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Effect of trees on photosynthesis rates in 40 day old dry season sorghum [*Sorghum bicolour* (L.) Moench] in the semi-arid zone of Nigeria

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ABSTRACT: Studies of the effect of 10 yeal old *Balanites aegyptiaca, Prosopis juliflora* and *Acacia nilotica* on photosynthesis rate in 40 day old dry season sorghum [*Sorghum bicolour* (L.) Moench] were conducted in agroforestry site in a Semi-arid area of Nigeria. Sorghum was planted at 1m interval between trees and no tree controls. Diurnal trends of Photosynthetically Active Radiation (PAR), Stomatal conductance, (g_s) transpiration rate (E), assimilation rate (A) and water use efficiency (A/E) were measured using an Infra Red Gas Analizer. The result showed that the assimilation rate of sorghum varied with tree species. *B. aegyptiaca* reduced PAR to a smaller extent as a result, assimilation, stomatal conductance, and water use efficiency was highest in sorghum intercropped with this species followed by *P. juliflora* and least was in sorghum intercropped with *A. nilotica.* Reduced assimilation of sorghum intercropped with *P. juliflora* and *A. nilotica* was as a result of reduced incident radiation and increased competition for limited moisture. Increased rate of photosynthesis can lead to high biomass and yield. It can be concluded that *B. aegyptiaca* can be integrated as part of Semi-arid agroforestry and when pruning is applied to *P. juliflora* and *A. nilotica* to reduce their level of competition. It therefore, shows that with appropriate choice of tree species it is possible to maintain a sustainable agroforestry system in the Semi-arid areas.

Key Words:

Introduction

Dry season sorghum production in Nigeria is on the vertisolic soil found in the Semi-arid north eastern region near Lake Chad at Latitude 13 – 14°E and Longitude 12 – 13°N (1). Flood waters arising from the short wet season which will normally drain to the lake are contained in the fields by contour bounds to reduce run off and aid infiltration. The area remains flooded during the raining season and the bunds are broken only at the end of the rainy season to allow drainage prior to growing the crop. The crop is transplanted from nursery seedlings grown during the rains on some what raised sandy areas and growth is solely from residual moisture (2, 1). It has been suggested that there is a need to integrate crops and trees in fields to facilitate natural regeneration of fertility, soil moisture conservation and improvement of overall productivity of the system (3).

Growth of crops as determined by classical growth analysis using destructive harvesting is integrative and so is important for determining long term changes. However, destructive sampling is subject to substantial sampling error. To understand the immediate response of the crop to various stresses, it is necessary to measure the carbon dioxide exchange of a leaf in the presence of light (4, 5).

Instantaneous measurement of carbon dioxide and water vapour exchange provides an alternative and direct method of measuring productivity with important advantages over measurements of dry weight change: that is, it is instantaneous, non-destructive, and allows seperation of photosynthesis gain from respiratory losses (5, 4). The opening of the stomatal aperture for transpiration and carbon dioxide exchange and dry matter production depends on the amount of available water and light (5). Although information on instantaneous gain in carbon in rainfed sorghum is available, in dry season Sorghum the information is still lacking (7). This paper, therefore, aims at providing such information.

Materials and Methods

The experiment site was the Overseas Development Administration (ODA) now Directorate for Foreign and International Development (DFI) experimental site at new Marte, near Maiduguri in North eastern Nigeria. The site consisted of plots measuring 25m x 25m which has been planted previously with trees of different ages at 5m interval. Dry season sorghum was planted three species treatments and no tree control at 1m interval. Measurement were made on the youngest fully expanded leaves of 40 day old sorghum integrated with trees and control. Data were downloaded on spread sheets and means were obtained. The standard errors of the means were calculated to determine variation in the treatments means.

Results

The diurnal trends of the various parameters measured Photosynthetically Active Radiation (PAR), stomatal conductance (g_s) transpiration rate (E), Assimilation rate (A) and water use efficiency (A/E) of sorghum intercropped with 10 year old trees are presented in Figure 1. Examination of the diurnal trends of PAR showed that variation was due to tree species size, so that large trees had low PAR, that is large trees resulted in low incident PAR on sorghum leaves.
Examination of the effect of treatments on diurnal course of A showed that in the control treatment this was similar to that of PAR. In the *B. aegyptiaca* treatment, the diurnal courses indicated a higher A than in the *P. juliflora* and *A. nilotica* treatments.

Examination of instantaneous water use efficiency (A/E) showed considerable variation in the values of A and E, but the ratio A/E showed much smaller variability between leaves across the different treatments. Values of A/E for sorghum in control, *B. aegyptiaca* and *P. juliflora* showed little difference between treatments despite large difference in the absolute values of assimilation (A) and transpiration (E). However, A and E are higher in the control of *B. aegyptiaca* treatment while E was higher in the *A. nilotica* than the *P. juliflora* but contrastingly A was higher in *P. juliflora*.

Diurnal courses indicated generally higher g_s in Control and *B. aegyptiaca* treatments. In the *P. juliflora* and *A. nilotica* tree treatments, g_s of the crop was depressed compared to the Control treatment and g_s showed generally a similar trend as E.

Discussion

Response of single leaves of sorghum intercropped with 10 year old trees showed that the stomatal conductance early in the morning was low because of low light levels (8). However, at around 8a.m., light increases were slight, towards afternoon treatment differences were more apparent.

Since A and E are dependent on g_s (Sanchez-Diaz and Kramer, (9); Graham et al., (10) and since g_s is

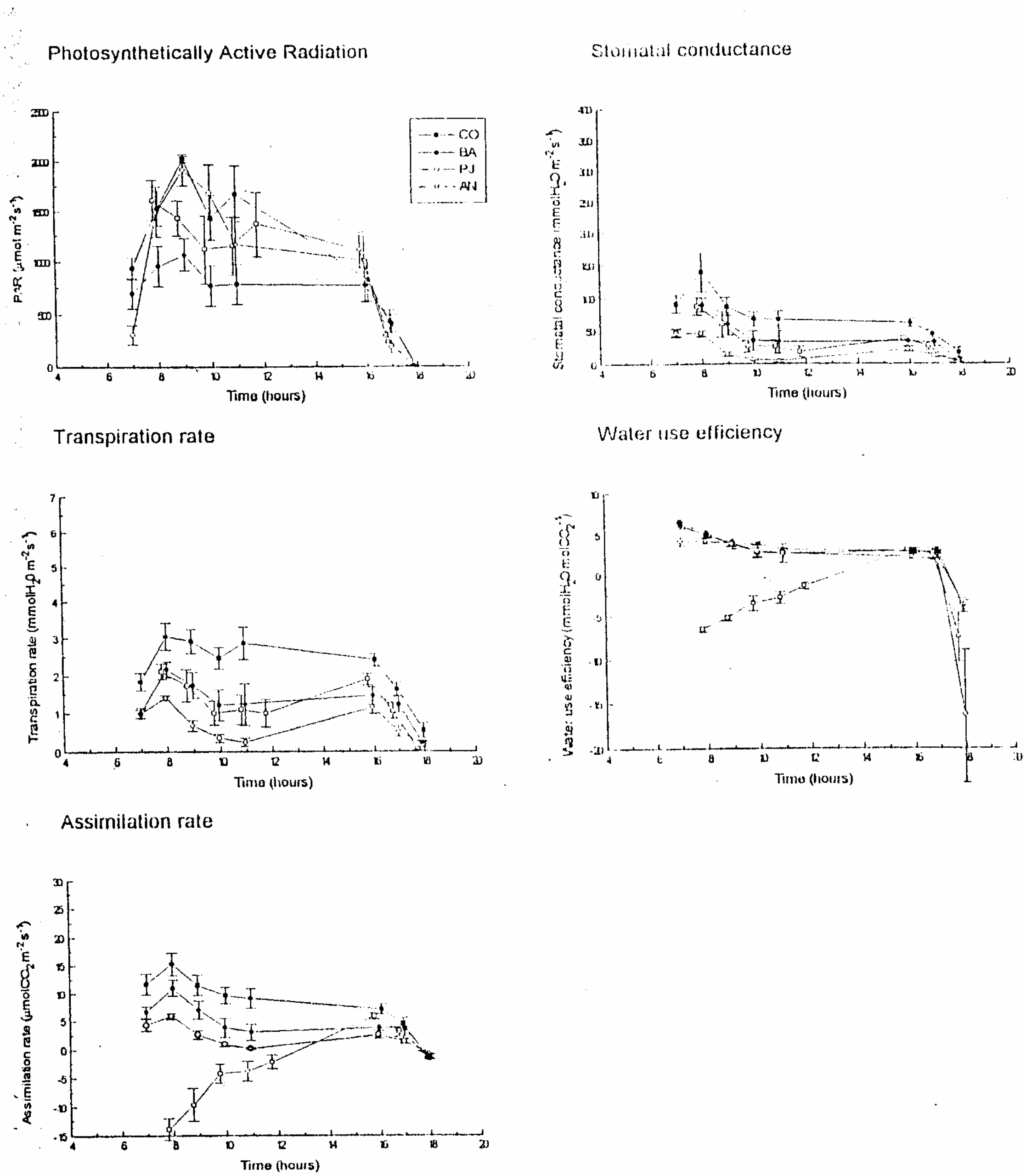

Fig. 1: Comparison of effect of 10 year old trees and control upon diurnal trends of photosynthetically active radiation (PAR), stomatal conductance(g_s), transpiration rate(E), assimilation rate(A), and water use efficiency(A/E) of 40 day old sorghum.

directly affected by light levels and soil moisture (Glover (11); Rawsonet al., (12) sorghum in control and sorghum intercropped with *B. aegyptiaca* had higher g_s than those intercropped with the *P. juliflora* and *A. nilotica* treatments. In addition, if stomata are open, A is related to PAR, but the PAR was high while g_s was low especially in *P. juliflora* and *A. nilotica* an indication that the stomata were closing to conserve water.

The higher g_s and E was therefore responsible for the high A under the Control and *B. aegyptiaca* treatments. It has been well established that high A can lead to high growth rate and productivity. Wong et al., (6); Von Caemerer and Farquhar (13); Alhamdani et al., (14) have reported also of the correlation between stomatal conductance and assimilation and thus single leaf photosynthesis and final biomass. As with most crops there was little variation in water use efficiency and indication that the crop was maximizing water use (11). However, g_s and A were high in control and *B. aegyptiaca* treatments compared to that of sorghum plants grown under the *P. juliflora* and *A. nilotica*. This showed that the main cause of the low assimilation was moisture shortage. The assimilation compared to transpiration was most affected in sorghum under the *A. nilotica* treatment, probably root exudates of this tree can reduce the assimilatory ability of the crop. The low photosynthesis rate can lead to poor performance of the crop under these trees. Ehrler and Van Barel, (15); Hsiao (16); Turner (17); Steiner, (18); Jones et al., (19) have reported of low stomatal conductance and therefore assimilation and water use efficiency in rainy season sorghum and the correlation of single leaf photosynthesis and final biomass. It can concluded therefore, that single leaf phoptosynthesis responses can lead to appropriate selection of trees for sustainable agroforestry in the Semi-arid areas. Appropriately, it can be suggested that sorghum can be planted along with *B. aegyptiaca* and *A. nilotica* to reduce the level of competition.

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