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Provenance variation in seed and seedlings attributes of *Quercus glauca* Thunb. in Garhwal Himalaya, India

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Abstract: Provenance variation in seed and seedling attributes of *Quercus glauca* Thunb. was investigated. Significant differences were obtained in morphological and seedling attributes with populations. Altitude of seed source showed significant inverse correlation with seed length, seed weight and seedling weight. But altitude showed significant positive correlation with percentage germination and root collar diameter of seedlings. Significant positive correlation between seed weight and seedling weight was also observed.

Additional key words: Glaucous-leaf Oak, altitude, seed mass, morphological variation

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Introduction

Quercus glauca Thunb. is middle sized evergreen tree with a dense rounded crown and clean large cylindrical trunk. In moist localities of Garhwal hills, *Quercus glauca* grown in association with *Q. leucotrichophora* and *Rhododendron arboreum* forests (Gaur 1999). The species is a source of fuel, fodder and timber in Garhwal hills, therefore, it is also cultivated in traditional agroforestry systems of Garhwal hills (Negi et al. 1999). Owing to its multiple uses, it has been over-exploited through out the region for fuel, fodder and timber (Bhatt and Badoni 1995). Apart from this, the natural regeneration of this species is sporadic in nature and poor due to anthropogenic disturbance and consumption of acorns by herbivores (Himalayan langoor, *Presbytis entellus*) (Upreti et al. 1985).

Information on morphological variation in seed characteristics amongst the natural populations of a species has been reported to be useful for tree improvement programmes because quality of seeds determines the performance of seedlings for survival, growth and biomass allocation. In general, variation in germination of different species has been shown in relation to altitude, longitude and latitude of seed origin (Singh et al. 2004, Mwase et al. 2006, Andersen et al. 2008 and Saikia et al. 2009). Keeping these facts in view, the present study is an attempt to evaluate the seed and seedling characteristics of *Q. glauca* so that promising seed sources can be identified for the production of quality seedlings of this potential tree species for mass afforestation in agroforestry systems of Garhwal hills.

Materials and Methods

Mature seeds of *Q. glauca* were collected from a wide altitudinal range (930 to 1830 m asl) within their natural distribution (Table 1). The word seed/seeds refers to the true seed with the pericarp (true seed + pericarp = an acorn). For each site, seeds were collected from 10 randomly selected healthy and mature standing trees in the month of December. Each site was 100m apart from each other to avoid narrowing down the variation sampled due to relatedness (Schmidt 2000). Seeds were collected from eight provenances and each provenance provided 3-4 kg of seeds which were brought to the laboratory and allowed to dry in shade for 24 h. Seeds were stored in deepfreeze at 10±2^{0}C in cotton bags, and sown in the nursery in first week of March. Seed breadth (in the middle portion of the seed) and length of each provenance were recorded with the help of a micrometer (Bestomake) by selecting randomly seed populations in three replicates (each consisting of 100 seeds). Whereas, seed weight (g/100 seed) was recorded by choosing eight random samples of each population, i.e., 100 seeds per seed lot (ISTA 1999).

Mature and healthy seeds of each population were tested for germination by sowing them into nursery in the experimental garden of the department of Forestry (located at 550 m asl in Tehri district, Uttarakhand, India) in four replication in complete randomized block design. For each replicate, 100 seeds of each source were sown in nursery beds of 10.0 m^2 size (5.0 × 2.0 m) in the month of March, at a spacing of 20 cm from plant to plant and 50 cm row to row. On average, 5 kg of farmyard manure (FYM) was applied in each nursery bed (at the rate of 5 ton/ha) before seed sowing. Seeds were sown at 5 cm depth into the soil. The nursery beds were exposed to full sunlight and irrigated frequently to keep them moist. Data were recorded for percentage emergence. At the end of one year of growth, 10 randomly selected seedlings from each replicate were uprooted and washed thoroughly with running tap water to assess root-shoot length. Both the parameters were measured with the help of meter tap. Shoot length was considered the growth above the ground. Root collar diameter (with the help of micrometer at ground level) and number of leaves/seedling (by counting) were measured for each provenance. Likewise, fresh weight and dry weight (after drying to constant weight in an hot air oven at 80°C for 24 h) of the seedlings were measured by using electronic top pan balance (Shimadzu Corporation Japan make) with a total weighing capacity of 220g and readability of 0.1 mg. Seeding vigour index (SVI) was also calculated as dry matter production of seedling × germination percentage (Abdul-Baki and Anderson 1973). The seed and seedling attributes were statistically analyzed by using SPSS software package, version 10.0.1 (SPSS Inc., Chicago, USA) for analysis of variance, co-efficient of variance and correlation coefficients to record the effect of altitude on germination and growth performance of seedlings.

Table 1. Geographical description and morphological attributes (± S.D.) of seeds of *Q. glauca,* collected from different provenances (value in parenthesis indicate coefficient of variance (CV %)

Seed Source	Altitude (m asl)	Latitude (N)	Longitude (E)	Rainfall (mm)	Temperature °C		Soil pH	Seed length (cm)	Seed breadth (cm)	Seed weight (g/100 seed)
					Min	Max				
Tharali	890	30°34'	79°30'	1285.9	4.2	36.0	5.81	2.09±0.02^{abc} (4.18)	1.26±0.27^{b} (6.78)	156.66±3.3^{bc} (3.68)
Kakragad	980	30°29'	79°5'	1166.0	2.0	27.3	5.82	2.30±0.02^{a} (6.55)	1.09±0.12^{de} (9.59)	148.33±4.4^{bc} (9.82)
Kulsari	1100	30°5'	79°28'	1269.5	3.0	26.3	5.82	1.98±0.06^{bc} (9.59)	1.39±0.14^{a} (3.72)	140.33±2.9^{c} (9.35)
Harmani	1200	30°6'	79°25'	1385.9	3.2	26.3	5.80	2.11±0.01^{abc} (2.69)	1.38±0.07^{a} (3.76)	183.33±4.4^{a} (3.20)
Phata	1300	30°34'	79°3'	1636.0	1.3	24.8	5.67	2.15±0.02^{ab} (3.95)	1.19±0.53^{bc} (9.78)	163.33±8.8^{b} (8.75)
Ranpounga	1400	30°35'	79°2'	1499.6	2.2	27.8	5.59	2.18±0.04^{ab} (5.87)	1.16±0.12^{cd} (3.39)	113.00±6.7^{d} (9.42)
Nauty	1660	30°12'	79°12'	1587.98	1.2	24.2	5.68	1.03±0.02^{d} (3.66)	1.04±0.08^{e} (2.58)	106.66±6.7^{d} (5.14)
Kondubagar	1830	30°34'	79°2'	1540.0	1.6	26.5	5.97	1.86±0.09^{c} (16.84)	1.26±0.19^{b} (5.20)	106.66±5.7^{d} (3.57)
Mean								1.96	1.22	139.79
"r"								–0.58**	–0.25	–0.43**

Values in the same column with the same letter do not differ significant ($P<0.05$). "r" represents correlation coefficients computed between altitude and seed characteristics. ** Significant at $P< 0.01$.

Results

Table 1 shows geographical and morphological variation between seed collection sites. Significant ($P<0.05$) variation was observed in seed length, breadth and weight between eight seed lots. Seed length ranged from 1.03 to 2.30 cm with lowest to Nauty and Kakragad provenance while seed breadth ranged from 1.04 at Nauty to 1.39 at Kulsari seed provenance. Seed weight was maximum (183.33 g/100 seed) to Harmani and the lowest for Nauty and Kondubagar populations, i.e., 106.66 g/100seed. Seed length and weight showed significant ($P < 0.01$) inverse correlation with elevational range of seed source. Coefficient of variance (CV %) showed that all three characters were not equally variable since there was 84.0% difference between the lowest and highest CV for length; 74.0% for breadth and 67% for seed weight (Table 1).

Table 2 represents the data on seedling attributes of different provenances of *Q. glauca*. Average shoot length was the lowest (19.83 cm) for Ranpounga and the highest (25.20 cm) to Harmani populations, after one years' growth. Whereas, root length was the highest (18.66 cm) for Kakragad and lowest for Phata population, i.e., 13.10 cm. Significant variations were also observed for number of leaves per seedling, collar diameter, fresh and dry weight of seedlings. Kakragad and Kulsari sources produced the heaviest (4.6 g/seedling-dry weight basis) and Ranpounga the lightest seedlings with seedling weight of 4.0 g/seedling. Seedling vigour index (SVI) was highest to Kondubagar and the lowest to Tharali. Elevational range of the provenance exhibited significant positive correlation with percentage germination ($P < 0.01$) and root collar diameter ($P < 0.05$) of seedlings, but seedling weight was significantly ($P < 0.01$) inversely correlated with altitude of seed origin. Strong positive correlation ($P < 0.01$) between seed weight and seedling weight of *Q. glauca* was also recorded.

Coefficient of variance for the seedling characteristics showed wide differences between altitudinal populations. On average, there was 82.0% difference between the lowest and the highest CV for shoot length; 85.0% for root length; 88.0% for collar diameter and 71.0% for dry weight of seedlings (Table 2).

Discussion

Morphological characteristics of *Q. glauca* seeds are influenced by altitudinal variation and due to these variations, significant differences were recorded in germination percentage and seedling attributes of the species. Seed length and weight exhibited significant inverse ($P < 0.05$) correlation with rainfall of seed origin. Variation among seed population with respect to seed dimension (length and breadth) and weight have earlier been reported in many species including *Cordia*

Table 2. Provenance variation in root and shoot attributes of *Q. glauca* seedlings (Values in parenthesis indicate coefficient of variance CV %)

Seed source	Germination per cent	Shoot length (cm)	Root length (cm)	No. of leaves/seedling	Root collar diameter	Fresh weight (g/seedling)	Dry weight (g/seedling)	Root/shoot ratio (Dry weight basis)	SVI
Tharali	43.3^{c}	21.53^{c} (6.33)	18.00^{ab} (4.70)	6.33^{c}	0.264^{bc} (14.45)	9.04^{b} (6.35)	4.35^{b} (16.44)	1.19^{ab}	188.4^{c}
Kakragad	43.3^{c}	23.00^{b} (7.53)	18.66^{a} (21.65)	6.33^{c}	0.258^{cd} (5.82)	9.80^{a} (14.16)	4.60^{a} (18.03)	1.13^{bc}	199.2^{c}
Kulsari	43.3^{c}	20.00^{d} (5.00)	15.66^{d} (19.50)	7.66^{a}	0.261^{bc} (7.48)	7.99^{c} (4.99)	4.60^{a} (18.03)	0.97^{de}	199.2^{c}
Harmani	53.3^{b}	25.20^{a} (13.05)	17.66^{ab} (3.26)	5.66^{d}	0.244^{d} (11.80)	7.47^{cd} (27.52)	4.40^{b} (13.14)	1.29^{a}	234.5^{b}
Phata	43.3^{c}	22.66^{bc} (2.54)	13.10^{e} (7.69)	7.00^{b}	0.253^{cd} (4.09)	8.73^{b} (26.94)	4.43^{ab} (17.17)	0.86^{ef}	191.8^{c}
Ranpounga	60.0^{a}	19.83^{d} (2.38)	16.66^{bcd} (12.49)	7.66^{a}	0.273^{ab} (1.78)	8.67^{b} (12.27)	4.01^{c} (6.70)	1.19^{ab}	240.6^{b}
Nauty	63.3^{a}	22.00^{bc} (4.54)	16.00^{cd} (15.57)	5.66^{d}	0.253^{cd} (2.02)	7.95^{c} (6.37)	4.02^{b} (5.27)	0.80^{f}	254.5^{b}
Kondubagar	63.3^{a}	22.00^{bc} (4.54)	17.00^{bc} (14.03)	6.33^{c}	0.280^{a} (5.15)	7.22^{d} (10.56)	4.41^{ab} (10.39)	1.05^{cd}	279.2^{a}
Mean	51.64	22.03	16.60	6.58	0.261	8.36	4.35	1.01	223.4
"r"	0.84**	0.09	–0.19	–0.14	0.39*	–0.65**	–0.51**	0.14	0.89**

Values in the same column with the same letter do not differ significant ($P<0.05$). "r" represents correlation coefficients computed between altitude and seedling attributes. **Significant at $P< 0.01$, *Significant at $P<0.05$. SVI=Seedling vigour index.

africana (Loha et. al. 2006); *Pinus roxbrughii* (Ghildiyal et al. 2009), *Dalbergia melanoxylon* (Amri et al 2008) and *C. australis* (Singh et al. 2006b). Differences in germination of various species have also been observed in relation to altitude (Vera 1997; Tripathi and Khan 1990; Singh et al. 2004). Hence, the present findings are in conformity with the observations of the earlier workers.

There was great variation in seed weight of the populations of the *Q. glauca* and middle altitude (1200–1300 m asl.) populations exhibited higher seed weight as compared to high and low altitude populations. Variation in seed weight may partly be due to the different position of seed on mother plants or partly due to variable environmental conditions to which the mother plants were subjected during the growing season (Harper 1977). Thus seed weight is an important factor in determining the over-all performance of seedlings as it exhibited significant ($P < 0.01$) positive correlation with seedling weight of the species. Significant correlation was found between seed weight and seedling growth in *A. nilotica* (Ginwal et al. 1996) and this was considered to be an important trait for early selection of population. Variation in *Q. glauca* seedling traits could be due to wide range of distribution. Such variation in relation to habitat has also been reported in *Albizia chinensis* (Dhanai et al. 2003); *Grewia Optiva* (Uniyal et al. 2003) and *Celtis australis* (Singh et al. 2006a). Causes of such variability might be generally attributed either to (a) genetic characters of source population/plant (Bewley and Black 1994), or (b) impact of mother plant environment (Gutterman 1992). Tripathi and Khan (1990) also observed that seed weight of *Quercus dealbata* and *Q. grifithii* was strongly correlated with their seedling weight, which supports to the present findings. Thus larger food reserves may allow more pre-photosynthetic growth of seedlings and this in turn may contribute to better growth and survival of seedlings that emerge from heavy seeds. Large differences in germination traits were found between the provenances in the field. The ranking was species-specific, but largely consistent across all tested environments (Bischof et al. 2006). Significant differences between populations of *Trigonobalanus doichangensis* were also observed in seed length, seed weight and seedling morphological characters (Zheng et al. 2008). Simth and Fretwell (1974) also reported that production of large seeds would yield larger seedlings that may grow well even in adverse environmental conditions. Harper (1977) pointed out that the larger food reserves in the acorns may influence the growth of oak seedlings even after 15 years of plantation.

In case of present study, significant provenance variations have been recorded in seed and seedling weight of *Q. glauca*. Hence, the provenances which produce heavier seedlings should be identified for seedling production so as to achieve fair success in plantation even in harsh environmental conditions. However, all the seed and seedling characters should be considered as important traits for the selection because seedling of seed lots selected on the basis of one character alone may some time not give the desired level of superiority. Seed population selection should, therefore, be made on the basis of multi traits consideration as reported by Ginwal et al. (1996) and Vakshasya et al. (1992).

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References

Abdul-Baki A.A., Anderson J.D. 1973. Relationship between decarboxylation of glutamic acid and vigour in Soyabean seed. Crop Science 13: 227–232.

Amri E., Lyaruu H.V.M., Nyomoral A.S., Kanyeka Z. 2008. Effect of timing of seed collection and provenance on seed viability and germination of *Dalbergia melanoxylon*. Botany Research Journal 1: 82–88.

Andersen US., Cordova J.P.P., Nielsen N.B., Kollmann J. 2008 Provenance variation in germination and seedling growth of *Abies guatemalensis* Rehder. Forest Ecology and Management 255: 1831–1840.

Bewley J.D., Black M. 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York, pp. 221.

Bhatt B.P. Badoni A.K. 1995. Remarks on the fodder plants of Garhwal Himalaya. In: Echoes of Environment. Chadha, S.K. (ed.). Himalayan Publishing House, New Delhi, p. 52–75.

Bischoff A., Vonlanthen B., Steinger T., Müller-Schärer H. 2006. Seed provenance matters — Effects on germination of four plant species used for ecological restoration. Basic and Applied Ecology 7: 347–359.

Dhanai C.S., Uniyal A.K., Todaria, N.P. 2003. Sources variation in *Albizia cheninsis* Mer.: Seed and Seedling Characteristics. Silvae Genetica 52: 259–266.

Gaur R.D. 1999. Flora of the district Garhwal northwest Himalaya (with ethnobotanical notes). Transmedia Publication Center, Srinagar Garhwal, Uttarakhnad, India, pp. 811.

Ghildiyal S.K., Sharma C.M., Gairola S. 2009. Additive genetic variation in seedling growth and biomass of fourteen *Pinus roxburghii* provenances from Garhwal Himalaya. Indian Journal of Science and Technology 2: 37–45.

Ginwal H.S., Gera M., Srivastava R.L. 1996. Seed source variability in some seed and seeding characteristics of twenty provenances of *Acacia nilotica* WILLD. Ex. DEL. Range Management and Agroforestry 17: 49–59.

Gutterman Y. 1992. Maternal effects on seed during development. In: The Ecology of Regeneration in Plant Communities Seeds. Fenner M. (ed.). Wallingford CAB International, pp. 27–59.

Harper J.L. 1977. The Population Biology of Plants. Academic Press, London.

ISTA 1999. International Rules for Seed Testing. Seed Science and Technology, 27, Supplement, Zurich, Switzerland.

Loha A., Tigabu M., Teketay D., Lundkvist K., Fries A. 2006. Provenance variation in seed morphometric traits, germination, and seedling growth of *Cordia africana* Lam. New Forests 32:71–86.

Mwase W.F., Bjornstad A., Ntupanyama Y.M., Kwapata M.B., Bokosi J.M. 2006. Phenotypic variation in fruit, seed and seedling traits of nine *Uapaca kirkiana* provenances found in Malawi. : 15–21.

Negi A.K., Bhatt, B.P., Todaria N.P. 1999. Local population impacts on forests of Garhwal Himalaya, India. The Environmentalist 19: 293–303.

Saikia S.P., Bhau B.S., Rabha A., Dutta S.P. Choudhari R.K., Chetia M., Mishra B.P., Kanjilal P.B. 2009. Study of accession source variation in morpho-physiological parameters and growth performance of *Jatropha curcas* Linn. Current Science 96: 1631–1636.

Schmidt L. 2000. Guide to Handling of Tropical and Subtropical Forest Seed. Danida Forest Seed Center, Denmark, pp. 511.

Singh B., Bhatt B.P., Prasad P. 2004. Effect of seed source and temperature on seed germination of *Celtis australis* L.: a promising agroforestry tree-crop of Central Himalaya. Forests Trees and Livelihoods 14: 53–60.

Singh B., Bhatt B.P., Prasad P. 2006a. Variation in seed and seedling traits of *Celtis australis*, a multipurpose tree, in Central Himalaya, India. Agroforestry Systems 67: 115–122.

Singh B., Uniyal A.K., Bhatt B.P., Prasad P. 2006b. Altitudinal variation in seed characteristics of *Celtis australis* L. Forests, Trees and Livelihoods 16: 291–296.

Smith C.C., Fretwell S.D. 1974. The optimal balance between size and number of offspring. American Naturalist 108: 499–506.

Tripathi R.S., Khan M.L. 1990. Effects of seed weight and microsite characteristics on germination and seedling fitness in two species of *Quercus* in a subtropical wet hill forest. Oikos 57: 289-296.

Uniyal A.K, Bhatt B.P., Todaria N.P. 2003. Provenance variation in seed and seedling characteristics in *Grewia oppositifolia* Roxb. in Central Himalaya, India. Plant Genetic Resources Newsletter IPGRI, Rome, Italy, 136: 1–7.

Upreti N., Tewari J.C., Singh S.P. 1985. The oak forest of Kumaon Himalaya: Composition, diversity and regeneration. Mountain Research and Development 5: 163–174.

Vakshasya R.K., Rojora O.P., Rawat, M.S. 1992. Seed and seedling traits of *Dalbergia sissoo* Roxb: Seed source variation studies among ten provenances in India. Forest Ecology and Management 48: 265–275.

Vera M.L. 1997. Effects of altitude and seed size on germination and seedling survival of heathland plants in north Spain. Plant Ecology 133: 101–106.

Zheng Y.L., Sun W.B., Zhou Y., Coombs D. 2009. Variation in seed and seedling traits among natural populations of *Trigonobalanus doichangensis* (A. Camus) Forman (Fagaceae), a rare and endangered plant in southwest China. New Forests 37: 285–294.