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Evaluation of five teak (*Tectona grandis* L. F.) provenances for germination test to find out reasons of low germination

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ABSTRACT

The high economic importance of teak was widely used due to its durability, physical and aesthetic property and also known as king of timber. It has a high demand in international market and distributed throughout India and Southeast Asia. Therefore, the species is now widely planted and the rate of plantation establishment is increasing year by year in India as well as the tropical countries. However, extremely low and erratic germination rates are a significant problem for the teak plantation industry as well as the deployment of planting material from breeding programs. Therefore, five teak provenances i.e. Bardipada, Bhenskatri, Kalibel, Kaprada and Mandvi from Gujarat natural teak forests had been selected for germination test to find out reasons of low germination. Our result showed significant differences ($p \leq 0.01$) in all the studied characteristics. Drupe germination was maximum at 3rd month (16 %), 6th month (18.50 %), 9th month (23 %), 12th month (35 %), with alternate drying & wetting treatment (17.50 %) and seed germination (55.25 %) in Mandvi provenance followed by Bardipada provenance while lowest in Kaparada provenance. Overall, Mandvi and Bardipada provenances were performed better than all others. The comparison of different germination traits showed the presence of seed dormancy in teak. The major factors for poor germination in teak are physical, mechanical, chemical and embryo dormancy or combined dormancy two or more types such as chemical and embryo dormancy for deployment of superior genetic materials.

Key words: *King of timber, Plantation industry, Drupe germination, Seed germination, Seed dormancy*

INTRODUCTION

The economic importance of teak with its high quality wood in international and national market has long been recognized. *Tectona grandis* Linn. f. (family: Lamiaceae) has been cultivated for timber production for over 500 years[4]. It is native to Southeast Asia and India; distributed in the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Telengana, Maharashtra, Gujarat, Chhattisgarh, Madhya Pradesh, Rajasthan, Uttar Pradesh, Manipur, Orissa *etc*[18].

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Consequently the species is now widely planted and the rate of plantation establishment is increasing year by year in the tropics. India has the largest teak forest and teak plantation area *i.e.* 9.0 million ha.[2] among all the teak-growing countries of the world. Nevertheless, there are difficulties in establishing large scale plantatations of teak because of poor and erratic germination. Extremely low germination rates are a significant problem for the teak plantation industry[18]as well as the deployment of planting material from breeding programs[10]. Some form of seed dormancy has been contributed to poor germination in teak[11]. Dormancy mechanisms have evolved in many plant species to delay germination until conditions are more conducive to seedling survival[6]. Similarly, review of germination procedures indicated that none of the methods used were reliable and no definite procedures which systematically rendered improved germination. Various pre-germination treatments are locally applied within the native range of teak in attempts to improve its germination. These include scorching, immersion in hot, warm or cold water or water mixed with cow dung, alternate soaking and drying, burying near a termite mound and acid scarification[9,18].Scientific investigations of teak germination have generally evaluated pre-germination treatments similar to those used by villagers and foresters in its native range[18] and they have not been designed to specifically identify the dormancy mechanisms relevant to teak. Therefore, teak seed dormancy has probably evolved to postpone germination. Teak seeds naturally germinate from within a drupe. Each drupe consists of a thin, pubescent exocarp surrounding a thick spongy or corky mesocarp, which in turn surrounds the woody endocarp or 'stone'[16] (Fig. 1). The endocarp is quadrilocular and contain between 0 to 4 seeds although one seed is most common[3,15]. On an average one seed is fully developed and three remain undeveloped in most of tetralocular fruit of teak. High temperature seems to be an inclining factor for hastening the process of lignification. The anatomical studies of the teak fruit revealed the presence of tubular appendages, extending right from the hilum up to the regular quadruple openings in the pericarp, through U-shaped depressions in the endocarp (Fig. 1). These tubular appendages which remain unlignified for considerable time might have a functionary role of gaseous exchange during the process of seed development and after ripening and might be helping in water imbibition at the time of germination[8]. It has been proposed but not proven that teak seeds are subject to combined dormancy made up of two or more separate dormancy mechanisms[11]. The candidate dormancy mechanisms are physical, mechanical, chemical and embryo[14,13].

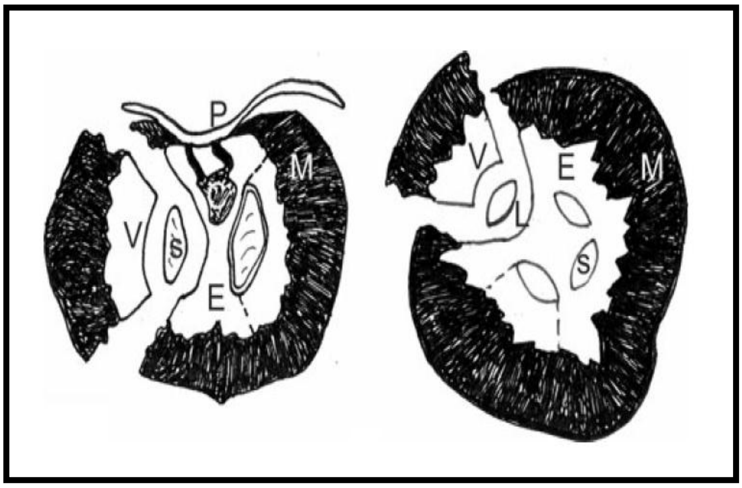

Fig. 1: Longitudinal and transverse sections of a teak fruit showing newly described features by Slator *et al.* (2013) such as C= central cavity; E= endocarp; L= locule; M= mesocarp; P= pore; S= seed; V= valve

For better understanding of the dormancy mechanisms in teak seed could provide a framework for understanding why various pre-germination treatments have emerged through teak's native range and why treatment effects may vary between seedlots[11,20,13]. Therefore, the present germination study has been taken with the specific objectives to find out the reasons of low germination whether physical, mechanical, chemical and/ or embryo seed dormancy within five teak provenances.

MATERIAL AND METHODS

The present research was conducted to evaluate the five teak provenances for germination test to find out reasons of low germination. Fruits/ drupes of teak were collected during April to July, 2015 from five provenances *i.e.* Bardipada, Bhenskatri, Kalibel, Kaprada and Mandvi (Fig. 2; Table 1). The Latitude, longitude and altitude was recorded with the help of GPS (Table 1).

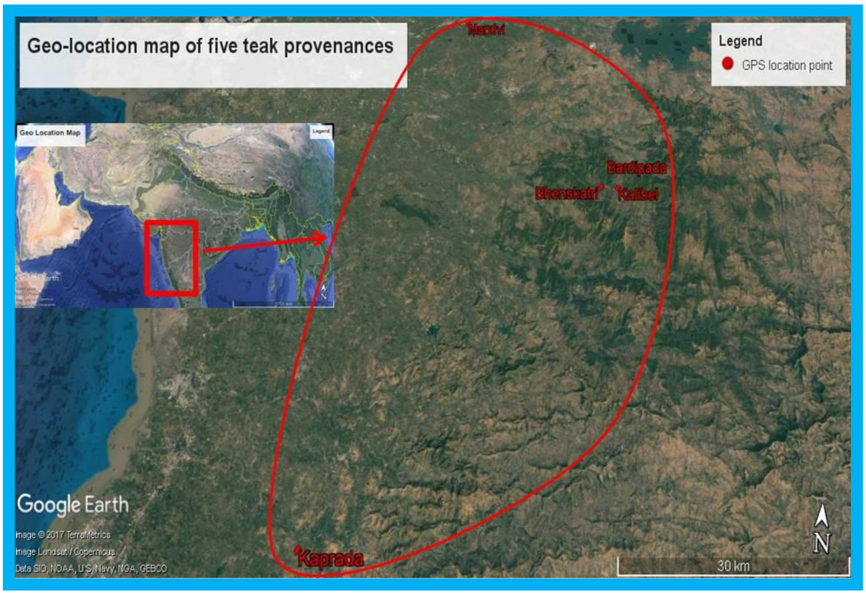

Fig. 2: Geographic locations of five teak provenances represented in the research study

400 fruits/drupes of 10 trees from each provenance in four replications (100 fruits/ replications) were employed for germination test. The investigation carried out in the Forest Nursery, College of Forestry (green house), ACHF, Navsari Agricultural University, Navsari, Gujarat, situated at 20°95'N latitude, 75°90'E longitude at an altitude of 10 m above the mean sea level. The study period was extended from April, 2015 to April, 2016. Then drupe was broken by using Falcon Pruning Secateur to take seed from drupe (with one or more seed/kernel in a drupe). Drupe and seed were sown separately in the nursery beds with sand: soil: FYM (2:1:1) and germination was recorded up to 12 months. All standard nursery practices followed such watering, weeding *etc.* time to time. These data were subjected to statistical analysis using MS excel 2007 and ANOVA was constructed for studied parameters.

Table 1: Geo-climatic variables of five teak provenances

Provenance	Latitude (N)	Longitude (E)	Altitude (m)	Annual Rainfall (mm)	Annual Temperature (°C)
Bardipada	20°57'56.3"	73°36'40.5"	221	1784	25.1
Bhenskatri	20°55'59.1"	73°32'49.3"	161	2081	26.8
Kalibel	20°55'58.8"	73°34'29.3"	204	2081	26.8
Kaparada	20°25'58.0"	73°07'57.8"	95	2154	24.3
Mandvi	21°14'51.0"	73°18'54.8"	110	1539	27.4

RESULTS AND DISCUSSION

Germination test

There were significant differences (p≤ 0.01) in all the germination traits among five provenances of *T. grandis* (Table 2).

Table 2: Analysis of variance for germination traits of teak

Traits	Provenance (df = 4)		
	Mean Square	**F Value**	**P > F**
Drupe Germination (%) at 3 month	38.700	21.500	<0.01
Drupe Germination (%) at 6 month	44.450	23.191	<0.01
Drupe Germination (%) at 9 month	44.450	32.133	<0.01
Drupe Germination (%) at 12 month	38.700	11.382	<0.01
Drupe Germination (%) with DW Treatment	55.075	31.471	<0.01
Seed Germination (%)	357.075	57.904	<0.01

Note: DW = Alternate drying and wetting treatment (seven time every three days interval)

Drupe germination was maximum at 3^{rd} month (16.00±0.41 %), 6^{th} month (18.50±0.65 %), 9^{th} month (23.00±0.71 %), 12^{th} month (35.00±0.41 %), with alternate drying & wetting treatment (17.50±0.65 %) and seed germination (55.25±1.25 %) in Mandvi provenance followed by Bardipada provenance. However, germination was lowest at 3^{rd} month (10.50±0.65 %), 6^{th} month (13.50±0.65 %), 9^{th} month (18.00±0.41 %), 12^{th} month (29.50±0.65 %), with DW treatment (12.50±0.65 %) and seed germination (41.00±1.29 %) in Kaparada provenance (Table 3).

Table 3: Mean variation for germination traits among five provenances of teak

Provenance	Drupe Germination (%) at 3 month	Drupe Germination (%) at 6 month	Drupe Germination (%) at 9 month	Drupe Germination (%) at 12 month	Drupe Germination (%) with DW Treatment	Seed Germination (%)
Bardipada	16.00±0.41	18.50±0.65	23.00±0.71	35.00±0.41	17.50±0.65	55.25±1.25
Bhenskatri	11.50±0.65	14.75±0.48	19.25±0.48	30.50±0.65	13.25±0.63	43.50±0.65
Kalibel	14.50±0.65	17.00±0.71	21.50±0.65	33.50±0.65	15.75±0.48	48.00±1.29
Kaparada	10.50±0.65	13.50±0.65	18.00±0.41	29.50±0.65	12.50±0.65	41.00±1.29
Mandvi	18.00±0.91	22.00±0.91	26.50±0.65	37.00±1.68	21.75±0.85	64.25±1.55
Mean	**14.10**	**17.15**	**21.65**	**33.10**	**16.15**	**50.40**
SE(m)±	0.67	0.69	0.59	0.92	0.66	1.24
C.D.	2.04	2.11	1.79	2.80	2.01	3.78
C.V.	9.52	8.07	5.43	5.57	8.19	4.93

Causes of low germination in teak

When we were comparing germination result of five teak provenances and overall mean with help of graphs showed the presence of all four type seed dormancy or may be combined dormancy two or more types such as embryo and chemical dormancy. Drupe (with stony seed coat) germination with alternate drying and wetting treatment was higher than drupe germination at 3^{rd} month in green house nursery condition (Fig. 3). This was showed the presence of physical dormancy in teak seed. The alternate drying and wetting treatment of drupe improved the imbibitions of seeds inside fruit. Physical dormancy requires the exclusion of water from the embryo via an impenetrable seed coat or fruit wall[6]. Physical dormancy has been reported by Dabral (1976); Tewari (1992); Schmidt (2000) which was an important dormancy mechanism affecting teak seed germination.

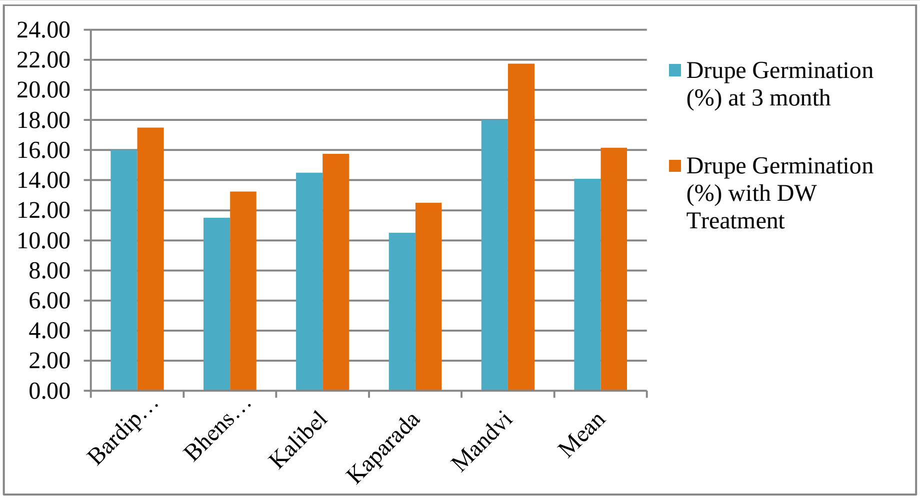

Fig. 3: Comparison of drupe germination at 3rd month and with DW treatment

Seed (without seed coat) germination was higher than drupe germination at 3rd month in green house nursery condition (Fig. 4) and germination was increased 3-4 folds (Table 3). This was showed the presence of mechanical dormancy in teak seed. Therefore barrier such as hard stony endocarp was found for delay germination in teak. Rajput and Tiwari (2001) was reported mechanical dormancy as stony endocarp of teak fruit as a mechanical barrier to germination which cannot be penetrated by emerging radicles without the opening of valves[7]. Slator *et al.*[16] proved mechanical dormancy act rather than physical dormancy. Slow germination of teak seed has been previously attributed due to the endocarp or whole pericarp involving to ‘‘soften’’[11,18,20,19].

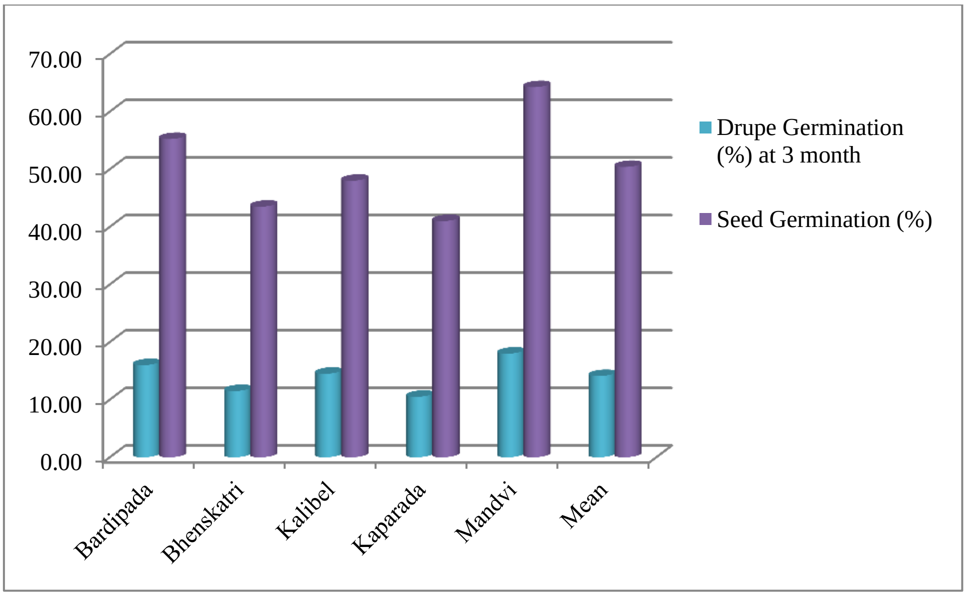

Fig. 4: Comparison of drupe germination at 3rd month and seed germination

Drupe germination at 12th month was higher than drupe germination at 3rd month in green house nursery condition (Fig. 5) and germination was increased 2-3 folds (Table 3). This type delay germination occurred due to the presence of embryo dormancy in teak seed for ripening of embryo. Morphological embryo dormancy involves a requirement for embryo maturation or after-ripening after dispersal in young seeds[6]. The very low rates of germination in fresh seedlots compared to those at least 1 year old has led to suggestions that embryo dormancy is present in teak[8,3,17].

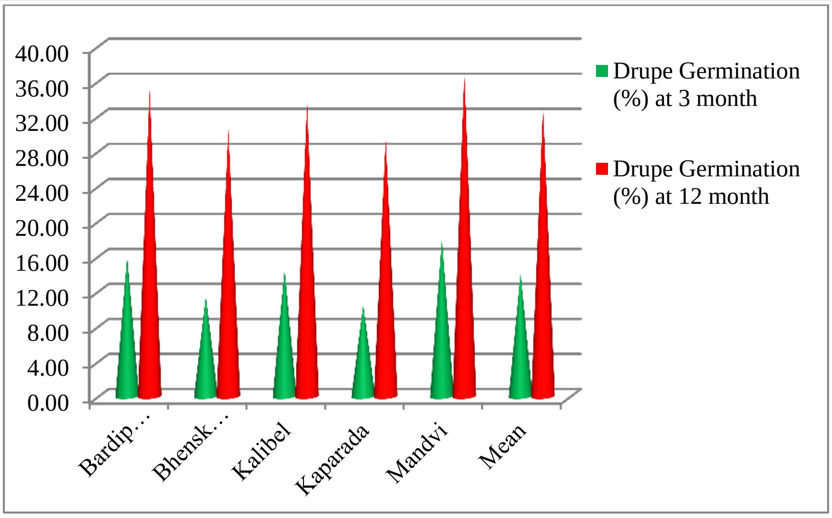

Fig. 5: Comparison of drupe germination at 3rd month and 12th month

Drupe germination was increased from 3rd month to 12th month consistently in green house nursery condition (Fig. 6) among all five teak provenances with overall mean. The continuously delay germination occurred due to the presence of chemical dormancy in teak seed where chemical leach out from the drupe over a period with water. Chemical dormancy occurs when chemical germination inhibitors prevent embryo growth[6]. Water soluble chemicals derived from the mesocarp of teak fruit have shown germination inhibition activity when applied to the seeds of various crop plants[5,1,12], so this mechanism is also possibly relevant to teak.

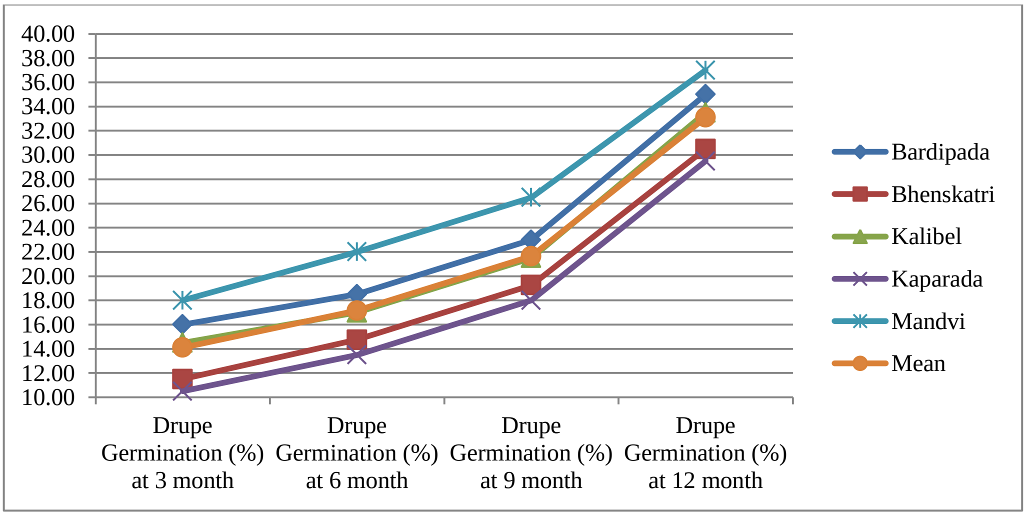

Fig. 6: Comparison of drupe germination at 3rd, 6th, 9th and 12th month

Thus, overall seed dormancy *i.e.* physical, mechanical, chemical and embryo dormancy or combined dormancy two or more types such as chemical and embryo dormancy were the reasons of low germination within five teak provenances in the study.

CONCLUSION

The most valuable timber of the world known as king of timber was distributed throughout India, where Gujarat state has natural teak forests. Five teak provenances were studied for germination traits to access the reasons of low germination. All the characters were showed significant differences among five provenances of *T. grandis.* Overall, Mandvi and Bardipada provenances were performed better than all others. The major factors for poor germination in teak are physical, mechanical, chemical and embryo dormancy or combined dormancy two or more types such as chemical and embryo dormancy for deployment of superior genetic materials.

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