Study the morphological variations and germination behaviour of seeds of four promising fodder tree species

Commented [m1]: Morphological variation and germination behavior of seeds for some fodder tree species

Abstract

The study was conducted the morphological and germination behavior of a four fodder tree species *viz., Gmelina arborea, Sesbania grandiflora, Moringa oleifera* and *Bauhinia purpurea* under nursery conditions. Experiment was carried out at the nursery of the ICFRE Eco-Rehabilitation, Prayagraj, Uttar Pradesh, during April 2021 and different germination parameters *viz.*, germination percent, survival percent, germination capacity, germination energy, vigour index, mean daily germination and mean germination time along with seed morphological parameters were studied in four replications. The highest seed length and width was recorded in *B. purpurea* (17.57 mm ± 2.79) and (13.38 mm ± 1.95) respectively, seed thickness in *M. oleifera* (10.92 mm ±1.39), the highest seed weight was recorded in *G. arborea* (65.95 gm ± 0.79). Seeds of *S. grandiflora* recorded highest germination percent (83.42 %), seedling vigour index (762.30), mean daily germination (6.41) and germination index (66.11), highest seed germination capacity value (84.90 %), seed germination value (52.50 %), highest survival of seedling value (96.16 %) among three other fodder species despite being the smallest seed size. Such an investigation may help in developing conservation strategies in nursery conditions and fodder availability during lean period.

Keywords: Nursery, Survival percent, Germination Time, Germination Energy, Vigour index.

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Introduction

Fodder trees can provide enough protein and energy to keep rumin microbes active and thus increase their capacity to digest fibre, allowing livestock to use dry-season pastures [1]. Except in hilly areas, where trees are a major source of green fodder for livestock, the ability of trees for green fodder production is underappreciated in India. As a result, forests are not only a valuable but also inexpensive source of fodder. The expense of gathering fodder from forests falls mostly into the non-monetized segment of the economy. This is because most fodder collected from forests is used to feed livestock on the homestead, and only a small amount is sold on the open market. As a result, forests save a lot of money in this region and contribute a lot to the country's economy.

In India, there is a wide range of fodder production. Despite the lack of accurate estimates, various communities have conducted periodic assessments of fodder production in our nation [2]. Despite this, just 0.1 percent of the land is used for fodder production. As a result, it is critical to increase fodder production by planting fodder trees. A consistent supply of seeds is a requirement for any planting programme [3]. The aim of the present investigation "Study of the morphological variations of seeds and germination behaviour of four promising fodder species" was to understand the morphology of seeds with respect to germination and to draw conclusions in order to combat with the problem of natural regeneration the fodder species is facing over a period of time. Such an investigation may help in developing conservation strategies in nursery conditions. Keeping above points in view the present study was conducted to study the variation in seed and germination of four fodder species *viz.*, *Gmelina arborea, Sesbania grandiflora, Moringa oleifera* and *Bauhinia purpurea*.

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Materials and Methods

The present investigation was undertaken in the nursery at Padilla, a research extension of the ICFRE-Eco Rehabilitation Centre, Prayagraj, Uttar Pradesh, during April 2021 to May 2021 at an elevation lying between 25.28 °N latitude and 81.54 °E longitude in the plain area of Prayagraj, Uttar Pradesh, India.

The mature fruits were collected to study the variation of seeds of selected four fodder species. The seeds were extracted mechanically. Diseased or damaged seeds were discarded. The seeds were either oven dried or sun-dried. They were cleaned with the help of aspirator (Agrosaw) and through winnowing. All unwanted material such as bracts, broken, injured or diseased seeds or other impurities were discarded. After cleaning the seeds, observations on seed morphological characters were recorded. The following methods were used for the seed study.

Seed length and width of four replicates consisting of 10 randomly selected undamaged seeds were measured upto two decimal places with the help of digital vernier caliper from the center of the hilum to opposite side of seed and right angle to the plane of hilum and was expressed in mm.

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Seed thickness of four replicates consisting of 10 randomly selected undamaged seeds were measured upto two decimal places with the help of digital vernier caliper at right angle to hilum and right angle to plane of hilum and was expressed in mm.

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Seed weight of four randomly selected samples having 100 seeds per sample was taken as per ISTA (1993) guidelines using electronic balance (model: Goldtech – GTSC Series 500g × 50 g). The seed shape and colour was observed through visually.

The germination experiments were conducted under the nursery conditions. Before sowing of seeds in polybags, polybags were filled with the mixture of soil, sand and farm yard manure decomposed in 2:1:1 ratio. Also, the seeds of all the four species were soaked in water for 24 hours before sowing in polybags. A total of 2000 polybags were filled for sowing of seeds of each species separately with 4 replications of 500 species each. Single seeds of each species were sown in each polybag. A single seedling was maintained per polybag after germination. Adequate watering and care were taken regularly. Seed germination data was recorded daily up to 28 days.

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Twenty-five representative seedlings from each species were selected and 10 polybags were arranged in each row to make 4 replicates. Seedlings of the four species were raised in polybags upto 1 month and data on germination was also recorded.

Observations on germination were recorded using the following methods.

Germination percent was calculated by the formula:

$$\text{Germination (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total number of sown seeds}} \times 100$$

Mean germination time was calculated based on the following equation of Ellis and Roberts [4].

$$\text{MGT} = \frac{\Sigma Dn}{\Sigma n}$$

Where, n is the number of seeds, which germinated on day D, and D is the number of days calculated from the beginning of the test.

Germination index was calculated by using the following formula given by Kendrick and Frankland [5] as:

$$\text{GI} = \frac{\text{Total germination percent}}{\text{Time (hours) taken for 50\% germination}} \times 100$$

Surviving plants in each bed were counted one month after sowing seeds in the nursery and the survival percent was worked out as follows:

$$\text{Survival (\%)} = \frac{\text{Total number of seedlings survived}}{\text{Total number of seedlings}} \times 100$$

The seedling vigour index was calculated by given formula (Abdul-Baki and Anderson [6]). Seedling vigour index was used for determining percentage and seedling length for each tree species:

$$\text{SVI} = \text{Germination (\%)} \times \text{seedling length (cm)}$$

The cumulative number of seeds that germinated at the end of test period plus total number of ungerminated viable seeds at the end of the test expressed in percentage.

Germination energy (GE) was calculated on the basis of the percentage of the total number of seeds that had germinated up to the time of peak germination, generally taken as the highest number of germinations in 24 hrs period.

Mean Daily Germination (MDG) was calculated according to the following formula of Scott *et al.* [7].

$$\text{MDG} = \frac{\text{FGP}}{\text{D}}$$

Where,

FGP = Final germination percent

D = day of maximum germination

The data was analyzed statistically for the assessment of general mean, standard deviation, standard error of mean, range and coefficient of variation.

Results

a) Evaluation of the morphological variation of the seeds of the four fodder species.

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On an average seed size ranged (7.16 to 17.57 mm) and seed width (4.36 to 13.38) among four selected tree species. The highest seed length and width was recorded in *B. purpurea* (17.57

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mm ± 2.79), (13.38 mm ±1.95), followed by *M. oleifera* (17.19 mm ±2.06), (12.08 mm ±1.43) and *G.arborea* (14.42 mm ±2.16), (9.72 mm ±1.86) whereas lowest seed length was recorded in *S. grandiflora* (7.16 mm ± 0.59), (4.36 mm ±0.45), respectively shown in table 1.

Table 1: Length (mm) and width (mm) of the four fodder species.

	Length (mm)				Width (mm)			
	M. oleifera	*S. grandiflora*	*G. arborea*	*B. purpurea*	*M. oleifera*	*S. grandiflora*	*G. arborea*	*B. purpurea*
Mean	17.19	7.16	14.42	17.57	12.08	4.36	9.79	13.38
S. d. ±	2.06	0.59	2.16	2.79	1.43	0.45	1.86	1.95
SE m ±	0.65	0.19	0.68	0.88	0.45	0.14	0.59	0.62
Maximum	19.67	8.31	17.03	22.89	15.13	5.25	12.57	15.52
Minimum	13.78	6.24	10.63	13.86	9.83	3.75	7.03	10.43
C.V. (%)	11.98	8.20	14.98	15.86	11.87	10.31	18.97	14.57

The average seed thickness ranged between 2.60 to 10.92 mm. The highest seed thickness was recorded in *M. oleifera* (10.92 mm ±1.39), followed by *G. arborea* (9.02 mm ± 1.20) and *B. purpurea* (2.81 mm ±0.48) also the lowest value was recorded in *S. grandiflora* (2.60 mm ±0.52) whereas the average seed weight varied from 6.75 gm to 65.95 gm. The highest seed weight was recorded in *G. arborea* (65.95 gm ±0.77), followed by *B. purpurea* (25.75 gm ±0.52), *M. oleifera* (21.97 gm ± 0.65) and also the lowest value was recorded in *S. grandiflora* (6.75 gm ± 0.66) depicted in table 2.

Table 2: Thickness (mm) and weight (gm) of the four fodder species.

	Thickness (mm)				Weight (gm)			
	M. oleifera	*S. grandiflora*	*G. arborea*	*B. purpurea*	*M. oleifera*	*S. grandiflora*	*G. arborea*	*B. purpurea*
Mean	10.92	2.60	9.02	2.81	21.97	6.75	65.95	25.75
S. d. ±	1.39	0.52	1.20	0.48	0.65	0.66	0.77	0.52
SE m ±	0.44	0.16	0.38	0.15	0.33	0.33	0.38	0.26
Maximum	13.49	3.11	11.09	3.81	22.81	7.48	66.67	26.41
Minimum	8.64	1.37	7.49	2.39	21.29	6.04	65.12	25.23
C.V. (%)	12.71	19.89	13.35	17.03	2.96	9.71	1.17	2.03

Data pertaining to the seed shape, surface and colour is represented in Table 3. The seed shape of the four fodder species varied from triangular, glabose, cylindrical to ellipsoidal.

Whereas surface varied from glabrous to smooth. Also, the colour of the species varied from grey to reddish or rust brown.

Table 3: Shape, surface and colour of the seeds of four fodder species.

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Species/ character	Shape	Surface	Colour
M. oleifera	Triangular, winged	Glabrous	Grey
B. purpurea	Globose, concavo -convax	Smooth	Rust brown
S. grandiflora	Cylindrical	Smooth	Reddish brown
G. arborea	Ellipsoidal-oblong	Glabrous smooth	Brown

b) Variations in early germination behaviour of seedling of the four fodder species in nursery conditions.

Seed size is used to predict germination and seedling growth rates in the nursery and for a short time after plantation establishment [8]. Seed germination varies due to a combination of environmental and genetic factors during seed formation and subsequent care handling [9]. Average seed germination percent ranged from 42.13 to 83.42 % among different fodder tree species. The highest seed germination percent was observed in *S. grandiflora* (83.42 %± 0.44), followed by *B. purpurea* (66.14 % ±0.40) and *M. oleifera* (64.58 % ±0.53) whereas lowest seed germination percent was observed in *G. arborea* (42.13 % ± 0.33) shown in table 4.

The mean germination time ranged from 14.19 to 23.45 days. The maximum mean germination time of 23.45 days have been recorded for *G. arborea*, followed by *M. oleifera* 20.15 days, *B. purpurea* 19.43 days and minimum have been recorded for *S. grandiflora* 14.19 days. Highest MGT in *G. arborea* indicated late and slow germination. Lowest MGT in *S. grandiflora* indicated an early and rapid germination as compared to other fodder species. MGT indirectly expresses the rapidity of germination as lower the mean germination time, faster the germination shown in table 4.

Table 4: Seed germination percent and mean germination time of four fodder species under nursery conditions.

	Germination %				Mean Germination Time (days)			
	M. oleifera	*S. grandiflora*	*G. arborea*	*B. purpurea*	*M. oleifera*	*S. grandiflora*	*G. arborea*	*B. purpurea*
Mean	64.58	83.42	42.13	66.14	20.15	14.19	23.45	19.43
S. d. ±	0.53	0.44	0.33	0.40	0.27	0.15	0.65	0.40

SE m ±	0.26	0.22	0.16	0.20	0.13	0.07	0.33	0.20
C.V. (%)	0.81	0.53	0.78	0.60	1.34	1.06	2.78	2.05

The data on germination index of different fodder tree species presented in table 5 revealed that on an average the GI values ranged from 29.85 to 66.11. The maximum average GI value was recorded for *S. grandiflora* (66.11), followed by *B. purpurea* (40.29), *M. oleifera* (39.42), whereas the minimum GI value was recorded in *G. arborea* (29.85) among different fodder species. The corresponding higher values for GI represent comparatively higher germination percentage. The average SVI values ranged from 366.53 to 762.30. The maximum SVI value was recorded in *S. grandiflora* (762.30), followed by *B. purpurea* (643.29), *M. oleifera* (642.57), whereas the minimum value was recorded for *G. arborea* (366.53).

Table 5: Germination index and seedling vigour index of four fodder species under nursery conditions.

	Germination Index				Seedling Vigour Index			
	M. oleifera	*S. grandiflora*	*G. arborea*	*B. purpurea*	*M. oleifera*	*S. grandiflora*	*G. arborea*	*B. purpurea*
Mean	39.42	66.11	29.85	40.29	642.57	762.30	366.53	643.29
S. d. ±	0.72	0.66	0.76	0.71	5.37	6.90	5.50	6.30
SE m ±	0.36	0.33	0.38	0.35	2.69	3.45	2.75	3.15
C.V. (%)	1.83	1.00	2.56	1.76	0.84	0.91	1.50	0.98

Average seed germination capacity ranged from 60.65 to 84.90 % among different fodder tree species. The highest seed germination capacity value was observed in *S. grandiflora* (84.90 %), followed by *B. purpurea* (74.00 %) and *M. oleifera* (72.10 %) whereas lowest seed germination capacity value was observed in *G. arborea* (60.65 %). The mean germination energy ranged from 39.95 to 52.50 % among different fodder tree species. The highest seed germination energy value was observed in *S. grandiflora* (52.50 %), followed by *B. purpurea* (52.02 %) and *M. oleifera* (50.19 %) whereas lowest germination energy value was observed in *G. arborea* (39.95 %) shown in table 6.

Table 6: Germination capacity and germination energy of four fodder species under nursery conditions.

	Germination Capacity (%)				Germination Energy (%)			
	M.	*S.*	*G.*	*B.*	*M.*	*S.*	*G.*	*B.*

	oleifera	grandiflora	arborea	purpurea	oleifera	grandiflora	arborea	purpurea
Mean	72.10	84.90	60.65	74.00	50.19	52.50	39.95	52.02
S. d. ±	0.77	0.68	0.87	0.75	0.73	0.72	0.70	0.58
SE m ±	0.39	0.34	0.43	0.37	0.36	0.36	0.35	0.29
C.V. (%)	1.07	0.80	1.43	1.01	1.45	1.38	1.75	1.11

The average survival of seedling values ranged from 94.49 to 96.16 %. The highest survival of seedling value was observed in *S. grandiflora* (96.16 %), followed by *M. oleifera* (94.98 %) and *B. purpurea* (94.52 %) whereas lowest survival of seedling value was observed in *G. arborea* (94.49 %). The average MDG values ranged from 3.54 to 6.41. The maximum MDG value was recorded in *S. grandiflora* (6.41), followed by *B. purpurea* (4.44), *M. oleifera* (4.21), whereas the minimum value was recorded for *G. arborea* (3.54) shown in table 7.

Table 7: Survival of seedling and mean daily germination of four fodder species under nursery conditions.

	Survival of Seedling (%)				Mean Daily Germination			
	M. oleifera	*S. grandiflora*	*G. arborea*	*B. purpurea*	*M. oleifera*	*S. grandiflora*	*G. arborea*	*B. purpurea*
Mean	94.98	96.16	94.49	94.52	4.21	6.41	3.54	4.44
S. d. ±	0.91	1.38	0.44	0.81	0.11	0.06	0.08	0.09
SE m ±	0.45	0.69	0.22	0.41	0.05	0.03	0.04	0.05
C.V. (%)	0.96	1.44	0.47	0.86	2.58	1.01	2.27	2.14

Discussion

The characteristics of seed depict the sum of total effect of various stresses and strains, which the species has been subjected to during evolution in its specific habitat of origin [10]. The feature of seeds such as shape; sculpturing and color provide critical identification of the systematic position of the species [11]. The number and shape of the seed were the only reliable distinction between two genera *Chlorophytum* and *Anthericum* of the Liliaceae. Further the species of *Ocimum* (Labiateae), genera *Sisymbrella* and *Nastrutium* (Cruciferae) were distinguished by the presence or absence of mucilage on the testa of seeds. Hairy outgrowths on the testa, their length and color provided useful characters in the distinction of genera and/or species of Malvaceae, Convolvulaceae, Asclepiadaceae and Acanthaceae [12].

Seed weight depends on reserve food material, which is produced as a result of double fertilization (endosperm) and is dominated by maternal traits, also influenced by the nutrient availability at the time of seed setting and environmental factors [13]. Seed size variation and its influence on early growth in *Terminalia arjuna.* Poor correlation observed between seed length and width. While significant correlation was observed between seed size and weight. Maximum germination percentage, faster initial growth and higher biomass of seedlings were observed in larger sized seeds [14].

Seed size influences seedling emergence, germination, and other agronomical aspects, and it is a generally accepted measure of seed quality [15]. The nutrient content of seeds varies by species and is dependent on seed size [16]. Seed size is also thought to be a significant evolutionary feature that influences how many plant species reproduce [17]. Seed sizes directly influence the germination time [18,19], germination percentage [19] and seedling vigour [20], which can indirectly determine plant distribution and abundance across different habitats [21]. Plant seed size, on the other hand, varies dramatically between and within species, often by several orders of magnitude [22,23].

Large seeds, in comparison to medium and/or small seeds, tend to produce stronger seedlings due to their higher energy content [24]. Nonetheless, when compared to light seeds, heavy-weighted seeds produce better seed germination, survival, and initial seedling development [25,26]. For many species, however, conflicting findings have been recorded. In *S. grandiflora* spp., for example, small or medium-sized seeds germinate faster and at higher percentages than large-sized seeds [27], in *Prunus jenkinsii* [25], in *Copaifera langsdorfii* [19], etc. Early germination from the selected medium-sized seeds of *S. grandiflora* proved out to be significant under nursery conditions [28].

Unexpected low germination rate had been recorded in *G. arborea* [29]. Suggested the possibility of the presence of inhibitory substances in the fleshy pericarp of *G. arborea*. Fruit colour, size, fermentation, depulping and the time of collection were found to affect germination of *G. arborea* seeds [29.30.31]. The growing media and seed pre-sowing treatments significantly influenced the initiation of germination, peak germination day, cessation of germination, germination percent, mean daily germination, days to 50 percent germination of the total seeds germinated, peak value, germination value, mean germination time, mean germination rate, coefficient of velocity of germination, germination energy, germination rate index, germination index and Timson's rate index (TRI) in *G. arborea* seeds [32].

Seed germination and seedling growth are both affected by a number of environmental factors including light, moisture, temperature and the availability of oxygen and CO_2. The management of these factors changes from species to species. Seed germination is one of the important characters that help to calculate seed rate for seedling propagation. The seed size is a considerable and significant factor in the germination and early stage of plant growth [33].

Seeds of *S. grandiflora* recorded highest germination percent, seedling vigour index, mean daily germination and germination index among all the other species despite being the smallest seed size. The observations are in line with Agboola [34] who studied the effect of seed size on germination, seedling growth and dry matter accumulation in 1–3-month-old seedlings of three tropical tree species *viz., Tectona grandis, Ceiba pentandra* and *Leucaena leucocephala*. It was found that seed size has no significant effect ($p=0.05$) on the rate and total percentage germination of seeds of *L. leucocephala* and *C. pentandra* but the rate of germination and relative growth rate (RGR) in *T. grandis* was faster and higher for small seeds than large seeds.

Also, Ferreira *et al.* [35] conducted study to determine the influence of seed size on germination and vigour of *Acacia senegal* seedlings and concluded that the percentage and the germination speed were not affected by seed size but the primary root and seedling length increased with seed size as well as the weight of the hypocotyls. Souza and Fagundes [14] worked on 300 seeds collected from 30 individuals of *Copaifera langsdorffii.* All the seeds were sorted according to size and were placed in germination trays with vermiculite as substrate and observed that small sized seeds had higher germination percentage and germinated faster when compared to large sized seeds.

Among the other three fodder species the highest germination percent, seedling vigour index, mean daily germination, germination capacity, germination energy, survival of seedling and germination index was recorded in *B. purpurea* followed by *M. oleifera* and *G. arborea*. This can be attributed due to the maximum seed size of the seeds. Similar observations were also recorded by Karki *et al.* [36] who conducted an experiment to study the effect of different seed sizes on the germination and seedling growth of a temperate tree species. The seeds were classified into different classes based on seed length, width and weight. Large sized seeds showed maximum germination percentage, germination rate and mean daily germination. The main reason for such variation was difference in levels of starch and other food storage materials. Studied the effect of seed size on germination traits in *Terminalia arjuna* genotypes but they observed that seedling vigor was a positive function of seed size. It was concluded that medium and large sized seeds had higher germination and seedling establishment [37].

Studied the effect of seed size and weight on seed germination of *Alangium lamarckii* and reported that the large size seeds gave maximum (76%) germination followed by medium size (74%) and small size seeds characterized by low germination percentage (59%) [38]. The effect of seed size, sowing orientation and depth on germination and seedling in neem. Seed sizes directly affected the germination and seedling growth with large sized seeds having 95% germination as compared to small sized seeds with 75% germination [39].

Conclusion

The aim of this investigation was to measure the variability of seed morphological characteristics and germination behavior of the four fodder tree species under nursery conditions. The initial growth performance is very crucial for any species, as it gives an idea or reflects about the performance in field. Adoption of these fodder trees species would benefit in numerous ways.

These fodder trees around agricultural fields and along village boundaries will provide shelterbelt for the crop, fodder availability for cattle while also improving the microclimate of the villages. Also, this study would help in drawing conclusions in order to combat with the problem of natural regeneration the fodder species is facing over a period of time. Such an investigation may also help in developing conservation strategies in nursery conditions and fodder availability during lean period.

Lack of adequate fodder in forest is one of the reasons behind large scale damage to agricultural crop by wild animals such as neelgai. If fodder requirement is fully met from sources outside the forest, damage to forest from man and domestic animals would be checked. Development of community pastures seems to be an effective measure to tide over the problem of fodder scarcity. It is, therefore, important to raise plantations of fodder trees and grasses on community lands, forest land or degraded land near the village which would provide fodder to all the families living in the area. Fodder trees and shrubs can provide enough protein and energy to keep rumin microbes active and thus increase their capacity to digest fibre, allowing livestock to use dry-season pastures.

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