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Review

Okra (*Abelmoschus* spp.) in West and Central Africa: Potential and progress on its improvement

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Okra (*Abelmoschus* spp.) is a traditional vegetable crop with considerable area under cultivation in Africa and Asia with huge socio-economic potential in West and Central Africa. It has been called "a perfect villager's vegetable" because of its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) it provides. However, okra has been considered a minor crop and no attention was paid to its improvement in the international research program in past. This review describes a general overview of okra's nutritional and economic potential with special reference to its past and recent progress on germplasm regeneration, genetic studies and efforts on genetic improvement in West and Central Africa.

Key words: *Abelmoschus*, genetic improvement, germplasm, okra, West and Central Africa.

INTRODUCTION

To meet demand for nutritionally balanced food for the world's increasing population and relieve the intense pressure on land use and natural resources, plant species used as food must be diversified (Hughes, 2009). Inclusion of a wide array of indigenous vegetable species in cereals-, tubers- and livestock-based agriculture will be crucial to contribute to food/nutritional security and income diversification for stakeholders in the subsistence farming system that predominate in the underdeveloped and developing world. Therefore, improving the genetic potential of indigenous vegetables like okra (*Abelmoschus* spp.) is of paramount importance. Okra has considerable area under cultivation in Africa and Asia with huge socioeconomic potential. In West and Central Africa (WCA), okra is called Gombo (French), Miyan-gro (Hausa), La (Djerma), Layre (Fulani), Gan (Bambara), Kandia (Manding), Nkruma (Akan), Fetri (Ewe) and is among the most frequently and popularly consumed traditional vegetables. In the African context, okra has been called as "a perfect villager's vegetable" because of its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) it provides to diet (NAP, 2006). However, okra has been considered a minor crop and until recently no attention was paid to its improvement in the international research program (Duzyaman, 1997). This review presents a general overview of okra's nutritional and economic potential with special reference to past and recent progress on its

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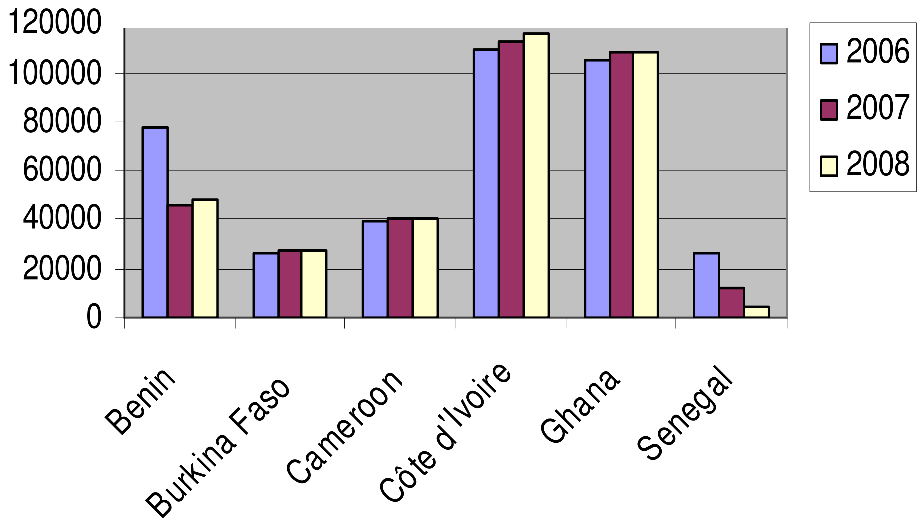

Figure 1. Okra production (tonnes) in some West Africa countries.

progress on its improvement in WCA region.

PRODUCTION STATISTICS AND CROPPING SYSTEMS

Home to about 100 million of the world's poorest people, WCA has world's most fragile ecosystem for agriculture, yet about 80% population depend on agriculture for their livelihoods. The WCA region accounts for more than 75% of okra produced in Africa, but the average productivity in region is very low (2.5 t/ha) compared to East (6.2 t/ha) and North Africa (8.8 t/ha) (FAOSTAT, 2006). Nigeria is the largest producer (1,039,000 t) followed by Cote d'Ivoire, Ghana and others (Figure 1) (FAOSTAT, 2008).

In the region, okra is traditionally cultivated as a rainy season crop by women, often on most marginalized lands easily accessible to them. The region's soil is low in organic matter and land degradation is a crucial challenge to be addressed. With the rapid urbanization and population growth, market-oriented okra production is increasing in peri-urban zones. Okra is now cultivated as an irrigated crop during the dry season, where it is often produced in mixed cropping with onion and other crops. On the degraded land, okra has proved to be an important rain-fed crop along with roselle (*Hibiscus sabdariffa*) (Pasternak et al., 2009). A common intercropping combination in southwest Nigeria is maize/okra relay cropping followed by watermelon or bush greens and jute mallow or fodder crop of sweet potato. Okra is suitable for intercropping with papaya (Adelana, 1986; Aiyelaagbe and Jolaoso, 1992). In the peri-urban areas of Abidjan, year-round intensive okra production is dominated by men, who produce and supply up to 30% of the market demand (Kouame, personnel communication).

DOMESTICATED SPECIES

There are four known domesticated species of *Abelmoschus*. Among these, *A. esculentus* (common okra) is most widely cultivated in South and East Asia, Africa, and the southern USA. In the humid zone of WCA, *A. caillei* (West African okra) with a longer production cycle, is also cultivated (Siemonsma, 1982). Plants of *A. manihot* sometimes fail to flower and this species is extensively cultivated for leaves in Papua New Guinea (Hamon and Sloten, 1995), Solomon Islands and other South Pacific Islands (Keatinge, 2009). The fourth domesticated species, namely, *A. moschatus,* is cultivated for its seed, which is used for ambretee in India and several animism practices in South Togo and Benin (Hamon and Sloten, 1995).

TAXONOMY, CYTOLOGY AND ORIGIN

Okra was previously included in the genus *Hibiscus*. Later, it was designated to *Abelmoschus*, which is distinguished from the genus *Hibiscus* by the characteristics of the calyx: spatulate, with five short teeth, connate to the corolla and caduceus after flowering (Kundu and Biswas, 1973; Terrell and Winters 1974). Although about 50 species have been described, eight are most widely accepted (Borssum, 1966; IBPGR, 1990). There is significant variation in the chromosome numbers and ploidy levels in *Abelmoschus.* The lowest chromosome number known is $2n$ = 56 for *A. angulosus* (Ford, 1938) and the highest are close to 200 for *A. caillei* (Siemonsma, 1982). Even within *A. esculentus*, chromosome numbers $2n$ = 72, 108, 120, 132 and 144 are in regular series of polyploids with n = 12 (Dutta and Naug, 1968).

Table 1. Okra's potential for research and contribution to enhanced livelihoods.

Criterion	Potential
General knowledge	Okra offers many production possibilities, however, there are limited studies conducted on okra biology and production due to limited resources devoted to the species by national and international research institutes.
Citation in literature	Out of 100 species described in a popular vegetable textbook of Africa, only three were important and indigenous; okra was among these three.
Indigenous and general adaptation	Early domestication took place in Africa because of its wider adaptation in the region.
Specific adaptation (breeding)	Fast maturing types would be well-suited to tropical heat, humidity and also to dry (rain-fed) and hot (Sudano-Sahelian) conditions.
Food and nutritional security	Pods contain high amounts of dietary fiber and they are often dried, stored, and consumed as soup/souse much like a staple food. Half a cup of the cooked pods (fresh) provides about 10% of the recommended levels of vitamin B6, folic acid and vitamins A and C. The seed (usually consumed with pods) protein is distinct from both cereals and legumes.
Market/income security	Because it can easily be dried, mould (powder) and stored for long periods (unlike perishable vegetables), producers, and processors are better able to add value and take advantage of seasonal fluctuations in price.
Biomass for fuel	Besides pod yield, the foliage and stems can weigh up to 27 t/ha. This biomass is likely to become useful with fuel prices increasing worldwide and new technologies promising efficient conversion to liquid fuels. It is worth mentioning that okra stems generate considerable heat without sparks, excessive smoke, or bad odors.
Others industrial uses	The potential for non-vegetable use are: paper pulp, like its close relative kenaf, oil seed, mucilage, sacks and ropes, bioabsorbent, medicine etc.

*Mostly synthesized from National Academies Press, 2006.

Contradicting evidence exists on the geographical origin of *A. esculentus*. One putative ancestor (*A. tuberculatus*) is native to Uttar Pradesh in North India, suggesting that *A. esculentus* originated in India. The other evidence is based on the plants cultivation in ancient times, and the presence of another putative ancestor (*A. ficulneus*) in East Africa, suggesting northern Egypt or Ethiopia as the geographical origin of *A. esculentus*. So far *A. caillei* (2*n* = 196 to 200) has been located only in WCA, so this region can be recognized as its origin and is believed to be amphipolyploids between *A. esculentus* (2*n* = 130 to 140) and *A. manihot* (2n = 60 to 68).

POTENTIAL OF OKRA

Potential for enhancing livelihoods

Okra has huge potential for enhancing livelihoods in urban and rural areas and to several stakeholders (Table 1) (NAP, 2006). It offers a possible route to prosperity for small-scale and large-scale producers alike and all those involved in the okra value chain, including women producers and traders.

Nutritional potential

K, Na, Mg and Ca are the principal elements in pods, which contain about 17% seeds. Presence of Fe, Zn, Mn and Ni also has been reported (Moyin-Jesu, 2007). Fresh pods are low in calories (20 per 100 g), practically no fat, high in fiber, and have several valuable nutrients, including about 30% of the recommended levels of vitamin C (16 to 29 mg), 10 to 20% of folate (46 to 88 µg) and about 5% of vitamin A (14 to 20 RAE) (NAP, 2006). Both pod skin (mesocarp) and seeds are excellent source of zinc (80 µg/g) (Glew, 1997; Cook et al., 2000). Okra seed is mainly composed of oligomeric catechins (2.5 mg/g of seeds) and flavonol derivatives (3.4 mg/g of seeds), while the mesocarp is mainly composed of hydroxycinnamic and quercetin derivatives (0.2 and 0.3 mg/g of skins). Pods and seeds are rich in phenolic compounds with important biological properties like quartering derivatives, catechin oligomers and hydroxycinnamic derivatives (Arapitsas, 2008). These properties, along with the high content of carbohydrates, proteins, glycol-protein, and other dietary elements enhance the importance of this foodstuff in the human diet (Manach et al., 2005; Arapitsas, 2008). Dried okra sauce (pods mixed with other ingredients and regularly consumed in West Africa) does not provide any beta carotene (vitamin A) or retinol (Avallone et al., 2008). However, fresh okra pods are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol (Kendall and Jenkins, 2004). Seven-days-old fresh okra pods have the highest concentration of nutrients (Agbo et al., 2008).

Seed as potential edible oil and flour source

Like soybean oil, okra seed oil is rich (60 to 70%) in unsaturated fatty acids (Crossly and Hilditech, 1951; Savello et al., 1980; Rao, 1985). Seed protein is rich in tryptophan (94 mg/g N) and also contains adequate amounts of sulfur-containing amino acid (189 mg/g N) — a rare combination that makes okra seeds exceptionally useful in reducing human malnutrition (NAP, 2006). Okra seed protein with good protein efficiency ratio (PER) and net protein utilization (NPU) values is comparable to many cereals (except wheat) and its oil yield is comparable to most oil seed crops except oil palm and soybean (Rao, 1985). Moreover, okra seed oil has potential hypocholesterolemic effect (Rao et al., 1991). The potential for wide cultivation of okra for edible oil as well as for cake is very high (Rao, 1985). Okra seed flour could also be used to fortify cereal flour (Adelakun et al., 2008). For example, supplementing maize ogi with okra meal increases protein, ash, oil and fiber content (Akingbala et al., 2003). Okra seed flour has been used to supplement corn flour for a very long time in countries like Egypt to make better quality dough (Taha el-Katib, 1947). However, long-term rodent/animal feeding trials would be pertinent before making final recommendations for wider consumption of okra seed flour.

Mucilage and its potential

Okra mucilage refers to the thick and slimy substance found in fresh as well as dried pods. Mucilaginous substances are usually concentrated in the pod walls (not in seeds) and are chemically acidic polysaccharides associated with proteins and minerals (Woolfe et al., 1977). Although nature of the polysaccharides varies greatly, neutral sugars rhamnose, galactose and galacturonic acid have been reported often (Hirose et al., 2004; Sengkhamparn et al., 2009). The okra mucilage can be extracted as a viscous gum using various procedures. Such diversity in the extraction procedures seems to contribute to the observed variability in the mucilage chemical composition (Ndjouenkeu et al., 1996). Okra mucilage is a renewable and inexpensive source of biodegradable material. Its physical and chemical properties include high water solubility, plasticity, elasticity and viscosity (BeMiller et al., 1993). Most physical and chemical properties are influenced by factors such as temperature, pH, sugar and salt contents, and storage time (Woolfe et al., 1977; Baht and Tharanathan, 1987). Okra mucilage has potential for use as food, non-food products, and medicine. Food applications include use as a whipping agent for reconstituted egg whites, as an additive in the formulation of flour-based adhesives, and as an additive in India for clarifying sugarcane juice. Non-food applications include brightening agents in electro deposition of metals, as a deflocculant in paper and fabric production, and as a protectant to reduce friction in pipe-flow (BeMiller et al., 1993; Ndjouenkeu et al., 1996). Polysaccharides can be combined with acrylamide to develop new biodegradable polymeric materials (Mishra et al., 2008). Potential of mucilage for medicinal applications includes uses as an extender of serum albumin (BeMiller et al., 1993), as tablet binder (Ofoefule et al., 2001) and as suspending agent in formulations (Kumar et al., 2009). Okra mucilage is used in Asian medicine as a protective food additive against irritating and inflammatory gastric diseases (Lengsfelf et al., 2004).

PAST AND PRESENT RESEARCH FOR DEVELOPMENTAL EFFORTS

Germplasm management

The Bioversity International in collaboration with the Institut de Recherche pour le Développement (IRD, formerly ORSTOM) conducted okra germplasm exploration in several WCA countries from 1982 to 1986. Along with Asian and African collections, a core collection at ORSTOM in Montpellier, France was established. However, active collections from this core are no longer available for the breeding use. More than 3000 collections along with collections from Asia are maintained and distributed by National Plant Germplasm System (NPGS), United States. Nevertheless, the West African accessions under-represent collections from countries like Niger (3) and Chad (5). AVRDC – The World Vegetable Center, in collaboration with its partners, has initiated countrywide explorations and would like to continue exploring in un-explored regions. For instance between 2008–2009, 102 new accessions from Mali, Senegal, Niger and Guinea have been collected and regenerated for public use. Varietal data collected and

Table 2. List of selected popular okra cultivars in some of WCA countries.

Country	Name of cultivar
Senegal	Lolli, Indiana, POP-11 (Emerald), Volta, Lima (F_1), PoP-12 (landrace)
Mali	Yelen, Clemson Spineless, Sabalibougou, Keleya
Cote d'Ivoire	Hire, Perkins Long Pod, Koto, Tomi (*A. caillei*)
Cameroon	Clemson Spineless, Volta, Emerald; Gombo Paysan, Gombo Cafeier
Togo	Konni (purified landrace), Local (*A. caillei*)
Ghana	Indiana, Saloni (F_1), Asontem, Torkor
Nigeria	LD 88, Clemsion, Spineless, Lady's Finger, V-35, White Velvet, Ex-Borno
Niger	Konni, Terra (purified landrace), Volta

analyzed on landraces (traditional variety) and improved cultivars used by farmers from Burkina Faso has revealed that considerable genetic diversity in the form of on-farm richness and community evenness is maintained in landraces (Jarvis et al., 2008).

Genetic improvement

In countries like USA and India, a number of okra varieties have been developed through breeding efforts. Many of these were introduced in WCA countries and are still popular (Table 2). There is a series of very good reports on genetic studies in okra, especially from Nigeria by Ariyo and associates. Multivariate analysis of 14 characters (pod yield, branch per plant, leaves per plant, days to flowering, plant height at flowering and maturity, pods per plant, edible pod length and width, mature pod length, duration of flowering, life span, seeds per pod, 100 seed weight) of 30 genotypes collected from different geographical areas revealed no relationship between clustering pattern and geographical distribution of okra genotypes (Ariyo, 1987). Pod yield and several yield-contributing characters lack stability due to strong environmental influence, suggesting the need for breeding for specific environment (Ariyo, 1990). Diversity in pod shape/size and flowering behavior account for most of the variation between the genotypes of WCA origin (Duzyaman, 1997) and scope for further gain in pod yield per plant is limited because of low phenotypic and genotypic variability (Ariyo, 1990). To break the yield barrier in existing genotypes of common okra (*A. esculentus*) and breed for different market types, a hybridization-based breeding strategy would be desirable.

Although some of the WCA national agricultural research system (NARS) and private seed companies have ongoing okra improvement projects, they have never been supported through international okra research. Despite okra's recognized potential and significant area and consumption in the developing world in general and in West Africa in particular, it has been considered an economically minor crop (Duzyaman, 1997). Commercial okra cultivation in the region faces many challenges including photoperiod sensitivity and cold temperatures that limit year-round availability of fresh pods; shelf-life, fiber/mucilage content, and pest resistance, especially root-knot nematodes, tomato fruit worm and begomoviruses. To overcome these challenges, a long term breeding project was warranted.

Since, 2003, AVRDC – The World Vegetable Center and its partners, have been introducing, testing and promoting new cultivars. Efforts are sustained through pure line selection for high yielding cultivars with high mucilage content. Three promising lines (Sasilon, Batoumambe and Safi) are currently being promoted in Mali and The Gambia. In 2007, okra improvement activities were initiated at center's outreach office that execute AVRDC/ICRISAT joint vegetable breeding project at Sadore, Niger. In the first phase, about 250 okra accessions representing collections from most parts of the world were introduced, regenerated, and characterized for morphological data. The regenerated species include: common okra (*A. esculentus;* 175), West African okra (*A. caillei;* 45) and other *Albemoschus* species like *A. ficulneus, A. manihot, A. manihot* var. *tetraphyllus, A. moschatus* and *A. tuberculatus*. Although these accessions mostly represent previous collections from WCA and South Asia, a few representative accessions from the Middle East, USA and East Africa were also introduced and maintained. These germplasm lines, along with recycled inbreds derived from a popular hybrid (Lima) in the region are available for use. As okra has large acreage under rain-fed conditions, our breeding goal is focused on developing okra lines for both rain-fed and irrigated production systems. Efforts are being made to screen germplasm against root knot nematode. Considering the potential of West African (*A. caillei*) okra, we are also developing inter-specific crosses and efforts to overcome hybrid breakdown barriers is underway, to facilitate pre-breeding and broadening of genetic base. A short duration Konni variety selected from a local population in Niger has been proven to be the "best bet" so far; it is being mass disseminated in the Sudano-Sahel under both rain-fed and irrigated conditions (Pasternak,et al. 2009). Selection and cross-breeding efforts by the Center have laid out a full-fledged okra improvement plan for WCA with potential to expand it to Asia. However,

Table 3. Potential of recombination breeding involving two *Abelmoschus* spp.

Species	Cytogenetics	Contrasting traits
A. esculentus (common okra) 95% cultivated area	Amphidiploid (2*n*=130-140): *A. tuberculatus* or *A. ficulneus* (2*n*-58-60) x unknown?	Poor adaptation in humid zone, more susceptible to biotic stresses, less vigorous, short life cycle (suitable for short rainy season areas), usually day neutral, cultivated in both rainy (rain fed) and dry (irrigated) seasons
A. caillei (West African okra) 5% cultivated area	Amphipolyploid (2*n* = 196-200): *A. esculentus* (2*n*=130-140) x *A. manihot* (2*n* = 60-68)	Better adaptation in humid zone, tolerant/ resistant to biotic stresses, more vigorous, longer life cycle, mostly photoperiod sensitive, cultivated mainly in dry season

achievements made and platforms set up so far need follow-up to ensure significant and sustained progress.

West African okra (*A. caillei*) as potential donor species

West African okra (*A. caillei*, also known as Guinean type) accounts for only 5% of the total world production of okra (Siemonsma and Kouame, 2004), but it is a very important crop in tropical areas of Cote d'Ivoire, Benin, Cameroon, Nigeria, Ghana and Togo. This relatively newly identified amphipolyploid species (Siemonsma, 1982) is known for possessing a gene pool of variation that may be useful for okra improvement of both temperate and tropical types (Table 3) (Martin et al., 1981). *A. caillei* is gradually replacing common okra in the tropical-humid region because of its better adaptation under humid zone and tolerance to biotic stresses (Siemonsma, 1982). Indeed under very limited and erratic rainfall in the Sudano-Sahel, earliness of *A. esculentus* (being amphidiploid) as compared to *A. caillei* (being amphipolyploid) was preferred during early domestication. In Asia, *A. caillei* has been utilized as a resistant source to breed Yellow vein mosaic virus resistant common okra variety (Nerkar and Jambhale, 1985). The inter-specific cross between *A. caillei* and *A. esculentus* is successful with the possibility of gene transfer, although the partial hybrid breakdown barrier must be overcome (Fatokun, 1987). The study on geographical distribution and extent of natural outcrossing in Benin and Togo suggests that genetic integrity of these two species is not threatened (Hamon and Hamon, 1991).

Molecular markers

Reports on marker development in okra are very scanty and have been limited to characterization of cultivars. An agreement between clustering patterns obtained from morphological traits and molecular markers in *Abelmoschus* spp. has been demonstrated (Mortinello et al., 2001). Ninety-three accessions of common (*A. esculentus*) and West African (*A. caillei*) could be distinguished using random amplified polymorphic DNA (RAPD) markers (Aladele et al., 2008). Use of sequence related amplified polymorphism (SRAP) in marker aided selection (MAS) for various traits in Turkish germplasm has been suggested (Gulsen et al., 2007). Recently, 20 okra accessions from Burkina Faso were analyzed using 16 primers designed to amplify SSR regions of *Medicago truncatula*. Two accessions were found distinct from the other 18, based on the presence of an unique 440 bp fragment generated primer MT-27 and also based on presence of hairs on fruits and delayed maturity of these two accessions (Sawadogo et al., 2009).

Biotic stresses

Although okra is considered a robust crop, under large-scale commercial production, yield losses are very high due to the incidence of a number of biotic and abiotic stresses. The most relevant biotic stress of okra is the leaf curl disease caused by the begomovirus (Okra leaf curl virus, OLCV) transmitted by the white fly (*Bemisia tabaci*). OLCV disease has been found to be more prevalent in the savannah area than in the tropical-forest region (N'Guessan et al., 1992). This viral disease is followed by root-knot nematodes (*Meloidogyne* spp.) which are major production hurdles, not only in the WCA but also in Middle-East Asia (Fauquet and Thouvenel, 1987; Atiri and Fayoyin 1989). Serious efforts to screen germplasm for viral resistance and utilization of resistance sources are pending. Several pests also cause serious damages on okra (Table 4), such as the tomato fruit worm (TFW) (*Helicoverpa armigera*) the most destructive pest of okra. The TFW may be controlled by trap cropping using pigeon-pea borders (Youm et al., 2005). Such an approach is being followed on okra in Niger, where the small size of okra fields and the farmer practice of planting borders of other crops (example, sesame, roselle etc.) are assets for the adoption of such a technique (Ratnadass et al., 2010).

Table 4. Economically important pests of okra in WCA.

Name (causal agent)	Symptom	Remarks/control measures
Leaf curl disease (Okra Leaf Curl Virus, OLCV)	Green-yellow mottling of leave, turn curved and irregular, plants stunted and bear yellow or wrinkled fruits with dark spots.	Resistant/tolerant cultivars not available; weed management and control of virus-transmitting whiteflies (*Bemisia tabaci*) using insecticides
Powdery mildew (*Erysiphe cichoracearum*)	Mainly older leaves, petioles and stems are affected. A large part of the leaf surface is covered by the talc-like powder composed of fungal spores. Spores are easily blown by winds and helps disease to spread.	Selection of field far from source of inoculum; weed management and application of selected fungicides
Cercospora (*Cercospora abelmoschi*)	Brownish spots on lower leaves that contain fungal spores; later leaves become yellow and drop	Weed management to reduce source of inoculums
Shoot and fruit borer (*Earias* spp.)	Larvae bore into the tender shoots, developing buds, flowers, fruits and feed on inner tissues. The affected shoots wither and growing points are killed, damaged buds and flowers fall.	Use of ash on young larvae
Tomato fruit worm (TFW; *Helicoverpa armigera*)	Young larvae feed on tender foliage, advanced stage/s attack the pods and one larva may destroy many pods. External symptoms appear in the form of a bored hole.	Use of insecticides, neem extract, *Bacillus thuringiensis;* weed management; rotations with non-host crops; trap crops e.g. pigeon pea
Cotton seed bug (*Oxycarenus hyalinipennis*)	Feeds on okra seeds. Results in considerable reduction in germination rate	Removal of weed and malvaceous hosts near okra fields
Red spider mites	Colonies of mites can be found feeding on ventral surface of leaves, resulting in yellow spots on dorsal surface.	Use of crop resistance; application of specific acaricides; weed management
Root knot nematodes (*Meloidogyne* spp.)	Plants wilt and appearance of root galls/knots of different sizes and infected roots also become enlarged and distorted.	Weed management; crop rotation and intercropping; mix cropping or cover cropping with non host crops

Abiotic stresses

Unlike most of the popular vegetables, okra is traditionally cultivated as a rain-fed crop in the region. However, during the initial one month after sowing, optimum soil moisture is required for good crop establishment. Okra, being a tropical crop, is also sensitive to the mild winters of the Sudano-Sahel. Drought and salinity are major abiotic factors adversely affecting okra production in the region.

CONCLUSION

Although the region of WCA has diverse genetic resources of indigenous crop species, these have not received sufficient effort for genetic improvement. It is evident that adaptations to climate change by rural communities over the past three decades have combined institutional supports as well as technical fixes like faster-maturing crop species and cultivars (Vermuelen et al., 2008). The availability of improved planting materials and technology pertaining selected crop species like okra would further enhance livelihoods of the poor. Dietary portfolio studies to maximize reduction of low-density lipoprotein cholesterol have indicated that plant-based diets (rich in viscous fibers) may be an effective strategy for the prevention of hyperlipidemia. Fortunately, okra along with eggplant is considered by medical experts as the most important vegetable sources of viscous fiber (Kendall and Jenkins, 2004). With expanding research and developmental programs, AVRDC – The World Vegetable Center and its partners are poised to undertake long-term research to unlock recognized potential of okra for food, nutrition and income security not only in WCA but also in East and North Africa, and several regions of Asia. Okra's potential as an industrial crop also has been tested in the developed world (Camciuc et al., 1998). The development and use of resistant/tolerant cultivars against major pests and their promotion is often a more rewarding and appropriate option for the sustainability of smallholder. This is especially relevant in the developing and underdeveloped world, where farmers often do not have the capability to diagnose pests and have limited access to good-quality pesticides. In addition, pesticide abuse leads to adverse impacts on human and environmental health, and there are increasing reports on the development of pesticide resistance in pests. Nevertheless, we fully recognize that resistance breeding and other management tactics based on agro-ecological approaches are complementary, and should not be viewed or considered in isolation. It is not possible to extend the list of pests chosen to be tackled through resistance breeding and/or genetic engineering, nor are all biotic stresses amenable to effective control via genetic pathways.

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