



# **Evaluation of Varietal and Location Effects on Growth, Yield and Economics of Potato (*Solanum tuberosum* L.) in Eastern Uttar Pradesh, India**

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## **Authors' contributions**

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

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## ABSTRACT

Potato (*Solanum tuberosum* L.) is the fourth most important food crop globally after maize, wheat, and rice and plays a vital role in food and nutritional security. In India, it is a major Rabi crop with Uttar Pradesh as the leading producer. However, potato performance varies across environments, making location and variety-specific evaluations essential for enhancing productivity and profitability. The present study was conducted during the Rabi season of 2024-25 in three blocks of Siddharth Nagar district, Uttar Pradesh, namely Bansi (L<sub>1</sub>), Barhni (L<sub>2</sub>) and Itwa (L<sub>3</sub>), to evaluate the growth, yield and economics of four potato varieties: Lal Gulab (V<sub>1</sub>), Chipsona-1 (V<sub>2</sub>), Kufri Sindhuri (V<sub>3</sub>), and Kufri Pukhraj (V<sub>4</sub>). The experiment was laid out in a factorial randomized block design with three replications. Significant differences were observed among locations and varieties. Barhni recorded the tallest plants (32.68 cm) and maximum shoots per plant (4.75), while Itwa produced the highest tuber number per plant (7.40) and average tuber weight (61.79 g). The maximum tuber yield (27.37 t ha<sup>-1</sup>) was observed at Bansi (L). Among varieties, Kufri Pukhraj outperformed others, recording the highest plant height (36.12 cm), tuber number (9.50), tuber weight (72.64 g) and yield (30.20 t ha<sup>-1</sup>), followed by Chipsona-1. Lal Gulab was the lowest-yielding variety (25.40 t ha<sup>-1</sup>). Economic analysis revealed Kufri Pukhraj as the most profitable with gross return ₹447,556 ha<sup>-1</sup>, net return ₹331,069 ha<sup>-1</sup> and B:C ratio 2.84. Overall, Kufri Pukhraj demonstrated superior adaptability and profitability across all locations. These findings provide strong evidence for recommending Kufri Pukhraj to farmers in the region, as its higher yield and profitability can directly enhance farm income and support sustainable potato cultivation.

**Keywords:** Potato; varieties; location; economic analysis; yield performance.

## 1. INTRODUCTION

“Potato (*Solanum tuberosum* L.) is one of the most important non-grain food crops in the world, ranking third after rice and wheat in terms of human consumption and fourth in terms of global output” (Andati et al., 2023). Globally, it is cultivated on more than 19 million hectares with an annual production exceeding 350 million tonnes (Martini et al., 2023). The crop is valued not only as a staple source of carbohydrates but also for its rich nutritional profile, including dietary fiber, vitamin C, potassium and antioxidant compounds, which make it an integral component of balanced diets (Górska-Warsewicz et al., 2021; Li et al., 2025). Moreover, potato is one of the most efficient crops in terms of dry matter production per unit area and time, thus offering high yield potential and food security benefits, particularly in developing countries (Amare et al., 2022; Asnake et al., 2023). In India, potato has a long history of cultivation and plays a pivotal role in the vegetable economy. The country ranks among the top producers globally after china (Kumar and Shobana, 2024), with Uttar Pradesh contributing more than 30% to the national production (Kovalev, 2024). Potato is grown across diverse agro-climatic zones of the country, from the Indo-Gangetic plains to high-altitude regions, under both irrigated and rainfed conditions (Kumar et al., 2015; Bhardwaj et al., 2022; Bhardwaj et al., 2023). Its short growth

cycle, high productivity and suitability for multiple cropping systems have made it a preferred crop for farmers. Beyond domestic consumption, potato also has significant industrial importance, being used in chips, French fries, starch and alcohol production, thereby contributing to agribusiness and rural livelihoods (Hameed et al., 2018; Kumar et al., 2024; Hu et al., 2025).

Despite its potential, potato productivity and profitability are often constrained by several factors, including the choice of unsuitable varieties, climatic variability and soil-related constraints (Mdoda et al., 2023). Farmers in many regions, including Eastern Uttar Pradesh, still rely on traditional varieties with lower yield potential and limited market demand. In contrast, improved varieties such as Kufri Pukhraj, Kufri Sindhuri, Chipsona-1 and Lal Gulab have been developed to cater to diverse consumer and industrial preferences, combining desirable traits such as high yield, better storability and disease tolerance. However, varietal performance is highly location-specific, as growth, yield attributes and tuber bulking are influenced by agro-ecological conditions, soil fertility and management practices (Rana et al., 2009; Kharumnuid et al., 2021; Biradar et al., 2025). Equally important is the economic viability of potato cultivation, which determines farmers' adoption of improved varieties. While yield is a key determinant, profitability is governed by

multiple factors including cost of cultivation, market price and benefit–cost (B:C) ratio. Hence, varietal evaluation should integrate both agronomic performance and economic returns to provide practical recommendations for farmers (Rai and Bajgai, 2023; Kumar et al., 2025; Rai et al., 2025).

The Siddharth Nagar district of Uttar Pradesh, situated in the North-Eastern Plain Zone, represents an important potato-growing area with clay loam to sandy loam soils and a subtropical climate. The district is characterized by small and marginal farmers, where selection of suitable potato varieties can play a crucial role in enhancing yield and farm income. In this context, systematic evaluation of popular potato varieties across different locations in the district is essential for identifying the most productive and profitable options. Therefore, the present investigation was undertaken to study the growth behavior, yield attributes, tuber yield and economics of four potato varieties across three blocks of Siddharth Nagar district, with the ultimate aim of recommending the most suitable variety for enhancing productivity and profitability in the region.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The field experiment was carried out during the Rabi season of 2024-25 at three blocks of Siddharth Nagar district, Uttar Pradesh, India, geographically situated between 27°00' to 27°28' N latitude and 82°45' to 83°10' E longitude. The study area falls under the North-Eastern Plain Zone (Zone VII) and is characterized by a subtropical climate with hot, dry summers and cold, dry winters. The maximum temperature during May-June reaches up to 43 °C, whereas in December-January it declines to about 4 °C. The region receives an average annual rainfall of approximately 1300 mm, the majority of which occurs during the monsoon months of July to September. The predominant soil types of the experimental sites range from clay loam to sandy loam.

### 2.2 Experimental Details

The experiment was conducted using a two-factorial randomized block design (RBD) comprising three locations, namely L<sub>1</sub>: Bansi, L<sub>2</sub>: Barhni, and L<sub>3</sub>: Itwa and four potato varieties, viz. V<sub>1</sub>: Lal Gulab, V<sub>2</sub>: Chipsona-1, V<sub>3</sub>: Kufri Sindhuri

and V<sub>4</sub>: Kufri Pukhraj. Each treatment was replicated thrice, with the varieties evaluated from ten farmers' fields within each block. The experimental fields were prepared by two passes of a cultivator followed by one pass of a rotavator. Planting was carried out using a potato planter at a spacing of 30 cm × 45 cm. Fertilizer was applied at the recommended rate of 150:80:100 kg N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O ha<sup>-1</sup> through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The full doses of phosphorus and potassium, along with 50% of nitrogen, were applied as basal at the time of sowing, while the remaining 50% nitrogen was top-dressed in split applications. Weed management was accomplished manually by hand weeding at 30 days after sowing (DAS). Irrigation was scheduled four times at appropriate intervals during the crop growth period. The recorded data were subjected to statistical analysis of variance (ANOVA) following the procedures outlined by Gomez and Gomez (1984). The study was undertaken under the SARAL Project, implemented across 150 Gram Panchayats of Siddharth Nagar district, covering 30,000 smallholder and marginal farmers. The project is supported by The Hans Foundation and executed by People's Action for National Integration (PANI), Ayodhya.

## 3. RESULTS AND DISCUSSION

### 3.1 Yield Attributes

The results indicated that location and varietal differences significantly influenced the growth and yield performance of potato (Table 1 and Fig. 1). Among the locations, Barhni recorded the tallest plants (32.68 cm) and the maximum number of shoots per plant (4.75), while Itwa produced the highest number of tubers per plant (7.40) and average tuber weight (61.79 g). The maximum tuber yield (27.37 t ha<sup>-1</sup>) was obtained at Bansi, whereas Barhni had the lowest yield (27.17 t ha<sup>-1</sup>). Across varieties, Kufri Pukhraj performed best, with the highest plant height (36.12 cm), number of tubers per plant (9.50), average tuber weight (72.64 g) and tuber yield (30.20 t ha<sup>-1</sup>), while Chipsona-1 produced the maximum number of shoots per plant (5.00). Conversely, Lal Gulab exhibited the lowest performance for plant height (29.25 cm), tuber weight (56.25 g) and yield (25.40 t ha<sup>-1</sup>). Kufri Sindhuri, despite having relatively taller plants (33.00 cm), recorded the lowest number of tubers per plant (5.50) and a moderate yield (26.25 t ha<sup>-1</sup>). The location × variety interaction

was significant for plant height and tuber weight, with Kufri Pukhraj at Barhni recording the maximum plant height and at Itwa the highest tuber weight, while Lal Gulab at Bansi and Kufri Sindhuri at Bansi registered the lowest values, respectively.

### 3.2 Economic Returns

The economic analysis of potato cultivation as influenced by different locations and varieties is presented in Table 2 and Fig. 2. The cost of cultivation remained nearly uniform across locations, ranging from ₹119,364 ha<sup>-1</sup> (Barhni) to ₹119,703 ha<sup>-1</sup> (Itwa), while among varieties, it varied slightly, being highest in Lal Gulab

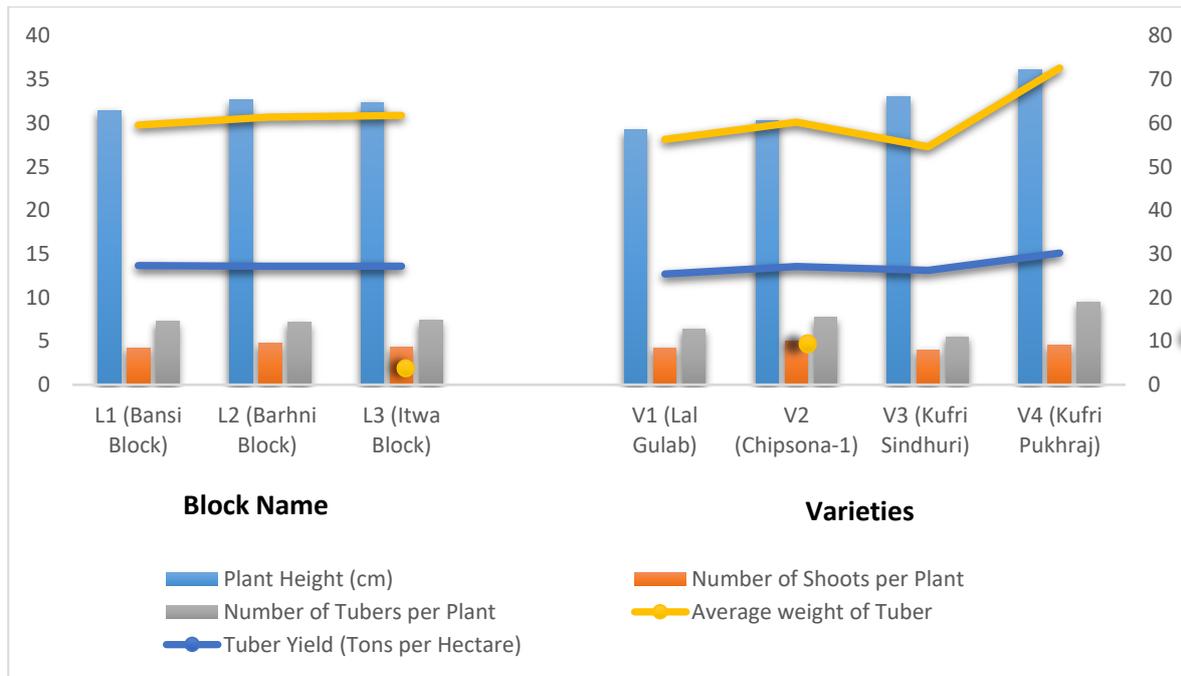
(₹120,434 ha<sup>-1</sup>) and lowest in Kufri Pukhraj (₹116,486 ha<sup>-1</sup>). Gross and net returns did not differ significantly among locations, though Bansi recorded slightly higher gross return (₹410,550 ha<sup>-1</sup>) and net return (₹291,143 ha<sup>-1</sup>) compared to Barhni and Itwa. Similarly, the benefit–cost (B:C) ratio across locations remained statistically at par, ranging from 3.41 to 3.44. In contrast, varietal differences exhibited significant effects on gross and net returns as well as B:C ratio. Kufri Pukhraj recorded the highest gross return (₹452,983 ha<sup>-1</sup>), net return (₹336,497 ha<sup>-1</sup>) and benefit–cost ratio (3.89), indicating its superior economic viability over other varieties. Chipsona-1 followed next with gross and net returns of ₹406,833 ha<sup>-1</sup> and ₹286,304 ha<sup>-1</sup>, respectively

**Table 1. Effect of location and varietal differences on growth, yield attributes and tuber yield of potato**

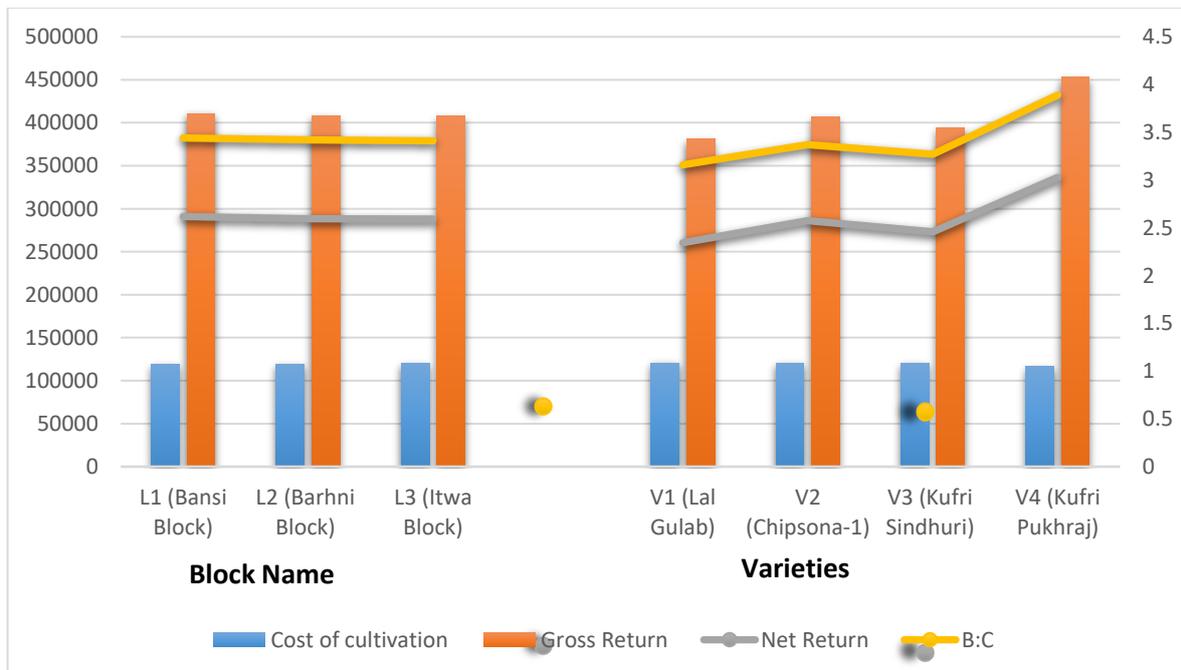
Treatments	Plant Height (cm)	Number of Shoots per Plant	Number of Tubers per Plant	Average weight of Tuber	Tuber Yield (Tons per Hectare)
<b>Block Name</b>					
L <sub>1</sub> (Bansi Block)	31.44	4.23	7.27	59.54	27.37
L <sub>2</sub> (Barhni Block)	32.68	4.75	7.16	61.42	27.17
L <sub>3</sub> (Itwa Block)	32.40	4.33	7.40	61.79	27.18
SEM ±	0.27	0.15	0.14	0.48	0.21
CD (P=0.05)	0.78	NS	NS	1.40	NS
<b>Varieties</b>					
V <sub>1</sub> (Lal Gulab)	29.25	4.25	6.40	56.25	25.40
V <sub>2</sub> (Chipsona-1)	30.33	5.00	7.70	60.20	27.12
V <sub>3</sub> (Kufri Sindhuri)	33.00	4.00	5.50	54.58	26.25
V <sub>4</sub> (Kufri Pukhraj)	36.12	4.50	9.50	72.64	30.20
SEM ±	0.31	0.18	0.16	0.55	0.25
CD (P=0.05)	0.90	0.52	0.48	1.62	0.72
L*V Interaction	1.56	NS	NS	2.80	NS

**Table 2. Effect of location and varietal differences on Economics of potato cultivation**

Treatments	Cost of cultivation	Gross Return	Net Return	B:C
<b>Block Name</b>				
L <sub>1</sub> (Bansi Block)	119407	410550	291143	3.44
L <sub>2</sub> (Barhni Block)	119364	407613	288249	3.42
L <sub>3</sub> (Itwa Block)	119703	407700	287997	3.41
SEM ±	861	3194	3194	0.03
CD (P=0.05)	NS	NS	NS	NS
<b>Varieties</b>				
V <sub>1</sub> (Lal Gulab)	120434	380983	260549	3.16
V <sub>2</sub> (Chipsona-1)	120529	406833	286304	3.37
V <sub>3</sub> (Kufri Sindhuri)	120516	393683	273167	3.27
V <sub>4</sub> (Kufri Pukhraj)	116486	452983	336497	3.89
SEM ±	994	3688	3688	0.03
CD (P=0.05)	NS	10815	10815	0.09
L*V Interaction	NS	NS	NS	NS



**Fig. 1. Graph showing the Effect of location and varietal differences on growth, yield attributes and tuber yield of potato**



**Fig. 2. Graph showing the Effect of location and varietal differences on Economics of potato cultivation**

and a B:C ratio of 3.37. Kufri Sindhuri achieved moderate profitability (B:C 3.27), while Lal Gulab proved least remunerative with the lowest gross return (₹380,983 ha<sup>-1</sup>), net return (₹260,549 ha<sup>-1</sup>) and B:C ratio (3.16). The interaction effect

of location × variety was non-significant for all economic parameters.

The superiority of Kufri Pukhraj both in terms of yield and economic returns suggests its strong

adaptability and genetic potential for tuber bulking, consistent with earlier findings of Kant et al. (2020), Das et al. (2021) and Mishra et al. (2021), who also reported its wide suitability and profitability across diverse agro-climatic zones. Similarly, Mehara et al. conducted an experiment at the College of Agriculture, Indore, identified potato varieties suitable for growth, yield and quality. Kufri Lauvkar performed best for growth parameters, yield and commercial cultivation under Malwa conditions, while Kufri Chipsona-1 showed the highest dry matter (Mehara et al., 2018). Kumar et al. evaluated the effect of water stress on morphological traits of four potato cultivars. Water stress at the tuber initiation stage caused the greatest reduction in shoot height and leaf area, with Kufri Pukhraj showing the least reduction and Kufri Lauvkar the highest. Root depth was most affected by stress at tuber maturity, while Kufri Pukhraj maintained the highest leaf area under stress conditions (Kumar et al., 2017). Sruthi et al. in Southern Telangana, evaluated six potato varieties for growth and yield. Kufri Pukhraj showed the highest sprouting percentage and lowest mortality, while Kufri Chipsona-3 recorded the greatest plant height, leaf number, tubers per plant and tuber yield. Both Kufri Chipsona-3 and Kufri Pukhraj demonstrated strong potential for commercial cultivation in Telangana (Sruthi et al., 2021). Mishra et al. evaluated four high-yielding potato varieties under different planting dates in the North Central Plateau Zone of Odisha. Kufri Pukhraj recorded the highest mean tuber yield, and planting on 15<sup>th</sup> November produced superior yields across all varieties (Mishra et al., 2021). However, the overall consistency of Kufri Pukhraj across locations indicates that varietal choice played a more decisive role than location in determining yield and profitability.

#### 4. CONCLUSION

The study demonstrated that both location and varietal differences significantly influenced the growth, yield attributes and economics of potato cultivation in Siddharth Nagar district of Uttar Pradesh. Among the tested locations, Bansi recorded the highest tuber yield, while Barhni and Itwa exhibited better performance in plant growth and yield components, respectively. Among the varieties, Kufri Pukhraj consistently outperformed others, producing the tallest plants, maximum tuber number and weight and the highest tuber yield. It also provided the maximum gross and net returns with the highest benefit-cost ratio, thereby proving to be the most

productive and profitable variety across locations. In contrast, Lal Gulab was the poorest performer both in yield and economics. These findings suggest that Kufri Pukhraj holds greater adaptability and economic viability for the region and can be recommended for large-scale cultivation under similar agro-ecological conditions.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that No generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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