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EFFECTS OF LEAF LITTERS OF NITROGEN-FIXING TREES AND WATERING REGIMES ON THE EARLY GROWTH OF *Citrus tangelo* J. W SEEDLINGS

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Abstract

There is shortage of characterized facts on the influence of plant-located fertilizer on the growth of Citrus tangelo. Research was carried out on the effects of leaf litters of selected nitrogen-fixing trees and watering regimes on the early growth of Citrus tangelo. The experiment selected a 6x5 factorial duplicated five times and laid out in Randomized Complete Block Design to assess the effect of different leaves of nitrogen-fixing tree species (Prosopis africana, Jacaranda mimosifolia, Pentaclethra macrophylla, Vitex doniana, Enterelobium cyclocarpum and Casuarina equisetifolia) and watering regimes (1, 2, 3, 4 and 5days' interval) on the growth of Citrus tangelo. The experiment involved a total of one hundred and fifty seedlings. Analysis of Variance (ANOVA) was performed on the outcome of C. tangelo seedlings cautiously transplanted into pots with and without 10g of leaf litters of nitrogen-fixing trees. The leaf litters of nitrogen-fixing trees and watering regimes significantly ($P<0.05$) embellished the growth of C. tangelo. Result revealed that highest height (7.64cm), significant leaf area (12.21cm^2), significant leaf area index(1.40), significant total fresh weight (3.37g) and significant total dry weight (0.96g) were recorded from seedlings cultivated in the soil corrected with leaf litter of J. mimosifolia at 12 WAT. The result of interaction showed significant parameters from seedlings planted in the soil improved with leaf litters of J. mimosifolia and subjected to daily watering at 12 WAT. Highest nitrogen (1.92 %), phosphorus (36.7mg/100g) and potassium (618.36 mg/100g) uptake were recorded from seedlings cultivated in J. mimosifolia, P. africana and C. equisetifolia, sequentially. The use of leaf litter of J. mimosifolia improves the early growth and nutrient uptake of C. tangelo.

Key Words: *Fruit trees, Slow growth, Soil restoration, Fertilizer trees, Watering Regime*

Introduction

The soil is very main determinant in food guarantee. Inadequate soil fertility leads to food instability (Akinrinde, 2006). Declining soil fertility is a major production restriction in Africa, especially in Nigeria (Aduradola *et al.,* 2016). Gruhn *et al.* (2000) established that soil fertility is the basic limitations to fruitful agriculture in any arid and semi-arid Africa. Most of agricultural practices grown to reinforce soil potency are facing socio economic and ecological challenges that deterred their capability to secure food for people (Adekola and Usman, 2009). Akinnifesi *et al.* (2007) established that the use of not organic fertilizers and lime by smallholder farmers is facing challenges of incompetent supply on account of delivery problems and restrictive costs. Olowe and Akintunde (2012) noted that overdone synthetic manure pollutes the environment.

The lack, bulk, offensive odour and disease upsurge have lowered the use of animal fertilizer as manure (Adekola and Usman, 2009). Moreover, Emeghara *et al.* (2012) stated that farmyard manure raised the occurrence of weeds. These challenges confronting soil have resulted to insufficiency of soil nutrient in most fields (Adekola and Usman, 2009). Adelani *et al.* (2014) recommended agroforestry as a reasonable answer to these challenges. ICRAF (1997) outlined agroforestry as an active ecologically-located natural resources management system that through the integration of trees on farms and in agricultural landscape diversifies and sustains production for increased socio-economic and environmental users at all level. Lundgren and Raintree (1982) too delineated agroforestry as a composite name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are intentionally used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems, there are both ecological and economical interactions between the different components.

Biomass transfer method is a common agroforestry practice that is used for enhancement of the land with the litter of nitrogen-fixing trees. WAC (2018) established that nitrogen-fixing tree species have the strength to fix atmospheric nitrogen through collaboration with bacteria or fungi in their root nodules. Nitrogen-fixing trees can take over nitrogen (N) lost in harvest, possess the special ability to establish in N-deficient soils, and provide as of yet not fully fulfilled benefits to ecosystem services (Kurppa *et al.,* 2010., Araujo *et al.,* 2012., Jensen *et al.,* 2012., Nygren *et al.,* 2012). The most universal N_2–fixing trees used in tropical agroforestry systems includes the legumes *Acacia* spp*, Erythrina* spp, *Gliricidia* spp., *Inga* spp and *Leucaena* spp that form cooperative unions with a numerous variety of N_2-fixing bacterial species (Bala *et al.,* 2003).

Nitrogen fixation approximates for several tree species commonly selected in agroforestry systems have been comprehensively reviewed and established, 5% for *Calliandra calothyrsus* (Stahl *et al.,* 2002), 92% for *Gliricidia sepium* (Nygren *et al.,* 2000)., 20 to 48% for *Coffee arabica* (Snoeck *et al.,* 2000), 85 to 86% for *Gliricidia sepium* and 74 to 81% for *Inga edulis* (Kurppa *et al.,* 2010). Leaf litter of the nitrogen fixative genus alder (*Alnus*) has excellent actual concentrations of N (often above 3%); in contrast, pine needle litter is nitrogen poor (frequently under 0.4%) (Berg and McClaugherty, 2003). Berg and McClaugherty (2003) established that a particular plant variety decides the value of its litter. The tree litters which serve as plant-based organic manure release nutrient into soil during break down and mineralization. Gangwar *et al.* (2006) established that the use of organic manure from tree litters assist to increase soil biopores and soil aeration, higher soil organic carbon content, and better soil aggregation.

Litter develops soil quality by accumulating the organic matter and nutrients to the soil (Mahmood and Hoque, 2008; Ngoran, *et al.,* 2006; Triadiati *et al.,* 2011). Leaf litter is the chief and quickest source of organic matter and nutrient to the soil relative to other litter types (Hossain *et al.,* 2011, Park and Kang-Hyun, 2003). The source of organic matter and nutrient to the soil will improve the growth and yield of Crop as *Citrus tangelo* to meet its population demand for Nigerians. Tangelos are a distinguishing composite of mandarin sweet and grape fruit or pummelo. Yuma (2018) established that tangelos are made from composite of *Citrus paradisi* and *Citrus reticulate* or from a cross between the Duncan grape fruit and the Dancy tangerine. *Citrus tangelo* belongs to the classification of Rutaceae. Not only are tangelos full accompanying flavour, they are more an excellent beginning of vitamins C and A (Yuma 2018). They are larger in breadth; hold more liquid squeezed from plant and kinder than tangerines and these create bureaucracy to be an excellent snack choice (Yuma 2018). Mike (2015) established that citrus seedlings as tangelo take a very long time to evolve and for the root to pierce into soil. Oranges, lemons, Persian lime, and tangerines produce fruits between 5-7years. The grapefruit, pomelo and tangelo produce fruits from 8-12 years of age (Darren, 2010).

Nutrition in citrus plays a main act for asserting vigour, yield and quality fruit production for longer period (Hemant *et al.,* 2020). Cruz (2018) reported that *C. tangelo* is nitrogen demander. Nitrogen plays live parts in metabolic processes and phenology of plant (Khan *et al.,* 2013) and evenly advancing cellular division and increase (Shehu *et al.,* 2010). Pandey *et al.* (2000) established that nitrogen supply has substantial effects on plant growth and development. Nitrogen is also vital to plant as water. Water and fertilizer are critical for citrus growth and fruit yield (Ma *et al.,* 2022). Water is individual of ultimate restricting material determinants of growth and productivity (Pirzad *et al.,* 2011) as well as distribution of the plants in the tropics (Bongers *et al.,* 2004). Water is the footing of growth, necessary by plants for the produce of carbohydrates.

Water is the foundation of life, required by plants for the produce of carbohydrates and as a means for transportation of foods and mineral elements (Isah *et al.,* 2013; Oboho and Igharo, 2017). For tree nurseries, regular watering is essential for the production of good quality seedlings. This is because any inactivity in seedling growth or subsequent mortality translates into business-related misfortune to a nursery operator. The loss may affect the seedlings to the extent that they will not reach good size for grafting and transplanting as well as for sale (Mng'omba *et al.,* 2011). The amount of water required by a plant depends on the species type, age, and the dominant climatic condition of the growing site. Inadequate water could lead to undersize growth or even end of life of a plant. Oboh and Igharo (2017) reported that there is increasing challenges about water availability specifically in dry land forestry and nursery raised seedlings.

In order to advance tenable use of water in the nurseries, it is alive to enact optimum water necessities for tree seedlings growth (Mukhtar *et al.,* 2016) that as a consequence help in lowering the cost of setting stock in commercial nurseries (Mng'omba *et al.,* 2011). Water is essential in soil management. Inadequate supplies of nutrients and water leading to stunted growth, slow growth, chlorosis or cell death as well as plant death (Morgan and Connolly, 2013; Mohammad *et al.,* 2016; Filipovic, 2021). Adequate water and plant based organic fertilizer needs to be supplied to slow growing *C. tangelo* to enhance its growth for meeting population demand.

Water is available and the leaf litters of nitrogen-fixing trees are affordable, accessible and environmentally friendly. Oyun *et al.* (2015) established that for the distinct management problems of tropical soils, there is need to form native, home grown, affordable, adoptable and adaptable methods to manage the soils for sustainable cropping. Little information is available on the effect of leaf litter of nitrogen-fixing trees and watering regime on the preliminary growth of *C. tangelo.* In this light, investigation was conducted into effects of leaf litters of nitrogen-fixing trees and watering regime on the early growth of *C. tangelo.*

Materials and Method

Experimental Site

The experiment was completed activity in the screen house of Federal College of Forestry Mechanization, Afaka, Kaduna. The college is situated in the Northern Guinea Savannah ecological zones of Nigeria. The college lies within latitudes 10^o 34′ and 10^o 35′ and longitudes 7^o 20′ and 7^o 21′ (Adelani 2015). The vegetation is open woodland with tall, broad trees, usually with small boles and broad leaves (Otegbeye *et al.,* 2001).

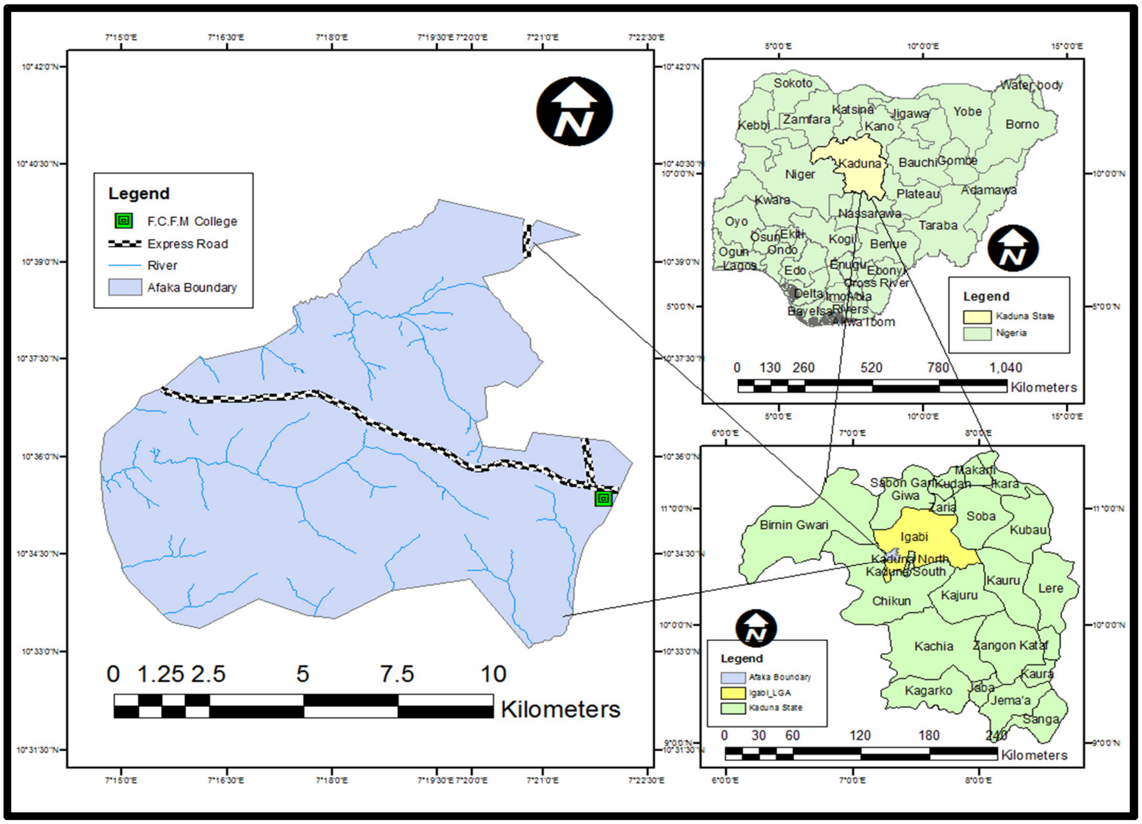

Fig. 1: The location of Federal College of Forestry Mechanization, Afaka, Kaduna State, Nigeria

Experimental Materials

The biomass transfer method which involves the collections of wet leaves was used because some nitrogen-fixing tree species were not located in the same site. The samples of each leaves were air dried, milled and weighed (10g). The river sand was collected from the floor of the dam, passed through 2mm sieve and soaked in 10% hydrochloric acid for 24hours to eliminate impurities, organic matter and nutrient residue in accordance with the recommendation of Adelani *et al.* (2014). The samples of disinfect sand (0.75kg) were thoroughly mixed with 10g of leaves of nitrogen-fixing trees and then filled into polypots of 20x10x10cm^3 dimensions. The potting mixture was watered at 200ml to field capacity before and after transplanting the seedlings. The sand without the addition of leaf litters was used for control. Distil water was administered to the seedlings. A month-old seedling of *Citrus tangelo* was transplanted into the pots with and without the prepared combination of nutrient and sand.

Experimental Design

Pot experiment was administered in a screen apartment. The effects of leaf litters of nitrogen fixing trees and watering regimes were evaluated. A 6 x 5 factorial experiment planned in Randomized Complete Block Design was used to evaluate the effect of different leaves of nitrogen fixing tree species (*Prosopis* *africana, Jacaranda mimosifolia, Pentaclethra macrophylla, Vitex doniana, Enterelobium cyclocarpum* and *Casuarina equisetifolia*) and watering regimes (1, 2, 3, 4 and 5days' interval) on the preliminary growth of *Citrus tangelo.* Seedling assessment was evaluated fortnightly after transplanting. Seedlings were transplanted into 4cm depth of soil. Growth variables noticed include: seedling height using meter rule, collar girth using Vernier caliper. The number of leaves computed manually and Leaf area was derived by linear measurement of leaf length and leaf width as expressed by Clifton-Brown and Lewandowski (2000).

LA=0.74xLxW (1)

Where, LA =Leaf area=Product of linear dimension of the length and width at the broadest part of the leaf.

Leaf area index was computed by leaf area/ land area (2)

The fresh and dry weight were determined by the use of Mettler Top Loading Weighing Balance before and after oven dried at 70ºC for 72 hours (Umar and Gwaram, 2006).

Chemical Analysis of Leaf Litters of Nitrogen Fixing Trees and the C. tangelo Plant

Each sample of milled leaves of nitrogen fixing tree species after air dried was analyzed chemically for nitrogen, phosphorus and potassium (NPK) content at the Federal University of Agriculture Abeokuta, Ogun State, Nigeria laboratory. Ascertainment of total nitrogen, and available phosphorus were done by Macrokjeldahi and Bray method respectively. Extracts from the digestion of the leaves of the agro-forestry tree species were used to diagnose potassium by flame photometry. Tissue analysis was evaluated for the whole plant of *C. tangelo* seedlings to determine the nutrient uptake**.**

Nutrient uptake of the C. tangelo seedlings

Tissue analysis was also done for the sample of whole plant of *C. tangelo* seedlings before transplanting in the beginning and after transplanting at end of the experiment respectively to determine nutrient uptake. Nitrogen, Phosphorus and Potassium content were determined by Macro Kjeldahi method, Bray-1 method and flame photometry method respectively.

Nutrient Uptake was evaluated by Method of Sharma *et al.* (2012) = % N % P % K x Dry matter kg ha-1/100 (3)

Actual nutrient uptake was determined by changes in nutrient uptake at the beginning and the end of the experiment.

Data Analysis

Data were collected and subjected to analysis of variance (ANOVA) using SAS (2003). A comparison of significant means was accomplished using Fishers' Least Difference LSD at 5% level of significance.

Results

There was no significant difference (p>0.05) between height of seedlings planted in the soil amended with and without leaf litters of nitrogen-fixing tree species and watering regimes. Highest height of 7.64cm was recorded from seedlings planted in soil with *J. mimosifolia*. Highest height of 7.21 cm was recorded in seedlings subjected to daily watering regimes (Table 1).

Table 1: Effect of leaf litters of nitrogen-fixing tree species and watering regimes on the height (cm) of *C. tangelo*

N F T S	W	A	T			
	2	4	6	8	10	12
P.africana	6.12[a]	6.92[a]	7.12[a]	7.12[a]	7.12[a]	7.12[a]
J. mimosifolia	6.20[a]	6.76[a]	7.64[a]	7.64[a]	7.64[a]	7.64[a]
P. macrophylla	5.56[a]	6.12[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]
V. doniana	5.76[a]	5.76[a]	6.68[a]	6.68[a]	6.68[a]	6.68[a]
E. cyclocarpum	5.92[a]	5.92[a]	6.92[a]	6.92[a]	6.92[a]	6.92[a]
C. equisetifolia	5.76[a]	5.76[a]	6.56[a]	6.56[a]	6.56[a]	6.56[a]
SE $\pm$	1.36	1.36	1.36	1.36	1.36	1.36
W. R						
1	6.30[a]	6.36[a]	7.20[a]	7.20[a]	7.20[a]	7.21[a]
2	5.90[a]	6.16[a]	6.90[a]	6.90[a]	6.90[a]	7.20[a]
3	6.21[a]	6.33[a]	7.13[a]	7.13[a]	7.13[a]	7.13[a]
4	5.50[a]	5.93[a]	6.90[a]	6.90[a]	6.90[a]	6.90[a]
5	5.51[a]	5.86[a]	6.80[a]	6.80[a]	6.80[a]	6.80[a]
SE$\pm$	1.30	1.30	1.30	1.30	1.30	1.30
NW	NS	NS	NS	NS	NS	NS

*Means on the same column having different superscripts are significantly different (p<0.05)
Key: NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime, WAT= Weeks After Transplanting, NW=Nitrogen fixing trees and Watering Regimes, NS= Not Significant

There was no significant difference (p>0.05) between the girths of seedlings planted in the soil mixed with and without leaf litters of nitrogen fixing species. Highest girth of 1cm was recorded from seedlings planted in soil amended with all nitrogen fixing tree species (Table 2).

Table 2: Effect of the leaf litter of nitrogen-fixing tree species and watering regimes on the girth (cm) of *C. tangelo*

N F T S	W	A	T			
	2	4	6	8	10	12
P. africana	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
J. mimosifolia	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
P. macrophylla	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
V. doniana	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
E. cyclocarpum	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
C. equisetifolia	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
SE$\pm$	0.00	0.00	0.00	0.00	0.00	0.00
W. R	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
1	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
2	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
3	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
4	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
5	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
SE$\pm$	0.00	0.00	0.00	0.00	0.00	0.00
NW	NS	NS	NS	NS	NS	NS

*Means on the same column having different superscripts are significantly different (p<0.05)
Key: WAT= NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime, Weeks After Transplanting, NW=Nitrogen fixing trees and Watering Regimes, NS= Not Significant

There was no significant difference (p>0.05) between the numbers of leaves of seedlings planted in the soil mixed with and without leaf litters of nitrogen-fixing species. Highest number of leaves of 5.32 was recorded from seedlings planted in the soil improved with leaf litters of *C. equisetifolia* and *E. cyclocarpum.* Highest number of leaves of 6.53 was recorded from seedlings subjected to daily watering regime, while the least value of 2.06 was recorded in seedlings subjected to 5days' watering interval (Table 3).

Table 3: Effect of leaf litters of nitrogen-fixing tree species and watering regimes on the number of leaves of *C. tangelo*

N F T S		W	A	T		
	2	4	6	8	10	12
P.africana	2.48[a]	3.44[a]	3.56[a]	4.32[a]	4.32[a]	4.32[a]
J. mimosifolia	3.20[a]	4.32[a]	4.36[a]	5.16[a]	5.20[a]	5.20[a]
P. macrophylla	3.24[a]	4.08[a]	4.08[a]	5.04[a]	5.12[a]	5.12[a]
V. doniana	3.20[a]	4.12[a]	4.12[a]	5.04[a]	5.08[a]	5.08[a]
E. cyclocarpum	3.12[a]	4.00[a]	4.08[a]	5.08[a]	5.08[a]	5.32[a]
C. equisetifolia	2.88[a]	3.84[a]	3.92[a]	5.28[a]	5.32[a]	5.32[a]
SE±	1.50	1.80	1.90	2.00	2.00	2.00
W. R						
1	5.00[a]	6.00[a]	6.00[a]	6.53[a]	6.53[a]	6.53[a]
2	2.53[a]	3.36[a]	3.33[a]	4.46[a]	4.46[a]	4.70[a]
3	2.93[a]	3.86[a]	3.90[a]	4.86[a]	4.93[a]	4.93[a]
4	2.56[a]	3.10[a]	3.13[a]	4.63[a]	4.70[a]	4.70[a]
5	2.06[a]	3.46[a]	3.46[a]	4.43[a]	4.43[a]	4.43[a]
SE±	2.00	1.70	1.70	1.80	1.80	1.80
NW	NS	NS	NS	NS	NS	NS

*Means on the same column having different superscripts are significantly different (P<0.05
Key: WAT= NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime, Weeks After Transplanting, NW=Nitrogen fixing trees and Watering Regimes, NS= Not Significant

The leaf area of seedlings planted in *J. mimosifolia* was significantly (p<0.05) different from that of control. Highest leaf area of 12.21cm^2 was recorded from seedlings planted in *J. mimosifolia* at 12 WAT. Highest leaf area of 14.18cm^2 was recorded from seedlings subjected to daily watering at 12 WAT. The least leaf area value of 6.49cm^2 was recorded from seedlings subjected to 5days' watering interval at 2 WAT. Seedlings predisposed to daily watering were significantly (p<0.05) different from that of other watering regimes (Table 4).

Table 4: Effect of leaf litter of nitrogen-fixing tree species and watering regimes on the leaf area (cm^2) of *C. tangelo*

NFT S	W	A	T			
	2	4	6	8	10	12
P.africana	7.32^{a}	7.94^{ab}	9.40^{ab}	10.12^{ab}	10.12^{ab}	10.12^{ab}
J. mimosifolia	8.97^{a}	9.06^{a}	11.04^{a}	12.21^{a}	12.21^{a}	12.21^{a}
P. macrophylla	7.24^{a}	7.24^{b}	9.31^{ab}	11.20^{ab}	11.20^{ab}	11.20^{ab}
V. doniana	6.86^{a}	6.64^{a}	9.04^{ab}	9.39^{b}	9.39^{b}	9.39^{b}
E. cyclocarpum	8.86^{a}	8.86^{a}	9.92^{a}	10.30^{ab}	10.30^{ab}	10.30^{ab}
C. equisetifolia	7.15^{a}	6.53^{b}	8.09^{b}	8.51^{b}	8.51^{b}	8.51^{b}
SE$\pm$	0.86	0.68	0.70	1.02	1.02	1.02
W. R						
1	11.59^{a}	11.48^{a}	13.77^{a}	14.18^{a}	14.18^{a}	14.18^{a}
2	7.18^{b}	6.98^{b}	8.49^{b}	9.69^{b}	9.69^{b}	9.69^{b}
3	6.67^{b}	6.67^{b}	8.49^{b}	9.53^{b}	9.53^{b}	9.53^{b}
4	6.73^{b}	6.61^{b}	8.38^{b}	9.26^{b}	9.26^{b}	9.26^{b}
5	6.49^{b}	6.67^{b}	8.10^{b}	9.26^{b}	9.26^{b}	9.26^{b}
SE$\pm$	0.56	0.62	0.64	0.92	0.92	0.92

*Means on the same column having different superscripts are significantly different ($P<0.05$).
Key: WAT= NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime, Weeks After Transplanting, FW= Fresh Weight, TFW-Total Fresh Weight, DW=Dry Weight, TDW=Total Dry Weight, Rs=Rates, L=Leaf, S=Shoot, R=Root

Significant leaf area of 22.65cm^2 was recorded from seedlings planted in the soil ameliorated with leaf litters of *J.mimosifolia* and subjected to daily watering at 12 WAT. The least leaf area value of 4.55cm^2 was recorded from seedlings planted in soil amended with leaf litters of *C. equisetifolia* and subjected to 5days' watering interval at 2 WAT (Table 5).

Table 5: Interactive effect of the leaf litters of nitrogen-fixing tree species and watering regimes on the leaf area (cm^2) of *C. tangelo*

NFTS	W.R	W		A	T		
		2	4	6	8	10	12
P.africana	1	6.57[b]	8.62[b]	11.14[b]	12.85[ab]	12.85[ab]	12.85[ab]
	2	8.20[ab]	8.20[b]	9.37[b]	9.46[ab]	9.46[ab]	9.46[ab]
	3	8.69[ab]	9.33[b]	9.46[b]	9.46[ab]	9.46[ab]	9.46[ab]
	4	7.15[b]	7.15[b]	9.20[b]	9.20[ab]	9.20[ab]	9.20[ab]
	5	5.99[b]	6.42[b]	7.83[b]	8.74[b]	8.74[b]	8.74[b]
J.mimosifolia	1	16.83[a]	18.10[a]	20.87[a]	22.65[a]	22.65[a]	22.65[a]
	2	6.80[b]	6.80[b]	8.74[b]	10.56[ab]	10.56[ab]	10.56[ab]
	3	7.49[b]	7.49[b]	9.65[b]	9.88[ab]	9.88[ab]	9.88[ab]
	4	6.23[b]	6.23[b]	7.83[b]	9.20[ab]	9.20[ab]	9.20[ab]
	5	6.23[b]	7.97[b]	7.97[b]	9.20[ab]	8.74[b]	8.74[b]
P.macrophylla	1	10.40[ab]	10.40[ab]	13.53[ab]	13.53[ab]	13.53[ab]	13.53[ab]
	2	6.83[b]	6.83[b]	9.24[b]	12.34[ab]	12.34[ab]	12.34[ab]
	3	5.85[b]	5.85[b]	7.58[b]	10.62[ab]	10.62[ab]	10.62[ab]
	4	6.14[b]	6.14[b]	7.26[b]	10.56[ab]	10.56[ab]	10.56[ab]
	5	6.98[b]	6.98[b]	8.97[b]	8.97[ab]	8.97[ab]	8.97[ab]
V.doniana	1	8.69[ab]	8.69[b]	11.25[ab]	11.25[ab]	11.25[ab]	11.25[ab]
	2	7.60[ab]	7.60[b]	9.88[b]	10.91[ab]	10.91[ab]	10.91[ab]
	3	5.55[b]	5.55[b]	8.97[b]	8.97[b]	8.97[b]	8.97[b]
	4	5.55[b]	5.55[b]	8.97[b]	8.97[b]	8.97[b]	8.97[b]
	5	6.01[b]	6.01[b]	7.15[b]	7.15[b]	7.15[b]	7.15[b]
E.cylocarpum	1	15.81[ab]	15.81[ab]	18.09[ab]	18.09[ab]	18.09[ab]	18.09[ab]
	2	7.96[b]	8.02[b]	8.86[b]	8.93[b]	8.93[b]	8.93[b]
	3	6.58[b]	6.58[b]	8.40[b]	8.74[b]	8.74[b]	8.74[b]
	4	6.48[b]	6.48[b]	7.66[b]	8.23[b]	8.23[b]	8.23[b]
	5	6.60[b]	6.60[b]	7.45[b]	7.49[b]	7.49[b]	7.49[b]
C.equisetifolia	1	7.83[ab]	7.83[b]	9.43[b]	10.11[ab]	10.11[ab]	10.11[ab]
	2	7.94[ab]	7.94[b]	9.65[b]	10.57[ab]	10.57[ab]	10.57[ab]
	3	6.20[b]	6.55[b]	7.83[b]	7.99[b]	7.99[b]	7.99[b]
	4	6.12[b]	6.83[b]	7.66[b]	7.66[b]	7.66[b]	7.66[b]
	5	4.55[b]	5.87[b]	6.21[b]	6.21[b]	6.21[b]	6.58[b]
SE±		3.30	3.90	5.60	5.60	5.60	3.90

*Means on the same column having different superscripts are significantly different ($P<0.05$)
Key: NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime,
WAT= Weeks After Transplanting

Significant leaf area index of 1.40 was recorded from seedlings planted in *J. mimosifolia* at 12 WAT. The least value of 1.00 was recorded from seedlings subjected to 5day watering intervals at 2 WAT (Table 6).

Table 6: Effect of leaf litter of nitrogen-fixing tree species and watering regimes on leaf area index on *C. tangelo*

NFT S		W	A	T		
	2	4	6	8	10	12
P.africana	1.53^{b}	1.53^{b}	1.53^{b}	0.93^{c}	0.93^{c}	0.93^{c}
J. mimosifolia	1.48^{b}	1.48^{b}	1.05^{c}	1.09^{b}	1.09^{b}	1.40^{a}
P. macrophylla	1.70^{b}	1.70^{ab}	1.21^{bc}	0.69^{c}	0.69^{c}	0.69^{c}
V. doniana	2.09^{a}	2.09^{a}	2.04^{a}	1.39^{a}	1.39^{a}	1.39^{a}
E. cyclocarpum	1.75^{ab}	1.75^{ab}	1.75^{ab}	1.07^{bc}	1.07^{bc}	1.07^{bc}
SE$\pm$	0.15	0.15	0.13	0.11	0.11	0.11
W. R						
1	1.93^{a}	1.93^{a}	1.78^{a}	1.18^{a}	1.18^{a}	1.18^{a}
2	1.78^{a}	1.78^{a}	1.61^{a}	1.13^{ab}	1.13^{ab}	1.13^{ab}
3	1.72^{a}	1.72^{a}	1.51^{b}	1.09^{ab}	1.09^{ab}	1.09^{ab}
4	2.03^{a}	2.03^{a}	1.83^{a}	1.30^{a}	1.30^{a}	1.30^{a}
5	1.00^{a}	1.00^{a}	0.92^{c}	0.89^{b}	0.89^{b}	0.89^{b}
SE$\pm$	0.06	0.14	0.12	0.10	0.10	0.10

*Means on the same column having different superscripts are significantly different ($P<0.05$)
Key: NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime,
WAT= Weeks After Transplanting

Significant leaf area index of 2.78 was recorded from seedlings planted in the soil amended with leaf litters of *J. mimosifolia* and subjected to daily watering at 12 WAT. The least leaf area index value of 0.51 was recorded from seedlings planted in soil amended with leaf litters of *P.macrophylla* and subjected to 3days' watering interval at 2-6 WAT (Table 7).

Table 7: Interactive effect of the leaf litters of nitrogen-fixing tree species and watering regimes on the leaf area index

NFTS	W.R		W	A	T		
		2	4	6	8	10	12
P.africana	1	1.20^{b}	1.54^{b}	1.54^{b}	1.97^{ab}	1.97^{ab}	1.97^{ab}
	2	0.98^{b}	0.98^{b}	0.98^{b}	1.19^{b}	1.75^{ab}	1.75^{ab}
	3	1.09^{b}	1.24^{b}	1.24^{b}	1.24^{b}	1.52^{ab}	1.52^{ab}
	4	0.71^{b}	0.71^{b}	0.96^{b}	0.96^{b}	0.96^{b}	1.06^{b}
	5	0.71^{b}	0.71^{b}	0.71^{b}	0.73^{b}	0.76^{b}	0.76^{b}
J.mimosifolia	1	1.43^{b}	1.43^{b}	1.43^{b}	2.78^{a}	2.78^{a}	2.78^{a}
	2	1.76^{b}	1.76^{b}	1.76^{b}	2.48^{ab}	2.48^{ab}	2.48^{ab}
	3	1.22^{b}	1.22^{b}	1.22^{b}	2.48^{ab}	2.48^{ab}	2.48^{ab}
	4	1.54^{b}	1.54^{b}	1.54^{b}	1.29^{b}	1.29^{b}	1.29^{b}
	5	0.94^{b}	1.16^{b}	1.16^{b}	1.24^{b}	1.24^{b}	1.24^{b}
P.macrophylla	1	0.57^{b}	0.57^{b}	0.57^{b}	1.44^{b}	2.13^{ab}	2.13^{ab}
	2	0.76^{b}	0.76^{b}	0.76^{b}	1.54^{ab}	2.04^{ab}	2.04^{ab}
	3	0.51^{b}	0.51^{b}	0.51^{b}	1.12^{b}	1.80^{ab}	1.80^{ab}
	4	0.79^{b}	0.79^{b}	0.79^{b}	1.12^{b}	1.55^{ab}	1.55^{ab}
	5	0.85^{b}	0.85^{b}	0.85^{b}	0.85^{b}	0.99^{b}	0.99^{b}
V.doniana	1	1.13^{b}	1.13^{b}	1.13^{b}	2.00^{ab}	2.00^{ab}	2.00^{ab}
	2	0.94^{b}	0.94^{b}	0.94^{b}	1.65^{ab}	1.66^{ab}	1.66^{ab}
	3	0.96^{b}	0.96^{b}	0.96^{b}	1.55^{ab}	1.55^{ab}	1.55^{ab}
	4	0.84^{b}	0.84^{b}	0.84^{b}	1.48^{ab}	1.48^{ab}	1.48^{ab}
	5	0.76^{b}	0.76^{b}	0.76^{b}	0.96^{b}	0.96^{b}	0.96^{b}
E.cyclocarpum	1	2.40^{a}	2.40^{a}	2.40^{a}	2.40^{ab}	2.40^{ab}	2.40^{ab}
	2	1.21^{b}	1.21^{b}	1.21^{b}	2.19^{ab}	2.19^{ab}	2.19^{ab}
	3	1.41^{b}	1.41^{b}	1.41^{b}	1.99^{ab}	1.99^{ab}	1.99^{ab}
	4	1.11^{b}	1.11^{b}	1.11^{b}	1.11^{b}	1.40^{b}	1.40^{b}
	5	0.76^{b}	0.76^{b}	0.76^{b}	0.76^{b}	0.79^{b}	0.79^{b}
C.equisetifolia	1	1.80^{b}	1.80^{b}	1.80^{b}	2.19^{ab}	2.19^{ab}	2.19^{ab}
	2	1.94^{ab}	1.94^{ab}	1.94^{ab}	1.63^{ab}	1.63^{ab}	1.63^{ab}
	3	1.27^{b}	1.27^{b}	1.27^{b}	1.53^{ab}	1.53^{ab}	1.53^{ab}
	4	1.39^{b}	1.39^{b}	1.39^{b}	1.50^{ab}	1.50^{ab}	1.50^{ab}
	5	1.01^{b}	1.01^{b}	1.01^{b}	1.31^{b}	1.31^{b}	1.31^{b}
SE$\pm$		0.59	0.59	0.59	1.05	1.03	1.05

*Means on the same column having different superscripts are significantly different (P<0.05)

Key: NFTS=Nitrogen Fixing Trees Species, W.R=Watering Regime,
WAT= Weeks After Transplanting

Significant total fresh weight (3.37g) and total dry weight (0.96g) were recorded from seedlings planted in the soil with *J. mimosifolia*. Highest total fresh (1.72g) and total dry weight (0.79g) were recorded from seedlings subjected to daily watering regime (Table 8).

Table 8: Effects of leaf litters of nitrogen-fixing trees and watering regimes on the fresh and dry weight (g) of *C. tangelo* seedlings

NFT S	F.W(g)			T.F.W(g)	D.W (g)			T.D.W(g)
	Leaf	Shoot	Root		Leaf	Shoot	Root	
P.africana	0.32^{c}	0.26^{b}	0.36^{c}	0.94^{c}	0.16^{b}	0.08^{a}	0.21^{b}	0.45^{b}
J. mimosifolia	1.18^{a}	0.35^{ab}	1.84^{a}	3.37^{a}	0.34^{a}	0.12^{a}	0.50^{a}	0.96^{a}
P. macrophylla	0.33^{c}	0.23^{b}	0.43^{c}	0.99^{c}	0.16^{b}	0.07^{a}	0.29^{ab}	0.52^{b}
V. doniana	0.30^{c}	0.18^{a}	0.33^{c}	0.81^{c}	0.16^{b}	0.06^{a}	0.20^{b}	0.42^{b}
E. cyclocarpum	0.48^{b}	0.45^{a}	0.75^{b}	1.68^{b}	0.17^{b}	0.15^{a}	0.33^{b}	0.65^{ab}
C. equisetifolia	0.28^{c}	0.32^{ab}	0.64^{bc}	1.24^{c}	0.14^{b}	0.10^{a}	0.31^{ab}	0.55^{b}
SE±	0.06	0.06	0.06	0.17	0.05	0.05	0.05	0.14
W. R								
1	0.59^{a}	0.27^{a}	0.86^{a}	1.72^{a}	0.27^{a}	0.09^{a}	0.43^{a}	0.79^{a}
2	0.47^{ab}	0.36^{a}	0.68^{ab}	1.51^{b}	0.24^{a}	0.13^{a}	0.37^{a}	0.74^{a}
3	0.48^{ab}	0.27^{a}	0.70^{ab}	1.45^{b}	0.25^{a}	0.10^{a}	0.38^{a}	0.73^{a}
4	0.48^{ab}	0.27^{a}	0.70^{ab}	1.45^{b}	0.25^{a}	0.10^{a}	0.38^{a}	0.73^{a}
5	0.37^{b}	0.27^{a}	0.53^{b}	1.17^{c}	0.18^{a}	0.09^{a}	0.28^{a}	0.55^{a}
SE±	0.09	0.09	0.09	0.26	0.05	0.05	0.05	0.15
NW	NS	NS	NS	NS	NS	NS	NS	NS

*Means on the same column having different superscripts are significantly different (P<0.05).

Key: NFTS= Nitrogen Fixing Tree Species, W.R= Watering Regime, NW=Nitrogen fixing trees and Watering Regimes, N.S=Not Significant, FW- Fresh weight, TFW- Total fresh weight, DW- Dry weight, TDW- Total dry weight

Percentage NPK composition of leaf litters of nitrogen-fixing tree species

Highest percentage values of N (2.66%), P (1.96%) and K (2.08%) were recorded for leaf litters of *J. mimosifolia, V. doniana* and *C. equisetifolia* sequentially. The least value of nitrogen (0.05%), phosphorus (0.02%) and potassium (0.07%) were recorded for nutrient content of untreated soil respectively (Table 9).

Table 9: Percentage NPK composition of leaf litters of nitrogen-fixing tree species

N F T S	% N	% P	% K
P.africana	1.97	0.85	1.88
J. mimosifolia	2.66	0.68	2.02
P. macrophylla	2.21	0.89	1.79
V. doniana	2.56	1.96	1.73
E. cyclocarpum	2.38	0.93	1.92
C. equisetifolia	2.63	0.96	2.08
Control	0.05	0.02	0.07

NFTS= Nitrogen Fixing Tree Species

Highest nitrogen (1.92%), phosphorus (36.7mg/100g) and potassium uptake (618.36mg/100g) were written from seedlings cultivated in *J. mimosifolia*, *P. africana* and *C. equisetifolia* sequentially. The least values of nitrogen (0.75%), phosphorus (1.83mg/100g) and potassium (1.65mg/100g) were written for nutrient uptake of seedlings cultivated in an unamended soil (Table 10).

Table 10: Plant nutrient uptake from the nitrogen-fixing tree species

NFTS	Nutrient		
	N%	Pmg/100g	Kmg/100g
P.africana	1.42	36.71	186.45
J.mimosifolia	1.92	18.11	328.63
P.macrophylla	1.44	6.32	108.31
V.doniana	1.78	8.52	81.38
E.cyclocarpum	1.20	20.86	98.86
C.equisetifolia	1.21	10.16	618.36
Control	0.75	1.83	1.65

NFTS= Nitrogen Fixing Tree Species
N=Nitrogen, P=Phosphorus, K=Potassium

Discussion

The height and numbers of leaves of seedlings planted in the soil mixed with and without leaf litters of nitrogen fixing species were not significantly difference. Contrary to these findings, Etuk and Edem (2014) reported significant increase in the number of leaves and height from *Gnetum africanum* intercropped with *Leucaena leucocephala* tree and benefited from its pruned leaf litters. Incorporating pruned leguminous tree species litters in the subsurface layers improves soil fertility for increased growth variables of *Gnetum africanum* (Etuk and Edem, 2014).

Significant leaf area and leaf area index reported from *C. tangelo* seedlings cultivated in the soil influenced with leaf litters of *J. mimosifolia* could be traced to its richness in nitrogen. Nitrogen controls the progress and development of plants (Aref and Shetta, 2013). OECD and EUROSTAT GROSS (2007) established that nitrogen is an essential factor for plant development. Hemant and Manju (2020) established that nitrogen is essential component of amino acids, protein, nucleic acid, enzymes and alkaloids. Nitrogen is very main in biochemical and physiological functions of plants (Shah *et al.,* 2016) and in embellishing the yield as well as food quality of plant (Ullah *et al.,* 2010). Ahmad *et al.* (2009) reported that optimum rate of N increases photosynthetic process, leaf area production, leaf area duration as well as net assimilation rate.

Nitrogen, a major food for plants is an essential constituent of protein (build from amino acids that involves in production of chemical responses and transportation of electrons) and chlorophyll (enable the process of photosynthesis) present in many major portions of the plant body (Shah *et al.,* 2016). Shah *et al.* (2016) established that nitrogen imparts dark-green color in plants, promotes leaves, stem and other vegetative part's growth and development. Nitrogen produces speedy early growth, improves fruit quality, embellishes the growth of leafy vegetables, and increases protein content of fodder crops. It encourages the uptake and utilization of other nutrients including potassium, phosphorous and controls overall growth of plant (Bloom, 2015; Hemerly, 2016).

The imperfection of nitrogen causes lowered development, (Hu and Schmidhalter, 2005) presentations of chlorosis (changing of the green color into yellow color of leaves), and presentations of red and purple spots on the leaves, restrict lateral bud growth (from which leaves, stem and branches develop) (Shah *et al.*, 2016). Mostly, the inadequacy manifestations first perform on earlier leaves (Bianco *et al.,* 2015) then leaf senescence starts and excessive application of nitrogen has adverse effects on plant growth, promotes extra dark-green colour on the leaves, makes succulents the entire growth and favours less fruit quantity with less quality. Overuse of N causes excess vegetative growth particularly in tropical areas (Shah *et al.,* 2016).

Least growth parameter written from seedlings cultivated in the soil without enhancement compared to that of amended soil with highest growth parameters revealed the importance of organic manure. It could be deduced that the organic manure embellishes the growth of plant seedlings. Similar observations have been made by Okunomo (2010a) (*Tetraplura tetraptra*) Okunomo, (2010b) (*Parkia bicolor*)., Aderounmu *et al.* (2016) (*Morinda lucida*)., Asinwa *et al.*(2017) (*Massularia acuminata*) .,Olajiire-Ajayi *et al.* (2018) (*Mansonia altissima*)., Ojelabi *et al.*(2018) (*Pterocarpus erinaceus*)., Agbo-Adediran and Osho, (2019) (*Entandrophragma angolense*)., Adelani (2019) (*Citrus tangelo*)., Riandana *et al.* (2019) (*Citrus nobilis* sin) (*Citrus grandis* L. Osbeck)., Azmi *et al.* (2019) (*Ficus Carica*)., Hemant *et al*. (2020) (*Citrus sinensis* L.) and Shengian *et al.* (2022) (*Zizyphus jujuba* Mill.cv.). Organic manure or organic fertilizer contains appropriate nutrients to improve the growth of *Citrus tangelo.* Citrus plants can produce well when fertilized with organic fertilizers and fertilizers containing nutrients N, P, K, and Ca with the right dosage and time of application (Srivastava, 2009; Garhwal *et al.,* 2014). Ma *et al.* (2022) reported that fertilization is an important part of citrus crop management.

Conclusion

One of the challenges that are facing the approval of agroforestry technology to improve soil fertility is incompetent news on our accepted nitrogen fixing trees for farmers to explore. The leaf litters of nitrogen fixing trees are cheap source of nutrient to enhance the growth of our slow growing plant. The slow growth of our fruit trees as *Citrus tangelo* has restricted supply and population demand of its fruits as well as associated benefits. Investigation administered to embellish growth of *C. tangelo* with affordable, accessible available manure as leaf litter of nitrogen fixing trees showed that leaf litter of *J. mimosifolia* and daily watering improves its growth.

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