International Journal of Plant & Soil Science

Volume 35, Issue 18, Page 1731-1736, 2023; Article no.IJPSS.103388
ISSN: 2320-7035

Leaf trait Adaptation in *Grewia optiva* Drummond along Altitudinal Gradient in the North Western Himalayas

Jyoti Dhiman [a++*], H.P. Sankhyan [a#], Neerja Rana [b†], Parul Sharma [c‡] and Shikha Thakur [a‡]

[a] Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh, India.
[b] Department of Basic Sciences, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh, India.
[c] Department of Biotechnology, College of Horticulture, Dr. YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i183453

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103388

Original Research Article

Received: 30/05/2023
Accepted: 02/08/2023
Published: 07/08/2023

ABSTRACT

The current study was carried out between year 2020-2023 in the Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). This study was carried out in four altitudinal ranges of Himachal Pradesh and Uttarakhand (400 to 800 m (A1), 801-1200 m (A2), 1201-1600 m (A3), and 1601-2000 m (A4) above mean sea level (a m s l). Leaf morphometric traits such as leaf area, leaf length, leaf

[++] Ph. D. Student;
[#] Professor and Head;
[†] Associate Professor;
[‡] Assistant Professor;
**Corresponding author: E-mail: jyotid175@gmail.com;*

width and petiole length increased from the A1 (400-800 m) altitudinal zone to the A2 (800-1200 m). These apparent characteristics, however, declined more as the altitudinal range increased from A2 to A4. Maximum values were reported for A2 (800-1200 m altitudinal range) in relation to average leaf area, length, width, and petiole length. The reason being the as elevation increased, leaves became thicker and water content reduced and leaves size became smaller. Plants can develop adaptive strategies in response to environmental change produced by an elevational gradient as elevation increases, the temperature always drops, limiting leaf area expansion due to heat and energy availability. However, according to our findings, the leaf area steadily increase up to 800-1200 m a m s l (A2 altitudinal zone). This counterintuitive pattern could be explained by the impact of precipitation and temperature fluctuations on LA.

Keywords: Leaf morphometric; leaf length; leaf width leaf areal Grewia optiva.

1. INTRODUCTION

Agriculture sector is critical to India's economy, with over 70% of the country's entire population directly relying on it. Animal raising with agriculture is a widespread practise in India's mountainous areas, where trees give sustenance to farmers' animal populations. At the same time, owing to the rain-fed conditions in the highlands and the farmers' modest land holdings, they have limited possibilities to produce green fodder on their land. As a result, trees planted on their land to supply fodder should be very nutritious and may be included into animal diets as a blend with dry straws to give maximum nutrition for enhanced livestock-based productivity. This can only be accomplished by selecting trees with more nutritious feed from their native geographical location and mass multiplying them to cover a region.

Grewia optiva, also known as Biul/Bihul/Bhimal and belonging to the Tiliaceae family, is a prominent tree planted in agroforestry systems in the western and central Himalaya. This tree is valued by the majority of Uttarakhand's hill farmers since it is superior to other fodder tree species in terms of palatability, quicker growth, ease of propagation, and forage production [1]. During the winter months, when no other green fodder is available, it provides feed. This tree's leaves are an excellent source of fodder in the mid Himalayan area because they retain a significant quantity of nutrients [2], and it has therefore been classed as a good grade fodder tree [3]. It has about 70% potential DM digestibility and 56.7 per cent effective degradability, making it a good energy source for ruminants [4]. Its leaves contain 17.4-21.0 % crude protein, 17.0-21.5 % crude fiber, 10.4-21.5 % total ash, 4.2-6.0 % ether extract and 40.4-50.2 % nitrogen free extract [5]. It is the most prevalent tree in the Tehri area and has been extensively cultivated in the Himalayan region, reaching elevations of 2000 m [6]. The quality of this fodder tree varies according to local variables acting on it, or it may be a combined manifestation of the genetic makeup of the tree species and the local environmental conditions. In the fields of ecology, genetics, and crop management, measurements of variation in leaf trait (leaf size) are an effective measure in examining the influence of the environment on plants. As leaf size is an adaptation and reaction to the environment, it may be used to predict the circumstances under which plants grow: climate, terrain, soils, and so on. Geneticists, ecologists, and agronomists are all interested in these interactions. Agricultural practices try to improve plant growth conditions. Leaf area is one of the factors that agricultural experts, particularly agronomists, use to determine optimal agricultural practices. Farmers should also examine to see whether they are providing an appropriate environment for their annual and perennial crops. Leaf area may be used to monitor biological and physical stressors such as herbivory, grazing, and drought. When studying crops or natural ecosystems, ecophysiologists employ leaf area measurements. Leaf size is a basic foliage physiognomic characteristic, and numerous studies have tried to explain the prominent variation in leaf size at the global scale. Characteristic correlations between leaf size and climate have been employed to gain insight into adaptive modifications in leaf size. The differences in leaf size can significantly alter whole-lamina and whole-leaf integrated chemical and structural characteristics, and thereby modify general scaling relationships between plant structure, chemistry and function [7]. The leaf can be considered as a microcopy of plant, variation in leaf morphology can reflect plant capacity to acquire, use and conserve resources [8]. Climatic conditions change with altitude, exposure and slope, resulting in a patchy distribution of microhabitats. Changes in abiotic and biotic conditions can lead to major modifications in selection pressure on plant life-history traits Pluess and Stocklin [9]. As a result, the present study was conducted to assess the adaptations in leaf traits over an altitudinal gradient

2. MATERIALS AND METHODS

This study was conducted in the four altitudinal ranges (400 to 800 m, 801-1200 m, 1201-1600 m and 1601-2000 m above mean sea level (a m s l), of Himachal Pradesh (H.P.) and Uttarakhand (U.K.) (Table 1) to assess the magnitude of variations in leaf traits of *Grewia optiva* Drummond along an altitudinal gradient. During the months of March-April 2020 (when species was in leafing and flowering stage), an ecogeographical survey of *Grewia optiva* populations was conducted in eight districts of Himachal Pradesh and Chamba block of district Tehri-Garhwal of Uttarakhand to identify sites occurring at four different altitude ranges where species occur almost in abundance. In each altitudinal zone, five populations (4 from H.P. and 1 from U.K.) were selected for evaluation of variations in leaf morphometric characteristics. As a result, the total populations/sites under study were twenty (sixteen populations from H.P. and four from U.K). The four superior individuals (20-30 cm diameter class) of *Grewia optiva* Drummond were identified at minimum 100 m and maximum 200 m distances and chosen for further study using the check tree method at each selected site.

2.1 Collection of Leaf Sample

The collection of leaf samples was carried out from selected areas during December month (when the species was in the seed ripening and fodder lopping stage). The sample size of 12 leaves were collected from the entire crown (top, middle and base) of each tree including leaves of all sizes (Suri and Dalal, 1963). The leaf size i.e., leaf area measured with leaf area meter model CI-202, CID, Inc.), while, leaf length and leaf width measured with measuring scale.

Table 1. Detail of populations selected from four altitudinal ranges in Himachal Pradesh and the Chamba block of District Tehri Garhwal, Uttarakhand

Altitudinal Zone (amsl)	Populations	District	Altitude (amsl)	Latitude	Longitude
A1(400-800 m)	P1(Harsar)	Kangra	482m	32.1046^0 N	76.0387^0 E
	P2(Sujanpur Tihra)	Hamirpur	515m	31.8339^0 N	76.5055^0 E
	P3(Dramman)	Kangra	740m	32.2246^0 N	76.1653^0 E
	P4(Ghumarwii)	Bilaspur	700m	31.4491^0 N	76.7048^0 E
	P5(Daggar)	Uttarakhand	785m	30.3718^0 N	78.1809^0 E
A2(800-1200 m)	P6 (Kalanjri Devi)	Hamirpur	854 m	31.6662^0 N	76.5410^0 E
	P7 (Sihunta)	Chamba	900 m	32.3017^0 N	76.0882^0 E
	P8 Dodar	Mandi	982m	31.6990^0 N	76.7324^0 E
	P9(Kuthar)	Solan	1127m	30.9731^0 N	76.9672^0 E
	P10(Kutuldi)	Uttarakhand	1136m	30.1839^0 N	78.2255^0 E
A3 (1200-1600 m)	P11(Awah devi)	Hamirpur	1219m	31.5871^0 N	76.5110^0 E
	P12 (Dharot)	Solan	1500m	30.9495^0 N	77.0949^0 E
	P13(Neri)	Shimla	1520m	31.0922^0 N	77.1269^0 E
	P14(Basni)	Sirmaur	1552m	30.8033^0 N	77.2275^0 E
	P15(Jagdhar)	Uttarakhand	1585m	30.3233^0 N	78.3984^0 E
A4 (1600-2000 m)	P16 (Shoghi)	Shimla	1712m	31.0421^0 N	77.1198^0 E
	P17 (Sangrah)	Sirmaur	1830m	30.6957^0 N	77.4257^0 E
	P18 (Ghanahatti)	Shimla	1900m	31.1385^0 N	77.0838^0 E
	P19 (Garhkhal)	Solan	1800m	30.9019^0 N	76.9809^0 E
	P20 (Ranichauri)	Uttarakhand	1730m	30.3212^0 N	78.4064^0 E

2.2 Statistical Analysis

The data derived were analyzed using the one way ANOVA. Statistical analysis was done by using OPSTAT software.

3. RESULTS AND DISCUSSION

The altitudinal variation (mean value) in leaf morphometric characteristics of *G. optiva* among populations has been documented in Table 2 and Fig 1. These features include leaf length (cm), leaf breadth (cm), leaf area (cm^2) and petiole length (cm).

Changes in the altitudinal zone were found to cause variations in the mean values of leaf morphometric parameters such as leaf length, leaf width, leaf area and petiole length. The highest value for the leaf morphometric characteristics was shown by populations in the A2 altitudinal zone, while, the lowest value was shown by populations in the A4 altitudinal zone.

Yuksek et al. [10] studied the variations in leaf length of *Vaccinium arctophylos* present at different altitude and found that the most extended leaf length was measured at the second altitude, while the lowest leaf length was found at the first altitude. The difference in leaf length can be attributed to a number of different causes, including environmental conditions, high pressure, and low air temperature, as well as the gradient in altitude. Yuksek et al. [10] studied variations in leaf width in *V. arctophylos* and documented that the average variation in leaf width (2.92-0.036 cm) was lowest at higher altitude, which matches the current study's findings. Bresson et al. [11] found leaf size of European oak and beech was negatively correlated with altitude. Pyakural and Wang, 2013 showed that the morphological variations in birch might be related to natural diversity in birch populations due to environmental differences at habitat origin. In current study we observed that leaf area increased with increasing altitudinal range from A1 to A2 and then further decreased from A2 to A4. The present investigation supported by Milla and Reich [12], they found that as elevation increased, leaves became thicker and water content reduced; However, Guo et al. [13] found that as elevation increased, leaves size became smaller. Plants can develop adaptive strategies in response to environmental change produced by an elevation gradient (Rudgers et al. 2019; Cui et al. 2020); [14]. According to Pan et al. [15] and Sun et al. [16], when elevation increases, the temperature always drops, limiting leaf area expansion due to heat and energy availability. However, according to our findings, the steadily rose up to 800-1200 m a m s l (A2 altitudinal zone). This counterintuitive pattern could be explained by the impact of precipitation, temperature fluctuations and variations in soil nutrients on leaf area [17].

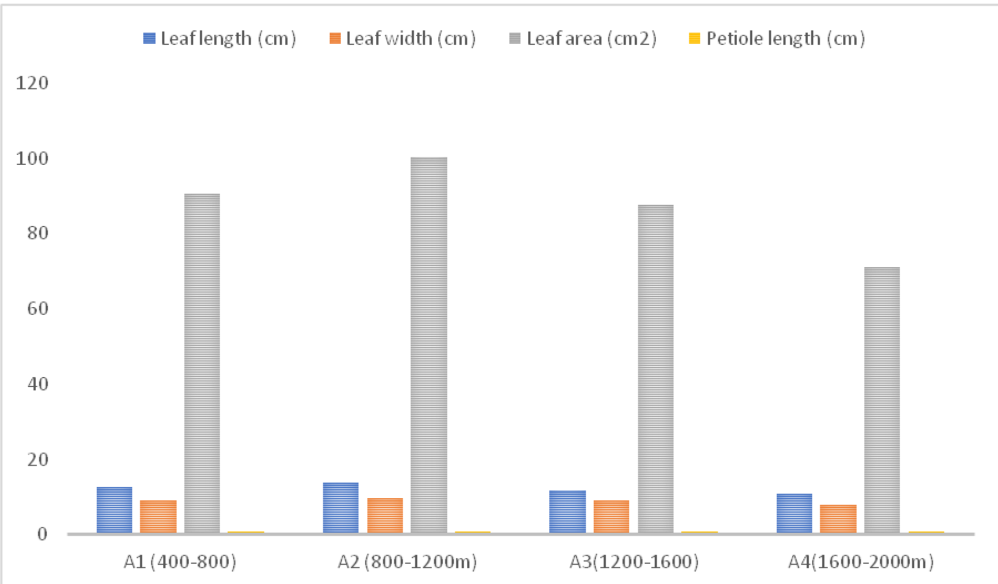

Fig. 1. Altitudinal variations in (mean value) leaf morphometric characteristics among populations of *Grewia optiva* Drummond

Table 2. Altitudinal variations in (mean value) leaf morphometric characteristics among populations of *Grewia optiva* Drummond

Altitudinal Zone (a m s l)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Petiole length (cm)
A1 (400-800 m)	12.74	9.09	90.86	0.99
A2 (800-1200 m)	13.97	9.67	100.40	1.05
A3(1200-1600 m)	11.82	9.23	87.65	0.97
A4(1600-2000 m)	11.07	8.07	71.16	0.95
SEM	0.73	0.07	2.71	0.05

4. CONCLUSION

The study well evaluated the adaptations in leaf traits over an altitudinal gradient in The North western Himalayas. Leaf area is one of the factors that agricultural experts, particularly agronomists, use to determine optimal agricultural practices. Based on the findings, the leaf areas steadily increase up to 800-1200 m a m s l (A2 altitudinal zone).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mukherjee A, Modal T, Bist JK and Pattanayak A. Farmer’s preference of fodder trees in mid hills of Uttarakhand: A comprehensive ranking using analytical hierarchy process. Range Management and Agroforestry. 2018;39:115-20.
2. Katoch R, Singh SK, Tripathi A, Kumar N. Effect of seasonal variation in biochemical composition of leaves of fodder trees prevalent in the mid-hill region of Himachal Pradesh. Range Management and Agroforestry. 2017;38:234-40.
3. Sahoo B, Garg AK, Mohanta RK, Bhar R, Thirumurgan P, Sharma AK and Pandey AB. Nutritional value and tannin profile of forest foliages in temperate sub-Himalayas. Range Management and Agroforestry. 2016;37:228-32.
4. Singh B, Makkar HPS, Negi SS. Rate and extent of digestion and potentially digestible dry matter and cell wall of various tree leaves. Journal of Dairy Science. 1989;72:3233-39.
5. Sankhyan HP, Bhagta S. Fodder quality analysis of open pollinated seedling seed orchard of *Grewia optiva* Drummond. The Bio Scan. 2016;11:709-13.
6. Bijalwan A, Dobriyal MJR. Productivity of wheat (*Triticum aestivum*) as intercrop in *Grewia optiva* based traditional agroforestry system along altitudinal gradient and aspect in midlle hills of Garhwal Himalaya, India. American Journal of Environmental Protection. 2014;2(5):94.
7. Niinemets U, Portsmuth A, Tena D, et al. Do we underestimate the importance of leaf size in plant economics? Disproportional scaling of support costs within the spectrum of leaf physiognomy, Annals of Botany (Lond). 2007;100:283.
8. Zahidi A, Bani-Aameur F, Mousadik A. Variability in leaf size and shape in three natural populations of *Arganiaspinosa* (L.) Skeels, International Journal of Current Research and Academic Review. 2013;1(3):13.
9. Pluess AR, Stöcklin J.. The importance of population origin and environment on clonal and sexual reproduction in the alpine plant Geum reptans, Functional Ecology. 2005;19:228 .
10. Yuksek F, Altun L, Karaoz O, Sengonul K, Yuksek T and Kucuk M., 2013. The Effect of Altitude on Soil Properties and Leaf Traits in Wild *Vaccinium arctostaphylos* L. Populations in the Forest Understory in Firtina River Basin. Paper published in the proceedings of International Caucasian Forestry Symposium held from October 24-26, Artvin, Turkey. 2013;577-583.
11. Bresson CC, Vitasse Y, Kremer A, Delzon S. To what extent is the altitudinal variation of functional traits driven by genetic adaptation in European oak and beech? Tree Physiology. 2011;31:1164 .
12. Milla R, Reich PB. The scaling of leaf area and mass: the cost of light interception increases with leaf size. P. Roy. Soc. B Biol. Sci. 2007;274:2109–2114. DOI: 10.1098/rspb.2007.0417.
13. Guo ZW, Lin H, Yang QP. Altitudinal patterns of leaf traits and leaf allometry in bamboo *Pleioblastus amarus*. Front. Plant Sci. 2018;9:1110.

DOI: 10.3389/fpls.2018.01110

14. Cubino JP, Biurrun I, Bonari G, Braslavskaya T, Font X, Jandt U, et al. The leaf economic and plant size spectra of European forest understory vegetation. Ecography. 2021;44:1311–1324. DOI: 10.1111/ecog.05598.
15. Pan S, Liu C, Zhang WP, Xu SS, Wang N, Li Y. The scaling relationships between leaf mass and leaf area of vascular plant species change with altitude. Plos One. 2013;8:e76872. DOI: 10.1371/journal.pone.0076872
16. Sun J, Fan RR, Niklas KJ, Zhong QL, Yang FC, Li, M. Diminishing returns, in the scaling of leaf area vs. dry mass in Wuyi Mountain bamboos. Southeast China. Am. J. Bot. 2017l104:993–998. DOI: 10.3732/ajb.1700068
17. Pyakurel A, Wang JR. Leaf morphological variation among paper birch (*Betula papyrifera* Marsh.) genotypes across Canada, Open Journal of Ecology. 2013;3(4):284.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103388