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Bhat (Black soybean):
A sustainable choice for hill farming

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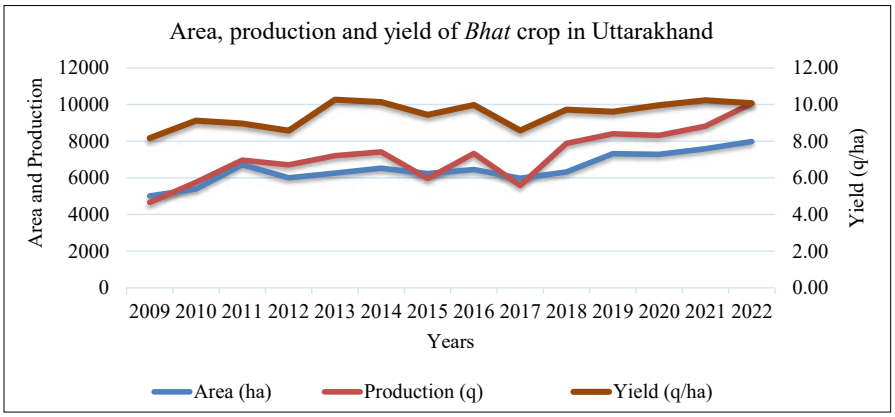
Bhat, *a legume crop, is cultivated in the hill regions of Uttarakhand under organic conditions. It thrives well in high-altitude, nutrient-poor soils and has become a staple in the local diet due to its nutritional benefits.* Bhat *is particularly nutrient-dense, containing sufficient amounts of protein, fat, carbohydrates, dietary fibre, and minerals. The trend analysis of* Bhat *crop performance in Uttarakhand shows that its production has increased by 3.25%, driven by both an increase in cultivated area (2.08%) and yield (1.02%) over the past 15 years. This steady growth reflects both farmer and consumer preference for* Bhat *and its sustainability amidst changing climate. The trend analysis revealed better growth and stability of* Bhat *in Kumaon region in comparison to Garhwal. To ensure sustainable production of* Bhat *in the future, it is essential to promote the latest varieties (VL Bhat 201 and VL Bhat 202) and scientific management practices among farmers and increase consumer awareness to support nutritional and economic security.*

Keywords: Black soybean, Climate resilience, Hill agriculture, Productivity trends

THE black-seeded soybean, *Glycine max* (L.) Merrill, member of the Fabaceae family, is a *kharif* season crop, locally known as *Bhat* or *Bhatmas,* and is cultivated widely in the Kumaon region of Uttarakhand. *Bhat* serves as a popular dietary staple in hills, given its nutritious richness and adaptability to grow at different altitudes up to 2286 m amsl. This crop suits well to agroecology of hills, thriving in poor soil and rainfed conditions making it an essential part of the region's food and nutritional security. Local communities enjoy *Bhat* in various traditional forms such as roasted whole beans, chutneys, and dals/ gravies, which makes it an essential part of the region's ethno-culinary traditions.

In terms of nutritional composition, it is a rich source of proteins (32.1–39.8%), fats (10.8–19.6%), carbohydrates (30%), dietary fibre (21.77–30.31%) and minerals (3.93–6.15%) which contribute significantly to the balanced diets. Beyond its nutritional values, *Bhat* demonstrates its remarkable adaptability to the climatic variabilities. The crop is of hardy nature and survives well under moisture stress, requires minimal external inputs and has a short crop duration, all of which makes it an ideal crop for smallholder rainfed based hill agriculture. Owing to these traits, *Bhat* is often regarded as a climate resilient, potential crop for sustainable hill agriculture. In this lieu, it becomes imperative to determine the status of the crop through the assessment of district wise trends of the crop area, production and productivity over the years. Crop performance analysis helps to have valuables insights for future strategies and planning for *Bhat* across Uttarakhand.

In Uttarakhand, traditional farming systems are experiencing a dip in area and production. Although, food grains still dominate the cropping area dynamics in the state, their share in total area has dropped down from 90.85% in 2000 to 84.86% in 2023. But the area dedicated to pulse production has increased in the same time-period from 5.26–6.51%. Similar upward moving trend in area, production and productivity in *Bhat* crop is observed over the time-period between 2009–2022. In this period, the area dedicated to *Bhat* has increased from 5,013 ha to 7,983 ha with production increasing from 4,660 MT to 9,564 MT and average yield moving up from 8.17 q/ha to 11.98 q/ha. *Bhat* occupies 19% of the total area under *kharif* season pulses, emerging as one of the major pulses in Uttarakhand. These trends indicate farmers' interest in *Bhat* cultivation, driven by its low-input intensive, more resilient and hardy nature. The simultaneous rise in area, production and average yield highlight not just wider adoption but better crop performance, attributed to traditional food preferences in the state and rising consumer demands in nearby metropolitan areas, improved cultivation practices, and increased awareness regarding *Bhat's* nutritional and



Source: https://agriculture.uk.gov.in/pages/display/224-department-structure

ecological advantages. Overall, the positive trends also underscore *Bhat's* potential to contribute for sustainable mountain farming, agro-ecological conservation, and livelihood resilience in Uttarakhand. However, supportive policy measures, market linkages and value addition are a must to strengthen the crop scenario in the state.

Trend analysis

***Trend analysis of* Bhat *in Uttarakhand*:** To estimate the long-term growth pattern and structural changes in the area, production and yield of *Bhat* in Uttarakhand, a trend analysis was carried out using Compound Annual Growth Rate (CAGR) approach. While growth estimate suggests the direction and magnitude in the parameters, they do not reflect the year-to-year variabilities. Hence, to assess the instability and fluctuation in *Bhat* performance, Cuddy-Della Valle Instability Index (CDVI) index was calculated. The dual approach of CAGR and CDVI ensures a comprehensive understanding of crop growth parameters and their stability over time.

To interpret the CDVI results, the index values are categorized into three levels:

Table 1. Formulae used to estimate growth (CAGR) and instability (CDVI) in *Bhat* cultivation

Sr. No.	Formula
CAGR (Compound Annual Growth Rate)	$y_t = a + b_t + U_t$ g = (antilog b - 1) * 100
CDVI (Cuddy-Della Valle Instability Index)	CDVI = CV*(1-Adjusted $R^2)^{0.5}$

- **Low instability (0–15):** This range indicates minimal fluctuations, suggesting stable trends in the variable, which is desirable for planning and sustainability.
- **Medium instability (>15–30):** Medium instability suggests some degree of unpredictability, which may necessitate moderate risk management measures.
- **High instability (>30):** Values in this range indicate substantial fluctuations, highlighting a high degree of volatility, which could imply vulnerability to external shocks (e.g. weather, market prices) and may require significant intervention for.

Performance of *Bhat* crop

The results of the trend analysis vis-a-vis area, production and yield of black seeded soybean have been presented in Table 2. The results demonstrated that the overall production of *Bhat* in Uttarakhand has increased by 3.25%, driven by expansion in area and yield. Specifically, the total area under cultivation has expanded by 2.08%, while the yield per unit area has improved by 1.02% during 2008–2022 period. In Kumaon region, Nainital witnessed the maximum growth in area, production, and yield. Along with Nainital, Pithoragarh, Bageshwar, Almora and Champawat are the major *Bhat* cultivating districts, contributing significantly to the overall increase in output. The CDVI values for these districts indicated overall stability in crop performance indicators, essential for scientific cultivation interventions. However, in the Garhwal region of the state, there is a decreasing trend for area and production, highlighting the general decline in area under agriculture and a structural shift toward cash crops in plain regions like Dehradun. It is evident from the fact that Dehradun district observed a major decline in area, production and yield of *Bhat* crop. The CDVI values suggested that *Bhat* crop performance is more stable in Kumaon region, compared to Garhwal. However, in context of Uttarakhand, the CDVI of area, yield, and production in the last 14 years has shown low instability values implying steady growth, suitable for future scientific interventions in form of high yielding varieties and management practices.

VLB 202 crop in field

Amidst the backdrop of declining overall agricultural production in hills, *Bhat* crop has shown remarkable resilience through expansion in area and production in the last decade. The major factors responsible for the expansion are: a) climatic adaptability of crop which assures stable production to the farmers, b) nutritional richness that boosts its demand among consumers from hills as well as from plain regions, and c) traditional and cultural dominance of *Bhat* in the state. These factors have resulted in the growth of *Bhat* in Uttarakhand, posing it as an alternative to other food grain crops.

Table 2. District-wise performance and CDVI values of black soybean (2008–22)

District	CAGR			CDV Index values		
	Area	Production	Yield	Area	Production	Yield
Kumaon Division						
Almora	1.86%	3.00%	1.21%	5.19	20.83	15.68
Bageshwar	2.90%	4.76%	1.86%	20.54	17.46	8.54
Champawat	0.88%	4.04%	3.52%	19.54	19.46	6.19
Nainital	6.92%	11.37%	3.98%	41.09	38.04	4.71
Pithoragarh	4.02%	5.36%	1.38%	8.85	10.12	11.06
Garhwal Division						
Chamoli	-0.69%	-0.85%	-0.11%	13.93	14.62	5.25
Dehradun	-18.21%	-18.72%	-4.27%	39.25	43.50	29.99
Pauri Garhwal	-5.37%	-4.51%	0.95%	12.18	15.44	7.02
Rudarprayag	-6.96%	-7.85%	-0.72%	48.04	42.18	7.70
Tehri Garhwal	-4.93%	-2.96%	2.08%	29.36	26.66	4.50
Uttarkashi	-4.93%	-2.96%	2.08%	23.82	22.72	5.14
Overall	2.08%	3.25%	1.02%	6.58	11.38	5.41

Data Source: https://agriculture.uk.gov.in/pages/display/224-department-structure (Authors own estimates)

Constraints and way forward

Despite having considerable growth in the area and production, productivity of *Bhat* remains stagnant, resulting in poor economic gains to growers. Farmer often cultivate local cultivars which are of indeterminate and lodging prone plant types with low yield potential of around 600 kg/ha. Consequently, evidences from literature highlights that the returns from the *Bhat* cultivation remain unviable with a benefit:cost ratio below 0.5. Farmers' lack of awareness regarding improved varieties, unavailability of quality seed and inputs, high extension gap and local cultivation practices negatively affect the overall gains.

Notably, some improved varieties of *Bhat*, released by ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora have demonstrated high yield potential, which can significantly enhance the productivity and economic gains in the region. Therefore, there is an urgent need to popularise these varieties among farmers along with scientific management practices to improve the status of the crop.

Grains of *Bhat*

Table 3. *Bhat* varieties with high yield potential

Bhat variety	Average yield (t/ha)
VL *Bhat*-201	1.64
VL *Bhat*-202	1.59
VLS-77	1.9
VLS-89	2.32
VLS-99	2.3

Furthermore, recent initiatives of Government of Uttarakhand aimed at promoting and branding local organic products have enhanced the demand and better market prices, indicating bright economic prospects for the *Bhat* crop. There exist entrepreneurial opportunities for local youth in targeting and exploring niche markets for promoting the crop. However, realising this potential requires coordinated efforts among researchers, extension agencies, and farmers to ensure timely availability of high-yielding varieties, adoption of scientific cultivation practices, and establishment of effective marketing linkages.

SUMMARY

Climate resilience and nutritional richness of *Bhat* crop make it a potential crop for rainfed-based hill agro-ecosystem. Crop performance showcases an increasing and steady trend in its area, production and productivity over the years, highlighting its resilience despite having a decrease in overall agricultural production in hill region. *Bhat* is highly adapted to high altitudes, nutrient poor soil conditions, which increases its suitability for small and marginal farmers of mountains. Furthermore, this pulse crop is deeply embedded in the traditional food and dietary habits of Uttarakhand. The crop is highly nutritious, containing significant proportions of minerals and dietary fibres. Apart from its dietary importance, *Bhat* is highly climate resilient and tolerant to moisture stress with low input requirements. These traits position *Bhat* as a sustainable option for hill farming system in Uttarakhand. The trend analysis of *Bhat* using Compound Annual Growth Rate (CAGR) and Cuddy-Della Valle Instability Index for the time period between 2008–22, unveiled growth and stability in *Bhat* cultivation, especially in Kumaon region of the state. The overall area increased at an annual rate of 2.08%, backed by a 3.25% increase in production and a 1.02% consequent increase in yield. Furthermore, *Bhat* crop has witnessed an increase in total area, production and average yield, accounting for 19% of the total pulse area in the state. District wise analysis revealed more stable performance in Kumaon districts of Nainital, Pithoragarh, Bageshwar, Almora and Champawat, whereas, the Garhwal districts show negative growth in *Bhat* area, with Dehradun exhibiting the major declining trends. The major concern for *Bhat* cultivators is its lower yield and high dependence on local cultivars leading to poor economic returns. With the introduction of high yielding cultivars, growers could potentially increase the productivity and profitability of *Bhat* in the region, which further offers many entrepreneurial opportunities for effective market linkages. With the right support, black soybean could become a staple food beyond the hills, improving both farmer's income and nutritional security.

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