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Studies on the pod, seed and germination traits of *Acacia catechu* from Uttarakhand

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Abstract
Acacia catechu Willd. commonly known as Khair has a place with family Fabaceae occurs in tropical moist deciduous forests, dry tropical forests and tropical thorn forests. The present investigation was directed to illuminate the pattern of variation in pod, seed characteristics and germination behaviour among *Acacia catechu* seed sources collected from different districts of Uttarakhand (*viz*. Dehradun, Rishikesh, Haridwar, Udham Singh Nagar and Nainital). All pod characters i.e. weight, length, breadth, number of seeds per pod and seed characters i.e. length, width, weight, thickness and seed volume were recorded. Germination parameters include germination percentage, germination value, germination period, germination speed, which varied significantly among different seed source. The variation observed among different seed source may probably be influenced by different intensities of natural constrains acting upon these traits in the prevailing geographic/climatic conditions. On the basis of pod weight (67.24), seed weight (29.70) and germination percentage (79.56) it was concluded that Udham Singh Nagar showed best results to develop selection criteria for tree improvement programmes for Uttarakhand. The present study is helpful in selecting a good source of superior seed quality for healthy seedlings. The significant variation observed among different seed sources may probably be influenced by different intensities of natural constraints acting upon these traits in the prevailing geographic/climatic conditions.

Keywords: seed source - trait - variations - germination behaviour - *Acacia catechu*

Introduction
Acacia catechu Willd, found crosswise over India in dry blended timberlands, for the most part as a little tree, up to a tallness of 3 m. *Acacia catechu* seeds are level, dull dark colored and measure 5-8 mm in distance across (Bisht and Ahlawat, 1999). The seeds are consumable and the concentrate of its heartwood is a vital element of the conventional Indian 'Paan'. In the natural habitat of khair, the absolute maximum shade temperature varies from 40°C to 50°C and the absolute minimum from 2.5°C to 7.5°C. The mean daily maximum temperature in May which is generally the hottest month in the hot weather varies from 37.5°C to 43.5°C. The mean daily minimum temperature in January which is the coldest month of the year varies from 1.0°C to 2.1°C.
Germination of a seed is the underlying, and under a few conditions, basic advance in afforestation by regular or artificial means. Germinability is a measure of the capacity of populace of seeds to sprout or the most extreme level of seeds that will grow under good conditions (Ranal and Santana 2006). Seed gives the normal source to multiplication and safeguarding of greenery. Geographic variety exists in backwoods trees because of the hereditary separation and ecological difference. Forest tree improvement programs begin with the investigation of accessible variety in the whole scope of species dispersion and delimitation of seed sources equipped for giving the best adjusted trees.
Variation in seed sources draw attention to provide superiority planting material. Morphological variation in pod, seed parameters is useful to provide healthy seed source for mass afforestation or tree breeding strategy. Several workers have already reported that information on seed characteristic may be useful for farming practices. Keeping in view the importance of *Acacia catechu* in improvement and reforestation of degraded land, the proposed investigation will be conducted.

Materials and methods
The present investigations were carried out in Department of Basic Sciences at Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. A brief accounts of the materials used and methodologies adopted are presented under the following heads:

1. Sample collection
Pods were collected from 15 to 25 year old matured and healthy *Acacia catechu* Willd. tree from different geographic sites in Uttarakhand. The principal characteristics of all sites studied are summarised in Table 1. Thoroughly mixed bulk pods collected from different sources were sun dried. The seeds were extracted; healthy undamaged seed were kept in airtight bags.

Table 1: Sites of sample collection of *Acacia catechu* from Uttarakhand

Code	Location	District	Altitude (amsl)	Latitude	Longitude	Rain fall (mm/yr-2016)	Plant height (m)	Plant diameter (cm)
UKA-1	FRI	Dehradun	575 42	30°.20.634N	78°.0.380E	1351.6	18.0	24.0
UKA-2	Lal Kuon	Nainital	371 35	29°.3.998N	79°.30.761E	1787.2	28.5	34.2
UKA-3	Rani Pokhri	Rishikesh	484 38	30°.11.361 N	78°.12.067E	1351.6	17.6	23.5
UKA-4	Udham Singh Nagar	Pant Nagar	412 45	29°.2.575N	79°.30.927E	734.4	22.0	29.2
UKA-5	Chidiyapur	Haridwar	830 40	29°.43.852N	78°.14.965E	1104.2	21.0	29.0

2. Pod parameters

Pod weight: Weight of 100 pods were measured on electronic balance, average value was computed and expressed in grams (g).

Pod size: Three replications of 100 undamaged, healthy pods were studied for pod dimensions *viz*., pod length, width and thickness using Digital Vernier Callpier and expressed in millimeters (mm).

Number of seeds per pod: Three replicates were counted to calculate the average number of seeds per pod.

3. Seed Parameters

Seed weight: 1000 seed weight (g) was recorded as per ISTA (1966) method.

Seed size: Seed dimensions *viz*., length, width and thickness were measured with Digital Vernier Callpier and expressed in millimeters (mm).

Seed volume: Seed volume was determined by water displacement method (Pandey, 1991) [10] and expressed in cubic centimeters (cc). Hundred seeds of each source were put in a graduated cylinder. The total volume of water displaced divided by the number of seeds gave volume per seed.

4. Germination studies

Three replications, each containing 100 seeds were placed on petriplate containing Whatmann Filter paper placed in germination cabinets at 20±2°C. Seed were observed daily for germination and daily count were taken. Moisture is checked regularly, so that seed do not get dried. Daily germination counts were recorded for two weeks or till it become constant for consecutive days. Each seed was considered to be germinated when the radical attained approximately 1 cm length. Daily germination counts were recorded and germination value (GV) was calculated according to Czabator (1962) [4]. The speed of germination was expressed in terms of germination value.

Germination percentage: It is the percent of germinated seeds at the completion of germination.

Peak Value of Germination (PV)

Peak value was calculated by the following formula.

PV = Highest seed germinated/ Number of days

Mean daily germination (MDG)

Mean daily germination can be calculated by the following formula.

MDG = Total number of germinated seeds/ Total number of days

Germination value

It is an index combining speed and completeness of seed germination. Germination value will be calculates according to Czabator (1962) [4].

G.V. = P.V. × M.D.G.

Where,

G.V. = Germination value

P.V. = Peak value of germination

M.D.G. = Mean daily germination

Germination energy index (GEI): Germination energy index was calculated using the formula Grouse and Zimmer (1958) [5].

Germination Period: Number of days taken to complete the germination was recorded for each replication.

Results

Variability in pod

Pod characteristics of different seed source of *Acacia catechu* in Uttarakhand are presented in Table 2. In Uttarakhand samples maximum pod weight (67.24 g) was recorded with Udham Singh Nagar seed source and lowest (31.65 g) was recorded with Nainital. The pod collected from Udham Singh Nagar s exhibited maximum (9.71 cm) pod length and lowest (6.40 cm) in Haridwar. Maximum pod width was recorded with Rishikesh (1.73 cm) and minimum of (1.10) cm in Nainital. Maximum pod thichness was observed in Udham singh nagar (1.46mm) whereas lowest in Haridwar (1.34mm). Pods collected from Rhishikesh exhibited maximum number of seeds/pod (7.45) and lowest (6.50) number of seeds/pod was recorded with Nainital. All the pod characters show high statistical variability among all the sites except pod thickness. However Rhishikesh shows similarities in pod length.

Variability in Seed characteristics

The maximum seed weight (34.25 g) was recorded with Rhishikesh and minimum (20.24g) was recorded with Haridwar seed source. Highest seed volume (1.55 cc) was observed in Rishikesh and minimum (0.65cc) was recorded with Haridwar. Maximum (7.77 mm) seed length was observed in Rishikesh and minimum (6.32 mm) seed length was observed with Haridwar seed source. Maximum (6.49 mm) seed width was recorded with Rishikesh and minimum (4.27 mm) seed width was recorded with Haridwar seed source. Maximum seed thickness was recorded with Rishikesh (1.55 mm) and minimum of (1.25 mm) in Haridwar. All seed characters show high statistical variability among all the sites except pod thichness. However Dehradun showed similarities in seed weight. Dehradun and Rishikesh showed similarities in seed volume respectively. Seed length and seed thickness showed highly variability.

Germination studies

Result of various germination parameters revealed that highest germination percent showed by Rhishikesh (82.76%) and lowest germination was recorded with Dehradoon (68.45%). Germination value was highest in Rishikesh (407) and lowest was in Dehradoon (285.14). Germination energy index was highest in Rhishikesh (8.32) and lowest in Haridwar (4.03). Germination period was lowest in Rishikesh (10.48) and highest in Haridwar (15.87). Dehradun, Udham Singh Nagar and Haridwar showed similarities in germination percentage.

Table 2: Pod, seed and germination characters of *A. catechu*

S. No.	Traits	Dehradun	Nainital	Rhishikesh	Udham singh nagar	Haridwar	CD
1	Pod weight (g 100^{-1})	43.21^{c}	31.65^{j}	54.15^{b}	67.24^{a}	39.90^{d}	1.715
2	Pod length (cm)	6.63^{d}	8.88^{b}	8.21^{c}	9.71^{a}	6.40^{e}	0.171
3	Pod width (cm)	1.35^{b}	1.10^{c}	1.73^{a}	1.62^{a}	1.12^{c}	0.172
4	Pod thichness (mm)	1.37^{a}	1.43^{a}	1.41^{a}	1.46^{a}	1.34^{a}	0.172
5	Number of seeds/pod	7.26	6.50	7.45	6.82	6.80	NS
6	Seed weight (g 1000^{-1})	22.85^{d}	27.76^{c}	34.25^{a}	29.70^{b}	20.24^{e}	1.628
7	Seed volume(cc)	1.52^{a}	0.91^{c}	1.55^{a}	1.06^{b}	0.65^{d}	0.078
8	Seed length (mm)	6.92^{c}	7.21^{b}	7.77^{a}	7.64^{a}	6.32^{d}	0.172
9	Seed width (mm)	4.92^{d}	5.92^{b}	6.49^{a}	5.58^{c}	4.27^{e}	0.172
10	Seed thickness (mm)	1.34^{b}	1.37^{a}	1.55^{a}	1.39^{c}	1.25^{b}	0.172
11	Germination percentage	68.45^{d}	78.34^{c}	82.76^{a}	79.56^{b}	80.44^{b}	1.715
12	Germination energy index	5.36^{c}	5.28^{c}	8.32^{a}	8.06^{b}	4.03^{d}	0.172
13	Germination value	285.14^{d}	309.13^{c}	407.13^{a}	391.23^{b}	316.98^{c}	17.15
14	Germination period (days)	11.45^{d}	14.56^{c}	10.48^{e}	14.76^{b}	15.87^{a}	0.171

Pod length did not exhibit any significant correlation with other pod traits, *viz*. width, weight, number of seeds $pod^{-1}$and seed traits, *viz*. seed weight, volume, thickness, width, length, germination (%), germination period, germination energy and germination value (Table 3). However, pod width, pod weight and number of seeds pod^{-} showed significant correlations with each other and other seed traits. Pod width showed significant positive correlations with number of seeds pod^{-} and germination value. Pod weight also showed a significant correlation with seed and pod traits except seed width and germination period (Table 3).

Seed traits showed significant correlations among themselves and also with germination parameters. With seed parameters, significant positive correlations among seed weight, thickness, germination (%), germination value and negative correlations with germination period were noticed. However correlation of seed weight, seed width and seed thickness was observed to be non-significant with germination value. Germination period showed positive correlation with pod width and seed thickness whereas a significant (0.01 and 0.05) negative correlation with no of seed pod^{-1}, seed weight, seed length, seed width, and germination value. Germination percentage exhibited a positive correlation with germination period (Table 3).

There is no significant correlation between characters with geographical factors. However, latitude and longitude is correlated with seed length, latitude negatively correlated whereas, longitude positively correlated. Rainfall has negative correlation with pod weight.

Table 3: Correlation coefficient(r) among pod, seed and germination traits of *A. catechu*

		1	2	3	4	5	6	7	8	9	10	11
1	Pod weight (g 100^{-1})	1										
2	Pod length (cm)	0.640^{*}	1									
3	Pod width (cm)	0.781^{*}	0.201	1								
4	Number of seeds/pod	0.688^{*}	-0.148	0.672^{*}	1							
5	Seed weight (g 1000^{-1})	0.686^{*}	0.620	0.673^{*}	0.780^{*}	1						
6	Seed length (mm)	0.735^{*}	-0.147	0.634^{*}	0.660^{*}	0.125	1					
7	Seed width (mm)	0.348	0.524	0.710^{*}	0.834^{**}	0.840^{**}	0.338	1				
8	Seed thickness (mm)	0.785^{*}	0.365	0.707^{*}	0.178	0.597	0.240	0.858^{**}	1			
9	Germination percentage	0.644^{*}	0.335	0.199	0.654^{*}	0.824^{**}	0.340	0.760^{*}	0.310	1		
10	Germination value	0.728^{*}	0.488	0.823^{**}	0.710^{*}	0.492	0.648^{*}	0.473	0.402	0.635^{*}	1	
11	Germination period (days)	-0.371	-0.226	0.732^{*}	-0.700^{*}	-0.667^{*}	-0.698^{*}	-0.712^{*}	0.647^{*}	0.436	-0.660^{*}	1

Table 4: Simple correlation (r) between characters studies and geographical factors of *A. catechue*

Characters	Latitude	Longitude	Altitude	Rainfall
Pod weight (g 100^{-1})	0.004	-0.038	0.028	-0.741^{*}
Pod length (cm)	0.427	-0.390	-0.106	-0.347
Pod width (cm)	-0.013	0.106	-0.424	-0.299
Number of seeds/pod	-0.238	0.212	-0.008	-0.122
Seed weight (g 1000^{-1})	0.430	-0.420	0.041	-0.063
Seed volume(cc)	0.614	-0.554	0.036	0.170

Seed length (mm)	-0.665*	0.748*	-0.528	0.015
Seed width (mm)	0.277	-0.221	0.101	0.056
Seed thickness (mm)	0.299	-0.250	0.325	-0.136

Discussion

Environmental deviation effects on phenotypic characters are generally negligible under controlled conditions. Apart from genetic factors, germination is influenced by seed source, pre-treatment, seed maturity (Edwards and El-Kassaby 1988), and seed size (Helium 1990). However, in this study pod characteristics did not exhibit any significant correlation with climatic factors and indicated a non-clinal variation, whereas seed sources representing moderate rainfall regions produced larger pods with more number of seeds than the humid and sub-humid regions (Tables 1,2,4). Large seed frequently have greater percent germination or emergence than small seeds. On the other hand, small seeds may germinate more quickly than large seeds and, thus have a competitive advantage. Seed size also affects seedling biomass usually; the seedling from large seeds are larger than those from small seeds, especially in the early stage of growth.

A marked variation in seed parameters, *viz*. seed weight, length, width and thickness, among different seed sources was recorded. A strong correlation between seed weight and germination percentage in different seed sources, which gives a suitable base for the consideration of seed weight in delineating and understanding the geographic variation, may possibly be due to cumulative effects of both internal (maternal) and external (environmental) conditions prevailing during the process of seed development as earlier reported by Harper *et al.* (1970) [17]. Its apparent that seed sources from moderate rainfall areas, i.e. Una, Udham singh nagar, Dehradoon and Bilaspur produced higher seed weight. This could be possibly because the population from moderate rainfall area developeda better source-sink relationship resulting in the formation of better seed size to faciliiate quick and uniform germination, hence faster root-shoot growth. The variation among seed source with respect to seed size and weight has already been reported earlier by many workers (Krishan & Toky 1996, Sidhu 1997) [14, 15].

Variability in pod and seed traits has also been reported in *Acacia nilitica* subsp. indica (Ahlawat *et al*. 2007) [1], *Ceratonia siliqua* L. (Hela *et al*. 2008) [6] and *Delbergia sisso* (Singh and Bhatt, 2008) [13].

Germination is one of the most important criteria of seed quality, because it affects plant establishment and therefore the yield and quality of plant. Similar germination parameters were observed by Arthanari *et al*. (2013) [2], Masoodi *et al*. (2014) [9] and Kant and Kuamri, (2016) [8] in *Caesalpinia sappan*, *Abies pindrow* and *Tecomella undulate*, respectively.

Conclusion

The present study is helpful in selecting a good source of superior seed quality for healthy seedlings in plantation programmers in near future. The variation observed among different seed source may probably be influenced by different intensities of natural constrains acting upon these traits in the prevailing geographic/climatic conditions. On the basis of these pod, seed characteristics and percent germination it was concluded that Rishikesh of Uttarakhand showed best results to develop selection criteria for tree improvement programmes for Himachal Pradesh and Uttarakhand respectively.

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