

Nutritional and Pharmaceutical Potentials of Okra (*Abelmoschus esculentus*) Plant and Its Biotic Stresses -An Overview

Lokesh*

Entomology Department, CCS Haryana Agricultural University, Hisar-125001, India

*Corresponding Author E-mail: lok.hau@gmail.com

Received: 12.07.2017 | Revised: 23.07.2017 | Accepted: 24.07.2017

ABSTRACT

Okra (Abelmoschus esculentus), a traditional vegetable crop in Asia and Africa has huge socio-economic potential. It originated from Ethiopia and then spread, worldwide covering tropical, subtropical and warm temperate regions. Okra belongs to Malvaceae family and is a good source of carbohydrates, protein, vitamins, enzymes, and total minerals. It is used in medicines for curing ulcers, chronic dysentery and genito-urinary disorders. It provides relief from hemorrhoids and finds applications in plasma replacement and as blood volume expander. However, okra has been considered a minor crop and less attention has been paid to its improvement in the international research program. This paper presents an overview of Okra's taxonomy, geographic origin and distribution, morphology, biochemical, nutritional and pharmaceutical potentials. At the end, biotic and abiotic stresses in Okra have also been discussed.

Key words: Malvaceae, Tropical, Hemorrhoids, Morphology, Nutritional Potential.

INTRODUCTION

For the sustainable food security of ever growing world's population, there is an urgent need of diversifying the food supplying plant species. Underutilized indigenous crops often excel in terms of low input requirements, adaptability in the environmental and convenient harvesting characteristics. Many of them can also provide a good source of protein, minerals, and vitamins to alleviate micronutrient malnutrition that affects about half of the world's population¹. Okra (*Abelmoschus esculentus*), known by different names such as lady's fingers in English-

speaking countries, asbamia in the Middle East and bhindi in India, belongs to the family malvaceae and genus *Abelmoschus*. It is cultivated in tropical, subtropical and warm temperate regions of the world for its tender green pods and leaves which are cooked and commonly consumed as boiled vegetables². But the Okra crop rarely reaches to its full yield potential in most of these areas, due to the use of unimproved cultivars, limited fertilizers and irrigation inputs and the limited investments in breeding programs that are aimed at enhancing its yield³.

Cite this article: Lokesh, Nutritional and Pharmaceutical Potentials of Okra (*Abelmoschus esculentus*) Plant and Its Biotic Stresses -An Overview, *Int. J. Pure App. Biosci.* 5(4): 1890-1907 (2017). doi: <http://dx.doi.org/10.18782/2320-7051.5197>

Okra can be grown on diverse variety of soils, however, at well drained soils with adequate organic matter high yields can be obtained⁴. Fruits and vegetables such as okra have basic useful properties in providing excellent health and nutritional qualities as these are rich in vitamins and enzymes necessary for proper body function and prevention of chronic diseases⁵. Though Okra is a traditional a vegetable, rich in nutrients and with high economical potential, yet it has so far been considered as a minor crop and a little attention is being paid to its improvement in the international research program⁶. The total commercial production of okra in the world is estimated at about 5 million tons, with India and Nigeria being the predominant producers⁷. In the present review, okra's geographic origin and distribution, morphology, biochemical and nutritional potentials, biotic and abiotic stresses and protection against common diseases and Pests have been reviewed.

Taxonomy of Okra

Though Okra was earlier considered as a section *Abelmoschus* of the genus *Hibiscus* in the family Malvaceae⁸, later on the section *Abelmoschus* was raised to the rank of distinct genus⁹ and was accepted in the taxonomic and contemporary literature¹⁰. The genus *Abelmoschus* differs from the genus *Hibiscus* by the characteristics of the calyx, spatulate, with five short teeth, connate to the corolla and caducous post-flowering^{11,12}. The taxonomists have described about 50 species in the genus *Abelmoschus*. The taxonomical revision by Van Borssum Waalkes¹³ and Bates¹⁴ is considered the most fully documented studies of the genus *Abelmoschus*. An up-to-date classification of *Abelmoschus* adopted at the International Okra Workshop held at National Bureau of Plant Genetic Resources (NBPGR)¹⁵ is given in Table 1. Among these, whereas, the first three species are wild as well as cultivated, the remaining are all wild in nature.

Table 1: Classification in the Genus *Abelmoschus* adopted by

S.No.	Species
1.	<i>A. moschatus</i> Medikus- subsp. <i>moschatus</i> var. <i>moschatus</i> - subsp. <i>moschatus</i> var. <i>betulifolius</i> (Mast) Hochr- subsp. <i>biakensis</i> (Hochr.) Borss. subsp. <i>tuberosus</i> (Span) Borss.
2.	<i>A. manihot</i> (L.) Medikus- subsp. <i>tetraphyllus</i> (Roxb. ex Hornem.) Borss. var. <i>tetraphyllus</i> - var. <i>Pungens</i>
3.	<i>A. esculentus</i> (L.) Moench
4.	<i>A. tuberculatus</i> Pal & Singh
5.	<i>A. ficulneus</i> (L.) W & A.ex. Wight
6.	<i>A. crinitus</i> Wall.
7.	<i>A. angulosus</i> Wall. ex. W, & A.
8.	<i>A. caillei</i> (A. Chev.) Stevels

Cytogenetic Relationship among Taxa

There is huge variation in the chromosome numbers and ploidy levels of different species in the genus *Abelmoschus*. Whereas the lowest number reported is 2n=56 for *A. Angulosus*¹⁶,

the reported highest chromosome number, close to 200, is for *A. manihot* var. *Caillei*¹⁷⁻¹⁹. The chromosome number and ploidy levels of different species are presented in Table -2.

Table 2: Chromosome Numbers (2n) in *Abelmoschus*

Species	Chromosome Numbers (2n)	Ploidy Level	Genep o (GP)	Reference
<i>A. esculentus</i>	72	-	GP1	Teshima ²⁰ , Ugale <i>et al.</i> ²¹ and Kamalova ²²
“	66	-	“	Ford ¹⁶
“	118	2	“	Tischler ²³
“	108	2	“	Datta and Naug ²⁴
“	120	2	“	Tischler ²³ , Purewal and Randhawa ²⁵ and Datta and Naug ²⁴
“	122	2	“	Tischler ²³
“	126-134	2	”	Chizaki ²⁶
“	124	2	“	Kuwada ^{27,28}
“	130		“	Skovsted ²⁹ & Joshi and Hardas ³⁰ ; Gadwal <i>et al.</i> ³¹ , Joshi <i>et al.</i> ³² , Singh and Bhatnagar ¹⁷ ; Joshi and Hardas ³³
“	132	2	“	Medwedewa ³⁴ and Roy and Jha ³⁵
“	131-143	2	“	Siemonsma ^{18,19}
“	144	2	“	Datta and Naug ²⁴
“	132	2	“	Breslavetz <i>et al.</i> ³⁶ and Ford ¹⁶
<i>A. manihot</i> -ssp. <i>Manihot</i>	66	1	GP 3	Skovsted ²⁹ , Kamalova ³⁷
“	60	1	GP 3	Teshima ²⁰ ; Chizaki ²⁶
“	68	1	GP 3	Kuwada ^{27,38}
<i>var. tetraphyllus</i>	138	2	GP 3	Gadwal In: Joshi and Hardas ³³
-ssp. <i>Tetraphyllus</i>	130	2	GP 3	Ugale <i>et al.</i> ²¹
<i>A. moschatus</i>	72	1	GP 3	Skovsted ²⁹ ; Gadwal <i>et al.</i> ³¹ ; Joshi <i>et al.</i> ³²
-ssp. <i>Tetraphyllus</i>	138	2	GP 3	Gadwal In: Joshi and Hardas ³³
<i>A. ficulneus</i>	72	1	GP 2	Hardas and Joshi ³⁹ ; Kuwada ^{28,38} ; Gadwal <i>et al.</i> ³¹ ; and Joshi <i>et al.</i> ³²
“	78	1	GP 2	Skovsted ²⁹ (1935)
<i>A. tuberculatus</i>	58	1	GP 2	Joshi and Hardas ³⁰ ; Kuwada ^{28,38} ; Gadwal <i>et al.</i> ³¹ ; Joshi <i>et al.</i> ³²
<i>A. angulosus</i>	56	1	GP 3	Ford ¹⁶
(<i>A. manihot</i> var. <i>caillei</i>)	185-199	3	GP 3	Siemonsma ^{18,19}
<i>A. caillei</i>	194	3	GP 3	Singh and Bhatnagar ¹⁷

Source: Charrier⁴⁰ and Siemonsma⁴¹

As reported by several authors, the chromosome number (2n) of *A. esculentus* L. (Moench) is quite variable. However, the somatic chromosome number around 2n=130, is more frequent, and the numbers 2n=72, 108, 120, 132 and 144 are in regular series of polyploids with n=12²⁴. However, the existing taxonomical classifications at the species level in the genus *Abelmoschus* needs updating as the detailed cytogenetical observations on Asian material of okra and its species are likely to reveal the existence of more

amphidiploids in the genus¹⁸. Aladele *et al.*,⁴² had collected 50 West African genotypes (*A. caillei*) and 43 Asian genotypes (*A. esculentus*) accessions of okra and assessed for their genetic distinctiveness and relationship using random amplified polymorphic DNA, as a probe. They observed that the thirteen primers used, revealed clear distinction between the two genotypes. The observed more diversity among the Asian genotypes may be because they were originally collected from six different countries in the region. The recent

studies at molecular level suggest that a deeper study into the variable polymorphism at chromosomal level in the genus *Abelmoschus*, is needed.

Geographic Origin and Distribution of Okra

There are two different hypotheses concerning the geographical origin of Okra (*Abelmoschus esculentus*). Some authors, on the basis of its ancient cultivation in East Africa around 12th century B.C and the presence of the putative ancestor (*A. ficulneus*), suggest that it originated from North Egypt or Ethiopia. Some others believe that its one putative ancestor (*A. tuberculatus*) is native from northern India. Okra plants are now found all around the world from Mediterranean to

equatorial areas of the world, especially in tropical and sub-tropical countries⁴³. Cultivated and wild species of Okra are found overlapping in Southeast Asia, which is considered as the centre of its diversity. The spread of the other species is the result of their introduction to America and Africa. In India, eight *Abelmoschus* species of okra are existing at present, however, out of these, *Abelmoschus esculentus* is the only known cultivated species. The species *Abelmoschus moschatus* occurs as wild but is also being cultivated for its aromatic seeds and the rest are truly wild types. Distribution of wild *Abelmoschus* species in different phyto-geographical regions of India are presented in Table-3.

Table 3: Distribution of wild *Abelmoschus* species over different phyto-geographical regions in India

Sr. No.	Species	Phyto-geographical region
1.	<i>A. ficulneus</i>	Jammu & Kashmir, Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh
2.	<i>A. cancellatus</i>	Uttaranchal, Himachal Pradesh, Uttar Pradesh, Orissa
3.	<i>A. manihot</i> ssp. (<i>tetraphyllus</i> var. <i>tetraphyllus</i>)	Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Orissa, Chhattisgarh
4.	<i>A. crinitus</i>	Uttaranchal, Madhya Pradesh, Orissa
5.	<i>A. manihot</i> ssp. <i>Tetraphyllus</i>	Uttaranchal, Himachal Pradesh, Jammu & Kashmir, Assam, Andaman & Nicobar var. <i>pungens</i> Islands
6.	<i>A. moschatus</i> ssp. <i>Moschatus</i>	Uttaranchal, Orissa, Kerala, Karnataka, Andaman & Nicobar Islands
7.	<i>A. tuberculatus</i>	Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra
8.	<i>A. moschatus</i> ssp. <i>Tuberosus</i>	Kerala and parts of Western Ghats in Tamil Nadu
9.	<i>A. angulosus</i>	Tamil Nadu, Kerala

Source: Bisht and Bhat⁴⁴.

Morphology of Okra

Okra (*Abelmoschus esculentus*) an annual plant, is mainly propagated by seeds and has life for 90-100 days. Its stem is robust, erect and variable in branching and the height from

0.5 to 4.0 metres. Okra's leaves are alternate and usually palmately five lobed, the flower is axillary and solitary. The images of okra flower bud and immature seed pods are shown in figure-1.



Fig. 1: Okra (*Abelmoschus esculentus*) flower bud and immature seed pod

Source: Tripathi *et al.*⁴⁵

Okra plants are characterized by their indeterminate growth and the flowering being continuous, depending upon biotic and abiotic stress. The plant usually bears its first flower one to two months after sowing. Okra's fruit is capsule shaped and grows quickly after flowering. The okra flowers are 4-8 cm in diameter, with five white to yellow petals with a red or purple spot at the base of each petal and the bud appears at the axil of leaf. The style is surrounded by a staminal column which may bear more than 100 anthers. The pollen may come in contact with the stigmas through a lengthening of the staminal column or by insect foraging⁴⁶. Okra plants continue to flower and to fruit for an indefinite time, depending upon the variety, soil moisture, fertility and season. The regular harvesting stimulates continued fruiting for a longer duration. The okra pods are harvested immature before becoming highly fibrous. Generally, the fibre production in the fruit starts 6 to 7 days after the initiation of fruit formation. and a sudden increase in fibre content from 9th day has been observed⁴⁷. The edible seed pods are harvested when immature and eaten as a vegetable within a week after pollination.

Eshiet & Brisibe³ studied morphological characteristics and yield traits of four cultivars of okra (NHAe-47-4, V35, LD88 and a local variety and compared in a field plot to aid in the development of selection strategies that could be used for okra (*Abelmoschus esculentus* L. Moench) improvement. Their results demonstrated that the okra varieties differed significantly ($p < 0.05$) in plant height at flowering (50-128 cm), number of leaves at flowering (7- 19), number of days to flowering (72-112 days), pod length (3.23-6.83 cm) and one hundred seed weight (3.87-4.42g). However, there were no significant ($p > 0.05$) differences between the cultivars in terms of certain yield characters including average number of pods and average number of seeds per pod per plant.

Biochemical and Nutritional Potential of Okra

Okra provides an important source of carbohydrates, proteins and minerals which are often lacking in the diet in developing countries⁴⁸. The composition of edible portion of okra is given in Table 4.

Table 4: Composition per 100 g of edible portion of okra

Calories	35.0	Calcium	66.0mg
Moisture	89.6 g	Potassium	103.0 mg
Carbohydrates	6.4 g	Iron	0.35 mg
Protein	1.9 g	Magnesium	53.0 mg
Fibre	1.2 g	Copper	0.19 mg
Fat	0.2 g	Thiamine	0.07 mg
Minerals	0.7 g	Riboflavin	0.01 mg
Phosphorus	56.0 mg	Nicotinic acid	0.06 mg
Sulphur	30.0 mg	Oxalic acid	8.0 mg
Sodium	6.9 mg	Vitamin C	13.10 mg

Source: Gopalan et al.⁴⁹.

Okra fruit is a major source of carbohydrates, vitamins, minerals and fibers but it is reportedly low in sodium saturated fat and cholesterol⁵⁰⁻⁵². Carbohydrates in okra are mainly present in the form of mucilage^{53,54}. The immature okra leaves and pods can be eaten raw or as a cooked vegetable and can also be pickled. Due to high contents of proteins (20%) and oil (20%) in okra seeds^{55,40}, the potential for wide cultivation of okra for production of edible oil and cake, is very high⁵⁶. The nutritional analysis of okra seeds by Dhruve et al.⁵ have shown that these contain valuable proteins, oils, carbohydrates and antioxidants. Therefore, the consumption of okra seeds can provide the necessary energy to the body and can boost the immune system of body, as well, against diseases. Okra seed flour could also be used to fortify cereal flour⁵⁷⁻⁵⁹. Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries⁶⁰. Mature fruits and stems containing crude fibre are used in the paper industry and are also used for clarification of sugarcane juice from which gur or brown sugar is prepared⁶¹. Greenish-yellow edible okra oil has a pleasant taste and odor and is high in unsaturated fatty acids such as oleic acid and linoleic acid⁶². Okra oil has also been reported to have potential hypocholesterolemic effect⁶³. Farooq et al.⁶⁴ have found okra oil suitable for use as a biofuel. Okra, served with soy sauce, became a popular vegetable in Japanese

cuisine towards the end of the 20th century and breaded, deep fried okra is served in the southern United States.

Medicinal Properties of Okra

As no endogenous toxins or significant levels of anti-nutritional factors have been found in Okra thus it is believed that its consumption should not be causing any disease in humans, animals or plants. Some reported medicinal values of okra include- curing of ulcers, relief from hemorrhoids⁶⁵(Adams, 1975). It is also useful in genitourinary disorders, spermatorrhoea and chronic dysentery⁶⁶(Nandkarni, 1927). Okra has found application as a plasma replacement or blood volume expander⁶⁷⁻⁷¹(Savello et al. 1980; Markose & Peter 1990; Lengsfeld et al. 2004; Adetuyi et al. 2008; Kumar et. 2010)) . The alcohol extract of okra leaves can alleviate renal tubulointerstitial disease and improve renal function^{53,54}(Liu et al. 2005; Kumar et al. 2009).

Insect Pest on Okra Plant

The okra crop can be attacked by a number of insect pests causing heavy loss in its production. The insect pests of okra include-shoot and fruit borer (*Earias sp*) (spotted bollworm), fruit borer (*Helicoverpa armigera*) and sucking pests such as jassids, aphids, ants and whitefly.

Shoot and Fruit Borer (*Earias sp.*)

The shoot and fruit borer, *Earias vittella* (Fabricius) spotted bollworm and *Earias*

insulana are most serious as these can cause 88 to 100 percent damage to fruits⁷². Whereas, in case of *E. vittella*, the fore wings are pale white with broad wedge-shaped horizontal green band in the middle, *E. insulana* are uniformly green. The images of *Earias vittella*

and *Earias insulana* adults are shown in Figures 2A and 2B, respectively. Fully grown larvae of shoot and fruit borer is stout and brownish with milky white markings (figure 2C) and an okra fruit damaged by this pest is displayed in Figure 2D.

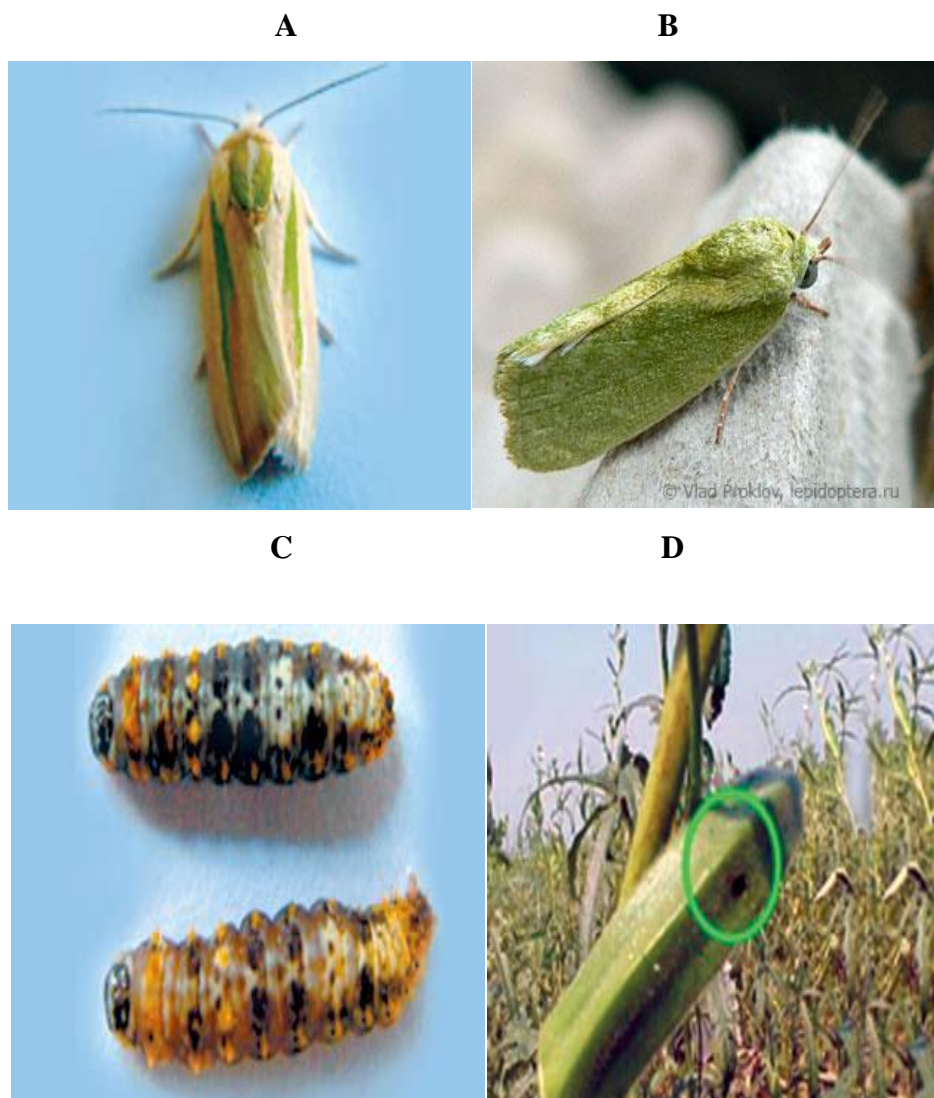


Fig. 2: A: Adult of Shoot and Fruit Borer (*Earias vittella*); B: Adult of Shoot and Fruit Borer (*Earias insulana*); C: Larvae of Shoot and Fruit Borer; D: Fruit damaged by Shoot and Fruit Borer (Source: Maharashtra Hybrid Seeds Company Ltd)

Fruit Borer (*Helicoverpa armigera*).

The incidence of fruits borer (*Helicoverpa armigera*) on okra occurs under humid condition after the rainfall. Each moth lays hundreds of eggs on leaves, floral buds and tender fruits. Initially, small brown caterpillar bore into the top shoot and feeds inside it,

before the fruit formation. Later on, developed larvae of fruit borer bores circular holes inside the fruit and feed on it (Figure 3A). Larvae move from one fruit to another and may destroy many fruits. External symptoms appear in the form of a bored hole. The adult of fruit borer is shown in figure-3B.



Fig. 3: A: Larvae of Fruit Borer (*Helicoverpa armigera*) (Source: <http://sindominio.net/>) : B: Adult of Fruit Borer (*Helicoverpa armigera*) (Source: <http://ppis.moag.gov/>)

Jassids (*Amrasca biguttula biguttula*)

The adults of Jassids (*Amrasca biguttula biguttula*) are wedge shaped (2 mm) pale green with a black spot on posterior half of each of the fore wings (Figure 4). Each female inserts about 15 yellow eggs into leaf veins on the underside. The adults and nymphs suck sap

from the under surface of the leaves and also inject toxins causing curling of leaf edges. Consequently, leaves turn red or brown, also called as ‘Hopper Burn’, then dry up and shed. On transformation into winged adults, these feed on the plant juice.



Fig. 4: Jassids (*Amrasca biguttula biguttula*) Source: <http://sindominio.net/>

Lokesh et al.⁷³, screened some okra genotypes for field resistance against leafhopper using nymph population and leaf injury index, as a probe. Lokesh and Singh⁷⁴ studied the influence of Leaf Vein morphology in okra’s eight genotypes: three resistant (HRB 128-1-1, HRB 118-2-1 and HRB 105-2-2(GS), two moderately resistant (HRB 108-2-1 and ST 2), two susceptible (HRB 107-4-1 and HRB121-1-1) and one cultivated variety (Varsha Uphar) on the oviposition of the leafhopper species

Amrasca biguttula (Hemiptera: Cicadellidae). The resistant genotypes harboured significantly ($p < 0.05$) less leafhopper nymphs and indicated lower visual injuries than the susceptible genotypes. Number of eggs laid per leaf was less in the resistant genotypes (156.8–174.4) than that in susceptible ones (256.0–280.4), thereby, indicating ovipositional antixenosis. Among the leaf veins (main, lateral and subveins), lateral veins received maximum number of

eggs, except, in genotypes HRB 118-2-1 and HRB 121-1-1, in which subveins received maximum number of leafhopper eggs. The impact of trichome density on main vein ($r = -0.80$) and lateral veins ($r = -0.93$) in relation to oviposition was negative and significant. Similarly, trichome length on lateral veins ($r = -0.77$) and subveins ($r = -0.88$) also showed a negative and significant correlation with oviposition of leafhopper. Except the thickness of subveins ($r = 0.82$), which showed a positive and significant correlation with oviposition, the influence of length and

thickness of different category of leaf veins was non-significant.

Whiteflies (*Bemisia tabaci*)

The whitefly serves as the vector for the spread of yellow vein mosaic virus (YVMV) disease that causes damage to okra crop. The female lays stalked yellow spindle shaped eggs on the lower surface of the leaf (figure 5). Nymphs and adults suck the sap usually from the under surface of the leaves and excrete honeydew causing a sickly appearance on leaves coated with sooty mold.



Fig. 5: Whitefiles (*Bemisia tabaci*) Source: <http://c.photoshelter.com>

Benchasri⁷⁵ observed the economic damage on okra by a number of insects including- *bemisia tabaci* genn, *aphis gossypii* glover, *thrips palmi* karny, *amrasca biguttula* ischida, and *xanthodes transversa* guenee on the cultivated plot of okra during the June 2009 and 2010 season. They have also reported that agroclimatic factors such as temperature, relative humidity and rainfall have direct effect on the growth and population trend of the insect pests.

Abang et al.⁷⁶ studied resistance of Okra germplasm, collected from different locations around the world, to the melon aphid (*Aphis gossypii*) under natural infestation. The basis of resistance of okra was elucidated by studying their biochemical and biophysical properties. There was no significant difference between the susceptible and resistant okra

accessions in terms of leaf tannins, free amino acids, total sugars and total phenols. The higher leaf nitrogen content was reported to favour the aphid infestation on okra and settling behaviour showed that aphids did not discriminate between the susceptible and resistant okra accessions for oviposition and feeding.

Green Peach Aphid (*Myzus persicae*)

Green Peach Aphids are soft-bodied, pear-shaped insects with a pair of dark cornicles and cauda protruding from their abdomen. The yellow-green nymph, may be with wings or wingless, however, the wingless forms are most common (Figure 6). These feed in colonies and can attain high densities on young plant tissue, causing water stress, wilting and the reduced plant growth rate.



Fig. 6: Adult of Green Peach Aphid (*Myzus persicae*).

Source: <http://matrixbookstore.b>

Ants

Ants are eusocial insects of the family *formicidae*, identified by their elbowed antennae and the distinctive node-like structure forming their slender waists. These live in highly organised colonies occupying large territories and millions of individuals. Larger colonies consist of sterile, wingless females forming castes of

"workers", "soldiers", or other specialised groups. Antcolonies also have some fertile males called "drones" and one or more fertile females called "queens". Okra plants attacked by ants can be destructive to its pods (Figure 7A). Ants feed on the sugar content and moisture of plant and cause its discoloration or distortion. A group of adult ants is shown in figure 7B.

A



B



Fig. 7: A:Ants on an okra pod' *Soucre: <http://issg.org>*; **B:** A group of adult ants

Red Spider Mites

It is a red-coloured, minor and irregular non-insect pest (figure 8) that severely infests okra crop in dry and warm atmosphere. The nymphs and adults suck the cell saps from under surface of the leaf and ultimately cause defoliation. In case of severe infestation the

leaves are dried up and then dropped away. Colonies of red mites can be seen feeding on the ventral surface of leaves under protective cover of silken webs, resulting in the appearance of whitish yellow spots on the dorsal surface of leaves.



Fig. 8: Red Spider Mites" Source: <http://ikisan.com>

Strategies to control Pests

Though several strategies have been recommended for controlling the pests, the use of suitable insecticides has been found most effective in providing immediate relief to the pests affected okra crop. About 95 % populations of Asian countries are using insecticides for controlling the pests and such practice may continue in days to come until some reliable alternative for pests control measures, are developed.

Major Diseases of Okra

Although Okra is a robust crop for domestic as well as commercial production, yet its yield losses are high due to the incidence of a number of biotic and abiotic stresses.

Biotic stresses

Yellow Vein Mosaic Virus (YVMV)

Yellow Vein Mosaic Virus causes a destructive viral disease in okra that infects it at all stages of its growth. The characteristic symptom of the disease is appearance of a homogenous interwoven network of yellow veins enclosing islands of green tissues (Figure 9).



Fig. 9: Okra leaves infected with Yellow Vein Mosaic Virus (YVMV)

Soucre: <http://ikisan.com>

The fruits of the infected plants become pale yellow to white in color and deformed attaining small and tough texture. The disease causes 50-100 % loss in the crop yield as well as quality if the plants get infected within 20 days after germination⁷⁷. Development and use of improved varieties with high yield potential, Copyright © August, 2017; IJPAB

superior pod quality and resistance to YVMV would play an important role in bringing sustainability of okra.

Cercospora Leaf Spot

Cercospora is a genus of ascomycete fungi. Most species of this genus cause plant diseases, and form leafspots. It is a relatively

well-studied genus of fungus, but there are countless species yet undescribed, and even still much to learn about the best-known of the species. Three species of *Cercospora*, namely, *C. abelmoschi*, *C. malayensis* and *C. hibisci* cause leafspots in okra. Whereas, *C.*

malayensis causes brown, irregular spots, *C. abelmoschi* causes sooty black, angular spots (figure-10). The affected leaves roll, wilt and fall. Due to leafspots, severe defoliation occurs during humid seasons⁶⁰.



Fig. 10: *Cercospora abelmoschi* Leafspot infection in Okra (*Abelmoschus esculentus*) leaf.

Soucre: <http://www.ikisan.com>

Fusarium Wilt

Fusarium wilt is a common fungal disease, caused by pathogen: *Fusarium oxysporum* (f. sp. *Vasinfectum*). Fusarium wilt is a serious soil borne disease and it is found wherever okra is grown intensively. It enters through the roots and interferes with the water conducting vessels of the plant. The fungus invades the roots, colonizes the vascular system and thereby restrict water translocation. The leaves of the affected plants show yellowing, loose turgidity and eventually, the plant dies.

Powdery Mildew

Powdery mildew is a common fungal disease that occurs in many types of plants including

Okra. On the infected plant, a white, powdery growth appears on the upper leaf surfaces (figure-11). There are many different species of *powdery mildew* fungi such as: *Erysiphe cichoracearum* and *Sphaerotheca fuliginea* and each species attacks only specific plants. The disease caused by *Erysiphe cichoracearum* is most common in okra growing areas and *Sphaerotheca fuliginea* was reported from Bangalore in India⁷¹. This disease slows down photosynthesis, resulting in the reduction of economic yield. Severely infected leaves detach and fall to the ground.



Fig. 11: Powdery Mildew on Okra (*Abelmoschus esculentus*) Leaf. ‘

Source: American Phytopathological Society (APS) Featured Image

Damping Off

Damping off is a soil-borne fungal disease that affects new seedlings, flowers and seeds of okra (*Abelmoschus esculentus* L.) plant. It is now considered among the serious and destructive

diseases of okra with disease incidence reaching 50 to 75% in some areas. It is caused by *Phytophthora nicotianae* and the identified causal agents of damping-off are: *Pythium* spp., *Rhizoctonia* spp., and *Fusarium solani*. Damping off disease may kill seedlings before or soon after they emerge. Infection before seedling emergence results in poor germination due to decay of seeds in soil. The severity of the disease depends on the pathogen's intensity in the soil and on the environmental conditions. It is most prevalent in highly humid, cold and cloudy weather, wet and compacted soil and in overcrowding conditions⁷⁸. If the the seedlings decay starts at the emergence, the seedlings topple down on the ground and collapse and is referred as "damp-off".

Enation Leaf Curl

Leaf curl disease is a serious viral disease of okra (*Abelmoschus esculentus* L.) in tropical and subtropical areas and its transmission occurs through whitefly (*Bemisia tabaci*). The disease is caused by *begomovirus-satellite* complexes. Akhtar et al.⁷⁹ identified and reported *begomovirus* and associated *betasatellite* and *alphasatellite* in symptomatic okra plants from Barka, in the Al-Batinah region of Oman. The symptoms of this disease are curling of leaves in an adaxial direction and enations on the under surface of the leaves rendering them thick and deformed. In case of heavy infection the newly emerged leaves also show bold enations, thickening and curling. The plant growth is retarded and fruits

from infected plants are small and deformed⁸⁰.

This viral disease is followed by root-knot nematodes (*Meloidogyne* spp.) which cause major production hurdles not only in the West and Central Africa (WCA) but also in Middle-East Asia⁸¹⁻⁸² (Fauquet and Thouvenel, 1987; Atiri and Fayoyin 1989).

Root-Decaying Disease

Root rot is a disease that attacks the roots of plants including okra, growing in cold and damp soil that prevents the roots from absorbing oxygen they require to survive⁷¹. This disease causes poor growth, wilted leaves, early leaf drop, branch dieback, and eventually cut short of affected plant life to any extent. A plant root infected with root rot disease is displayed in figure-12. Weakened roots are more susceptible to soil fungus, which is another cause of root rot. Okra is apt to the attack of fungi such as: *Macrophomina phaseolina*, *Rhizoctonia bataticola*, *R. solani*, *Fursarium solani*, *Pythium butleri*, *Phytophthora palmivora*, *Cercospora abelmoschii* and *Erysiphe cichoracearum*⁸³. Though the chemicals, such as chloropicrin or methyl bromide, won't completely cure the disease yet these can reduce the level of the infection. These fumigants are applied in and around the base of the infected plants or in holes left after the infected plant has been removed. Ahmad et al.⁸⁴ investigated the effect of *Trichoderma harzianum* and *T. viride* and three fungicides: *Benlate*, *Ridomil* and *Dithane M-45*, on the management of fusarium root rot in okra under screen house conditions. They reported that the disease incidence and percent mortality were significantly reduced by applying fungicides and antagonists when compared with untreated check plants.



Fig. 12: A plant root infected with root rot disease. (Source: Panhandle Agriculture)

Abiotic stresses

Drought and salinity are major abiotic factors adversely affecting okra crop production. During the initial one month after sowing, optimum soil moisture is necessary for good crop establishment. Unlike most of the popular vegetables, okra is traditionally cultivated as a rain-fed crop. Okra, being a tropical crop, is sensitive to even mild winters. Soil salinity is one of the most important among the abiotic stresses and is an environmental constraint which provokes grave threats to agricultural crops including Okra. The impacts of salinity in the affected areas include deterioration of soil fertility and diminished crop productivity. Jeyaprabha et al.⁸⁵ have reported the salinity responses of selected okra cultivars on certain physiological and biochemical attributes. Their results have revealed that, whereas, the root dry weight decreased, the root water content and shoot/root ratio are increased significantly ($P < 0.05$) with an increase of salt concentration over 25-125 mM. Further, there was an increase in membrane permeability, associated with electrolyte leakage, when okra seedlings were exposed to high levels of salt i.e. 100 and 125 mM NaCl.

CONCLUSION

Okra (*Abelmoschus esculentus*(L)) is an important nutritive vegetable crop that finds several pharmacological applications. As

medicine it is used for the cure of various ailments such as blood pressure, diabetes, chronic dysentery and genitourinary disorders. Okra plant is prone to infection by different types of diseases - causing microbes as well as to the attack of diverse pests, therefore, it needs proper treatment and protection against these stresses to avoid crop yield losses. Biotic and abiotic stresses in Okra have been described.

REFERENCES

1. Hughes, J., Just Famine Foods? What Contribution Can Underutilized Plants Make to Food Security? *Acta Hort. (ISHS)*. **806**: 39-47 (2009).
2. Chattopadhyay, A., Dutta, S., Chatterjee, S., Seed Yield and Quality of Okra as Influenced by Sowing Dates. *African J. Biotechnology*. **10**: 5461-5467 (2011).
3. Eshiet, A.J, Brisibe, E.A., Morphological Characterization and Yield Traits Analysis in Some Selected Varieties of Okra (*Abelmoschus Esculentus* L. Moench). *Adv Crop Sci Tech* **3**: 197(2015).
4. Akinyele, B.O., Temikotan, T., *International J. Agric. Research*. **2**: 165-169 (2007).
5. Dhruve, J.J., Shukla, Y.M., Shah, R., Patel, J. and Talati, J.G., Contribution of Okra (*Abelmoschus esculentus* L.) Seeds Towards the Nutritional Characterization,

- World J. Pharmacy and Pharmaceutical Sciences*. **7**: 1009 (2015).
6. Duzyaman, E., Okra: Botany and Horticulture, *Hort. Rev.* **21**: 42- 68 (1997).
 7. Gulsen O.S, Karagul, S. and Abak, K., Diversity and Relationships Among Turkish Germplasm by SRAP and Phenotypic Marker Polymorphism. *Biologia* **62**: 41-45 (2007).
 8. Linnaeus C., *Species Plantarum*. 1753. Vol. I & II. Stockholm.
 9. Medikus, F.K., Ueber Einige Kunstliche Geschlechter aus der Malvenfamilie, den der Klasse der, *Monadelphien*. 45-46 (1787).
 10. Hochreutimer, B.P.G., Centres of Origin for Family Malvaceae *Candolla*. **2**: 79 (1924).
 11. Kundu, B.C. and Biswas C., Anatomical Characters for Distinguishing *Abelmoschus* spp. and *Hibiscus* spp., *Proc. Indian Sci. Cong.* **60**: 295-298 (1973).
 12. Terell, E.E. and Winters, H.F., Change in Scientific Names for Certain Crop Plants. *Hort.Sci.* **9**: 324-325 (1974)
 13. Borssum, W. and Van, I., Malesian Malvaceae Revised, *Blumea*. **14**: 1- 251 (1966).
 14. Bates, D. M., Notes on the cultivated Malvaceae 2, *Abelmoschus*. *Baileya*. **16**: 99-112 (1968).
 15. IBPGR., International Board for Plant Genetic Resources, International Crop Network Series, Report of an International Workshop on Okra Genetic Resources, Rome: International Board for Plant Genetic Resources (1991).
 16. Ford, C.E., A contribution to a Cytogenetical Survey of the Malvaceae. *Genetica*. **20**: 431-452(1938).
 17. Singh H.B. and Bhatnagar A., Chromosome Number in an Okra From Ghana. *Indian J. Genet. Plant Breed.* **36**: 26- 27 (1975).
 18. Siemonsma, J.S., La Culture du Gombo (*Abelmoschus* spp) Legume Fruit. Thesis Univ Wageningen, the Netherlands (1982).
 19. Siemonsma, J.S., West African Okra. Morphological and Cytological Indications for The Existence of a Natural Amphiploid of *Abelmoschus esculentus* (L.) Moench and *A. Manihot* (L.) Medikus, *Euphytica*. **31**(1): 241-52(1982).
 20. Teshima, T., Genetical and Cytological Studies in an Interspecific Hybrid of *Hibiscus Esculentus* and *H. manihot*. *J. Fac Agric. Hokkaido Univ.* **34**: 1-155 (1933).
 21. Ugale, S.D., Patil R.C. and Khupse, S.S., Cytogenetic Studies in the Cross Between *Abelmoschus esculentus* and *A. tetraphyllus*, *J. Maharashtra Agric. Univ.* **1**(2-6): 106-110 (1976).
 22. Kamalova, G.V., Cytological Studies of Some Species of the Malvaceae, *Uzbekistan Biologija Zurnali* **3**: 66-69 (1977).
 23. Tischler, G. Pflanzliche Chromosomen-Zahlen (Nachtrag no. 1). *Tab Biol.* **7**: 109-226 (1931).
 24. Datta, P.C and Naug, A. A Few Strains of *Abelmoschus esculentus* (L.) Moench. Their Karyological in Relation to Phylogeny and Organ Development, *Beitr, Biol, Pflanzen.* **45**: 113-126 (1968).
 25. Purewal, S. S. and Randhawa, G.S., Studies in *Hibiscus Esculentus*. Chromosome and Pollination Studies. *Indian J. Agri. Sci.* **17**: 129-136 (1947).
 26. Chizaki, Y., Breeding of a new interspecific hybrid between *Hibiscus esculentus* L. and *H. Manihot* L. *Proc. Crop Sci. Soc. (Japan)*. **6**: 164-172 (1934).
 27. Kuwada, H., Crosscompatibility in the Reciprocal Crosses Between *Abelmoschus esculentus* and *A. manihot*, and the Characters and Meiosis in F1 Hybrids. *Jap. J. Breed.* **7**: 93-102 (1957).
 28. Kuwada, H., The New Amphidiploids Plant Named "*Abelmoschus tuberculatus-esculentus*", Obtained From the Progeny of the Reciprocal Crossing Between *A. Tuberculatus* and *A. Esculentus*. *Jap. J. Breed.* **16**: 21-30 (1966).

29. Skovsted, A., Chromosome Number in the Family Malvaceae. *J. Genet.* **31**: 263-269 (1935).
30. Joshi, A.B. and Hardas, M.W., Chromosome number in *Abelmoschus tuberculatus*. Pal & Singh - A Species Related to Cultivated Bhindi. *Curr. Sci. Bangalore.* **22**: 384-385 (1953).
31. Gadwal, V.R., Joshi, A.B., and Iyer, R.D., Interspecific Hybrids in *Abelmoschus* through Ovule and Embryo Culture. *Indian J. Genet. Plant Breed.* **28**: 269-274 (1968).
32. Joshi, A.B., Gadwal, V.R., and Hardas, M.W. Evolutionary Studies in World Crops. In Diversity and Change in the Indian Sub-Continent. Hutchinson, J.B. (Ed.), London: Cambridge University Press. pp. 90-105(1974).
33. Joshi, A.B. and Hardas, M.W., Okra Simmonds, N.W. Evolution of Crop Plants, London: Longman (1976), pp. 194-195.
34. Medwedewa, G.B., Karyological Review of 15 Species of the Genus *Hibiscus*. *J. Bot. Urss.* **21**: 533-550 (1936).
35. Roy, R.P. and Jha, R.P., A Semi-asyaptic Plant of *Abelmoschus Esculentus* (L.) Moench (= *Hibiscus esculentus* L.). *Cytologia.* **23**: 256-361 (1958).
36. Breslavetz, L., Medvedeva, G., and Magitt, M., Zytologische Untersuchungen der Bastpflanzen, *Z. Zuchtung.***19**: 229-234 (1934).
37. Kamalova, G.V., Cytological Studies of Some Species of the Malvaceae, Uzbekistan Biologija Zurnali. **3**: 66-69 (1977).
38. Kuwada, H., F1 Hybrids of *Abelmoschus Tuberculatus* x *A. manihot* with Reference to the Genome Relationship. *Jap. J. Breed.* **24**: 207-210 (1974).
39. Hardas, M.W. and Joshi, A.B., A Note on the Chromosome Numbers of Some Plants. *Indian J. Genet.Plant Breed.* **14**: 47-49 (1954).
40. Charrier, A., *Genetic resources of the genus Abelmoschus Med. (Okra)*, IBPGR, Rome (1984).
41. Siemonsma, J.S., *International Crop Network Series. Report of an international workshop on okra genetic resources, IBPGR, Rome*, **5**: 52-68 (1991).
42. Aladele, S.E., Ariyo, O. J. and deLapena, R.. Genetic Relationships Among West African Okra (*Abelmoschus caillei*) and Asian Genotypes (*Abelmoschus esculentus*) using RAPD, *African J. Biotech.* **7 (10)**: 1426-1431 (2008).
43. Arapitsas, P., Identification and Quantification of Polyphenolic Compounds from Okra Seeds and Skins. *Food Chem.* **110**: 1041-1045 (2008).
44. Bisht, I.S. and Bhat, K.V., Chapter 5. Genetic Resources, Chromosome Engineering and Crop Improvement Okra (*Abelmoschussp.*) (2006), p. 149-185.
45. Tripathi, K.K., Warriar, R., Govila, O.P., Ahuja, V., Biology of *Abelmoschus esculentus* L. (Okra). In. *Series of Crop Specific Biology Documents*, Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Govt. of India (2011).
46. Thakur, M. R. & Arora, S. K., Okra, In: Vegetable Crops in India. Eds. Bose, T.K. and Somm, M.G. pp. 606-622. NoyaProkash, Calcutta. India (1986).
47. Nath, P., Vegetables for the Tropical Region. ICAR. New Delhi, (1976).
48. IBPGR, International Board for Plant Genetic Resources Report on International Workshop on Okra Genetic Resources Held at the National Bureau for Plant Genetic Resources, New Delhi, India (1990).
49. Gopalan, C., Rama Sastri, B.V. and Balasubramanian, S., Nutritive Value of Indian Foods. National Institute of Nutrition (NIN), ICMR (2007).
50. Moaward, F.G., Abdelwhab, B.M., Abdelnahun, F.M. and Shehaya, F.W., *Annals of Agricultural Science*, **21**: 603-613 (1984).
51. Adeboys, O.C., Oputa, C.O., Effect of Galex on Growth and Fruit Nutrient Composition of Okra (*Abelmoschus*

- esculentus* L. Moench), *Int. J. Agric.* **181**: 9(1996).
52. Kendall, C.W.C., Jenkins, D.J.A., A Dietary Portfolio: Maximal Reduction of Low-Density Lipoprotein Cholesterol with Diet. *Current Atherosclerosis Reports.* 6:492-498 (2004).
53. Liu, I.M., Liou, S.S., Lan, T.W., Hsu, F.L., Cheng, J.T., Myricetin as the Active Principle of *Abelmoschus moschatus* to Lower Plasma Glucose in Streptozotocin Induced Diabetic Rats. *Planta Medica.* **71**: 617-621 (2005).
54. Kumar, R., Patil, M.B., Patil, S.R., Paschapur, M.S., Evaluation of *Abelmoschus Esculentus* Mucilage as Suspending Agent in Paracetamol Suspension, *Intern. J. Pharm. Tech. Res.* **1**: 658-66 (2009).
55. Tindall H. D., Vegetable in the Tropics, Macmillan press Ltd., London, Frist Edition, (1983).
56. Rao, P.U., Chemical Compostion and Biological Evaluation of Okra (*Hibiscus esculentus*) Seeds and Their Kernels, *Qual. Plant Food Human Nutr.* **35**: 389-396 (1985).
57. Taha El-Katib, M.M., Value of Adding Cotton Okra, Fenugreek Seed to Maize Flour, *Nature.* **156**: 716 (1947).
58. Akingbala, J.O., Akinwande, B.A., Uzo-Peters, P.I., Effects of Color and Flavor changes on Acceptability of Ogi Supplemented with Okra Seed Meals, *Plant Foods Human Nutr.* **58**: 1-9 (2003).
59. Adelakun, O.E., Oyelade, O.J., Ade-Omowaye, B.I.O., Adeyemi, I.A., & Van, M., Influence of Pre-treatment on Yield, Chemical and Antioxidant Properties of Nigerian Okra Seed (*Abelmoschuse sculentus* Moench) Flour: DOI: 10.1016/j.fct.2008.12.023 (2008).
60. Moekchantuk, T. & Kumar, P., Export Okra Production in Thailand. Inter-country Programme for Vegetable IPM in South & SE Asia phase II. Food & Agriculture Organization of the United Nations, Bangkok, Thailand (2004).
61. Chauhan, D.V.S., Vegetable Production in India, Ram Prasad and Sons, India (1972).
62. Martin, F.W., Okra, Potential Multiple-Purpose Crop for the Temperate Zones and Tropics, *Economic Botany*, **36 (3)**: 340-345 (1982).
63. Rao, P.S., Rao, P.U. & Serikeran B., Serun Cholesterol, Triglycerides and Total Fatty Acids of Rates in Response to Okra (*Hibiscus Esculentus*) Seed Oil, *JAOCA.***68**: 433 (1991).
64. Farooq A., Umer, R., Muhammad, A. & Muhammad, N., Okra (*Hibiscus esculentus*) Seed Oil for Biodiesel Production, *Applied Energy.* **87(3)**: 779-785 (2010).
65. Adams C.F., Nutritive Value of American Foods in Common Units, U.S. Department of Agriculture, Agric Handbook. **425**: 29 (1975).
66. Nandkarni, K.M., Indian Meteria Medica, Nadkarni and Co., Bombay (1927).
67. Savello, P.H., Martin F.W. & Hill J.M., Nutritional Composition of Okra Seed Meal. *J. Agric. Food Chem.* **28**: 1163-1166 (1980).
68. Markose, B.L. & Peter, K.V., In: Okra Review of Research on Vegetable and Tuber Crops. Technical Bulletin 16, Kerala Agricultural University Press, Kerala, India, (1990) P. 109.
69. Lengsfeld, C., Titgemeyer, F., Faller, G. & Hensel, A., Glycosylated Compounds from Okra Inhibit Adhesion of Helicobacter Pylori to Human Gastric Mucosa, *J. Agric. Food Chem.* **52**: 1495-1503 (2004).
70. Adetuyi, F.O., Osagie, A.U. & Adegunle, A.T., Effect of Postharvest Storage Techniques on the Nutritional Properties of Benin Indigenous Okra *Abelmoschuseculentus(L)* Moench. *Pakistan J. Nutrit.* **7**: 652-657 (2008.).
71. Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, D., Kouame, C., Okra (*Abelmoschusspp.*) in West and Central Africa: Potential and Progress on Its Improvement, *African J. Agric. Res.* **5**: 3590-3598 (2010).

72. Radake, S.G. & Undirwade, R.S., Seasonal abundance and insecticidal control of shoot and fruit borer, og on okra, *Abelmoschus esculentus*(L.), *Indian J. Ent.*, **43**: 283-287(1981).
73. Lokesh, Singh R. and Dhankar, S.K., Screening of Okra Genotypes for Field Resistance Against Cotton Leafhopper., *Haryana J. Hort. Sci.* **34(1-2)**: 170-173(2005).
74. Lokesh & Singh, R., Influence of Leaf Vein Morphology in Okra Genotypes (Malvaceae) on the Oviposition of the Leafhopper Species *Amrascabi guttula* (Hemipteracidae). *Entom. Gen.* **28(2)**: 103-114 (2005).
75. Benchasri, S., Preliminary Studies on Incidence of Insect Pests on Okra (*Abelmoschus esculentus* (L.) Moench) in Thailand. *Bulg. J. Agric. Sci.*, **19**: 209-215 (2013).
76. Abang, A.F., Srinivasan, R., Kekeunou, S., Hanna, R., Chagomoka, T., Chang, J.C. and Bilong Bilong, C.F., Identification of Okra (*Abelmoschus* spp.) Accessions Resistant to Aphid (*Aphis gossypii* Glover) in Cameroon, *African Entomology.* **22(2)**: 273- 284 (2014).
77. Rashid, M.H., Yasmin L., Kibria M.G., Mollik A. & Hossain S., Screening of Okra Germplasm for Resistance to Yellow Vein Mosaic Virus Under Field Conditions. *Pakistan J. Plant Pathol.* **1**: 61-62 (2002).
78. Ek-Amnuay, P., Plant Diseases and Insect Pests of Economic Crops. Amarin Printing and Publishing Public Co. Ltd, Bangkok, Thailand (2010), pp. 379.
79. Akhtar, S., Khan, A.J., Singh, A.S & Briddon, R.W. Identification of a Disease Complex Involving a Novel Monopartite Begomovirus with Beta- and Alphasatellites Associated with Okra Leaf Curl Disease in Oman, *Arch Virol.* **159**: 1199 (2014).
80. Ghanem. G., Okra Leaf Curl Virus: a Monopartite Begomo Virus Infecting Okra Crop in Saudi Arabia, *Arab J. Biotechnol.* **6**: 139-152 (2003).
81. Fauquet, C. & Thouvenel, J.C., Okra Leaf Curl Virus. In: Plant Viral Diseases in the Ivory Coast, vol. 46. Documentations Techniques, ORSTOM, Paris, France, (1987), pp. 96-97.
82. Atiri, G.I. & Fayoyin, G.A., Horizontal Resistance to Okra Leaf Curl Virus in Okra Germplasm. *Ann. Appl. Biol.*, **144**: 152-153 (1989).
83. Mithal. M.J., Low Cost and Pollution Free Technology Against Root Rot of Okra. www.pakistan.com. (2006).
84. Ahmad, Z., Saifullah, Raziq, F., Khan H & Idrees, M., Chemical and Biological Control of Fusarium Root Rot of Okra, *Pak. J. Bot.* **44**: 453-457 (2012).
85. Jeyapraba, J., Mahendran, S. and Sujirtha, N., Growth Physiology and Membrane Permeability of Okra (*Abelmoschus esculentus* L.) Seedlings as Affected by Salinity, *Intern. Plant & Soil Science.* **9(5)**: 1-5 (2016).