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HEIGHT GROWTH AND MOISTURE DISTRIBUTION IN SORGHUM INTERCROPPED WITH GMELINA, LEUCAENA AND PARKIA IN THE SOUTHERN GUINEA SAVANNA ZONE OF NIGERIA

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ABSTRACT

Growth and moisture distribution assessments of sorghum intercropped with Parkia, Leucaena and Gmelina on plinthustalf in the Southern Guinea Savanna Zone of Nigeria were carried out over four growing seasons. Compared to sole crop, reduced sorghum height (15 and 30 %) due to Gmelina was observed in the second and third growing seasons respectively. However, the presence of Gmelina was beneficial to sorghum height growth during the fourth growing season leading to 60 % above the sole crop. Moisture build-up reached peaks in sorghum root, stem and leaf at 90 days after sowing, Legume's beneficial effect on moisture distribution in root, stem and leaf of sorghum was in the order: Leucaena > Parkia > no legume in year IV. Sorghum intercropped with Gmelina in year IV contained significantly higher moisture content than sorghum without it. Suggestions to enhance the performance of sorghum while in intercropping with the investigated trees were proferred.

Key Words: *Intercropping, simultaneous intercropping, sequential intercropping, agri-silviculture, pruning, thinning.*

INTRODUCTION

Comparatively, sorghum is a poor yielder than maize but it is clearly a more effective utilizer of residual moisture (Fawusi and Agboola, 1980). The extent of vegetative growth that precedes heading determines the quality and the use to which the stubbles of sorghum can be put after harvesting. Added to this is the fact that sorghum, at the end of tillering is critically affected by moisture stress. Leyton (1983) asserted that if water is in short supply during this stage the yield of sorghum may be irreversibly harmed. Adequate moisture in the leaf aided by sufficient light energy would be beneficial to sorghum productivity as the leaf is the major seat of photosynthesis (Mengel and Kirkby, 1978). Moreover, different parts of cereal crops are known to contribute differently to the grain yield (Fischer *et al.* 1976). Changes that occur at different stages in the life of sorghum would ultimately determine the quantity and quality of the final yield.

Grain sorghum might have been selected or bred to maximize yield when grown in isolation and trees may be seen as competitors for essential resources. Nevertheless, non-nitrogen-fixing and nitrogen-fixing trees, pruned or thinned adequately in agri-silviculture with annual crop, present a farming system in which arable crop yields can be enhanced. The tree rooting system is expected to bring about some stability that can lead to soil conservation but the tree canopy may also lead to shading thereby reducing the amount of solar radiation available to the companion cereal crops. What is needed therefore would be mutual interaction (Connor, 1983) and proper management techniques that would reduce the adverse effects that may result when trees are integrated into agro-ecosystems. Appropriate pruning and thinning regimes become imperative in the management of the tree component of an agri silvicultural system involving sorghum to minimize shading effect. The aim of this investigation therefore was to evaluate the growth and moisture distribution in sorghum under intercropping with Gmelina, Leucaena, and Parkia.

MATERIALS AND METHODS

This investigation was conducted at Ilorin (8° 3' N and 4° 33' E) in the Southern Guinea Savanna Zone of Nigeria. The description of the climate and vegetation of the study area has been given elsewhere (Fagbemi, 1991).

The 0.4 ha experimental plot was cleared in the year preceding this investigation, sown to cowpea and treated with Galex 500 EC as herbicide. Cymbush 10 EC was the insecticide used, while single superphosphate was applied as fertilizer. It was tractor ploughed at the first year of this investigation but no subsequent harrowing or ridging throughout the study. Also no agro-chemicals were employed throughout the course of this study. The area was divided into 9 (16 m x 24 m) main blocks separated from each other by 5 m foot path. Each main block was further divided into 4(16 m x 6 m) compartments. Fifty per cent of the split-plots came under simultaneous intercropping whereby sorghum was grown along with the tree crops right from the beginning. Sequential intercropping was brought about in which case some split split plots were left to tree crops/fallow for the first two years before sorghum was included in years III and IV.

Two sorghum plants per hole and one plant per hole for tree crops were left after thinning within the first month (June) of sowing. Planting of crops followed a west-east orientation. While the trees had an experiment of 4 m x 2 m, sorghum had 1 m x 0.5 m spacing.

Sole tree compartment contained 12 plants/96 m (1250/ha), while sorghum population was 40,000 per hectare in sole plot. Where a single tree species was combined with sorghum, 89.74 % of the total plant population was made up of sorghum while the tree component accounted for the rest 10.26 %. However, in a split-plot containing the combination legume, gmelina and sorghum, the percentage composition was in the order 10.26, 7.69 and 82.05 % respectively. Intercropping was by growing sorghum within the alleys and along the intra-space of the tree hedgerows. One crop of sorghum was grown per annum. In June of the third year, Leucaena and Gmelina were pruned. However, Parkia, Leucaena and Gmelina populations were each thinned to half in June of year IV.

Monthly height measurements were taken. During the first month of sorghum assessment, samples were carried whole to the laboratory. Subsequently, the plant samples were first weighed then sub-sampled and bagged in polythene material preparatory to oven-drying in the laboratory. The sorghum plants were separated into roots, stem (sliced) and leaf for oven drying at 70°C for 48 hours (Agboola and Corey, 1973). Percentage moisture content of samples was calculated as follows:

% MC = Fresh weight Final (Oven) dry weight x 100 / Fresh weight

Manual weeding was carried out twice in the first season, and three times yearly thereafter.

Before the first planting, some physical and chemical analysis of the soil were carried out. Soil samples from 0 15 cm and 15 - 30 cm layers were air dried, ground and passed through a 2mm sieve. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1951). Soil pH was measured in 1:2 soil-water suspension using pH metre (McLean, 1965). Nitrogen was determined by the regular Macro-Kjeldahl method of Jackson (1962) and available P by the Bray P - 1 method (Bray and Kurtz, 1945). Organic matter was determined by the modified wet dichromate oxidation method (Piper, 1944). Exchangeable cations were extracted with neutral normal NH_4OAC. Potassium, Ca and Na in the extract were determined by atomic absorption spectrophotometry. Exchangeable acidity (H + Al) was determined by extracting 2.5 portion of soil with 25 ml of 1 M KCl and 10 ml of extract titrated with 0.01 M NaOH, using phenolphthalein as indicator (McLean, 1965). Effective cation exchangeable capacity (ECEC) of the soil was taken as the sum of the exchangeable bases (K, Ca, Mg and Na) and exchangeable acidity. Available Mn and Zn were determined by extracting 2.5g of soil with 25ml of modified $NaHCO_3$ (Hunter, 1972). Concentration of these micronutrient in the filtrate were read off the atomic absorption spectrophotometer.

The experimental layout for the study was a randomized complete block design (RCBD) with a split-plot (years I and II) and a split split plot years III and IV) arrangements. For the planting, 3 legumes (Leucaena, Parkia and nil); 2 woody trees (Gmelina and nil) and 2 planting sequences (simultaneous and sequential) were involved.

For the purpose of statistical analysis on sorghum height growth, the data for years I and II were pooled. Two split-plots in terms of the presence or absence of Gmelina were used in each block of 3 Legumes. This resulted in 6 split plots and with 3 replicates each, the total number was 18. In years III and IV, analysis on height and moisture distribution in sorghum were carried out on yearly basis. Four split-split-plots were recognized with regards to the presence or absence of Gmelina, whether simultaneous or sequential intercropping in each block of 3 legumes. This gave 12 split-split-plots and with 3 times replication, the total was 36. Analysis of variance was the statistics used and test of significance on the means was performed by LSD once the F-ratio was significant.

RESULTS

The physico-chemical properties of the experimental soil as at June of the first year are presented in Table 1. The 0 - 15 cm soil layer had 73 %, 11 % and 16 % sand, clay and silt respectively. The lower, 15 - 30 cm soil layer was more acidic than the upper 15cm stratum. In all other chemical elements determined other than Na, Mn and Ea, the upper 15cm soil layer was significantly higher than the lower 15 - 30 cm layer (Table 1).

The result of the analysis of variance on the effects of legume, Gmelina, time of sampling and year (I and II) on sorghum height growth at Ilorin is presented in Table 2. Effects due to the different crop combinations is illustrated by Fig. 1. Effect of legume was not significant on sorghum height growth during the first two years. Gmelina, time of sampling and year led to significant differences (Table 2). In both years I and II, the fastest growth rate was recorded during the fourth month of growth.

Effects of the different crop combination on sorghum height growth in year III (Fig. 1) were such that growth was significantly higher outside than within Gmelina plot. Planting order differed significantly within and not outside Gmelina plot. In year IV, simultaneous sole cropping of sorghum did not grow in height beyond the first 60 days after sowing. However, height growth of sorghum in sequential sole plots attained 40 cm at 90 days after sowing but beyond which there was no more growth in height. There was no significant difference in sorghum height when it was simultaneously or sequentially intercropped with Leucaena or sequentially combined with Gmelina in year IV (Fig. 1).

Significant differences in moisture distribution in the root, stem and leaf of sorghum were due to the presence of Leucaena and Gmelina, and time of sampling in year II (Table 3). The moisture content of the root, stem and leaf of sorghum that was intercropped with Leucaena was significantly higher than in no legume or Parkia blocks. Root moisture started building up from the first month reaching a peak (79.94 %) 90 days after sowing. It then decreased to 47.78%, 180 days after sowing. There was no stem formation during the first month of growth. The stem moisture content at 60 days after sowing was 45.77%, increasing to 85.03 % at 90 days. It decreased to 75.77 % at 120 days after sowing; 66.77 % at 150 days and finally 65.69 % at 180 days after sowing. There was no significant difference between the leaf moisture contents at 30 and 60 days after sowing. The moisture content peaked at 90 days then a decrease in the leaf moisture content with 180 days recording a mean value of 20.11 %.

In year III Leucaena significantly affected sorghum root moisture content when compared to the effects of Parkia and no Legume (Table 4). The moisture content of sole sorghum stem was significantly lower than when sorghum was either combined with Parkia or Leucaena. The highest leaf moisture content was recorded during the third month of growth. The second month of growth resulted in significantly higher moisture than within the first month. The least leaf moisture content of 15.43 % was obtained 180 days after sowing (Table 4). Sorghum contained more moisture in the root, stem and leaf when intercropped with Gmelina than without it. Planting sequence had no significant effect on moisture distribution in sorghum during the third growing season.

The beneficial effect of legume on sorghum root, stem and leaf moisture contents was in the order of Leucaena > Parkia > no legume in year IV (Table 5). The effect of time of sampling on moisture distribution in sorghum in year IV, was similar to that of year III. The presence of Gmelina led to enhanced moisture in the root, stem and leaf than when it was absent. Planting sequence had no significant effect on root, stem and leaf moisture contents.

DISCUSSION

The absence of any adverse effect on sorghum height growth from the tree components in the first year might have been due to the fact that the trees were not yet fully established and there was less competition while the initial soil fertility was at its peak during the first season. Within the first year also, shading was expected to be minimal as some tree and sorghum crops were raised simultaneously. In both years I and II, the fastest growth rate was recorded during the fourth month of growth This was probably due to the fact that, that was the last phase of active vegetative growth before the reproductive stage sets in and it was during this stage that Kassam and Stookinger (1973) recorded the maximum leaf area index in this variety of sorghum.

Unlike in the first and second cropping seasons, when the effect of Leucaena was not significant on sorghum height, the results from the third and fourth cropping seasons were that Leucaena led to significantly higher sorghum growth. This could be due to its beneficial effect in enhancing soil fertility through its N fixing ability (Hogberg and Kvaranstrom, 1982; Sanginga *et al*, 1989 a & b) and the nutrient release from its pruning (Kang *et al*, 1984). Leucaena's ability to nodulate in this agro-ecosystem has been confirmed by Fagbemi and Nwoboshi (1991). On the whole, sorghum height growth during the third cropping season was better than in year IV. There were pruning of the tree crops in year III and thinning in year IV. The companion sorghum crop would have benefited from the decomposed mulch (IITA, 1984; Van der Kruijs *et al*, 1989). Enhanced cereal growth has been reported due to the effect of mixed silviculture of trees (MaClean *et al*, 1992; Fagbemi, 1994, 1996). The difference in the two years might be due to the very poor performance of sorghum in sole plots in year IV. This could have resulted from soil exhaustion in terms of the low nutrient status of this savanna soil that has about 73 % sand content in the upper 15 cm soil layer. In this study apart from ploughing that was carried out in the first year, no further tillage was practised. The result from the bulk density determination in reduced tillage system increased with the year in this zone (Fagbemi, 1991). Lal (1979) attested to the fact that the maintenance of good soil physical properties is as important as the soil chemical status. In the southern guinea savanna zone of Nigeria where this study was conducted, farmers are known to practice some form of cultivation to increase the volume of soil that crop roots could explore. Since farmers use the sorghum stems to stake the yams that follow it in rotation, healthy and tall sorghum stems are usually desired. It is evidently clear therefore, that zero or reduced tillage system (Lal *et al*, 1978) without fertilizer input and with the amount of mulch provided under this study would not be able to satisfy the requirements for good sorghum production in the agro-ecosystem under study on a sustainable basis.

Moisture distribution in sorghum components was found to be significantly enhanced when intercropped with either Leucaena or Gmelina. Higher soil moisture content has been reported under Leucaena hedgerow alleys in an area in Lusaka, Zambia with erratic rainfall and where periodic droughts and crop failures are common (Chirwa *et al*, 1994). Enhanced moisture in sorghum plant is a reflection of the soil moisture status. The high moisture content of sorghum at 90 days after sowing was probably advantageous since the fastest growth rate in this cereal was recorded during the fourth month. Even at the time of harvest, the stem still contained as much as 65 % moisture content. Any cropping system that confers the potential of overcoming moisture stress at tillering stage would lead to enhanced sorghum growth and development (Leyton, 1983). The integration of the investigated trees into sorghum ecosystem has indicated this possibility. The root may be expected to continue to absorb water since sorghum is a biennial crop which tillers but usually grown as annual crop (Purseglove, 1972). Whereas, sorghum is an effective utilizer of residual soil moisture (Fawusi and Agboola, 1980); the high moisture build up recorded in sorghum consequent upon its intercropping with the investigated tree species would prove advantageous especially in a year that records poor rainfall distribution. It is hoped that the findings of this study would encourage more research on the development of mutual interactions between sorghum and the trees investigated.

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Table 1. Mean Physico chemical properties of plinthustalf of the study site.

Depth (cm)	%			%			meg/100g of soil						ppm		
	Sand	Clay	Silt	pH	OM	N	K	Ca	Mg	Na	Ea	CCEC	P	Mn	Zn
0-15	73.01	10.64	16.15	5.96	1.76	0.99	0.25	4.64	1.30	0.038	0.04	6.27	3.30	25.55	2.14
15-30	68.63	10.61	19.26	5.73	1.26	0.65	0.20	3.27	0.89	0.049	0.04	4.45	[illegible].32	25.53	1.67
LSD (0.05)	2.094	0.062	2.024	0.061	0.255	0.009	0.041	0.553	0.055	0.017	0.012	1.214	0,231	2.89	0.437

Column means with the same letter do not differ significanly at 5% level of probability.

Table 2. Effect of legume, time of sampling, Gmelina and year on sorghum height growth (years I & II).

Treatment	Height
Legume:	
No legume	481.45
Leucaena	486.68
Parkia	481.43
LSD (0.05)	9.1918
Time:	
30 days	81.08
60 days	154.98
90 days	236.55
120 days	355.60
150 days	379.56
LSD (0.05)	11.8862
Gmelina:	
Present	236.44
Absent	246.66
LSD (0.05)	7.5175
Year:	
Year I	277.70
Year II	205.41
LSD (0.05)	7.5175

Column means with the same letter do not differ significantly at 5% level of probability.

Table 3: Effect of legume, time of sampling and Gmelina on moisture distribution in Sorghum (Year II).

Treament	% Moisture content of components		
	Root	Stem	Leaf
Legume:			
No legume	55.84	67.13	44.06
Leucaena	56.95	68.40	45.88
Parkia	55.94	67.89	44.30
LSD (0.05)	0.51042	0.3918	1.3914
Time:			
30 days	42.56	-	44.74
60 days	43.48	45.77	45.44
90 days	79.94	85.03	72.62
120 days	73.30	75.77	60.70
150 days	50.37	66.77	26.80
180 days	47.78	65.69	20.11
LSD (0.05)	0.7218	0.5058	1.9677
Gmelina:			
Present	57.42	68.61	46.13
Absent	55.06	67.00	44.03
LSD (0.05)	0.4168	0.3199	1.1362

Column means with the same letter do not differ significantly at 5% level of probability.

Table 4. Effect of legume, time of sampling, Gmelina and planting sequence on moisture distribution in sorghum (Year III).

Treament	Plant componemt moisture content (%)		
	Root	Stem	Leaf
Legume:			
No legume	43.82	53.84	35.80
Leucaena	47.06	56.36	37.96
Parkia	45.71	56.01	38.44
LSD (0.05)	0.4037	0.6232	0.4012
Time:			
30 days	36.21	-	38.74
60 days	36.75	40.70	37.43
90 days	63.22	68.56	60.77
120 days	56.22	61.96	52.39
150 days	42.23	53.98	19.82
180 days	38.75	51.99	15.43
LSD (0.05)	0.6141	0.7372	0.6324
Gmelina.			
Present	48.00	56.72	38.81
Absent	43.13	54.16	36.05
LSD (0.05)	0.3551	0.4662	0.3651
Planting sequence:			
Simultaneous	44.49	55.41	37.37
Sequential	45.64	55.48	37.49
LSD (0.05)	0.35514	0.46624	0.36514

Column means with the same letter do not differ significantly at 5% level of probability.

Table 5. Effect of legume, time of sampling, Gmelina and planting sequence on moisture distribution in sorghum (Year IV).

Treament	Plant componemt moisture content (%)		
	Root	Stem	Leaf
Legume:			
No legume	49.02	58.96	39.82
Leucaena	55.13	67.15	43.78
Parkia	51.38	63.23	43.08
LSD (0.05)	0.5770	0.7598	0.5230
Time:			
30 days	39.69	-	42.23
60 days	39.76	43.25	40.33
90 days	74.71	79.64	68.95
120 days	68.60	70.58	57.83
150 days	46.91	62.35	22.00
180 days	43.14	59.76	18.42
LSD (0.05)	0.7384	0.8738	0.7542
Gmelina:			
Present	54.81	66.29	43.68
Absent	50.12	61.39	41.78
LSD (0.05)	0.5757	0.6450	0.5941
Planting sequence:			
Simultaneous	52.27	63.88	42.77
Sequential	52.84	64.43	42.77
LSD (0.05)	0.5757	0.6450	0.5941

Column means with the same letter do not differ significantly at 5% level of probability.

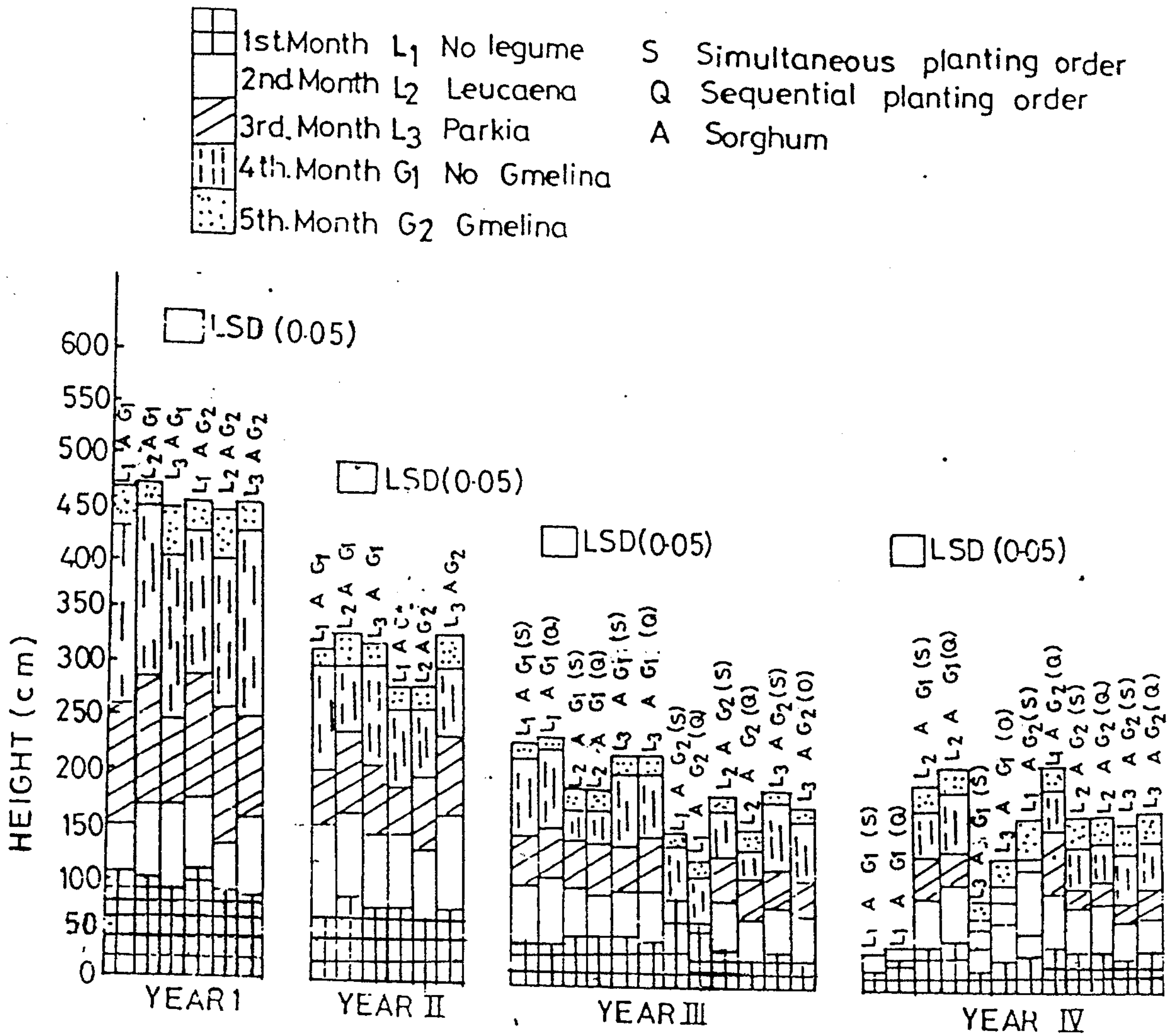

Fig 1 Sorghum height growth under different crop combinations