Journal of Agriculture, Pure and Applied Science and Technology ISSN 2073-8749
Printed by Moi University Press

Response of Tea (Camellia sinensis) to intercropping with African nightshade (Solanum scabrum)

Maritim Joseph[a*], Onyango Collins[a], Onyango Mary[b], Ng'etich Wilson[c]

[a] Department of Botany and Horticulture- Maseno University P. O. Private Bag Maseno, Kenya. E-mail:martmjos@yahoo.com
[b] Department of Horticulture, Jomo Kenyatta University of agriculture and technology, P.O. Box 63000 Nairobi
[c] Department of Soil science, Moi university, Box 1125 Eldoret

* Author for correspondence and reprint requests

J. agric. pure appl. sci. technol. 1, 5-11 (2009); received January 10/February 20, 2009

The main objective of the study was to evaluate suitability of African nightshades as an intercrop in young tea as a cover crop and at the same time provide a high nutritive source of vegetable. The study was conducted at Simotwet tea estate of James Finlay Kenya Ltd in Kericho. The African nightshades (*Solanum scabrum*) were introduced between rows of teas 1.2 m apart with varying plant densities of 1, 2, 3 and 5 rows. The plots were laid out in a complete randomized block design with six treatments and three replications. Six weeks after transplanting of African nightshades into a farm of young tea, growth and physiological measurements were carried out in both plants. Growth parameters studied included plant height, root depth and dry weight. Solar radiation using a ceptometer was also measured. The physiological parameters - CO_2 assimilation, transpiration, leave and air temperature were measured using Infrared gas analyzer. The suitability of intercropping was deduced by calculating the land equivalent ratio (LER)

Results from the study showed that at smaller inter-row spacing, height of African nightshades significantly increased ($p \leq 0.05$). Root depth in tea was also significantly reduced ($p \leq 0.05$) as the number of rows of African nightshades increased. All other growth and physiological parameters studied were not significantly affected ($p > 0.05$). Findings from the experiment showed that it's possible to intercrop young tea with African nightshades without compromising growth of tea when correct spacing is adopted.

Key words: S*olanum scabrum*, intercropping and C*amellia sinensis*

Introduction

African nightshades are widespread edible indigenous vegetable that are presently semi-cultivated. They are marketed country wide just like *Amaranthus spp.* in Kenya. African nightshades have been documented to have high nutritive value with high contents of Vitamins A and C, minerals and supplemental proteins (Chweya, 1997).

Tea is broadly divided into 2 groups, China teas *camellia sinensis* var *sinensis* and Indian teas *Camellia Sinensis* var *assamica*. Tea is an important crop and is one of the Kenya's leading foreign exchange earners. The tea industry supports over 330,000 smallholder tea farmers and provides employment to over 2 million people, mostly in rural areas (Anon,1981).

Tea farmers are faced with problems of getting enough food for subsistence because tea is a perennial crop that can be grown for over 50 years in the same piece of land. Intercropping system may therefore be an option that is yet to be exploited. Intercropping is the growing of two or more crops on the same piece of land at the same time. The aim of such a system is to increase the production from land whilst providing protection from soil erosion (Morgan, 1981). The suitability of intercropping can be determined by the land equivalent ratio (LER). Intercropping brings with it the challenge of competition for limited resources. Competition between and within plant species is a major determinant of crop yield. Plants compete for light, nutrients, space and moisture (Salisbury and Rose, 1986). Optimal plant population reduces competition and enables maximum crop yield. Therefore to achieve the maximum yield the correct spacing must always be observed (Onyango, 1993). The main objective of the study is to evaluate the suitability of African nightshades as an intercrop in young tea so as to act as a cover crop and at the same time provide a high nutritive source of vegetable in the wide spacing of 1.2m left between tea rows.

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 which is about 260 Km West of Nairobi 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. Prevailing climatic conditions between March and August 2004 when most data was collected is summarized in Table 1.

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

Month	**Total monthly sunshine hrs.**	**Mean air temperature ^{0}C**	**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

Planting material and cultural practices

The experiment was set up in farm with young teas that were planted in July 2003 of clone AHP SC 11/9. The area was previously a nursery for tea seedlings. During planting of tea the land was thoroughly cultivated; stumps were removed and burnt off, since tea

does not grow well in areas with patches of wood ash. The area was ploughed using tractors and planting holes made using hand operated drillers.
The depth of each planting holes was about 45cm. Tea was planted at a spacing of 75cm apart in rows and 120cm between rows. Soil conservation was by use of *Solanum scabrum* as a cover crop.

Seeds of African nightshade 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 with established young teas aged ten months and of clone AHP SC 11/9. DAP fertilizer was applied at a rate of 20 gm per planting hole according to (Chweya , 1997). *Solanum scabrum* was grown between rows of tea plants spaced 1.2 m apart at different spacing depending on treatment. The tea farm was lightly tilled before introducing the *Solanum scabrum*.

Experimental design and layout

Field experiments were laid out in a complete randomized block design (CRBD) with six treatments and three replications. Each plot measured 3.5 x 5.0 m with one block measuring 23.0 x 5.0 m. six treatments were applied as follows: Treatment1 (T1) Tea was grown as a sole crop at a spacing of 120 x 75 cm.Treatment 2 (T2**)** *Solanum scabrum* grown as a sole crop at a spacing of 30 x 15 cm. Treatment 3 (T3**)** *Solanum scabrum* grown between rows of young tea in a single row at spacing of 60 x 15 cm between plants. Treatment 4 (T4**)** *Solanum scabrum* grown between rows of young tea in two rows at spacing of 40 x 15cm between plants. Treatment 5 (T5) *Solanum scabrum* grown between rows of young tea in three rows at spacing of 30 x 15 cm between plants. Treatment 6 (T6) *Solanum scabrum* grown between rows of young tea in five rows at spacing of 20 x 15cm between plants.

Soil moisture content

Measurements were obtained using a TDR soil moisture meter (Soil Moisture Equipment Corp. S.A) six weeks after transplanting 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 12 cm 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.

Plant dry weight

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

Root growth

Root system of the plant were excavated by digging around each trunk within a radius of 60 cm. Soil was removed using hoe and a panga. Soils around the roots were removed by washing with water. Only roots with a diameter over 1mm were considered. The maximum root length growing horizontally and vertically was measured on week 6, 10 and 16 after planting.

Measurement of leaf and air temperatures, stomatal conductance, transpiration rate and CO_2 assimilation

This was done using Infra-Red Gas Analyzer (ADC, UK) on week 10, 12 and 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.

Photosynthetic active radiation (PAR) 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 were used to estimate canopy structure parameters such as leaf area index and ground cover.

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

Soil moisture did not show any significant difference ($p>0.05$) 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 intercropping on plant height

The tea height did not change significantly between treatments ($p>0.05$). However under high level of intercropping the tea registered a slight increase in height as compared to the control. This can be attributed to competition for light. Increased height can be attributed to the presence of longer internodes with no auxillary branches. This allows the plants to overtop the canopy and reach full sunlight.

Root depth of tea

There was a clear relationship between levels of intercropping to development of roots in tea. High density plots registered significantly shallower root depth ($p\leq0.05$) than the control. The control plants therefore had its roots growing deeper into the soil than those intercropped when measured at the end of experiment and differed significantly ($p\leq0.05$) from all the other treatments. The shallow rooting in tea was further favored by the environmental conditions of high rainfall during the months of April to August. This observation is in agreement with that reported by Bore (1994) who discovered that when tea plants are heavily mulched they tend to develop shallow rooting system.

PAR readings under tea and African nightshade canopies

There was correlation between leaf area index (L.A.I) and photosynthetic active radiation (PAR) values measured under canopies of tea and African nightshade intercrop. In control plots where the L.A.I was significantly ($p\leq0.05$) very low, the PAR values were very high while plots with highest number of rows of African nightshades registered very low values of PAR under its canopies. The control was significantly ($p\leq0.05$) different from all the treatments. The leaf area index is negatively correlated at 73% with the PAR values under the canopy (Fig 1).

CO_2 assimilation

Carbon assimilation in tea was not significantly affected by intercropping ($p\geq0.05$). However Tea plants grown alone had slightly higher levels of CO_2 assimilation while those growing in plots with high density of African nightshade intercrops had a slightly lower level of CO_2 assimilation. Carbon assimilation in tea plants was also affected by other internal and external factors within the plant environment (Fig.2). This is in agreement with findings by Netondo (1999) and Ng'etich (2003) who reported a positive correlation between the stomatal conductance and transpiration, indicating that stomatal closure is mainly responsible for reduced transpiration in tea.

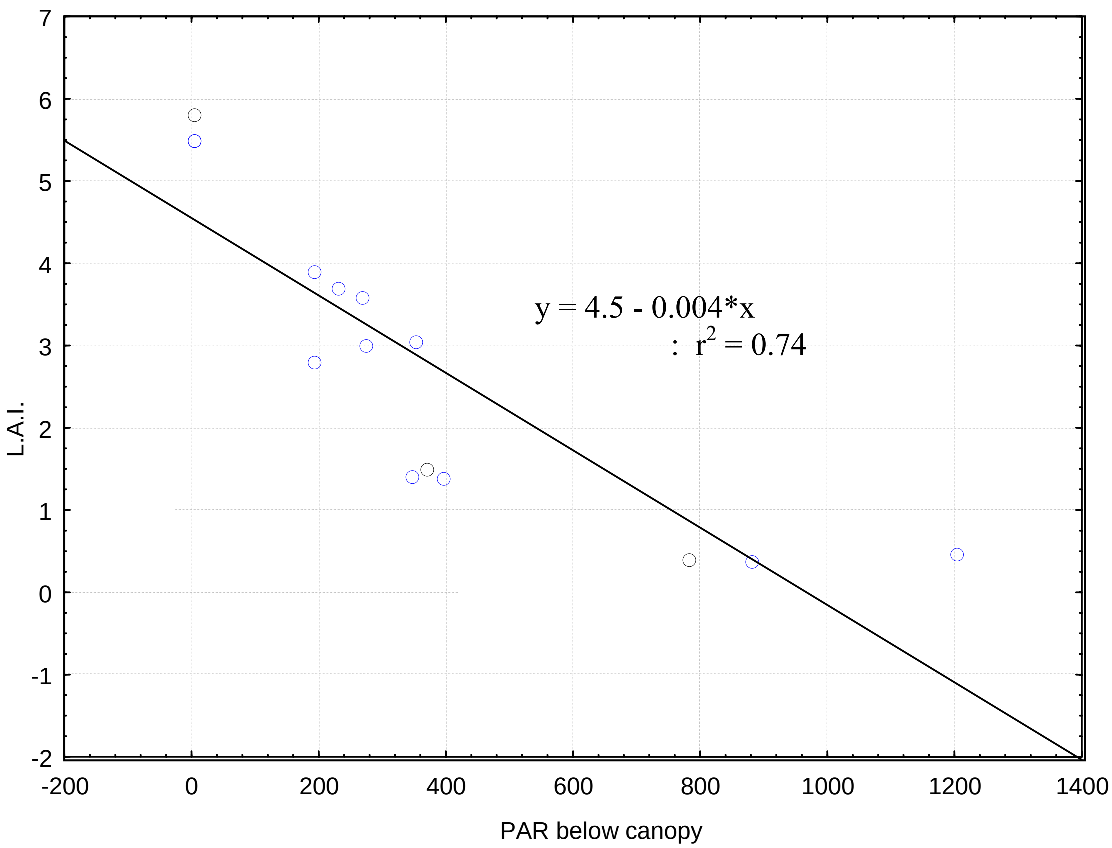

Fig. 1 Relationship between leaf area index and PAR below tea and African nightshade intercrop canopy.

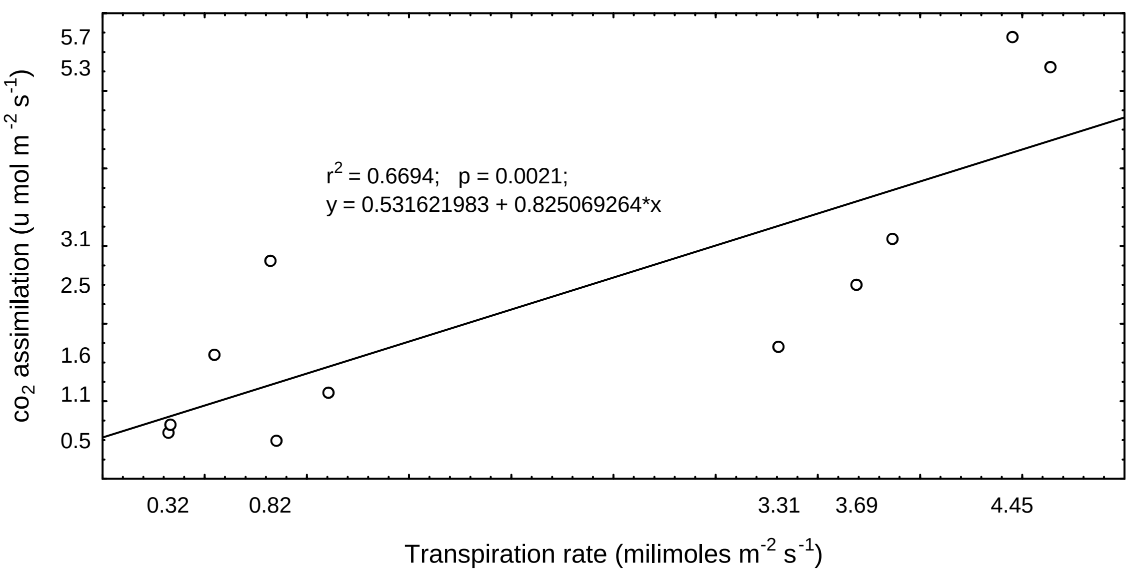

Fig. 2 The relationship between CO_2 assimilation rate and transpiration in Tea at the 16th week of the experiment.

Land equivalent ratio

The efficiency of an intercropping system can be evaluated by land equivalent ratio (LER). The LER is the ratio of the area under sole cropping, at the same level of management that gives an equal yield.

$LER= X_s/X_i + Y_s/Y_i$

Where X = tea sole crop X_i = tea intercrop. Y = African nightshade sole crop

Y_i = African nightshade intercrop

In this experiment the total fresh weight per plot was used as a measure of productivity. The LER values at optimum spacing of three rows between tea was 2.52 while LER under two and five rows were1.58 and 1.92 respectively. These results are consistent with observations by Martin and Snadon (1982) on Barley/common beans intercrops who observed that the LER based on seed weight was consistently greater than 1.0 when the crops were grow in alternate rows (1.85) than when sown within row mixture (1.53).

Acknowledgement

The authors convey their appreciation to the Tea research foundation of Kenya for providing laboratory space and equipment that led to the success of this research. We also recognize the contribution of James Finlay Company for providing the farm for this experiment.

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