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Research Article

Germination and Early Growth Assessment of *Tamarindus indica L* in Sokoto State, Nigeria

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Germination and early growth assessment of *Tamarindus indica L.* were conducted to determine the suitable medium for germination and seedlings establishment of the species in Sokoto State, Nigeria. The viable seeds of the study species were treated with Conc. H_2SO_4 for 30 minutes and boiling water for one hour and by soaking in water at room temperature for 12 hours. The treated seeds were placed in Petri dishes containing filter paper for germination assessment. The results indicated 68–95% germination of *T. indica* seeds within 3–19 days. Conc. H_2SO_4 treatment gave the highest germination percentage of 95%. *T. indica* seeds were treated with Conc. H_2SO_4 for 30 minutes and sown into four (4) different potting mixtures for early growth assessment. Collar diameter, seedlings height, and leaf number were the parameters measured. Seedlings grown in the mixture of river sand and cow dung (2 : 1) had the highest seedlings height and leaf number, while the highest collar diameter was obtained from seedlings grown in the mixture of river sand and poultry droppings (2 : 1). However, growing *T. indica* in the mixture of river sand and cow dung (2 : 1) after 30 minutes pretreatment was recommended.

1. Introduction

1.1. Germination of Seeds. Desertification, deforestation, and erosion are the most prominent factors responsible for biodiversity loss as well as soil degradation in the savanna regions. These resultant negative effects can be minimised through afforestation programmes. However, to achieve the aim of any regeneration programme, seed collection and germination must be taken into consideration, although germination of seeds is often very difficult for many useful species principally because of dormancy. In view of this, it is necessary to identify the most appropriate way of raising seedlings under different potting media (potting mixture) in the nursery.

Germination simply refers to a series of changes whereby an embryo grows into a seedling [1]. It involves absorption of water by the seed and splitting of seed testa giving rise to plumule (which grows upward and develops into stem and branches) and radicule (that grows downward and develops into root system). Germination can be either epigeal or hypogeal. In the former, the cotyledon appears above the soil surface as in the germination of *T. indica*, while in the latter the cotyledon remains beneath the ground, for example, germination of oil palm seeds.

Regardless of individual seed variety as well as ecological conditions of plants natural habitat, there are three conditions necessary for germination; these include moisture, temperature, and atmospheric oxygen [2]. Seeds absorb water from the soil by a process of imbibition which leads to the swelling and breaking of the seed coat. Following imbibition process, hydrolytic enzymes (hydrolase) are activated which break down the stored food substance into metabolically useful chemicals. Atmospheric oxygen is obtained by the seeds from the soil pore spaces, which is often used in aerobic respiration to supply energy until it grows out leaves (beginning of photosynthesis).

Temperature requirements for germination vary with species. Many seeds germinate at temperatures slightly above 60–75°F (16–24°C), though there are certain seeds that require exposure to cold temperature (vernalization) in order to break dormancy, for example, *Helleborus niger* of the family *Ranunculaceae* [3]. Nwoboshi [4] stated that low temperature prolongs the length of seed viability; hence creating artificially low temperatures has been found useful in seed storage. High temperatures affect germination of seeds by influencing the water holding capacity of the soil which, thus, determines to a large extent the survival of germinating seeds [5].

1.2. Tree Growth. Growth manifests itself as an irreversible change in size and form. Physiologically it may be regarded as synthesis of protoplasm, accompanied by a permanent change in size and form [6]. Growth and development of trees is very important in forestry, since it determines the amount of wood a forester can reasonably cut and the time interval required for trees in the forest to reach merchantable size. However, growth forms the basis for sustained yield forest management [7].

Forest trees continue to grow for most part of their lives [4]. However, this growth does not occur in any case haphazardly all over the tree, or at the same rate throughout the life of a tree; rather, it was restricted only to some growth centres or meristematic tissues found at the tips of shoots and roots as well as in the vascular cambium of trees. The growth initiated in the shoot and root meristems accounts for all the increase in length of the tree axis at both stem and root tips and it is responsible for the formation of lateral appendages such as branches, leaves, lateral roots, and root hairs as well as the floral parts, while the activity of vascular cambium accounts for the increase in diameter [8]. The knowledge of growth pattern as well as the growth centres in trees is of great silvicultural significance as it determines to a large extent how various environmental and cultural practices affect growth.

Generally, early growth assessment is of paramount importance in the choice of species to plant in any plantation establishment. Because if the choice is not properly conducted, experience has shown that no matter how carefully the crop is subsequently tended, the final result will be poor and mostly unprofitable, therefore in any plantation programme attempt should always be made to plant the right species in the right place [4].

1.3. Tamarind (Tamarindus indica). *T. indica* is a leguminous tree in the family fabaceae native to tropical Africa. The genus is a monotypic taxon, having only a single species [9]. It is cultivated widely in India, Bahamas, West Indies, and USA among others [10]. The species is a slow-growing one; long lived massive tree reaches under favourable condition a height of 12–24 m and a trunk circumference of 7.5 m. The bright green, fine feathery foliage is composed of pinnate leaves, each having 10–15 pairs of oblong leaflets 1.25–2.5 cm long and 5-6 mm wide which fold at night [11].

The leaves are bright green in colour, and shade briefly in very dry areas during the hot season. The flower is composed of five petals which are yellow with orange or red streaks. The fruits are flattish, bean like, and irregularly curved and with bulged pods which are borne in great abundance along the new branches and usually vary from 5 to 16 cm long and 2 to 3.3 cm in diameter [12]. The pods may be brown or greyish brown in colour which are composed of about 1–12 fully formed hard seeds, which are glossy burn, squarish in form (1.1–1.25 cm in diameter), and each is enclosed in a parchment-like membrane. However, the species grows well in clay, loam, sandy, and acidic soil types, with a high drought and aerosol salt resistance. A matured tree under favourable conditions may annually yield 150–225 kg of fruits [10].

The food uses of *T. indica* are many; the tender immature very sour pods are cooked as seasoning with rice, fish, and meats in India [10]. The fully grown, but still unripe fruits, called "swells" in Bahamas are roasted in coal until they burst and the skin is peeled back and the sizzling pulp is dipped in wood ashes and eaten [9]. In Northern Nigeria, drinks ("tsami") are prepared from the pounded and boiled pods. The leaves are eaten by cattle and goats. Tamarind pulp was found to supply 53.8% and 87.6% of the total essential and aromatic amino acids, respectively (FAO/WHO/UNU standard) [13].

T. indica is used as traditional medicine in India, Pakistan, Bangladesh, Nigeria, and most of the tropical countries. It is used traditionally in the treatment of abdominal pain, diarrhoea, dysentery, helminthes infections, wound healing, malaria and fever, constipation, inflammation, cell cytotoxicity, gonorrhoea, and eye diseases. It has numerous chemical values and is rich in phytochemicals, and hence the plant is reported to possess antidiabetic, antimicrobial, antivenomic, antimalarial, antiasthmatic, and antihyperlipidemic properties [14].

Tamarind wood was found to be useful in making furniture, wheels, mallets, rice pounders, mortars, pestles, ploughs, tent pegs, canoes, side planks for boats, cart shafts and axles, and naves of wheels, toys, oil presses, sugar presses, printing blocks, tools and tool handles, turnery, and so on [14]. However, in Northern Nigeria the tamarind wood is used in making mortars and pounders.

Despite food, wood, and medicinal values of *T. indica*, in Sokoto State, today only few stands of the species remained due to exploitation without proper management. Therefore, in view of this germination and early growth of *T. indica* in Sokoto State were studied.

2. Materials and Method

2.1. Study Area. The study area is Sokoto in Nigeria, situated between latitude 11–13° 05′N and longitude 40–05° 15′E. It falls within the Sudan savanna zone characterised by two distinct seasons (wet and dry seasons) of varying duration and intensity. The state has a total land mass of about 25, 973, 3 km^2. The rainy season is short often 3-4 months (usually from May to September) with highest fall in August. The mean annual rainfall is 550 mm–750 mm with relatively high temperature though it varies with season. The mean annual temperature is 34°C [15]. The vegetation of the area is characterised by few scattered trees amongst dominating herbaceous layers which are threatened by the inhabitants as a result of over exploitation without replacement. In addition, temperature, rainfall, and wind are the main climatic factors that are aggravating lack of vegetation in Sokoto state.

Therefore, the effect of climatic factors on seedlings establishment, tree growth, and development can however be modified by correct potting media and pretreatments in the propagation of seedlings.

2.2. Experimentation. The research work is comprised of laboratory tests and nursery activities. Two hundred (200) seeds of *Tamarindus indica* were obtained from Forestry and Fisheries Research Laboratory of Usmanu Danfodiyo University Sokoto. The average weight of 10 seeds of the species is 5 g and 0.5 g/seed. Germination assessment consists of 15 observation plots (Petri dishes) and each contains 10 viable seeds of the study species. Similarly, 16 observation plots (polythene bags containing potting mixtures) were used for early growth assessment. The whole experiment was conducted in a controlled condition; therefore data analysis was conducted descriptively.

2.3. Viability Test. There are several ways for testing seeds viability; these include scarification, cutting test, excised embryo technique, biochemical method, colour method, transparency, and germination method as well as floatation technique. However, floatation method is the fastest way of testing seeds viability, which is based on the observation that empty or nonviable seeds float while viable seeds sink or settle down to the bottom of the container [16]. In this experiment, 200 seeds of *T. indica* were soaked into a 400 mL beaker containing water and observed for 10 minutes to identify the viable seeds.

2.4. Germination Test

2.4.1. Concentrated Sulphuric Acid (Conc. H_2SO_4) Treatment. In this experiment, 50 seeds of *T. indica* were soaked into a beaker containing 200 mL of Conc. H_2SO_4 for 30 minutes which is accompanied by stirring in order to ensure equal treatment of the seeds. The treated seeds were then washed thoroughly with water and transferred to the Petri dishes containing moistened filter paper for germination assessment.

2.4.2. Hot Water Treatment. A 400 mL beaker was filled with water and heated to a temperature of 100°C using electric heater. Fifty (50) viable seeds were soaked into the boiling water, and the heat source was immediately removed; the seeds were allowed to settle in gradually cooling water for a period of one hour and then transferred to the Petri dishes containing moistened filter paper for germination assessment.

2.4.3. Normal Water Treatment. Similarly in this trial 50 viable seeds were soaked in 400 mL beaker containing 200 mL of water (at room temperature) for 12 hrs. The seeds were removed and transferred to the Petri dishes containing a moistened filter paper to examine the seed germination.

2.5. Early Growth Assessment of Tamarindus indica

2.5.1. Collection of Potting Mixtures. Cow dung was collected from Adarawa village and river sand and topsoil from Kwalkwalawa village, while fertilizer was obtained from Kara market, Sokoto.

2.5.2. Pot Filling. However, prior to the filling of containers, the soil was sieved using 2 mm mesh to remove stones and other particles. The cow dung was also crushed and sieved. A 25 cm × 20 cm sized polythene bags were filled with soil mixtures in the nursery: manure/topsoil/river sand (1 : 1 : 2), manure/river sand (1 : 2), poultry droppings/river sand (1 : 2), and fertilizer/river sand (285 g NPK/1 m^3 soil).

2.5.3. Seed Sowing. The seeds of the study species were pretreated with Conc. H_2SO_4 for 30 minutes before direct sowing into the polythene bags for early growth assessment. According to Colleen [17], seed should be planted at a depth of three times its diameter. However, in this research, the sowing depth was 3 cm. Watering was carried out once in a day (early morning) and twice in a day after complete germination (i.e., early morning and late evening).

2.5.4. Data Collection. During early growth assessment data on seedlings height, collar diameter, and leaf number were collected at 7-day interval after complete germination and stopped at 8th week.

3. Results and Discussion

3.1. Result of Viability Test. The viability of *T. indica* seeds using floatation method was found to be 99%, an indication that the seeds are pure and ready for any regeneration process. This agreed with Pamela [16] that floatation method was the best for testing the viability of seeds relatively larger than the size of tomato seeds.

3.2. Germination of T. indica. Conc. H_2SO_4 showed complete germination after 3 days and gave the highest germination percentage (95%), followed by soaking in boiling water (80%) whose complete germination was in 12 days while normal water treatment had complete germination in 19 days and gave 68% germination (Table 1). Therefore it was evident that all the pretreatments are very effective in hastening germination of *T. indica* seeds.

This result can be compared favourably with the finding of Muhammad and Amusa [18] who reported that seeds of *T. indica* germinate within 3 days after 60 minutes of pretreatment with Conc. H_2SO_4. The assessment also tallies with the work of Abubakar and Muhammad [19], in which seeds of *T. indica* were pretreated with Conc. H_2SO_4 and 100% germination was recorded. The results obtained in this research were also in line with the work of Ajiboye [20] who recorded 70–100% germination of *T. indica* seeds pretreated with Conc. HCL for 10 minutes within 3–5 days.

Germination percentage of 80% was observed from hot water (100°C) pretreatment. This opposed the finding of Byrd [21] that reduced germination percentage and seedlings vigour were observed due to high temperature which is very common with seeds that are exposed to great heat, especially when hot water and light burning pretreatment are applied to

Table 1: Effects of pre-treatment on germination of *T. indica* seeds.

Pre-treatment	Mean number of days before complete germination (days)	Mean germination percentage (%)
Conc. H_2SO_4	3	95
Boiling water	12	80
Water at room temperature	19	68

seeds in order to break their dormancy. Higher germination percentage obtained from hot water treatment agreed with the findings of Abubakar and Muhammad [19]. According to them, an experiment was carried out with *T. indica* by treating the seeds with hot water at 100°C and the germination percentage was 80%.

However, regardless of the purpose of plantation establishment, Conc. H_2SO_4, hot water, and normal water pretreatments are very essential in breaking dormancy and hastening germination of *T. indica* seeds. This is as a result of the treatments' ability to soften seed coat, making it permeable for water and nutrients.

3.3. Early Growth Assessment of Tamarindus indica Seedlings. The choice of appropriate potting media in propagating seedlings is of great silvicultural importance. However, the potting mixtures used in this research agreed with the opinion of Aklibasinda et al. [22].

Table 2 showed that river sand and poultry droppings (2 : 1) gave the highest collar diameter of 0.40 cm and river sand and cow dung (2 : 1) 0.36 cm, while 0.33 cm was recorded from the mixture of river sand, topsoil, and cow dung (2 : 1 : 1). The results obtained in this research agreed with the finding of Ugese, [23] where 0.38 cm was recorded as mean collar diameter of *T. indica* seedlings grown in the mixture of rice hull, poultry manure, and river sand (2 : 3 : 1). Similarly, the mixture of river sand/cow dung (2 : 1) gave the highest leaf number of 10 leaves, followed by river sand/topsoil/cow dung (8 leaves), and the least was 6-leaf number given by river sand/NPK. This opposes the work of Ugese, [23] who obtained 36.6 as leaf number of *T. indica* seedlings grown in the mixture of rice hull, poultry manure, and river sand (2 : 3 : 1) within 8 weeks. The potting mixture that gave the highest seedlings height was river sand/cow dung (24.74 cm), followed by river sand/topsoil/cow dung (18.50 cm) while the least was in river sand/NPK (13.25 cm). This agreed with the work of Banwar [24]. According to him, seedlings height of about 22 cm was recorded on *T. indica* seedlings grown in the potting mixture of cow dung/river sand (2 : 1). The finding of this research also agreed with the work of Ugese, [23], who recorded 20.6 cm as *T. indica* seedlings height grown in the mixture of rice hull, poultry manure, and river sand (1 : 2 : 3).

However, the performance of seedlings in the nursery has shown a direct relationship with the pretreatments employed. This was in line with the findings of Nwoboshi [4] that the main chemicals to be used in the tropics and Nigeria for seeds pretreatment are Conc. H_2SO_4, H_2O_2, and NaOH.

Table 2: Effects of potting mixtures on growth parameters of *T. indica*.

Potting mixture	Mean seedlings height (cm)	Mean leaf number	Mean collar diameter (cm)
River sand/poultry droppings	16.25	7.5	0.40
River sand/top soil/cow dung	18.50	8	0.33
River sand/NPK	13.25	6	0.35
River sand/cowdung	24.74	10	0.36

4. Conclusion

All the pretreatments applied in the laboratory proved effective, and Conc. H_2SO_4 treatment gave the highest germination percentage, which is attributed to its ability to soften seed coat, thereby rendering it permeable for water and nutrients, thus hastening germination, while the potting mixture of river sand and cow dung (2 : 1) was the best in terms of seedlings vigour. This was due to easy movement of water and nutrients as well as absorption by the root system.

5. Recommendations

From the results obtained in this experiment, the following recommendations were made.

(1) Floatation method is cheap, fast, and easy to adopt; hence it is recommended for small and medium sized seed viability test.

(2) Considering the cost and availability of the inputs, water pretreatment is recommended.

(3) The time for Conc. H_2SO_4 pretreatment should not exceed one hour, as long time soaking of *T. indica* seeds in acid (Conc. H_2SO_4) may destroy seeds embryo, thereby hindering germination.

(4) River sand and cow dung (2 : 1) mixture as the most readily available and effective input was recommended as potting mixture for propagating *T. indica* in the nursery.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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