Variations in growth and yield characteristics of three black nightshade species grown under high altitude conditions

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ABSTRACT

A field study on the growth and yield characteristics of African nightshades was conducted at Kisii Agricultural Training Center for two seasons in 2006/2007. The three species studied were *Solanum villosum* Miller, *S. americanum* Miller and *S. scabrum* Miller. The experiment was carried out under randomized complete block design (RCBD) with three replications. Of the three species tested, *S. villosum* was the tallest in both seasons by between 34% and 58.7% compared to *S. americanum* and *S. scabrum*. The internode lengths of both *S. scabrum* and *S. americanum* were also shorter compared to that of *S. villosum*. The edible yield of the African nightshade species was seasonal, with *S. americanum* giving the highest yield of 4.12t/ha in season 1, but the lowest yield of 2.31t/ha in season 2. *S. americanum* with the highest yield during rainy season (Season 1) coupled with average height and branching ability would be preferred for vegetable production, especially where rainfall is above 1200mm per annum

Keywords: African nightshade, yield, Solanum americanum, Solanum scabrum, Solanum villosum.

INTRODUCTION

African nightshades belong to the genus Solanum in the family solanaceae. 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 (Edmonds and Chweya, 1997). Some of the species like the bittersweet (Solanum dulcamara L) are cultivated for corticosteroid, which is an important compound in the pharmaceutical industry (Edmonds and Chweya, 1997). While Manoko et al. (2007) identifies nine African nightshade species, Maundu et al. (1999), reported at least five of these species to be the most common in Kenya. They include: L., Solanum villosum Miller., Solanum nigrum Solanum americanum Miller., Solanum scabrum Miller and Solanum physalifolium. The genus Solanum is very large and has other sections or groups. The species commonly known as black garden or common nightshade Solanum nigrum L. is one of the largest and most variable group of the genus Solanum.

African nightshades are among the many traditional leafy vegetables that continue to be cultivated by many Kenyan communities. 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 (Gockowski *et al.*, 2003). Like many traditional vegetables, African nightshades have multiple uses. They provide food security and are a source of better nutrition compared to some of the exotic vegetables in the Kenyan Market. They are nutritionally rich in, especially calcium, iron, and vitamins A and C (Schippers *et al.*, 2001).

Certain factors have however, contributed to the current poor state of production and utilization of African nightshade. According to Fenwick *et al.* (1990), the belief that the bitter species are poisonous has led to a decline in the use and consumption of traditional vegetables. These consequently led to reduced interest in terms of crop research and improvement on the same.

The widely reported toxicity of African nightshades has been attributed to the alkaloid solanine which has been associated with varying degrees of poisoning. These solanine type alkaloids are also responsible for the bitter taste often associated with these African nightshades (Edmonds and Chweya 1997). Everard *et al.* (1996) quoting Morris and Lee (1984) reported that glycol-alkaloid concentrations in excess of 20mg 100g⁻¹ fresh weight impart a bitter taste to potato tubers and can cause gastro enteritic symptoms, coma and even death. The toxic dose is considered to be approximately 2-5 mg kg⁻¹ body mass whereas the lethal dose is probably only 3-6 mg kg⁻¹.

Earlier decline in the use of the African nightshades was attributed to a shift towards exotic vegetables, which were thought to be of higher nutritional and social values as well as high yielding (Fenwick *et al.* 1990). However, problems of environmental degradation, shortage of arable land, poor soil moisture, diseases, pests and high production costs have reduced the reliability on exotic vegetables and narrowed the vegetable base of most households.

In an effort to enhance production and utilization of African nightshades among the farming communities in Kenya, this research investigated the growth and yield characteristics of three African nightshade species namely *S. scabrum* Miller, *S. villosum* Miller and *S. americanum* Miller.

MATERIALS AND METHODS

Study Site

The study was carried out at Kisii Agricultural Training Center in 2006 and was repeated in 2007. The study area was generally gentle sloping. The research site was at an altitude of between 1570 and 2015m a.s.l. Geographically, the region falls within the latitude range 0°, 30'S and 0°, 58 S and longitude 34°, 38' and 34° East. The soils are mainly loam soils classified as phaeozems (FAO/UNESCO, 1974). The area receives annual convectional type of rainfall of 1200-2000mm due to it's proximity to Lake Victoria and its hilly in topography. The average daily temperature range is 18-22°C

Planting Materials

Seeds of the three African nightshades were obtained from National Gene Bank Muguga in the year 2006 and bulked. Seeds were extracted from clean and disease free mature plants. The seeds were dried to constant weight and used for planting the experiment.

Experimental Design Treatment applications

The treatments were applied in a randomized complete block design (RCBD) with three replications. The three African nightshades tested in this study were:

 V_1 - S. scabrum Miller, V_2 -S. villosum Miller and V_3 -S. americanum Miller.

Land preparation and soil chemical analysis

Primary and secondary cultivations were done to attain a favorable tilth in preparation for transplanting.

Transplanting was done four weeks after emergence when the seedlings had at least 6 true leaves. At this stage, they were about 10 cm - 15 cm tall.

Measurement of growth and yield parameters

Nine plants per experimental unit were randomly selected and tagged for data collection. These plants were used throughout the experiment. The parameters studied were as follows.

Plant height: The height of each of the nine plants per plot was determined by measuring from ground level to tip of the longest stem of the plant at weekly interval for four weeks.

Internodes length: The fourth internodes of nine sample plants in an experimental unit were marked and their lengths determined between the adjacent nodes. The measurements continued at weekly interval starting from 6th week after transplanting to the termination of the experiment

Stem diameter: Fourth internodes of each of the nine sample plants were marked and their diameters determined using micrometer screw gauge. The measurements were taken at weekly intervals starting from 6th week after transplanting to the termination of the experiment. Averages of the nine measurements taken from each treatment were recorded as the score for that treatment.

Fresh weight: Each of the nine sampled plants was harvested on weekly basis and the mean used for the computation of fresh weight.

Dry weight: The nine sample plants that were harvested for fresh weight determination were placed under shade for 6 hrs to remove excess moisture. The plants were then dried at 70 °C to constant weight. The weight of each plant was recorded and average for each treatment taken as dry weight per plant for that treatment.

Edible yield: The term yield in this research was used to include all the parts of the plant that is usually harvested for vegetable use. It included single leaves and tender shoots which is usually 2 leaves and a bud. The harvesting was done at weekly intervals starting from 6 weeks after transplanting from a set of nine plants per treatment. Each time harvesting was done from the nine plants; total weight was determined using Salter Elite Electronic scale (model 3001, USA) with an accuracy of ±1g.

Physiological measurements

Light interception: Light interception was determined using Sunfleck PAR Ceptometers Model SF – 80 with which measurements were taken within the photo synthetically active radiation (PAR) waveband. This was done at the 4^{th} week after transplanting. The equation F = 1 - t (Sunfleck PAR

Ceptometers; operators manual) was used to get light interception where: F-Fractional PAR canopy absorption and t – Fraction of incident PAR radiation transmitted by canopy.

Chlorophyll concentration: Two plants per treatment were used for chlorophyll determination. Fresh tissue (1g) was sampled from the youngest fully expanded leaf, extracted with 90% acetone and read using a UV/Visible Spectrophotometer (Bausch & Lomb, Belgium) at 663, 645 and 750 nm wavelengths. Absorbance at 750 nm was subtracted from absorbance at the other two wavelengths to correct for any turbidity in solution before chlorophyll concentrations were calculated using the equations given by Strain and Svec (1966). Chl.a (mg.ml -1) = 11.64x (A663) - 2.16x (A645); Chl.b (mg.ml -1) =20.97x (A645) - 3.94x (A663); where (A663) and (A645) represents absorbance values read at 663 and 645 nm wavelengths respectively.

Data Analysis and Interpretation

Each set of data of a measured parameter was subjected to analysis of variance (ANOVA) using a Mixed Models procedure of SAS V8 statistical package (SAS Institute 1999). The UNIVARIATE procedure of SAS was used to check that the data were normally distributed before analysis.

RESULTS AND DISCUSSION

Growth and yield parameters measured were dependent on the species and season. Of the three species tested, *S. villosum* was the tallest species in both seasons compared to other species. The species was taller by between 34.4% and 58.7% compared to *S. americanum* and *S. scabrum* in both seasons (Figure 1). Among the species, the taller *S. villosum* species had longer internodes compared to the other two species.

The internode lengths of both *S. scabrum* and *S. americanum* were shorter by between 9 and 45% when compared to that of *S. villosum* (Figure 2).

The species with long internode (*S. villosum*), had thinner diameter compared to *S. scabrum* which exhibited dwarf growth, but with larger stems (Figure 3).

The largest fresh weight of the African nightshade species was observed in *S. scabrum*, but there were no differences observed in either dry weight or percent weight losses in all the three species in season 1 (Table 1a), while in season 2, the highest dry weight loss was observed in *S. americanum* (Table 1b).

Of the three species, *S. villosum* had the highest percent (50%) interception, but this was not significantly different from the amount of light intercepted by the other two species in season one. However, in season 2, light interception was significantly higher in all the three varieties compared to the percent interceptions in season 1. The highest interception observed in season 2 was 89% in *S. americanum* variety (Figure 4).

Chlorophyll content of the three African nightshade species was different in season 2, but not in season 1. In season 2, the mean chlorophyll content of *S. scabrum* and *S. villosum* was 26% higher than the amount observed in *S. americanum* (Figure 5).

The edible yield of African nightshade species was seasonal, with S. *americanum* giving the highest yield of 4.12t/ha in season 1, but the lowest yield of 2.31t/ha in season 2 (Table 2). The lower yield in the second season could be attributed to low rainfall during this period of production. The yield of *S. villosum*, a species which consistently showed vigorous growth characteristics like long internode and high branching capability was lower than *S. americanum* in the first season and *S. scarbrum* in the second season. The same trend was observed with *S. scabrum* that had the highest yield of 3.12t/ha in season 2, but the lowest yield in season 1 (Table 2).

Growth temperature at the site averaged 22°C which compares well with an average of 23°C reported by

altitude areas above 2000m with a humid climate. This climate is similar to that found at the site where

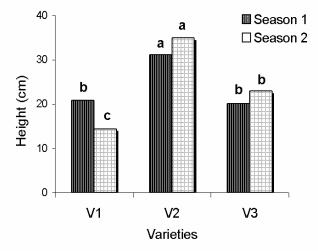


Figure 1. Variations in height of the three African nightshades (Season 1 and

Season 2) (V₁-S. scabrum, V₂– S. villosum, V₃– S. americanum)

Hackett and Carolane (1982) as the favorable mean temperature for African nightshades. Myers *et al.* (2004) also used a base temperature of 9° C in a study to predict germination of nightshades and weed emergence. The lowest temperature recorded during the study was 9° C. Differences in the rate of growth of the three species might be attributed to their adaptation to different altitude. For example, Maundu *at el.* (1999) found *S. scabrum* and *S. villosum* (which has dark green leaves) to be most prevalent in high

this research was conducted. A species such as *S. villosum* might have therefore grown taller because it was able to utilize growth factors such as light, nutrients and Co_2 more efficiently under this altitude compared to the other species. The highest yield of 3.51ton/ha obtained from this species in season one was however lower than total leaf yield of 5 t/ha reported by Edmonds and Chweya (1997) obtained from six sequential harvests of the same species.

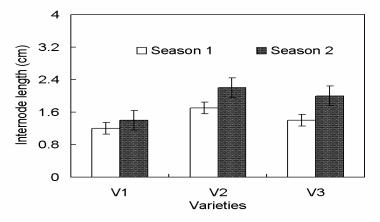


Figure 2. Comparative differences in internode length of three African nightshade species (Season 1 and Season 2) (V₁-*S. scabrum*, V₂- *S. villosum*,

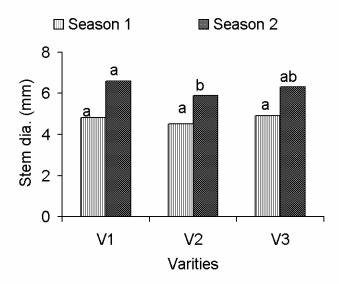


Figure 3. Comparative differences in stem diameter of three African nightshade species (Season 1 and Season 2) (V₁-S. scabrum, V₂–S. villosum, V₃–S. americanum)

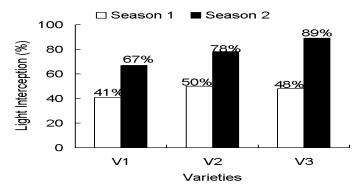


Figure 4. Percent light Interception by the three African nightshade species (V1-

S. scabrum, V2-S. Villosum, V3-S. americanum.)

CONCLUSION

This study provides useful information on the growth characteristics and yield potential of the three African nightshade species. Produced under similar condition *S. scabrum* would be the best species in areas with low precipitation, while, *S. americanum*, which exhibited the good growth characteristics such as high number of branches and larger stems would be recommended for production in areas with high precipitation.

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