 (8.00 – 18.00)	1.20 (0.00 – 4.00)	0.40 (0.00 – 2.00)	4.00 (0.00 – 10.00)	-
DANMEYER E (SBEC) IAR ABU	> One year	No treatment	2.80	0.80 (0.00 – 2.00)	0.80 (0.00 – 4.00)	-	-	-
PEPPER 1 TRF, U.I.	7 months	No treatment	6.00	1.20 (0.00 – 4.00)	2.40 (0.00 – 8.00)	-	3.60 (0.00 – 12.00)	1.6 (0.00 – 8.00)
RODO 1 NIHORT – IB	6 months	No treatment	13.20	3.20 (0.00 – 14.00)	11.20 (2.00 – 22.00)	4.00 (2.00 – 6.00)	-	-
SAKARHO (SBEC) IAR, ABU	> One year	No treatment	0.00	1.60 (0.00 – 4.00)	0.80 (0.00 – 2.00)	0.80 (0.00 – 2.00)	-	-
TATTASAI Ex-HUNKUYI IAR, ABU	> One year	No treatment	0.00	0.80 (0.00 – 4.00)	1.20 (0.00 – 4.00)	-	0.40 (0.00 – 2.00)	1.20 (0.00 – 6.00)

TATTASAI L2289 IAR, ABU	> One year	No treatment	1.20	0.40 (0.00 – 2.00)	1.60 (0.00 – 4.00)	-	-	-
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Source of CULTIVAR: IAR, ABU, Inst. Of Agric. Res., Ahmadu Bello University, Zaria, Kaduna State Nigeria; TRF, U.I Teaching & Res. Farms, University of Ibadan, Ibadan, Oyo State, Nigeria; NIHORT, IB, National Inst of Hort. Res. Ibadan, Oyo State, Nigeria

Table 2: Fungi on Surface-Sterilized Seeds of Nigerian Cultivars of Capsicum frutescens and C. annum after 7 days incubation

Fungi on Surface-sterilized seeds of Nigerian Cultivars of Capsicum spp.	Number of Cultivars Infected	Mean and (Range) of Percent % Infection
<i>Aspergillus flavus</i> ex Fries	8	11.80 (0.40 – 55.60)
<i>Aspergillus niger</i> van Tegg	6	2.60 (0.40 – 15.20)
<i>Aspergillus tamarii</i> Kita	4	0.80 (0.40 – 1.20)
<i>Cochliobolus lunatus</i> Nelson & Haasis – anamorph <i>Curvularia lunata</i> (Wakker) Boedjin	3	1.50 (0.40 – 3.60)
<i>Corynespora asiicola</i> (Berk & M.A. Curtis) Wei	1	1.60
<i>Curvularia pallescens</i> (Boedjin)	3	0.90 (0.40 – 2.00)
<i>Fusarium moniliforme</i> Sheldon	7	3.20 (0.40 – 14.00)
<i>Fusarium pallidoroseum</i> (Cooke) Sacc.	2	1.80 (1.60 – 2.00)
<i>Macrophomina phaseolina</i> (Tassi) Gold	3	0.70 (0.40 – 1.20)
<i>Pithomyces chartarum</i> (BERK & M.A. Curtis) MB Ellis	1	1.20
<i>Thielavia terricola</i> (Gilman & Abbot) Emmons	1	1.20
<i>Colletotrichum capsici</i> (Syd) Butler and Bisby	2	6.60 (0.40 – 23.20)

Table 3: EXOTIC and less exotic Pepper CULTIVARS, Source, Seed Treatment before Collection and Germination (%) after 7 days Incubation

Exotic and less exotic PEPPER CULTIVARS	Source	Seed Treatment before collection	Germination (%) after 7 days Incubation
Califorma Long slim	I.A.R., ABU, Zaria	Not indicated	0.40
Cherry Type L2118	Samara in Zaria	Not indicated	31.20
Dantsiga (SBEC)	I.A.R., ABU, Zaria	Not indicated	12.80
Fresno Chili Grande	I.A.R., ABU, Zaria	Not indicated	21.60
Gbafum	Yandev	Not indicated	48.80
Green Leaf Tabasco	I.A.R., ABU, Zaria	Not indicated	6.80
Hungaria	Gboko, Benue State	Not indicated	45.60
Hungarian Yellow Wax Hot	I.A.R., ABU, Zaria	Not indicated	37.60
Ikongyaa	Yandev	Not indicated	76.00
Ikongyaa (big type)	Yandev	Not indicated	36.00
Kashin Bargu (SBEC)	I.A.R., ABU, Zaria	Not indicated	0.00
Kimba (SBEC)	I.A.R., ABU, Zaria	Not indicated	0.00
Long Red Cayenne	Gboko, Benue State	Not indicated	7.60
L2190 (SBEC)	I.A.R., ABU, Zaria	Not indicated	0.00
L3874	Samara in Zaria	Not indicated	63.20
Mild California N/A	I.A.R., ABU, Zaria	Not indicated	34.00
Red Cherry Large	I.A.R., ABU, Zaria	Not indicated	33.20
Red Chili	I.A.R., ABU, Zaria	Not indicated	0.0
S.B.E.C. L2096	Samara in Zaria	Not indicated	62.40
TCA 14xxx76	I.A.R., ABU Zaria	Not indicated	0.00
Tattasai L2096	I.A.R., ABU Zaria	Not indicated	0.00
Tattasai L2164	I.A.R., ABU Zaria	Not indicated	0.00
Tattasai L2194	Samara in Zaria	Not indicated	50.80

Table 4: Fungi on Unsterilized Seeds of Exotic and less exotic Cultivars of *Capsicum* spp. After 7 days Incubation

Fungi on Unsterilized seeds of Exotic Cultivars of Pepper	Number of Cultivars Infected	Overall Mean and (Range) of Percent % Infection
<i>Aspergillus flavus</i> Link ex Fries	22	13.55 (0.40 – 55.60)
<i>Aspergillus niger</i> van Tiegh	15	2.61 (0.40 – 15.20)
<i>Aspergillus ochraceus</i>	1	0.40
<i>Aspergillus wentii</i>	9	1.91 (0.40 – 9.60)
<i>Cercospora</i> sp.	2	0.40
<i>Chaetomium</i> sp.	17	3.55 (0.40 – 15.20)
<i>Colletotrichum</i> sp.	7	8.06 (0.80 – 23.20)
<i>Curvularia lunata</i> (Wakker) Boedjin	16	1.05 (0.40 – 3.20)
<i>Curvularia pallescens</i> (Boedjin)	10	0.92 (0.40 – 2.00)
<i>Fusarium equiseti</i>	2	3.00 (1.60 – 4.40)
<i>Fusarium moniliforme</i> Sheldon	21	3.11 (0.40 – 14.00)
<i>Fusarium solani</i>	1	0.40
<i>Graphium</i> sp.	3	0.53 (0.40 – 0.80)
<i>Macrophomina</i> sp.	1	0.40
<i>Penicillium</i> sp.	12	1.77 (0.40 – 6.00)
<i>Phoma</i> sp.	19	2.72 (0.40 – 12.40)
<i>Spegazzinia</i> sp.	1	0.40
<i>Stemphylium</i> sp.	2	1.00 (0.40 – 1.60)
<i>Verticillium</i> sp.	1	0.40
<i>Rhizopus</i> sp.	12	5.23 (0.40 – 32.80)

DISCUSSION

Seed samples of thirty-one cultivars of pepper, *Capsicum* species were collected from Benue, Kaduna and Oyo States of Nigeria for Seed-health test in this study. Several cultivars were sown and transplanted into pots in the Greenhouse for a mini-field project, but there was slight yellowing of the leaves and later marked Curl-up of the leaf margins. The symptoms were identified as Curly-top virus disease at the International Inst. of Tropical Agriculture, Ibadan, through Prof. Ekpo (personal communication), before the plants were destroyed. There is dearth of information in literature on Curly-top virus disease on Nigerian cultivars of pepper. The cultivars were thereafter separated into two sets of Exotic plus less exotic in one set and Nigerian Cultivars in the second set for the seed-test. There are seven cultivars that are regarded as Indigenous or Nigerian plus one called Cherry Sweet that had been adopted by farmers in the SouthWest (Nigeria) which are in the first set. The second set are twenty-three cultivars that are Exotic or less exotic and are so referred to in this paper.

The eight Nigerian cultivars were examined firstly without surface-sterilization on blotter and scored for viability after seven days incubation. The seeds were also surface-sterilized and examined for seed-borne fungi after seven days of incubation. The experimental design was completely randomized with five (5) replicates in each cultivar and 50 seeds per cultivar replicate. The working sample was therefore 250 seeds per cultivar using standard blotter technique under alternating cycle of 12 hours near Ultraviolet (NUV) light and 12 hours darkness, in an incubating room of $27 \pm 2^{\circ}\text{C}$ temperature. The Exotic plus less exotic cultivars

were not surface-sterilized before examination under the 12hours NUV light and 12hours darkness for seven days. Germination counts were taken after the incubation.

Germination was generally low in the Nigerian Cultivars with zero (0.00%) germination in Cultivar Sakarho (SBEC) and Tattasai Ex-Hunkuyi. The germination range in the other six cultivars were 1.20% to 23.60% as follows: Tattasai L2289 1.20%, Danmeyere (SBEC) 2.80%, Cherry Sweet 3.20%, Pepper 1 6.00%, Rodo 1 13.20%, and Atarugu 23.60%. Seven cultivars of the Exotic plus less exotic did not germinate (0.00%). Four of the cultivars had very low germination of 0.40% to 12.80% and germination percentage was between 21.60% and 76.00% in twelve cultivars. Three reasons adduced for low viability in the two sets of cultivars are length of storage of the seeds (from 6months and over), lack of seed treatment and probably mixed infections with either bacteria or viruses or nematodes. Surface contaminants associated with the unsterilized seeds of the Nigerian cultivars are *Phoma sp.*, *Chaetomium sp.*, *Penicillium sp.*, *Rhizopus stolonifer* and *Cladosporium sp.*. Among these *Phoma sp.* and *Chaetomium sp.* were associated with all the eight cultivars and *Cladosporium spp.* with only two cultivars. Twenty fungi namely *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus ochraceus*, *Aspergillus wentii*, *Cercopora sp.*, *Chaetomium sp.*, *Colletotrichum sp.*, *Curvularia lunata*, *Curvularia pallescens*, *Fusarium equiseti*, *Fusarium moniliforme*, *Fusarium solani*, *Graphium sp.*, *Macrophomina sp.*, *Penicillium sp.*, *Phoma sp.*, *Rhizopus sp.*, *Spegazzina sp.*, *Stemphitium sp.* and *Verticillium sp.*, were associated with the Exotic plus less exotic cultivars. Overall mean Infection in the Exotic set was highest for *Aspergillus flavus* 13.55%, followed by *Colletotrichum sp.* 8.06% and then 5.23% by *Rhizopus sp.* The three highest infections on the Exotic cultivars are 55.06%, 32.80% and 23.20% also by the three fungi *Aspergillus flavus*, *Rhizopus sp.* and *Colletotrichum sp.* in that order respectively. Seed-borne saprophytes cause seed-rot especially members of the *Aspergillus* genus, seed discoloration, seed weight and germination reduction and are thus economically important and should be excluded by seed treatment (Al-Askar *et al.*, 2013). Twelve fungi in nine genera were isolated from the surface-sterilized seeds of the Nigerian cultivars namely *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus tamarii*, *Cochliobolus lunatus*, *Colletotrichum capsici*, *Corynespora casicola*, *Curvularia pallescens*, *Fusarium moniliforme*, *Fusarium pallidroseum*, *Macrophomina phaseolina*, *Pithomyces chartarum* and *Thielavia terricola*. Among these *Aspergillus flavus* detected on the eight cultivars was the dominant fungus, followed in second place by *Fusarium moniliforme* associated with seven cultivars and third is *Aspergillus niger* associated with six cultivars. However overall mean infection for *A. flavus* 11.80%, *Colletotrichum capsici* 6.60% and *Fusarium moniliforme* 3.20% were the highest. The highest infection recorded in any cultivar replicate was 55.60% by *Aspergillus flavus*, next is 23.20% by *Colletotrichum capsici* and then 15.2% by *Aspergillus niger*.

Colletotrichum capsici, *Aspergillus niger* and *A. flavus* were the predominant fungi associated with *Capsicum frutescens* seeds from Gboko and Ohimini Local Government Areas of Benue State in Nigeria (Chigoziri and Ekefan, 2013). The two local government areas grow peppers on a large scale (Chigoziri and Ekefan, 2013). The authors in the report also isolated two other species of *Colletotrichum* (*C. coccodes* and *C. dematium*), five other species of *Aspergillus* (*A. fumigatus*, *A. parasiticus*, *A. sect wentii*, *A. sect clavati* and *A. brevipes*), three species of *Fusarium* including species *solani* (detected on the Exotic Cultivars in this study), one species of *Rhizopus* not that recorded in this study, two species of *Penicillium* and one of *Phoma*, among others. Balogun *et al.*, (2005) found *Penicillium digitatum*, *Aspergillus flavus*, *A. niger* and *Verticillium sp.* to be the major fungi responsible for diseases of the fruits, seeds, stems and leaves of

peppers (*C. annuum* and *C. frutescens*) that resulted in total crop failure and high yield loss in a Vegetable Crop Plantation in Ilorin (Kwara State) Nigeria in 2003 and specifically recorded *Verticillium* species as responsible for wilting of the pepper plants. Guldekar *et al.*, (2017) also reported the four fungal genera *Aspergillus*, *Fusarium*, *Curvularia* and *Colletotrichum* to be seed-borne on Chilli pepper (*Capsicum annuum*) collected from several locations of the Nagpur district in India. A fifth genus *Alternaria* was also reported on the seeds. *Colletotrichum capsici* with mean infection of 6.60% on the Nigerian cultivars in this study and also reported on pepper in the three cited reports in the foregoing (Benue and Kwara State of Nigeria and India) is regarded as the most severe or destructive pathogen of peppers in Nigeria (Amusa *et al.*, 2004). It causes ripe fruit rot plus stem die back and yield loss of about 95% have been reported in farmers' fields (Amusa *et al.*, 2004). Up to fifty percent (50%) pepper fruit yield loss and seed/seedling rot has been attributed to three species of *Colletotrichum* namely *C. capsici*, *C. gloeosporioides* and *C. acutatum* as well as *Alternaria alternata* and *Fusarium oxysporium* (Chanhan Rinkal *et al.*, 2018). Yield losses of up to 84% have been reported due to anthracnose/dieback/ripe foot rot caused by *Colletotrichum capsici* (*C. truncatum*: Ranathunge *et al.*, 2012) (Than *et al.*, 2008, Linu *et al.*, 2013). Mongkolporn and Taylor (2018) reported that *Colletotrichum* species are causal agents of the most significant *Capsicum* Pepper Cultivars Crop losses globally. *C. capsici* was the most frequently occurring fungus on pepper seed samples from the Ashanti Region of Ghana (Gyasi *et al.*, 2020). The two genera *Fusarium* (species *solani* and *verticilloides*) and *Aspergillus* (species *flavus*) were second in frequency on the Ghanaian seed samples (Gyasi *et al.*, 2020). Wilt of pepper by the fungal genus *Fusarium* and *Verticillium* has been reported in several parts of the world including Nigeria (Chigoziri *et al.*, 2013; Sarhan and Sharif, 1986; Camino *et al.*, 1990; Liang, 1990). *Corynespora* isolated from the Nigerian seed cultivars in this study is known to be parasitic on leaves (Barnett and Hunter, 1998). The fungal genus *Sclerotium bataticola*, a soil inhabitant which causes root rots (or tuber/corm rots or rots of other crop organs produced in or on the soil surface) produces conidia belonging to the imperfect fungus *Macrophomina* (Agrios 1988). *Macrophomina* is parasitic (Agrios 1988). It may thus initiate stem rot disease on pepper. *Pithomyces chartarum* and *Thielavia terricola* have not being reported on *Capsicum* species and are therefore new records on *Capsicum* seeds in Nigeria.

One of the reasons given for low viability of the two sets of cultivar seeds in this study is lack of seed treatment. Continuous use of farmers-saved seeds without seed treatment results in high incidence of seed-borne diseases and field epidemics. This is the reason for which farmers are being discouraged from seed-saving without treatment in developing countries (Gyasi *et al.*, 2020). The option of plant extracts, oils and bio control agents for treatment of seeds is being emphasized and encouraged also and not fungicides because they have short field retention time, without environmental residues (environmental threats). Ekefan *et al.*, (2009) reported the suppression of the growth of *Colletotrichum capsici* and reduction of its incidence on seeds and soil (where the pathogen survives), with *Trichoderma harzianum* and suggested further research to establish better control with *T. harzianum* especially in combination with a proven Plant extract. Gyasi *et al.*, (2020) tested the efficacy of garlic, ginger and neem extracts on six seed-borne pathogens of *Capsicum* namely *Colletotrichum capsici*, *C. gloeosporioides*, *Fusarium solani*, *F. verticilloides*, *Aspergillus flavus* and *A. niger*. They reported effective control of the *Colletotrichum* and the *Aspergillus* pathogens with 60% aqueous garlic extract and 60% aqueous ginger extract. The Neem extract controlled the seed-borne *Aspergillus* pathogens only. The *Fusarium* wilt pathogens were not adequately controlled with the extracts. Fundings and

trials with oils, biocontrol agents and plant extracts are being suggested as needful in Nigeria now, so that proven materials can be given free or with subsidy to small-holder (local) and large-holder farmers as often as required. By this substantial reductions in seed/ seedling loss, pre and post-harvest fruit losses or crop failure will be realized.

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