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A study of intra-specific competition in *Solanum scabrum* grown at different inter-row spacing within tea plants

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The study was conducted at Simotwet tea estate of James Finlay Kenya Ltd in Kericho, from October 2003 to August 2004. The African nightshades (*Solanum scabrum*) were grown at different plant spacing of 20x15cm, 30 x 15cm, 40 x 15cm and 60 x 15cm. The plots were laid out in a complete randomized block design of four treatments and three replications. Six weeks after transplanting of African nightshades into the field; growth and physiological measurements were carried out. Growth parameters studied included plant height, root depth, dry weight, flowering time, fruit maturity and seed yield. Photosynthetic active radiation (PAR) was measured by use of a Ceptometer. Infrared gas analyzer was used to measure CO_2 assimilation, transpiration, leaf and air temperature. Occurrences of weeds and pests during the period of experiment were recorded.

The results from the experiment showed that at smaller inter row spacing African nightshades height significantly ($p \leq 0.05$) increased. The time taken for attainment 50% flowering and 50% fruit maturity were delayed significantly ($p \leq 0.05$) by reducing the inter-row spacing. All other growth and physiological parameters studied were not significantly ($p > 0.05$) affected. Findings from this experiment show that optimal productivity of *Solanum scabrum* occurs at a spacing of 30 x 15 cm.

Key words: *Solanum scabrum*, intercropping and African nightshades

Introduction

African nightshades are widespread cooked indigenous vegetable that are presently semi-cultivated. They are marketed country wide just like *Amaranthus spp.* in Kenya (Chweya, 1997). African nightshades are found in all the eight provinces of Kenya at altitudes ranging from 620-2200m above sea level (Kemei *et al.,* 1995). They are commonly found as weeds in cultivated fields and in pruned tea. The three forms easily recognized in Kenya are *Solanum scabrum*, *Solanum americanum* and *Solanum villosum* with all being used as leafy vegetables (Maundu, 1997). African nightshades have been documented to have high nutritive value with high contents of Vitamins A and C, minerals and supplemental proteins. It can be recognized with relative ease by its strong green or purple stems with more or less serrated wings. Plants are usually about 60cm high but could grow to 1.2m or higher. There are both small and large leaved cultivars with different leaf shapes. Leaves have entire to sinuate margins and apices that are acute to obtuse. It is the only species whose berries remain on the plant at maturity. The dark purple fruit have a distinct bloom when young and become glossy when they get older.

The main objective of the study was to establish the optimal spacing desired to reap maximum productivity from African nightshades.

Materials and Methods

The study was carried out at Simotwet tea estate next to Changana tea factory in Kenya. The estate is 16 Km from Kericho town and about 50 Km south of the equator. It lies at 2175m above sea level and receives a mean annual rainfall of 2160mm. The estate is managed by James Finlay (K) Ltd. The experiment commenced on October 2003 until August 2004. Table 1 gives a summary of the prevailing climatic conditions between March and August when most data was being collected.

Seed bed preparation

Seeds of African nightshades were obtained from Maseno University botanic garden and first subjected to a germination test before being sown shallowly in fine tilled nursery. The seedlings were not watered for a week to harden them before being transplanted. They were then transplanted into plots. DAP fertilizer was applied at rates of 20gm per planting hole (Chweya, 1997).

Experimental design and layout

Field experiments were laid out in a complete randomized block design (CRBD) with four treatments and three replications. Each plot measured 3.5x5.0m with one block measuring 23.0 x 5.0m. Four treatments were applied as follows: Treatment 1 (T1) *Solanum scabrum* grown at spacing of 20 x 15cm. Treatment 2 (T2) *Solanum scabrum* grown at a spacing of 30 x 15 cm between plants. Treatment 3 (T3**)** *Solanum scabrum* grown at a spacing of 40 x 15 cm. Treatment 4 (T4**)** *Solanum scabrum* grown at spacing of 60 x 15 cm between plants.

Soil moisture determination

The measurements were obtained using a TDR soil moisture meter six weeks after planting and thereafter every two weeks. TDR soil moisture meter was preferred over gravimetric method because it is accurate, fast and handy. Probe number two measuring about 12cm in length was inserted into the soil. Six random sites were selected in each plot and the average taken as the soil water content in percentage.

Plant height

Vertical height above the soil surface was measured using a tape measure on three randomly sampled plants per plot from the sixth week after transplanting. Other measurements followed after every two weeks until the sixteenth week.

Dry Weight.

Freshly uprooted plants were put in an oven set at 70°C for 36-48 hrs until a constant weight was achieved. The dry weight was measured using an analytical balance. This was done on week 6, 10 & 16 after planting.

Days to 50% flowering

This was taken on a weekly basis by scoring the flowering plants per plot and expressing them as a percentage of the total plants in the plot. The data was presented in graph which was then used to draw regression lines so as to get the exact dates that each treatment attained 50% flowering. The same procedure was applied to get Days to 50% fruit maturity.

Fruit and seed yield.

Fruits harvested from each plot were weighed in sacks. They were then trashed to release seeds. The fine mast was washed several times to get rid of unwanted fruit parts. The seeds settled at the bottom of the washing container. Finally the clean seeds were sun dried until suitable moisture content for storage was reached. It was then weighed and packed in sisal bags ready for transport to Maseno university botanic garden seed bank.

Gas exchange measurements

This was done using Infra-Red Gas Analyser (ADC, UK) on week 10, 12 & 16 after transplanting. The leaf temperature sensor is a precision thermistor which is plugged into the jack socket on the left hand side of the leaf chamber head (PLC /3-B).

The upper most fully mature leaf was clipped with a PLC/3-B leaf chamber with an area of 6.25 cm^2.The chamber was left in position for about 15 seconds to allow an equilibrium to be attained before readings were taken.

Phototosynthetic active radiation measurements

PAR measurements were done using Sunfleck ceptometer (Pullman, U.S.A) from week 6 to 14 after transplanting every fourth night. Measurement of the sunfleck fraction beneath a canopy at different sun elevations was measured by inserting the ceptometer at different levels under the canopy. Measurements obtained could be used to estimate canopy structure parameters such as leaf area index, ground cover, gap fraction and leaf angle distribution.

Statistical analyses of the data

Data collected from the six treatments and their three replications were statistically analyzed using statistical computer package (Statistica 10.0). Analysis of variance (ANOVA) was carried out to determine if treatment effects were significant at 5%, 1% and 0.1%. The treatment means were separated using the least significant difference

(LSD) test at 5% level to determine which treatment means were significantly different from each other. Correlations and regressions were done to determine the relationship of some relevant parameters.

Results and Discussion

Soil moisture

The soil moisture did not show any significant ($p>0.05$) difference with treatments and was more less dependant on the amount of rainfall. The months of April to August coincided with the rainy season at Kericho as shown in table 1

Effects of competition on plant height

African nightshades showed a steady increase in plant height depending on treatments. African nightshades at T4 appeared relatively shorter while those in T1 were taller and extended to a maximum of 1.2m.This observations were however not significant ($p>0.05$). This could be attributed to competition for light. Smith *et al.,* (1990) noted that stems of various dicots show increased rates of elongation even when they grown near another plant.

Days to 50% flowering and fruit maturity

Plant density affected both the number of days taken to flowering and fruit maturity. Generally the number of days taken to attain 50% flowering was significantly ($p \leq 0.05$) increased as the inter row spacing of African nightshade decreased. This meant that a closer inter-row spacing tended to delay flowering of African nightshades. A similar trend was observed in the attainment of 50% fruit maturity. According to Levitt (1980) plants respond to light stress by delaying emergence of flowers, delaying fruit ripening and accelerating leaf senescence among others. Closer inter-row spacing apart from delaying flowering and fruit maturity prolonged the vegetative phase of the African nightshades. A longer vegetative phase is a desirable quality of a leafy vegetable crop that makes intercropping at higher density highly beneficial.

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Average fruit and seed yield of African nightshades

The fruit yield significantly ($p \leq 0.05$) increased with reduction of inter-row spacing of African nightshades (Table 2). The total seed yield followed a similar trend but showed a sharp decline in the number of kilograms produced. A closer analysis of fruit and seed yield per plant however showed a reverse trend as shown in the table 2 where plants that were widely spaced produced heavier and larger fruits while plants closely spaced produced smaller and lighter fruits per plant. This is in agreement with findings of Ezidinma (1974) and Enyi (1973) who when working on cowpeas observed that yields increased with increased plant densities. Reducing the inter-row spacing increased the plant density. This therefore caused an increase in the yield of the seeds in two ways. One way is through the increased number of plants which yielded more seeds than in the widely spaced plants which had lower plant population and subsequently yielding fewer seeds. Another reason for the increased yield with higher plant densities were from the increased competitive ability of crop plants, for they were able to smoother the weed forming canopies.

There was correlation between leaf area index (L.A.I) and photosynthetic active radiation (P.A.R.) values measured under canopies of African nightshade. In plots with wider spacing the L.A.I was significantly ($p \leq 0.05$) very low, the PAR values were very high while plots with smaller inter-rows of African nightshades registered very low values of P.A.R under its canopies. The leaf area index is negatively correlated at 73% with the PAR values under the canopy.

CO_2 assimilation

Carbondioxide assimilation in African nightshades was affected by other internal and external factors within the plant environment. The external factors included time, PAR and leaf temperature. The internal factors that affected carbon assimilation included stomatal conductance and the transpiration rate. There was high correlation of 76% between stomatal conductance and carbon assimilation (fig. 3).

Incidence of weeds

In plots where the inter-row spacing was small weeds were totally suppressed and even in cases where it appeared, it was controlled using the less expensive methods of hand pulling. The prolonged vegetative life of African nightshades at smaller inter-row spacing though being beneficial aspect of a leafy vegetable, had higher incidence of pest attack. Table 3 below summarizes the farm operations performed during the period of the experiment. Studies with other crops have shown that increased seed rates can hasten formation of dense canopies and thus increase the ability of the crop to compete for incoming radiation, shade weeds and help prevent the establishment of late weed flushed (Berkowitz, 1988).

Table 1**:** Mean monthly weather records at Simotwet estate between March to August 2004

Month	**Mean sunshine hrs./day**	**Mean temperature 0C**	**Total rainfall mm/month**	**% RH**	**Total wind run Km/day**
March	197.2	25.0	142.5	72	83.0
April	163.1	22.0	188.9	68	61.3
May	235.4	22.0	181.8	68	80.7
June	198.5	22.0	69.7	67	134.3
July	225.2	22.0	114.3	67	124.0
August	196.7	22.0	64.6	68	122.0

Table 2. Fruit and seed yield of African nightshade after harvesting in the 16th week

Treatment	Total fruit yield (kg)	Average fruit yield Per plot (Kg)	Average fruit fresh wght.(g)	Total seed yield (kg)	Average seed yield per plot (kg)	Average seed yield per plant. (g)
T4	222	74.0	1.33	7.8	2.6	9.56
T3	155	51.7	1.52	5.4	1.8	14.06
T2	171	57.0	1.41	6.0	2.0	10.42
T1	236	78.7	1.34	8.4	2.8	10.29
L.S.D.($p\leq 0.05$)	3.70	2.76	0.04	0.103	0.27	0.71

P.A.R. readings under African nightshade canopies

Table 3. Effects of intercropping on weeding frequency and pest management throughout the entire period of the experiment

Treatment	*Weeding frequency*	*Weeding method*	*Frequency of pest control*
T4	2	Spraying	0
T3	2	Hand pulling	0
T2	1	Hand pulling	1
T1	1	Hand pulling	2

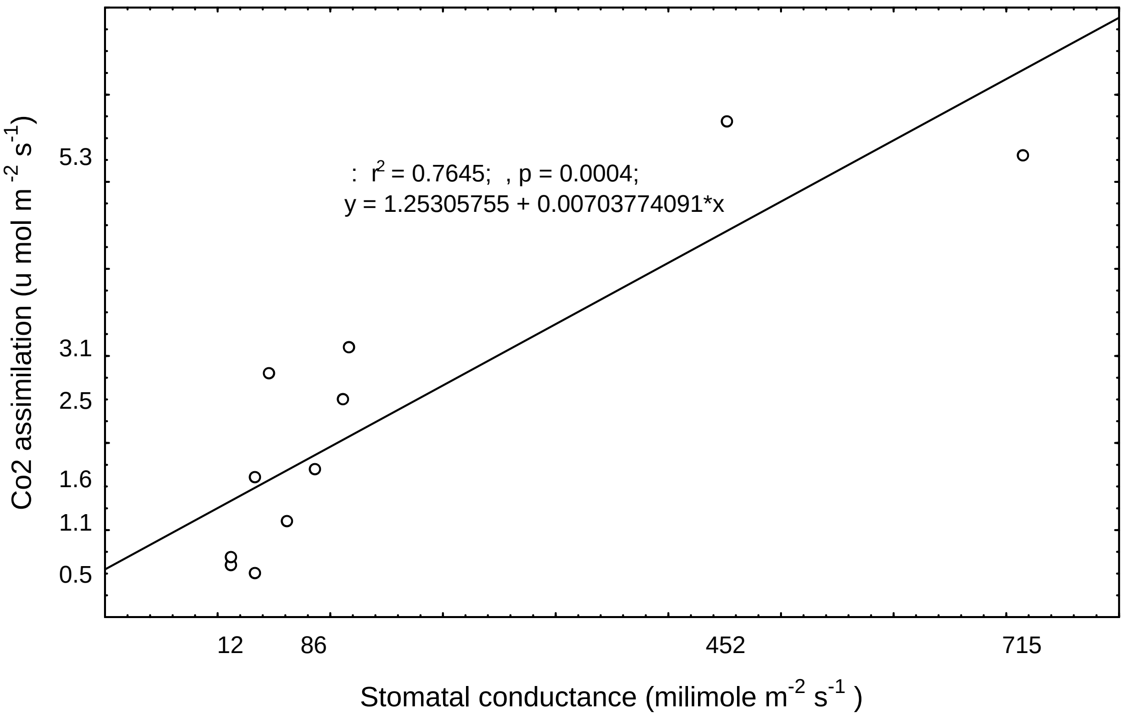

Fig. 3 Relationship between CO_2 assimilation and stomatal conductance in African nightshade at 16th week

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