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Effect of tree pruning on net assimilation rate (NAR) and crop growth rate (CGR) of dry season sorghum (*Sorghum Bicolor* (L.) Moench in the semi and zone of Nigeria

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ABSTRACT: The effect of *balanites aegyptiaca*, *Prosopis juliflora* and *Acacia nilotica* on Net Assimilation Rate (NAR) and Crop Growth Rate (CGR) of dry season sorghum, (*Sorghum bicolor*(L.) Moench) was investigated in October/November, 1995. *B. aegyptiaca* were small and so were not pruned but *P. juliflora* and *A. nilotica* were pruned. The result showed that the effect of tree species on sorghum varied with tree species such that *B. aegyptiaca* did not reduce Net Assimilation rate (NAR) and therefore Crop Growth Rate. Pruning *P. juliflora* significantly ($P<0.05$) improved Net Assimilation rate and consequently Crop Growth Rate over the unpruned treatment. However, *A. niloticaI whether pruned or unpruned as well as unpruned P. juliflora* inhibited Net Assimilation Rate and Crop growth in sorghum significantly ($P<0.05$) compared with the small canopy *B. aegyptiaca* and the non tree control. Competition for limited moisture and light was responsible for decrease in assimilation per unit area of leaf resulting in low crop growth. The result suggests that *B. aegyptiaca* or pruned *P. juliflora* can be planted with dry season sorghum.

Key words: Dry season sorghum, Net Assimilation rate, Crop Growth Rate, Agroforestry.

Introduction

In the Sudano-Sahelian zone, pressure on natural resources from increasing human population density is leading to a decrease in the length of the traditional bush-fallow cycle, and the progressive removal of woody vegetation from the landscape. Over exploitation has caused, in turn, a decrease in soil fertility and structural stability, leading to reduced infiltration of water, lower crop yields, and the need for people to walk further to collect firewood, fodder and fruit. The planting or retaining of indigenous trees on crop fields, a type of land use practice embraced by the term 'agroforestry' which is common in the humid and sub-humid tropics, could provide a single, low input solution to these problems if positive effects of the trees on the system, such as amelioration of the soil, outweigh the negative effects, such as competition with the crop for limited soil moisture (1,2,3). In the sudano-sahelian, north eastern Nigeria, sorghum production is on the vertisolic soils found in the semi-arid north eastern region near Lake Chad at Latitude 13-14°E and Longitude 12-13°N (4). In this area of Nigeria, more than 80% of the population is rural, engaging in arable farming of dry season sorghum (*Sorghum bicolor* (L.) Moench) grown as a sole crop and as the main source of income. The dry season sorghum is locally known as 'Masakwa'. Flood waters arising from the short wet season, which could naturally drain to the lake are contained in fields with contour bunds to reduce run off and aid of the rainy season (September/October) to allow drainage prior to growing the crop. The crop is transplanted at this time from nursery seedlings grown during the rains on somewhat raised sandy areas, and growth is solely upon residual moisture (5,4).

Determining the effects of trees on crop yield in both the short and medium term is essential to the promotion of tree establishment and retention of cultivated land.

Accordingly, there have been various published studies of the growth and yield of sorghum in semi-arid areas. Hocking and Rao (6) observed a reduction in yield and carbon accumulation in sorghum grown in association with the aggressive, exotic legume, *Leucaena leucocephalain* a semi-arid area of India as compared with sole cropping. Similarly, Singh, *et al* (7) showed that the growth of sorghum decreased with proximity to trees, because of a reduction in dry matter when intercropped, and a higher soil moisture content in the monocropped fields than in the intercropped, and a higher soil moisture content in the monocropped fields than in the intercropped. Kater, *et al* (8) working on sorghum observed a reduction in yield when grown with three tree species compared to higher yield of the sole crop. Although Doggett (9) has shown that monocropped sorghum can be grown in India on residual moisture in vertisols, no literature exists on the growth and assimilation of dry season sorghums (10,9).

Materials and Methods

The site for the experiment was the United Kingdom Overseas development Authority agroforestry field station in New Marte, near Maiduguri. The site consisted of plots measuring 25mx 25mwhich have been previously planted with trees. Sixteen plots were used from the 11 year old trees. There were four treatments (three species) and a control. Of the three species, *A. nilotica* and *P. juliflora* were pruned while *B. aegyptiaca* were small in size and so, were left unpruned. Each treatment therefore had four plots.

Seedlings of a white-seeded variety of "Musakawa" sorghum were obtained from local farmers in Kaje village. Because of wide variation in size of seedlings of the same age, uniform healthy seedlings of not more than four fully expanded leaves, regardless of age, were selected and transplanted.

Plots were bunded and weeded at two weeks prior to transplanting so as to conserve moisture and reduce competition between weeds and the crop. Seedlings were treated to normal cultural practices; removing one third of the shoot and severing most of the roots. The roots portion was immersed in standing water for 48 hours before removing and transplanting. By this time the roots had resumed growth. Plots were transplanted at one day intervals between the 19th September and 5th October 1995, after inundation when most of the rains had ceased. Plant spacing was 1mx1m except where the space was occupied by a tree. A heavy wooded spike was used to make holes in the soil after which 400ml of water was poured in each, before placing the transplant.

Plots were samples in the order they were planted, at daily intervals between plots. Sampling of the sorghum plants was conducted sequentially at 20 days intervals throughout the growing season, which lasted for 100 days. Prior to the first sampling, a randomized sampling schedule was drawn up. At each sampling time, a table of random numbers generated were used to identify ten sorghum plants for destructive harvesting for biomass determination.

The leaf area of the sorghum plant were measured using a portable leaf area meter. Leaf area index was calculated as the leaf area per unit land area (1m^2). All harvested vegetative matter was initially sun dried pending oven drying at 80°C to constant weight. This type of destructive sampling lasted 100 days at 20 days intervals. Therefore, five such harvest were made. Crop growth rate was calculated as change in biomass over time. The net assimilation was calculated as the crop growth rate divided by the leaf area index.

Soil samples for moisture determination (500g), were taken at a depth of 30cm. Immediately after soil samples were obtained they were put in plastic bags and weighed. The soil samples were then oven-dried at 105°C for 48 hours to obtain dry weights. Gravimetric soil moisture content (%) was calculated as (fresh weight – dry weight/dry weight x 100.

Crown area of the trees were also measured using the telescopic rule at eight points around each tree crown (at 45° increments). A fibron tape was laid on the ground fixed at the base of the trunk and laid in the appropriate direction using the positions of neighbouring trees for correct alignment. A sighting pole was used to project a vertical line upwards from the tape. The pole was moved along the tree trunk until the tip of a branch first contacted or became in the line with the pole. The crown radius was read from the tape.

The design of the experiment was unbalanced as a result of the non-pruning of *Balanites*. The effects of treatments were, therefore analyse using a general linear model to allow for unequal replication at the plot level. To be able to compare the control and *Balanites*, control and the pruned or non-pruned treatments and within pruned treatments, three different Standard Error of the Differences (s.e.ds) of the means were calculated. Accordingly, Control was abbreviated CO; *Balanites aegyptiaaca*, BA; pruned *Prosopis juliflora*, PJ+, unpruned PJ-; pruned *Acacia nilotica*; AN+; unpruned, AN-. Therefore, three LSD values (a, for comparing CO and BA; b, for comparing CO and all other treatments and; c, for comparing *P. juliflora* PJ+ with PJ- and *A. nilotica* AN+ with AN-treatments) were calculated. Means wereseparated from each other using the Least Significant Differences (LSD). Means were judged to be significantly different at P<0.05 (F. test).

Results

Between 20-40 DAT sorghum in CO and BA treatments had the highest NAR (Fig. 1). This showed that even at an early establishment stage, CO and BA were assimilating faster per unit leaf area. The NAR reached a peak at40-60 DAT, BA having the highest assimilation rate while PJ+ was higher than PJ- and both AN+ and AN-. At 60-80 DAT, control and BA treatments had the highest NAR, while PJ- and AN- and AN+ had a low or negative assimilation.

The crop growth rate also showed a similar treatment trend (Fig. 1). In CO, BA and PJ+ treatments, the crop displayed atypical sigmoid pattern of growth.

Crop growth rate was higher between 40 and 60 DAT and also showed that PJ-, AN+ and AN- had very low growth rates. Between 60-80 DAT, the same pattern was observed (Fig. 1).

When soil moisture was considered, at 20 DAT, the soil moisture was highest in the control though not significantly different from *B. aegyptiaca* and pruned *A. nilotica* treatments, but remained significantly different from both pruned and unpruned *P. juliflora* as well as unpruned *A. nilotica* (Table 1). At 40 DAT, control had significantly higher soil moisture than the other treatments. Pruned *P. juliflora* had significantly higher soil moisture than the unpruned treatment. On the contrary, unpruned *A. nilotica* had higher soil moisture than the pruned treatment. At 60 DAT, control treatment was not significantly greater than the *B. aegyptica* treatment, but significantly greater than all the pruned treatments. Pruned *P. juliflora* had soil moisture which was significantly greater than the pruned*P. Juliflora*. Unpruned *A. nilotica* had significantly higher soil moisture than the pruned *A. nilotica* treatment.

Table 1: Effect of trees on gravimetric soil moisture content.

Treatment	% Soil moisture		
	20 DAT	**40 DAT**	**60 DAT**
Control	16.02	14.11	12.13
Unpruned *B. aegyptiaca*	16.01	12.10	12.00
Pruned *P. juliflora*	13.91	11.9	11.01
Unpruned *P. juliflora*	13.01	9.91	5.10
Pruned *A. nilotica*	13.02	10.10	7.12
Unpruned *A. nilotica*	14.50	11.00	10.13
LSD (5%)	a*NS	a.1.01	a.NS
	b.1.20	b.1.20	b.0.71
	c.NS	c.1.25	c.1.10

*a. for comparing control and *B. aegyptiaca;* b. for comparing control and all other treatments; c. for comparing within pruned and unpruned treatments.

Fig. 1

When crown sizes were considered, unpruned *P. juliflora* had bigger sizes followed by unpruned *A. nilotica* (Table 2). The *B. aegyptiaca* were small (Table 2).

Table 2: Crown Size of tree species

Treatment	**Crown sizes (m)**
Control	-
Unpruned *B. aegyptiaca*	0.41 (0.07)*
Pruned *P. juliflora*	1.75 (0.06)
Unpruned *P. juliflora*	2.30 (0.04)
Pruned *A. nilotica*	0.83 (0.06)
Unpruned *A. nilotica*	1.26 (0.07)

*Values in parentheses are standard errors of the means.

Discussion

At early establishment, assimilation per unit was low (Fig. 1), as the season progressed assimilation reached a peak. High Net Assimilation Rate (NAR) and Crop growth Rate (CGR) were obtained in control. *B. aegyptiaca* and pruned *P. juliflora* treatments. The results has shown that trees have different effect on net assimilation rate and growth rate of sorghum. The lack of difference between the control, unpruned *B. aegyptiaca* and pruned *P. juliflora* was attributed in part to the small crown sizes of *B. aegyptiaca* (table 2) which resulted in reduced competition for light as a result, high leaf assimilation rate was obtained. It could be that the control and *B. aegyptiaca* or pruned *P. juliflora* treatments had similar level of competition with the crop. The result is in agreement to that reported by Bullock *et al* (11); Stout *et al* (12) that shortage of light and moisture is responsible for reduction in assimilation and crop growth. The significant difference between pruned and unpruned *P. juliflora* indicated that lack of pruning management in the unpruned *P. juliflora* treatment resulted in increased competition with the crop for available light and moisture (Table 1) which inhibited assimilation per unit area of leaf and therefore crop growth. In complete contrast to*P. Juliflora*, pruning *A. nilotica* reduced NAR, despite the crop having high amount of light and soil moisture, an indication that the trees responded differently to pruning.

The difference observed between pruned and unpruned *P.. juliflora* demonstrated clearly the advantages of the pruning management strategy in terms of reduction in competition for resources for crop growth. This is in agreement to similar reports by Benge (13) and Ralhan *et al* (14) that pruning management can reduce the level of competition in some species and increase productivity of associated crops. Since assimilation can lead to high crop growth rate and consequently productivity, the high NAR and CGR in the control and *B. aegyptiaca* aswell as pruned *P. juliflora* treatments shows the potential of high productivity (15). It thus suggests that *B. aegyptiaca* and *P. juliflora* can be planted with sorghum particularly when pruning is applied to the *P. juliflora* in a similar study, Puri and Bangarwa (16) reported that it is not advisable to plant *A. nilotica* with wheat. Equally, the planting of dry season sorghum with *A. nilotica* tree is not advisable.

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