Annals of Arid Zone 64(2): 267-272, 2025

Performance of Buckwheat Genotypes in Leh-Ladakh

Anurag Saxena[1]*, M.S. Raghuwanshi[2], Stanzin Landol[3], Md. Raza[3] and Jigmat Stanzin[3]

[1]*ICAR-National Dairy Research Institute, Karnal 132 001, India*

[2]*ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur 440 033, India*

[3]*Regional Research Station, ICAR-Central Arid Zone Research Institute, Leh-Ladakh 194 201, India*

Received: December 9, 2024 Accepted: January 27, 2025

Abstract: Buckwheat (Fagopyrum spp.) is an adaptable crop, growing in a variety of situations that can tolerate a range of edaphic and abiotic stresses with notable nutritional and ecological value, making it ideal for high-altitude regions like Ladakh. This study investigates the morphological traits of different buckwheat genotypes and local varieties, being cultivated in Ladakh, with a major focus on assessing its adaptability to local environmental stressors, growth characteristics, and yield potential. The aim was to determine the morphological traits that best support resilience in Ladakh's cold-arid climate and to recommend suitable genotypes for their suitability in terms of yield attributes. Findings indicate that specific morphological characteristics, such as stem robustness and compact canopy structure, confer advantages in challenged situations like Ladakh. Highest seed yield (1210.7 kg ha^{-1}) and dry matter yield (22.01.1 kg ha^{-1}) was seen in IC-107116; it has green/brown stem colour with elliptic seed shape and green leaf blade colour.

Key words: Buckwheat, Ladakh, high-altitude agriculture, crop evaluation.

****Correspondence***
Anurag Saxena
drasaxena@gmail.com

Citation
Saxena, A., Raghuwanshi, M.S., Landol, S., Raza, M. and Stanzin, J. 2025. Performance of Buckwheat Genotypes in Leh-Ladakh. Annals of Arid Zone 64(2): 267-272

https://doi.org/10.56093/aaz.v64i2.162201

https://epubs.icar.org.in/index.php/AAZ/article/view/162201

Buckwheat is one of the domesticated crops of Asia and food crop of China since 5000 to 6000 years ago (Myers and Meinke, 1994; Hayder, 2021). While it is believed to be cultivated first in the Himalayan region of Asia from were spread to other part of the world. It provides food security to traditional and resource poor farming community since 1900s. There are different types of its cultivars available in Kargil and Turtuk i.e. common buckwheat called (Geyass) in local language and Tartary buckwheat (brow) and wild buckwheat (Khebrow) or weed. In many areas where agricultural production relies on a limited number of crops, biodiversity is at risk of significant decline. Buckwheat (*Fagopyrum* sp.) is an environmentally friendly crop with the potential to balance biodiversity preservation and crop productivity. It serves as an effective cover crop for weed suppression and aids in the ecological restoration of degraded ecosystems (Björkman and Shail, 2013). In addition, this crop helps in soil binding and checking soil erosion. It is one of the important and nutritious crops of the mountain regions and it is the only crop, which can be grown up to 4500 m (Joshi and Paroda, 1991) and this possesses a high lysine content, which is an important amino acid for human health (Kumar *et al*., 2024). Its cultivation is also linked to an increase in agricultural pollinator species (Taki *et al*., 2009). Several buckwheat species are cultivated globally, only few are widely utilized in agriculture and the food industry (Krkošková and Mrázová, 2005).

Buckwheat (*Fagopyrum esculentum*), a pseudo-cereal, holds a unique place in the agro-ecosystem of Ladakh, where agriculture is constrained by extreme climatic conditions and a short growing season. Despite its name, buckwheat is not related to wheat or the grass family (Ohnishi, 1998). The plant produces triangular seeds and flowers that are usually white, though pink or yellow variations also occur (Brennan, 2020). As a short-duration, broadleaved, herbaceous annual crop that thrives in moist, cool climates, buckwheat is well-suited for Ladakh's limited growing season, impacted by early winters and snowfall.

In high-altitude farming like Ladakh, morphological traits like stem robustness, leaf size, and canopy structure are critical for resilience against environmental challenges such as wind, low temperatures, and limited water availability. Although buckwheat is adaptable, there is limited research on evaluating morphological traits under Ladakh situations. This study evaluated key morphological characteristics of various buckwheat genotypes and examine their role in enhancing crop resilience and yield stability in a given situation of Leh-Ladakh.

Materials and Methods

The experiment took place at the Regional Research Station (RRS) of the ICAR-Central Arid Zone Research Institute (CAZRI) in Leh, Ladakh, situated at an altitude of 3,320 m above mean sea level, with geographical coordinates of 33.8°N latitude and 77.7°E longitude. During June and July, maximum temperatures in Leh ranged from 22°C to 25°C, while minimum temperatures varied between 5°C and 7°C. The temperature difference between day and night is significant during this period, reaching up to 18°C. Clear skies contribute to intense sunshine and high levels of insolation. Ladakh's cold-arid climate is characterized by minimal rainfall, intense solar radiation, and large diurnal temperature variations, necessitating unique adaptations in crop morphology. The availability of solar irradiation is abundantly available in cold arid regions at Leh-Ladakh e.g. 7-7.5 kWh m^{-2} day^{-1} (Santra, 2015). Prior to initiating the experiment, initial soil properties were analyzed. The soil was sandy loam in texture, had pH of 7.9, organic C 0.31% (Walkley and Black, 1934) and CEC 5.6 cmol p^{+} kg^{-1} (Schollenberger and Simon, 1945).

The experiment involved nine buckwheat genotypes: IC-107981, IC-329199, IC-107153, IC-341674, IC-107116, IC-328190, IC-37294, IC-107983, and IC-107982 and four local and proven landraces such as PRB-1, Himgiri, Local Kargil and Local Turtuk. These were evaluated in a Randomized Block Design (RBD) with three replications for two consecutive years 2019 and 2020. The plots were prepared by applying farmyard manure (FYM) at a rate of 10 t ha^{-1}. No inorganic fertilizer was added. For grain production, seeds of each genotype were sown in rows at with the seed rate 35 kg ha^{-1}, with row spacing of 30 cm and plant spacing of 15 cm, and at a soil depth of 5 cm (Sharma and Mir, 2000). Seedlings typically emerged within a period of 4 to 5 days. Two irrigations were applied before flowering and pod formation stages. Five plants were randomly tagged for recording of growth parameters randomly. All the growth and yield parameters were recorded till harvest. Leaf blade length and width were also measured using a meter scale, and expressed in centimeters. Morphological data were recorded throughout the growing season (May to September) across stages of germination, vegetative growth, and maturity.

The crop was harvested when seeds were fully matured (below 25% moisture content) and were dried to a moisture level of about 14% or less for safe storage. Seed yield was recorded. For dry matter yield at harvest, plants from one-meter continuous row length were sampled, sun-dried, then oven-dried at 65°C until a constant weight was reached, with dry matter yield expressed in kg ha^{-1}. The data were analyzed statistically using analysis of variance (ANOVA) for each quantitative parameter and significance was interpreted using F-test as per Gomez and Gomez (1984).

Table 1. Performance of different buckwheat genotypes and varieties with respect to plant height, leaf blade length and leaf blade width

Buckwheat variety	Plant height (cm)	Leaf blade length (cm)	Leaf blade width (cm)
PRB-1	91.0	6.7	6.6
IC-107981	108.8	5.6	5.8
IC-329199	92.4	4.4	5.0
IC-107153	121.4	6.2	6.6
IC-341674	90.6	5.5	6.4
Local Kargil	90.6	5.4	6.4
IC-107116	86.4	4.6	5.4
Local Turtuk	73.8	3.4	4.3
IC-328190	92.0	4.3	4.6
IC-37294	80.8	5.1	5.5
Himgiri	91.8	5.6	7.0
IC-107983	70.4	4.8	5.8
IC-107982	73.9	5.1	6.1
S.Em (±)	2.97	0.20	0.27
CD (0.05)	8.67	0.58	0.79

Results and Discussion

The farming region experiences a mean annual precipitation of 80 to 300 mm, which is regarded as scarce and minimal in the arid landscape of the mountainous terrain. The Himalayan Mountains and the Indus River system are two significant geographic features that limit the potential for large-scale agricultural activities in the Leh region. However, the area is unique and representative of the Tibetan plateau. Historically, its agriculture enabled the region to be self-reliant in food grains, particularly with small landholdings relying more on subsistence farming. Key crops grown include buckwheat, barley, and potatoes, cultivated on meticulously constructed stone-built terraces.

Table 1 presents the plant height measurements for various buckwheat genotypes. The plant height across the genotypes ranged from 70.4 cm to 121.4 cm. The maximum plant height (121.4 cm) was observed in the IC-107153 variety, followed by IC-107981 at 108.8 cm, both of which were significantly taller than IC-329199 (92.4 cm) and IC-328190 (92.0 cm). Local Kargil landraces and IC-341674 genotype recorded similar heights of 90.6 cm.

The plant heights of Local Turtuk and IC-107982 genotype were statistically comparable. PRB-1 and Himgiri genotypes measured 91.0 cm and 91.8 cm, respectively; although numerically different, the difference was not statistically significant. Similarly, IC-107116 (86.4 cm) and IC-37294 (80.8 cm) were also statistically at par. The shortest plant height (70.4 cm) was recorded in the IC-107983 variety.

Leaf blade lengths measured across different buckwheat genotypes has been presented in table 1. The maximum leaf blade length (6.7 cm) was recorded in the PRB-1 variety, which was statistically comparable to that of IC-107153 (6.2 cm). Both IC-107981 and Himgiri varieties displayed similar leaf blade lengths (5.6 cm), which were statistically at par with IC-341674 (5.5 cm) and Local Kargil (5.4 cm). Similarly, IC-37294 and IC-107982 exhibited leaf blade lengths of 5.1 cm, statistically comparable to IC-107983 (4.8 cm). The leaf blade length in IC-107116 was statistically similar to that of IC-329199. The shortest leaf blade length was recorded in the Local Turtuk landraces of buckwheat.

Data pertaining to leaf blade length of different buckwheat genotypes is presented in Table 1. Himgiri variety exhibited the widest leaf blades at 7.0 cm. The PRB-1 and IC-107153 varieties had similar leaf blade widths of 6.6 cm, which were statistically comparable to those of IC-341674 and Local Kargil. IC-107982 variety showed a 22% increase in leaf blade width compared to IC-329199, and it was significantly wider than that of IC-328190 (4.6 cm). However, IC-107982 was statistically similar to IC-107981, IC-107983, IC-37294, and

Table 2. Characteristics of different buckwheat genotypes

Variety	Stem colour	Seed shape	Leaf blade colour
PRB-1	dark brown	ovate	pale green
IC-107981	brownish	ovate	greenish
IC-329199	brown	ovate	green
IC-107153	pale red	ovate	green
IC-341674	pale red	ovate	pale green
Local Kargil	pale red	tetrahedral	pale green
IC-107116	green/brown	elliptic	green
Local Turtuk	green whole	triangular with broad base and pointed tip	light green
IC-328190	reddish green	elliptic	green
IC-37294	brownish	ovate	green
Himgiri	light green to brown	elliptic	light green
IC-107983	light green brownish	elliptic	green
IC-107982	reddish	elliptic	brownish green

IC-107116, which had widths of 5.8 cm, 5.8 cm, 5.5 cm, and 5.4 cm, respectively. The narrowest leaf blade width (4.0 cm) was observed in the Local Turtuk variety.

Considerable variation was observed in flower colour, leaf blade colour, and stem colour among different buckwheat genotypes (Table 2). The PRB-1 variety displayed pinkish-white flowers on a dark brown stem with pale green leaf blades, while none of the other varieties produced flowers. The IC-107982 variety exhibited a reddish stem colour with brownish-green leaf blades.

The IC-107153, IC-341674 genotypes and Local Kargil variety had pale red stems, though they differed in leaf blade color. IC-107153 displayed green leaf blades, whereas IC-341674 and Local Kargil showed pale green leaf blades. The IC-107981 and IC-37294 genotypes both had brownish stems but varied in leaf blade color, with IC-107981 showing greenish leaf blades and IC-37294 green leaf blades.

The Himgiri and IC-107983 had stems that ranged from light green to brownish, yet differed in leaf blade color. Himgiri had light green leaf blades, while IC-107983 had green leaf blades. genotypes IC-329199, IC-107116, and IC-328190 all showed green leaf blades but had varying stem colors: IC-329199 had a brown stem, IC-107116 showed a green-brown stem, and IC-328190 exhibited a reddish-green stem.

Table 2 presents the seed shapes of various buckwheat genotypes, which were categorized into two types: ovate and elliptical. The PRB-1, IC-107981, IC-329199, IC-107153, and IC-37294 genotypes exhibited ovate-shaped seeds, while elliptical-shaped seeds were observed in IC-107116, IC-328190, Himgiri, IC-107983, and IC-107982 genotypes.

The highest yield (Table 3) was recorded in IC-107116 (1210.7 kg ha^{-1}) followed by IC-37294 (1066.7 kg ha^{-1} IC-107983 (993.7 kg ha^{-1}) and Local Kargil (960 kg ha^{-1}). Table 3 presents the dry matter yield recorded across different buckwheat genotypes, which ranged from 333.3 to 2200.1 kg ha^{-1}. It was noted that the dry matter yield was almost double of the grain yield of the crop. The highest dry matter yield (2200.1 kg ha^{-1}) was observed in the IC-107116 at par to IC-107983 (2140.2), followed by 1869.9 kg ha^{-1} in IC-37294. The dry matter yield of Local Turtuk and Kargil were 736.7 and 1806.7 kg ha^{-1}, respectively.

The findings suggest that while high-yielding varieties offer greater productivity, local buckwheat genotypes provide essential advantages in terms of resilience and nutritional value (Chou *et al*., 1999; Dziedzic *et al*., 2012). The short growing season and risk of late frost underscore the importance of selecting varieties with rapid maturation and cold tolerance. Integrating both high-yielding and locally adapted varieties could potentially allow farmers to maximize yield while ensuring crop stability, crucial for food security in high-altitude regions.

Table 3. Performance of different buckwheat genotypes with respect to seed and dry matter yield

Buckwheat variety	Seed yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})
PRB-1	309.3	703.3
IC-107981	381.3	624.3
IC-329199	426.7	788.21
IC-107153	549.3	1106.7
IC-341674	136.0	351.3
Local Kargil	960.0	1806.7
IC-107116	1210.7	2200.1
Local Turtuk	298.7	736.7
IC-328190	197.3	501.4
IC-37294	1066.7	1869.9
Himgiri	197.3	333.3
IC-107983	993.7	2140.2
IC-107982	530.7	945.10
CD (= 0.05)	67.71	145.67
S.Em (±)	23.20	49.91

The observed trade-offs between productivity and adaptability highlight a potential breeding pathway to develop new varieties that combine high yield with environmental resilience. Additionally, the higher nutritional value of local varieties supports the case for their conservation as an important food resource in Ladakh's agroecosystem.

Conclusion

This evaluation of buckwheat genotypes revealed that the significant differences in yield, nutritional quality, and environmental adaptability. Local varieties are well-suited to Ladakh's unique conditions, offering advantages in resilience and nutrition, while high-yielding genotypes provide promising options for productivity. The highest seed yield (1210.7 kg ha^{-1}) and dry matter yield (22.01.1 kg ha^{-1}) was seen in IC-107116 which has as green/brown stem colour with elliptic seed shape and green leaf blade colour. Hence, IC 107116 is better for overcoming of seed and fodder shortage in Ladakh. Integrating both types can enhance food security while preserving biodiversity in Ladakh. Further research focusing on breeding programs tailored to Ladakh's high-altitude conditions could foster the development of optimized varieties for this region.

References

Björkman, T. and J. W. Shail. 2013. Using a buckwheat cover crop for maximum weed suppression after early vegetables. *HortTechnology* 23(5): 575–580. doi: 10.21273/HORTTECH.23.5.575.

Brennan, D. 2020. Health benefits of buckwheat, Nourish by WebMD, 2 September 2020. https://www.webmd.com

Cho, S.S., Prosky, L. and Dreher, M. 1999. *Complex Carbohydrates in Foods*. Marcel Dekker, Inc., New York, NY.

Dziedzic, K., Gorecka, D., Kucharska, M. and Przybylska, B. 2012. Influence of technological process during buckwheat groats production on dietary fibre content and sorption of bile acids. *Food Research International* 47: 279-283.

Gomez, K. A. and Gomez, A. A. 1984. *Statistical Procedures for Agricultural Research*. John Wiley & Sons.

Hayder, Yadullah 2021. Buckwheat (*Fagopyrum* sp.) in Turtuk Valley (Ladakh India). *International Journal of Research Publication and Reviews* 2(9):19-23.

Joshi, B.D. and Paroda, R.S. 1991. *Buckwheat in India*. NBPGR, Shimla Sci. Monogr. No. 2, pp. 1-117.

Kumar, H., Guleria, S., Kimta, N., Dhalaria, R., Nepovimova, E., Dhanjal, D.S., Alomar, S.Y. and Kuca, K. 2024. Amaranth and buckwheat grains: Nutritional profile, development of functional foods, their pre-clinical cum clinical aspects and enrichment in feed. *Current Research in Food Science* 9: 100836. doi: 10.1016/j.crfs.2024.100836

Krkošková, B. and Mrázová, Z. 2005. Prophylactic components of buckwheat. *Food Research International* 38(5): 561-8. doi: 10.1016/j.foodres.2004.11.009.

Myers, R.L. and Meinke, L.J. 1994. Buckwheat multiple purpose short season. University of Missouri. *Extension Bulletin* G-4306.

Ohnishi, O. 1998. Search for the wild ancestor of buckwheat: The wild ancestor of cultivated common buckwheat and of Tartary buckwheat. *Economic Botany* 52(2): 123-133.

Santra, P. 2015. Scope of Solar Energy in Cold Arid Region of India at Leh Ladakh. *Annals of Arid Zone* 54(3&4): 109-117.

Schollenberger, C.J. and Simon, R.H. 1945. Determination of exchange capacity and exchangeable bases in soil—ammonium acetate method. *Soil science* 59(1): 13-24.

Sharma, J.P. and Mir, A.A. 2000. Agronomic techniques for sustainable crop production. In: *Dynamics of Cold Arid Agriculture*, pp. 59-81. Kalyani publisher, Ludhiana, India.

Taki, H., Okabe, K., Makino, S., Yamaura, Y. and Sueyoshi, M. 2009. Contribution of small insects to pollination of common buckwheat, a distylous crop. *Annals of Applied Biology* 155(1): 121-129. doi: 10.1111/j.1744-7348.2009.00326.x.

Walkley, A.J. and Black, I.A. 1934. Estimation of soil organic carbon by the chromic acid titration method. *Soil Science* 37: 29-38.

Printed in June 2025