Research Article

Influence of Organic Fertilizers on the Early Growth of *Tamarindus indica* L

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Abstract

Inadequacy of information on the early growth responses of *T. indica* seedlings to manure sources has limited its propagation. In an attempt to enhance the growth of *T. indica,* an investigation was conducted to assess the influence of organic fertilizers on the growth of *T. indica*. The experimental design adopted was a Completely Randomised Design with six treatments replicated five times. The treatment consisted of 10g of each manure (cowdung, goat droppings, rabbit droppings, poultry droppings, pig droppings and control) assessed on the early growth of *T. indica* seedlings. Six months old *T. indica* seedlings were transplanted into pots with and without manure and subjected to 200ml of water daily. Data collected were subjected to Analysis of Variance (ANOVA) at 5% level of significance. Results obtained showed that manure sources significantly ($P<0.05$) enhanced the growth of *T. indica*. Significant height (27.82cm), number of leaflets (67.00), total fresh weight (5.57g) and total dry weight (2.54g) were recorded from seedlings planted in the soil amended with goat droppings respectively at 12 weeks after transplanting. Highest girth (0.33cm) and significant leaflet area (9.98cm^2) were recorded from seedlings planted in the soil improved with cowdung and poultry droppings respectively at 12 WAT. Goat droppings enhanced the growth of *T. indica* seedlings.

Key words: Plant growth, organic fertilizer, soil amendment, indigenous fruit trees

Résumé

Le manque d'informations sur les premières réponses de croissance des semis de T. indica aux sources de fumier a limité sa propagation. Dans une tentative d'améliorer la croissance de T. indica, une enquête a été menée pour évaluer l'influence des engrais organiques sur la croissance de T. indica. Le plan expérimental adopté était un plan complètement randomisé avec six traitements répétés cinq fois. Le traitement consistait en 10 g de chaque fumier (bouse de vache, crottes de chèvre, crottes de lapin, crottes de volaille, crottes de porc et témoin) évalué sur la croissance précoce des plantules de T. indica. Des semis de T. indica âgés de six mois ont été transplantés dans des pots avec et sans fumier et soumis à 200 ml d'eau par jour. Les données recueillies ont été soumises à une analyse de la variance (ANOVA) à un niveau de signification de 5 %. Les résultats obtenus ont montré que les sources de fumier augmentaient significativement (P<0,05) la croissance de T. indica. Une hauteur significative (27,82 cm), un nombre de folioles (67,00), un poids frais total (5,57 g) et un poids sec total (2,54 g) ont été enregistrés à partir de semis plantés dans le sol amendé avec des excréments de chèvre respectivement à 12 semaines après le repiquage. La circonférence la plus élevée (0,33 cm) et la surface foliaire significative (9,98 cm2) ont été enregistrées à partir de semis plantés dans le sol amélioré avec de la bouse de vache

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et des excréments de volaille respectivement à 12 WAT. Les excréments de chèvre ont amélioré la croissance des semis de T. indica.

Mots clés : Croissance des plantes, engrais organique, amendement du sol, arbres fruitiers indigènes

Introduction

In the humid tropics of West and Central Africa, forest tree species provide an array of medicinal, nutritional and industrial produce, which are of direct relevance to the well-being of the people (Gbadamosi and Oni, 2004; Kokutse *et al.,* 2014; Alaba *et al.,* 2015). Most of these woody perennials have multiple uses, and wherever grown, they are highly valued by the local farmers (Atangana *et al.,* 2014). One of the indigenous woody perennials is *Tamarindus indica,* an indigenous economic tree species that 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. The species is valuable and more of it needs to be propagated. The slow growth characteristics of *T. indica* have limited its propagation. Bello and Zubairu (2015) stated that the *T. indica* is a slow- growing one. The slow growth of seedlings of *T. indica* is a threat to population demand and biodiversity conservation.

The growth of *T. indica* needs to be enhanced by fertilizers. The use of inorganic fertilizer has been implicated with negative consequences such as nitrate leaching, groundwater pollution, degradation of soil structure and decrease surface water infiltration (Pondel *et al.,* 2001). The unavailability and unaffordability of inorganic fertilizers make a strong case for the use of alternatives obtained from organic sources (Dianda *et al.,* 2009; Oviasogie *et al.,* 2013). Thus, farmers and tree growers are seeking alternatives such as the application of organic fertilizer for the correction of nutrient deficiencies in agriculture and forestry (Tanimu *et al.,* 2007; Agele *et al.,* 2016). FAO (1994) recommended that any fertilizer material of organic origin must have nutrient such as N, P and K. These suggest that organic fertilizers are very suitable as alternative sources of nutrients for seedlings in nursery production.

They are obtained from the composting or processing of organic materials from plant (crop residues, seaweed), animal (poultry droppings, cow dung), urban/industrial (municipal wastes) and microbial sources (fungi). These organic fertilizers have been successfully used for soil enhancement in arable crop production and could potentially be explored in raising of tree seedlings (Omisore *et al.,* 2009). Organic fertilizers are bio-degradable and easily decompose, being broken down into smaller and soluble particles by the microbial community (Aderounmu and Olajuyigbe, 2019). Hence the use of organic fertilizer in the nursery portends advantages such as soil replenishment, increased soil friability, improved beneficial soil life, increased growth and yield, prevention of hardpans, recycling and reduction of waste, minimized greenhouse gas emissions, and plant protection against diseases.

The increase in soil organic matter resulting from manure application helps to reduce the impact of rainfall, surface run-off and erosion. Higher quality and quantity of organic matter also improve soil fertility by enhancing the supply of nitrogen, phosphorus and potassium. Organic matter helps to maintain soil structure and moderate soil temperature, while slowly releasing nutrients and reducing the risk of leaching. Agera *et al.* (2019) reported that organic manure decreases the danger of over-fertilization because the nutrients are released slowly. These attributes tend to increase seedling performance particularly in the nursery (Ipinmoroti *et al.,* 2006; Oviasogie *et al.,* 2013). The increased seedling performance requires knowledge of nursery management. In plant nursery management, the nutrient requirements of tree species differ. Hence efforts are required to identify the appropriate fertilizers that could enhance each plant growth (Nwoboshi, 2000). Little information is available on the use of organic fertilizer to boost the growth of *T. indica*. In this light, this investigation was conducted to assess the influence of organic fertilizers on the early growth of *T. indica*.

Materials and Method

The research was conducted in the screen house of the Federal College of Forestry Mechanization, Afaka, Kaduna State during wet season of 2015. The College is located in the Northern Guinea Savannah ecological zones of Nigeria. It is situated in Igabi Local Government Area of Kaduna State, Nigeria (Fig 1). It lies between Latitude 10º 35' and 10º 34' and Longitude 7º 21' and 7º 20' (Adelani, 2015). The mean annual rainfall is approximately 1000mm. The vegetation is open woodland with tall broad leave trees (Otegbeye *et al.,* 2001).

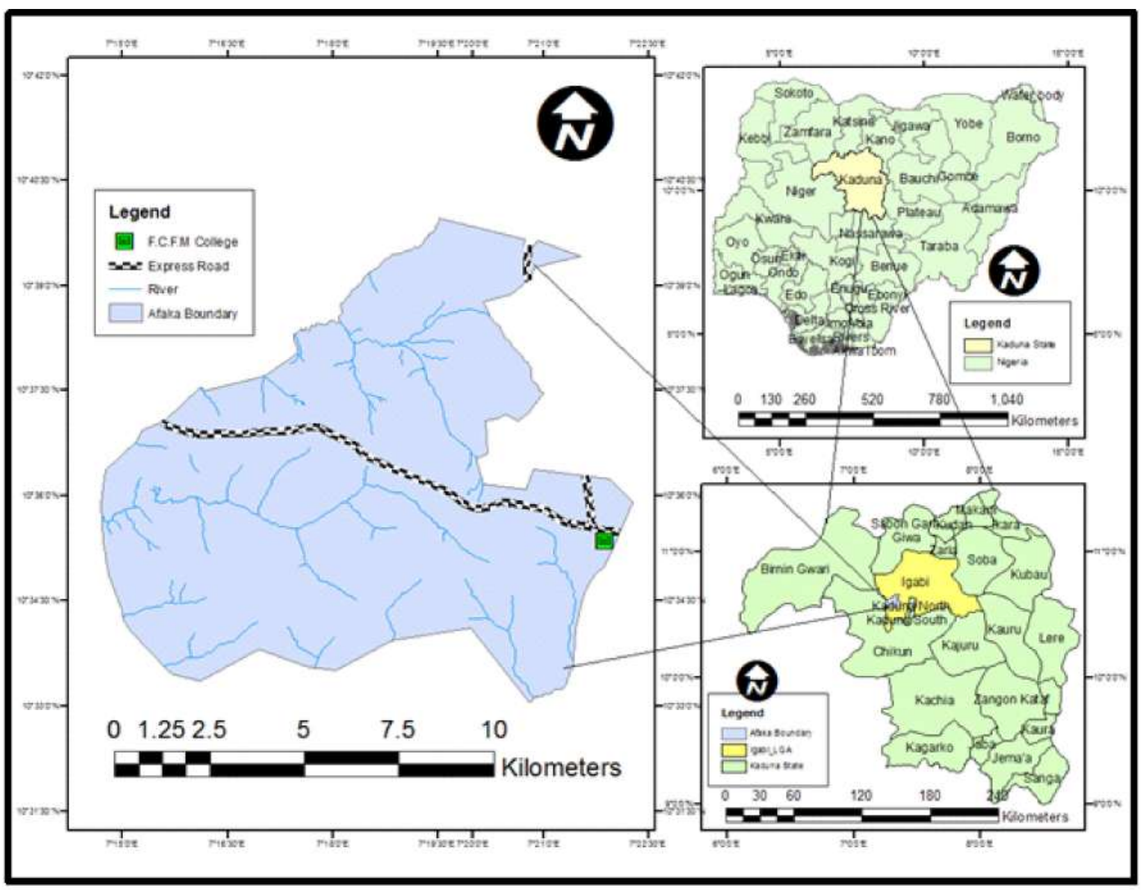

Fig 1: The location of Federal College of Forestry Mechanization, Afaka, Kaduna State, Nigeria

Experimental Procedure

The seeds were sourced from Afaka Forest, Kaduna State. Three hundred seeds were extracted from fruits and air dried for thirty minutes. The viability of the randomly selected seed samples were assessed using the cutting method (Schmidt, 2000). The sowing media (river sand), which was collected from the floor of the College dam was made to pass through 2mm sieve and then sterilized at 160°C for 24hours. The polythene pots used were $20x10x10cm^3$ in dimension and filled with sterilized river sand and arranged in the screen house. After six months of germination of seeds, uniform seedlings were available for the growth experiment.

Influence of organic fertilizers on the early growth of *Tamarindus indica*

The experimental design adopted to determine the influence of organic fertilizers on the early growth of *Tamarindus indica* was a Completely Randomised Design with six treatments replicated five times. The treatment consisted of 10g of each organic fertilizer (Cowdung, goat droppings, rabbit droppings, poultry droppings, pig droppings and control) applied on the *T. indica* seedling growth. The experiment involved a total of thirty seedlings. Six month old seedlings were transplanted into potting mixture with or without manure and subjected to 200ml of distilled water daily. Seedlings planted in sand without mixture of manure served as control. Growth parameters assessed every three weeks included; Seedling height (using meter rule); girth (using viener caliper); the number of leaflets were counted manually. Leaflet area was obtained by linear measurement of leaflet length and leaflet width as described by Clifton-Brown and Lewandowski (2000).

$$LA=0.74xLxW \qquad (1)$$

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

The fresh and dry weight were determined by the use of Mettler Top Loading Weighing Balance, but dry weight was taken from oven dried seedlings at 70°C for 72hours (Umar and Gwaram, 2006).

Data analysis

The data on the influence of organic fertilizers on the early growth of *Tamarindus indica* were subjected to one way analysis of variance (ANOVA) using SAS (2003). Comparison of significant means was accomplished using Fishers Least Significant Difference (LSD) at 5% level of significance.

Results

A significant height of 27.82cm was recorded from seedlings planted in the soil influenced with goat droppings at 12 weeks after transplanting (WAT). The least value of height (14.24cm) was recorded from seedlings planted in the unamended soil (control) at 3 WAT (Table1).

Table 1: Influence of organic fertilizers on the height (cm) of *T. indica* seedlings

Organic fertilizer	Weeks	After	Transplanting	
	3	6	9	12
Cowdung	25.48[ab]	25.72[ab]	25.82[ab]	26.12[ab]
Goat droppings	27.18[a]	27.42[a]	27.60[a]	**27.82[a]**
Rabbit droppings	24.10[ab]	24.26[ab]	24.42[ab]	24.70[ab]
Poultry droppings	25.24[ab]	25.38[ab]	25.62[ab]	26.22[ab]
Pig droppings	23.52[ab]	23.54[ab]	23.54[ab]	23.74[ab]
Control	**14.24[b]**	14.34[b]	14.52[b]	14.72[b]
SE ±	3.81	5.09	5.10	5.14

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

A significant number of leaflets of 67.00 were recorded from seedlings planted in the soil enhanced with goat droppings at 12 WAT. The least value of number of leaflets of 16.60 was recorded from seedlings planted in the soil without influence of manure (control) at 3WAT (Table 2).

Table 2: Influence of organic fertilizers on the number of leaflet of *T. indica* seedlings

Organic fertilizer	Weeks	After	Transplanting	
	3	6	9	12
Cowdung	44.40[ab]	46.60[ab]	49.00[ab]	53.40[ab]
Goat droppings	59.20[a]	61.60[a]	63.60[a]	**67.00[a]**
Rabbit droppings	32.00[b]	32.80[b]	34.20[b]	36.20[b]
Poultry droppings	49.80[ab]	52.60[ab]	54.60[ab]	58.80[ab]
Pig droppings	18.20[b]	20.20[b]	22.40[b]	25.00[b]
Control	**16.60[b]**	18.60[b]	19.40[b]	21.00[b]
SE ±	9.99	10.05	10.10	10.15

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

There was no significant (P>0.05) difference among the girths of seedlings enhanced with and without organic fertilizers at 3 to 12 WAT. Highest girth of 0.33cm was recorded from seedlings planted in the soil amended with cowdung at 12 WAT. The least value of 0.18cm was recorded from seedlings planted in the soil without amendment of organic fertilizers (control) at 3 WAT (Table 3).

Table 3: Influence of organic fertilizers on the girth (cm) of *T.indica* seedlings

Organic fertilizer	Weeks	After	Transplanting	
	3	6	9	12
Cowdung	0.32[a]	0.32[a]	0.33[a]	**0.33[a]**
Goat droppings	0.28[a]	0.29[a]	0.29[a]	0.31[a]
Rabbit droppings	0.20[a]	0.20[a]	0.22[a]	0.29[a]
Poultry droppings	0.24[a]	0.24[a]	0.24[a]	0.25[a]
Pig droppings	0.26[a]	0.26[a]	0.26[a]	0.26[a]
Control	**0.18[a]**	0.18[a]	0.20[a]	0.20[a]
SE ±	0.09	0.07	0.26	0.02

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

A significant leaflet area of 9.98cm^2 was recorded from seedlings planted in the soil amended with poultry droppings at 12 WAT. The least value of 4.84cm^2 was recorded for leaflet area of seedlings planted in the soil without the influence of organic fertilizers (control) at 3 WAT (Table 4).

Table 4: Influence of organic fertilizers on the leaflet area (cm^2) of *T.indica* seedlings

Organic fertilizer	Weeks	After	Transplanting	
	3	6	9	12
Cowdung	8.86[a]	8.94[a]	9.36[a]	9.64[a]
Goat droppings	7.56[a]	7.78[ab]	8.00[ab]	8.78[a]
Rabbit droppings	6.12[ab]	6.20[b]	6.40[b]	6.60[b]
Poultry droppings	7.98[a]	8.12[ab]	9.72[a]	**9.98[a]**
Pig droppings	5.56[ab]	5.66[b]	5.88[b]	6.16[b]
Control	**4.84[b]**	4.94[b]	5.28[b]	5.54[b]
SE ±	0.87	0.86	0.85	0.85

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

Significant total fresh weight (5.57g) and total dry weight (2.54g) were recorded from seedlings planted in the soil improved with goat droppings. The least values of 2.95g and 1.36g were recorded for total fresh and dry weights of seedlings planted in the soil without amendment of organic fertilizers (control) respectively (Table 5).

Table 5: Influence of organic fertilizers on the fresh and dry weight (g) of *T. indica* seedlings

Organic fertilizer	FW			TFW	DW			TDW
	L	S	R		L	S	R	
Cowdung	2.57^{ab}	1.01^{a}	1.60^{ab}	5.18^{ab}	0.96^{ab}	0.80^{a}	0.60^{a}	2.36^{ab}
Goat droppings	2.79^{a}	1.07^{a}	1.71^{a}	**5.57^{a}**	1.04^{a}	0.86^{a}	0.64^{a}	**2.54^{a}**
Rabbit droppings	2.47^{ab}	0.95^{ab}	1.52^{ab}	4.94^{ab}	0.93^{ab}	0.76^{ab}	0.57^{ab}	2.26^{ab}
Poultry droppings	2.60^{ab}	1.00^{a}	1.61^{a}	5.21^{ab}	0.99^{ab}	0.80^{a}	0.61^{a}	2.40^{ab}
Pig droppings	2.33^{ab}	0.91^{ab}	1.46^{ab}	4.70^{ab}	0.86^{ab}	0.73^{ab}	0.54^{ab}	2.13^{ab}
Control	1.49^{b}	0.56^{b}	0.90^{b}	**2.95^{b}**	0.56^{b}	0.46^{b}	0.34^{b}	**1.36^{b}**
SE	0.47	0.18	0.29	0.94	0.18	0.14	0.11	0.43

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

Nutrient composition of manure source applied

Highest percentage nitrogen (0.27%), phosphorus (4.15mg/kg) and potassium (9.96%) were recorded from pig droppings, pig droppings and goat droppings respectively. The least values of 0.04%, 0.07mg/kg and 0.17% were recorded for nitrogen, phosphorus and potassium content of soil without manure.

Table 6: Nutrient composition of manure sources applied

Manures	N %	P mg/kg	K %
Cowdung	0.19	0.51	1.08
Goat droppings	0.04	0.57	**9.96**
Rabbit droppings	0.13	0.34	2.91
Poultry droppings	0.07	1.82	6.29
Pig droppings	**0.27**	**4.15**	1.16
Control	**0.04**	**0.07**	**0.17**

Discussion

Significant growth parameters were recorded from seedlings planted in the soil improved with goat droppings. A similar observation has been made by Khaple *et al.* (2012) who stated that among the organic nutrients treatments of *Grevillea robusta*, goat manure was found to be the best which produced highest growth parameters. It could be inferred that goat manure enhances the growth of plants. Similar observations have been made by Duarsa *et al.* (1996), Maerere *et al.* (2001), Awodun *et al.* (2007), Gichangi *et al.* (2010) and Usman (2015). The ability of goat manure to enhance the growth of *T. indica* seedlings relative to others could be adduced to its release of potassium better than others. The result of this investigation revealed that goat manure contained the highest amount of potassium which influenced the growth parameters of *T. indica* seedlings. The essential characteristics of its potassium content accounted for highest growth parameters of *T. indica* planted in it.

Potassium is an essential element that functions in the activation of enzymes (Mengel *et al.,* 2001; Marschner, 2012), the translocation of photosynthates and the synthesis of cellulose, a building block of every plant cell wall (Anghinoni and Bissani, 2004; Havlin *et al.,* 2005; Sardans and Penuelas, 2005; Pettigrew, 2008; Wang *et al.,* 2013), transplant of sugars from leaves to fruits, and production and accumulation of oils (Romheld and Kirky, 2010), turgor regulation within the guard cell during stomatal movement (Wang *et al.,* 2013). Xu *et al.* (2020) reported that appropriate potassium supply enhanced photo assimilates transport from leaves to roots as well as from roots to leaves and increased nitrogen use efficiency (NUE) by influencing photosynthesis, C and N metabolizing enzyme activities, nitrate assimilation gene activities, and nitrate transport. It plays an important role in yield and quality improvement (Marschner, 2012; Oosterhuis *et al.,* 2014), cell growth (Hepler *et al.,* 2001) and growth and development of plant roots (Xu *et al.,* 2020). An efficient potassium status may facilitate osmotic adjustment which maintains higher turgor pressure, relative water content and lower osmotic potential, thus improving the ability of plants to tolerate drought stress (Kant and Kafkafi, 2002; Egilla *et al.,* 2005).

Among the fertilizers investigated, goat manure gave highest growth parameters of *T. indica* seedlings. Contrary to the result of this investigation, various researchers have reported diverse responses of manure to the seedlings of forest tree species. Egbewole (2017) reported highest growth parameters for *Araucaria heterophylla* seedlings planted in soil treated with poultry droppings. *Albizia zygia* and *Blighia welwitschii*, seedlings had the best results in soil treated with 6g of composite fertilizer, while *Lophira alata* and *Pterocarpus soyauxii* seedlings showed best growth in soils treated with 9g of composite fertilizers for all other parameters (Andrew *et al.,* 2019). Buochuama and Akhabue (2020) stated that cow manure enhanced the growth of *Streculia setigera* seedlings. Thus cowdung could be utilized to make nutrient available for optimal growth of *Tamarindus indica* seedlings (Sodimu *et al.,* 2020). Rotowa *et al.* (2020) recommended the use of poultry droppings in raising *Eucalyptus torelliana.*

The use of fish pond sediment as organic manure enhanced the growth of *Dennettia tripetala* seedlings (Anozie *et al.,* 2020). Agera *et al.* (2019) recommended poultry droppings as the most suitable organic manure for nurturing juvenile seedlings of *Eucalyptus camaldulensis* in the nursery for plantation purposes. The application of poultry manure significantly increased the vegetative growth of *Moringa oleifera* (Dania *et al.,* 2014). Haouvang *et al.* (2017) stated that organic amendments in general and cow dung compost in particular could constitute the best fertilizer to improve growth of *Moringa oleifera* in pots. Based on the research findings, farmers can use poultry manure at an application rate of 500g per planting pot for improving the growth of *Coffea arabica* seedlings (Musagomba, 2017). Oroka and Ureigho (2019) recommended the use of *Tithonia* + poultry manure mixture for better performance of *Irvingia wombolu* seedlings. The increase in growth of seedlings with poultry droppings application stressed its importance during the seedling emergence of tree plants (Agboola and Adedire, 2002).

The least growth parameters recorded from seedlings planted in the soil without influence of organic fertilizer showed that there was no enough nutrient present and released by sand. Organic fertilizers released the nutrient for the growth of *T. indica* compared with poor fertility sand used under the control experiment. All seedlings planted in organic fertilizers performed better than those of untreated seedlings. These results are consistent with the reports of Rotowa *et al.* (2020) who stated that plant growth is directly related to the availability of nutrients in the soil as the *Eucalyptus torelliana* planted in treated soil samples performed better than those in the untreated soil. The organic fertilizer improves the organic carbon status and available NPK and S in the soil, thereby sustaining soil health and improving plant growth (Aderounmu and Olajuyigbe, 2019). This is in consonance with the reports of Musagomba, (2017) who documented that at all application levels, all the organic fertilizers performed better than the control (untreated soil) when used for *Coffea arabica.*

Conclusion

To forestall the threat of extinction of our indigenous economic tree species like *T. indica,* adequate nutrition with the use of natural, safe, affordable and environmentally friendly fertilizer is essential, for successful growth of the seedlings to meet population demand and ensure biodiversity conservation. Investigation on the influence of organic fertilizer on the growth of *T. indica* revealed that goat droppings enhance its growth better than other studied manure.

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Key: WAT= Weeks After Transplanting
Key: FW= Fresh Weight, TFW= Total Fresh Weight, DW=Dried Weight, TDW=Total Dried Weight