EFFECTS OF ORGANIC FERTILIZERS ON EARLY GROWTH OF TAMARIND (*TAMARINDUS INDICA*L)

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Adelani, D.O., Olorukooba, M. M. and Suleiman, R. (2019): Effects of Organic Fertilizers on Early Growth of Tamarind(*tamarindus Indica*l) .*Nigerian Journal of Forestry, 49 (1)* 51 - 57

Abstract
Nursery experiments were conducted during the dry and wet seasons of 2015 to 2016 at Federal College of Forestry Mechanization, Afaka, Kaduna, Nigeria with the objective to evaluate the effects of organic fertilizers on the growth of *Tamarindus indica,* in order to meet population demand of this endangered species for agroforestry systems. The experiments were laid in a Completely Randomized Design (CRD) with five replicates to assess the effects of organic fertilizers on the growth of *T. indica* in both dry and wet seasons. Result revealed that highest height (24.76cm)., significant number of leaflet (80.60)., widest girth (0.30cm) and significant leaflet area (14.60cm^2) were recorded from seedlings planted in soil amended with 30g each of rabbit droppings, rabbit droppings, pig droppings and rabbit droppings respectively during dry season. Significant height (30.08cm)., significant number of leaflets (151.40)., widest girth (0.33cm) and significant leaflet area (15.50cm^2) were recorded from seedlings planted in the soil amended with 30g each of rabbit droppings, rabbit droppings, pig droppings and rabbit droppings respectively during wet season. Highest nutrient composition values of 0.15% (N), 5.46mg/kg (P) and 32.37% (K) were recorded for pig droppings, rabbit droppings and goat droppings respectively. Rabbit droppings significantly ($P<0.05$) enhances the growth of *T. indica* seedlings. Planting of *T. indica* seedlings in rabbit droppings in both seasons is recommended for agro-forestry systems.

Keywords: Seedlings, Seasonal Growth, Organic Fertilizer, Rabbit Droppings

Introduction

The trend of deforestation in the Northern Nigeria has led to the diminishing of important resources of some indigenous economic tree species that contribute immensely to the subsistence daily life and welfare of people all over the world especially in rural area (Afolabi and Adeyele, 2016). *Tamarindus indica* is an example of such indigenous economic tree species. *Tamarindus indica* is widely distributed in Sudan and other Afro-Asian countries (Warda *et al.,* 2007). The species is indigenous to tropical Africa, particularly in the Sudan (Morton, 1987). Adeola and Aworh (2010) stated that *Tamarindus indica* grows wild in Africa in locales as diverse as Sudan, Cameroon, Nigeria, Zambia and Tanzania. In Arabia , it is found growing wild in Oman , especially Dhofa , where it grows on the sea-facing slopes of mountains.

Lewis *et al.*(2005) stated that *Tamarindus indica* is a member of the family Fabaceae, sub-family Caesalpinioideae which is the third largest family of flowering plants with a total of 727 genera and 19, 327 species. The tree is commonly known as "tsamiya" in Hausa, "Icheku Oyibo" in Igbo, Ajagbon" in Yoruba, and "Tamarind" in English languages respectively. Samina *et al.* (2008) reported that its young seedlings, leaves and flowers of mature trees are eaten as vegetable and in curies, salads and soup. Its sour pods are cooked as seasoning with rice, fish and meats. Its fruit pulp is used for the preparations of beverages in different regions (Samina *et al.,* 2008).

Moreover, this fruit tree species contribute to overcome nutritional problems and are important sources of income for rural communities (Ambé, 2001; Akinnifesi *et al.,* 2004) during the critical food insecure season. The *T. indica* fruit contains high levels of carbohydrate, which provides energy and has good content of protein with many essential amino acids that help to build strong and efficient muscles (Atawodi *et al.,* 2014). It is also rich in the minerals: potassium, phosphorus, calcium, magnesium and can provide small amounts of iron as well as vitamin A (Aida *et al.,* 2001, Samina *et al.,* 2008). The species is valuable and more of it needs to be propagated. Bello and Zubairu (2015) stated that the species is a slow-growing one. *T. indica* need to be fertilized for it to grow well. Inadequate soil fertility limits the growth and domestication rate of *T. indica.* Rachel (2015) stated that fertilizers boost the soil's reserves of elements essential to the healthy growth and development of plants.

There is paucity of silvicultural information on growth requirement of *T. indica*. It is therefore necessary to establish specific organic manure that results in economical production and that maximize growth and survival as well as further development of the *T. indica* seedlings in the nursery and thereafter in the field. Raising seedlings of *T. indica* with appropriate source of organic fertilizers that are cheap and easily adopted will enhance mass production of its seedlings which influence availability of its benefits for Nigerians.

Materials and Method

The pot experiments were carried out during the dry and wet seasons at the nursery of Federal College of Forestry Mechanization, Afaka, Kaduna State, Nigeria. It is located at 644 meter above the sea level. It is situated in Igabi Local Government Area of Kaduna State, Nigeria. It is situated in the Northern Guinea Savanna ecological zone of Nigeria. It is located between latitude 10^{o} 34′ and 10^{o} 35′ and longitude 7^{o} 20′ and 7^{o} 21′ (Adelani, 2015). Mean annual rainfall and humidity are approximately 1000 mm and 29% respectively. The vegetation is open woodland with tall trees, usually small boles and broad leaves (Otegbeye *et al.,* 2001). The seedlings were sourced from the nursery of Federal College of Forestry Mechanization, Afaka, Kaduna. The sowing media (river sand), which was collected from the College dam, was sieved with 2mm sieve and sterilized at 160^{o}C for 24 hours as done by Adelani and Joseph, (2014). The poly pots (size: 20x25x25cm^{3}) used for the experiment were filled with the sterilized sand in the nursery.

Chemical Analysis of Manure Applied

Each sample of manure cured for two weeks and air dried was analyzed chemically for nitrogen, phosphorus and potassium (NPK) content at the Federal University of Agriculture Abeokuta, Ogun State, Nigeria laboratory. Determination of total nitrogen was done by Macro Kjeldahi method. Available phosphorus (P) was extracted by Bray-1 method and determined colourimetrically. Extracts from the digestion of manure were used to determine potassium by flame photometry.

Effects of organic manure on the growth of *T. indica* were laid in a completely randomized design with five (5) replicates during dry and wet seasons. Treatments consisted of organic manure (cow dung, goat droppings, rabbit droppings, poultry droppings and pig droppings) at the same rate (30g) and control used during dry and wet seasons. Sand was also soaked in 98% concentration of hydrochloric acid for 24hours; washed with distilled water and air dried for 24 hours. One seedling was transplanted into a pot contained the mixture of sand and each manure. Seedlings planted in sand soil without the mixture of manure served as control. A seedling was planted in 5cm depth of potting mixture in a pot and 120ml of water daily per seedling was applied regularly. Schmidt (2000) recommendation of subjecting the seedlings to thorough and regular watering at initial stage of establishment was adopted in this experiment**.**

Growth parameters were monitored every two weeks for 8 weeks dry season and 8 weeks wet season. Growth parameters assessed include: Seedling height (using meter rule); girth (using venier caliper); the number of leaves were counted manually and Leaf area was obtained by linears measurement of leaf length and leaf width as described by Clifton-Brown and Lewandowski (2000).

LA = 0.74xLxW [1]

Where: LA = Leaf Area

LxW = Product of linear dimension of the length and width at the broadest part of the leaf.

The data collected on seedlings growth were subjected to analysis of variance ANOVA in CRD. Significant means were separated at 5% Least Significant Difference (LSD).

Results and Discussion

Dry Season

Effect of Organic Manure on the Height of *T. indica* Seedlings at the Rate of 30g

The result of effect of organic manure on the height of *T. indica* seedlings at the rate of 30g is presented in Table 1. There was no significant difference among the height of seedlings planted in different manure at 8 weeks after transplanting (WAT). Highest height of 24.76cm was recorded from seedlings planted in rabbit dropping amended soil. This result is in consonance with the report of Adelani *et al.* (2014a) who reported highest height of 13.76 cm for *Chrysophyllum albidum* seedlings planted in soil mixed with 0.6g rabbit droppings. The least value of 11.76cm was recorded for height of *T. indica* seedlings planted in soil without amendment of manure (control) at 2 WAT.

Table 1: **Effect of Organic Fertilizers on the Height (cm) of *T. indica* Seedlings at the Rate of 30g**

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	16.78^{ab}	17.28^{ab}	18.56^{ab}	19.12^{a}
Goat droppings	17.62^{ab}	17.98^{ab}	18.62^{ab}	20.08^{a}
Rabbit droppings	21.74^{a}	23.46^{a}	24.20^{a}	24.76^{a}
Poultry droppings	14.88^{ab}	15.68^{ab}	16.16^{ab}	18.70^{a}
Pig droppings	21.44^{a}	22.58^{a}	22.90^{ab}	23.30^{a}
Control	11.76^{b}	12.78^{b}	13.18^{b}	13.86^{a}
. .	3.59	3.61	11.35	11.35

*Means on the same columns with the same alphabets are not significantly different at (P<0 .05)
WAT=Weeks After Transplanting

Effect of Organic Fertilizers on the Number of Leaflets of *T. indica* Seedlings at the Rate of 30g

The result of the effect of organic fertilizers on the number of leaflets of *T. indica* seedlings at the rate of 30g is represented in Table 2. The significant number of leaflets of 80.60 was recorded from seedlings planted in the soil mixed with rabbit droppings at 8 WAT. It could be deduced that highest composition of phosphorus in rabbit droppings influenced the number of leaves. Phosphorus enhances the growth of plants. *Phosphorus is an important component of Gliricidia sepium (Adelani et al., 2014b) which help in the germination of seeds (Smith, 2014) and seedling growth (*Adelani *et al.,* 2014a). Phosphorus is considered a primary nutrient for plant growth (Hinsinger, 2001) and is needed to sustain optimum plant production and quality (Zapata and Zaharah, 2002). The element is essential for cell division, reproduction, and plant metabolism; moreover, its role is related to the acquisition, storage, and use of energy (Epstein and Bloom, 2004).

In addition, phosphorus plays an important role in lateral root morphology (Williamson *et al.,* 2001) and root branching (Lopez-Bucio *et al.,* 2003) and influences not only root development, but also the availability of nutrients (Jin *et al.,* 2005). Therefore, plants have developed various strategies for obtaining optimum phosphorus from soils, including increases in root surface area, specific root length (SRL), and root-shoot ratio (Tang *et al.,* 2009; Xu *et al.,* 2012). The growth-promoting role of phosphorus application has been reported previously (Williamson *et al.,* 2001, Waraich *et al.,* 2015; Pandey *et al.,* 2006).

The lowest number of leaflets of 9.30 was recorded from *T.indica* seedlings planted in the soil without the mixture of manure (control).

Table 2: **Effect of Organic Fertilizers on the Number of Leaflets of *T. indica* Seedlings**

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	18.00[a]	20.00[a]	22.20[b]	30.80[ab]
Goat droppings	18.00[a]	26.60[a]	50.80[a]	70.20[ab]
Rabbit droppings	25.40[a]	31.20[a]	47.80[a]	80.60[a]
Poultry droppings	15.40[a]	14.40[a]	19.00[b]	50.40[ab]
Pig droppings	19.40[a]	19.20[a]	16.80[b]	67.40[ab]
Control	14.00[a]	14.00[a]	14.30[b]	14.50[b]
SE±	9.79	9.30	10.78	25.08

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)
WAT=Weeks After Transplanting

Effect of Organic Fertilizers on the Girth of *T. indica* Seedlings at the Rate of 30g

The result of the effect of organic fertilizers on the girth of *T. indica* seedlings at the rate of 30g is presented in Table 3. There was no significant difference among the girths of seedlings planted in different manure. This result is in consonance with the report of Adelani *et al.* (2020a) who stated that girths of *Citrus tangelo* seedlings planted in soil unamended and soil amended with leaf litters of nitrogen fixing trees were not significantly different at 12WAT. Widest girth of 0.30cm was recorded from *T. indica* seedlings planted in the soil mixed with pig droppings. Similar observation has been recorded by Ewetola *et al.* (2014) who reported highest crown diameter of 95.45cm for *Panicum maximum* fertilized with swine manure in the early rain season. The narrowest value of 0.16cm was recorded for girth of *T.indica* seedlings planted in the soil without amendment of manure.

Table 3: **Effect of Organic Fertilizers on the Girth (cm) of *T. indica* Seedlings at the Rate of 30g**

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	0.19[a]	0.20[a]	0.20[a]	0.27[a]
Goat droppings	0.21[a]	0.24[a]	0.24[a]	0.25[a]
Rabbit droppings	0.25[a]	0.26[a]	0.27[a]	0.28[a]
Poultry droppings	0.18[a]	0.21[a]	0.21[a]	0.21[a]
Pig droppings	0.25[a]	0.26[a]	0.27[a]	0.30[a]
Control	0.16[a]	0.18[a]	0.18[a]	0.20[a]
SE±	0.52	0.49	0.43	0.50

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)
WAT=Weeks After Transplanting

Effect of Organic Fertilizers on the Leaf let Area of *T. indica* Seedlings at the Rate of 30g

The result of the effect of organic fertilizers on the leaflet area of *T. indica* seedlings at the rate of 30g is presented in Table 4. A significant leaflet area of 14.60cm^2 was recorded from seedlings planted in rabbit dropping amended soil at 8WAT; while the least value of 2.00cm^2 was recorded from seedlings planted in an unamended soil (control) at 2WAT.

Table 4: Effect of Organic Fertilizers on the Leaf Let Area (cm^2) of *T. indica* Seedlings at the Rate of 30g

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	3.72^a	4.24^a	4.46^{ab}	6.50^{ab}
Goat droppings	3.36^a	5.18^a	7.52^a	7.70^a
Rabbit droppings	6.04^a	2.90^a	9.30^a	14.60^a
Poultry droppings	2.56^a	2.90^a	4.96^{ab}	10.08^a
Pig droppings	3.06^a	3.64^a	5.20^{ab}	8.70^a
Control	2.00^a	2.30^a	2.35^b	3.10^b
SE±	1.81	1.79	1.76	1.80

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)
WAT=Weeks After Transplanting)

Wet Season

Effect of Organic Fertilizers on the Height of *T. indica* Seedlings at the Rate of 30g

The result of effect of organic fertilizers on the height of *T. indica* seedlings at the rate of 30g is presented in Table 5. A significant height of 30.08cm was recorded from seedlings planted in the soil mixed with rabbit droppings. Similar observation has been made by Adelani *et al.* (2020b) who reported significant height of 25cm from *Chrysophyllum albidum* seedlings planted in the soil amended with leaflitter of *Acacia senegalensis* at 16 weeks after transplanting. Contrary to the result of this experiment, Amhakhian and Isaac (2016) reported that *Abelmoschus esculentus* seedlings planted in soil mixed with *poultry manure had the highest values in all the growth parameters and was significantly different from other treatments, even rabbit droppings and control. The least value of 14.50cm was recorded from height of T.indica seedlings planted in an unamended soil.*

Table 5: Effect of Organic Fertilizers on the Height (cm) of *T. indica* Seedlings at the Rate of 30g

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	19.84^{ab}	19.96^{ab}	20.10^{ab}	25.34^{ab}
Goat droppings	23.66^{ab}	23.94^{ab}	24.16^{ab}	24.40^{ab}
Rabbit droppings	29.64^a	29.80^a	29.92^a	30.08^a
Poultry droppings	23.32^{ab}	23.46^{ab}	24.62^{ab}	26.22^{ab}
Pig droppings	26.18^a	26.28^{ab}	26.52^{ab}	26.82^{ab}
Control	14.50^b	14.84^b	15.00^b	15.21^b
SE±	3.81	5.09	5.10	5.14

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)

Effect of Organic Fertilizers on the Number of Leaflets of *T. indica* Seedlings at the Rate of 30g

The result of the effect of organic fertilizers on the number of leaflets of *T.indica* at the rate of 30g is presented in Table 6. A significant number of leaflets of 151.40 were recorded from seedlings planted ain the soil amended with rabbit droppings. The least value of number of leaflets of 18.60 was recorded from seedlings planted in an unamended soil (control).

Table 6: Effect of Organic Fertilizers on the Number of Leaflets of *T. indica* Seedlings at the Rate of 30g

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cowdung	22.60^{c}	24.00^{d}	25.80^{d}	27.20^{d}
Goat droppings	109.40^{a}	110.60^{b}	112.40^{b}	115.60^{b}
Rabbit droppings	145.00^{a}	146.20^{a}	149.20^{a}	151.40^{a}
Poultry droppings	55.20^{b}	52.40^{c}	59.40^{c}	63.60^{c}
Pig droppings	72.20^{a}	74.20^{c}	76.80^{c}	79.40^{c}
Control	18.60^{d}	19.00^{d}	19.40^{d}	21.00^{d}
SE±	0.99	10.05	10.10	10.15

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)
WAT=Weeks After Transplanting

Effect of Organic Fertilizers on the Girth of *T. indica* Seedlings at the Rate of 30g

The result of the effect of organic fertilizers on the girth of *T. indica* seedlings at the rate of 30g is presented in Table 7. There was no significant difference among the girths of seedlings planted in the soil mixed with different manure. Highest number of girth of 0.33cm was recorded from seedlings planted in the soil mixed with pig droppings at 8 WAT. The lowest girth of 0.17cm was recorded from seedlings planted in the soil enhanced with cowdung.

Table 7: Effect of Organic Fertilizers on the Girth (cm) of *T. indica* Seedlings at the Rate of 30g

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	0.17^{a}	0.18^{a}	0.18^{a}	0.18^{a}
Goat droppings	0.26^{a}	0.26^{a}	0.26^{a}	0.29^{a}
Rabbit droppings	0.28^{a}	0.28^{a}	0.29^{a}	0.30^{a}
Poultry droppings	0.21^{a}	0.21^{a}	0.21^{a}	0.25^{a}
Pig droppings	0.32^{a}	0.32^{a}	0.32^{a}	0.33^{a}
Control	0.20^{a}	0.20^{a}	0.21^{a}	0.22^{a}
SE±	0.09	0.07	0.02	0.03

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)
WAT=Weeks After Transplanting

Effect of Organic Fertilizers on Leaflet Area of *T. indica* Seedlings at the Rate of 30g

The result of the effect of organic fertilizers on the leaflet area of *T. indica* seedlings at the rate of 30g is presented in Table 8. A significant leaflet area of 15.50cm^{2} was recorded from seedlings planted in the soil mixed with rabbit droppings. This result is in consonance with the observation of Adelani *et al.* (2020a) who reported significant leaf area of 18.24cm^{2} from seedlings planted in the soil influenced with leaflitters of *Jacaranda mimosifolia* at 12weeks after transplanting. The narrowest leaflet area of 3.10cm^{2} was recorded from *T.indica* seedlings planted in the soil not influenced with manure at 2 and 4 WAT.

Table 8: Effect of Organic Fertilizers on Leaflet Area (cm^{2}) of *T. indica* Seedlings at the Rate of 30g

Manure	Weeks	After	Transplanting	
	2	4	6	8
Cow dung	3.12^{c}	3.20^{c}	3.44^{c}	3.52^{c}
Goat droppings	7.84^{b}	7.98^{b}	8.18^{b}	8.38^{b}
Rabbit droppings	14.90^{a}	15.10^{a}	15.30^{a}	15.50^{a}
Poultry droppings	9.08^{b}	9.24^{b}	9.42^{b}	99.72^{b}
Pig droppings	8.92^{b}	9.06^{b}	9.32^{b}	9.60^{b}
Control	3.10^{c}	3.10^{c}	3.20^{c}	3.25^{c}
SE±	0.87	0.86	0.85	0.85

*Means on the same columns with the same alphabets are not significantly different at (P<0.05)

Nutrient Composition of Manure Types Applied
Highest nutrient composition value of 0.15% (N), 5.46mg/kg (P) and 32.37% (K) were recorded for pig droppings, rabbit droppings and goat droppings. The least values of 0.04% (N), 0.74mg/kg (P) and 0.17% (K) were recorded for sand without the addition of manure (Table 9).

Table 9: Nutrient Composition of Manure Types Applied

Manure	N%	Pmg/kg	K%
Cowdung	0.15	2.39	4.81
Goat droppings	0.06	2.96	32.37
Rabbit droppings	0.13	5.46	31.80
Poultry droppings	0.09	3.87	24.81
Pig droppings	0.22	5.45	3.15
Control	0.04	0.74	0.17

Conclusion
Human activities deplete the population of indigenous trees species during irreversible conversion of forest to other land use. This indigenous trees species, Tamarindus indica is in the endangered list. The increase in population demand for forest product is increasing but the afforestation rate is decreasing. To meet the current demand for the forest products through propagation and domestication, there is need to embrace cheap, fast, natural, accessible and adoptable techniques as use of organic fertilizers. Nutrition trial of T. indica for dry and wet seasons through the use of organic fertilizers is essential as it determines the growth and yield in the long run. The result of trial on effect of organic fertilizer during dry and wet seasons revealed that rabbit droppings enhanced growth of *T. indica* seedlings. For maximum growth to be recorded, *T. indica* seedlings need to be planted in rabbit droppings in both dry and wet seasons.

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