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Effects of three tree species on microclimate and soil amelioration in the central rift valley of Ethiopia

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The effect of *Balanites aegyptiaca*, *Acacia tortilis* and *Acacia seyal* on soil fertility and microclimate was studied in the central rift valley of Ethiopia. Sampling was done in randomized complete blocks at 1/3 radius, 2/3 radius and at crown edge radius from the tree base and control was maintained at an open area. All soil and microclimatic parameters observed under the canopy distances were significantly different from the open control (P<0.05) except soil texture. Soil bulk density increased from the trees base to open field. Available Nitrogen under crown of *A. tortilis* in all crown radii was much higher than that of *B. aegyptiaca* and *A. seyal*; available Potassium was significantly higher under *B. aegyptiaca* and *A. tortilis* at their 1/3 and 2/3 crown radii. *B. aegyptiaca* at 1/3 crown radius had significantly higher level of available Phosphorus. Cation exchange capacity (CEC) was significantly higher under the 1/3 and 2/3 crown radii of all the involved trees. Soil moisture decreased whereas relative illumination, soil and below canopy temperatures showed increasing trend towards the crown periphery revealing the significant canopy cooling effect. Inclusion of higher number of these trees can reduce adverse climatic effects in the semi-arid valley and supplement organic source of nutrients.

Key words: *Acacia seyal, Acacia tortilis, Balanites aegyptiaca,* microclimate modification, soil amelioration.

INTRODUCTION

Low soil fertility is the most fundamental cause for low agricultural productivity, food insecurity, low income and poverty in Ethiopia (Abebe, 2006). Maintenance of soil quality is considered essential for ensuring sustainable land use. Hence, land resource management must aim at soil conservation (Parysow, 2001). Loss of soil quality is explained through increased bulk density, reduced inorganic matter content and availability of soil nutrients (Brenner, 1994). Agroforestry can be a viable option to alleviate the degradation and loss of soil fertility from the agricultural fields.

The central rift valley in Ethiopia is being noticed for a shift in the use of land from dense woodland with palatable pasture to a farm land with scattered trees for growing agricultural crops to feed the growing population. The system is described as agroforestry parkland where naturally regenerated and scattered individual trees occur in cultivated fields. The scattered trees provide ecological

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services such as soil fertility and microclimate amelioration (Tomlinson et al., 1995; Boffa, 1999; Bayala et al., 2002; Teklehaimanot, 2004).

Parkland agfroforestry is an important land use system that has a positive influence on maintaining soil fertility, mainly due to the tree component (Kamara and Haque, 1992; Mulongey and Merck, 1993). The effect of the tree component on soil can be seen by comparing soil properties under individual tree canopies with surrounding tree-less areas. According to Tilahun (2007), *Faidherbia albida* has shown a 50 to 100% increase in organic matter and nitrogen under the canopy. In semi-arid climates, it is common to find higher soil organic matter and nutrient content under tree canopies than in adjacent open land and cropland (Rao et al., 1998). The presence of trees on farmland adds nutrients to the soil through biological nitrogen fixation and efficient nutrient cycling (Tadesse et al., 2002). This is an inexpensive and environmentally safe organic N source that has the potential of meeting nitrogen demand, the most important and scarce agricultural nutrient element (Nair, 1984).

Trees influence microclimate and soil property through organic matter accumulation and canopy produced shade which reduces evaporation from the soil surface and modifies air temperature extremes (Hugues and Philippe, 1998). Tree roots hold soil in place and tree crown reduces the intensive force of rainfall and also acts as physical barrier in controlling runoff. The contribution of *Acacia tortilis* and *Balanites aegyptiaca* to soil fertility improvement in Afar region of Ethiopia was documented by Abule et al. (2005). The tree species (*A. tortilis, B.aegyptiaca* and *Acacia seyal*) taken up for this study, are generally considered valuable species for soil improvement and conservation (Nyberg and Högberg, 1995; Raddad and Luukkanen, 2007). Thus, the present study was initiated with the objective to assess and compare the farm trees potential in site and soil amelioration in the semi-arid environment.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Arsi Negelle district, which is located in West Arsi zone of Oromia, a regional state of Ethiopia. The district is 210 km south of Addis Ababa at 38° 30´ to 38° 40´ E and 7°25´ to 7° 40´N. It is a part of the Ethiopian central rift valley, covering an area of 1400 km^2 (Efrem et al., 2009). The topography of the area is flat to undulating. According to local climatic classification, the altitude ranges from 1610-1680m.a.s.l is categorized as dry Weyna Dega/savannah (Azene et al., 2007). The annual rainfall of the site is between 500 and 835 mm, characterized by high intensity and short duration showers occurring mainly from June to August, sometimes extending up to September. The area is known for its high temperature with little variation between dry and rainy season. The mean monthly maximum temperature is 28°C and minimum temperature is 13.8°C.

The soil is dark brown to dark greyish brown Vitric Andosol and The surface soil, as Murphy (1968) explained, is generally loose (low bulk density, friable-coarse sandy loam). Soil pH ranges from 7.3 to 8.5 (alkaline) while organic matter varies between 2.93 and 3.10%. The soil is deficient in phosphorus (< 12.4 kg ha^{-1}), and to a lesser extent, also in nitrogen (< 272 kg ha^{-1}) as indicated by FAI (1977). The vegetation of the area is classified mainly as *Acacia-Balanities* vegetation type (Nazereth, 1998) with some thorny shrubs of *A. tortilis* and *A. seyal.* Crop production is primarily rain fed and livestock rearing is the mainstay of livelihood of the local population. The major crops grown are maize, wheat, *teff* and barley under parkland agrisilviculture system.

Experimental details

Three tree species namely *B. aegyptiaca* (L.) Del., *A. tortilis* (Forsk.) and *A. seyal* (Del.) were taken.

Distances from tree base were: at 1/3 of tree crown radius; 2/3 of tree crown radius; crown edge; and open control away from canopy/tree root influence. Soil physico-chemical properties and some microclimatic changes under tree crown were then studied at 0 at 20 cm soil depth at three distances from tree base and one open control common for all the three tree species. The experiment was conducted in randomized complete blocks with three replications.

Tree selection and soil sampling

Tree selection

Nine scattered trees, three from each species were randomly selected in the blocked area based on their relative similarities in diameter at breast height (DBH) and total height. There were dissimilarity in crown diameter and crown area measured (Tables 1 and 2) for the tree species involved, hence, variables were studied at 1/3, 2/3 and crown edge of the individual trees so as to enable comparison between species.

Soil sampling

Three concentric circles were drawn under each tree crown at 1/3 crown radius, 2/3 crown radius and edge of the crown. Additionally, samples were also taken from the blocks in the open control area away from tree effect. Aiming for a representative soil samples, four sub-composites from each direction under nine trees and four distances including the open control area were collected. Hence, thirty six samples which consisted of 144 sub-composites were analysed for soil fertility.

Data collection

Data on physico-chemical properties of soil

The distribution of different particle size fractions for soil texture evaluation was determined by the modified Bouyoucos method using a hydrometer after destruction of organic matter with 30% of H_2O_2 and using 5% sodium hexametaphosphate (Calgon) as a dispersing agent (Day, 1965; Gee and Bauder, 1989). Soil bulk density (g/cm^3) was determined using the non-destructive core-volume method by dividing the weight of oven dried soil in the core (g) to the volume of the dry soil (cm^3). Soil pH was determined in water at a soil-water suspension ratio of 1:2.5 after stirring for 2 h; a reading was made using combined electrode method (Jackson, 1973). Similarly, electrical conductivity was measured from the same soil-water suspension prepared for pH determination, using a conductivity meter at 25°C (Jackson, 1973).

Table 1. Mean height, DBH, and crown area distribution of the selected *Balanites aegyptiaca, Acacia tortilis* and *Acacia seyal* tree species.

Tree species	Height (m)	Std. error	DBH (cm)	Std. error	Crown area (m^2)	Std. error
B. aegyptiaca	8.33	0.33	37.44	0.46	90.05	11.54
A. tortilis	12	0.58	39.23	0.30	236.55	17.79
A. seyal	8.35	0.43	30.89	0.55	126.65	13.61

Table 2. Mean distance in meter of crown radii of the studied tree species.

Tree species	Crown radius	Mean distance in meter	Std. error
B. aegyptica		3.07	0.19
A. tortilis	1/3 crown radius	5.01	0.20
A. seyal		3.65	0.19
B. aegyptica		4.35	0.27
A. tortilis	2/3 crown radius	7.08	0.28
A. seyal		5.17	0.27
B. aegyptica		5.33	0.33
A. tortilis	Crown edge	8.67	0.35
A. seyal		6.33	0.33

Available nitrogen was assessed by Alkaline Potassium Permanganate method by using the Kjeldhal distillation unit where the digest was distilled in the presence of sodium hydroxide and distillate trapped in 0.02N H_2SO_4. The ammonia liberated was titrated with 0.02 N NaOH to assess the available nitrogen content of the samples (Subbiah and Asija, 1956).

Available phosphorus was determined by the Olsen method in which samples were extracted with sodium bicarbonate solution at pH 8.5 and the P content in the extracted samples was determined calorimetrically after they developed the blue colour with ammonium molybdate in the presence of ascorbic acid as a reducing agent (Olsen et al., 1954).

Available potassium was measured by the Neutral Ammonium Acetate extraction method (Merwin and Peech, 1951). The extracted sample was estimated by flame-photometer. Soil organic carbon was determined by Rapid Titration method in which the organic matter was oxidised by potassium dichromate in the presence of concentrated H_2SO_4.The excess potassium dichromate was back titrated with ferrous ammonium sulphate using diphenylamine indicator (Walkley and Black, 1934).

The cation exchange capacity (CEC) of the samples was estimated by 1 M Ammonium Acetate extraction method as outlined by Reeuwijk (2002).

Modification of microclimatic conditions

Sampling and all the measurements in the microclimate of the area were carried out in the midday of the study period. Soil moisture was determined gravimetrically where the samples of fresh soil were weighed and oven-dried at 105°C for 24 h. The percentage of water present in the soil was calculated as the weight difference between field soil and oven dried soil, divided by the weight of the oven dried soil, multiplied by 100. Soil temperature was measured using a Mercury Soil Thermometer whereas below canopy temperature by using Digital Infrared Thermometer (Model AG–42). The relative illumination for the respective distances under canopy was calculated in relation to open field by using Lux meter. The data was collected for three months during the main rainy season, that is, in the months of May, June and July; reason being foliage regrowth and full crown cover is achieved during this time.

Data analysis

The data collected from laboratory analysis on soil physico-chemical properties and field observation on microclimatic changes was subjected to two way analysis of variance (ANOVA). The significant differences between means were determined by LSD at 5% probability level.

The values for microclimatic study were the averages of the daily observations at midday of the particular month.

RESULTS AND DISCUSSION

Evaluation of the tree species potential in soil amelioration

Soil texture

The difference in the treatment effects of the trees on the mean values of soil particle fractions of sand, silt and clay at different distances from the trees base at 0 to 20 cm soil layer was not significant (Table 3). As a result, the particle size distribution of the soils at the measured soil layer of all treatments was categorized under sandy loam textural class indicating no significant effect of the tree

Table 3. Particle size distribution as affected by tree species and distance from tree bole.

Species	Crown radius	Soil particle distribution			Textural class
		Sand%	Silt%	Clay%	
	1/3 crown radius	63.00	22.33	14.66	Sandy loam
B. aegyptiaca	2/3 crown radius	61.00	24.66	14.33	Sandy loam
	Crown edge	63.00	24.33	12.66	Sandy loam
	1/3 crown radius	66.33	21.00	12.66	Sandy loam
A. tortilis	2/3 crown radius	66.33	21.00	12.66	Sandy loam
	Crown edge	65.66	21.00	12.66	Sandy loam
	1/3 crown radius	60.33	23.00	16.66	Sandy loam
A. seyal	2/3 crown radius	59.66	25.00	15.33	Sandy loam
	Crown edge	59.00	24.33	16.66	Sandy loam
	Open control	63.33	22.33	13.66	Sandy loam
LSD 0.05		7.29 (NS)	6.21 (NS)	5.19 (NS)	

species involved in soil texture. The finding is in agreement with Akpo et al. (2005) who reported no significant influence of tree species on soil texture modification. Soil texture is mainly dependent on parent materials of the soil. It affects soil quality; influences the nutrient supplying ability of soil solids, soil moisture and air relations, and root development (Spur and Barnes, 1980).

Soil pH

Analysis of soil pH revealed that it was not significantly affected by the different treatment combinations of tree species and the distances from tree base (Table 4). It was observed to be slightly above neutral in all the treatments; however, in semi-arid climates such as the area under study, pH at this range is expected and normal. For the growth of the most predominant crop of the area under study which is maize, the pH value is slightly higher; yet, would not be deleterious and need gypsum application. Agbede (2008) and Hailemariam et al. (2010) reported lower pH values under *B. aegyptiaca* at Goblel and Korbebite sites from northern Ethiopia. Higher organic matter and clay content coupled with sufficient soil moisture may have led to the lower pH values.

Electrical conductivity

The maximum and significantly higher mean value of electrical conductivity was recorded under *B. eagyptica* at 1/3 and 2/3 crown radii whereas the mean values of electrical conductivity recorded under the other tree crown radii were much lower and statistically at par with the open control and one another (Table 4). The higher values at the inner and middle crown radii of *B. aegyptiaca* may be caused due to the relatively higher leaf biomass and fruit drop which upon decomposition release soluble nutrients to the soil. Hailemariam et al. (2010) also reported higher EC value under canopy than the open field of *B. aegyptiaca* at Limat site in northern Ethiopia.

Organic carbon in soil

Soil organic carbon under *A. tortilis* at 1/3 crown radius was recorded the highest; it was also statistically at par with and significantly high under tree crown of other treatments as compared to the open control area. However, *B. aegyptiaca* at the crown edge had lower value of organic carbon due to the narrower crown radius and its sparse crown edge cover which possibly yield less leaf litter at that distance (Table 4). Rao et al. (1998) argues that it is common to find higher soil organic matter and nutrient content under tree canopies than in adjacent open land and cropland in semi-arid climates. For soil under cultivation, mineralization is favoured over humification (Brinson *et* al., 1980; Toky et al., 1989). The major avenues for addition of organic matter to the soil where trees are growing, is through litter that is, leaves, twigs, branches, fruits, and so on (Quideau and Bockheim, 1996).

Available Nitrogen

Available nitrogen was significantly influenced by the combined treatments of tree species and distances where the maximum value was recorded under *A. tortilis* at 1/3 crown radius which however, was statistically at par with its mean value at 2/3 crown radius and crown

Table 4. Bulk density, pH, electrical conductivity and organic carbon as influenced by tree species and distance from tree bole.

Species	Crown radius	Bd gcm^{-3}	pH	EC (dS/m)	%OC
A. aegyptiaca	1/3 crown radius	0.94^{a}	7.68^{a}	0.13^{a}	2.49^{a}
	2/3 crown radius	1.02^{b}	7.31^{a}	0.13^{a}	1.62^{a}
	Crown edge	1.10^{b}	7.58^{a}	0.11^{b}	1.35^{b}
A. tortilis	1/3 crown radius	0.87^{a}	7.63^{a}	0.10^{b}	2.83^{a}
	2/3 crown radius	0.95^{a}	7.66^{a}	0.08^{b}	2.24^{a}
	Crown edge	1.02^{b}	7.6^{a}	0.08^{b}	2.17^{a}
A. seyal	1/3 crown radius	0.97^{a}	7.69^{a}	0.12^{b}	2.73^{a}
	2/3 crown radius	1.10^{b}	7.74^{a}	0.11^{b}	2.14^{a}
	Crown edge	1.11^{b}	7.73^{a}	0.10^{b}	2.16^{a}
	Open control	1.24^{b}	7.66^{a}	0.09^{b}	1.32^{b}
$LSD_{0.05}$		0.23	0.47(NS)	0.03	0.55

Different superscript alphabets within a column at a particular treatment represent significant difference from the control at P < 0.05

Table 5. Available Macronutrients and CEC as influenced by tree species and distance from tree bole.

Species	Crown radius	Soil variables			
		Av. N (kg/ha)	Av. P (kg/ha)	*Av. K (kg/ha)*	CEC (cmol Kg^{-1})
B. aegyptiaca	1/3 crown radius	159.93^{a}	14.34^{a}	211.61^{a}	34.31^{a}
	2/3 crown radius	139.02^{b}	12.63^{b}	188.26^{a}	32.69^{a}
	Crown edge	129.62^{b}	10.29^{b}	171.5^{b}	31.69^{b}
A. tortilis	1/3 crown radius	185.02^{a}	12.86^{b}	216.96^{a}	37.55^{a}
	2/3 crown radius	169.34^{a}	12.63^{b}	198.62^{a}	33.29^{a}
	Crown edge	164.11^{a}	11.41^{b}	189.09^{a}	29.75^{b}
A. seyal	1/3 crown radius	157.84^{a}	13.11^{b}	$153.96^{b,bc}$	34.65^{a}
	2/3 crown radius	139.02^{b}	11.33^{b}	$145.26^{b,bc}$	32.69^{a}
	Crown edge	137.02^{b}	11.22^{b}	136.99^{c}	28.56^{b}
	Open control	111.15^{b}	9.06^{b}	106.38^{d}	23.83^{c}
$LSD_{0.05}$		33.35	4.32	29.21	5.03

Different superscript alphabets within a column at a particular treatment represent significant difference from the control at P < 0.05

edge, *B. aegyptiaca* and *A. seyal* at their 1/3 crown radius (Table 5). The lowest value of available nitrogen was recorded at the open control which was preceded but statistically alike to the values under *B. aegyptiaca* and *A. seyal* at their 2/3 crown radius and crown edge. Despite the higher contribution of the tree species in available nitrogen content, the observed values in both the soil layers were categorized as “low fertility class” as per the ratings of FAI (1977). Total nitrogen and the mineral nitrogen flux had progressive decrease from the trunk to the canopy margin under the tree of *Acacia Senegal, B. aegyptiaca and Adansonia digitata* in semi-arid zones of northern Senegal (Young, 1989). Higher soil nitrogen content under tree canopies than away from tree influence was reported for all distances and soil depths under *F. albida*, *B. aegyptaica* and *Cordia africana* (Kamara and Haque, 1992; Akpo et al., 2005; Abebe Yadessa et al., 2009).

Available Phosphorus

Significantly higher amount of available phosphorus was recorded under *B. aegyptiaca* at 1/3 crown radius, which was followed by statistically different values under *A. seyal* and *A. tortilis* at their 1/3 crown radius. On the other hand, minimum value of available phosphorus was recorded at the open control away from tree influence which however, was statistically same to the values in the rest of the trees distance treatments (Table 5). Higher level of available phosphorus at the closest distance to the tree base can be ascribed to organic phosphorus input from leaf litter deposition and release at mineralization, higher microbial population stimulated by organic matter input which supported phosphorus solubilisation from fixation. However, the observed values near the tree base for available phosphorus put the soil under category of “medium fertility class” (FAI, 1977). The soil in the open control away from tree influence is deficient in available P content is in agreement with the findings of Fikru (1998). Soil phosphorus concentration decreased as the distance increased from the bole to the outside of the canopy (Kamara and Haque, 1992).

Available Potassium

The analysis indicated that the mean value of available potassium content was significantly higher under *A. tortilis* at 1/3 crown radius, which was followed by statistically same values under *B. aegyptiaca* at 1/3 and 2/3 0crown radii; and *A. tortilis* at all crown distances (Table 5). Lowest available potassium content was recorded at the open control which was preceded by the value under *A. seyal* at the crown edge (Table 5). The observed values under the trees’ crown radii for available potassium are in the medium range (FAI, 1977). In soil amelioration study, high total nitrogen and potassium concentration was observed under canopy of *Parkia biglobosa* (Jacq.) Benth. in West Africa (Tomlinson et al., 1995). The reason behind the high concentration of available potassium under canopy than the open area might be high organic matter accumulation, decomposition and release in the soil (Brady and Weil, 2002).

Cation exchange capacity

The treatment combinations involving tree species and distances from tree base have significantly influenced the mean values of cation exchange capacity of the soil. Cation exchange capacity (CEC) was maximum (37.55 cmol kg^{-1}) under *A. tortilis* at 1/3 crown radius which however, was statistically similar to the mean values at its 2/3 crown radius; *B. aegyptiaca* and *A. seyal* at 1/2 and 2/3 crown radii. The minimum value of 23.83 cmol kg^{-1} cation exchange capacity was recorded at the open control which was preceded, but statistically similar to the values under *A. tortilis* and *A. seyal* at their crown edge (Table 5). Soil with CEC values above 25 cmol kg^{-1} is commonly taken as having a good nutrient holding capacity. The results depict the trees’ influence with added organic matter to attain higher CEC values at their inner crown radii. Similar findings by Taddese et al. (2002) state the concentration of CEC under canopy of *Millettia ferruginea* to be higher than the open field in south Ethiopia. In the middle awash rift valley of Ethiopia, concentration of CEC under canopy of *Prosopis juliflora* was higher as compared to the open area with no clear difference in soil layers (Ameha, 2006).

Tree species relative effect on microclimate during the main cropping season

Soil moisture

Soil moisture is one of the factors that hinder crop success in the semi-arid rift valley. The valley has history of several crop failures due to erratic rains. Under canopy of the studied tree species it appeared to be significantly higher than the open control. The highest soil moisture recorded in the month of May was 11.3% under *B aegyptiaca* at the 1/3 crown radius which increased to 12.87% in June (Figure 1). Then due to the denser canopy cover, *A. tortilis* took over the maximum in July which was recorded 18.99%. The differences in soil moisture from the maximum at 1/3 crown radius of the tree species over the open control were 4.13, 4.55 and 7.87% in May, June and July respectively. The soil moisture, from the beginning of the first month of cropping season to the second and third month increased under each tree species. The reasons for this change were increased rainfall, decreased evapotranspiration and increased relative humidity in the valley. Similarly, Kessler (1992) reported that improved availability of water under tree canopies was due to decrease in actual evapotranspiration as well as better water infiltration. On the other hand, Akpo et al. (2005) observed that soil moisture under shade was not significantly different under *A. tortilis* and *B. aegyptiaca*, suggesting that there was no species effect on soil moisture content.

Soil temperature

The tree species had cooling effect with their aboveground influence on the soil under crown cover. The lowest temperature recorded was 30°C under *B. aegyptiaca* at 1/3 crown radius in the month of May. Later on it decreased under 1/3 canopy radius of *A. tortilis* to 28 and 25°C in the month of June and July respectively. About 6.11, 4.44 and 6.0°C reduction in soil temperature was achieved (Figure 2) over the maximum at the open control in May, June and July respectively. In a similar microclimate modification study, Lin (2007) observed that the amount of shade cover is directly related to the

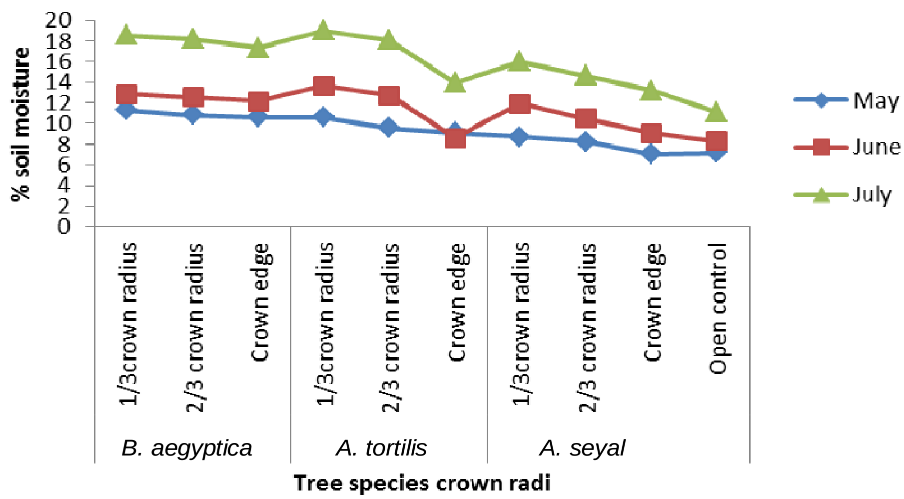

Figure 1. Soil moisture as influenced by tree species and distance away from tree base.

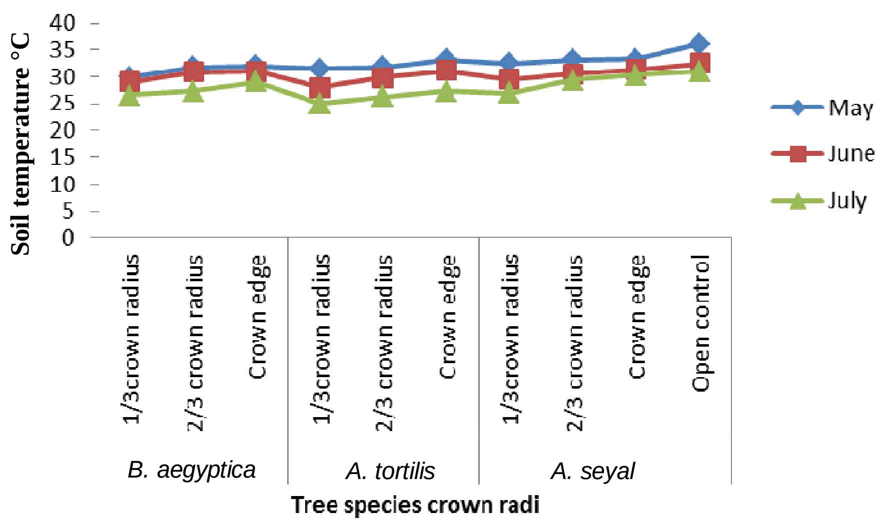

Figure 2. Soil temperature in °C as influenced by tree species and distance from tree base.

mitigation of variability in microclimate for the crop of interest. The use of agroforestry systems is an economically feasible way to protect crop plants from extremes in microclimate and should be considered a potential adaptive strategy for farmers in areas that will suffer from extremes in climate.

Below-canopy temperature

In the month of May erratic rains stimulated the regrowth of new flush leaves on the trees thereby influencing the below canopy temperature of the trees. *B. aegyptiaca* do not shed all the leaves in the dry season and moreover it develops edible fruits of pecan nut size during the dry season. Therefore, *A. tortilis* and *B. aegyptiaca* had significantly lower below canopy temperature in the studied months over the open control. Accordingly, mean temperature reductions over the open control during May, June and July were 6.3, 6.7 and 7.3°C at 2/3 crown radius of *A. tortilis*, 1/3 crown radius of *B. aegyptiaca* and 1/3 crown radius of *A. tortilis* respectively (Figure 3). However, below canopy temperatures at crown edge of *B. aegyptiaca*, at 2/3 crown radius and crown edge of *A. seyal* were statistically same to the open control. Narrower were the below canopy temperature differences at middle and peripheral distances of *A. seyal* to that of the open control. From the data, it is evident that *A. tortilis* is superior in reducing below canopy temperature at its nearest and middle canopy distances as compared

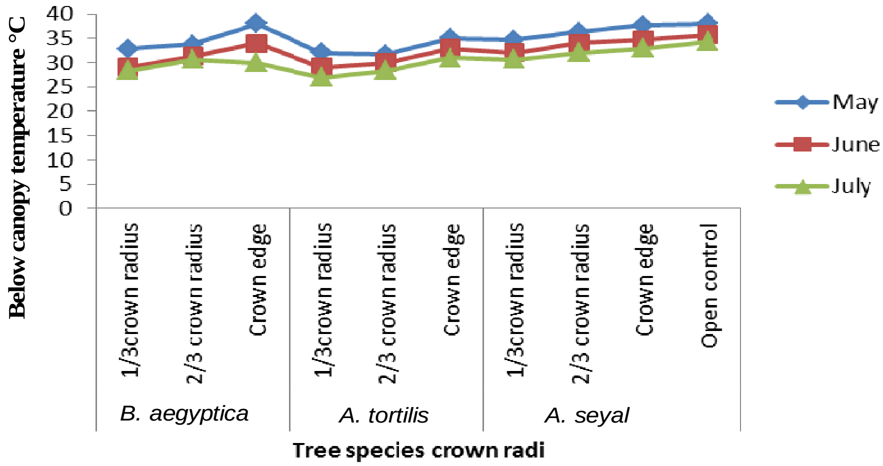

Figure 3. Below canopy temperature in °C as influenced by tree species and distance from tree base.

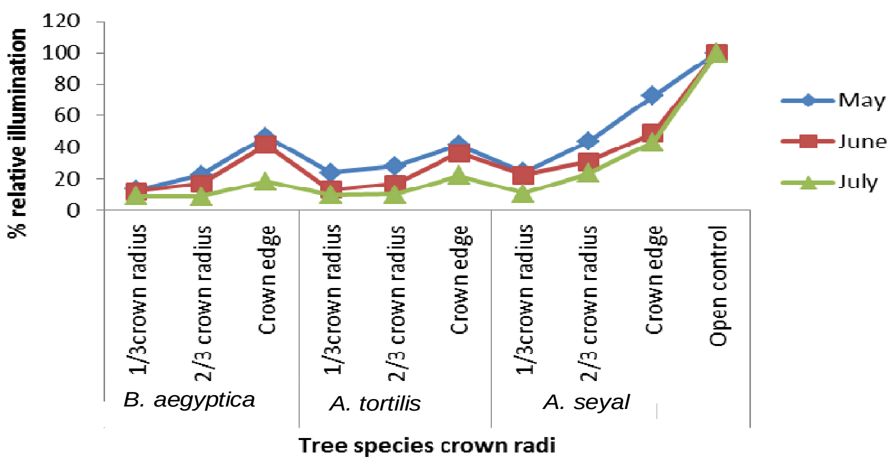

Figure 4. Percent relative illumination as influenced by tree species and distance from tree base.

to the other tree species. Akpo et al*.* (2005) recorded mean difference of 5°C between the shaded, that is, 1 m away from the tree trunk and in the open, that is, 16m away from trunk areas in the midday. The authors interestingly noted that early in the morning temperature under the shade was higher than in the open by about 1.5°C. The results indicated that trees reduce below canopy temperature fluctuations by decreasing the maxima and increasing the minima.

Percent relative illumination

The tree canopies during the month of May had transmitted much of the light received from the sun. When the deciduous trees regrow new leaves stimulated by the first rains, the canopy started to cover reducing the light transmission ratio in the following months. Relative illumination followed decreasing trend from May through June to July. In all the studied months, light transmission was the lowest through the crown of *B. aegyptiaca* at the 1/3 crown radius followed by *A. tortilis*. Percent relative illumination received at 1/3 crown radius under *B. aegyptiaca* was reduced by 86% in May, 87.9% in June and 91.44% in July over the open area. However, much higher intensity of relative illumination was received at the middle and peripheral distances of the trees species under study (Figure 4). Trees and shrubs may reduce solar radiation under canopies by 45 to 60% in the Sahelian zone and 85 to 95% in the Sudan savannah. The transmission of direct solar radiation through tree canopies at midday differed a little across species, that is, *A. tortilis* 21.3%, *B. aegyptiaca* 16.8% and *Ziziphus Mauritania* 20.1% (Akpo et al., 2005).

Conclusion

From the findings of the study of the effect of the trees on soil and microclimate, it can be concluded that (i) the tree species studied had no effect on soil texture; (ii) there is an improvement in the physical properties of the soil and also an increase in the content of plant available nutrients in the soil below tree canopies. *A. tortilis* contribute much higher level of available N than that of *B. aegyptiaca* and *A. seyal* in all crown radii; however, it was found to be in lower range to satisfy growth of associated crops and requires inorganic amendments. Available K was significantly higher under *B. aegyptiaca* and *A. tortilis*. *B. aegyptiaca* at 1/3 crown radius had significantly higher and superior level of available phosphorus. Similarly, CEC was significantly higher under the 1/3 and 2/3 crown radii of all the involved trees than in the open field. (iii) There is favourable effect on the microclimate as shown by a reduction in relative illumination, soil and below canopy temperatures as well as higher level of soil moisture below tree canopies; (iv) The semi-arid rift valley demands higher tree density than it currently has, to have broader area canopy cover to avert crop failure and ensure crop success, reduce livestock heat stress and improve food security in the region.

Conflict of Interest

The authors have not declared any conflict of interests.

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