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SHORT COMMUNICATION

Variations in the Seed Germination in *Sapindus mukorossi* in Relation to Tree Age Dependent Seed Vigour

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Abstract Planted trees of *Sapindus mukorossi* Gaertn. are important source of medicinal seed pericarp in mid hill areas. Also, the seeds of this species are supposed to require the pre-treatments for improvements in germination. Studies on seed germination in relation to the seeds collected from trees varying in age at different sites and seeds from identical trees varying in sizes may be informative. A study on seed germination in *S. mukorossi* in relation to above parameters has indicated that, the seeds from mature trees (>30-years old; mean seed weight 1.72 ± 0.13–2.26 ± 0.14 g) germinated better as compared to the seeds from young trees (10–12 years old; mean seed weight 1.01 ± 0.17–1.97 ± 0.14 g). This study has indicated that, the seeds from mature trees having relatively better seed weight germinate more as compared to the seeds collected from young trees.

Keywords Germination · Pericarp · Seed vigour · Soapnut · Tree age

Seed is an important innovation in due course of evolution of land plants [1]. Seeds character is important ecological trait, which influences the regeneration strategy of plants [2]. Seed mass in trees varies in relation to the tree age and provenances [3, 4], and is also important for germination and survival of plants [5]. Provenance dependent variations in the seed masses are considered as fitness trait for successful establishment of plants [6]. Production of few large and many small seeds by an individual plant may have advantages; like, bigger seeds will have high energy potential for germination in the moist and shaded habitats; while, small seeds will be less visible to the predators [7, 8]. Germinability of seeds under natural conditions is determined by dispersal dependent placement of seeds in suitable habitats, proper positioning of seeds and seeds size [9–11]. Generally, large seeds of the tree species are known to germinate better [12–14]; however, dormant seeds of some plants may require specific pre-treatments for improvements in the germination [15].

Some genus of Sapindaceae including *Sapindus mukorossi*, do not possess physical dormancy; rather, their seed contains folded embryos, similar to those of non-physically dormant seed producing species [16]. Germination in *S. mukorossi* and *S. emerginatus* is also dependent on seeds size and orientation [13, 15]. Regeneration of *S. mukorossi* is not reliable, because the seedlings under natural conditions do not survive due to high mortality, therefore, techniques like micropropagation through shoot buds and somatic embryogenesis from leaf explants are tested for propagation of this species [17, 18]. Alternatively, nursery grown seedlings of this species are planted in different places. Seeds pericarp or seeds pulp shows inhibitory effects on the germination of some other tree seeds [19, 20]. Although, seeds pericarp of *S. mukorossi* (soapnut or Reetha) has high medicinal value, is used as main ingredient of herbal disinfectants and is among highly traded minor forest products from Uttarakhand [21].

Consideration of tree age, provenance and seeds size is valuable for propagation and conservation of important species [22]. The seeds of some species collected from young trees are known to germinate less as compared to the mature trees [23].

Matured seeds of *S. mukorossi* were collected from 3 to 5 planted trees from three locations, viz. Kothiyalsain-

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Chamoli (abbreviated as KTS; 1000 m, tree age 10 years), Mandal-Chamoli (abbreviated as MDL; 1550 m, tree age 12 years) and Baasot-Bhikiyasain, Almora (abbreviated as BST; 1000 m, tree age >30 years) in Uttarakhand, India, in the last week of February 2014. Tree age at MDL and KTS is based on the actual years of plantation, while, the tree age at BST was confirmed from the natives. Pericarp from the seeds was removed for avoiding the deterioration of seeds. On the basis of visual observations, seeds from each provenance were segregated in three lots (a) large, (b) medium and (c) small. Visually uniform, each seed selected for germination in each category was weighed. Seeds of each population-without any pre-treatment were sown in triplicate; each replicate containing 25 seeds, in 8 × 6 inches dimension black colored polybags, containing; soil, farmyard manure (FYM) and sand (3:1:1) at Mandal-Chamoli (1550 m) under the shade nethouse condition in the last week of April 2014. Polybags were watered twice or thrice in a week and experiment was monitored up to 3 months for recording the observations seeds germination. During this period, the temperatures under shade net-house were 16.16 ± 2.33 °C (min.) and 32.93 ± 2.55 °C (max.). Obtained data were used for calculating Mean germination time (MGT), % germination and two factor analysis of variance (ANOVA). Germination data calculated in percentage were transformed to ARCSINE for analysis of variance. MGT was calculated according to the formula used by Kuniyal et al. [14], viz. $MGT = \sum(nD)/\Sigma N$; where, n = number of newly germinated seeds after incubation period in days, D, and ΣN = total number of seeds germinated at the end of the test.

Mean germination time (MGT) for the seeds collected from >30-year old trees (BST) was from 44.27 ± 1.02 to 46.98 ± 1.67 days, while, the MGT for the seeds from 10-year old trees (KTS), was from 54.82 ± 3.18 to 55.33 ± 0.19 days. MGT for seeds collected from 12-year old trees (MDL), was from 45.93 ± 0.69 to 51.81 ± 5.97 days (Table 1). Seeds from mature trees (tree age >30 years, from Baasot; BST, mean seed weight 1.72 ± 0.13–2.26 ± 0.14 g) germinated 70.67 ± 2.31–88.00 ± 4.00 %, as compared to the 45.33 ± 6.11–69.33 ± 6.11 % germination of seeds collected from 10 to 12 years old trees from Kothiyalsain (KTS; mean seed weight 1.47 ± 0.14–1.73 ± 0.16 g) and Mandal (MDL; mean seed weight 1.01 ± 0.17–1.97 ± 0.14 g), respectively (Table 1). Mean germination time (MGT) in relation to tree age varied significantly (LSD 3.25, $P < 0.1$) and also seed germination was better in the seeds collected from mature trees (significant, LSD 6.03, $P < 0.1$). Although, the seeds of different size (large, medium and small) from identical seeds sources varied in germination; however, statistically the variations were not significant. In general, large seed germinated better as compared to the small and medium seeds.

MGT for the seeds collected from mature trees was less as compared to the 10 and 12 year old trees. Also, the germination of the seeds collected from mature trees was better as compared to the 10 and 12 year old trees. Nearly 45–88 % germination was recorded in the seeds collected from different sources and varying in sizes. It is encouraging that, the seed germination without any pre-treatment was identical to the studies conducted with the application of pre-treatments for improvement of germination in other species of *Sapindus*. As 67–70 % germination in *S. drummondii* through treating seeds with concentrated sulphuric acid for 45–60 min [24] and 56–88 % in not-inundated or inundated seeds with cold or hot water in *S. detergence* [25] is reported.

Seeds collected from young trees were light in weight; therefore, germination in this species seems to be

Table 1 Seed germination behaviour of *Sapindus mukorossi* Gaertn. in relation to tree age, seed size and provenances

Seed collection sites, tree age (years) and altitude	Seed size	Mean seed weight (g)	Mean germination time; MGT (days)	Seed germination (%)[a]
Kothiyalsain (KTS; 10 years)	Large	1.73 ± 0.16	54.82 ± 1.46*	50.67 ± 10.07
1000 m	Medium	1.58 ± 0.16	55.33 ± 0.19*	48.00 ± 10.58
	Small	1.47 ± 0.14	55.41 ± 3.18*	45.33 ± 6.11
Mandal (MDL; 12 years)	Large	1.97 ± 0.14	51.81 ± 5.97*	69.33 ± 6.11**
1550 m	Medium	1.53 ± 0.25	50.93 ± 2.18*	62.67 ± 12.22**
	Small	1.01 ± 0.17	45.93 ± 0.69	57.33 ± 9.24**
Baasot (BST; >30 years)	Large	2.26 ± 0.14	44.27 ± 1.02	88.00 ± 4.00**
1000 m	Medium	2.02 ± 0.13	46.16 ± 0.92	74.67 ± 4.62**
	Small	1.72 ± 0.13	46.98 ± 1.67	70.67 ± 2.31**

* Significant, LSD 3.25, $P < 0.1$

** Significant, LSD 6.03, $P < 0.1$

[a] Variations in the seed germination in relation to seed size were not significant (LSD 6.03, $P < 0.1$)

Fig. 1 Seedlings of *Sapindus mukorossi* after 1 week of emergence from the large (L), medium (M) and small (S) seeds collected from Baasot (BST)

dependable on tree age dependent seed vigour. The variations in seed germination in relation to seed sizes were considerable, generally large seed or seeds with more weight germinated better as to the small or seeds with less weight. Seeds collected from KTS population, which was the youngest population, may be rather weak in terms of seeds physiological vigour as compared to the MDL or BST. Likewise to other diverse seed producing tree species, seed weight is important factor for the germination in *Sapindus* sp. [15].

Generally, *S. mukorossi* in mid hill areas exists as planted trees and beneath mature trees it is exceptional to find its seedlings. Fruiting in planted trees of *S. mukorossi* starts after 10 years of plantation and onward next year of fruiting, fruits yield and seeds size improves gradually. Majority of soap nuts are collected for commercial purposes and whatever quantity of seeds remains as leftover may not be able to germinate due to the inhibitory effect of pericarp. If seeds were sown with pericarp, none of the seeds was able to germinate. None of natural and instant mechanism is observed for the removal of its saponin rich pericarp. Inadequate regeneration of this medicinal tree species may have adverse impact on its survival. Excluding inhibitory effect of seed coat or pericarp, it seems, seed dormancy do not exists in *S. mukorossi*, and therefore, no pre-treatment is required for the improvements of seed germination in this species. Observations on growth performance of the seedlings emerged from different seed sizes (Fig. 1) and studies on germination of seeds produced in current year are in progress.

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