Bioscience Research Communications
Vol. 15, No. 1, February 28, 2003
Printed in Nigeria

0795-8072/2003 $12.00 + 0.00

BRC 2002006/15104

Effect of trees on grain yield of dry season sorghum [*Sorghum bicolor* (L.) Moench]

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(Received February 8, 2002)

ABSTRACT: The effect of three tree species, *Balanites aegyptiaca, Prosopis juliflora* and *Acacia nilotica* on biomass production and grain yield of dry season sorghum [*Sorghum bicolour* (L.) Moench] was investigated in 100-day old sorghum. Sorghum was planted between trees which were pruned or unpruned. Significant differences ($P<0.05$) in biomass and yield components were observed. Treatment effect on 100 grain weight and grain number per panicle were observed between treatments, but individual grain weights were not affected by the treatments. Unpruned *B. aegyptiaca* had no depressing effect on biomass or grain yield, while unpruned *P. julifora* depressed yield but pruning this species increased both biomass and consequent grain yield only over the unpruned treatment. However, *A. nilotica* whether pruned or unpruned inhibited biomass production and grain yield in the crop. Competition for limited moisture, light and nutrients between the crop and trees was responsible for depressing biomass and consequently grain yield in the crop. The result has shown the potential of sustainable agroforestry system in the semi-arid area using *B. aegyptiaca* and with managed *P. julifora*.

Key Words: Sorghum (*Sorghum bicolor*); Grain yield; Dry season; Tree-crop integration.

Introduction

In Nigeria, the area of dry season sorghum production is on the vertisolic soils found in the semi-arid north eastern region near Lake Chad at Latitudes 13 – 14°E and Longitudes 12 – 13°N (1). Dry season sorghum grows to maturity on residual moisture stored in this dark clay soil. “Masakwa” is the name given to this transplanted land race of Sorghum (*Sorghum bicolour* [L.] Moench. Dry season sorghum is transplanted from nursery seedlings grown during the rains on somewhat raised sandy areas. Growth is solely dependent upon residual moisture (1,2).

Since the crop is grown as a sole crop, few trees may be found sparsely scattered in agricultural fields. However, in most instances, the trees are not planted deliberately as an agricultural practice. The need to integrate crops and trees in the field to facilitate natural regeneration of fertility, soil moisture conservation and improve overall productivity of the systems is very clear. The ultimate aim is the development of long term sustainable agricultural systems (3 – 5).

Yield components analysis relates grain yield to the number of ears per unit ground area or number of ears per head and mean weight per grain (6). The grain yield is a measure of how much assimilate is partitioned to the development of the yielding organs (7). Partitioning of assimilates itself is influenced by factors such as competition between other sinks, plant population and the availability of growth resources. In sorghum, however, once the crop has produced the panicle, most of the assimilates including those stored during the growth stages are translocated to the ears (8).

Grain growth represents the storage of material from current photosynthesis in the leaves and panicle together with material remobilised from temporary storage in other parts of the plant (8, 9). It is well established that any factor that affects crop photosynthesis during anthesis can reduce assimilate supply and its partitioning and, therefore crop yield (10 – 13). Although, Kessler (1992) reported increases in yield in rainy season sorghum in association with trees in a semi-arid area, reports of effects of trees on dry season sorghum are still lacking (14). This paper aims at bridging the literature gap.

Materials and Methods

The site for the experiment, was the United Kingdom, Directorate for Foreign and International Development (DFID) agroforestry experiment site located at New Marte vertisoli area, in North eastern Nigeria. The sites consisted of 480 plots measuring 25m by 25m which were previously planted with trees of different ages. The experimental design was a completely randomise design.

Sixteen plots were used from the 11 year old trees. There were four treatments (three tree species and a control). Of the three species, *A. nilotica* and *P. julifora* were pruned while *B. aegyptiaca* trees were small in size and so were left unpruned. Each treatment therefore had four plots.

Plots were bunded and weeded two weeks prior to transplanting so as to conserve moisture and reduce competition between weeds and the crop.

Seedlings of a white seeded variety of “Masakawa” sorghum were obtained from local farmers in Kaje village near the experimental site in New Marte. Because of the 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.

Seedlings were treated to normal cultural practices; removing one third of the shoot and severing most of the roots. The root portion was immersed in standing water for 48 hours before removing them for transplanting. By this time, the roots had started to regrow.

Plots were transplanted at one day intervals between the 19^{th} September and 15^{th} October, 1994, after inundation when most of the rains had ceased. Plant spacing was 1.25m x 1.25m except where a space was occupied by a tree. A heavy wooded spike was used to make holes in the soils. Then about 400ml of water was poured into each hole before introducing the transplant.

Plots were sampled in the order in which they were planted. Therefore, sampling was carried out at daily intervals between plots. For biomass determination, randomly selected sorghum plants were sampled at 20 days interval up to 100 days. Each plant to be harvested was carefully cut from the base and immediately sun dried pending oven drying at 70°C to constant weight. At 100 days, a table of random numbers was used to generate 10 numbers of sorghum plants to be harvested. Grains were manually separated and grain number determined. They were then oven dried at 70°C to constant weight. Then, 100 seeds were randomly selected and weighed and divided by 100 to determine the individual grain weight.

The design of the experiment was unbalanced as a result of the non-pruning of *B. aegyptiaca*. The effects of treatments were therefore analysed using a general linear model to allow for unequal replication at the plot level. To be able to compare control and *B. aegyptiaca*, control and the pruned or non-pruned treatments and within pruned treatments, three different standard error of the differences (s.e.d.s.) were calculated. Therefore, three LSD values (a, for comparing CO and BA; b for comparing CO and all other treatments and c for comparing PJ+ with PJ- and AN+ with AN-treatments) were calculated. Means were separated from each other using Least Significant Differences (LSD). Means were judged to be significantly different at $P<0.05$ (F. test).

Results

At 20 DAT, there was no significant difference in biomass production between the treatments (Table 1), but by 40 DAT, the Control and BA treatments though not different from each other remained significantly higher than the other treatments. No differences were observed between pruned and unpruned treatments. By 60 DAT, there was no significant difference between CO and BA treatments but CO was significantly higher than pruned PJ+, the PJ+ was significantly higher than PJ- with no significant difference between pruned or unpruned Acacia nilotica. The same pattern continued up to 80 DAT. At 100 DAT, the CO and BA though not significantly different from each other but remained significantly different from the PJ+ and AN+ with AN-. The pruned PJ+ was however significantly higher than the unpruned PJ-. No significant difference was observed between the Acacia nilotica treatment.

Table 1: Effect of trees with or without pruning on total dry matter (g) of sorghum per plant at different sampling times.

Treatment		20(DAT)	40	60	80	100
CO		0.9	2.5	2.7	3.8	4.8
BA		1.0	2.7	3.0	3.8	4.1
PJ+		0.7	0.5	2.6	1.9	2.5
PJ-		0.8	0.4	0.5	0.3	0.4
AN+		0.8	0.2	1.0	0.2	0.5
AN-		0.7	0.2	0.8	0.1	0.3
LSD (5%)	a*	NS	2.1	2.1	1.7	1.1
	b	NS	0.9	0.4	0.2	0.5
	c	NS	NS	0.9	1.1	1.4

*a, for comparing CO and BA; b for comparing CO and all other treatments and; c for comparing PJ+ with PJ- and AN+ with AN- treatments.

The grain yield was not significantly different between the control, *B. aegyptiaca* and pruned *P. julifora* treatments, but was significantly higher in the control compared with the pruned and unpruned *A. nilotica* unpruned *P. julifora* treatments (Table 2). Pruning of *P. julifora* produced a significantly higher grain yield than in both the unpruned *P. julifora* and even in pruned *A. nilotica*. The grain yield in unpruned *P. julifora*, pruned *A. nilotica* and unpruned *A. nilotica* treatments did not differ significantly. Highest seed numbers were produbed in *b. aegyptiaca*. However, the yield was not significantly greater than in the control but significantly greater than pruned *P. julifora* treatment. Grain number in control was only marginally greater than pruned *P. julifora* but significantly greater than in unpruned *P. julifora*, pruned *A. nilotica* and unpruned *A. nilotica* – treatments. Also, grain number in pruned *P. julifora* was significantly greater than in the unpruned *P. julifora* and in pruned *A. nilotica*. There was no significant difference between grain number in pruned *A. nilotica* and the unpruned *A. nilotica.*

Weight of 100 individual grains did not show significant difference between the control and *B. aegyptiaca* treatment (Table 2). However, significant differences were obtained between the control and the other four treatments. Differences were not significant between pruned treatments.

Table 2: Effect of trees with or without pruning management on yield components in dry season sorghum, *Sorghum bicolor*.

Treatment	Grain Yield (gm^{-2})	Number of grains (gm^{-2})	Weight of 100 grains (g)
Control (CO)	101.02	1098	5.10
B. aegyptiaca (BA)	130.11	2600	4.74
Pruned P. Julifora (PJ)	64.34	1480	4.48
Unpruned P. julifora (PJ-)	2.70	150	4.00
Pruned A. nilotica (AN+)	11.74	245	4.37
Unpruned A. nilotica(AN-)	3.40	200	4.05
LSD (5%)	a* = NS	a = NS	a = NS
	b = 41.61	b = 630	b = 0.50
	c = 45.76	c = 800	c = NS

*a, for comparing CO and BA; b for comparing CO and all other treatments and; c for comparing PJ+ with PJ- and AN+ with AN- treatments.

Discussion

The high yield in the Control, *B. aegyptiaca* and the managed *P. julifora* was as a result of the availability of light, moisture and nutrients. Fischer and Wilson (15) and Fischer and Palmer (16) reported on the dependence of sorghum yield on the availability of light and moisture. The availability of these resources has been known to increase photosynthetic efficiency and therefore biomass accumulation. It will be implied that high photosynthetic rate in sorghum in the control, *B. aegyptiaca* and pruned *P. julifora* treatments led to high biomass accumulation and consequently grain yield. Green (6), Manjunath and Parvatikar (17) and Gonzale-Hernandez et al. (18) have reported a linear relationship of biomass with grain yield in sorghum.

On the contrary, the unpruned treatment along with pruned *A. nilotica* depressed photosynthesis and consequently resulted in low biomass. The yield was therefore low. Reduced soil moisture and light, and nutrients deficiency or any factors that can limit crop growth during anthesis have been reported to reduce grain yield in sorghum (19, 20)..

No difference was observed in 100 grain weight between control and *B. aegyptiaca* presumably because the moisture level in the Control and *B. aegyptiaca* was similar since moisture deficit grain filling is usually accountable for differences in individual grain weights (21). Significant difference was observed between the control and the remaining treatments (both pruned and unpruned *P. julifora* and *A. nilotica*) which suggested that although the grain weight is a fairly uniform component of yield, severe differences in moisture and light level can nonetheless reduce the grain weight (22). Blum and Navel (23) and Howell (24) have reported the dependence of grain weight of sorghum on the availability of moisture, nutrients and light. No difference were observed within pruned or unpruned *A. nilotica* and *P. julifora*, which indicated that once the crops survived up to maturity the grain weights remained fairly constant. This result is in agreement with the proposal of Gallagher et al (25) that individual grain weight for a particular cultivar is a fairly stable character.

This study has shown the potential for a sustainable agroforestry system in the semi-arid environment with *B. aegyptiaca* and when pruning management is applied to *P. julifora*. Grain yield of sorghum intercropped with *B. aegyptiaca* and pruned *P. julifora* were higher than in the pruned and unpruned *A. nilotica* as well as in unpruned *P. julifora* treatments. It can be suggested therefore, that dry season sorghum can be integrated with *B. aegyptiaca* and when pruning management is applied to *P. julifora*. However, the planting of dry season sorghum with *A. nilotica* is not advisable.

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