



# Germination Pattern and Root Trainer Performance of *Terminalia arjuna*: A Troublesome Tree Species in Plantation Trials

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## Abstract

In order to study the germination pattern and root trainer technology for *Terminalia arjuna*, its seeds were procured from two places of central Kerala and their germination studies were conducted in six different sowing media using fresh, pretreated and seeds stored up to three months. Germination value (GV) for all the field trials was calculated that showed highest for fresh seeds without pretreatments sown in PBCP and RTCP. Maximum GV for pretreated seeds were recorded in control and in gibberellic acid (100 ppm) treated seeds sown in PBCP and RTCP. Analysis of variance shows significance at 1% level between medium, between pretreatments and between years of study. Transplantation shock, bulkiness, and frequent change of polythene bags cause additional labor by conventional method but root trainers have advantages such as requiring no change of medium, least possibility of transplantation shock, advantage of air pruning, prevention of root coiling due to antispiral design and requirement of small area which makes them suitable for mass production of seedlings.

## Keywords

Germination Value, *Terminalia arjuna*, Rooting Media, Root-Trainers

Subject Areas: Agricultural Science

## 1. Introduction

Indian forests of different types are always known for their multifarious functions, and hence form an important

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component of the life supporting system. During the last decade Indian government together with other governmental and non-governmental agencies have given more importance on the use of local species for plantation, as they are eco-friendly and environmentally safe [1]. This trend has increased the demand for planting material, including primarily local, indigenous, endemic and little known under-utilized plant species. *Terminalia arjuna* Wight & Arn. trees are commonly found throughout the greater part of the Indian Peninsula, from Avadh southwards, and in Southern, Western and Central India. It is also found in Sri Lanka [2] [3]. In Kerala it grows mainly along riverbanks in the dry deciduous forests [4]. The timber is used for carts, agricultural implements, water troughs, boat building and other domestic purposes. The bark is used in various medicinal preparations [4]. For the mass propagation of *Terminalia arjuna*, root trainer technique is important and hence this study concentrates on comparative germination results and interpretation in root trainers in addition to the traditional methods.

## 2. Materials and Methods

Mature fruits were collected from cultivated mother plants at Prof. T C Joseph memorial Garden (P2), Union Christian College, Aluva and from Peechi natural stands, Thrissur (P2). All experiments in the present study was conducted during 2007 (Y1), 2009 (Y2) till 2013 (Y3) in the nursery of T.C Joseph Memorial Botanical Garden, Department of Botany, Union Christian College, Aluva, +10°7'30.65", +76°20'3.32", Kerala State, India. Sample size for each germination trials using seeds samples from different sites, with and without pretreatments and in different medium of sowing was kept 100. The experimental trials using fresh seeds were repeated for three years (Y1, Y2 and Y3) and germination pattern of stored seeds were gathered up to three months at one months interval (M1, M2 and M3).

Germination studies of fresh seeds without pretreatments, with pretreatments and stored seeds up to 3 months at one-month intervals were carried out in six different media such as raised standard nursery bed (NB), germination tray with polyurethane sheets (GT), polythene bag with potting mixture (PBPM), polythene bags with coir pith (PBCP), root trainers with potting mixture (RTPM) and root trainers with coir pith (RTCP) and their results showing Germination Percentage, Percentage of sound seeds which do not germinated (obtained by embryo cut test), were obtained for each tests. Germination value was calculated by the formula by [5]. Number of seeds germinated in each day and the day taken for germination were recorded. Cumulative germination percentage was calculated for each treatment at the end of each trial. Germination value (GV) was calculated using the following formula as given by Czabator (1962).

$$G.V = \text{Final M.D.G} \times P.V$$

where, GV is the germination value, Final MDG represents final mean germination, which is calculated at the cumulative percentage of full seed germination at the end of the test divided by number of days from sowing to the end of the test and PV is the peak value (the maximum mean daily germination recorded at any time during the test). Viability percentage was also calculated by using the equation Germination percentage + percentage of sound un-germinated seeds. At the end of the germination period, all remaining un-germinated seeds were cut and examined and the percentage of fresh, viable and possibly viable seeds was recorded as sound un-germinated seeds. All the germination percentages obtained were subjected to ANOVA study to make comparisons between media, year of study, place of seed collection, effect of pretreatments and effect of storage up to three months in all the study species.

## 3. Results

### 3.1. Fruit and Seed Characteristics

Fruit is a drupe, ovoid to obovoid, five winged, reddish brown, glabrous, 4 to 5 cm × 2.5 to 3 cm. On an average fruits weigh 296 to 425 per kilogram. Seeds are delicate with a leafy cotyledon and difficult to separate from the woody pericarp (**Figure 1**).

### 3.2. Germination Performance of Fresh Seeds in Different Sowing Media

Germination studies of fresh seeds without pretreatments, with pretreatments and stored seeds up to 3 months at one-month intervals were carried out in six different media such as raised standard nursery bed (NB), germination



**Figure 1.** Seeds of *Terminalia arjuna*.

tray (GT), polythene bag with potting mixture (PBPM), polythene bags with coir pith (PBCP), root trainers with potting mixture (RTPM) and root trainers with coir pith (RTCP) and their results showing Germination Percentage, Percentage of Sound Seeds which do not Germinated (obtained by embryo cut test), Viability Percentage, Peak Value (PV), Final Mean Daily Germination (MDG) FINAL, and Germination Value (GV) were obtained for each tests and tabulated (**Tables 1-3**).

In the germination study of fresh seeds without pretreatments, maximum sound seeds which did not germinate after the completion of germination was observed when sown in NB and the maximum viability percentage obtained was 69.43%, when seeds sown in RTCP. Highest Peak Value (PV), Final MDG and Germination Value were recorded in seeds when sown in RTCP. Germination value (GV) was minimum for seeds sown in NB (**Table 1**).

### 3.3. Effect of Pretreatments in the Germination of Fresh Seeds in Different Sowing Media

In the germination study of fresh seeds with pretreatments, maximum percentage of sound seeds that did not germinate after the completion of germination was 33.33% when seeds were sown after pretreatment. The maximum viability percentage recorded was 87.5%. Highest Peak Value (PV) was observed in the germination result of seeds pretreated with 100 ppm gibberellin for 20 minutes and sown in PBCP and the lowest Peak Value obtained was 0.17, when seeds sown after treatment with cold water, hot water and untreated seeds. Maximum value for Final MDG recorded after pretreatment with 100 ppm gibberellin and sown in RTPM and the minimum was 0.3, when seeds were sown after pretreatment with cold water. Maximum Germination Value was 0.8178 for seeds sown in root trainers with coir pith after treatment with hot water (**Table 2**).

### 3.4. Effect in Germination of Stored Seeds Using Different Sowing Media

Germination study of stored seeds show maximum viability percentage obtained was 58.33% when seeds sown after two and three months of storage. Highest Peak Value (PV) was observed in the germination result of seeds sown after one month of storage in GT and the lowest Peak Value obtained was 0.19 when sown in NB after two months of storage. Maximum value for Final MDG was obtained when seeds stored for one month were germinated in RTCP. Maximum Germination Value was, 0.493 for seeds germinated in PBPM after two month of storage (**Table 3**).

### 3.5. Analysis of Variance for Comparing Germination Percentage of Fresh Seeds

The results of ANOVA for comparing germination percentage with out pretreatment show significance at 1% level between medium of seed sowing and non significant between years of study and place of collection (**Table 4**). Maximum mean germination was obtained when seeds were sown in RTCP (48.61<sup>a</sup>) and PBCP (47.92<sup>a</sup>). The mean germination of seed samples collected from the two places (P1 36.57<sup>a</sup> and P2 36.80<sup>a</sup>) and between years of

**Table 1.** Germination of fresh seeds without pretreatments in *T. arjuna*.

Sowing Medium	Place of Collection	Germination Percentage	Sound Ungerminated Seeds	Viability Percentage	Peak Value (PV)	MDG Final	Germination Value (GV)
NB	P1	33.33	25	58.33	0.28	0.83	0.2324
	P2	35.3	25	60.3	0.29	0.86	0.2494
GT	P1	17.5	25	42.5	0.15	0.54	0.081
	P2	17.5	29.17	46.67	0.15	0.54	0.081
PBPM	P1	36.11	20.83	56.94	0.28	0.9	0.252
	P2	35.3	25	60.3	0.29	0.9	0.261
PBCP	P1	47.21	20.83	68.04	0.35	1.28	0.448
	P2	48.6	20.83	69.43	0.35	1.28	0.448
RTPM	P1	36.11	20.83	56.94	0.29	0.9	0.261
	P2	36.11	25	61.11	0.28	0.88	0.2464
RTCP	P1	48.6	20.83	69.43	0.4	1.35	0.54
	P2	48.6	16.67	65.27	0.35	1.36	0.476

study (Y1 36.11<sup>a</sup>, Y2 37.85<sup>a</sup>, Y3 36.11<sup>a</sup>) shows homogeneity in mean germination percentage.

### 3.6. Analysis of Variance for Comparing Germination Percentage of Pretreated Seeds

Among the six types of pre-treatments and sowing medium used, the F-value shows significance at 1% level from the results showing analysis of variance found in **Table 5**. The mean germination under different medium and its comparison show homogenous results between the six media used in the present study. The maximum germination after treatment was observed when treated with hot water (54.17<sup>a</sup>) and minimum value of (22.22<sup>c</sup>) when seed coats were removed.

### 3.7. Analysis of Variance for Comparing Germination Percentage of Stored Seeds

It is obvious from the of ANOVA table for comparing germination percentage of stored seeds that there is significance at 1% level between media of study (**Table 6**). Maximum mean germination was (48.60<sup>a</sup>) when three months stored seeds were sown in RTCP and the minimum mean percentage was recorded when seeds were sown in GT (20.83<sup>c</sup>). It is obvious from the results (M1 38.89<sup>a</sup>, M2 39.58<sup>a</sup>, M3 38.19<sup>a</sup>) that mean germination percentage has no decrease and remains homogenous even after three months of storage.

## 4. Discussion

For the germination studies of the *Terminalia arjuna*, the analysis of variance for comparing germination percentage of fresh seeds in different sowing medium show that there is no significance between the two collection points within the Kerala state in the present study (**Table 4**). Comparing the results in analysis of variance it is shown that the values are homogenous as mean germination of seed samples collected from the two places (P1 36.57<sup>a</sup> and P2 36.80<sup>a</sup>) and between years of study (Y1 36.11<sup>a</sup>, Y2 37.85<sup>a</sup>, Y3 36.11<sup>a</sup>) shows homogeneity in mean germination percentage.

Comparing the results in analysis of variance for comparing germination percentage in show differences in mean germination due to different pretreatments. Seeds of *T. arjuna* have maximum germination performance with hot water treatment. Pretreatment with soaking seeds in concentrated H<sub>2</sub>SO<sub>4</sub> results better germination but cold water treatment and seed coat removal have least effect. Concentrated sulphuric acid can consequently desiccate tissues and eventually cause cell separation [6] [7] but in the present study as the fruits has hard and woody fruit wall the germination percent has found to be increased.

Homogenous values were observed after the first, second and third month of storage but mean percentage is

**Table 2.** Effect of pretreatments on germination in the seeds of *T. arjuna* (Figure 2).

Pretreatment	Sowing Medium	Germination Percentage	% of Sound Ungerminated Seeds	Viability Percentage	Peak Value (PV)	MDG Final	Germination Value (GV)
COLD WATER	NB	33.33	25	58.33	0.28	0.83	0.2324
	GT	12.5	25	37.5	0.17	0.3	0.051
	PBPM	37.5	25	62.5	0.28	0.91	0.2548
	PBCP	41.67	29.17	70.84	0.35	1.02	0.357
	RTPM	37.5	25	62.5	0.29	0.93	0.2697
	RTCP	41.67	20.83	62.5	0.35	1.02	0.357
HOT WATER	NB	58.33	25	83.33	0.45	1.62	0.729
	GT	16.67	25	41.67	0.17	0.56	0.0952
	PBPM	54.17	33.33	87.5	0.45	1.42	0.639
	PBCP	62.5	25	87.5	0.46	1.74	0.8004
	RTPM	50	25	75	0.41	1.38	0.5658
	RTCP	62.5	20.83	83.33	0.47	1.74	0.8178
Conc. SULPHURIC ACID	NB	62.5	20.83	83.33	0.29	1.04	0.3016
	GT	37.5	28.33	65.83	0.19	0.69	0.1311
	PBPM	41.67	33.33	75	0.28	1.3	0.364
	PBCP	54.17	25	79.17	0.35	1.64	0.574
	RTPM	50	25	75	0.3	1.64	0.492
	RTCP	50	20.83	70.83	0.35	1.56	0.546
SEED COAT REMOVED USING KNIFE	NB	50	33.33	83.33	0.19	0.72	0.1368
	GT	20.83	37.5	58.33	0.2	0.41	0.082
	PBPM	12.5	28.67	41.17	0.18	0.74	0.1332
	PBCP	20.83	33.33	54.16	0.2	0.83	0.166
	RTPM	25	28.67	53.67	0.19	0.83	0.1577
	RTCP	29.17	29.16	58.33	0.17	0.99	0.1683
CONTROL	NB	33.33	25	58.33	0.28	0.81	0.2268
	GT	16.67	33.33	50	0.28	0.59	0.1652
	PBPM	37.5	33.33	70.83	0.31	0.91	0.2821
	PBCP	45.83	29.17	75	0.28	1.15	0.322
	RTPM	37.5	25	62.5	0.35	1.25	0.4375
	RTCP	50	20.83	70.83	0.28	1.19	0.3332
GIBBERLLIN (100 ppm)	NB	41.67	20.83	62.5	0.35	1.19	0.4165
	GT	16.67	37.5	54.17	0.17	0.56	0.0952
	PBPM	45.83	20.83	66.66	0.38	1.39	0.5282
	PBCP	54.17	16.67	70.84	0.5	1.75	0.875
	RTPM	45.83	20.83	66.66	0.37	1.93	0.7141
	RTCP	54.17	16.67	70.84	0.5	1.75	0.875



**Figure 2.** Seedlings of *T. arjuna* in root trainers.

**Table 3.** Effect of seed storage on germination in the seeds of *T. arjuna*.

Period of Storage	Medium of Sowing	Germination Percentage	% of Sound Ungerminated Seeds	Viability Percentage	Peak Value (PV)	MDG Final	Germination Value (GV)
M1	NB	33.33	2.5	35.83	0.318182	0.9522857	0.303
	GT	20.83	20.83	41.66	0.4	0.8679167	0.347166667
	PBPM	41.67	12.5	54.17	0.291667	1.0965789	0.319835526
	PBCP	45.83	8.33	54.16	0.304348	1.2730556	0.387451691
	RTPM	41.67	88.33	130	0.333333	1.0965789	0.365526316
	RTCP	50	4.17	54.17	0.238095	1.3157895	0.313283208
M2	NB	33.33	12.5	45.83	0.190476	0.8771053	0.167067669
	GT	20.83	25	45.83	0.466667	0.9468182	0.441848485
	PBPM	45.83	12.5	58.33	0.409091	1.2060526	0.493385167
	PBCP	45.83	12.5	58.33	0.380952	1.1751282	0.447667888
	RTPM	41.67	12.5	54.17	0.375	1.0965789	0.411217105
	RTCP	50	8.33	58.33	0.347826	1.3513514	0.470035253
M3	NB	33.33	12.5	45.83	0.217391	0.8771053	0.190675057
	GT	20.83	20.83	41.66	0.266667	0.8332	0.222186667
	PBPM	41.67	12.5	54.17	0.333333	1.0684615	0.356153846
	PBCP	45.83	12.5	58.33	0.347826	1.2060526	0.419496568
	RTPM	41.17	12.5	53.67	0.333333	1.1127027	0.370900901
	RTCP	45.83	12.5	58.33	0.391304	1.2386486	0.484688602

**Table 4.** Results of ANOVA for comparing germination percentage of fresh seeds Without pretreatments in *T. arjuna*.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
Medium	1448.203	5	289.641	137.883	<0.001*
Place	0.159	1	0.159	0.076	0.789 <sup>ns</sup>
Year	8.708	2	4.354	2.073	0.177 <sup>ns</sup>
Medium * Place	2.876	5	0.575	0.274	0.917 <sup>ns</sup>
Medium * Year	18.166	10	1.817	0.865	0.589 <sup>ns</sup>
Place * Year	0.657	2	0.329	0.156	0.857 <sup>ns</sup>
Error	21.006	10	2.101		
Total	1499.775	35			

\*\*Significant at 1 % level; \*Significant at 5% level; ns: non significant at 5% level.

**Table 5.** Results of ANOVA for comparing germination percentage of fresh seeds with pretreatments in *T. arjuna*.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
Treatment	1222.635	5	244.527	10.949	<0.001**
Medium	688.548	5	137.710	6.166	0.001**
Error	558.329	25	22.333		
Total	2469.512	35			

\*\*Significant at 1% level; \*Significant at 5% level; ns: non significant at 5% level.

**Table 6.** Results of ANOVA for comparing germination percentage of stored seeds in *T. arjuna*.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
<b>Medium</b>	593.165	5	118.633	206.380	<0.001**
<b>Period</b>	1.916	2	0.958	1.667	0.237 <sup>ns</sup>
<b>Error</b>	5.748	10	0.575		
<b>Total</b>	600.829	17			

\*\*Significant at 1% level; \* significant at 5% level; ns non significant at 5% level.

not increased by storage (M1 38.89<sup>a</sup>, M2 39.58<sup>a</sup>, M3 38.19<sup>a</sup>). Dent [8] was of the opinion that seeds can be stored in sealed tins and gunny bags for a year without much loss of viability, which, stands well in the present study. Luna [9] points that germination percentage of many tree species vary when seed samples from different regions are used but it is not proved through the present results. However in the present study germination of stores seeds was restricted to three months, which may be a major limitation of the study.

From the results of ANOVA for comparing germination percentage of stored seeds (Table 6) it is observed that there is significance at 1% level between sowing media and the mean germination percentages shows homogenous values in all the media except in germination tray.

Root trainers used in forest nurseries have been found effective as they have ridges of the specified type (anti-spiralling rib design) which force the developing roots to grow downward to the drainage hole, where they stop growing because of low humidity and air pruning effect which is effective when they are placed above the soil surface with the help of stand. The growth and survival of an out planted tree seedling is much related to the ability of its root system to promote regeneration of new roots, known as root growth potential (RGP) and its growth into the surrounding soil [10] [11]. For raising seedlings of tree species in plant nurseries, polythene bags of different gauges and size are the most common form of containers used widely. Even though, they are handy and economical they have inherent problem of root coiling which influences considerably the growth of seedl-

ings after out planting in the field as the spiral roots prevent the seedling from becoming properly established in the surrounding soil [12], and eventually leading to strangulation [13]. Although it can occur in any container type, root spiraling is most prominent in round and smooth walled plastic containers. To overcome the problem of root coiling in seedlings at least partially, the alteration of design in containers with vertically oriented ridges, ribs or grooves that protrude into the growing medium and present an obstacle to spiral and [14] recommended ribs about 2 mm (0.08 inch) high on the inner cavity wall. The root trainer technique developed may be useful in mechanized nurseries for mass production of seedlings in future plantation programs.

## 5. Conclusion

The technology developed through the present study is purely a reproducible one. A cultivator without adequate experience in the field can follow this technology and can produce any number of propagules to his desire. The tree species selected for the present study *Terminalia arjuna* is a well known tree species in indigenous medicine. Besides they are also suitable as avenue trees especially in the tropical area. Seed availability of the selected tree species is seasonal hence the optimum time to harvest fruits is during peak fruit ripening period. Seeds of *Terminalia arjuna* were gathered from two places of central Kerala and their germination studies were conducted in six different sowing media using fresh, pretreated and seeds stored up to three months. Germination value (GV) for all the field trials was calculated that showed highest for fresh seeds without pretreatments sown in PBCP and RTCP. Maximum GV for pretreated seeds were recorded in control and in gibberellin 100 ppm treated seeds sown in PBCP and RTCP. Application of hot water is recommended as pretreatment for the species and seed coat removal also favors germination. It is noted that *Terminalia arjuna* does not drop its germination percentage even after storage for three months. Analysis of variance shows significance at 1% level between medium, between pretreatments and between years of study. Transplantation shock, bulkiness, and frequent change of polythene bags cause additional labor by conventional method but root trainers have advantages such as requiring no change of medium.

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