Growth and yield response to fertilizer application and nutritive quality of Huckleberry (*Solanum scabrum* Mill.) varieties cultivated in the Mount Cameroon Region.

Abstract

This study evaluated the effects of fertilizer on growth, yield and the nutritive value of three varieties of huckleberry ("White stem", "Bamenda" and "Foumbot"). The treatments were NPK (20:10:10) at levels 0, 100, 150, 200Kg/ha and 10 Mg/ha poultry manure, and the experiment was a randomized complete block design with three replicates. Results indicated that plants supplied with 200 Kg NPK/ha fertilizer treatment had the highest plant height (66 cm) and leaf number (242) in "White stem" and "Bamenda" varieties respectively and these were significantly different from the control (P = 0.05). Leaf area was highest in "Foumbot" variety (343.1 cm^2) while longest tap root length and number of primary lateral roots were noted particularly in "White stem" control plants and this was significantly different (P = 0.05) from plants supplied with fertilizers. Plants supplied with 10 Mg/ha poultry manure recorded highest total yield for "White stem" (44.83 Mg/ha) while plants supplied 200 Kg NPK/ha had maximum yield for the "Bamenda" and "Foumbot" varieties (36.96 and 31.84 Mg/ha respectively). The "White stem" variety had highest crude protein (303.8 mg/100g) and ß-carotene content (1.9 mg/100g); "Bamenda" variety had highest total lipid (8.15%), and crude fibre (14.15%) contents, while total ash was highest in "Foumbot" (16.54%). Appropriate fertilizer levels would considerably improve huckleberry yield as well as improve income of vegetable farmers.

Keywords: Fertilizer, growth, leafy vegetable, nutritive value, *Solanum scabrum;* yield.

Introduction

Many green leafy vegetables are grown across Africa and among these are traditional leafy vegetables (TLVs) which according Gockowsky *et al*. [1] are considered as vegetables originally domesticated or cultivated and utilized in Africa over many generations. Green leafy vegetables in developing countries now occupy an important place in diets owing to increase awareness of their nutritional and medicinal uses; in addition to that they form a cheap source of food [2,3].

Huckleberry (*Solanum scabrum* Mill) is probably one of the most important TLVs consumed by most rural communities across Africa [4], especially in the humid savanna and forest zones of West and Central Africa. *Solanum scabrum* belongs to the section *Solanum,* centering on species commonly referred to as black garden or common nightshades (*Solanum nigrum*-related species) [5]. According to Mwai *et* al. [4] *S. nigrum*-related species are distributed throughout the world, with centres of diversity occurring in South America, Australia and Africa. Berinyuy *et al*. [6] however précised that although *S. nigrum*-related species do occur in cooler parts of Africa, *S. nigrum* is not cultivated anywhere as a vegetable in Africa unlike *Solanum scabrum*, which is the most widely cultivated and have their greatest diversity in Africa. Morphologically, *S. scabrum* can be identified with relative ease by its strong stem with more-or-less toothed wings. The flowers are either white or light purple and have brown or dark-yellow anthers. Its berries are sub-spherical, dark purple in colour and 15 -17 mm in diameter; and do not drop at maturity. This fruit retaining character together with the large and firm berries is highly distinctive for *S. scabrum* [6].

The vegetable, *S. scabrum*, is very popular in the daily diets of communities in the western highlands of the West Region, the South West and the North West Regions of Cameroon. A number of local variants have been selected as reported by Edmonds and Chweya [5] and

according to Shippers [7], there are both small- and large-leaved cultivars with different leaf shapes and colour, which might be green or dark-purple. The different communities in Cameroon have their own preference and cultural attachment to a particular variety of *S. scabrum* [8]. In some areas, character such as bitterness is appreciated more than in other areas [6]. The small purple-leaf type called "Bamenda", the large-leaf type called "Foumbot" and the intermediate-leaf type "White stem", found largely in the Buea area are the three varieties of *S. scabrum* commonly grown in the western highland zones and Southwest region of Cameroon [9].

Solanum scabrum play an important role in income generation and subsistence for poor resource farmers, particularly women with little capital, and limited access to land [10,11,12]. The demand of *S. scabrum* in Cameroon has increased progressively over the last two decades partly owing to urbanization. As a result of varietal preferences for this vegetable, rural migrants moving into cities continue to contribute to the promotion of *S. scabrum* consumption and its commercialization [1]. Another aspect influencing *Solanum scabrum* consumption as a crucial food security resource is its reported nutritional value. *S. scabrum* contains sufficient amount of protein, carotene, iron, vitamin (A and C) and mineral salts [3,13,14]. More so, this leafy vegetable has the ability to fit into the year-round production system and therefore it is used by many poor households as a cheap dietary alternative to fish and other protein sources [8].

Although *S. scabrum* is a very important vegetable in households in Cameroon, there are some constraints limiting its production thereby making its supply unable to meet up with the increasing demands from new urban markets within Cameroon and neighbouring countries such as Equatorial Guinea, Nigeria and Gabon [8]. Policy makers in Cameroon continue to treat this vegetable as a minor crop and give it low research priority in agronomic research.

There is the lack of appropriate agronomic practices in *S. scabrum* cultivation and this been associated to the crops' poor yields [4]. Furthermore, there have been relatively limited studies on yield response to fertilization of the three varieties of *S. scabrum* identified in Cameroon.

According to Amanullah *et al*. [15] farmers have often tended to the high use of fertilizers particularly poultry manure in tropical farming systems in an attempt to enhance soil nutrients and increase crop yields. Survey studies of some traditional leafy vegetables including *S. scabrum* varieties to fertilization showed that most farmers apply fertilizers at variable levels [16,17]. Specific baseline information is needed in order to recommend the appropriate level of fertilization for optimum growth and productivity of these vegetable varieties in the Mount Cameroon Region. This study was set up to evaluate the effects of fertilizer (NPK (20:10:10) at three dose levels and poultry manure) application on growth and yield, and nutritive value of three varieties of *S. scabrum* grown in the Mount Cameroon region.

Materials and Methods

Study Site

The Mount Cameroon Region is located in the South West Region of Cameroon and covers an area of main mass of about 50 km long and 35 km wide [18]. This study was carried out between the months of February and October 2016 within the Mount Cameroon Region precisely in the Faculty of Science Research Farm, University of Buea, Cameroon. Buea is located on the eastern slope of Mount Cameroon [18]. The area has a predominantly humid tropical climate, showing a definite rainy and dry season [19]. The mean rainfall and temperature of Buea is 2800 mm and 23 ˚C per annum respectively [18]. The soils are

volcanic in origin and have been considered relatively fertile. In spite of this, intensive and continuous cultivation of crops on these soils have left them nutrient deficient [18].

Seedling production, land preparation and transplanting.

The three varieties of *S. scabrum* ("White stem", "Bamenda" and "Foumbot") seeds used for this study were obtained from farmers' fields in Buea, Cameroon. Seedlings were raised from seeds using wooden boxes (dimension 1 x 0.5m and 12 cm depth), and they were filled with a mixture of garden soil and sand in the ratio of 3:1 (v/v) and kept in the nursery. The trays were watered. Seeds of the three *S. scabrum* varieties were each uniformly mixed in handful volumes of sand and broadcasted on separate trays. Trays were inspected daily and watered (when need be) as at when due. Weeds were controlled on seedlings by hand weeding. A land area of 27 x 35 m was cleared and raked. Within this area a 20 x 31m portion was divided into three blocks of 8 x 16.5m. Each block was separated from the other by three-meter spacing. Experimental units within each block consisted of 15 raise beds of 2.5 x 2m separated by 1m paths. Raise beds were made manually with a hoe to a height of 15 cm. Seedlings of the three varieties of *S. scabrum* ("White stem", "Bamenda" and "Foumbot") were transplanted at four weeks old and having an average height of 10 cm with about 4-6 true leaves. Transplanting was done in the evening hours of the day following irrigation of the ridges. The plant spacing distance was 25 x 25 cm was adopted [20], giving a plant density of 16 plants /m² or 160000 plants/ ha.

Experimental design and treatment

The experimental design used for this study was a randomized complete block design consisting of five treatment for each *S. scabrum* variety: NPK 20: 10: 10 at; 100Kg/ha^{-1} 150Kg/ha^{-1} , 200Kg/ha^{-1} ; 10 t/ha^{-1} poultry manure, and a control with no application of inorganic fertilizer or poultry manure, with each treatment replicated three times. Prior to

transplanting seedlings, organic manure treatment ridges were incorporated two week earlier with poultry manure. Side-dressing application (5 cm from seedling) of inorganic fertilizer was done in two splits and the first split application was done three days after transplanting and the second, two weeks after transplanting (2WAT). Weed control was carried out manually using hand, cutlass and hoe.

Data collection

Growth and Yield Measurements

Growth data was collected at six weeks after transplanting. Fifteen randomly assigned plants were tagged per treatment for growth measurements. A total of 450 plants were measured; 30 plants/ treatment per variety. Growth parameters measured included the following:

Plant height was measured to the nearest 0.1cm using a meter rule. The ruler was placed at ground level beside the plant stem to the shoot tip. The number of leaves per plant was counted. Leaf area was calculated simply by multiplying leaf length (from point of petiole attachment to stem to apex of leaf) by the leaf width (broadest portion across the entire leaf width). Present formulae LAI, LA etc. A measuring tape was used to measure leaf length and leaf width. Leaf area index per plant was derived by calculating the average leaf area and dividing the value obtained by the feeding area of the plant. Root morphology of the three varieties was studied by excavating the plants' roots with a shovel at 30cm from four sides around the stem at depths of approximately 40 cm. Three plants per treatment were assessed. After excavation, the roots of individual plants were washed with water to remove soil particles and tissue paper was used to remove water from the root surface. The length of the tap root was measured and the number of primary lateral roots was counted.

Harvesting was carried out within a one square meter quadrat per treatment plot at six and eight weeks after transplanting. Principally, harvested plants were cut with a sharp knife at 5

cm above soil level. Fresh weight was obtained and recorded in Kg/ha. With the second harvest, plants were cut 6 cm from the soil surface.

Nutrient analysis

Laboratory analysis were done at the "Centre de Reserche en Alimentation et Nutrition" (CRAN), Yaoundé-Cameroon and evaluated for crude protein, crude fibre, total carbohydrates, β-carotene (pro-vitamin A), lipid content, total ash (mineral content) and the total energy content of the different *S. scabrum* varieties. Oven dried leaves and edible stems of control treatment plants were used for these analyses due to the high cost in the analyses. Plant samples were ground, sieved with a 1mm sieve and the fine powder collected was put coded transparent polythene bag.

Total Ash content was obtained using method described by Bergeret [21]. Porcelain capsules were washed with distilled water, rinsed with 10% nitric acid and oven dried (105˚C for 1 hour). Once cooled the porcelain capsules were weighed and weight obtained recorded as P_1. Three grams (3 g) of plant sample (P) from each variety was weighed in porcelain capsule and put in a furnace at 550˚C for 6 hours after which the capsules were transferred with a furnace pincer to cool in a desiccator. 30 minutes after cooling, the porcelain capsule and its content were weighed (P_2). The percentage ash content was calculated by the formula:

$$\text{Total ash (g/100g of dry matter)} = \frac{(P_2 - P_1) \times 100}{P_1} \quad \text{.....equation 1.}$$

Total Lipid content was measured using Soxlet reflux heat extraction method according to Bergeret [21]. Oven dried round bottom flask was weighed (P_1). Two grams (2 g) of dry sample (P_2) was wrapped in a filter paper and placed in a cartridge cellulose paper. The assembled cartridge was introduced in a Pyrex Soxlet extractor apparatus (model: 3840-S, Corning, New York) mounted on a round bottom flask. The solvent (hexane 40-60˚C) was

poured into the extractor until Sipho nation commenced. A supplementary quantity of solvent was added until the siphon tube level is attained. The round bottom flask is heated for 6 hours. After heating is completed, the cellulose cartridge was removed and the solvent residue was obtained by heating in a rotatory evaporator. The flask containing the lipid is oven dried at 105˚C for 24 hours, cooled in a desiccator and weighed (P_3). Plant total lipid content was calculated as:

$$\text{Lipid content (g/100g of dry matter)} = \frac{(P_3 - P_1)\,(100)}{P_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{equation 2.}$$

Crude fibre content was determined using method described by A.O.A.C. [22]. 10ml of sulfuric acid (0.26N H_2SO_4) was added into a test tube containing about 0.4g of delipidated sample material (P_1), obtained from lipid extraction. The test tube was heated in a water bath at 100˚C for 30 minutes and allowed to cool. After cooling the content was poured to filter in a filtering glass and rinsed three times with distil water. The filtered sample was transferred into test tube and boiled in 10ml of potassium hydroxide (0.23N KOH) for 30 minutes. Test tube content was removed, allowed to cool, filtered in a filtering glass after which was rinsed three times with distilled water and acetone respectively. The filter glass was then oven dry at 105˚C for 8 hours, removed and placed in a desiccator to cool. Cooled filter glass and content was weighed (P_2). Weighed filtered glass and content was transferred into a furnace at 550˚C for 4 hours after which when cooled was weighed (P_3). Crude fibre content of the sample was estimated as:

$$\text{Crude fibre (g/ 100g of dry matter)} = \frac{(P_2 - P_3) \times 100}{P_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{equation 3.}$$

Total crude protein was determined using the Kjeldahl method according to A.O.A.C. [22]. The procedure involves three phases: mineralization, distillation and titration. *Mineralization:* Into a long test tube, properly washed with distilled water and dried at 105˚C in the oven for

1 hour, about 1g of dried plant sample (P) and 10 ml of concentrated sulphuric acid was put and heated in a mineralization chamber for 2 hours. The temperature of the heater was progressively increased until the coloured mixture in the test tube became transparent. The mineralized solvent obtained was allowed to cool for 24 hours.

Distillation: A 250 ml conical flask containing 20 ml of distilled water, 30 ml of boric acid and four drops of Tashiro's indicator (mixed 0.03% Methyl Red and 0.1 % Methylene Blue) was used to distil the acidic solution containing the digested samples. This operation was carried out in a Kjeltec System Distilling Unit ™ (model: 1002, FOSS Tecator AB, Sweden). In this device, 40 % of sodium hydroxide was introduced to neutralize the acidic content in the test tube. The condensation product derived from the test tube was absorbed in the conical flask. The distillation process was stopped after 4 minutes when the colour of the solution in the conical flask had changed from violet to green.

Titration: The green distillate solution was next titrated with sulphuric acid (0.1N H_2SO_4) and the titration process was stopped at the point when the green solution turned transparent. The volume of acid V (ml) used for the titration was noted. To derive the amount of basic solution used in neutralizing the acidic reagents, the percentage of nitrogen in the sample was calculated by the equation:

% Nitrogen = (V x 1.4) /P, where the value 1.4 represents milliequivalent weight of N x 100.

The percentage crude protein in the sample was calculated as follows:

% Protein = % nitrogen x 6.25……..……. equation 4.

Where, 6.25 is the protein-nitrogen conversion factor.

Total Carbohydrate in plant sample was deduced by method of difference from already obtained values of protein, lipid and ash. Assuming 100% of sample is made up of protein, lipid, ash (minerals) and carbohydrate, total carbohydrate content was calculated as:

Carbohydrate content (g / 100g of dry matter) = 100 - (protein + lipid + ash) …. equation 5.

Complete oxidation of fats (lipids), proteins and carbohydrates produce 9, 4 and 4 Kcal/g respectively [22]. Based on these caloric values obtained from the oxidation of lipids, protein and carbohydrates, the total energy content of each *S. scabrum* variety was deduced.

β - carotene content was determined using the procedure described by A.O.A.C. [22]. In principle, plant sample was heated under reflux in the presence of potassium hydroxide followed by hydrolyses with hexane. The β- carotene fraction was then recuperated by chromatography under a column of silica gel and analysed by spectrophotometry at 450 nm. For the preparation of the unsaponifiable fraction, about 1g (M) of the sample was placed in a 250 ml flask. 4 ml and 1 ml of 80% alcohol and potassium hydroxide were respectively added. The flask was put in a boiling water bath for 3 minutes after which 5 ml of distilled water was added and allowed to cool. The mixture was transferred into a 25 ml test tube and 5 ml of hexane was added. On addition of hexane, the mixture separated into two layers. The top aqueous layer was collected with a pipette and poured in a 50 ml volumetric flask. This process was repeated three times, each time using 5 ml of hexane. The volume of aqueous solution in the volumetric flask was made up to 50ml (V_1) by addition of hexane. 5 ml of this solution (V_2) was taken and subjected to fractionation with silica gel suspended in hexane within a chromatographic column of 10 cm depth. Recuperation of β-carotene was done by elusion with a mixture of solvent hexane-acetone 9:1 (v/v). The eluant obtained was diluted with hexane to 50 ml (V_3). The absorbance of the eluant was read directly in a UV spectrometer (Jenway model 6300, Cole-Parmer Ltd, UK) at 450 nm against pure hexane. The values read was the optical density (O.D) of the solution expressed as follows:

O.D = 0.0789C - 0.001 where C is a constant obtain from a standardized curve of β-carotene. The β-carotene content was estimated by the relationship:

$$\beta\text{-carotene} = \frac{CV_1 \times V_3}{M \times V_2}\ \mu g/\ g \quad \text{..... equation 6.}$$

Where: M is weight of sample, V_1 is volume of aqueous solution, V_2 is the volume of solution subjected to fractionation and V_3 is volume of diluted eluent.

The value obtained was then converted to Vitamin A content by dividing by 6, considering that 6µg of β-carotene is equivalent to 1 µg of Vitamin A [23].

Data Analyses

Two-way analyses of variance (ANOVA) was performed on the data collected for growth characters using the computer software GenStat 15th edition (VSN International, Hemel Hempstead UK). Data exploration suggested that assumptions of data normality were acceptable and sample residual plots suggested to a large extent that data were normally distributed with constant variance. The treatment means were separated using the least significant difference (L.S.D.) test at 0.05 probability level.

RESULTS

Plant Height

Plant height was significantly (P =0.05) increased by fertilizer application (Table 1). For each vegetable variety, there were significant differences (P =0.05) in plant height across the treatments. Maximum plant heights were obtained with application of 200 Kg NPK/ha for "White stem" (66.0 cm) and least was obtained in control with "Foumbot" (24.3 cm). It was observed that "Bamenda" obtained highest plant height (58.3 cm) with 10 Mg/ha poultry manure treatment. Plant height for "White stem" variety in all NPK doses was higher than that of "Bamenda" variety (Table 1).

Table 1. Effect of fertilizer treatment on growth parameters in *Solanum scabrum* varieties at six weeks after transplanting.

Parameter	Plant height (cm)			Leaf number			Leaf Area (cm^2)			Leaf Area Index			Tap root length (cm)			Number of primary lateral roots		
Fertilizer Treatments	WS	BA	FB	WS	BA	FB	WS	BA	FB	WS	BA	FB	WS	BA	FB	WS	BA	FB
Control	34.3	38.3	24.3	96	164	32	82.6	49.5	205.8	13.1	12.7	7.0	24.4	22.2	22.7	43	26	26
100KgNPK ha	48.8	34.7	49.7	109	68	53	56.0	102	450.3	12.7	9.8	39.7	14.6	19.2	14.7	25	42	19
150KgNPK/ha	59.7	36.0	25.3	152	78	48	110.2	58.2	262.0	25.3	8.9	19.8	20.5	22.7	16.7	37	29	28
200KgNPK/ha	66.0	41.5	40.7	124	243	39	175.6	71.3	422.5	35.8	27.2	26.8	14.1	14.0	17.1	213	23	26
Poultry manure	50.7	58.30	26.0	149	171	39	100.3	84.7	375.1	23.6	20.5	24.8	22.3	20.0	17.7	23	31	32
Means	51.9	41.8	33.2	126	145	42.3	105	73	343	22.1	15.8	23.6	19.2	19.63	17.8	30	30.2	26.3
LSD (0.05)	22.46	21.4	14.51	66.45	114.4	29.96	96.0	88.8	250.5	24.71	12.56	25.2	4.3	4.48	5.5	12.97	3.35	3.1

LSD (0.05). *Solanum scabrum* varieties (WS: White stem; BA: Bamenda; FB: Foumbot)

Leaf number

There were variation in leaf number response to fertilizer treatment of the three *Solanum scabrum* varietites. Significant differences (P = 0.05) in leaf number across treatments were obtained in "Bamenda" variety but not with the "White stem" and "Foumbot" varieties. The "Foumbot" variety irrespective of the treatments, had the lowest leaf number (Table. 1). The "Bamenda" variety, had the highest leaf production in plants treated with 200 Kg NPK /ha (242 leaves) and it was 48 % higher than control plants (Table. 1).

Leaf area and leaf area index

There was significant (P = 0.05) effect of treatments on leaf area and leaf area indices of the vegetable varieties. Average leaf area of "Foumbot" variety (343.1 cm^2) was considerably greater than those of the "Bamenda" (73 cm^2) and white stem (105 cm^2) varieties (Table 1). Highest mean leaf area index (35.8) was obtained on "White stem" plants supplied with 200 Kg NPK/ha while the Foumbot variety in control had the least mean leaf area index of 7.0 (Table. 1).

Root morphology

Fertilizer application significantly (P =0.05) decreased tap root length while there was an increase number of primary lateral roots in the control plants of the three varieties (Table. 1), The highest tap root length (24.4 cm) was noted for control plants of white stem plants and the effects was similars for the other varieties though the values were lower. The control plants of "White stem"also had the highest number of primary lateral roots (43) and this was significantly different (P =0.05) from plants supplied with fertilizers. (Table. 1).

Yield

First and second fresh harvest yields response of *Solanum scabrum* varieties to fertilizer treatments are presented in Table 2. Fertilizer treatments significantly (P =0.05) influenced fresh first and second harvest yields (Table 2). Similarly, the total yield of treated plants was significantly greater than those in control. The total fresh biomass for vegetable varieties ranges 10- 45Mg/ha, 12 - 37 Mg/ha and 12-32 Mg/ha for "White stem", "Bamenda" and

Table 2. The effects of treatments on fresh harvested yields *Solanum scabrum* varietie

Treatment	First harvest yield (Mg/ha)	Second harvest yield (Mg/ha)	Total yield (Mg/ha)	First harvest yield (Mg/ha)	Second harvest yield (Mg/ha)	Total yield (Mg/ha)	First harvest yield (Mg/ha)	Second harvest yield (Mg/ha)	Total yield (Mg/ha)
NPK 200Kg/ha	18.68	21.87	40.55	28.16	8.8	36.96	19.84	12.00	31.84
NPK 150Kg/ha	16.16	5.25	21.41	10.20	8.13	18.34	14.80	9.27	24.07
NPK 100Kg/ha	9.45	3.64	13.09	7.73	4.23	11.96	12.74	7.33	20.07
Poultry manure	29.31	15.51	44.82	22.68	10.50	33.18	9.11	7.10	16.21
Control	8.57	1.47	10.04	7.26	4.67	11.93	5.08	6.80	11.88
Means	16.43	9.55	25.98	15.21	7.27	22.47	12.31	6.5	20.8
LSD (0.05)	0.1	3.61	3.12	0.03	5.15	5.15	0.09	8.5	6.5

"Foumbot" respectively, with control treatment plants having the lowest yields. The "Bamenda" and "Foumbot" varieties, had the highest total yield in plants supplied with 200 Kg NPK /ha fertilizer and this was three times more than plants in control. "White stem" plants supplied with 10 Mg/ha poultry manure gave the highest total yield (45 Mg/ha) was attained with poultry manure (Table. 2). Based on varietal yield, "White stem" performed best, followed by "Bamenda" and lastly "Foumbot" under 10 Mg/ha poultry manure and 200 Kg NPK/ha treatment applications as indicated in Table 3.

Table 3. Camparison of *Solanum scabrum* varieties within treatments at eight weeks after transplanting.

	Total yield (Mg) per fertilizer treatment				
Varieties	100 Kg NPK/ha	150 KgNPK/ha	200 Kg NPK/ha	10Mg Poultry manure	Control
White stem	13.09	21.41	40.55	44.82	10.04
Bamenda	11.96	18.34	36.96	33.18	11.93
Foumbot	20.07	24.07	31.84	16.21	11.88
Means	15.04	21.27	36.45	31.4	11.28
LSD (0.05)	8.51	7.5	5.66	4.99	2.83

LSD (0.05).

Nutritive value of three varieties of S. scabrum

The nutritive values of the edible partion of the three *Solanum scabrum* varieties per 100 g dry weight are presented in Table 4. Nutritive components varied significantly (P = 0.05) among vegetable varieties. Highest levels of crude protein (303.8 mg/100g), β-carotene (1.9 mg/100g), vitamin A (333ug/100g) and carbohydrates (66.15%) were obtained from "White stem" variety while the highest levels of crude fibre (14.15%), and total lipid (fats) were obtained from the "Bamenda" variety. The "Foumbot" variety had significantly (P= 0.05) highest level of minerals (total ash) (16.54%) compared to "White stem" and "Bamenda" varieties.

Table 4. Nutritive value of *S. scabrum* varieties at eight weeks after transplanting (100g dry matter)

Plant varieties	Total Ash (% DM)	Crude Protein (mg/100g)	Total Lipid (% DM)	Crude fibre (%DM)	Carbohydrate content (%DM)	β-carotene (mg/100g)	Vitamin A (ug/ 100g)	Energy content (Kcal/g)
White stem	15.38b	303.8a	7.19b	11.28c	66.15a	1.99a	333.00a	8.44a
Bamenda	14.34c	246.17b	8.15a	14.25a	63.26c	1.32b	219.25b	8.26b
Foumbot	16.54a	246.17b	7.25b	12.85b	65.50b	0.60c	100.0c	8.11c

Means with the same letter within the columns are not significantly different at LSD (0.05).

DISCUSSIONS

This study revealed that fertilizer application generally improved plant height, leaf number, and leaf area index of *S. scabrum* although varieties of the vegetable differed in their respond to the fertilizer treatments. Plant height, leaf number and leaf area index (LAI) were highest in plants supplied with 200 Kg NPK/ha fertilizer. These observations are consistent with studies by Edmonds and Chweya [5] who reported that nightshades require large amounts of nutrients to encourage vigorous growth and increase leaf production. It was noted by other authors that drastic reduction in *Solanum villosum* leaf area was as a result limited nitrogen supply [24, 25]. The increased vegetative growth observed by plants supplied with high dose of NPK in this study may be related to role of potassium (K) present in the NPK fertilizer. Potassium (K) improves nitrogen (N) use efficiency in plants [26]. The variation in growth response of the *S. scabrum* varieties in this study may be attributed to the high degree of inter-specific diversity reported among nightshades. Studies have indicated that *S. scabrum* exhibit different growth habits [6,27]. Some accessions of the vegetable have large leaves and reduce branches thus attain high leaf area and leaf area index compared to accessions with

smaller leaves and multiple branches [28], as the case in this study with the three *S. scabrum* varieties.

Enhanced root growth (represented by tap root length and number of primary lateral roots) was more exhibited in "White stem" plants in control than plants supplied with fertilizers. This is in line with studies by De Giorgio and Fornaro [29] who reported that higher N levels can reduce root growth and biomass. In contrast, separate root system morphology studies have demonstrated that total root length and root surface area increased with increased N application (120 Kg/ha) in *Oryza sativa* [30], and greater root length response can be obtain at N fertilization rate of 127.5 Kg N/ ha compared with either the absence of fertilizer N or the higher rate of 255 Kg N /ha in *Zea mays* [31]. Longer tap roots may provide benefits to plants in infertile or competitive environments [32]. In this study, the higher tap root length and higher number of primary lateral roots of control plants suggest adaptive change in root morphology of plants to extract adequate nutrients from lower soil depth.

Poultry manure has been shown to increase soil organic matter content and its application at 10 Mg/ha has been recommended for obtaining better yield in solanaceae vegetables [8,33]. In this study total yields for "White stem" and "Bamenda" *S. scabrum* varieties were optimum at 10 Mg/ha poultry manure and 200 Kg NPK/ha respectively. This is consistent with studies by Boukong *et al.* [8], who reported *S. scabrum* yields in the range of 23.5-42.2 Mg/ha with 10 Mg/ha poultry manure. Given that yields were also maximized at 200 Kg NPK/ha in this study, it appears the recommended nutrient dose for *Solanum scabrum* compares to that of *Solanum aethiopicum* (207 Kg N/ ha) reported by Adu *et al*. [26].

The results of this study also indicates a higher second harvest yield advantage obtained with application of 10 Mg/ha poultry manure than those obtained with 150Kg and 100 Kg NPK/ha. Similar to this study, Mwai *et al.* [34] reported that nitrogen rates of up to 120

Kg/ha did not produce significant response in leaf yield in Solanum species. It was observed that the release of plant nutrients in poultry manure is gradual and their use in vegetable production helps to improve soil texture and enhances better leaf yield [35]. It was observed that harvested yield in "Foumbot" variety supplied with 10 Mg/ha poultry manure in this study was three times lower than values reported by Boukong *et al.* [8] in similar study carried out in the western highland zones of Cameroon and which used the same fertilizer level. This inconsistency in yield of "Foumbot" variety between the two studies suggests that environmental factors and soil conditions are important features to be considered in *S. scabrum* production.

Several studies have reported that the leaves of traditional leafy vegetables tend to be a good source of protein, crude fibre, iron and vitamins [2,13,36,37], with the consumption of solanaceae vegetables playing vital roles in providing dietary diversity and nutrition security for many households [26]. Edmonds and Chweya [5] reviewing investigations on the nutritive value of black nightshades, *Solanum nigrum* L. and related species reported nutrient per 100-g value ranges for crude protein (2.8-5.8g), crude fibre (0.6-1.4g), carbohydrate (3.3-5.0g), total ash (3.3-8.8g), ß-carotene (1.7-11.6mg) and calories (38kcal) and these were relatively higher than nutritive values obtained in this study. The carbohydrate content and mean energy values obtained in this study were respectively two and four folds lower than those obtained by Edmonds and Chweya [5]. It is worth noting that information is limited on species *S. scabrum* nutrient analysis hence the reason why results of this study may not compare well with previous studies on related Solanum species.

The nutrient values of traditional leafy vegetables may vary with soil fertility, plant age and the type (i.e. variant or species). Chweya [10] found that protein content in leaves was increased by nitrogen application and further indicated that some plant nutrients reduced as a

result of drying the leaves of the vegetable. In this study, samples used for nutrient analysis were oven dried leaves from the plants in control. This may have to some extend influence the amount of nutrients to be obtained in the nutrient analysis. Variations in nutrient contents across varieties were recorded in this study. These variations in nutrient content are a common occurrence that has earlier been reported in other leafy vegetables including amaranth, nightshade and African eggplant species [38]. The ß-carotene content for example was found in black nightshade, *solanum nigrum* varieties growing in different district areas in Tanzania to vary between 1.09 mg and 5.02 mg per 100g of edible portion [38]. The ß-carotene content for "White stem" (1.99 mg) and "Bamenda" (1.3 mg) in this study compare well with those values reported in *Solanum nigrum* by Weinberger and Msuya [38]. This was however not the case when comparing crude protein values for *S. nigrum* reported by Edmonds and Chweya [5], which were on average slightly higher than those from this study.

CONCLUSIONS

The present study shows that the vegetative growth and yield of *S. scabrum* varieties were significantly influenced by fertilizer application. Maximum plant height, leaf number, and leaf area index measures were obtained when 200 Kg NPK/ha fertilizer was applied to plants; while lowest growth and yields responses were recorded in control plants. Only control "White stem" plants exhibited significant increase in parameters of root morphology. 10 Mg/ha poultry manure and 200 Kg NPK/ha fertilizer application were identified as doses for optimum total harvest yields for *S. scabrum* varieties however 10 Mg/ha poultry manure was not favourable for "Foumbot" cultivation. Nutrient analysis suggests consuming *S. scabrum* varieties can provide an opportunity in addressing some nutritional and health challenges. For example, the "White stem", richer in ß-carotene can be consumed to improve eye vision, while the "Bamenda" which contains high levels of crude fibre might be good to ease digestion. When appropriate levels of fertilizers are applied, *Solanum scabrum* cultivation

could offer a plausible solution to the food security challenges as well as improve income of vegetable farmers.

REFERENCES

1. Gockowsky J, Mbazo'o J, Mbah G, Moulende T. African leafy vegetables and the urban and peri-urban poor. Food Policy. 2003; 28 (3): 221-235.

2. Prasad KN, Shiramurthy GR, Aradhya SM. *Ipomoea aquatica*, an underutilized Green Leafy Vegetable: A Review. International Journal of Botany. 2008; 4(1): 123-129.

3. Muthomi J, Musyimi DM. Growth Responses of African Nightshades (*Solanum scabrum* Mill) Seedlings to Water Deficit. ARPN Journal of Agricultural and Biological Science. 2009; 4(5): 24-31.

4. Mwai GN, Ojiewo CO, Masinde PW, Agong SG. Good agricultural practices for African nightshade production in sub-Saharan Africa. Scripta Horticulturae. 2012; 15:55-73.

5. Edmonds JM, Chweya JA. (1997) Black nightshade: *Solanum nigrum* L. and related species. Promoting the conservation and use of underutilized and neglected crops. 15. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy. 1997. 113p.

6. Berinyuy JE, Fontem DA, Focho DA, Schippers RR. Morphological diversity of *Solanum scabrum* accessions in Cameroon. Plant Genetic Resources Newsletter.2002; 131:42-48.

7. Schippers R. African Indigenous Vegetables: An Overview of Cultivated Species. Chatham, UK: Natural Resources Institute/ACP-EU Technical Center for Agricultural and Rural Cooperation. 2000. 214p.

8. Boukong A, Ghogomu R, Mvondo Awono JP, Tabi FO, Meko G. Effect of plant spacing and use of organo-mineral fertilizers on biomass yield and profitability of *Solanum scabrum* cultivation on an aquox in the western highlands of Cameroon. Agriculture and Biology Journal of North America. 2017; 8(4): 122-131.

9. Besong MT, Sama-Lang P. Identification of Vegetables in Fako markets. In Schippers R. R, Budd L, Editors. Workshop on African Indigenous vegetables; 1997 January 13-18, Limbe, Cameroon. NR/IPGRI. 1997. p 67-69.

10. Chweya JA. Genetic enhancement of indigenous vegetables in Kenya. In: Guarino, L. (ed.), 1997, Traditional African Vegetables. Promoting the conservation and use of underutilized and neglected crops. Plant Genetic Resources Institute, Rome, Italy. 1997. p. 90-99.

11. Poubom CFN. The place of indigenous vegetables in the farming systems of Cameroon in Workshop on African Indigenous Vegetables. Proceedings of the NRI/IPGRI/CPRO workshop, 13-18 Jan. 1997, Limbe, Cameroon. 1997. p 52-57.

12. Mih AM, Fungod AGN, Mukom GM. Traditional Seed systems in Buea Area. Presented at the 10th Annual Conference of Cameroon Bioscience Society, Yaounde, Cameroon, 09-11 January 2003. 2003. p. 48-49.

13. Abukutsa MO, Kavagi P, Amoke P, Habwe FO. Iron and protein content of priority African indigenous vegetables in the Lake Victoria Basin. Journal of Agricultural Science and Technology. 2010; 2(1): 67-69.

14. AVRDC. Improving food security in sub-Saharan Africa through increased utilization of indigenous vegetables: studies on seed production and agronomy of major African vegetables. Final Technical Report, Project R7025 (C). 2001. p19.

15. Amanullah MM, Sekar S. Muthukrishnan P. Prospects and potential of poultry manure. Asian Journal of Plant Sciences. 2010; 9(4):172-182.

16. Kemgmegne B. Itinéraire technique de production de trois légumes indigènes d‟Afrique (*Solanum scabrum* ; *Solanum macrocarponet* ; *Corchorus olitorus*) dans le département de la Menoua Rapport de stage de pré-insertion – FASA – Université de Dschang. 2000; 30p.

17. Alongamo J, Kekehe E. Résultat des l‟enquête de production de la morelle noire dans le département de la Menoua, réalisée dans le cadre du stage d'insertion professionnelle du niveau 5 Ingénieur Agronome – FASA – Université de Dschang. 2007.

18. Mfombep PM, Fonge BA, Atembe-afac, Tabot PT. Soil type and admendment influence growth and yield of tomatoes *Lycopersicon esculentum* L. in the humid Mt Cameroon Region. International Journal of Current Research in Biosciences and Plant Biology. 2016; 3(8): 58-64.

19. Kinge TR, Egbe EA, Tabi EM, Nji TM, Mih AM. The first checklist of macrofungi of mount Cameroon. Mycophere. 2013; 4(4): 694-699.

20. Schippers R.R. African Indigenous Vegetables: an Overview of the Cultivated Species. University of Greenwich, Natural Resources Institute London, UK. 2000; 222p.

21. Bergert B. La Chimie Alimentaire dans un Laboratoire D'Outre Mer. Organisation du Laboratoire: Etude Critque der Techniques d'Analyses Employees au Laboratoire de la section nutrition de IRCAM, ORSTOM. 1955; 1-56.

22. A.O.A.C Official methods of analysis.13th Edn, Willliam Horwit (Edn) Washington, DC: Association of Official Analytical Chemists. 1980. 422 p.

23. De Luca L, Glover J, Heller J, Olson J, Underwood B. Recent Advances in Metabolism and Function of Vitamin A and their Relationship to Applied Nutrition. A report of International Vitamin A consultative group (IVACG). 1977. 44p

24. Masinde PW, Wesonga JM, Ojiewo CO, Agong SG, Masuda M. Plant growth and leaf N content of *Solanum villosum* genotypes in response to nitrogen supply. Dynamic Soil, Dynamic Plant. 2009; 3(1):36-47.

25. Grindlay DJC. Towards an explanation of crop nitrogen demand based on the optimization of leaf nitrogen per unit leaf area. Journal of Agricultural Science. 1997; 128: 377-396.

26. Adu MO, Asare PA, Yawson DO, Nyarko MA. Agronomic biofortification of selected underutilised solanaceae vegetables for improved dietary intake of potassium (K) in Ghana. Heliyon. 2018; 4 (8) e00750 PMID: 30167498. Retrieved 07 September, 2018 online from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6107906/

27. Fontem DA, Schippers RR. *Solanum scabrum* Mill. In: Grubben GJH, Denton OA (eds.), Plant Resources of Tropical Africa 2. Vegetables. PROTA Foundation Wageningen, Leiden, the Netherlands. 2004. p493-498.

28. Mwai GN. Morphological and Molecular Characterization and Yield Evaluation of Vegetable African Nightshades (Solanum L. Section Solanum) under Varying Cultural Practices. PhD Thesis, Maseno University, Maseno, Kenya. Mwai. 2007.

29. De Giorgio D, Fornaro F. Nitrogen fertilization and root growth dynamics in durum wheat. Italian Journal of Agronomy. 2012; 7(3):207-213.

30. Fan JB, Zhang YL, Turner D, Duan YH, Wang DS, Shen QR. Root physiological and morphological characteristics of two rice cultivars with different nitrogen-use efficiency. Pedosphere. 2010; 20(4): 446-455.

31. Costa C, Dwyer LM, Zhou X, Dutilleul P, Hamel C, Reid LM, Smith DL (2002) Root morphology of contrasting maize genotypes. Agronomy Journal. 2002; 94(1):96-101.

32. Xie Y, An S, Wu B, Wang W. Density-dependent root morphology and root distribution in the submerged plant Vallisnerianatans. Environmental and Experimental Botany. 2006; 57(1):195-200.

33. Opara CN, Asiegbu JE. Nutrient content of poultry manures and the optimum rate for eggplant fruit yield in a weathered tropical Ultisol. Biological Agriculture and Horticulture. 1996; 13(4):341-350.

34. Mwai GN, Onyango MOA, Onyango JC, Chadha ML, Oluoch MO. Effect of N-fertilization on yield components of nightshade. Acta Hort. 2009a; 806(2):727-732.

35. Mwai GN, Ojiewo CO, Masinde PW, Agong, SG. Good agricultural practices for African nightshade production in sub-Saharan Africa. Proceedings of a Technical Consultation Workshop held in Arusha Tanzania, 7-8 December 2009 on Good Agricultural Practices for African Indigenous Vegetables. 2012. p 55-74.

36. Opiyo AM. Effect of nitrogen application on leaf yield and nutritive quality of black nightshade *Solanum nigrum* L. Outlook on agriculture 2004; 33 (3): 209-214.

37. Nyadanu D, Lowor ST. Promoting competitiveness of neglected and underutilized crop species: comparative analysis of nutritional composition of indigenous and exotic leafy and fruit vegetables in Ghana. Genetic Resource and Crop Evolution. 2015; 62 (1): 131-140.

38. Weinberger K, Msuya J. Indigenous Vegetables in Tanzania - Significance and Prospects. Shanhua, Taiwan: AVRDC-The World Vegetable Center, Technical Bulletin No. 31, AVRDC Publication 04-600. 2004. 70 pp.