

Research Application Summary

Diversity among selected African nightshade genotypes found in Kenya

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Abstract

African nightshade (*Solanum nigrum* L.) is widely used as leafy herbs and vegetables, as a source of fruit and for various medicinal purposes in the world. Nonetheless the diversity of *Solanum nigrum* in terms of its morphological characteristics is not well known. The objective of this study was to examine morphological characteristics of selected African nightshade (ANS) genotypes. The study was conducted during the long rainy season between March – July 2015 and short rainy season between October-December 2015. The ANS genotypes were obtained from the Kenya National Gene Bank, AVRDC-Tanzania and Kenyan farmers. Nineteen genotypes were grown at two research stations using alpha lattice design replicated three times. Data were collected on both quantitative (plant height, leaf width, leaf length: leaf width ratio and number of berries per panicle) and qualitative (growth habit, leaf shape, leaf margin, flower and berry color) traits. Results showed that there were significant ($P \leq 0.05$) variations in both quantitative and qualitative traits. In terms of plant height, AVRDC TZ-BG 23 recorded a height of 120cm being the tallest genotype while AVRDC TZ-BG 14 and AVRDC TZ- MW 13 recorded heights of 27cm and 21cm, respectively and were the shortest genotypes. The improved genotype and AVRDC TZ (SS49) genotype produced the widest leaves, 12cm wide, while OARA type 1 and GKB 050287 had narrow leaves 2.1cm and 2.5cm, respectively. In terms of leaf shapes, the genotypes displayed three types in which GBK Genotype, Managu Nakuru County, AVRDC TZ-SS49 and the improved genotype leaves were ovate shaped, OARA type 1 and 2 leaves were rhomboid shaped while the remaining genotypes had lanceolate shape. The results further indicated that AVRDC-TZ -SS49 produced flowers with purple petals compared to white petals that were produced by all the other genotypes. Besides, there were variations among genotypes in mature berry colour in which 10 genotypes produced green berries, Kakamega 1, 2 and 3 orange berries and the improved genotype, GBK genotype, Managu Nakuru county, OARA type 1 and 2, and AVRDC –TZ (SS49) with purple berries. This study has documented morphological diversity that can be deployed in breeding programs for the ANS.

Key words: Genetic diversity, Kenya, morphological characteristics, *Solanum nigrum*

Résumé

La morelle africaine (*Solanum nigrum* L.) est largement utilisée comme herbes et légumes feuilles, source de fruits et pour divers usages médicinaux dans le monde. Toutefois, la diversité de *Solanum nigrum* en termes de ses caractéristiques morphologiques n'est pas bien connue. L'objectif de cette étude était d'examiner les caractéristiques morphologiques de certains génotypes de morelle africaine (ANS). L'étude a été menée pendant la grande saison des pluies entre mars-juillet 2015 et la petite saison des pluies entre octobre-décembre 2015. Les génotypes ANS ont été obtenus auprès de la banque nationale de gènes du Kenya, de l'AVRDC-Tanzanie et des agriculteurs kenyans. Dix-neuf génotypes ont été cultivés dans deux stations de recherche suivant un dispositif en alphaLattice avec trois répétitions. Les données ont été recueillies sur les traits quantitatifs (hauteur de la plante, largeur de la feuille, longueur de la feuille: largeur de la feuille et nombre de baies par panicule) que qualitatifs (habitude de croissance, forme des feuilles, marge foliaire, couleur des fleurs et des baies). Les résultats ont montré qu'il existe des variations significatives ($P \leq 0,05$) parmi les traits quantitatifs et qualitatifs. En ce qui concerne la hauteur de la plante, l'AVRDC TZ-BG 23 a enregistré une hauteur de 120 cm étant le génotype de plus haut taille alors que l'AVRDCTZ-BG 14 et l'AVRDC TZ-MW 13 ont enregistré des hauteurs de 27cm et 21cm respectivement et étaient les génotypes les plus courts. Le génotype amélioré et le génotype AVRDC TZ (SS49) produisaient les feuilles les plus larges, de 12 cm de large, tandis que le OARA de type 1 et le GKB 050287 avaient respectivement des feuilles étroites de 2,1 cm et de 2,5 cm. En ce qui concerne les formes des feuilles, les génotypes ont montré trois types dans lesquels les feuilles des génotypes GBK, Managu Nakuru County le , l'AVRDCTZ-SS49 et des génotype améliorées étaient ovales, les feuilles de OARA de type 1 et 2 étaient rhomboïdes alors que les feuilles des autres génotypes avaient une forme lancéolée. Les résultats ont en outre indiqué que l'AVRDC-TZ-SS49 produisait des fleurs avec des pétales violets par rapport aux pétales blancs produits par tous les autres génotypes. De plus, il y avait des variations chez les génotypes dans la couleur de baies mûrs pour laquelle 10 génotypes produisaient des baies vertes, Kakamega 1, 2 et 3 des baies orange et le génotype amélioré, le génotype GBK, Managu Nakuru County, OARA type 1 et 2 et AVRDC -TZ SS49) des baies pourpres. Cette étude a documenté une diversité morphologique qui peut être utilisée dans les programmes de sélection du ANS.

Mots clés: Diversité génétique, Kenya, caractéristiques morphologiques, *Solanum nigrum*

Background

Concerns about agro biodiversity use and conservation, coupled with poverty alleviation have contributed greatly to reawakened interest in African indigenous vegetables. Three top priority African indigenous vegetables have been identified for improvement and promotion through research and African nightshade (*Solanum nigrum*) is amongst them (Mwai *et al.*, 2007). African nightshade serves as an emerging food source in Africa. In Kenya the African nightshades are among the most highly distributed and widely consumed

leafy vegetables country wide (Poczai and Hyvonen, 2011). Kenyan growers of African nightshade have been reported to obtain yields of 1.5-3.0 tones/ha which are relatively lower than their potential yield of 30-50 tones/ha. Early flowering and excessive fruiting are a major limitation to leaf expansion and high yields. Increased use of indigenous vegetables like African nightshade and declining consumption of globally important vegetables such as cabbage, kales and spinach has been reported in Eastern Africa mainly because indigenous vegetables require less input to produce and consequently are more affordable for rural households in low income setups (Ojiewo *et al.*, 2013).

Literature summary

African nightshades were among the first indigenous leafy vegetables (ILVs) to be traded in urban markets and supermarkets in Kenya. Commercialization and domestication of these African nightshade genotypes depend on their diversity (Ojiewo *et al.*, 2013). Recent studies have shown that there is considerable diversity among African nightshade genotypes that causes variation in their morphological traits (Manoko *et al.*, 2007). Selection and breeding has been and still remain important approaches to variety development. The two are heavily dependent on genetic diversity. This diversity needs to be conserved and utilized (Ojiewo *et al.*, 2013). Selection is ordinarily done based on morphological characteristics of a plant that are normally indicative of the genetic differences or diversity.

Traditionally, diversity is estimated by measuring variation in phenotypic or qualitative traits and quantitative agronomic traits. This approach is however sometimes misleading as qualitative traits that can be relied on are often limited and expression of quantitative traits is subject to strong environmental influence that is ordinarily variant (Parmar *et al.*, 2013). An alternative to agro-morphological characterization is molecular characterization. In this approach, molecular markers are applied to develop a molecular map for a crop which is then used to determine linkage between a specific molecular marker and a strongly heritable trait. This holds great promise for breeding programmes as many traits are difficult to directly select from breeding populations (Rao, 2004). In morphological characterization, some of the parameters for assessing the diversity of African nightshade include phenotypic features such as growth habit of the plant, leaf shape, flower color, fruit color, number of fruits per panicle and days to 50% flowering (Ondieki *et al.*, 2011). Some of these parameters are indicative of yield, and increasing components such as leaf surface area through breeding results in improved yield potential (Stoilova and Pereira, 2013). Through studying the morphological, phenological and agronomic diversities inherent in landraces, high yielding varieties that are better adapted to biotic and abiotic stress can be developed (Stoilova and Pereira, 2013). Knowledge of phenotypic variation and relationships among genotypes will assist breeders to develop appropriate breeding strategies and to create the most adaptive and productive cultivars. Consequently, the aim of this study was to examine variations in morphological characteristics of *S.nigrum*, and relate them to yield attributes.

Study description

Nineteen genotypes of African nightshade were planted during the long rainy season between March – July 2015 and short rainy season between October-December 2015 using Alpha Lattice design at both Kenya Agricultural and Livestock Research Organization (KALRO) Muguga and KALRO Kisii. The KALRO Muguga is located at latitude 1°13' S, longitude 36°38' East while KALRO Kisii is located at latitude range 0°, 30' S and 0°, 58' S and longitude 34°, 38' and 34° East. Land was ploughed and harrowed to fine tilth. Seeds of each genotype were then directly drilled on single row plots of 200 cm length with 20 cm spacing between plants, 60 cm between rows and 75 cm between blocks in three replicates. At four weeks, thinning and gapping were done to ensure a plant stand of 10 plants per row was attained. At KALRO Muguga rainfall was supplemented with irrigation while in Kisii planting relied entirely on rainfall. This was because there were intermittent periods of drought in Muguga while in Kisii the rain was well distributed throughout the experimental period. The recommended agronomic practices and plant protection measures were followed to ensure normal healthy crop and Agro-morphological attributes of each entry were scored using the IPGRI descriptors list (Nandhini *et al.*, 2014).

Data collection and analysis

Quantitative data were collected on plant height, internode length, leaf width, leaf length, leaf length: leaf width ratio and number of berries per panicle while qualitative data were collected on plant growth habit, leaf color and shape, flower color, berry color and diameter. Data were subjected to analysis of variance using Genstat statistical package (Payne 2012) and means separated using protected Fishers least significance difference ($P \leq 0.05$).

Results

The results indicated that there was significant difference among the genotypes at $p \leq 0.05$ in plant height, internode length, number of nodes, leaf width (Table 1). The AVRDC TZ-BG 23 was the tallest genotype measuring 120 cm while AVRDC TZ -BG 14 and AVRDC TZ -MW 13 were the shortest genotypes with heights of 27 cm and 21 cm, respectively. The improved genotype and AVRDC TZ -SS49 genotypes produced the widest leaves of 12 cm wide while OARA type 1 and GKB 050287 had narrow leaves measuring 2.1 cm and 2.5 cm, respectively. The lowest leaf length: leaf width ratio of 1.6 was recorded in the improved genotype (Table 1).

The results also indicated that there was variation among genotypes in plant type and branching habit (Table 2). In plant type, GBK 050287, GBK 050295, Kisii types, AVRDC TZ-BG14, -BG22, -BG23, -MW13 and RC11 were creeping/prostrate, GBK 050572, OARA types and Kakamega types were semi erect while GBK Genotype, Managu Nakuru County, Improved type and AVRDC-TZ SS49 were erect. In terms of branching habits, GBK 050572, GBK Genotype, Managu Nakuru County, improved type, Kakamega types AVRDC TZ-GB14, SS49 and OARA type 2 were upright while GBK 050287, 0505292, Kisii types, OARA type 1, AVRDC TZ-BG 22, -BG23, -MW 13 and RC11 were spreading / drooping (Table 2).

Table1. Variations in quantitative traits of 19 *Solanum nigrum* genotypes obtained from farmers' fields in Kenya, National gene bank of Kenya and AVRDC Tanzania

Genotype	Plant height	Leaf length	Leaf width	Leaf length: width ratio	No of berries per panicle	
GBK Genotype	78	17.3	8.7	2	7	
AVRDC-TZ (BG 14)	26.6	9.5	3	3.2	6	
AVRDC-TZ(MW 13)	21	7	2.6	2.8	5	
GBK050287	64.9	8.5	2.5	3.4	7	
OARA type 1	68	5.7	2	2.6	6	
GBK050292	80	10.6	3.7	3	7	
improved type	85.4	19	11.7	1.6	9	
AVRDC-TZ(RC 11)	51	8.2	3	2.8	7	
AVRDC TZ (SS49)	60	24.3	11.7	2	7	
GBK 050572	70	15.6	5.6	2.8	11	
AVRDC TZ (BG23)	120	5.4	2.6	2.3	7	
Kakamega type 1	69	10.16	4	2.6	8	
Kakamega type 2	79	13	5.3	2.4	9	
Kakamega type 3	70	12.4	5.6	2.2	8	
Managu Nakuru county	83.6	16.8	8.6	2	8	
AVRDC-TZ BC22	72	11.4	4.2	2.7	6	
Kisii type 1	61	9.3	3	3.3	7	
Kisii type 2	73.3	9.2	3	3	7	
OARA type 2	63.7	13.5	5	2.7	7	
LSD (0.05%)		14.35**	2.89**	1.41**	0.12**	0.4**
CV (%)	13	14.2	16.5	3	3	

Variation was observed in leaf shapes and leaf margins with Managu Nakuru County, AVRDC-TZ -SS49 and improved type having ovate shaped leaves, OARA type 1 and 2 having rhomboid shaped leaves and GBK 050572, 050287, 050292, Kisii types, Kakamega types, AVRDC TZ-BG14,-BG22,-BG23,-MW13 -RC11 having lanceolate shaped leaves (Table 2). There were three types of leaf margins; OARA and Kakamega genotypes had Sinuate–dentate leaf margin, Kakamega type 3 genotypes had a mixture of sinuate-dentate and lobed leaf margin while the GBK 050572, 050287, 050292, GBK genotype, Managu Nakuru county, Kisii types, AVRDC TZ BG 14, GB22, BG23, SS49 and RC11 had leaves with entire margins (Table 2). All genotypes had leaves with pubescence surfaces (leaf hairiness) except GBK genotype and Managu Nakuru county leaves whose leaf surfaces were glabrous (Table 2).

Table 2: The diversity of qualitative attribute amongst 19 of the assessed African Nightshade genotypes

Accession No.	Plant type	Leaf shape	Leaf margin	Leaf hairiness	Flower colour	Branching habit	Berry colour
GBK 050572	2	2	1	2	1	3	3
GBK050287	3	2	1	2	1	5	3
GBK050292	3	2	1	2	1	5	3
GBK Genotype	1	1	1	1	1	3	1
Managu Nakuru county	1	1	1	1	1	3	1
Kisii 1	3	2	1	2	1	5	3
Kisii 2	3	2	1	2	1	5	3
OARA type 1	2	3	2	2	1	5	1
Improved type	1	1	1	2	1	3	1
Kakamega type 1	2	2	2	2	1	3	2
Kakamega type 2	2	2	2	1	1	3	2
Kakamega type 3	2	2	2,3	2	1	3	2
AVRDC-TZ (BG 14)	2	2	1	2	1	3	3
AVRDC-TZ(BG22)	3	2	1	2	1	5	3
AVRDC TZ (BG23)	3	2	1	2	1	5	3
AVRDC-TZ(MW 13)	3	2	1	2	1	5	3
AVRDC TZ (SS49)	1	1	1	2	2	3	1
AVRDC-TZ (RC 11)	3	2	1	2	1	5	3
OARA TYPE 2	2	3	2	2	1	3	1

Plant type: 1=Erect, 2=Semi erect 3=Creeping/prostrate; Branching habits: 3=Upright, 5=Spreading dropping; Leaf hairiness: 1=Glabrous, 2=pubescent; Leaf margin: 1) =Entire, 2) =Sinuate -dentate, 3) = Lobed; Leaf shape: 1) = Ovate, 2) = Lanceolate, 3) = Rhomboid Flower colour: 1) = White, 2) = Purple; Fruit colour: 1=purplish black, 2=Orange, 3=Green.

The results also indicated that there were differences among genotypes in flower colour and mature berry colour (Table 2). AVRDC-TZ (SS49) produced flowers with purple petals with the remaining genotypes producing flowers with white petals. The berries produced belonged to three colour categories that is green, orange and purple (Table 2). GBK 050572, GBK 050287, GBK050292, Kisii types, AVRDC TZ- BG 14 BG 22, BG23, MW 13 and RC 11 had green berries when mature, Kakamega types had orange berries and improved type, GBK genotype, Nakuru county and AVRDC –TZ (SS49) had purple berries.(Table 2)

Conclusion

The African nightshade genotypes under study varied in terms of morphological traits such as plant growth habits, leaf, flower and fruits characteristics. The genotypes had

either erect, semi erect or creeping plant type with upright or spreading branching habits. Most genotypes had pubescent leaves with only a few genotypes having glabrous leaves. Lanceolate shaped leaves were observed in most genotypes with the remaining few genotypes having either ovate or rhomboid shaped leaves. Only 1 out of the 19 genotypes had flowers with purple petals compared to the white petals observed. Fruit colours observed were purple, green and orange. From this observed phenotypic variation it can be deduced that there was diversity among the genotypes and these diverse genotypes can be introduced into a breeding program as parents to obtain African nightshade progenies with superior combinations.

Research Applications

Understanding genetic diversity is important for genetic improvement to enhance resistance/tolerance to both abiotic and biotic stresses. Crop genetic resources improvement is dependent on continuous incorporation of wild relatives, landraces and the use of modern breeding techniques. Characterization of African nightshade landraces will lead to selection of superior genotypes which can be used as breeding tools for improvement of African nightshade.

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