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Neodomestication and its Effect on Growth and Production of Wild Yam in Baringo and Uasin Gishu Counties of Kenya

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Abstract

Wild yam (Dioscorea spp.), particularly, Dioscorea schimperiana Kunth tubers have been used as food during times of severe famine. However, there is no documentation on attempted wild yam domestication in Kenya. Therefore, the study was conducted to assess the effect of domestication on growth and production of D. schimperiana, with the aim of developing new yam cultivars to be used to improve food security. Tubers of six (6) D. schimperiana accessions from five (5) selected localities including Kombosang (KB1), Moigutwo (MB1), Mormorio (MB2 and MB2C), Kolol (KE) and Chepsangor (CN) in North Rift region of Kenya were collected. Cultivated yam, Dioscorea alata (MN and MT) accessions obtained from Mathia and Mogoi in Nyeri and Trans-Nzoia Counties respectively, were used as reference. The tubers were sprouted in dark rooms and transplanted in Growth Pouches in the net-house and also in 2 feet holes in the field, spaced at 1m intra row and 1m inter row and staked. Data on internode and vine length, number of leaves, presence or absence of bulbils, number and fresh weight of tubers per plant per accession were recorded. The data collected were then subjected to analysis of variance and the differences among means adopted as significant at P≤0.05. All the five (5) field-grown D. schimperiana accessions significantly showed varied vegetative growth in the net-house and field accessions. The Dioscorea schimperiana produced longer internodes than the D. alata accessions. However, D. alata formed longer vines than the D. schimperiana accessions. Except Dioscorea alata which did not produce tubers in the field but small ones in net-house, D. schimperiana formed single large tubers per plant. Apparently, most D. schimperiana accessions namely, KE, MB1, MB2 and CN produced significantly heavier tubers compared to the control (MB2C), but. KB1 had similar tuber weight as the control. The results show that net-house and field cultivation improve tuber weight of D. schimperiana. Some D. scimperiana (KE, MB1 and CN) showed greater potential for domestication and could be cultivated to improve food security.

Keywords: Neodomestication, Wild Yam, *Dioscorea schimperiana* Kunth, *Dioscorea alata* L., Growth, Production

INTRODUCTION

The term 'yam' refers to all members of the genus Dioscorea, family Dioscoreaceae, and order Dioscoreales which are classified among the monocotyledons (O'Sullivan, 2010), which contains over 600 species in which only few are cultivated for food and medicine (IITA, 2006; O'Sullivan, 2010). Out of the over 600 known yam species, about 10 species are commonly cultivated for food (O'Sullivan, 2010), which include *Dioscorea rotundata* Poir (White yam), *Dioscorea cayenensis* (Yellow yam), *Dioscorea alata* (Water yam), *Dioscorea* *bulbifera* (Aerial yam), *Dioscorea esculenta, Dioscorea praehensalis* (Bush yam) and *Dioscorea dumetorum* (Jayakody et al., 2007). A large number of the other yam species are harvested from the wild in times of food scarcity (Bhandari et al., 2003). However, many wild yam species contain toxic or bioactive chemicals, and some of these are cultivated for pharmaceutical products (Okwu and Ndu, 2006; Nwosu, 2013). Yams are annual or perennial tuber-bearing and climbing plants, and wild yam is found climbing over shrubs or bushes and trees in their natural habitats. Wild yam is common in uncultivated or undisturbed environments such as damp woods and swamps, thickets, roadside fences and hedges. The wild yams mostly occur in Africa and Asia and especially found throughout the tropics and a few in the temperate regions of the world (Eka, 1998; Tamiru et al., 2008; APG III, 2009). But generally, *Dioscorea* is a pantropical genus, and different species have been independently domesticated on each continent (O'Sullivan, 2010). Wild yam has edible tubers and bulbils. It has also been used for centuries as a medicinal herb for a wide range of ailments such as many female medical challenges such as symptoms of menopause and to release the pain of child birth. In Nigeria, bitter yam is used as food for the diabetic patients and as herb for the treatment of various ailments. In the South-Western Nigeria, bitter yam is used in treating malaria (Dike et al., 2012). Although bitter yam is rich in phyto-nutrients (Medoua et al., 2005; Alozie et al., 2009), it has remained an underutilized tuber plant (Owuamanam et al., 2013).

The cultivated species of yams have been domesticated from their wild types. Wild yam domestication was preceded by *in situ* propagation by the forest hunting and food gathering societies particularly in West Africa, Philipines, Central Africa, Tanzania among others (Dounias, 2001). In the process of harvesting the wild yam, the gathering communities, ensure the maintenance of the wild yam tuber heads in the soil by reburying after harvesting the fleshy parts (Dounias, 2001). The plant is kept within its original environment to ensure its conservation in order to respond to the seasonal mobility of forest dwellers (Dounias, 2001). Until recently. field surveys in Benin and Nigeria have shown that the process of yam domestification is still practised by local farmers (Mignouna & Dansi, 2003; Vernier et al., 2003). Farmers transplant into their fields wild yams found in secondary forest (Dumont and Vernier, 2000). Once plants are cultivated, the wild traits disappear over several generations of clones (Chikwendu and Okezie, 1989). And just like in Ethiopia (Wendawek et al., 2013), wild yams are rarely domesticated in East Africa including Kenya, in spite of it having been harvested for famine food and other uses. Most African indigenous yam tubers are small in size and a few of them have been brought under cultivation (Wendawek et al., 2013). Yam grows optimally in well drained, moist sandy to loamy medium soils, and requires partial shade (Maundu et al., 1999; Gucker, 2009). Yam compared to grain crops is less vulnerable to variations in climate including rainfall, temperature among others, and also its harvesting, unlike cereals can be spread to varying times of the year without seasonal limitations. Thus, assuring households of some reliable source of food, hence food security (Gucker, 2009).

Yams have been primarily grown for their tubers, which are underground or aerial, and serve as a source of food (Hahn, 1995; Tamiru et al., 2008; APG III, 2009). Yam is a major contributor to food security in West Africa (Zannou, 2006). Aerial yam is predominantly grown in the Western and Eastern regions of Nigeria for its bulbils that are consumed during the famine season (Deb, 2002). *Dioscorea schimperiana,* one of the nine commonly consumed yams is an integral crop for food security in Cameroon (Leng et al., 2016).

In Kenya, not much information is available on *Dioscorea spp* and it is actually a neglected crop. However, there are still areas where yam cultivation is still on going around the central highlands where the major species is *D. minutiflora* Engl. (Maundu et al., 1999; Mwirigi et al., 2009). However, wild yam, a plant of humid and sub-humid tropics, is drought tolerant and also does well in semi-arid regions. But factors in the wild such as rocky soils, poor soil structure, extensive tree root systems among others, hinder yam tuber growth and development. Although wild yam is drought tolerant and has been used as food in many parts of the world including Kenya, there is no research information about wild yam domestication in Kenya. The current research was done to assess the effect of domestication on growth and production of indigenous wild yam, *Dioscorea schimperiana* with the aim of improving food diversification and food security in Baringo County and also contribute to its conservation.

MATERIALS AND METHODS

Description of Study Area

The net-house experiments were carried out at Biological Sciences'net-house (Botany Greenhouse 2, UoE/2/000023054), situated in latitude 0° 35' 1.96" N and longitude 35° 18' 33.26" E, at the University of Eldoret Arboretum. It stands on an altitude of 2,152 m above sea level. The University is located 9 km north east of Eldoret town in Uasin Gishu County, Kenya. The field study was carried out in an experimental plot at Mormorio in Baringo North Sub-county, Baringo County. The site is located at latitude 0° 41' 55.52" N and longitude 35° 46' 27.99" E, and situated at 13 km North-West of Kabartonjo town on the western scarps of Tugen Hills. It lies in Upper Midland (UM 4) zone (Jaetzold et al., 2010) and stands on an altitude of 1650 m above the sea level. Mormorio lies on gentle slopes of the southern side of Ngarau range/ridge characterized by natural thickets of trees and shrubs. Wild yam, *Dioscorea schimperiana* Kunth was found climbing over the natural thickets.

Collection of Yam Planting Material

The tubers of five (5) *D. schimperiana* accessions were collected from pre-surveyed, selected and georeferenced sites in three counties which included Kombosang, Moigutwo and Mormorio (Baringo), Kolol (Elgeyo-Marakwet) and Chepsangor in Nandi County (Table 1). Tubers of a cultivated yam, *Dioscorea alata* L. accessions were obtained from farmers' gardens in Mathia (Nyeri) and Mogoi (Trans-Nzoia). Farmers cultivate *D. alata* for consumption. All the yam tubers were transported from the sites of collection to Mormorio and University of Eldoret experimental sites. The yam accessions were then coded by the initial character of collection site and County which included KB1, MB1, MB2 from Kombosang, Moigutwo and Mormorio (Baringo County), KE from Kolol (Elgeyo Marakwet County), CN from Chepsangor (Nandi County), MN from Mathia (Nyeri County) and MT from Mogoi (Trans-Nzoia County).

Net-house and Field Experiments

Five (5) *D. schimperiana* accessions which included KB1, MB1, MB2, KE and CN were grown in net-house and field in order to determine their potential for domestication. Cultivated type, *D. alata* (MN and MT) were included as reference accessions.

Table 1: Brief descriptions of the seven sites where *D. schimperiana* and *D. alata* accessions were obtained

Yam accessions		**Collection site**	**County**			**Altitude (m)**
Code	**Type**			**Latitude**	**Longitude**	
KB1	Wild	Kombosang	Baringo	0° 46' 26.07" N	35° 44' 52.66" E	1297
MB1	Wild	Moigutwo	Baringo	0° 46' 51.27" N	35° 48' 38.95" E	1814
MB2	Wild	Mormorio	Baringo	0° 41' 55.52" N	35° 46' 27.99" E	1655
KE	Wild	Kolol	Elgeyo-Marakwet	0° 33' 42.70" N	35° 31' 28.48" E	1782
CN	Wild	Chepsangor	Nandi	0° 21' 5.99" N	34° 56' 28.61" E	1638
MT	Cultivar	Mogoi	Trans-Nzoia	1° 1' 19.97" N	35° 0' 12.08" E	1904
MN	Cultivar	Mathia	Nyeri	0° 26' 59.55" S	37° 10' 32.09" E	1868

Preparation of Yam Tubers for Planting

The *D. schimperiana* tubers of each accession were cut into mini tubers/mother tubers called setts that weighed 150 g and above, according to a slightly modified method of Asfaw, (2016) and O'Sullivan, (2010), and sprouted (Plate 1) in secured dark rooms at the experimental sites. The *Dioscorea alata* planting materials were pieces of woody rhizomes prepared and recommended by yam farmers (Plate 1).

Yam Planting and Agronomic Practices

Each sprouted tuber was transferred to a Growth Pouch filled with fertile forest soil, and replicated three times. Each plant in a Growth Pouch was watered daily with 2 litres of water (Amount of water that could uniformly moisten the soil in the Growth Pouch) in the morning and 2 litres in the evening. Each plant was staked with a twine that was suitably tied to the Growth Pouch and firmly suspended to the net house trusses. Data on internode and vine length, number of leaves and presence or absence of bulbils/plant were recorded six (6) months after planting, at physiological maturity, when the leaves started yellowing and drying up. The underground tubers were carefully and manually extracted from the Growth Pouches, and the bulbils were picked from the vines, seven (7) months after planting when the shoots had dried up. The soil was washed off the tubers with gentle stream of tap water. Then, the number and fresh weights of tubers and bulbils per plant was recorded. Furthermore, the accessions were assessed for the effect of domestication on their growth and production in an open field at Mormorio village in Baringo County, where MB2 accession was collected. The sprouted seedlings of each accession were transplanted to 2 feet holes applied with 2 kgs of farmyard manure (decomposed cowdung), spaced at 1m intra row and 1m inter row according to a modified method by Asfaw, (2016) and O'Sullivan, (2010). *Dioscorea schimperiana* (MB2) accession was planted in shallow (20 cm deep holes) applied with 2kgs per hole, of farmyard manure to match conditions in their natural environments, and treated as the control (MB2C). The experiment was laid out in a randomized complete block design where plants were raised in two blocks and within each block, each accession was randomly planted in plots measuring 4x3 m then replicated three times.

Plate 1: Sprouted yam tuber planting materials of *D. schimperiana* (KB1, MB1 and MB2, KE, CN) and *D. alata* (MN).

One month after planting, weeding and staking were carried out regularly. Each yam plant was staked using dry sticks to provide support and stimulate vine and leaf development to enhance photosynthesis. Three plants per plot were randomly sampled and tagged for data collection. Data on internode and vine length/plant, number of leaves/plant and presence or absence of bulbils/plant were recorded. The underground tubers were carefully and manually dug out, and the bulbils were picked from the vines, after the shoots had dried up. The soil was washed off the tubers. The number and fresh weight of tubers and bulbils per plant were assessed and recorded.

Data Analysis

The collected data were subjected to analysis of variance, and the differences adopted as significant at $P \leq 0.05$.

RESULTS

Effect of Net-house Domestication on Growth and Production of Wild Yam

All the net-house grown yam accessions formed shoots that varied in length. The *D. schimperiana* and *D. alata* accessions produced internodes that significantly varied in length from 9.1±0.3 to 14.6±0.3 cm (Table 2). The accession KE had significantly longer internodes compared to the other *D. schimperiana* accessions. The cultivated species MT and MN had shorter internodes compared to most of the *D. schimperiana* accessions. The accessions varied significantly in the number of leaves produced. KE produced significantly higher number of leaves than the other *D. schimperiana* accessions (Table 2). Moreover, KE and MB2 significantly produced a higher number of leaves relative to MT and MN. Most of the *D. schimperiana* accessions including KE, MB1, MB2 and CN, were similar in vine length except KB1 whose vines were the shortest, measuring less than a metre. The *D. schimperiana* accessions had significantly shorter vines compared to the cultivated types, MT and MN. All the net-house grown wild and cultivated yam accessions formed root tubers (Table 3). The *Dioscorea schimperiana* (KB1, MB1, MB2, KE and CN) accessions formed single deformed tubers that were different from the usually elongated/vertical tubers formed by *D. schimperiana* plants

(Plate 2 and Plate 3). The cultivated *D. alata*, MT and MN accessions formed more than one small and spined tubers which were significantly higher than the tuber number in KB1, MB1, MB2, KE, and CN accessions (Table 3, Plate 2). The yam tuber fresh weight/plant ranged from 56.9±1.9 to 415.2±20.2 g. Of the *D. schimperiana* accessions, MB1 and KE significantly produced heavier tubers than KB1, MB2 and CN. All the *D. schimperiana* (KB1, MB1, MB2, KE, and CN) accessions produced significantly heavier tubers than the *D. alata* (MN and MT). Furthermore, out the five *D. schimperiana* accessions, three that included MB1, KE and CN formed bulbils in some net-house grown plants. KE and CN plants produced similar number of bulbils that was significantly higher compared to MB1. *Dioscorea alata* accessions, MT and MN plants did not produce bulbils in net-house grown plants. Accession KE produced significantly heavier (11.9±0.5 g) bulbils followed by CN (8.1±0.4 g) and MB1 (6.6±0.4 g).

Table 2: Effect of net-House Cultivation on wild yam growth attributes

Yam accession	**Internode length (cm)**	**No. of leaves**	**Vine length (cm)**
KB1	9.1±0.3c	82.7±3.3c	101.3±3.1c
MB1	10.6±0.8bc	94.9±13.1bc	182.9±32.8b
MB2	12.0±1.3a-c	144.8±14.8ab	137.4±20.5b-c
KE	14.6±0.4a	173±3.6a	184.6±27.5b
CN	11.0±1.3bc	132.7±17.6a-c	133.4±17.7b-c
MT	9.2±0.3c	85.3±2.3c	378.6±16.3a
MN	11.2±0.5bc	85.1±2.5c	422.4±15.0a

Values with the same letter (s) in a column are not significantly different (*P*≤ 0.05), according to Tukey's test.

Table 3: Effect of net-House Cultivation on wild and cultivated yam yield attributes

Yam accession	**Tuber number/ plant**	**Bulbil number/plant**	**Tuber fresh wt (g)/plant**	**Bulbil wt (g)/plant**
KB1	1±0c	0±0c	300.4±9.5c-e	0±0d
MB1	1±0c	5±0b	415.2±20.2a	6.6±0.4c
MB2	1±0c	0±0c	297.1±12.3c-e	0±0d
KE	1±0c	9±0a	383.9±18.0ab	11.9±0.5a
CN	1±0c	9±0a	287.1±16.1de	8.1±0.4b
MT	2±0b	0±0c	56.9±1.9f	0±0d
MN	3±0a	0±0c	67.8±2.4f	0±0d

Values with the same letter (s) in a column are not significantly different (*P*≤0.05), according to Tukey's test.

Plate 2: Extracted root tubers of net-house grown yam accessions, MB1 and KB1 (Baringo), KEa and TE (Elgeyo-Marakwet), CNa (Nandi) and MN (Nyeri)

Plate 3: Wild Yam, *Dioscorea schimperiana* Kunth (KE1, CN, MB2, KB1 and MB1) and *D. alata* (MN) Underground Tubers Collected *in situ*

Effect of Field Domestication on Growth of *Dioscorea schimperiana* Kunth

All the five (5) field-grown *D. schimperiana* accessions significantly showed varied vegetative growth (Table 4). Accession KE had the longest internode length (17.6±1.0 cm), and MT the shortest (9.3± 0.3 cm). Generally, the yam wild accessions KE (17.6±0.4 cm), MB2 (16.2±1.0 cm) and CN (16.3±0.7 cm**)** significantly formed longer internodes compared to the control, MB2C (12.7±0.5 cm) and the cultivated accessions, MN (9.8±0.4 cm) and MT (Table 4). All the wild yam accessions formed leaves that ranged between 34±6 and 85±18 in number. All the *D. schimperiana* accessions had similar number of leaves as control MB2C. Accessions KE and MB1 produced similar number of leaves per plant as the *D. alata* accession, MN. *Dioscorea alata* accession MT produced similar number of leaves as KB1, MB1, MB2, KE and CN (Table 4). MN produced the highest number of leaves/plant while MB2C the lowest. The number of vines produced by the yam accessions ranged from 139.1±14.8 to 295.2±22.5 cm (Table 4). MB1 and KE produced significantly longer vines than KB1, MB2, CN and MB2C. But MB1 and KE had similar vine length as the cultivated types, MT and MN. Generally, the cultivated yam accessions, MN and MT significantly produced the longest vines, the highest number of leaves and the shortest internodes when compared with the wild yam accessions.

Effect of Field Domestication on Production of Wild Yam

All the field-grown *D. schimperiana* accessions including KB1, MB1, MB2, KE, CN and the control, MB2C formed tubers (Table 4, Plate 4) while the cultivated yam accessions, MT and MN did not. The wild yam KB1, MB1, MB2, KE and CN produced single elongated root tubers that were less fibrous than MB2C but similar in number as MB2C (Plate 4). Moreover, the accessions produced tubers that exhibited significant variation in tuber weight and ranged from 178.4±10.3 to 365±18.5 g.

Accessions KE, MB1 and MB2 produced significantly heavier root tubers/plant compared to KB1 and MB2C. However, all the *D. schimperiana* accessions formed slender, heavily fibrous and elongated/vertical underground tubers in their natural environments than when in cultivation (Plate 3). Except KE plants that formed few bulbils (Plate 4), the other accessions including KB1, MB1, MB2, CN and MB2C did not form bulbils in field-grown plants. Very few KE plants formed bulbils that were small and weighed 5.0±1.0 fresh weight (Plate 4). Although the field-grown plants of KB1, MB1, MB2 and CN accessions did not produce bulbils, they produced many larger bulbils when they were growing in their natural environments (Plate 5). *Dioscorea alata*, MN and MT did not produce bulbils.

Table 4: Vegetative growth attributes of field-grown *D. Schimperiana* and *D. alata* Accessions

Yam accession	Growth attributes Internode length (cm)	Number of leaves/plant	Vine length (cm)
KB1	11.7±0.5^{de}	39±7^{b}	196.1±9.5^{b-d}
MB1	14.7±0.8^{bc}	47±11^{ab}	261.7±16.5^{a-c}
MB2	16.2±1.0^{ab}	39±5^{b}	205.4±16.1^{b-d}
KE	17.6±0.4^{a}	63±11^{ab}	271.7±29.9^{ab}
CN	16.3±0.7^{ab}	35±5^{b}	180.0±9.2^{cd}
MB2C	12.7±0.5^{cd}	34±6^{b}	139.1±14.8^{d}
MT	9.3±0.3^{e}	60±3^{ab}	246.1±24.7^{a-c}
MN	9.8±0.4^{e}	85±18^{a}	295.2±22.5^{a}

Values with the same letter (s) in a column are not significantly different at $P \leq 0.05$, according to Tukey's test.

Table 5: Yield attributes of field-grown *D. Schimperiana* and *D. alata* Accessions

Yam accession	Yield attributes Tuber No/plant	Bulbil No/plant	Tuber wt (g)/plant	Bulbil wt (g)
KB1	1±0[a]	0±0[b]	227±17.3[c]	0±0[b]
MB1	1±0[a]	0±0[b]	287.5±4.5[b]	0±0[b]
MB2	1±0[a]	0±0[b]	277.2±13.6[b]	0±0[b]
KE	1±0[a]	1±0.2[a]	365.0±18.5[a]	5±1.0[a]
CN	1±0[a]	0±0[b]	306.9±6.3[b]	0±0[b]
MB2C	1±0[a]	0±0[b]	178.4±10.3[c]	0±0[b]
MT	0±0[b]	0±0[b]	0±0[d]	0±0[b]
MN	0±0[b]	0±0[b]	0±0[d]	0±0[b]

Values with the same letter(s) in a column are not significantly different at $P \leq 0.05$, according to Tukey's test.

Plate 4: Harvested Tubers of the Field Grown *D. schimperiana* Accessions (KE, CN, MB1, MB2), control (MB2C), and *D. schimperiana* Bulbils Produced by Accession KE in the Field

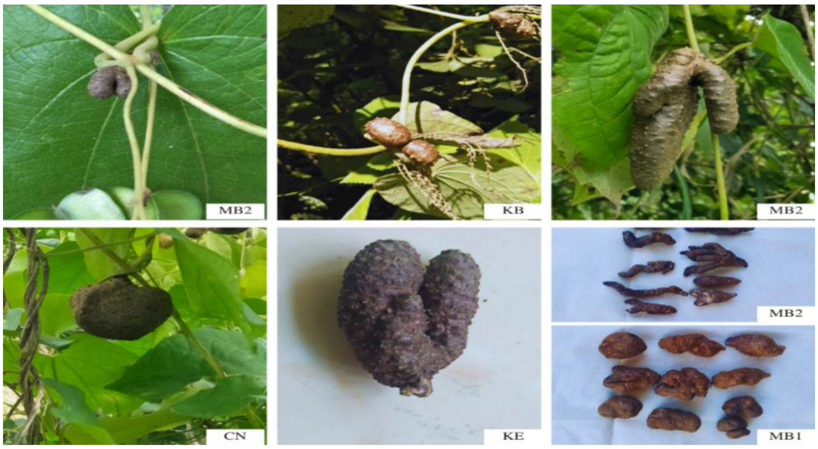

Figure 520: Wild Yam Bulbils Formed by *D. schimperiana* Plants *in situ* in Different Counties; MB2 and MB1 (Baringo), KE (Elgeyo-Marakwet), CN (Nandi).

DISCUSSION

The present study is the first in Kenya to assess the effect of cultivation/domestication on wild yam growth and production. The results revealed that all the *Discorea schimperiana* (KB1, MB1, MB2, KE and CN) accessions formed healthy vines, leaves and sizeable tubers. This indicates that the wild *D. schimperiana* can be propagated from tubers. Similarly, Zulu et al. (2019) in their propagation experiments found that *Dioscorea hirtiflora* subsp. pedicellata Milne-Redh can be propagated from tuber minisetts. On the other hand, the *D. alata* (MN and MT) woody rhizomes sprouted into vigorously growing vine and leaves, but formed very small tubers in net-house grown plants and none in the field-grown plants. Although use of woody rhizomes was a recommendation by farmers from yam growing areas particularly in Central Kenya, their failure to form tubers in field-grown plants or formation of very small tubers in net-house grown plants, could be attributed to ineffectiveness and inefficiency of the woody rhizomes planting material in supporting formation and growth of tubers. This can be supported by the observation that the *D. alata* woody rhizome planting materials took more than a month to sprout after planting in both net-house and field. Contrary to use of woody rhizomes, *D. alata* tubers have also been used as planting materials in West Africa, Indonesia and Australia (O'Sullivan, 2010). Moreover, changes in environmental conditions could have also affected the timely formation and growth of the *D. alata* tubers. The net-house and field results of *D. schimperiana* and *D. alata* showed similar trends in growth and production attributes. For example, the *D. schimperiana* results in the net-house were consistent with field results, where the internode lengths of KE, MB1, CN, MB2 and KB1 were longer while their vine lengths were shorter than for MT and MN. This finding implies that irrespective of environmental changes, *D. schimperiana* form internodes that are longer than *D. alata*. However, in spite of vigorous growth, internode and vine length in both net-house and field-grown *D. schimperiana* accessions were shorter than when they were growing in their natural environments. The formation of shoots that significantly varied in growth among the *D. schimperiana* and *D. alata* net-house grown accessions could be attributed to species and genotype differences as well as changes in environmental conditions between their collection and experimental sites. Thus, the findings suggest that cultivation induced growth of shorter vines in all *D. schimperiana* accessions. Furthermore, the results showed a higher number of leaves in net-house grown *D. schimperiana* than field grown accessions. However, in the net-house, KE and MB2 produced higher number of leaves per plant compared to CN, MB1 and KB1 but in the field, all the tested *D. schimperiana* accessions had similar number of leaves. The different agronomic practices employed in the net-house and field experiments and the ecological differences, could have caused the leaf number variation among the *D. schimperiana* accessions. Leaves are the primary photosynthetic organs involved in photosynthetic reactions that lead to starch and tuber formation (Dounias, 2001; McKey et al., 2010).

On production, the results revealed that most *D. schimperiana* accessions including KE, MB1, MB2 and KB1 produced relatively heavier tubers in net-house than in the field, depicting that partial light in net-house favours accumulation of more starch in tubers than in full light in the field. Also KE, MB1 and CN produced bulbils in net-house whereas only KE formed them in the field, again suggesting that partial light stimulates formation of tubers. The difference in production among *D. schimperiana* accessions could be attributed to agronomic differences adopted in net-house and field experiments. Furthermore, the production results showed that most of the accessions of *D. schimperiana* produced sizeable tubers under *ex-situ* cultivation compared to production in their natural environments. For instance, during tuber collection, it was observed that wild yam in their natural environments produced tubers that were slender and deformed due to due to presence of woody plant roots, stony/rocky soils and soil hard pan which hindered tuber penetration and expansion. Similarly, tubers of *D. schimperiana* accessions grew into different shapes in Growth Pouches because of the hindrance by the Growth Pouches and the concrete floor of the net-house to vertical growth of tubers. But planting yam in 2 feet holes led to formation of large undeformed tubers with expanded lower portion. Therefore, cultivation promotes tuber vertical growth and expansion. The variation in production between net-house and field-grown plants could be attributed to net-house controlled conditions such as partial light provided by net-house, supplemental supply of water to the net-house plants through watering and the agro-ecological difference between Mormorio (Baringo County) and University of Eldoret (Uasin Gishu County). Generally, all the *D. schimperiana* accessions displayed improved production under cultivation than in the wild environment. However, KE, MB1 and CN accessions showed greater response to cultivation. Moreover, the relatively larger tubers formed by the tested accessions could be associated with domestication process which increased their ability to store starch in their tubers and hence the size of the tubers (McKey et al., 2010). Domestication of root and cereal crops has been associated with the increase of starch production. In the wild environments, yams grow vines in the shades of support trees but when grown in open fields under full sunlight, they undergo a major transformation stimulated by the ecological change (McKey et al., 2010). The ecological change due to changes in quality and quantity of light, temperature among others during the domestication, stimulates adaptation by domesticates. For example, specific genes are associated with the change from shade to light environment. The changes are linked to expression of genes associated with physiological processes of regulation of photosynthesis for light and plant growth (McKey et al., 2010). Adaptation of the cultivated yams led to the selection of genes that enable efficient photosynthesis with increasing light and heat intensity. Optimizing photosynthesis is an important way to enhance production of carbohydrates, which are stored as starch in the tuber (Díaz et al., 2007). Hence, in this study, the field cultivation enhanced production of *D. schimperiana*.

In conclusion, cultivation enhanced production of some *D. schimperiana* (KE, MB1 and CN) accessions. Hence, KE, MB1 and CN showed greater potential for domestication. *Dioscorea schimperiana* could be cultivated to improve food security. More research is needed to assess the production of *D. alata* in Baringo and Uasin Gishu Counties.

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References

Alozie, Y., Akpanabiatu, M. I. Eyong, E. U. Umoh, I. B., & Alozie, G. (2009). Amino acid composition of *Dioscorea dumetorum* varieties. *Pak. Journal Nutr*ition. 8: 103-105.

APG III (2009). Angiosperm Phylogeny Group. An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society*. 161:105-121.

Asfaw, A., Editor (2016). *Standard operating protocol for yam variety performance evaluation trial*. IITA, Ibadan, Nigeria. pp 27.

Bhandari, M. R., Kasai T., & Kawabata, J. (2003). Nutritional evaluation of wild yam (*Dioscorea spp*.) tubers of Nepal. *Food Chemistry.* 82 (4), 619-623.

Chikwendu, V. E., & Okezie, C. E. A. (1989). *Foraging and farming. The evolution of plant* *exploration, chapter factors responsible for the enoblement of African yams; inferences from experiments in yam domestication*. Union Hyman London.UK. pp 344-357.

Deb, A. C. (2002). *Fundamentals of biochemistry*. (Eds 8). New Central Book Agency, Kolkata, India.

Díaz, M., de Haro, V., Muñoz, R., & Quiles, M. J. (2007). Chlororespiration is involved in the adaptation of Brassica plants to heat and high light intensity. *Plant Cell Environ*. 30:1578-1585.

Dike, I. P., Obembe, O. O., & Adebiyi, E.F. (2012). Ethnobotanical survey for potential anti-malarial plants in South-Western Nigeria. *J. Ethnopharmacol*., 144: 618-626.

Dounias, E. (2001). The management of wild yam tubers by the Baka pygmies in southern Cameroon. *Afr Stud Monogr*. 26:135-56.

Dumont, R., & Vernier, P. (2000). Domestication of yams (*Dioscorea cayenesis-D. rotundata*) within Bariba Ethnic group in Benin outlook in agriculture. 29, 137-142.

Eka, O. U. (1998). *Roots and Tuber Crops in International quality of plant foods, Post-harvest Research Unit Publications*, Univ-Benin: pp 1-31.

Gucker, C. L. (2009). *Dioscorea spp*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/

Hahn, S. K. (1995). Yams: Dioscorea species (Dioscoreacea) in Kambaska, K., Sahoo, S., and in Ghana. *African Journal of Agricultural Resolution*, 3:115-125.

IITA (2006). Yam. *Research Review*. International Institute of Tropical Agriculture, Ibadan, Nigeria. pp.1-4.

Jaetzold, R., Schmidt, H., Horntz, B., & Shisanya, C. (2010). *Farm management handbook of Kenya. Vol. II natural conditions and management information. 2nd edition. Part B.* Central Kenya-Northern Rift Valley Province

Jayakody, L., Hoover, R., Liu, Q., & Donner, E. (2007). Studies on tuber starches. II. Molecular structure, composition and physicochemical properties of yam (*Dioscorea sp.*) starches. *Journal*, 2 (3): 30-39.

Leng, M. S., Djeukeu, A. W., Gouado, I., & Ndjouenkeu, R. (2016). Current knowledge on *Dioscorea schimperiana* traditional drying technology in Cameroon. *Int. J. Adv. Res*., IJOAR 4 (11) .org Online: ISSN 2320-9186.

Maundu, P. M., Ngugi, G. W., & Kabugi, C. H. (1999). *Traditional food plants of Kenya*. National Museums of Kenya, Nairobi. pp. 298.

McKey, D., Elias, M., Pujol, B., & Duputié, A. (2010). The evolutionary ecology of clonally propagated domesticated plants. *New Phytol*. 186:318-332.

Medoua, G. N., Mbome, I. L. Agbor-Egbe, T., & Mbofung, C. M. F. (2005). Study of the hard-to-cook property of stored yam tubers (*Dioscorea dumetorum*) and some determining biochemical factors. *Food Res. Int*., 38: 143-149.

Mignouna, H. D., & Dansi, A. (2003). Yam (*Dioscorea ssp*.) domestication by the Nago and Fon ethnic groups in Benin. *Genet Resour Crop Evol*. 2003;50:519-528. doi: 10.1023/A:1023990618128

Mwirigi, P. N., Kahangi, E. M., Nyande, A. B., & Namati, E. G. (2009). Morphological variability within Kenyan Yam (*Dioscorea spp*). *Journal of Applied Biosciences* 16:894-901.

Nwosu, J. N. (2013). Evaluation of the functional and sensory properties of biscuits produced from aerial yam (*Dioscorea bulbifera*). *International Science and Investigation Journal*. 2(5): 1-17.

O'Sullivan, J. N. (2010). *Yam nutrition: nutrient disorders and soil fertility management.* ACIAR Monograph No. 144. Australian Centre for International Agricultural Research: Canberra. pp.112.

Okwu, D. E., & Ndu, C. U. (2006). International Journal of Molecular Medicine and Advanced Sciences 2(2):199-203.

Owuamanam, C. I., Iwuoha, C. I., Onuegbu, N. C., Ogueke C. C., & Nwosu, J. N. (2013). Quality characteristics of processed flours from trifoliate yam (*Dioscorea dumetorum*) as influenced by steeping and boiling in varying concentration of trona solution over time. *Am. J. Food Technology*. 8: 162-172.

Tamiru, M., Heiko, C. B., & Brigitte, L. M. (2008). Diversity, distribution and management of Yam landraces (*Dioscorea* *spp*.) in Southern Ethiopia. *Genetic Resources and Crop Evolution.* 55:115-131.

Wendawek, A. M., Fay, M. F., Smith, R. J., Sebsebe, D., Nordal, I., & Wilkin, P. (2013). Genetic diversity and species delimitation in the cultivated and wild Guinea yams (*Dioscorea spp*.) from Southwest Ethiopia as determined by AFLP (amplified fragment length polymorphism) markers. *Genetic Resource and Crop Evolution.* 60: 1365-1375.

Zannou, A. (2006). *Socio-economic, agronomic and molecular analysis of yam and cowpea diversity in the Guinea-Sudan transition zone of Benin.* Unpublished Ph.D. Thesis, Wageningen University.

Zulu, D., Ellis, R. H., & Culham A. (2019). Towards the domestication of *Dioscorea hirtiflora* subsp. pedicellata Milne-Redh, a wild edible yam in Zambia. University of Reading.