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Effect of Alley-Cropping with *Leucaena leucocephala* on the Growth of Budded Citrus Seedlings in the Nursery

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ABSTRACT: The efficacy of *Leucaena leucocephala* (Lam.) De-wit pruning in combination with NPK fertilizer was evaluated on the growth of budded citrus seedlings in the nursery between 1990 and 1995 in three consecutive croppings. The treatments applied to the budded citrus seedlings were: No *Leucaena* pruning and no fertilizer (L_0N_0), *Leucaena* pruning alone (L_1N_0), *Leucaena* pruning + 100 NPK/ha (L_1N_1), *Leucaena* pruning + 200 kg NPK/ha (L_1N_2) and 200kg NPK/ha (L_0N_2). Results obtained show that L_1N_2, L_1N_1 and L_0N_2 ; *Leucaena* plus 100kg NPK/ha and 200kg NPK/ha without leucaena enhanced better growth of budded seedlings of citrus during the first cropping. As from the second cropping the growth attributes recorded for the budded citrus seedlings in L_1N_0 plots compared favourably with the seedlings with fertilizer alone and combinations of fertilizer and *Leucaena* pruning. Treatment with *Leucaena* alone also enhanced leaf nitrogen contents of budded citrus seedlings than any of the treatments during the third cropping. All other treatments were significantly superior than the control in Manganese content. However, all other treatments impaired zinc and calcium absorption by the citrus seedlings. One hundred kilograms NPK 15-15-15kg/ha plus leucaena pruning is recommended for the first two croppings. However, from the third cropping *Leucaena* pruning alone compared favourably with fertilizer and leucaena/fertilizer combinations.

INTRODUCTION

Citrus as source of Vitamin C and Industrial raw material, is receiving greater attention. Consequently, there has been an intensive cultivation of citrus both in commercial orchards and on compound farms for home consumption and for cash. This has resulted in a sudden rise in the demand for budded Citrus seedlings.

The practice of shifting nursery site at the end of each cropping cycle for a more fertile land constitutes a major problem where land is limiting. Besides, the nursery needs to be sited near permanent source of water which also restricts nursery site to locations with regular water supply. Moreover the practice of moving the nursery site at the end of each cycle of seedling production is costly in terms of logistics.

The use of leguminous trees and shrubs as hedge rows in alley cropping systems for arable crop production has been found to be an improved alternative to bush fallow system in Nigeria (Kang *et al.*, 1981). This system has been found to increase yield and sustain the production of arable crops with little fertilizer application (Anon., 1984). Chen *et al;* (1989) reported that *Leucaena* maintained soil physical and chemical properties and improved the yield of some short duration vegetable crops in Southern Nigeria. However, information on the use of this practice in fruit tree seedling production has not received the deserved attention. This study was therefore aimed at testing the efficacy of *Leucaena leucocephala* pruning on the production of budded citrus seedlings with a view to maintaining a permanent citrus nursery site or reducing the frequency of shifting nursery locations.

MATERIAL AND METHODS

The experiment was established in the Citrus nursery of the National Horticultural Research Institute, (NIHORT) in Ibadan (07° 23'N, 03° 50'E). The total annual rainfall averaged over the five years (1991-1995) of the experiment was 1292.32mm and the mean temperature averaged over the period was 26.56°C. The soil belongs to Okemesi soil association and is of Apomu series (Jaiyeola, 1974). The physical and chemical properties of the soil at 0-15cm depth was determined before the study was commenced is presented in Table 1.

The experimental design was a randomized complete block replicated three times. The treatments applied to the budded citrus seedlings included: No *Leucaena* pruning and no fertilizer (L_0N_0), *Leucaena* pruning alone (L_1N_0), 100 kgN + 100 kg P_2O_5 + 100 kg K_2O/ha+*Leucaena* pruning (L_1N_1), 200kg N + 200 kg P_2O_5 + 200 K_2O/ha+ *Leucaena* pruning (L_1N_2) and 200 kg N + 200 P_2O_5 + 200 kg K_2O/ha alone (L_0N_2). Plot size was 4m x 10m ($40m^2$) and were separated by a space of 1m wide. The blocks were also separated by a space of

Table 1: Pre-planting soil analysis of experimental site.

Soil Properties	Values
pH (H_20)	7.27
Organic Carbon g. kg^{-1}	13.90
Total Nitrogen g. kg^{-1}	0.60
Available P mg. kg^{-1}	6.93
Exchangeable cations cmol. kg^{-1}	
Ca	2.82
Mg	0.88
K	0.29
Effective CEC cmol. kg^{-1}	4.21
Exchangeable micronutrients mg. kg^{-1}	
Mn	86.00
Fe	8.80
Cu	0.60
Zn	5.70

2m wide. Seeds of *Leucaena leucocephala* were obtained from the International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria and were sown in germination trays in the nursery. The leucaena seedlings were picked and transplanted to the field at 4 weeks old and at a spacing of 0.25m x 4.00m. The alleys were laid out in East/West direction to prevent shading of the citrus seedlings by the *Leucaena* hedge row. Cleopatra mandarin (*Citrus reticulata* Blanco) rootstock seedlings were raised in the alley at 30cm x 40cm in staggered spacing until they attained buddable size. The treatments were applied to the rootstock seedlings in two split doses, at 8 and 16 weeks after transplanting. The result of this earlier part had been reported by Olaniyan *et al*; (2001). The rootstocks were budded with Sweet orange (*Citrus sinensis* Osbeck L. Cv. Agege 1) at 30 weeks old. The treatments were again applied to the budded citrus seedlings in two split doses at 2 and 12 weeks after budding (WAB), using the band method. The studies were carried out in alternate years in 1991, 1993 and 1995.

Pruning was obtained from *Leucaena* at five months old at a height of 50cm above ground level. *Leucaena* biomass was determined and non-woody or easily decomposable parts such as leaves and green stems were spread in the alley for nutrients recycling. Subsequent pruning were carried out at 10 weeks interval. *Leucaena* dry matter was determined and nutrient contents were assessed on leaf samples. The analysis was carried out using the procedures outlined by the International Institute for Tropical Agriculture (IITA, 1984). Bud break of the scion (bud sprout) or bud survival was determined by counting at 6 WAB. Budded seedling growth assessment as affected by the treatments started 8 WAB. Chlorophyll content was assessed by the greenness of the leaves using scales 1-5 [1=Pale green; 2=Slightly green; 3=Green; 4=Deep green, and 5=deeper green]. Nutrients contents of the budded citrus seedling was determined using the leaf samples and analyzed by the method described by IITA (1984). This was done during the third cropping at 24WAB in 1995.

RESULTS

The treatments influenced bud survival in citrus nursery (Table 2), seedlings without pruning and fertilizer recorded the least percentage bud break (52.43%) in 1995. Results of the first study in 1991 showed that fertilizer with or without pruning enhanced higher leaf production and scion length (Table 3). There was no significant differences among the treatments with regards to the budded citrus seedling growth during the first year (Table 3). As the cropping cycle progressed, budded seedlings in the alleys with *Leucaena* pruning alone (L_1N_0) had the same growth with seedlings that received fertilizer alone (L_0N_2) or fertilizer combined

Table 2: Effects of *Leucaena, Leucaena* + fertilizer and fertilizer on budbreak of budded citrus seedings in Southwest Nigeria (28 days after budding).

	% Bud break	
Treatments	1993	1995
No application (L_0N_0)	88.4	52.43
Leucaena pruning alone (L_1N_0)	73.20	82.10
Leucaena pruning + 100kg NPK/ha (L_1N_1)	79.12	89.20
Leucaena pruning + 200kg/ha (L_1N_2)	80.37	85.27
200kg NPK/ha (L_0N_2)	86.21	80.70
S.E.	9.35	11.31
LSD (P = 0.05)	Ns	21.29

S.E. = Standard Error of Means.
Ns = Not significant

with *Leucaena* (L_1N_1 and L_1N_2). All treatments were significantly superior to the control (Table 3). Results of the leaf greenness showed that seedlings with treatment of *Leucaena* pruning alone (L_1N_0) as well as treatment with *Leucaena* plus 100kg NPK/ha. (L_1N_1) ranked best during the third assessment in 1995 while control (L_0N_0) was the poorest (Table 3). Nitrogen and Manganese concentration in the leaf of budded citrus seedlings were enhanced by leucaena and fertilizer application. Phosphorus concentration in the leaf of budded citrus was improved by application of 200kg NPK/ha. Fertilizer and leucaena in the soil impaired zinc and calcium absorption by the leaves of budded citrus seedling (Table 4).

The pre-planting soil analyses compared with the subsequent soil data showed no consistent trend on the values of Mg, C.E.C. and Cu (Not in the table), while

Table 3: Effect of *Leucaena* and NPK fertilizer on the growth of budded sweet orange seedling 24 Weeks after budding in the nursery.

Treatments	Scion diameter at 2m away from bud union (cm)		No. of leaves		Scion length (cm)		*Chlorophyll (Leaf Greenness)
	1st cropping 1991	3rd cropping 1995	1st cropping 1991	3rd cropping 1995	1st cropping 1991	3rd cropping 1995	
L_0N_0	1.06	0.73	65.17	33.23	59.03	50.50	1.67
L_1N_0	0.88	0.95	74.60	66.57	67.37	62.67	4.67
L_1N_1	1.12	1.08	94.53	80.27	70.47	71.23	4.67
L_1N_2	1.00	0.97	99.63	81.77	75.33	64.83	3.70
L_0N_2	1.11	1.12	1.00	77.50	82.17	65.43	3.30
S.E.	0.10	0.09	9.35	8.57	6.05	4.05	0.46
LSD = (P 0.05)	Ns	0.21	21.56	19.76	13.95	9.33	1.06

* 1= Pale green (low) 5 = Deep green (high) Ns = Not significant

Table 4: Nutrients concentration in the leaf of budded citrus seedlings as affected by *Leucaena* plus NPK fertilizer combinations 24 weeks after budding.

Treatments	Nutrient Contents (%)								
	N	P	K	Ca	Na	Fe	Mn	Zn	Cu
L_0N_0	1.73	0.03	0.19	0.72	0.06	0.04	0.78	0.89	0.002
L_1N_0	2.66	0.03	0.16	0.49	0.05	0.04	0.90	0.46	0.002
L_1N_1	2.29	0.04	0.15	0.55	0.06	0.04	1.04	0.67	0.002
L_1N_2	2.24	0.04	0.14	0.61	0.05	0.03	1.08	0.57	0.002
L_0N_2	1.73	0.07	0.20	0.53	0.06	0.06	1.08	0.43	0.001
LSD = (P 0.05)	0.02	0.01	Ns	0.15	Ns	Ns	0.19	0.19	Ns

Ns = Not significant

the following soil properties decreased with time: pH, Ca, K, Mn and Zn (Table 5). Leucaena pruning with or without fertilizer led to the improvement in the following soil properties, organic Carbon, N, P and Fe (Table 5). Soil texture (Sandy loam) remained the same during the cropping period. Biomass yield (Table 6) was enhanced with fertilizer and it increased with age. There was no significant difference between leucaena with fertilizer (L_1N_1 and L_1N_2) and without fertilizer (L_1N_0) in the leaf nutrient contents (Table 7).

DISCUSSION

The slow growth of budded citrus seedlings with leucaena pruning alone during the first study in 1991 suggested that the citrus seedlings needed "starter nutrients" during the early growth stages to boost the growth and reduce the competitive effects of the establishing *Leucaena* hedgerow (Agboola, 2000). However, after the first cropping the citrus seedlings that received *Leucaena* treatment alone compared favourably with treatment with fertilizer alone or fertilizer combined with leucaena. It could be explained that the first cropping period was the 'waiting period' when the nitrogen fixing apparatus of leucaena was developing. During the subsequent cropping periods the litter fall of leucaena would have decomposed, thus increasing the soil organic matter and releasing nutrients to the budded seedlings. The beneficial effect of alley cropping to maintain soil productivity over time has been reported by some authors (Kang *et al.*, 1981), Anonymous 1984; Ngambeki, 1985, Kang and Duguma 1985). Biomass production is very important in alley cropping, since the primary objective is to improve soil fertility.

Age of leucaena and rate of fertilizer application seem to be major factors that boosted the quality and quantity of biomass production of leucaena in this study. This agrees with the findings of Sanginga and Mulongoy (1992), who observed that the quality of the pruning changes with the age, and the conditions of the hedgerows. The highest zinc content recorded in the leaf of the control treatment over other treatments might have resulted because of excessive phosphorus accumulation which have been reported to adversely

Table 5: Effects of *Leucaena leucocephala* plus NPK Fertilizer on soil properties of a citrus nursery in Ibadan at the end of each study.

	pH (H_2O)			Org. C. g.kg^{-1}			Total N g.kg^{-1}			Avail. P.mg kg^{-1}			Ca cmol.kg^{-1}			K cmol.kg^{-1}			Mn mg.kg^{-1}			Fe mg.kg^{-1}			Zn mg.kg^{-1}		
Year	91	93	95	91	93	95	91	93	95	91	93	95	91	93	95	91	93	95	91	93	95	91	93	95	91	93	95
L_0N_0	7.4	6.9	5.6	10.2	11.8	13.9	1.0	0.6	0.4	-	4.8	7.3	3.4	3.0	1.2	0.2	-	0.1	-	-	20.3	-	-	12.7	-	-	3.1
L_1N_0	7.2	7.7	5.5	8.7	11.4	24.9	0.9	0.4	0.6	-	5.1	10.3	2.8	2.6	1.1	0.2	-	0.1	-	-	29.2	-	-	17.0	-	-	4.9
L_1N_1	7.2	6.6	5.4	10.9	12.0	19.5	1.1	0.6	0.6	-	6.8	8.5	3.3	3.0	1.3	0.4	-	0.2	-	-	35.0	-	-	18.9	-	-	4.0
L_1N_2	7.2	6.3	5.6	10.2	12.9	16.4	1.0	0.7	0.5	-	7.5	8.3	2.8	2.6	1.3	0.3	-	0.1	-	-	28.3	-	-	16.4	-	-	4.1
L_0N_2	7.2	6.8	5.5	10.3	14.2	17.0	1.0	0.5	0.4	-	4.8	7.0	3.3	2.3	0.6	0.3	-	0.1	-	-	24.4	-	-	12.9	-	-	3.5

L_0N_0 = Control (No fertilizer and *Leucaena* pruning); L_1N_0 = *Leucaena* pruning alone;
L_1N_1 = *Leucaena* pruning + 100kg NPK/ha; L_1N_2 = *Leucaena* pruning + 200kg NPK/ha;
L_0N_2 = 200kg NPK/ha.

Table 6.Effects of fertilizer treatments on biomass yield (t/ha) of *Leucaena leucocephala* in citrus based cropping system.

	1990		1991		1992		1993		1994		1995	
Treatment	F.W.	D.W	F.W.	D.W	F.W.	D.W	F.W.	D.W	F.W.	D.W	F.W.	D.W
Citrus + *Leucaena* only(L_1N_0)	3.04	0.48	39.77	6.36	66.19	10.59	103.42	16.54	101.54	16.24	82.08	13.13
Citrus + *Leucaena* + 100kg NPK/ha (L_1N_1)	5.54	0.88	60.58	9.67	83.13	13.29	119.08	19.05	110.54	17.68	83.86	13.41
Citrus + *Leucaena* + 200kg NPK/ha (L_1N_2)	5.38	0.86	66.59	10.65	83.42	13.34	113.25	18.17	110.96	17.75	82.50	13.20
S.E.	0.48	0.04	6.60	1.05	4.25	1.25	10.68	1.85	3.15	1.65	0.83	0.31
LSD (P=0.05)	1.33	0.11	18.32	2.91	11.80	Ns	Ns	Ns	Ns	Ns	Ns	Ns

F.W. = Fresh Weight D.W. = Dry Weight.

1990 - One pruning; 1991 – Four prunings;
1992 - Five prunings; 1993 - Four prunings;
1994 - Five prunings and 1995 - Three prunings.
40% biomass were woody materials.
Ns = Not significant

Table 7: Nutrients concentration in the leaf of five year old *Leucaena leucocephala.*

	Concentrations (%)								
	N	P	K	Ca	Na	Fe	Mn	Zn	Cu
L_1N_0	4.78	0.05	0.12	0.41	0.04	0.04	0.93	0.35	0.003
L_1N_1	4.89	0.05	0.10	0.44	0.05	0.02	0.90	0.32	0.002
L_1N_2	4.85	0.04	0.11	0.44	0.04	0.02	0.74	0.49	0.002
S.E.	0.65	0.01	0.04	0.08	0.01	0.01	0.12	0.09	0.001
LSD (P=0.05)	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Ns = Not significant

affect zinc absorption by the citrus leaf (Davies and Albrigo, 1994; Onwueme and Sinha; 1991).

CONCLUSION

The growth of budded citrus seedlings showed that 100kg/ha NPK with leucaena pruning should be adopted for the first two cropping cycles. From the third cropping, budded seedlings with leucaena pruning alone (L_1N_0) compared favourably with those with fertilizer alone (L_0N_2) and leucaena/fertilizer combinations (L_1N_1 and L_1N_2).

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