Journal of Research in Forestry, Wildlife & Environment Vol. 10(4) December, 2018
http://www.ajol.info/index.php/jrfwe
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E-mail: jfewr@yahoo.com
ISBN: 2141 – 1778
Afolabi et al., 2018

GROWTH RESPONSE OF *Pterocarpus soyauxii* TAUB. SEEDLINGS TO COMPOST APPLICATION UNDER VARIED WATERING FREQUENCY

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ABSTRACT

The impact of climate change as evident in many African countries include limited supply of water and desertification among others. Mitigating such effects partly required planting tree species capable of tolerating drought or extreme weather patterns. In view of this, the growth response of P. soyauxii seedlings to compost application under varied watering frequency was investigated. The experiment was 3 x 4 factorial treatments with 6 replicates laid out in a split plot completely randomized design. The first factor consisted 3 watering frequencies (watering once a week, two weeks and three weeks) while second factor included 4 levels of Aleshinloye compost (0, 45, 90, and 135 kg N/ha). Data collected include stem heights, stem diameter and number of leaves at interval of four weeks starting from four weeks after transplanting (WAT). Moisture contents and dry matter yields were obtained at 24th WAT. Analysis of variance results indicated that there was significant difference among the watering frequencies. Seedlings watered once a week had better growth in terms of stem diameter (6.66 mm), stem heights (42.7 cm), number of leaves (18.81), root (2.77g), shoot (6.16g) and total dry weights (8.92g) than those watered once in two weeks which was higher than those watered once in three weeks at 24 WATS. The effects of various compost rates were not significantly different from control on all the parameters. The interactive effects of both factors showed that the seedlings performed best when watered once a week under compost rate of 45 kg N/ha in terms of stem heights (49.1 cm), number of leaves (20.74), dry weights; root (3.5g), shoot (6.63g) and total dry weights (10.14g), Moisture contents; root (60.07 %) and total moisture content (123.5 %). Prolonged watering frequencies (intervals of 14 and 21 days) were too extreme for the optimum growth and adaptation of P. soyauxii seedlings. Watering of P. soyauxii seedlings for at least once in a week with application of compost at 45 kg N/ha is recommended to be adequate in order to maintain and sustain its growth during plantation establishment.

Keywords: compost application, watering frequency, optimum growth, moisture content

INTRODUCTION

In recent decades, many regions of the world have been experiencing an increasing rate of forest cover loss (CITES, 2016). This emanates from the impact of climate change, forest fires, habitat degradation or disease thereby leading into an increasing rate of desert encroachment. An adaptive management measure and reactive response to these already depleted forest levels include but not limited to intensive reforestation project involving planting of drought resistance economic important tree species. Such trees would help to restore the vegetal cover and improve the forest biodiversity. Furthermore, it would serve as barrier against destructive windstorm and desertification, conserve the soil surface against erosion and intense heat, aggregate loose soil particle, be a source of renewable and bioenergy, nutritious food, employment and the reservoir of sequestered carbon (Aba *et al.*, 2017).

Pterocarpus soyauxii is such a useful multipurpose tree endangered as result of its over-exploitation in the natural forest (Jansen, 2005). The tree originated

partly from south-eastern Nigeria where it is commonly called African padauk. Its wood is used for construction, carpentry, flooring, staircases, railway sleepers and boats because of its high durability. In addition, the tree is a good source of dye, vegetables and medicine (Jansen, 2005). It is a leguminous, light demander and fast-growing species which prefers a well-drained soil for good growth. The survival of any tree species when planted depends on genetic, climatic, biotic and edaphic factors (Bareja, 2011). These include the tree's ability to resist diseases and drought, good nutrients uptake and soil physical structure, adequate nutrients and moisture content. These couple with the health status of the tree will ensure optimum growth and better adaptability on the field.

According to Simon *et al*. (2011), species respond differently to water deficit and moisture stress. The increasingly rate of water scarcity in most geographical zones of the world as a result of climate change necessitated the assessment of water requirement and application frequency for tree species (Morrison *et al.,* 2009; Mekonnen *et al*., 2018). Application of organic and inorganic fertilizer is a way of providing adequate nutrition to growing seedlings while improving their quality, resistance and adaptation in the field (Adejoh *et al.,* 2015). However, high cost of inorganic fertilizer and its detrimental effects on long term usage necessitated the adoption of locally available and eco-friendly organic fertilizers. The use of organic fertilizer such as compost has been reported to improve drought resistance by increasing the water holding capacity of soil, stimulating better nutrient access and defensive biochemical reactions of plants (Paul, 2015; Adugna, 2016). Consequently, initial good nursery and silvicultural practices such as compost application is required for *P. soyauxii* tree in order to have healthy and well-nourished planting stock. Hitherto, information on the species response to compost application is still scanty. Moreover, the trees' ability to withstand drought at seedling stage has not been proved and reported by any scientific research. Hence, the goal of this research work was to provide an in-depth information on the growth response of the tree species to compost application under varied watering frequency with a view to establish the possibility of the tree species tolerating drought.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Screen-house of Central nursery of Sustainable Forest Management (SFM) Department, Forestry Research Institute of Nigeria (FRIN). The study site is located on longitude 07^{o}23'18″ N to 07^{o}23'43″N and latitude 03^{o}51'20″E to 03^{o}23'43″E. The climate of the area is West African monsoon with dry and wet seasons. The dry season span across November through March during which the experiment was conducted. The mean maximum temperature of the area at the period was 31.11 ^{o}C, minimum 22.76 ^{o}C while the mean daily relative humidity was about 71.8% (FRIN, 2018).

Soil collection and processing

The top soil used for the experiment was randomly collected at FRIN arboretum. It was collected at 0-15 cm depth with the aid of shovel and bulked. The soil was air spread, dried and sieved with 2*mm* sieve after which poly pots of 15cm x 20cm were each filled with 3kg of the soil. The subsample of the soil was taken to Laboratory of Soils and Tree nutrition section of Bioscience Department of the Institute for chemical and physical parameters analysis.

Compost application and transplanting

The organic fertilizer used was a popular commercial Aleshinloye compost. The sample of the compost was analysed for its essential nutrients' quantity at the same Laboratory. Equivalent compost quantity was mixed with the potted soil at 4 weeks before transplanting. The seedlings of *P. soyauxii* used were obtained from Tree improvement section of SFM department of the Institute. These were transplanted at 3 leaves stage, watered regularly and allowed to stabilize for 4 weeks at which they were subjected to different watering frequency on timely basis. Each pot received the same volume of water (250 ml) at every time interval.

Experimental design and Data collection

The study was conducted between the periods of November, 2017 to March, 2018. It was 3 x 4 factorial treatments with 6 replicates laid out in a

split plot Completely Randomised Design. The 3 represents watering frequency (WF) which include watering once a week, two weeks and three weeks. Watering was done in every morning of the first day of the required week. The 4 denote compost rates (CR) which were 0, 45, 90 and 135 kg N/ha. The data collected include stem diameter (mm), stem height (cm) and number of leaves starting from 4th weeks after transplanting (WAT) at 4 weeks intervals while moisture content and dry matter yields were obtained at 24th WAT. The data collected were subjected to analysis of variance using GenStat 9th Edition while significantly different means separated by Duncan Multiple Range Test.

RESULTS

Soil and Compost properties

The result revealed that the soil used for this study had pH value of 6.06 and the total N value of 0.13% which is classified to be low (Blakemore *et al*, 1987). The available P value was 2.18 mg/kg, Exchangeable bases; K^+, Na^+, Ca^{2+} and Mg^{2+} had the values of (0.19, 0.36, 3.67 and 2.06) $cmol^+ kg^{-1}$, respectively which according to FAO, (1980) are in a very low critical range except for Ca^{2+} that is low. The micro-nutrients; Mn^{2+}, Fe^{2+}, Cu^{2+} and Zn^{2+} had the values of (57.7, 20.8, 10.5 and 16.9) mg kg^{-1}, respectively (Table 1). The proportion of sand, silt and clay were 836, 96 and 68 g kg^{-1}, respectively while the nutrient composition of the compost used were generally high (Table 1).

Stem diameter (mm)

The results of different watering frequencies at average level of compost rates on the stem diameter of *P. soyauxii* seedlings at successive growth stages are presented in Table 2. At 4 weeks after transplanting (WAT), there was no significant difference among the stem diameter obtained as affected by watering frequencies however at 8 to 24 WAT, significant difference ($p \leq 0.05$) was observed. The seedlings watered once in every week had bigger stem diameter (2.76) than when watered once in three weeks (2.54) but similar to when watered once in two weeks (2.67) at 8 WAT (Figure 1).

Table 1. Pre-planting soil and compost chemical and physical properties

Properties	Soil	Compost
pH (H_2O, 1:2)	6.06	7.03
Organic C (g/kg)	11.0	109.7
Total N (g/kg)	1.30	20.8
Available P (mg/kg)	2.18	15.5
Exchangeable bases (cmol/kg)		
K	0.19	2.1
Ca	3.67	7.4
Mg	2.06	10.0
Na	0.36	1.2
Extractable micronutrients (mg/kg)		
Fe	57.7	185
Mn	20.8	60.7
Zn	10.5	29.0
Cu	16.9	10.6
Particle size (g/kg)		
Sand	836	
Clay	96	
Silt	68	
Textural class	Loamy sand	

The effect was slightly different at 12 WAT in which the stem diameter obtained when watered once in every week (4.47) was higher than both other treatments which were similar in their values.

Similar trend was followed across other weeks until 24 WAT where the stem diameter obtained when watered once in every week (6.66) was higher than when watered once in two weeks (4.69) which in turn higher than when watered once in three weeks (4.02). The effects of compost rates were only significant at 20 WAT while the interaction of both factors produced no significant difference ($p>0.05$) on the seedlings stem diameter across all the weeks. Seedlings applied with 135 and 45 kg N/ha had comparable stem diameter (4.99 and 4.89 respectively) to those applied 90 kg N/ha (4.65) but higher than control (4.01). Also, the stem diameter obtained from 90 kg N/ha applied seedlings was similar to that of control without application (Figure 2).

Table 2. Effect of watering frequencies and compost rates on stem diameter (mm) of *P. soyauxii* at successive growth stages

Treatments		Stem diameter (mm)Weeks after transplanting					
Frequency of Watering	**Compost rates**	**4**	**8**	**12**	**16**	**20**	**24**
Watering once a week	0	2.15	2.83	4.37	5.38	5.26	6.14
	45	2.23	2.80	4.54	5.89	6.36	7.01
	90	1.84	2.62	4.28	5.41	5.86	6.36
	135	2.11	2.78	4.68	5.49	6.32	7.13
Watering once in two weeks	0	1.99	2.54	3.23	3.96	4.09	4.67
	45	2.11	2.62	3.40	3.62	4.19	4.50
	90	2.20	2.83	3.77	4.06	4.39	4.91
	135	2.06	2.69	3.41	3.84	4.34	4.66
Watering once in three weeks	0	2.06	2.60	3.29	3.68	2.69	3.98
	45	2.07	2.58	3.53	4.32	4.12	3.88
	90	2.01	2.44	3.25	3.69	3.70	3.89
	135	1.86	2.54	3.68	4.18	4.32	4.33
LSD @ ($p\leq0.05$)							
Watering frequency (WF)		0.14	0.16*	0.28*	0.48*	0.61**	0.60*
Compost rate (CR)		0.16	0.18	0.33	0.56	0.70*	0.69
WF X CR		0.26	0.31	0.56	0.97	1.22	1.19

* significance at ($p\leq0.05$); ** significance at ($p\leq0.01$)

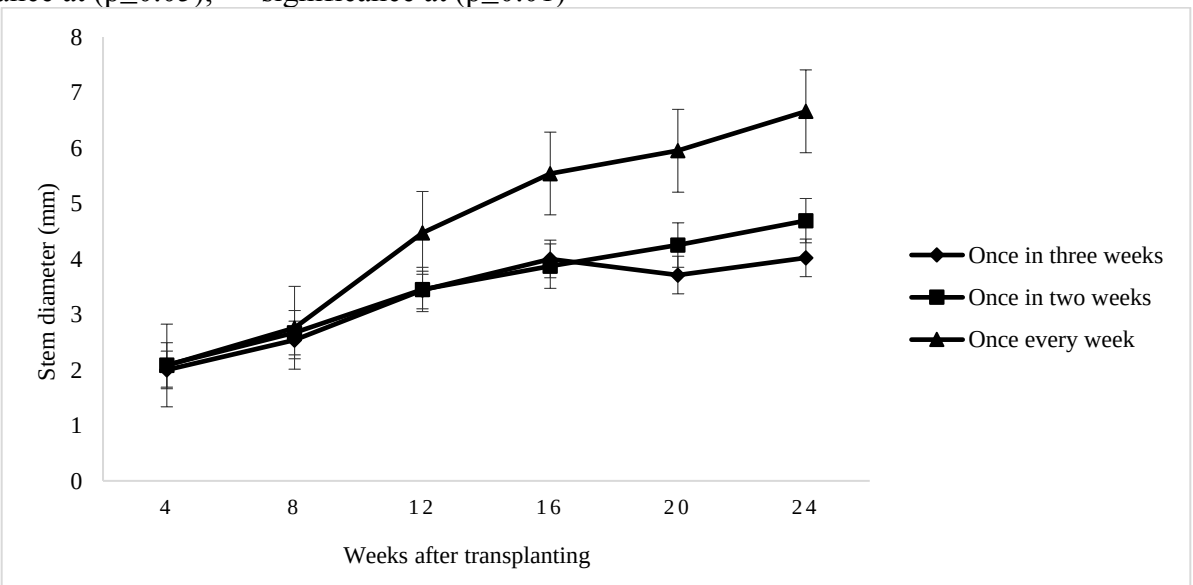

Figure 1. Effects of watering frequency on stem diameter (mm) of *P. soyauxii* at 24 weeks after transplanting

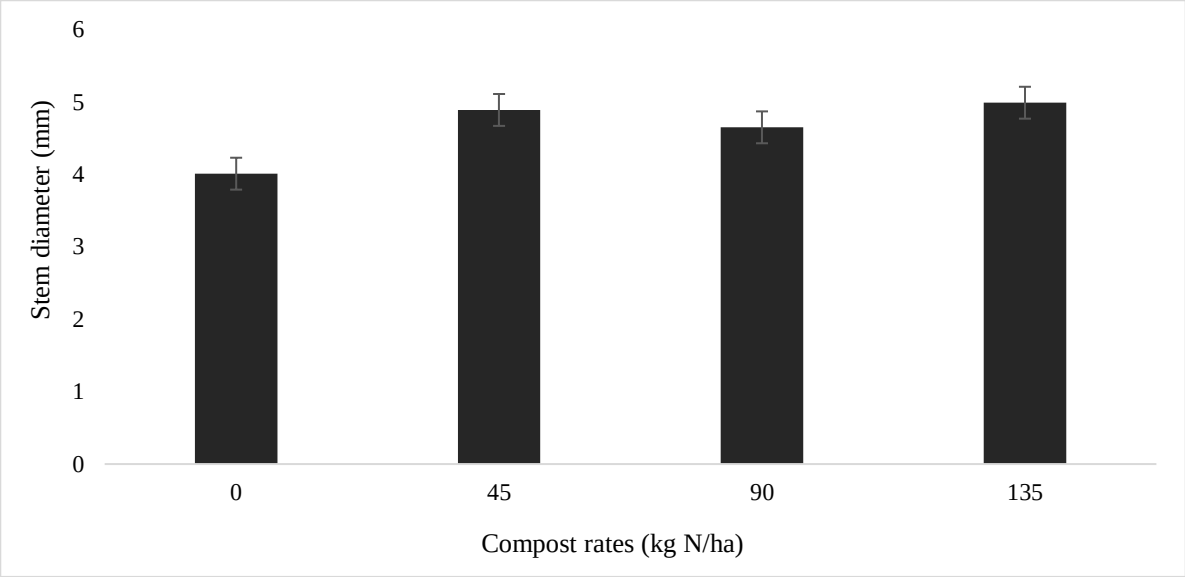

Figure 2. Effect of compost rates on stem diameter (mm) of *P. soyauxii* at 20 weeks after transplanting

Stem height (cm)

Table 3 shows the effects of different watering frequencies and compost rates on the stem height of *P. soyauxii* seedlings between 4 to 24 WAT. It was observed that there was significance difference ($p \leq 0.05$) in the effects of watering frequency while the stem height of the seedlings as influenced by compost rates were comparable ($p > 0.05$) across all the weeks. Similarly, the interactive effects of the factors on stem height was not significant at all successive growth stages. At 4 and 8 WAT, the mean height of the seedlings as influenced by the watering frequencies were relatively uniform (Figure 3). Whereas at 12 and 16 WAT, the mean heights of the seedlings watered once in every week was significantly higher ($p \leq 0.01$) than those watered either once in two or three weeks among which the mean heights obtained were comparable. The results at 20 and 24 WAT followed similar trend. The mean heights of the seedlings watered once in every week; 40.9 cm and 42.7 cm at 20 and 24 WAT were higher than other two treatments; watering once in two weeks, 29.7cm and 31.5cm, once in three weeks 24.0 and 22.8 respectively. At same period, height of the seedlings watered once in two weeks was higher than those watered once in every three weeks.

Number of leaves

The number of leaves produced by *P. soyauxii* seedlings as influenced by watering frequencies and compost rates are shown in Table 4. The results revealed there was significant difference ($p \leq 0.05$) among the watering frequency whereas compost application on number of leaves showed no significant different across the weeks. Moreover, effect of interaction between the two factors was not significant on number of leaves throughout the experiment. As presented in Figure 4, the number of leaves as affected by watering frequencies at 4 and 8 WAT were similar. However, at 12 WAT, seedlings watered once in every weeks produced significantly higher ($p \leq 0.05$) number of leaves than those under other treatments. At 16, 20 and 24 WAT, the number of leaves production followed similar trend. Plants watered once in every week had higher number of leaves (15.75, 16.5 and 18.81) than those watered once in two weeks (11.94, 11.5 and 11.81) which in turn produce more leaves than those watered once in three weeks (9.81, 4.56 and 4.56 respectively).

Table 3. Effect of watering frequencies at average level of compost rates on stem height (cm) of *P. soyauxii* at successive growth stages

Treatments		Stem height (cm) Weeks after transplanting					
Frequency of Watering	**Compost rates**	**4**	**8**	**12**	**16**	**20**	**24**
Watering once a week	0	9.67	16.00	30.40	25.15	33.9	27.7
	45	10.0	16.67	33.02	37.38	44.8	49.1
	90	8.67	15.02	29.18	32.45	40.2	45.8
	135	9.85	16.33	33.88	38.12	44.5	48.1
Watering once in two weeks	0	10.08	17.17	26.27	29.90	31.0	34.0
	45	10.18	17.92	25.33	24.68	26.4	27.7
	90	9.95	16.78	25.55	27.53	30.0	30.9
	135	9.05	15.75	25.18	25.55	31.6	33.5
Watering once in three weeks	0	9.48	14.75	21.67	22.57	16.5	16.6
	45	9.55	16.50	27.18	28.60	29.6	22.1
	90	9.12	14.67	22.32	23.25	22.0	25.5
	135	9.57	16.75	26.63	26.70	27.8	26.9
LSD @ ($p \leq 0.05$)							
Watering frequency (WF)		1.03	1.93	3.33**	4.14**	5.73**	7.23**
Compost rate (CR)		1.19	2.23	3.85	4.79	6.62	8.35
WF X CR		2.06	3.86	6.67	8.29	11.46	14.47

* significance at ($p \leq 0.05$); ** significance at ($p \leq 0.01$)

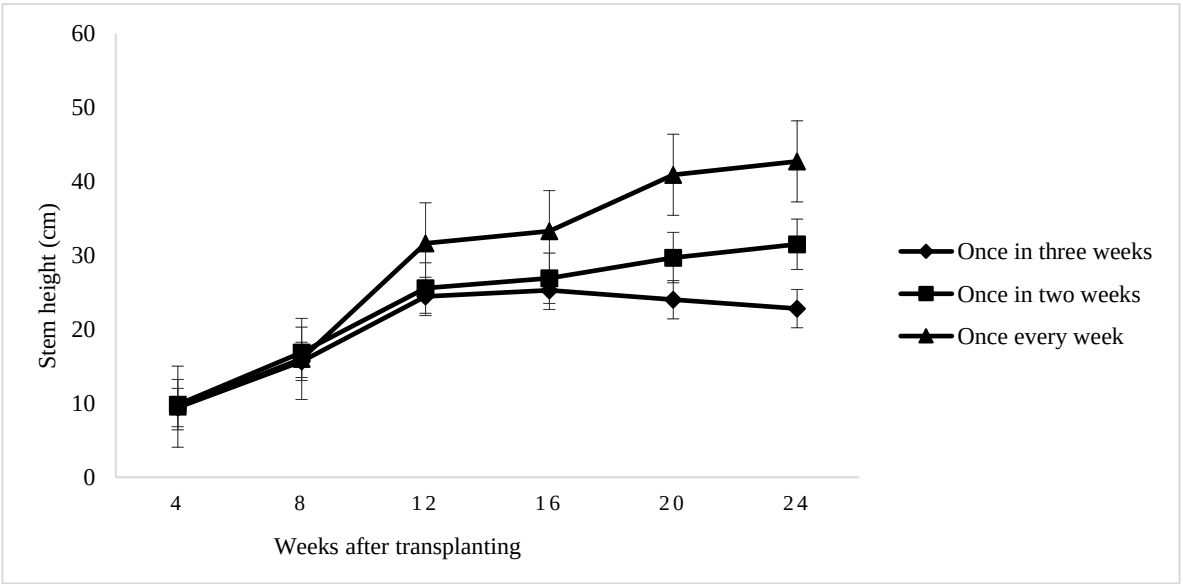

Figure 3. Effect of watering frequency on stem height (cm) of *P. soyauxii* at 24 weeks after transplanting

Table 4. Effect of watering frequencies at average level of compost rates on number of leaves of *P. soyauxii* at successive growth stages

Treatments		Number of leaves, Weeks after transplanting					
Frequency of Watering	**Compost rates**	4	8	12	16	20	24
Watering once a week	0	6.00	9.33	14.33	15.75	15.75	17.75
	45	6.00	9.83	15.67	16.25	18.50	20.75
	90	5.50	8.83	14.17	14.75	13.75	17.25
	135	6.00	9.00	15.00	16.25	18.00	19.50
Watering once in two weeks	0	6.17	9.67	13.33	12.00	9.75	11.25
	45	5.83	8.83	12.17	11.25	11.00	12.00
	90	6.00	8.83	11.50	10.25	10.25	9.75
	135	5.83	9.33	13.50	14.25	15.00	14.25
Watering once in three weeks	0	5.50	8.00	10.67	8.75	3.50	4.50
	45	6.17	9.00	12.00	10.25	3.00	3.00
	90	5.83	8.83	11.50	10.00	6.50	4.50
	135	6.00	9.17	13.17	10.25	5.25	6.25
LSD @ ($p \leq 0.05$)							
Watering frequency (WF)		0.58	0.79	1.03**	1.73**	2.87**	2.98**
Compost rate (CR)		0.67	0.92	1.19	2.00	3.31	3.44
WF X CR		1.17	1.59	2.07	3.46	5.74	5.96

* significance at ($p \leq 0.05$); ** significance at ($p \leq 0.01$)

Dry weights (g) and Moisture contents (%)

The results of the dry weight of *P. soyauxii* seedlings as affected by watering frequencies and compost rates are represented in Table 5. There was no significant difference observed among the compost rates and in the interaction of the two factors on the dry weights parameters of the seedlings at 24 WAT. Conversely, there was significance difference between the watering frequencies. Seedlings watered once a week was higher in root (2.77g), shoot (6.16g) and total dry weights (8.92g) than seedlings watered once in two weeks (1.15g, 3.14g and 4.29g in that order) which was higher than those watered once in three weeks (0.59g, 1.16g and 1.75g respectively) (Figure 5).

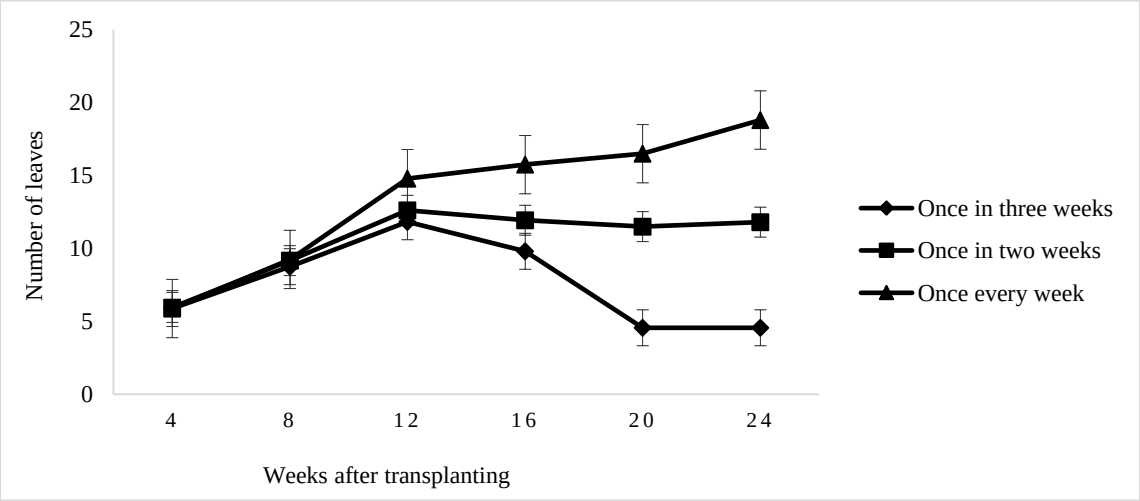

Figure 4. Effect of watering frequency on number of leaves of *P. soyauxii* at 24 weeks after transplanting

Table 5. Effect of watering frequencies and compost rates on dry weight (g) of *P. soyauxii* at 24 WAT

Treatments		Weight of Dried root (g)	Weight of Dried shoot (g)	Total weight of Dried matter (g)
Frequency of Watering	**Compost rates**			
Watering once a week	0	2.68	6.15	8.83^{ab}
	45	3.50	6.63	10.14^{a}
	90	2.48	5.54	8.02^{b}
	135	2.40	6.30	8.70^{ab}
Watering once in two weeks	0	1.17	3.25	4.43^{c}
	45	1.25	3.29	4.53^{c}
	90	1.05	2.75	3.80^{cd}
	135	1.12	3.28	4.40^{c}
Watering once in three weeks	0	0.54	1.00	1.54^{e}
	45	0.53	0.93	1.46^{e}
	90	0.68	1.49	2.18d^{e}
	135	0.61	1.21	1.82d^{e}
LSD @ ($p \leq 0.05$)				
Watering frequency (WF)		0.33**	0.72**	0.96**
Compost rate (CR)		0.38	0.83	1.11
WF X CR		0.65	1.43	1.93

* significance at ($p \leq 0.05$); ** significance at ($p \leq 0.01$)

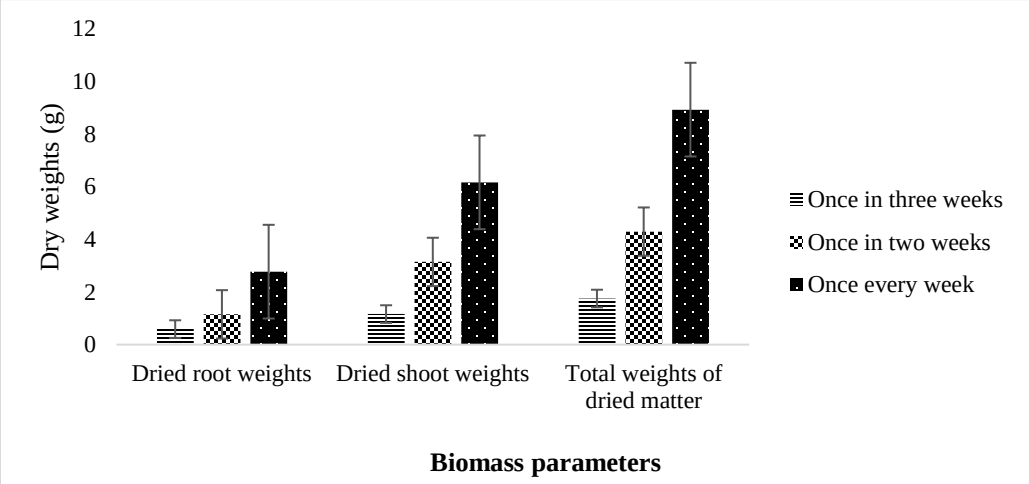

Figure 5. Effect watering frequency on dry weights of *P. soyauxii* at 24 weeks after transplanting

At 24 WAT, the root moisture content of the seedlings watered once in every week (59.18 %) was comparable to those watered once in three weeks (56.95 %) while both were higher than those watered once in two weeks (49.28 %) (Figure 6). In addition, the seedlings watered once in every week (63.92 %) had higher percentage shoot moisture contents than other two treatments which have similar values (59.84 % and 60.35 % for watering once in two weeks and in three weeks). Consequently, higher total moisture contents were obtained in seedlings watered once in every week (123.1%) over those seedlings watered once in three weeks (117.3 %) which was more than those seedlings watered once in two weeks (109.1 %). There was no significant difference among the compost rates and the interactions of the factors on the moisture contents of seedlings (Table 6).

Table 6. Effect of watering frequencies and compost rates on moisture content (%) of *P. soyauxii*at 24 WAT

Treatments		Root moisture contents	Shoot moisture contents	Total moisture contents
Frequency of Watering	**Compost rates**			
Watering once a week	0	57.51	64.07	121.6
	45	60.07	63.45	123.5
	90	57.68	65.62	123.3
	135	61.46	62.55	124.0
Watering once in two weeks	0	49.06	59.86	108.9
	45	47.41	58.93	106.3
	90	50.42	60,43	110.8
	135	50.24	60.16	110.4
Watering once in three weeks	0	51.39	58.32	109.7
	45	60.89	59.88	120.8
	90	55.31	59.82	115.1
	135	60.19	63.39	123.6
LSD @ (p≤0.05)				
Watering frequency (WF)		4.11**	1.99**	5.36**
Compost rate (CR)		4.74	2.30	6.19
WF X CR		8.21	3.98	10.73

* significance at (p≤0.05); ** significance at (p≤0.01)

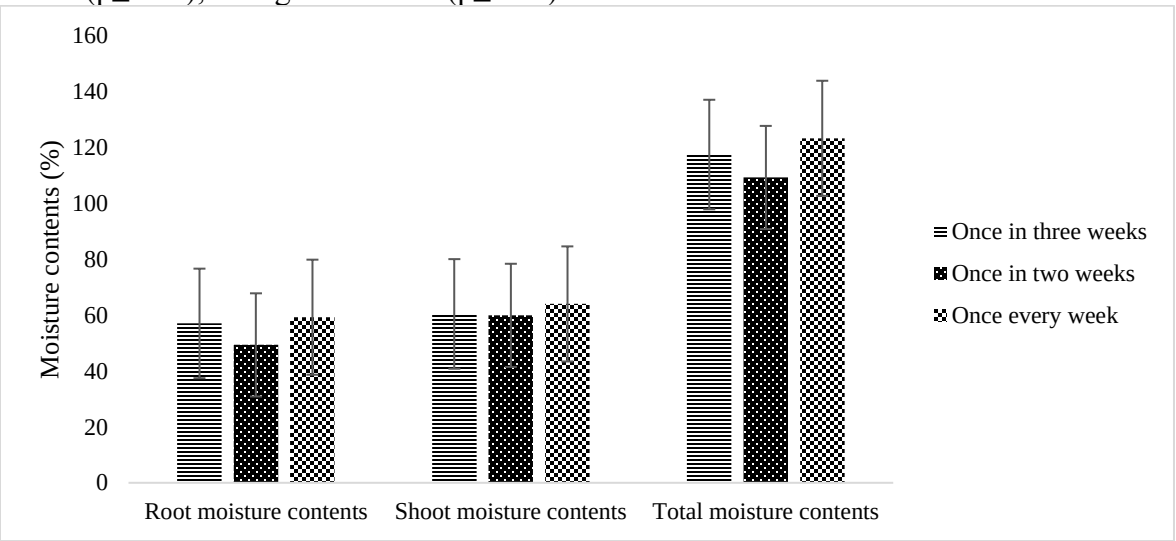

Figure 6. Effects watering frequency on moisture contents of *P. soyauxii* at 24 weeks after transplanting

DISCUSSION

The present study investigated the effect of watering frequencies and compost rates on the growth of *P. soyauxii* seedlings. Application of compost at different rates compared with control (No application) did not show significant different on the species growth attributes except for stem diameter at 20 WAT while the interactive effects of the factors did not show any significant differences on all the parameters considered at successive growth stages. This showed that nitrogen fertilizers such as compost may not be necessarily required for the early seedling growth of the tree species under reduced soil moisture. This phenomenon could be attributed to the leguminous nature of the species. This finding underscores the capability and provides evidence that nitrogen fixing tree like *P. soyauxii* could

survive in the natural ecosystem (Elevitch and Wilkinson, 2008).

As presented in Tables 2 to 6, watering frequencies affected the growth of the seedlings differently. The observed growth similarities in respect of stem diameter/height and number of leaves of the seedlings at 4 and 8 weeks after transplanting (WAT) revealed that soil moisture level was adequate for the seedlings at those weeks. This coupled with adequate and available nutrients made their growth to be comparable. From weeks 12 to 24 after transplanting, seedlings watered once a week had better growth in terms of stem heights, stem diameter, number of leaves, root, shoot and total dry weights than those

watered once in two weeks which was higher than those watered once in three weeks. Although the seedlings watered once at either two or three weeks survived the period of the moisture stress, nonetheless, some of them had stem shrinkage, dieback from apical tips and regenerated while some had their leaves shed. This finding indicated that prolonged watering frequencies at intervals of 14 and 21 days were too extreme for the optimum growth and adaptation of *P. soyauxii* seedlings. This result agrees with that of early studies on some Acacia species by Mohamed *et al*., (2013) who expressed that prolonged period of watering frequency (12 days) may perhaps have resulted to negative impact on seedlings development by affecting the water potential. The higher response of *P. soyauxii* seedlings obtained when watered once in every week revealed that 7 days interval was optimum for good growth of the plant. This outcome underlined the relationship between soil moisture, nutrient uptake and plant growth. This result is similar to that of Sale (2015) who observed highest height in *Parkia biglobosa* seedlings watered once in five days.

The results on higher root and shoot moisture content obtained from the seedlings watered once every week at 24 WAT justified their higher morphological growth over others. This was evidenced in the number of leaves produced and dry matter accumulated by the seedlings. Shoot growth is positively related to root volume and distribution, its ability to uptake and transport water and nutrients to the aerial plant parts (Mark and Roger, 2001). The higher root biomass could have positively influenced higher nutrient uptake which resulted into higher shoot growth of the seedlings.

CONCLUSION

The data of the study revealed that water frequency of watering once a week improved the stem diameter, stem heights, number of leaves, roots, shoot and total dry weights of *P. soyauxii* seedlings compared to other water frequency. Compost rate of 45 kg N/ha performed well on the seedlings with water frequency of once in a week. Therefore, raising of *P. soyauxii* seedlings could be achieved by watering once a week with compost application of 45 kg N/ha.

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