GSC Biological and Pharmaceutical Sciences, 2019, 08(02), 119–130

Available online at GSC Online Press Directory

GSC Biological and Pharmaceutical Sciences

e-ISSN: 2581-3250, CODEN (USA): GBPSC2

Journal homepage: https://www.gsconlinepress.com/journals/gscbps

(REVIEW ARTICLE)

Enumerations on seed-borne and post-harvest microflora associated with okra [*Abelmoschus esculentus* (L.) Moench] and their management

Sharma Dilip Kumar

Department of Science and Technology, Vardhman Mahaveer Open University, Kota, Rajasthan, India.

Publication history: Received on 03 August 2019; revised on 14 August 2019; accepted on 23 August 2019

Article DOI: https://doi.org/10.30574/gscbps.2019.8.2.0149

Abstract

Okra (*Abelmoschus esculentus* (L.) Moench) of Malvaceae is an important vegetable crop grown worldwide including India. Okra is attacked by various microorganisms like fungi, bacteria, viruses in the field or contaminate during harvesting, processing and packing or transportation. The frequency of damage by various diseases varies greatly with commodity, processing, growing conditions and the way of handling. The post-harvest diseases in transit and storage lead to waste of labor, time, field and money. The associated microflora reduces the quality, yield and market value of the crop. In this review, a brief data has been collected from various available resources about the various pathogen(s) or diseases associated with this crop.

Keywords: Diseases of okra; Fungal diseases; Bacterial diseases; Management of diseases; Uses of okra

1. Introduction

Okra [*Abelmoschus esculentus* (L.) Moench; syn. *Hibiscus esculentus* L.] of family Malvaceae is an important vegetable crop grown in many tropical, subtropical and warmer temperate areas [1]. Commonly it is known as bhindi, lady's finger or Gumbo (southern part of Europe and United States). The crop is a native of the Africa still found growing wild along the river Nile in Egypt as well as in Ethiopia. In India, it is grown over an average of 5849 MT with a production of 511 Ha; with 3.15 MT/ Ha productivity in Rajasthan [2, 3]. India has good ranking in the production in the world. Fresh okra is an important vegetable which is exported from India to Middle East U.K., Western Europe and USA. The important okra producing states are Haryana, Assam, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal [4].

Okra is an erect, coarse, robust annual herb in which flowers are borne singly in the leaf axile on peduncles. The plant has malvaceous floral organization with 8-10 very narrow, hairy, bracteoles forming an epicalyx. The leaves are, leathery or rough, large, alternate, cordate divided into 3-7 lobes with notched or toothed margins. Flower borne singly in the leaf axils on peduncles 2 to 5 cm long with malvaceous floral organisation The fruits are light green or sometimes red in colour, long (10-30 cm), beaked, ridged; more or less oblong hairy capsules that dehiscing longitudinally [5-9].

The fresh and green tender fruits are used as a vegetable or sliced and dehydrated to conserve them for later use. A large proportion of the crop is processed by canning, freezing or preserving in brine. The young tender mucilaginous fruits are used in tropical area cookery to thicken soups, sauces, and stews. In Europe, roast okra seeds have used as a substitute for coffee. Mucilage from the stem and roots are used for clarifying sugarcane juice, during gur (jaggery) manufacture in India, and used for sizing paper, particularly in China. A mucilage preparation from the fruit is used as a plasma replacement or blood volume expander. The young fruits are mucilaginous and contain numerous green of

* Corresponding author
E-mail address: drdilipsharma12@gmail.com

dark brown to black spherical but tuberculate seeds. The edible portion of the fruit (100g green fruit) approximately contains; 86.1% moisture, 9.7% carbohydrates, 2.2% protein, 1.0% fibers, 0.2% fats, and 0.9 % ash. The ripen seeds contain approximately 20% edible oil. Okra is a good source of vitamins A, B, C and minerals, especially Iodine [9-11].

Many seed-borne and post-harvest diseases affect the production of okra and cause enormous losses.

It is an important vegetable crop suffers from several fungal and bacterial species that causing severe losses reduces yield and market value of okra seeds [5, 6, 12-16]. A review giving a brief account of the important diseases affecting the crop is given here.

2. Seed-borne fungi

The seeds of okra are found to be associated with a large number of fungal species among them species of *Aspergillus, Alternaria*, botrytis, *Curvularia, Dreschlera, Chaetomium, Fusarium, Penicillium, Rhizoctonia bataticola*, *Colletotrichum*, *Macrophomian phascolina, Choanophora cucurbitarum, Ascochyta belmoschi, Rhizopus* reported as major fungi [15-26]. Five homeopathic drugs were tested against various fungal species and found effective. These drugs increased percent seed germination, root-shoot length of okra and inhibition of 22 fungi associated with seeds by Thuja, citric acid and sulfur 200 drugs [27].

Agrawal and Singh (2004) [28] studied the efficacy of latex of some plants and found *Calotropis procera, Datura innoxia, Michalia champaca* and *Ricinus communis* effective at 30% concentration against seed-borne fungi viz., *Aspergillus flavus*, A. fumigates, *A. niger, Cercospora* sp*., Fusarium* sp, *Rhizoctonia bataticola, Curvularia lunata* and *Penicillium* sp. that were eliminated completely.

Begum et al (2009) [29] tried aqueous leaf extracts of *Coleus aromaticus, Adathoda vasica, Vitex negundo, Solanum nigraum, Leucas aspera, Ocimum sanctum* and *Catharanthus roseus* as seed treatment to manage the fungal pathogens in okra (var. Arka Anamika). Extracts of Coleus *aromaticus* and *Vitex negundo* were found superior in reducing the incidence of mycolflora. All treatment resulted in increased percentage of seed germination and vigor of the seedlings. These extract also biomass, number of leaves, and number of seeds per fruit, seed density and ascorbic acid content in raw fruit.

It is found that in vitro tests, *Rhizobium meliloti* inhibited growth of the soil-borne root infecting fungi, *Macrophomina phaseolina, R. solani* and *Fusarium solani* while *Bradyrhizobium japonicum* inhibited *M. phaseolina* and *R. solani.* They also increased the shoot length and fresh weight [30]. Shahida et al (1994) [31] found that *Trichoderma harzianum, T. koningii, Gliocladium virens, Paecilomyces lilacinus, Brandyrhirhizobium japonicu*m and *R. meliloti* showed a significant control of *M. phaseolina, F. oxysporum* and *F. solani* infection on okra. Razeena and Ahmad (2007) [32] have reported in vitro inhibition of *Aspergillus flavus, A. niger, F. moniliforme* and *M. phaseolina* by *Pseudomonas flauorescens* and leaf extracts of *Lawsonia inermis*.

The crop is attacked by various microorganism or pests that are responsible for its poor quality and low yield *approx* 20-30% every year in most okra-growing areas of the country [33, 34]. Crop suffers from a number of *phytopathogenic* fungal and bacterial species causing severe losses, reduces yield and market value of okra seeds [5, 6, 12-15, 35]. Annotated list of Seed-borne Diseases has listed Ascochyta blight, pod spots (*Ascochyta abelmoschi*), stem and capsule disease (*Botrytis* sp.), anthracnose (*Colletotrichum dematium*), wilt (*Fusarium oxysporum* f. sp. *vansifectum* and *Fusarium solani*), charcoal and root rot (*Macrophomina phaseolina* and *Rhizoctonia solani*), bacterial blight (*Pseudomonas syringae*), okra leaf curl virus and yellow vein mosaic virus as seed-borne diseases [15]. About 32 fungal species on okra seeds from various districts of Rajasthan viz. Actinomycetes, *Arthrobotrys supberba, Aspergillus fumigates, Cladosporium oxysporum, Drechslera* sp., *Fusarium moniliforme, Stachyobotrys* sp., *Verticillium alboatrum* and 3 bacterial species namely *Ralstonia solanacearum* (Smith) Yabuuchi et al., *Pseudomonas syringae* var. *syringae* van Hall and *Xanthomonas axonopodis* var. *malvacearum* (Smith) Vauterin. Out of these 10 fungal species were found dominant associated on okra. This microflora severely affecting seeds germination and cause many seedling abnormalities like failure or delayed seeds germination, bacterial oozing, rotting, collapse of hypocotyls and cotyledonary leaves that resulting seedling mortality[6,16]. High incidence of 5 seed-borne fungal diseases was reported from Pakistan from the field. The treatment of seeds with of Vitavex-200 found effective to control these diseases and reduce the incidence [36]. Major seed-borne diseases of okra in Bangladesh are seed rot, seedling blight, die back, anthracnose, stem rot, die back, seed rot, germination failure or seed discoloration, seed rot and seedling blight [37].

In Bangladesh, okra suffers from number of diseases. Out of among them 14 are seed-borne like 6 are major and 8 are minor [38]. The most important seed-borne pathogens infecting the okra seeds are species of *Aspergillus, Fusarium, Macrophomina phaseolina, Colletotrichum, Curvularia* [39]. Major seed-borne fungal pathogens are *C. dematium* and *M. phaseolina,* both are seed transmitted. The infection of *Macrophomina phaseolina* individually or along with *Colletotrichum dematium* reported from Bangladesh [40]. In a seed health study from Bangladesh , seven fungi namely *Aspergillus flavus, A. niger, Fusarium* spp., *Macrophomina phaseolina, Colletotrichum dematium, Rhizopus* spp. and *Curvularia* spp. were found in the seed samples. Among the fungi, prevalence of *Aspergillus flavus* was maximal which was followed by Fusarium spp. All the seven fungal pathogens were more prevalent in farmer saved seed compared to other seed [39].

3. Fungal diseases

3.1. Fusarium wilt and root rot

Various species of Fusarium viz. *Fusarium oxysporium* f.sp. *vasinfectum, F. solani, Fusarium hibisci, F. pallidoroseum, F. ventricosum* and *Fusarium semitectum* cause wilt, root rot and 'Fusariosis' and stem canker in okra [16-18, 41-47]. Suryanarayan and Bhombe (1961) [17] isolated first time Fusarium sp. from okra seeds. Seed-borne nature of *F. oxysporum* f. sp. *vasinfectum* in okra was reported [44]. The crop sown in May-June was more vulnerable to wilt in the region of Punjab and Haryana and showed significant loss of 25-35% by *F. oxysporum* f. sp. *vasinfectum*. They observed presence of the mycelium in the xylem cells [41].

Effective control of *F. oxysporum* has been reported by plant parts and products of neem [49, 50]. Razeena and Ahmad (2007) [32] reported up to 85% inhibition of F. oxysporum by leaf extracts of *Lawsonia inermis* and up to 88.8% inhibition by *Pseudomonas fluorescens*. From Romania, Docea and Coroianu (1982) [51] reported *Fusarium oxysporum* f. sp. *vasinfectum* for the first time on *Hibiscus esculentus.* It was reported that the wilt of okra caused by *Fusarium oxysporum* f. sp. *vasinfectum* in the region of Punjab, Haryana (India) and Pakistan [41, 46]. *Fusarium oxysporium* caused browning and wilting with interval discoloration in the basal portion of the stem. Fusariosis of okra (*F. o.* f. sp *vasinfectum*) was reported from Rio de Janeiro and Guanabara [52]. The seed-borne nature of *F.o.* f.sp *vasinfectum* was reported and the seed were found 20-25% smaller as a result of infection as compared to normal seeds [44].

Esuruoso et al (1975) [18] tested freshly harvested seeds from 67 cvs. of okra in Nigeria. The incidence of *Fusarium moniliforme* was 100% as comparative to *F. pallidoroseum* and *F. solani* that has 37% and 30% incidence respectively, with other non-pathogenic fungi. It was observed severe root rot near Jaipur (Rajasthan) and West Bengal [45]. Isolation from diseased seedlings yielded *F. ventricosum*. Diseased seedlings wilt died in 15-20 days and confirmed the pathogenicity. The use of certified seeds and soil fumigation with 2, 3-bromopropionitrile and trichloronitroethylene recommended [42]. Gangopadhyay and Kapoor (1977) [44] controlled Fusarium wilt by seed soaking in 0.3 % Ziram.

3.2. Charcoal and root rot disease

Charcoal and Root Rot disease (*Rhizoctonia bataticola* (Taub.) Butler [syn. of *Macrophomina phoseolina* (*Tassi*) Goid] and *Rhizoctonia solani*) is widespread in India [53-55]. *M. phaseolina* also cause root rot [54], leaf blight [56] and die-back disease [57]. The seed samples of okra studied and reported that *M. phoseolina* is seed-borne in nature. They found infection persisting in seeds (seed surface and below the seed coat), in soil and plant debris mycelium, pycnidia or microsclerotia [58].

The pathogen caused rotting of the root and collar regions including browning and maceration of tissue of this region reported that pectolytic and cellulolytic enzymes (viz. polygalactouronase, polygalactouronate transeliminase and pectin methylesterase) play an important role in maceration and death of tissue of these regions [59]. In rotted tissue and stem, while only on stem microscloritia and mycelium was observed of the susceptible plants were only pycnidia [60]. In transmission study it caused pre- and post-emergence mortality and yield loss [61] and reports the transmission from seed to seedling.

A significant reduction in seed germination or root-shoot length and wet and dry weights of 7-days old okra plants was observed after inoculation of *Meloidoyne incognita, Rhizoctonia solani, Rhizoctonia bataticola* [62, 63]. Fakir and Mrida (1985) [40] observed 3.2% of plants were found infected by *M. phaseolina* and reported the transmission of pathogen. Seed treatment with Ceresan and Thiram [64-67], Difolatan (Captafol) and Kitazin [33] were used to control *R. bataticola*. Captan, Quintogene (PCNH) and Coppesan effectively controlled blight followed by *R. solani* [55, 65, 68].

Seed-borne infection (*R. bataticola*) controlled by neem oil treatment (80^{0}C), oil of ground nut, mustard, castor and sunflower oil at 95 ^{0}C [28]. The leaf extracts of *Azadirachta indica, Calotropis procera, Catheranthus roseus, Lawsonia rosea* and *Ricinus communis* at 30 ^{0}C concentration were found effective to control the pathogen. The extracts of onion and ginger were also found effective in enhancement of seed germination and controlling of the pathogen [28]. Razeena and Ahmad (2007) [32] reported 100% inhibition and improved seed germination against *M. phaseolina* by using leaf extracts of *Lawsonia inermis.*

The seed treatment with *Trichothecium harzianum, Gliocladium virens, Paecilomyces lilacinus, Bacillus subtilis* and species of *Streptomyces* control of root rot and reduced the infection *M. phaseolina, R. solani and Fusarium* sp. in okra [69]. *Trichoderma harzianum* and *T. koningii* have been reported to be highly antagonistic to *R. solani* (seedling blight) as compare to *T. viride* [70]. The uses of *Verticillium chlamydosporum, Paecilomyces lilacinus, Rhizobium meliloti* or soil amendments to control *R. solani* in okra were reported [71]. Antagonistic effect of *T. harzianum* and *G. virens* were found effective against to control *R. bataticola*. Both bioagents gave best control of the pathogen but seed germination and reduction in incidence of the pathogen were relatively higher in seeds treated with *T. harzianum* than *G. virens* [28]. The isolates of *Rhizobium* sp. screened from pea, lucemae and soybean nodules led to significant reduction in severity of Macrophomina root rot of okra, moongbean and sunflower in greenhouse [72]. *T. harzianum* and *T. koningii* were highly antagonistic to *Rhizoctonia solani* but the isolates of *T. viride* were less effective [70].

3.3. Leaf blight

Several species of Cercospora *viz. Cercospora abelmoschi* Eu & Ev., *C. hibisci, C. hibiscina* Eu. & Ev. and *C. malayensis* Stevens reported on leaves of okra causing leaf spots or sometimes blight disease [18,74-76]. C. *abelmoschi* appeared as sooty to dark olivaceous mold on the lower surface of the leaf [77]. These spots has grayish center with purple to red border in severe cases. The infected leaf areas fell out in severe cases and giving the appearance of shot holes. The infection was prevalent mainly on older lower leaves in wet weather conditions and generally at the time of fruit setting [18]. In the field trials at Tadong and Sikkim during 1984-85 studied the influence of sowing date on the development of Cercospora leaf blight and found that the crop remained disease free for upto 30 days after sowing (DAS). The lowest disease incidence and highest yield occurred on crops sown on March at 18^{0}C temperature [78]. Ghosh et al (2009) [79] screened 15 germplasms for resistance to Cercospora leaf spot disease but non them was found to be resistant, though two lines KS-422 and P-7 were found tolerant.

3.4. Leaf spot

The disease is caused by various species of *Curvularia*. In Nigeria *Curvularia* is reported as an important pathogenic fungus responsible for yield losses. It has been reported that *Curvularia abelmosci* causes disease in okra [80]. The *in vitro* efficacy of fungi toxicity of 5 fungicides on PDA (potato dextrose agar medium) @ 50, 100, 150, 200 and 250µg/cm^3 was tested for the control of leaf spots disease of Okra, caused by *C. lunata* in the Green house of Nigeria. All the five fungicides as Kototine, Apron plus, Benlate, Captan and Dithane M-45, inhibited the vegetative growth of *C. lunata* at all concentrations. At 150 to 250µg/cm^3 Kototine and Apron plus completely (100%) inhibited the mycelia growth of the fungus [81]. *C. lunata* is another seed-borne pathogen attack on okra, groundnut, Ogbono (*Irvingia gabonensis*) and African yam bean (*Sphenostylis stenocarpa*) [77].

3.5. Powdery mildew

The disease is caused by various genera like *Erysiphe cichoracearum, E. communis, E. abelmoschi, Leveillula laurica, Oidium abelmoschi* and *Sphaerotheca fuliginea* in different parts of the world [82]. In India it is caused by *E. Cichoracearum* [83] and species of Oidium [84, 85]. The okra leaves and stem produced circular or irregular spots (restricted to adaxial leaf surface only) that increase in size, coalesce and cover the entire laminar surface later on becoming powdery. Infected leaves showed an early sign of senescence and gloomy appearance [86]. Sataraddi et al (2009) [87] reported least disease index (66.4%) in cases of early sowing (1stJuly) and maximum percent disease index in case of late sowing (September 76.8% and October 77.8%) based on experiments carried out at Bijapur and Dharwad, Karnataka. It concluded that early sowing can help in reducing the disease occurrence. Neem oil and neem seed karnel extract are found effective in controlling the disease and lower the incidence of disease [88]. It was reported a positive effect (32.06%) in controlling disease intensity with *Trichoderma viride* @ 4g/litre of water as seed treatment [89]. Study of reaction of 36 okra cultivars to the pathogen was observed [90]. No immune or highly resistant cultivars were noted but 9 were found moderately resistant (11-25% infection) including a relatively high yielding cultivar.

3.6. Anthracnose

The disease is caused by species of *Colletotrichum* namely *Colletotrichum capsici, Colletotrichum hibisci* and *Colletotrichum dematium* in okra [86, 91]. They isolated the fungus from seeds ofokra and reported that the pathogen caused severe leaf blight with necrotic lesions which later becomes shot holes. The pathogen produced polygalactouronase (PG), polymethyl galactouronase (PMG) and cellulase. Leaf spot caused by *Colletotrichum dematium* in the Sehore (Madhya Pradesh) regions in 1982 and confirmed the pathogenicity [92].

4. Bacterial diseases

4.1. Bacterial leaf spot and blight

The disease was reported from Australia [93]; Brazil [94]; Romania [95] in *Hibiscus esculentus* caused by *Pseudomonas syringae* pv. *syringae.* Hibiscus leaves var. Apple Blossom commonly affected by purplish-black recorded dots 7.25 inch in diameter. The symptoms appeared on fruits and leaves under low RH and high temperature conditions. *Pseudomonas syringae* was found in association with *Xanthomonas campestris* pv. *esculenti* on leaves increasing the severity of the leaf blight. Seeds were smaller, irregularly shaped, chestnut coloured and strongly fluorescent under UV light [94, 95]. Bacterial leaf spot disease damaging winter crops of okra caused by *Xanthomonas esculenti* [43] and hypersensitive reaction studied in okra by *X. oryzae* [96, 97]. They studied the effect of extracellular polysaccharide (EPS) from *Xanthomonas campestris* pv. *oryzae* on five test plants. The EPS extracted from different isolates of the rice bacterial blight pathogen showed similar properties with regard to their toxic effect on the cutting of five test plants, indicating the non-specific nature of EPS on okra*.*

The Bordeaux mixture in 4:4:40 or Cu Oxychloride (lcz/3gal) checked the growth of *P. syringae* otherwise; pruning and burning fallen leaves should eliminate foci of infection [93]. Robbs *et al* (1969) [43] observed that Cu and carbonate fungicide gave the best control against *Xanthomonas esculenti.* Four antibiotics tested against *P. tabaci, P. phaseolina, Xanthomonas phaseoli, P. hibisci* (*P. syringae*) and *Xanthomonas carotae* in *vitro* and streptomycin was found most effective*.* Dry seed treatment @1g/kg against *P. syringae* on okra was found the most effective.

4.2. Viral diseases

4.3. Yellow vein mosaic or okra

The crop is attacked by several viruses but yellow vein mosaic virus is important attacked on okra [99]. The virus causing okra yellow vein mosaic (OYVMV) is known as yellow vein mosaic virus the most serious disease of okra. If the plants are affected in the early stage of growth there is a total loss so far as yield and quality of fruit. If the plants are infected within 35 days of germination their growth is retarded, few leaves and fruit are formed and the loss may be about 94%. Plants infected 50 and 65 days after germination suffer a loss of 84 and 49% respectively [100-104].

A virus induced mosaic of okra from Nigeria was reported [105]. The virus was transmitted by grafting or mechanical inoculation of okra, cotton, cowpea and *Chenopodium.* The effect of okra mosaic virus on growth and yield of okra plants varied with the time of inoculation during the early rains [106]. Inoculation 14 and 21 days after emergence (DAE) reduced the average weight of fruits/plants compared with those inoculated 28 DAE and the uninoculated control. Study of the natural incidence of OYVMV disease in relation to different dates of sowing has revealed that the lowest disease incidence occurred on okra sown at the beginning of October (16.7%) and the highest on crops sowing May and June (100%) with incidence in February and March crops of 36.5 and 54.2%, respectively [107]. The incidence of OYVMV on cv. Pusa Sawani varied from 75 to 91% in the plots sowing between early April and the end of June. A strong positive correlation was obtained by Nath and Saikia (1995) [108] between percent disease incidence and white fly (*Bemisia tabaci*) population (r =0.085) whereas a strong negative correlation was obtained from disease incidence and fruit yield (r=-0.84). In biochemical studies, OYVMV infection increased the levels of total reducing and non-reducing sugars. Starch, Ammonium, Nitrogen and total free amino acids decreased in diseased plants. Levels of chlorophyll and carbohydrates in infected okra declined with increase in severity of OYVMV symptoms, while lipids, nucleic acids level increased in diseased plants [109-111].

The highest loss of seeds (86.13%) occurred in plants showing symptoms on the 33th day after sowing and the least (32.85%) in those with symptoms on the 75th day [112]. It was suggested the use of seeds from healthy plants; seed treatment and isolation to assist in control of okra leaf curl virus and mosaic virus disease. The yellow-coloured polyethylene mulch significantly delayed the OYVMV symptoms as much as 69 days from the date of sowing in mulched crop as compared with only 28 days in unmulched [114]. Disease incidence in the mulched crop was 24.3% compared with 58.6 % in the control. They tested the pesticides against OYVMV and its vector (*Bemisia tabaci*) with soil application of Methyl phosphorodiothionate (Furatox-lOG) at 15 kg/ha followed by four foliar sprays of

Metasystox 25 Ec at 0.03% at 15-day intervals from the sowing date reduced incidence to 23.26 % (control 81.22%) and average white fly population to 59.66 % (from 23.1% and enhanced yield to 59.45 q/ha (from 23.8%). Fifty one *Abelmoschus esculentus* hybrids and 20 parents for OYVMV resistance during the rainy season at 35, 50 and 65 days after sowing were screened. Only one parent Parbhani Kranti and 11 hybrids were highly resistant, while the rest of the parents and hybrids were susceptible to OYVMV [115].

5. Post-harvest diseases

5.1. Fruit rot and pod spots

The disease is caused by various fungal species. *Rhizopus stolonifer* caused browning and softening of the pods which at high relative humidity covered by mycelium and fruit bodies of the fungus [116,117]. *Curvularia oryzae* was isolated from fruits of okra collected in markets in Allahabad [118]. Dry fruit rot disease is caused by *Aspergillus flavus* [119]. Seventy eight fruit samples of okra from different sites were collected (during 2011; 2012 and 2013) from various districts of Rajasthan. Eleven major fungal genera (*Aspergillus flavus, A. niger, A. nidulens, A. fumigates, Alternaria alternate, Curvularia lunata, Rhizopus nigricans, Cladosporium oxysporum, Penicillium chrysogenum, P. citrinum, Stachybotrus atra, Chaetomium globosum, C. murorum, Rhizoctonia bataticola*), and 4 bacterial genera (*Actinomycetes* sp., *Erwinia caratovora, Xanthomonas campestiris* pv. *campestris, X. c.* pv. *malvacearum, Pseudomonas syringae* pv. *syringae*) were found associated with post-harvested diseases or spoilage of okra fruits in the study. It was concluded that fungal pathogens cause the damage at high temperature, low relative humidity with poor aeration. These pathogens showed 04-72 % loss due to said pathogens [5]. The species of *Aschochyta* produces lesions with ash grey centers bearing minute fructification on fruit surface. The fungi *Cladosporium oxysporum* Berk and Curt produce fruit rot diseases [102].

Fruit rot is caused by *Pythium aphanidermatum* and *Phytophthora palmivora* on fruits during mishandled, bruised, packed tightly and transported or stored in humid and warm conditions [102]. Grey mold (*Botrytis cinerea*) reported from Romania on okra which on high relative humidity grows profusely [116]. The symptom appeared as whitening of the stem and pods which gradually attacked all aerial organs. Sclerotia were formed on the stem in the autumn. Choanophora pod rot (*Choanophora cucurbitarum*) reported from Rajasthan produces water soaked areas on green pods which later turned brownish black symptoms [120]. Seed-borne pathogen *Cladosporium cucurbitarum* with *Rhizoctona* sp. caused fruit rot of *Hibiscus esculentus* [121]. The *C. cucurbitarum* isolate was pathogenic to non-detached flowers and wounded fruit but not unwounded fruit and seedlings. Both were pathogenic to non-detached wounded or unwounded green fruit.

The pathogen was isolated from all parts of infected fruit of okra except the sepals withered flowers attached to young fruits after pollination from Nigeria. Water soaked symptoms commencing usually from the apical region. They evaluated 9 cultivars of okra in the early and late seasons for two years. Mean premature abortion induced by *Cladosporium cucurbitarum* ranged from 24 % for cv. NHAC 621 to 73 % for cv. NHAC-474 [122, 123].

Alternaria leaf spots and pod spots disease is caused by *Alternaria dianthi* and *A. zinniae* reported globally from India [60, 124]; *A. hibiscinum* [51] from Romania; and *Alternaria alternata* from Japan [125]. Symptoms appeared as brown sub-circular spots of varying sizes on pods. The expression of disease symptoms was greatly promoted at low and prolonged temperature. *Alternaria alternata* caused post-harvest disease and studied infection sources of the post-harvest development of Alternaria rot of okra. They pathogen attacked on old leaves and produced numerous conidia on dying or dead tissue [51, 125]. Fruit rot, transmission and pathogenicity of *Macrophomina phaseolina* and *Fusarium verticilloides* in okra was reported [126].

Effect of mehogoni, mehedi and allamanda extracts were tested to control seed borne fungi of okra seeds collected from 6 companies of notunbazar in Mymensingh district on blotter method was found prevalence from Bangladesh. *Fusarium oxysporum* (5.08%), *Aspergillus flavus* (4.50%), *A. niger* (6.50%), *Colletotrichum dematium* (4.67%), *Rhizopus stolonifer* (3.33%) and *Penicillium* sp. (3.00%) were found as predominant fungal genera. The germination was ranged from 70-95% and infections were recorded 0.80-6.1% in all the treated seeds [127].

In 2014-2016, the root disease of okra was discovered in 4 commercial fields surveyed in China. *Verticillium dahliae* isolated from the infected tissues and identified on the basis of morphological characteristics. The analysis of 3 sequences revealed 99-100% identity with the reported *V. dahliae* strain in GenBank [128].

Compliance with ethical standards

Acknowledgments

Author expresses sincere gratitude to the colleagues of the office/Institute in preparation of this review article.

Disclosure of conflict of interest

There is no conflict of interest.

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How to cite this article

Sharma DK. (2019). Enumerations on seed-borne and post-harvest microflora associated with okra [*Abelmoschus esculentus* (L.) Moench] and their management. GSC Biological and Pharmaceutical Sciences, 8(2), 119-130.