

Exploiting the Genetic Diversity of Vegetable African Nightshades

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ABSTRACT

African nightshades (*Solanum* section *Solanum*) are an important source of daily nutrients and income for small-scale farmers in sub-Saharan Africa and are a delicacy for urban inhabitants. The section is one of the most ubiquitous, largest and most diverse species groups of the genus *Solanum*, with more than 30 reported species. Complete profiling of the species in this section has been hampered by several morphological, cytological and taxonomic complexities. There is great diversity within the section that could be exploited to improve African nightshade for greater productivity, income generation and nutritional benefits. This paper outlines some factors responsible for the diversity and emphasizes the need for conservation, improvement and utilization of the agrobiodiversity within this section.

Keywords: African indigenous vegetables, African nightshade, Genetic diversity, *Solanum* section *Solanum*

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INTRODUCTION

African nightshades are some of the most widely consumed traditional leafy herbs and vegetables in Africa, where they are important sources of daily nutrition and income for small-scale farmers (Chweya and Eyzaguirre 1999). The leaves contain 87.2 g water, 1.0 mg iron, 4.3 g protein, 38 kcalories, 5.7 g carbohydrates, 1.4 g fibre, 20 mg ascorbic acid, 442 mg calcium, 75 mg phosphorus, 3660 µg β-carotene, and 0.59 mg riboflavin per 100 g fresh weight (K'Opondo *et al.* 2005). Consumption, demand, and market value of vegetable nightshades have rapidly and steadily risen as consumers become aware of their nutritional, economical and medicinal values. A diet containing African nightshade is recommended for malaria patients and pregnant or nursing mothers (Maundu *et al.* 1999; Mwai and Schippers 2004). Africans use the leaves of African nightshades to treat duodenal ulcers and stomach upsets, boils, and swollen glands among other ailments (Edmonds and Chweya 1997; Chweya and Eyzaguirre 1999). A decade

ago, these vegetables were mostly growing wild or semi-cultivated. In recent years, the resurgence in popularity has prompted rapid domestication and commercialization of nightshade production, from subsistence to commercial farming on contract for municipal, urban, super markets and hotel chains (Abukutsa-Onyango 2002; Mwai and Schippers 2004; Weinberger *et al.* 2011).

Origin and diversity of African nightshades

The centre of origin of most section *Solanum* species is South America. The centers of diversity for diploid species is South America, and to some extent North America, while the centers of origin of most polyploid species (tetraploids and hexaploids) are either in Europe or Africa. A large number of distinct taxa in section *Solanum* show their greatest diversity and concentration in the New World tropics, particularly in South America. *Solanum nigrum* L., a poisonous nightshade species, is predominantly Eurasian and does not occur naturally in South America or Africa (Heiser

et al. 1979). Another poisonous species usually mistaken for the edible nightshades is *Atropa belladonna* L. (Deadly Nightshade). Edible species such as *S. scabrum* Mill. and *S. opacum* A. Braun & C. D. Bouché are native to Australia. *S. americanum* Mill. and other species are native to North America and a huge number of taxa occur naturally in South America. The most common African representatives of section *Solanum* are also found in Europe and in Asia. The most important vegetable nightshade species is reported to be *S. scabrum*; it shows considerable diversity in vegetative features and fruits (which also are eaten), and it was probably domesticated in northern Nigeria, where perennial forms grow wild (Fontem and Schippers 2004).

Taxonomy and nomenclature of African nightshades

The taxonomy and nomenclature of African nightshades is complex due to extensive synonymy, frequent occurrence of spontaneous inter-specific hybrids, existence of polyploidy series, phenotypic plasticity, inconsistent use of many local names and discordant genetic variation (Edmonds and Chweya 1997). Taxonomic complexity associated with African nightshades has led to considerable confusion regarding the identification of popular nightshade vegetables. For example, most literature refers to Africa's vegetable nightshades as "*S. nigrum* L." but the true *S. nigrum* is not consumed. The species possibly referred to could be *S. scabrum*, *S. americanum*, *S. villosum* Mill. or *S. tarderemotum* Bitter. There are some morphological similarities between these species and the true *S. nigrum* (Schippers 2002; Mwai and Schippers 2004; Olet *et al.* 2005). To improve conservation and utilization of available diversity in African nightshade, several studies have been conducted to resolve this taxonomic confusion (Olet *et al.* 2005; Manoko 2007; Mwai 2007).

Genetic diversity and ecological adaptation of African nightshades

The worldwide distribution of the section *Solanum* could be due to its adaptive ability to flower very early, prolific berry and seed production, and ability to tolerate many diverse habitats (Ojiewo 2007). Although they perform well in a range of climatic conditions, African nightshades grow best under cool high-moisture conditions in medium to high altitudes. Studies by Masinde (2003) and Masinde *et al.* (2007) have shown that broad leaved genotypes are more susceptible to moisture stress than narrow leaved once. The same could be said with regard to response to high temperatures. The plants respond to heat and drought by leaf curling and reduction of leaf surface area in order to reduce the rates of transpiration; in so doing, the surface area for gaseous exchange and photosynthesis is reduced, thereby reducing the dry matter accumulation. Small-leaved genotypes are less affected. Optimum growth temperature ranges are 15-30°C for germination and 20-30°C for growth, but most species will grow within the range of 15-35°C. Low light intensities favor germination and intermittent light enhances germination at less favorable temperatures. Shade causes a decline in the total plant weight and leaf yield, although leaf production is unaffected by partial shade. Leaves harvested from shade-grown plants are less bitter than those harvested from plants grown in full sun (Edmonds and Chweya 1997). Nightshades tolerate shade, but grow better when exposed to full sunlight, as long as adequate water is available (Edmonds and Chweya 1997). Broad-leaved types are generally intolerant to water stress, while those with narrow leaves tolerate water stress better (Masinde *et al.* 2006). An annual rainfall of 500-1200 mm is adequate for growth of African nightshades. The plants perform best during high rainfall seasons, but such conditions also increase the prevalence of foliar diseases. Nightshades grow on various soil types, but are best adapted to high fertility; they grow very well in soils high in nitrogen,

phosphorus and rich in organic matter. Masinde *et al.* (2009, 2010) reported that nitrogen fertilization increased leaf yields 1.5-2.5 fold, but there were no genotypic differences in the level of response, indicating that genetic diversity may not necessarily influence nitrogen use efficiency. Sandy loam to friable clay soils with a pH range of 6.0-6.5 are particularly suitable.

Characterization of African nightshade germplasm

Organisms adapt to environmental change through natural selection. Populations with little genetic diversity have less adaptive potential (Hillis and Wiens 2000). Germplasm characterization and evaluation of genetic resources provide an estimation of genetic diversity, and are necessary for effective conservation of biodiversity (Jacoby *et al.* 2003).

Morphological characterization is the standard method to determine genetic diversity and continues to play a crucial role in the analysis and evaluation of germplasm. Morphological characterization allows for thorough sampling such that a large number of both living and herbarium specimens can be analyzed, but it is time-consuming, labor-intensive, susceptible to phenotypic plasticity, and does not provide information on particular genes, their number and the extent to which they account for observed variation (Hillis and Wiens 2000; Jacoby *et al.* 2003).

Unlike morphological traits, molecular markers yield a detailed characterization of genetic diversity independent of environmental influences and provide a large number of characters for analysis, making it possible to differentiate morphologically indistinguishable individuals. However, the cost of molecular analyses makes it difficult to sample a large number of individuals, and it is impossible to include herbarium materials (Hillis and Wiens 2000; Jacoby *et al.* 2003). Hillis and Wiens (2000) recommended complementary use of molecular and morphological methods to analyze genetic diversity.

Polyploidy and genetic diversity in African nightshades

Existence of high diversity and polyploidy in nightshades is widely recognized (Ojiewo *et al.* 2007a), and has been used to explain nomenclatural and taxonomic problems associated with the section (Edmonds and Chweya 1997; Jacoby *et al.* 2003). Olet (2004) reported that qualitative characters were more accurate in determining genetic relationships among nightshades compared with quantitative characters, but also noted that analyses of both qualitative and quantitative characters were similar to those generated from qualitative data. Similarly, after analyzing morphological diversity in nightshades from South Africa using 13 quantitative characteristics, Jacoby and others (2003) concluded that such characters were useful in determining genetic relationships between the species. Quantitatively variable characteristics increase with increasing ploidy level, and every additional attribute used in such analyses contains potential species-delimiting information, and therefore increases the resolution and accuracy of the analyses; this justifies the use of both qualitative and quantitative morphological variables (Hillis and Wiens 2000).

Mwai (2007) analyzed genetic diversity of vegetable nightshades using morphological traits and amplified fragment length polymorphism (AFLP) markers (Fig. 1) and identified six *Solanum* section *Solanum* species (Fig. 2), all of which are used as leafy vegetables in East and West Africa. They included one diploid (*S. americanum*), four tetraploids (*S. villosum*., *S. grossidentatum* A. Richard, *S. florulentum* Bitter, *S. tarderemotum* Bitter) and one hexaploid (*S. scabrum*). Cluster analyses revealed that species clustered according to ploidy level in both morphological and AFLP data sets and geographical origin did not affect the clustering pattern (Mwai 2007).

With six variants, *S. scabrum* had the highest morphological diversity (Mwai 2007). Variation within *S. scabrum*

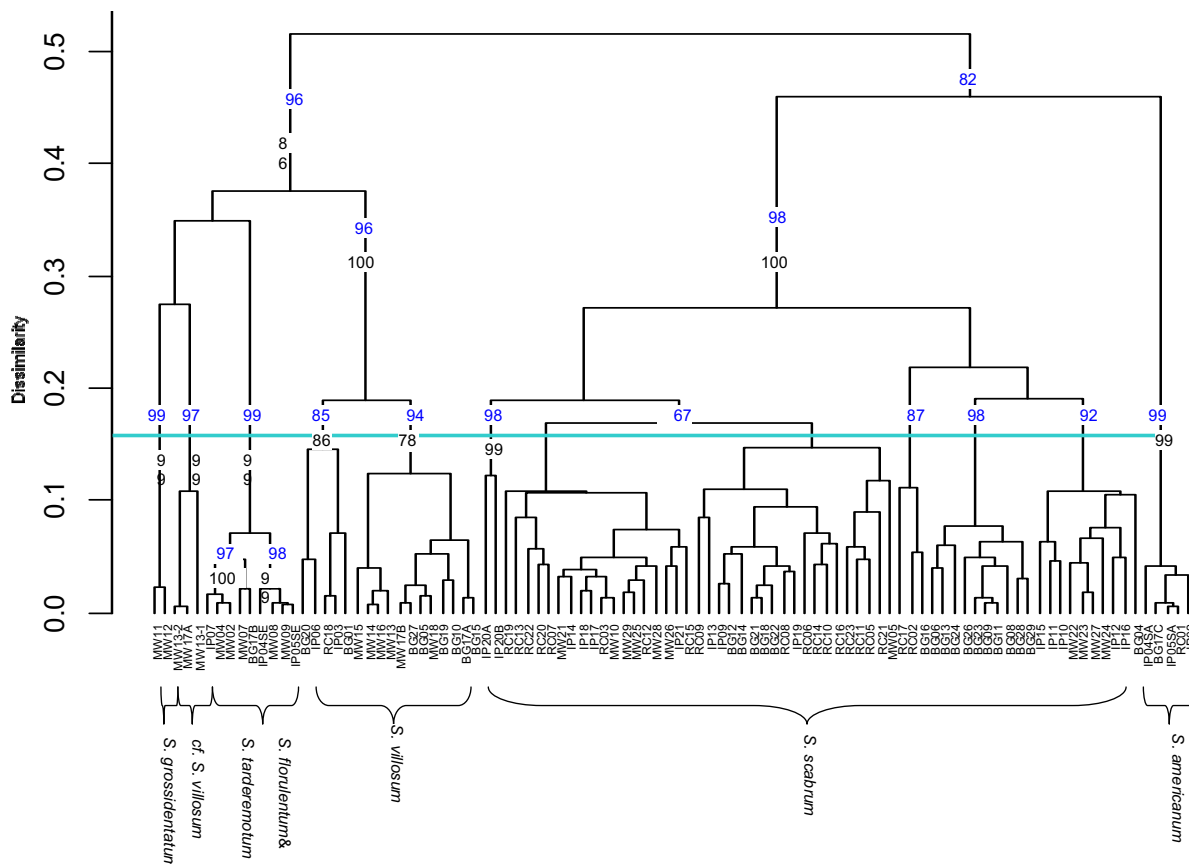


Fig. 1 The genetic diversity of vegetable African nightshades based on morphological and amplified fragment length polymorphism (AFLP) data. Figures show approximately unbiased support values for respective branches for morphological data (upper) and AFLPs (lower). Branches with single support values indicate morphological groups with low or not support in AFLP dataset. The dendrogram was pruned using the Kelley-Gardner-Sutcliffe penalty function to show the 12 morphological supported groups. Source: Mwai (2007).

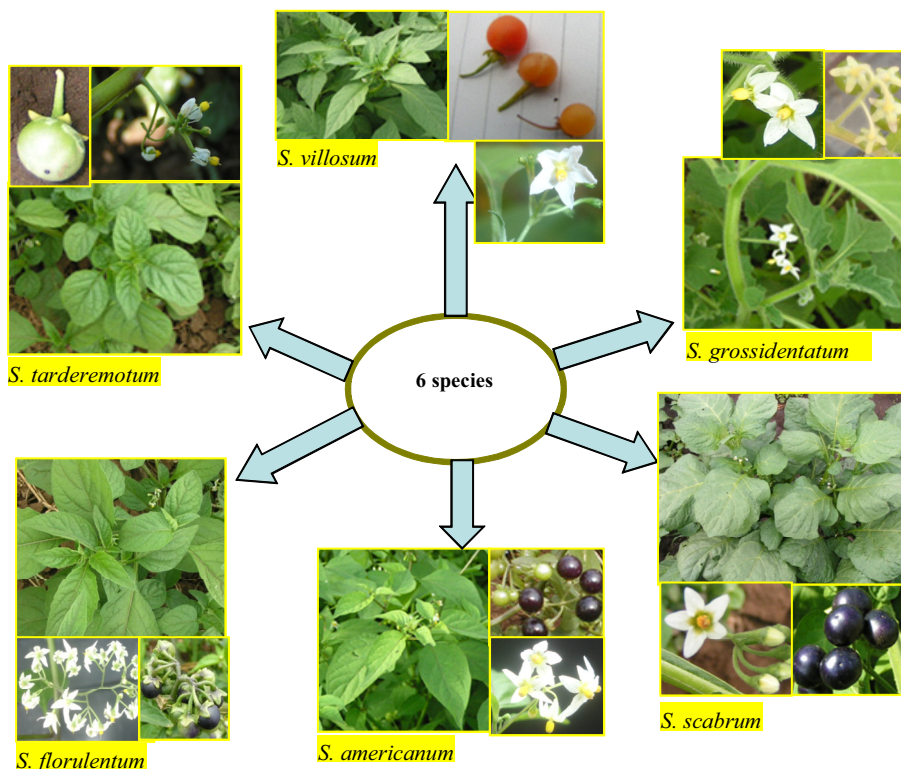


Fig. 2 Six *Solanum* section *Solanum* species (*S. americanum*, *S. villosum*, *S. grossidentatum*, *S. florulentum*, *S. tanderemotum* and *S. scabrum*) identified using morphological traits and amplified fragment length polymorphism AFLP markers. Source: Mwai (2007).

was mainly between plants with purple corollas, brown anthers and purple leaves and stems, and those with white corollas, yellow anthers and green leaves and stems. Previ-

ous studies had reported existence of extensive diversity in the species (Fontem and Schippers 2004). Olet (2004) recognized two *S. scabrum* subspecies and suggested the

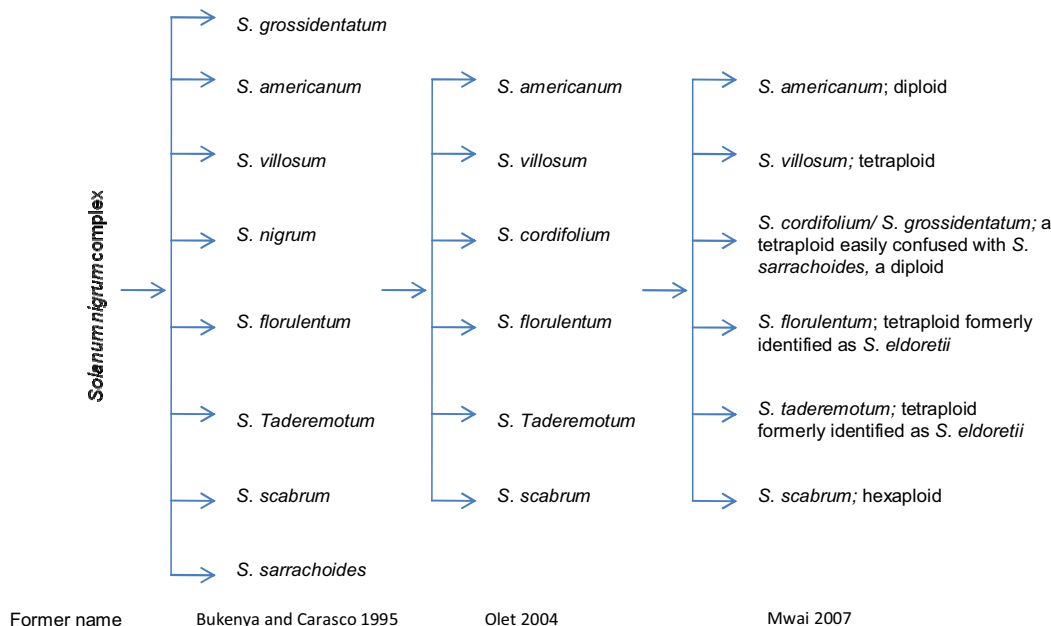


Fig. 3 Progress towards resolving the taxonomic complexities in vegetable African nightshades (*Solanum* section *Solanum*) consumed in Eastern Africa.

possibility of a third subspecies.

As observed by Mwai (2007), high intra-specific variation has been reported in *S. villosum* in Africa (Schippers 2002; Manoko and van der Weerden 2004a; Olet *et al.* 2005). Morphological diversity in the other species reported by Mwai (2007) was quite low. These results differed from previous studies in which high diversity is reported, such as *S. americanum* (Edmonds and Chweya 1997; Schippers 2002; Manoko and van der Weerden 2004b); and *S. taderemotum* (Olet 2004). However, these species were represented by only a few accessions compared with *S. scabrum* and *S. villosum*. While useful in elaborating genetic relationships between the species, the few accessions of these species studied were probably not enough to adequately estimate intra-specific diversity.

Bukenya and Carasco (1995) reported the occurrence of eight nightshade species in Uganda, including *S. americanum*, *S. florulentum*, *S. grossidentatum*, *S. nigrum*, *S. sarrachoides*, *S. scabrum*, *S. taderemotum*, and *S. villosum*. Olet (2004) reported the existence of six section *Solanum* species in Uganda, including *S. americanum*, *S. villosum*, *S. cordifolium* Dunal (Synonym: *S. hirsutum* Balb. ex Dunal), *S. florulentum* Bitter, *S. taderemotum* and *S. scabrum*. Accessions identified as the tetraploid *S. grossidentatum* A. Rich. earlier had been erroneously identified as *S. sarrachoides* Sendtn., a diploid. Although the two species are superficially quite similar (Olet 2004), cytological data indicated the accessions in the AVRDC collection to be tetraploid ($2n=48$). Morphological description of *S. cordifolium* by Olet (2004) approximates very closely *S. grossidentatum*, the most notable difference being that inflorescences are umbellate cymes in the former and extended cymes in the latter (Olet 2004). Material previously reported as *S. eldoretii* (Schippers 2002) or *S. taderemotum* (Mwai and Schippers 2004) was found to comprise two recognized tetraploid species, *S. taderemotum* and *S. florulentum* (Mwai 2007). This progress towards resolving the taxonomic complexities in vegetable African nightshades (*Solanum* section *Solanum*) consumed in Eastern Africa has been summarized in Fig. 3.

Interspecific hybridization and genetic diversity of African nightshades

The frequent occurrence of spontaneous inter-specific hybrids is widely reported (Edmonds and Chweya 1997; Manoko 2007), particularly among species of the same

ploidy level. Mwai (2007) reported three tetraploid accessions, one identical to herbarium specimens of *S. patens* Lowe, and similar to the yellow-berried variant of *S. villosum* described by Edmonds and Chweya (1997), who considered *S. patens* to be a synonym of *S. villosum*. However, other features characteristic of *S. taderemotum*, *S. florulentum* and *S. grossidentatum* led to doubt in identifying these accessions as *S. villosum*. The dense pubescence of the other two accessions made them close to *S. villosum* subspecies *villosum*, *S. grossidentatum* or *S. cordifolium*, according to descriptions by Edmonds and Chweya (1997) and Olet (2004). However, they differ in that while pubescence in all these species is reported as glandular, these accessions were consistently eglandular.

Plants that flower profusely but produce no fruits have been observed, suggesting spontaneous interspecific hybridization (Mwai 2007). Natural inter-specific hybridization is reported to occur in *Solanum* section *Solanum*, with the resultant hybrids often undergoing genetic breakdown in F_1 or F_2 generations, which would explain the observed profuse flowering followed by failure to set fruit. However, if backcrossing with a parental species occurs, the progeny would be fertile, resulting in a morphogenetically complex population and the consequence that identification of specimens collected from such a population would be difficult (Edmonds and Chweya 1997).

Genetic diversity and crop improvement of African nightshades

Polyploids of African nightshade accessions are inherently different from their diploid progenitors, probably due to increased variation in dosage-regulated gene expression (Guo *et al.* 1996). For genes having allele dosage effects, polyploidy increases the potential variation in expression levels (Osborn *et al.* 2003). For instance, changes in enzyme levels can affect many aspects of plant physiology, morphology and life history (Thompson *et al.* 1997). Significant morphological and physiological differences between some polyploid species and their diploid progenitors in vegetative traits such as growth rate and tolerance to biotic and abiotic stresses (de Bodt *et al.* 2005) and reproductive traits such as the initiation and duration of flowering, fertility, apomixis, self-compatibility and germination and organ size have been reported (Thompson *et al.* 1997). Autopolyploid *Dactylis glomerata* L. subsp. *lusitanica* showed an increase in overall vigor, with broader and

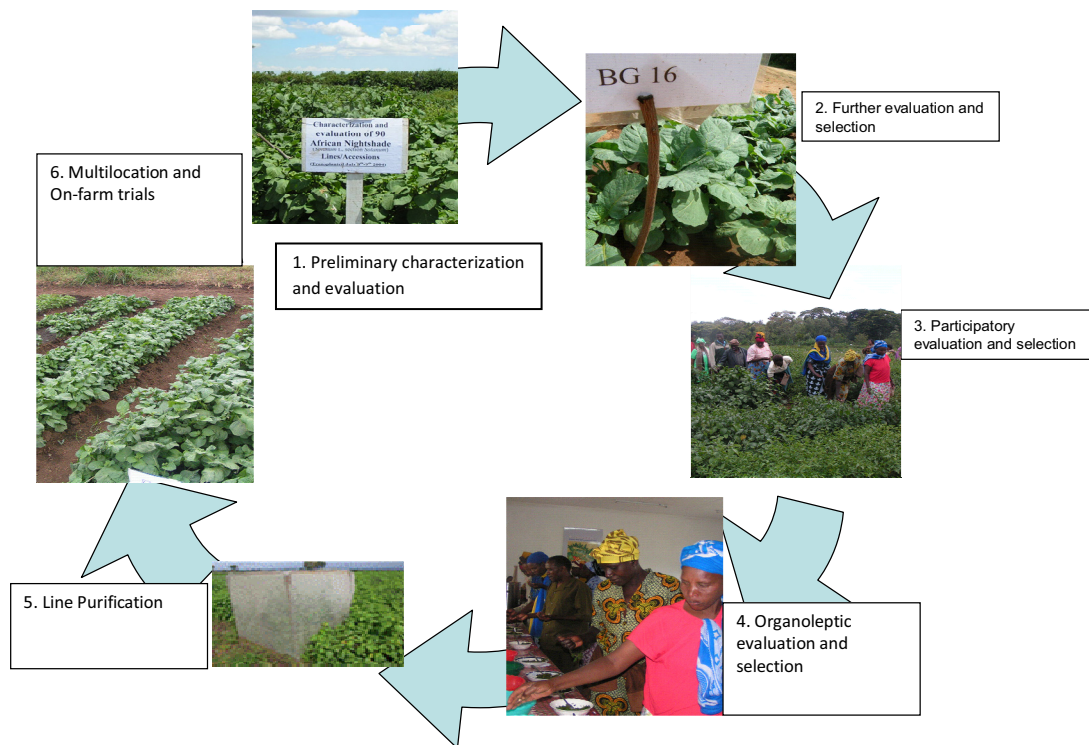


Fig. 4 Variety development of indigenous vegetables: Case of African nightshade “Nduruma”.

thicker leaves (Bretagnolle and Lumaret 1995). Side-by-side trials of 13 elite *Gossypium hirsutum* L. genotypes and 21 *G. arboreum* L. diploids (AA) adapted to a common production region (India) had average seed cotton yield of 1135 (± 90) kg/ha for the tetraploids, a 30% advantage over the 903 (± 78) kg/ha of the diploids, at similar quality levels (Paterson *et al.* 2005). Yield increase resulting from hybrid vigor is positively correlated with increased heterozygosity or diversity of the contributing genomes in autotetraploid alfalfa (Bingham *et al.* 1994), potato (Peloquin *et al.* 1994) and maize (Fasoula and Fasoula 2002).

Hybridization provides a mechanism for large and rapid adaptive transitions, made possible by the genetic variation of genes in a single generation (Rieseberg *et al.* 2003). Due to the occurrence of ploidy series in the *Solanum* section *Solanum*, there is broad genetic diversity that could be made use of in crop improvement through hybridization. However, cross-ploidy hybridization is limited by cross-incompatibility imposed by pollination and fertilization barriers. Combination of different genomes (or the increase in heterozygosity) can lead to hybrid vigor (heterosis).

During polyploidization, numerous mechanisms could consequentially destabilize chromosomes, including the loss of mitotic checkpoint function, abnormal amplification of centrosome, defects in the kinetochore-microtubule attachment, and movement of chromosome relative to the pole (Iarmarcovai *et al.* 2006). Errors in DNA metabolism, repair, recombination or other rearrangements of the DNA sequence, misregulation of the cell cycle, disruption of the mitotic spindle apparatus, and centrosomal duplication result in unequal segregation of the chromosomes at cell division, in numerical chromosomal changes, and in the production of aneuploid cells (Attard *et al.* 2006). Polyploidization often is accompanied with a reduction or complete loss of normal sexual reproduction in plants and animals, particularly in odd-ploidy individuals (such as triploids), a phenomenon known as heteroploidy. Due to these cross-ploidy and cross-pollination barriers, variety development in the African nightshades has been limited to selection breeding.

The AVRDC genebank holds some 128 African nightshade accessions from which germplasm improvement has been done for more than 10 years. The accessions were cha-

racterized at morphological and molecular levels. Selected accessions were evaluated for yield adaptation, and the best lines further selected with farmers and other stakeholders in participatory variety selection and organoleptic sessions (Fig. 4). Accessions agreed upon by AVRDC scientists and farmers (and other stakeholders) were purified and the resulting lines tested in different agroecologies before recommendation for official release. Two of these lines belonging to the species *S. scabrum* were officially released in Tanzania in 2011 under commercial names ‘Nduruma’ (from accession BG 16) and ‘Olevolosi’ (from accession SS 49) and entered into the national seed catalogue.

Genetic diversity and productivity of African nightshades

One of the most significant limiting factors to leaf productivity and yields is early and prolific flowering and berry/seed production. This is most severe in popular species such as *S. villosum* and *S. americanum*. Competition resulting from these reproductive functions normally follows soon after anthesis, reduces leaf productivity to extremely low levels, and can be reversed by inducing male sterility (Ojiewo *et al.* 2009). Temperature-sensitive male sterile mutants of *S. villosum* species have been developed (Ojiewo *et al.* 2007b) and characterized (Ojiewo *et al.* 2010) with greater yield potential under sterility conditions and seed production for propagation under fertility conditions (Ojiewo *et al.* 2007c, 2009).

Yields of species in AVRDC’s African nightshade collection range from about 5 t/ha to more than 70 t/ha with *S. scabrum* accessions recording the highest leaf, berry and seed yields. Apparently *S. scabrum* belongs to the hexaploid group, the highest ploidy in reported experiments (Mwai 2007). Octoploids induced from the tetraploid *S. villosum* through seed treatment with colchicine (Ojiewo *et al.* 2006) were reported to have up to 30-50% more leaf area and up to 35-50% more leaf dry weight compared with the tetraploid plants (Masinde *et al.* 2009). The octoploid plants tended to have fewer but larger leaves, yielding 1.3-1.6 times higher leaf fresh weight than their tetraploid progenitors (Masinde *et al.* 2010).

Mwai (2007) recognized three growth habits along

which leaf yield of vegetable nightshades could be patterned. *S. scabrum* accessions had large leaves, and only primary and secondary branches, thereby attaining high leaf area index (LAI) by maximizing the size of individual leaves and consequently producing very high leaf yields. *S. grossidentatum*, *S. villosum*, *S. florulentum* and *S. americanum* had much smaller leaves compared with *S. scabrum* but branched profusely, attaining a bushy growth habit, and maximizing their LAI by initiating a large number of leaves borne on numerous lateral shoots.

The third growth habit comprised some *S. villosum* accessions (cluster 5 in Fig. 1) and *S. tarderemotum*, which formed compact plants with primary and secondary branches only. With neither the advantage of large leaves nor many branches/leaves, these species were unable to attain photosynthetic efficiencies as high as those in the first and second groups and hence produced the lowest leaf yields. The high yields of *S. scabrum* also could be attributed to the higher ploidy level, which would confer larger plant dimensions to this hexaploid species compared with diploids and tetraploids (de Jesus 2003)

Due to the higher yield potential, *S. scabrum* has been cited as popular among commercial producers for urban markets (Mwai *et al.* 2007) and as the most important vegetable nightshade species due to its considerable diversity in vegetative features and fruit (Fontem and Schippers 2004). However, *S. villosum* types are still popular among many East African farmers who consider them “true traditional” types. *S. scabrum* types were introduced from West Africa where they are more popular.

Genetic diversity and nutrient properties of African nightshades

Some dietary phytochemicals taste bitter, acrid, or astringent, such as bitter phenols and tannins, bitter flavonoids in citrus, bitter glucosinolates in cruciferous vegetables, acrid and unguent isothiocyanates, and some bitter toxic compounds (Drewnowski and Gomez-Carneros 2000). For example, steroidal glycoalkaloids (SGAs) are responsible for toxicity widely associated with the nightshade family. At low levels, SGAs are harmless and are even reported to enhance flavor although they impart bitterness and varying degrees of toxicity. At high levels, however, SGAs may cause death in animals and humans (Laurilla 2004). SGA concentrations above 140 mg/kg of fresh weight are associated with bitter taste and unpleasant flavor. The recommended upper total glycoalkaloid (TGA) limit in plant foods is 200 mg/kg fresh weight (1 g/kg dry weight) (Lawson *et al.* 1992). Laurilla (2004) pointed out that since glycoalkaloids are highly heritable polygenic traits, breeding Solanaceous crops for resistance to pests/diseases and agroecological conditions may result in unintended increases in TGA content.

Mwai (2007) reported total glycoalkaloid content in vegetable nightshade leaves ranging between 79 and 169 mg/kg fresh weight, with mean TGA contents in the most widely cultivated species at 117, 101 and 113 mg/kg in *S. scabrum*, *S. villosum* and *S. tarderemotum*, respectively. These values were well below the recommended upper limit of 200 mg/kg fresh weight TGA in plant foods (Laurilla 2004), hence the conclusion that leaves of popular African vegetable nightshades do not contain toxic levels of SGAs (Mwai 2007).

Genotype differences in the flavonoid content of nightshade after processing have been reported. Cooking, oven drying, drying in direct sunshine and drying under shade had little effect on the flavonoid content of *S. scabrum* but affected the flavonoid content of *S. villosum* species (Koskei 2006). *In vitro* gastrointestinal digestion also shows that dialysability of iron and the concentrations of carotenoids and flavonoids are higher in *S. scabrum* than in *S. villosum* while bio-accessibility of these substances occurs more in *S. villosum* than in *S. scabrum* species (Koskei 2006). A hundred grams of raw *Solanum scabrum* leaves were found to

contain iron and protein values that could contribute to 100% and 50% of the recommended daily allowance (RDA), respectively for an adult (Abukutsa-Onyango *et al.* 2010). This is an indication that African nightshades could greatly contribute to alleviating high iron deficiency anaemia that is prevalent in SSA.

Economic value of the African nightshades

In Kenya, African nightshade and other indigenous vegetables traditionally used to be collected from the wild in surrounding bushes or weedy forms in cultivated fields in the rural areas. Town dwellers would receive small portions normally as souvenirs by neighbors or relatives travelling from rural areas. This trend slowly changed due to awareness creation and promotion activities by NGOs, research organizations and other interest groups; increased general health awareness and consciousness in the population; promotion of peri-urban production aided by positive agronomic practices such as efficient use of water, space and other inputs; improved presentation and increased supply through improvement of market chains; provision of external marketing support to producers; increased capacity for self-organization within producer groups; improvement in transport and communication infrastructure among other factors (Irungu *et al.* 2007).

Consumers started asking for African nightshade among other indigenous vegetables in the supermarkets while buying other items, compelling traders to start stocking them. AVRDC and Farm Concern International conducted a baseline survey 2003 and reported scanty commercialization in Nairobi and neighboring areas, weak seed supply systems and minimal indigenous vegetable awareness among farmers. The total trade in indigenous leafy vegetables was estimated at 31 tonnes per month primarily sourced from western Kenya and transported in gunny bags to Nairobi via night buses (Mwangi and Kimathi 2006). Consumption of indigenous vegetables in Nairobi increased from 31 tonnes in 2003 with an estimated farm gate value of USD 6,000 to 600 tonnes in 2006 with an estimated farm gate value of USD 142,860. AVRDC has supported this growth through improved lines, low input growing techniques, and nutrient enhancing cooking methods that also enhance palatability. The AVRDC recently reported that trade in indigenous vegetables could be some 9000 tonnes in Nairobi alone (AVRDC 2008). Selected high yielding lines suited to local tastes have been promoted to farmers in East Africa with the help of local partners. Supermarket displays and innovative promotions have raised urban consumer awareness. For most of the markets the first indigenous leafy vegetables to be traded in were the African nightshades. African nightshade has been reported to be the most common indigenous vegetable in Nairobi's urban markets and supermarkets, occupying 32% of the total indigenous vegetable market share (Irungu *et al.* 2007). The distribution network includes supermarkets, hotels and restaurants, kiosks, informal markets and street markets (Weinberger *et al.* 2011). The two most common species being traded in are *Solanum scabrum* (broad-leaved) and *S. villosum* (narrow-leaved).

As expected, the rapid growth in consumption and demand for indigenous vegetables caused a concomitant growth in demand for seeds. With financial support from the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) and in collaboration with various partners in Kenya and Tanzania, AVRDC has responded by training farmers in informal seed enterprises with some good results. For example, CABI-Africa reported that farmers in Kenya recorded an income average of \$4,500 per annum with one exceptional farmer earning US \$17,000 in 2010 from indigenous vegetables seed production (ASARECA 2012). Seed yield/acre has also been reported to increase by 10.6, 40.1 and 59.4% for African Nightshade, Jute Mallow and *Crotalaria*, respectively.

CONCLUSION

The nightshade family is usually considered to be comprised of poisonous plants or dangerous weeds. The section *Solanum*, covering a diversity of species commonly referred to as African nightshades, has proven to be an important source of dietary micronutrients such as iron, calcium, phosphorus and vitamins A and C, as well as methionine, an amino acid not commonly found in other types of vegetables. African nightshades in this section are also a good source of income for small-scale farmers. Their former status as “food for the poor” by the middle class and the affluent has changed in many countries but mainly in Kenya where they found their way in super markets. Traditionally collected from the wild, in semi-cultivation or weedy forms, with some degree of cultivation taking place their potential has not been fully exploited, but progress is on course. More recent research reports suggest there is considerable diversity among the African nightshades that confers variations in their growth patterns, flowering time, leaf sizes, shape, color, tastes (bitterness), and nutritional and nutraceutical value, as well as composition and quantities of anti-nutrient factors. These morphological and sensory differences among diverse African nightshade types also affect consumer and market preferences. The potential for full domestication and commercialization of African nightshades lies in this diversity of species, mostly caused by the occurrence of spontaneous inter-specific hybrids, existence of a polyploid series, and phenotypic plasticity. The potential for crop improvement through conventional breeding and hybridization will also depend on this rich diversity and the possible convergence of cytological traits for cross compatibility. For example, desirable traits may exist in accessions of different ploidy levels but barriers to cross-ploidy hybridization limit gene introgression and trait transfer for crop improvement. Selection breeding has been a useful method for variety development and still has good potential as long as the diversity is conserved and utilized.

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