



Seed maturation indices for better regeneration and multiplication of haldu (*Adina cordifolia*)

L S JEENA¹, R KAUSHAL², PARAG M DHAKATE³ and SALIL K TEWARI⁴

G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145

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Haldu (*Adina cordifolia* Roxb. Hook. f. ex Brandis) is large deciduous tree species of family Rubiaceae. It is one of the common associate species in West gangetic moist mixed deciduous forests and on well-drained deep soil in Shivalik. It also occurs in dry region of Ceylon and sub-Himalayan tracts from Nepal Eastward to Asom. In Western Himalayas, it is confined to outer slope up to 1000 m. The tree occurs scattered in the deciduous forests throughout India, with exception of arid region of Rajasthan (Mandal *et al.* 1984). The wood of the species is used for making doors and window frames, plywood. The species is also heavily exploited for fuelwood and fodder. Natural regeneration of the species is very difficult as the minute seeds (about 11 million seeds/kg) as well as young seedlings in forests are washed away very easily and thus survival and establishment in forests is very less. The species therefore requires immediate attention for its regeneration, cultivation and conservation (Kaushal *et al.* 2010). Exact knowledge of maturity time is therefore essential to avoid the collection of immature and non-viable seeds which can cause nursery and plantation failure. The present study was therefore conducted to develop seed maturation indices for better regeneration and multiplication of the *Adina cordifolia*.

Fruits of haldu were collected from Tanda (29°02 N, 079°23 E and 242.42 m amsl) and Lalkuan (29°04 N, 079°30 E and 230.2 m amsl) forests of tarai and Bhakara (29°10 N, 079°25 E and 287.87 m amsl) and Barheni (29°14 N, 079°17 E and 318.18 m amsl) forests of bhabar region.

Fruits were collected starting from first week of April and continued every seven days until the fruits were not

available. For collecting the fruits, five healthy average sized trees were selected on phenotypic basis. After collection, the fruits were brought at field laboratory of Agroforestry Research Centre (AFRC) of G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (29° N, 79°3 E and 243.84 m amsl) during April–May 2010. The fruits were dried in sunlight till opening. Fruit colour, moisture content per cent and specific gravity was recorded during each collection dates at all the collection sites as per standard procedure (ISTA 1993). The germination study was conducted in germinator which was maintained at 25±2°C temperature. The data were statistically analyzed using two way ANOVA (Snedecor and Cochran 1967) to find out the presence of significant difference between sites and dates. The analysis was carried out with the Statistical Package for Social Sciences (SPSS) windows software package.

At Tanda and Bhakara, the fruit colour changed from light greenish brown to light brown. At Barheni, the fruit colour changed from yellowish green to light brown and at Lalkuan, the fruit colour changed from light grayish brown to dark grayish brown (Table 1). Colour change in fruit, increased firmness or brittleness, decreased moisture content and specific gravity are reliable criteria for judging seed maturity. The difference in colour at different site may be attributed to difference in environmental conditions. Colour change has also been recommended as a ripeness indicator in neem (Bharathi *et al.* 1996), in *Quercus*, *Prunus cerasoides* (Tewari *et al.* 2011) and in *Bauhinia retusa* (Upadhyay *et al.* 2006)

Moisture content was higher at Barheni on each date of collection. Maximum moisture of 69.56% was observed in seeds collected from Barheni in the first week of April (Fig 1). Maximum mean germination occurred when the fruit moisture ranged between 38.59 to 46.37% at across the sites (Table 1, Fig 1). Thus in *Adina cordifolia* the moisture content of fruit between 38 and 46% can be adjudged indicators of seed maturation. Decline in moisture content from maturing fruits is closely related to seed maturity (Shah

*Short note

¹Project Assistant (e mail: lsjeena.agrof14@gmail.com), Division of Information and Project Management, CIMAP, Lucknow, Uttar Pradesh 226 015;

²Senior Scientist, CSWCRTI, Dehradun;

³DFO, Tarai Central Forest Division, Haldwani, Uttarakhand;

⁴Professor, Genetics and Plant Breeding, GBPUA & T Pantnagar, Uttarakhand

2005, Pandit *et al.* 2002, Shah *et al.* 2006). At physiological maturity, all nutrients cease to flow into fruit from parent plant and thus facilitate the drying of fruits and seed to low moisture content without losing viability (Harrington 1972). According to Maideen *et al.* 1990 and Edwards 1980, *Casuarina equisetifolia* and pine maturity is attained when the seed/cone moisture content is below 50%. Pandit *et al.* (2002) also observed that in *Populus ciliata*, the moisture content in capsule drop from 80 to 60% during maturation; which coincide with the maximum germination in seed.

Like moisture, specific gravity also showed decline with each collection date (Table 1). Specific gravity was maximum in Bhakra and Barheni in first week of April. Specific gravity decreased with advancement of collection period from first till final date of seed collection at all the sites. Specific gravity indices have proven reliable for *Cryptomeria japonica* (Mughal *et al.* 2007).

Different collection dates, site and interaction effect of date \times site showed significant variation for germination (Table 1). Germination increased with advancement of collection date and was maximum in seeds collected during

first week of May at all the sites. At all the sites maturity was observed in first week of May. The maximum germination percentage (84.03%) was recorded from Tanda site when seeds were collected on D₅ collection date. Data revealed that germination was more in seeds collected from *tarai* region (Tanda and Lalkuan) as compared to *bhabar* region (Bhakra and Barheni). *Bhabar* region is adjacent to the foothills of the Himalayas and consists of boulders and pebbles which have been carried down by the river streams. As the porosity of *bhabar* belt is very high, the streams flow underground. *Tarai* belt lies next to the *bhabar* region and is composed of newer alluvium. The underground streams reappear in this region and the region is excessively moist and thickly forested. It also receives heavy rainfall throughout the year (http://en.wikipedia.org/wiki/Indo-Gangetic_Plain). Thus, higher germination in *tarai* region as compared to *bhabar* region may be attributed to more moisture condition prevalent in the area which might have created congenial condition for seed growth which is also evident from the present finding, where more seed weight was observed in the seeds collected from *tarai* region.

Table 1 Variation in fruit characters and germination of *Adina cordifolia* seeds over the collection period at different sites

Site (S)	Date of collection (D)	Fruit colour	SG	Days taken to initiate germination	Germination (%)
Tanda (S ₁)	4 April (D1)	Light greenish brown	1.38	15.25	12.88 (05.00)
	11 April (D2)	Light greenish brown	1.32	12.25	16.41 (08.00)
	18 April (D3)	Light brown	1.25	9.25	24.15(16.75)
	25 April (D4)	Light brown	1.11	6.00	30.97 (26.50)
	2 May(D5)	Light brown	0.94	3.25	84.03 (98.50)
Bhakara (S ₂)	4 April (D1)	Light greenish	1.46	16.00	05.73 (01.00)
	11 April (D2)	Light greenish	1.37	12.50	10.36 (03.25)
	18 April (D3)	Light brown	1.28	8.75	18.42 (10.00)
	25 April (D4)	Light brown	1.18	5.50	26.91 (20.50)
	2 May(D5)	Light brown	0.98	3.50	60.17 (75.25)
Barheni (S ₃)	4 April (D1)	Yellowish green	1.45	14.50	09.05 (02.50)
	11 April (D2)	Greenish yellow	1.33	10.00	10.75 (03.50)
	18 April (D3)	Light brown	1.19	6.50	20.91 (12.75)
	25 April (D4)	Light brown	1.07	5.25	34.13 (31.50)
	2 May(D5)	Light brown	0.97	3.25	69.54 (87.75)
Lalkuan (S ₄)	4 April (D1)	Light grayish brown	1.35	15.00	09.97 (03.00)
	11 April (D2)	Dark grayish brown	1.24	10.50	12.22 (04.50)
	18 April (D3)	Dark grayish brown	1.13	7.50	20.01 (11.75)
	25 April (D4)	Dark grayish brown	1.02	5.00	41.84 (44.50)
	2 May(D5)	Dark grayish brown	0.95	3.75	59.51 (74.25)
CD (P = 0.05)					
D			0.016	0.49	0.93
S			0.014	0.43	0.83
D \times S			0.032	0.98	1.87

SG, Specific gravity; D, collection date; S, collection site

*Figures in parentheses are original values

*Figures outside parentheses are arc sign transformed values

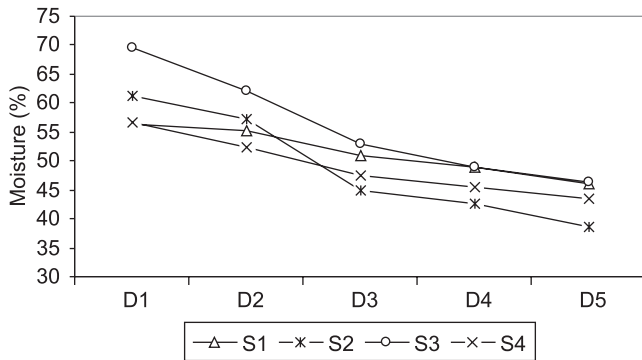


Fig 1 Variation in moisture content over the collection period at different sites

SUMMARY

Haldu (*Adina cordifolia* Roxb.) is one of the common associate species in moist mixed deciduous forests. In Western Himalayas, it is confined to outer slope up to 1000m. The wood of the species is used for making doors and window frames, plywood. The species is also heavily exploited for fuel wood and fodder. Fruits of *Adina cordifolia* were collected from four collection sites, (viz Tanda range, Bhakara range, Barheni range and Lalkuan range at five different collection dates, viz 1st week of April, 2nd week of April, 3rd week of April, 4th week of April and 1st week of May) for assessing seed maturation indicators. The results revealed significant variation in collection date and collection site for germination parameters. The change in fruit colour of *A. cordifolia* from light green to light brown and moisture content of fruit between 38 to 46% was adjudged useful indicator of seed maturation. Germination was maximum in seeds collected during first week of May at all the sites.

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