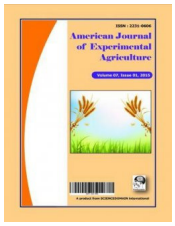

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Status and Production Practices of Vegetable African Nightshade (S*olanum nigrum* L.) in Selected Communities of Kenya

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: In order to improve production, utilization and conservation of African nightshades (ANS) in Kenya, this study set out to better understand the current status and agronomic practices employed by some of the Kenyan communities.
Study Design: The study entailed a survey of African nightshade farmers.

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Place and Duration of Study: The study was carried out in representative counties, Kisii, Kakamega and Nakuru, of Kenya between the months of October and November, 2015.
Methodology: A total of 630 ANS farmers (210 farmers per county) randomly sampled from purposively selected sub-counties in each of the three counties were used. The farmers interviewed consisted of men, women and youth. In addition, 6 focus group discussions consisting of 15 participants per group and 9 key informant interviews were conducted in each county to provide detailed information and opinion on the data collected during the survey. Data was collected on characteristics of Solanum farmers, agronomic practices in ANS production, amount of land allocated to ANS, income from ANS sales and challenges encountered in ANS production.
Results: Results indicated that 75-80% of the ANS growers were women and 63% of farmers in Kakamega had primary education while 56% in Kisii and 40% in Nakuru of the farmers had high school education. Production is in small holdings (<0.25 acres), 71%-80% of all farmers used hand hoes while planting methods differed among the communities with hill planting being dominant in Kakamega (70%) and broadcasting common in Nakuru (42%). Further >50% of the farmers mainly applied wood ash for pest and disease control while 73% used animal manure for plant nutrition. The farmers identified pests and diseases as the main challenge encountered during ANS production.
Conclusion: ANS production is mainly a women activity with formal education up to secondary school level. More land is being allocated for ANS production. However, the production is still on small scale using rudimentary tools and farmers employ traditional methods to control pests and diseases. Moreover, pests and diseases is the main limitation to increased production of ANS.

Keywords: African nightshades; production; underutilized; vegetables; Kenya.

1. INTRODUCTION

African nightshades (ANS) belong to the genus Solanum in the Solanaceae family. This family is made up of approximately 90 genera and between 2000 and 3000 species and is well distributed throughout the tropical and temperate regions of the world [1]. Some of the species like the bittersweet (*Solanum dulcamara* L.) are cultivated for corticosteroid, which is an important compound in the pharmaceutical industry [1]. Nine African nightshade species have been identified [2] and at least five of them have been identified to be the most common in Kenya [3] which include *Solanum nigrum* L., *Solanum villosum* Miller., *Solanum americanum* Miller., *Solanum scabrum* Miller and *Solanum physalifolium*. The species commonly known as black garden or common nightshade, *Solanum nigrum* is one of the largest and most variable group of the genus Solanum [4].

ANS are among the many traditional leafy vegetables that continue to be cultivated by many Kenyan communities [4]. The vegetable has been domesticated in Kenya for the last few centuries and is still regarded as a major vegetable by both producers and consumers in Kenya [5]. Like many of the traditional vegetables grown in Kenya, African nightshades have multiple uses such as food, nutrition, source of income, medicinal and spiritual. Therefore, production and conservation of a particular species will depend on its value among a given community. The belief that the bitter species are poisonous has led to a decline in the use and consumption of traditional vegetables [6] such as African nightshades. This has consequently led to a reduction in the production and conservation of some of Solanum species that were initially important for food and nutrition security of a majority of the rural communities in Kenya. The result is a continuation of the erosion of (agro) biodiversity and nutritional and dietary diversity of which, if not checked, will potentially lead to species extinction. To improve production, utilization and conservation of ANS in Kenya, it is imperative to better understand the current status of production and conservation efforts among communities.

2. MATERIALS AND METHODS

2.1 Study Sites

The study was carried out in representative counties, Kisii, Kakamega and Nakuru, of Kenya. Kisii and Kakemega counties lie in the south Western and Western parts of Kenya respectively and is home to the populous Abagusii and Abaluyhia communities. Nakuru County is located between Longitude 35° 28` and 35° 36` East and Latitude 0° 13` and 1° 10` South in the central Rift valley of Kenya is home

to the Kalenjin Community. The communities in the three Counties are predominantly small scale farmers. In Kisii County the average annual rainfall ranges from 1600 mm to 2000 mm. There are no pronounced wet and dry seasons in most of the area. Maximum rainfall occurs from March to May and only January and February are commonly considered 'dry'. Most of the Kisii area consists of well drained, deep to very deep, reddish brown, friable clayey soils with a high biological activity [7]. The annual average temperature is 25°C with minimum of 15°C. In Kakamega County the average annual rainfall ranges from 1600 mm to 2200 mm with distinct bimodal rainfall pattern with short rains received from August to November while the long rains are received from March to July. Soils are described as eutricnitisol, ferralo-orthicAcrisol and nito-rhodicferralsol [8] with average temperature of 21°C. Nakuru County has a bimodal rainfall pattern with short rains between October and December while the long rains are between March and May. The rainfall amounts are between 950 and 1500 mm per annum. Temperature ranges from 12°C to 29°C with an annual average of 21°C. The soil pattern in the county presents a complex distribution with three main classifications which are latosolic, planosolic and alluvial and lacustrine soils [8].

The study entailed a survey of 630 ANS farmers (210 farmers in each of the three counties) randomly sampled from producer groups in purposively selected sub-counties in each of the three counties. These sub-counties were Kisii Central and Gucha in Kisii County; Shinyalu and Navakholo in Kakamenga County, and Molo and Nakuru West in Nakuru County. The sampling approach followed four steps. In the first step, three counties were purposively sampled to cover the most important ANS producing and consumption counties in the country. In the second step, two sub-counties were purposively sampled from each of the three counties. The sub-counties were selected on account of being known at county level as ANS producing areas with producer groups in existence. In the third step, existing lists of ANS producer groups were used to systematically sample five (5) groups in each of the six sub-counties selected in step two. In step four, 21 farmers were systematically sampled from membership lists of the thirty producer groups sampled at step three. Thus 210 farmers from 10 producer groups in two sub-counties in each of the three counties sampled. The 210 farmers interviewed in each county consisted of men, women and youth and the aim of the interviews was to determine the gender involved in ANS production, amount of land allocated to ANS, agronomic practices, harvesting and postharvest handling and challenges encountered in ANS production, income from ANS sales and conservation status of the ANS species. In addition, 6 focus group discussions (FGD) consisting of 15 participants per group and 9 key informant interviews were conducted in each county to provide detailed information and opinion on the data collected during the survey.

Data were statistically analyzed for means and frequencies using SPSS version 15.0 [9].

3. RESULTS AND DISCUSSION

3.1 Characteristics of African Nightshade (ANS) Growers

Majority (75%-80%) of the ANS growers in all counties were women (Table 1) and this is attributable to the fact that ANS is largely a crop grown for domestic consumption as a vegetable. Traditionally, such crops are largely left to women to produce and market the surplus as appropriate. However, the presence of male growers (Table 1) participating in ANS production underscore a major emerging trend where men had identified the crop as a high value for income generation and were thus continually getting involved in its production across the three counties.

Table 1. The distribution by gender (%) of ANS growers in Nakuru, Kisii and Kakamega Counties

Gender	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
Male	25	20	22
Female	75	80	78

N=210

These results agree with those reported by Maundu, et al. [3] that women are the key persons in the production, use, and marketing of African leafy vegetables (ALVs). This would therefore mean that an improvement in the utilization and conservation for food security must include women in terms of capacity building. With *Solanum nigrum* increasingly featuring in both formal and informal markets, it is an important income source for the women and hence can be used to improve household

food and nutrition security as well as the living standards [10,11].

In terms of level of education, the study result showed that majority of farmers had either primary or high school education (Fig. 1). Nonetheless, there were small proportions of growers in all counties with no education or with college education including post-graduate training (Fig. 1).

This agrees with Irungu et al. [12] who reported that African leafy vegetable (ALV) farmers are more educated than the other categories of farmers, implying that the production of ALVs is a field for those endowed with human capital. This might be because one has to acquire knowledge on several aspects of ALVs such as their nutritive value and marketing strategies before embarking on their production. In addition, this can be explained by the high rates of unemployment in rural Kenya especially among high school leavers who resort to farming to earn their livelihoods. Given that this vegetable grows fast, require small portions of land, minimum or no application of external input and minimum expertise on production, majority of the people in the rural areas see it as a quick source of income.

The main occupation of the ANS growers were farmers and thus ANS growing was part of their daily work, however, there were business people who also grew ANS (Table 2). This was essentially because they had identified opportunities for selling ANS in the markets where they operated and therefore considered its production as another business enterprise.

Table 2. The main occupation of the respondents (%) in Nakuru, Kisii and Kakamega Counties

Occupation of respondent	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
Farmer	90	92	95
Teacher	2	2	0
Business	6	4	4
Civil servant	2	2	1

N = 210

These results agree with those of other studies in which African leafy vegetables (ALVs) are grown by majority of small scale farmers mainly for their home use as they are used as accompaniments to the main meal [1]. However, more recently they have been reported to be a source of income to these farmers [12,10,13]. Otieno, et al. [14] reported an increasing presence of Solanum genotypes among other ALVs in most supermarkets in Kenya. This is an indication that ALVs such as ANS are increasingly becoming important commercially in Kenya.

In terms of income from ANS sales, it was found that distribution was highly skewed (Table 3). The income was most skewed in Nakuru County where the range was very high and the standard deviation (Ksh.11,442) nearly as high as the mean (Ksh.11,762). Income was least skewed in Kakamega County where the range was high but the standard deviation (Ksh.3,534) was low (Table 3). Given that most of the income was from agriculture in all three counties it appears that intensity and commercialization varied from farmer to farmer within counties hence explaining the wide income ranges in all counties.

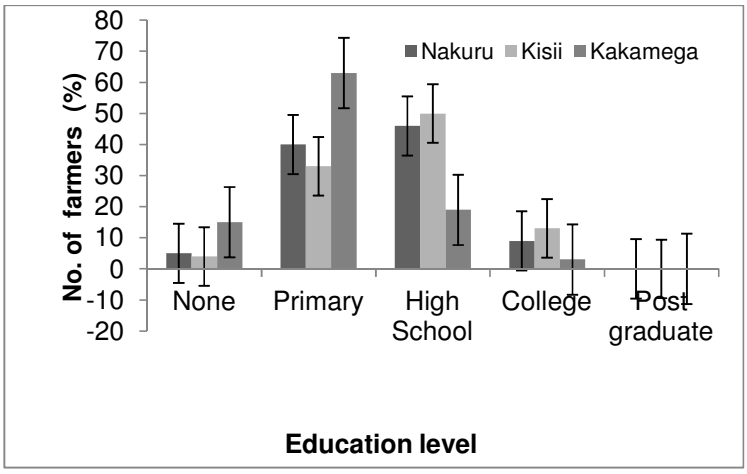

Fig. 1. The education level of ANS growers (%) in Nakuru, Kisii and Kakamega Counties
(Mean ± S.E.M = Mean values ± Standard error of means, N=210)

Table 3. The average amount of money (KES) obtained by farmers from ANS sales per month in Nakuru, Kisii, and Kakamega Counties

Amount of money from ANS sales	Average amount of Money from ANS sales/Month (KSH)		
	Nakuru	Kisii	Kakamega
Mean	11,762.3 (11,442)*	9,589.5 (7,968)	4,701.0 (3,534)
Range	89,500	49,970	25,500
Minimum	500	30	500
Maximum	90,000	50,000	26,000

N = 210 N

**Figures in brackets are standard deviations, KES – Kenya Shillings, 1USD = 100KES*

ALVs have gained commercial importance over the past 15 years as a result of the enormous growth in marketing [12]. There is a growing appreciation of ANS leafy vegetables by urban consumers, partly because of increasing awareness of the nutritive value of these species [10,15]. This contributes to the growing potential for commercialization of this vegetable as a source of income explains the high amount of income obtained from ANS in Nakuru County that is being mainly practiced in urban and peri-urban areas of the county as compared to the other two Counties.

3.2 Size of Land and Agronomic Practices for African Nightshade (ANS) Production

The land size set aside for ANS production by majority (80%) of the growers was about 0.25 of an acre or less (Table 4). This implies that ANS production in all the three counties was largely small-scale. This finding is reinforced by the fact that hardly one percent dedicated more than two acres to producing ANS in all three counties. Nonetheless, the fact that some farmers used more than half an acre for a single vegetable especially in the densely populated counties of Kisii and Kakamega underscores the economic importance of ANS in these regions. The variety of acreages under the vegetable ranging from under quarter an acre to just over two acres also implies that the motivation for planting ANS varied markedly between and within the three counties, essentially from production for domestic consumption for those growing on limited land to production for the market for those dedicating more than half acre to the crop.

In terms of changes to the size of land under ANS over the previous two years, the study found that farmers were largely bringing more land under the vegetable and more than 50% of the respondents in all the counties had increased the land under ANS in the last two years (Fig. 2). On the other hand, a larger proportion of farmers in Nakuru had increased their land under ANS than in Kisii and Kakamega counties.

Table 4. The average size of land (Acres) under ANS in Nakuru, Kisii and Kakamega Counties

Area in acres	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
≤0.25	85	88	83
0.5 – 1.0	9	5	3
1.1-1.5	3	4	11
1.6 – 2.0	1	2	2
>2	2	1	1

N = 210

Generally, change in acreage under ANS was more conservative in Kisii and Kakamega counties compared to Nakuru. This was attributable to the relatively bigger parcels of land per farmer in Nakuru County providing a larger room for manoeuver to farmers compared to Kisii and Kakamega with smaller land sizes due to high population density per unit area [16].

3.3 Land Preparation Technologies

The majority (at least 99%) of farmers across all three counties used hand hoes and only a minority (1%) used oxen-drawn ploughs or other methods of land preparation (Table 5). Given the small sizes of land used in production of ANS as mentioned in Table 4, use of oxen or any other type of mechanical land preparation will not be easy and this leaves the farmers with no other option other than the use of hand hoes. In addition, the use of oxen depends on whether a farmer owns the oxen. If not owned, the cost of hiring oxen was high and therefore farmers preferred to use family labour, mainly depending on the use of hand hoes, which they consider free.

The results agree with those reported by Bishop-Sambrook [17] who estimated that 65% of land in Sub-Saharan Africa (SSA) is prepared by hand

power while draught animal traction plays significant roles within certain farming systems, such as the maize mixed cereal systems of eastern and southern Africa preparing 25% of land while tractors only make a minor contribution to land preparation estimated at 10% of harvested area.

Table 5. Land preparation technologies used in the production of ANS in Nakuru, Kisii and Kakamega Counties

Land preparation technology	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
Hand Hoes	100	100	99
Oxen Plough/ tractor	0	0	1

N = 210

3.4 Planting Methods

The results indicated that planting method varied depending on the county (Fig. 3). Majority of the farmers (70%) in Kakamega County used the hill planting method while only 38% in Kisii and 24% in Nakuru used this method of planting. Broadcasting method was popular in 42% of ANS growers in Nakuru with 23% in Kisii and 3% in Kakamega using this type of planting. The farmers who used drilling method was highest in Kisii (34%) followed by Nakuru (26%) and Kakamega (23%). Transplanting method was not preferred by farmers in all the counties as indicated by less than 10% of the farmers that used this method of planting (Fig. 3).

Edmonds and Chweya, [1] reported that majority of the farmers in Kenya use broadcast or directly drilled ANS seed into well prepared seed beds. Although few studies have been conducted on the optimal depth of planting, the best germination has been reported to occur from seeds planted 0.25 cm deep. Seeds sown at deeper levels did not germinate so well, though seedlings did emerge from seeds planted up to 5 cm deep [18]. In addition, hill and/or drill planting has been shown to make weeding, fertilizer application, irrigation and harvesting more effective rather than by broadcasting [19]. With the increased promotion of production and utilization of ALVs for food and nutrition security [15], it is possible that farmers have been trained on better production packages for effective weed control, fertilizer application and harvesting of the ANS production. This could have led to more farmers preferring to use hill planting as opposed to broadcasting (Table 9) which is a traditional method of planting of most of the ALVs.

3.5 Rain Fed versus Irrigated African Nightshade (ANS) Production

ANS production was mainly rainfed (Table 6). However, in Kisii County there were almost as many farmers that practiced irrigated production (44%) as those that practice rainfed production (56%) of ANS (Table 6). Reports indicate that Kisii is one of the main sources of ANS sold in major towns in Kenya and is among the most preferred ALVs in the Kisii community [20]; this means that there is always demand for the vegetable hence farmers strive to produce it year round. This could therefore explain the high percentage (44%) of farmers producing ANS under irrigation in Kisii County.

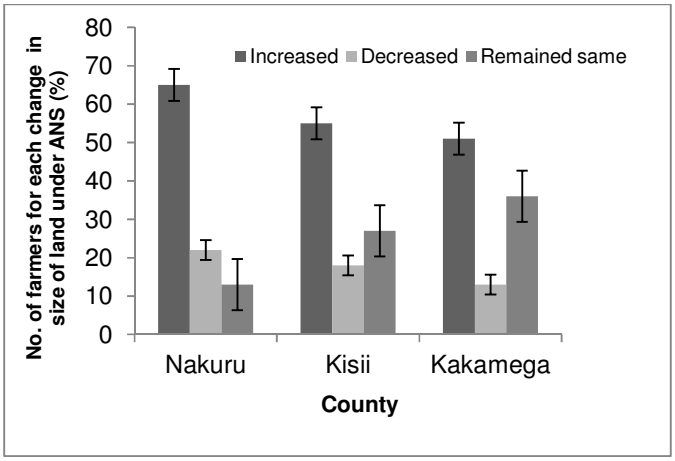

Fig. 2. Changes in size of land under ANS over the last two years in Nakuru, Kisii and Kakamega counties

(Mean ± S.E.M = Mean values ± Standard error of means, N=210)

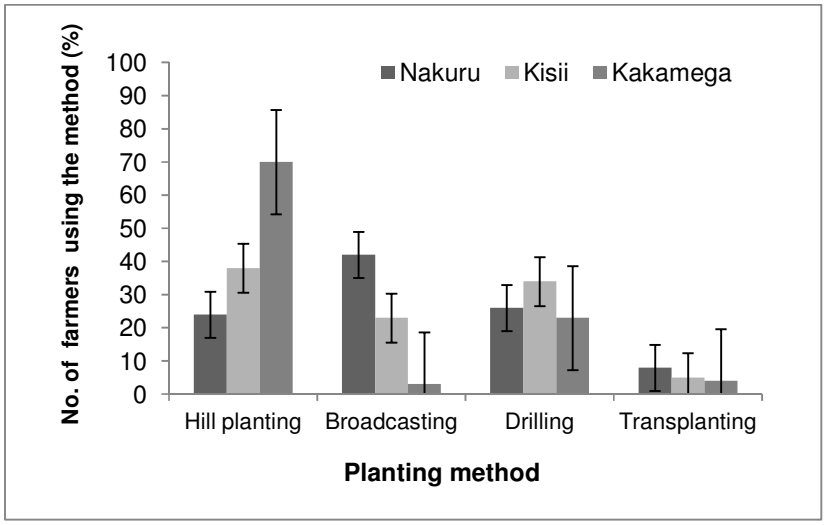

Fig. 3. Planting method used by ANS farmers (%) in Nakuru, Kisii and Kakamega Counties
(Mean ± S.E.M = Mean values ± Standard error of means, N=210)

3.6 Cropping Systems Used for ANS Production

The use of different cropping systems varied across the three counties under study (Fig. 4). The use of mono-cropping, in the production of ANS, was highest in Kakamega with 75% of the farmers practicing it followed by Kisii (53%) and Nakuru (40%). The rate of farmers intercropping ANS with other crops was highest in Nakuru at 48% followed by Kisii at 34% and Kakamega at 16%.

Table 6. Proportion of farmers (%) using either rain-fed or irrigated production of ANS in Nakuru, Kisii and Kakamega Counties

Production system	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
Irrigated	28	44	21
Rain-fed	72	56	79

N = 210

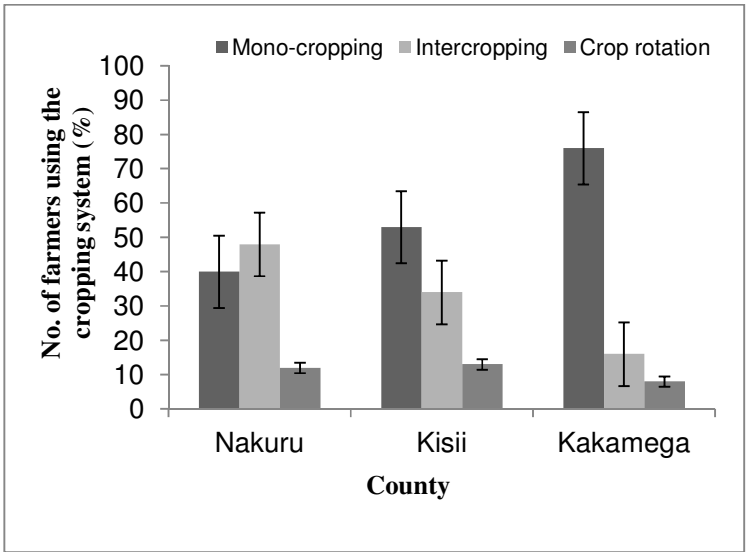

Fig. 4. Number of farmers (%) using different cropping system in ANS production
(Mean ± S.E.M = Mean values ± Standard error of means, N=210)

The least practiced cropping system was crop rotation with 13%, 12% and 8% of the farmers practicing it in Kisii, Nakuru and Kakamega counties respectively. Most of the communities in Kenya produce African indigenous vegetables (AIVs) as mono crops in small kitchen garden and not in the main production fields [15]. They are treated as minor crops and therefore not much significance is given in their production hence intercropping and crop rotation systems have not been explored by many farmers.

3.7 Control of Weeds, Pests and Diseases

Different methods were used in the crop protection against weeds, pests and diseases (Figs. 5 and 6). In terms of weed control, hoe weeding was the main method used in all the counties followed by hand pulling (Fig. 5). Use of chemicals for the control of weeds was very low (1% - 3%). For the control of pest and disease, the farmers mainly applied wood ash in all the counties with 65% of the farmers in Nakuru, 63% in Kakamega and 53% in Kisii using this method of control (Fig. 6). In addition, 15% uprooted infected plants and 20% of the farmers used chemicals in Nakuru, 32% uprooted infected plants and 14% used chemicals in Kisii while 37% uprooted the infected crops and no chemicals were used in Kakamega County (Fig. 6). Modern crop protection methods such as use of chemicals have not been employed by majority of the farmers. This is mainly due to the high cost of the chemicals and lack of knowledge on their use in the production of ANS as is the case for most of the traditional vegetables.

3.8 Plant Nutrition

For plant nutrition, 73% of the farmers in all the counties indicated the use of animal manure (Table 7) with Kakamega County leading at 82%, followed by Nakuru at 77% and Kisii at 58%. Apart from the use of animal manure, some of the farmers also combined both animal and chemical fertilizers (17%) which was much higher than the use of either compost manure (6%) or chemical fertilizers (3%) in all the counties (Table 7).

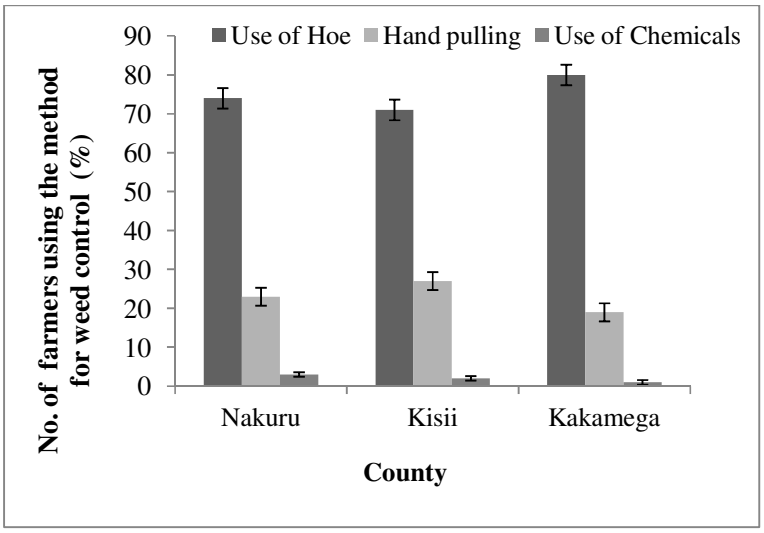

Fig. 5. Number of farmers (%) using different methods in the control of weeds during ANS production (Mean ± S.E.M = Mean values ± Standard error of means, N=210)

Table 7. Types of fertilizers used in the production of ANS by farmers (%) in Kakamega, Kisii and Nakuru Counties

Type of fertilizer used	No. of farmers (%)			
	Nakuru	Kisii	Kakamega	All counties
Animal manure (Cow, goat, chicken)	77	58	82	73
Compost manure	8	10	4	7
Chemical fertilizers	4	5	2	3
Animal manure and chemical fertilizer	11	27	12	17

N = 210

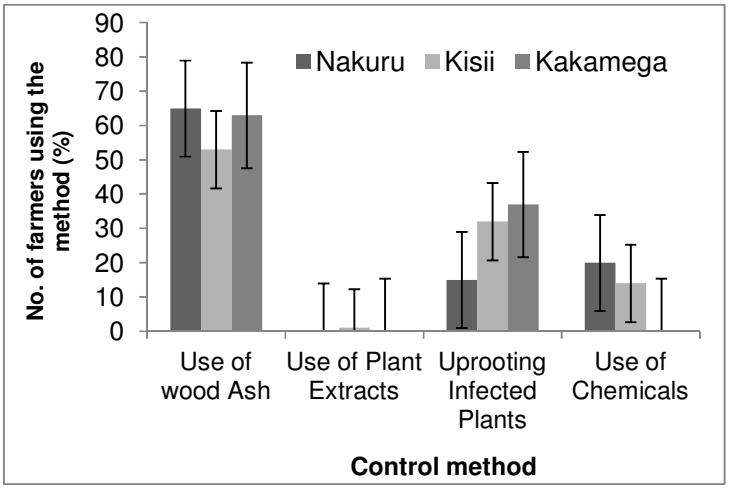

Fig. 6. Number of farmers (%) using different methods in the control of pests and diseases during ANS production

(Mean ± S.E.M = Mean values ± Standard error of means, N=210)

Abukutsa-Onyango [15] reported that majority of the ALVs in Western and Nyanza use mainly animal manure in their production, which was also the case in this study. Small scale farmers who are the main producers of these vegetables have limited access to inputs such as chemical fertilizers and quality seed. This makes them to use the locally available materials as sources of nutrition for the crops.

3.9 African Nightshades (ANS) Yields

The results indicated that the total yield for ANS per season was < 50 kg for 63% of the farmers in Kisii, 59% in Nakuru and 54% in Kakamega counties (Table 8). However, 16% of the farmers harvested between 51-100 kg of ANS per season in all counties. Worth noting is the 9% of farmers in the counties that harvested more than 250 kg of ANS per season (Table 8). Harvesting of the vegetables was done by either harvesting leaves only, cutting of tender branches and leaves or by uprooting the whole plant. The frequency of harvesting mainly being on a weekly basis and this continued for a period of between two and six months.

A total of five to eight harvests, at weekly intervals over a 6-8 week growing period, are usually possible [21]. It is possible that the harvesting style and frequency could have determined the length of the harvesting period [1] hence the total yield obtained. In addition, the genotype grown, prevailing climatic conditions and soil fertility in each of the counties could have been major factors determining the length of the harvesting period [22]. ANS genotypes are known to differ in the number of days to flowering depending on the prevailing conditions during growth [23] and high amounts of rainfall combined with high soil fertility and frequent harvesting of the leaves stimulates continuous production of new leaves and delays flowering. The growth and yield of most leafy vegetables is strongly influenced by soil fertility when this has been enhanced by an inorganic fertilizer, but not by manure [24]. It is possible that with majority of the farmers using farm yard manure as opposed to inorganic fertilizers, the vegetables do not receive sufficient amounts of nutrients to boost their production.

Table 8. Total ANS yields (Kg) per season obtained by the farmers (%) in each county

Yield (Kg)	No. of farmers (%)			
	Nakuru	Kisii	Kakamega	All counties
≤50	59	63	54	59
51 – 100	17	12	18	16
101 – 150	3	2	4	3
151 – 200	8	10	12	10
201 – 250	4	3	1	3
>250	7	9	11	9

N= 210

3.10 Challenges Encountered During ANS Production

The main challenge encountered during the production of ANS was pests and diseases as identified by 74% of the farmers in Nakuru, 70%

in Kisii and 60% in Kakamega (Table 9). Inadequate seed supply and inadequate rainfall were identified as other challenges in ANS production by more than 10% of the farmers in all the counties. The respondents did not have current knowledge on pests and disease control in ANS to produce maximum yields. This implies that there is urgent need for dissemination of best practices to enhance pest and disease control in ANS to maximize on yields. This approach has high potential for success because the ANS farmers are already hard working and motivated; attributes necessary for effectiveness in extension work [25].

Table 9. Challenges encountered by farmers (%) in the production of ANS

Challenges encountered in production	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
Inadequate knowledge on production	4	3	3
Pests and diseases	74	70	60
Inadequate seed supply	12	14	13
Droughts/ inadequate rainfall	8	12	23
Inadequate capital	1	0.5	1
Lack of interest by young farmers	1	1	0

N = 210

3.11 Source of Information on ANS Production

The main source of information on ANS production was extension service providers for 55% of the farmers in Nakuru, 66% in Kisii and only 31% in Kakamega (Table 10). Other farmers were a source of information for 33% of the farmers in Nakuru, 26% in Kisii and 44% in Kakamega. Media as a source of information was reported by only 4% of the farmers in Nakuru and 3% for both Kisii and Kakamega counties. The increased awareness of the health protecting properties of non-nutrient bio-active compounds found in fruits and vegetables, has directed immense attention to African leafy vegetables such as ANS as vital components of daily diets [26]. This information is mainly with the extension workers or other farmers who have attended training offered by the extension workers explaining the high percentage of farmers who depend on extension providers as their main source of information on the production of ANS.

Table 10. Sources of information for ANS production by farmers (%) in Kakamega, Kisii and Nakuru Counties

Source of information	No. of farmers (%)		
	Nakuru	Kisii	Kakamega
Extension service providers (mainly private)	55	66	31
Other farmers	33	26	44
Media	4	3	3
Others	8	5	22

N = 210

4. CONCLUSION

The study established that majority of the ANS producers were women which was in line with the customs of people in the three communities under study where women were in-charge of finding vegetables for their families and generally preparing food. Nonetheless, men in all three counties grew ANS mainly for commercial purposes. Besides, ANS was commercialized in all three counties, but it was doing better as a cash crop in Nakuru County where relatively more land was dedicated to the crop. In Kisii and Kakamega, ANS was very much a small-scale crop produced mainly on 0.25 acres or less per producer. Further, for plant nutrition, ANS farmers mainly used animal manure and control of pests and diseases was by application of wood ash or hand pulling of affected plants. Majority of the ANS farmers produced under rain-fed conditions and irrigation was scanty in all three counties. This disadvantaged the ANS farmers during dry seasons when vegetable markets are usually good in terms of scarcity and higher prices. The ANS farmers identified pests and diseases as the main challenges that they faced in production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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