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Comparative performance of major potato varieties under different agro-climatic zones of Uttar Pradesh

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ABSTRACT

Potato (*Solanum tuberosum* L.) is a major food and cash crop in India, with Uttar Pradesh (UP) being the leading producer. The state encompasses diverse agro-climatic zones, which significantly influence the performance of potato varieties. This review synthesizes available literature on the comparative performance of major potato cultivars across different agro-climatic regions of Uttar Pradesh. The study highlights the role of genotype × environment interactions, climatic variability, and agronomic practices in determining yield, stability, and adaptability. Findings suggest that no single variety performs uniformly across all zones, emphasizing the importance of region-specific varietal selection for enhancing productivity and sustainability.

Introduction

Potato is one of the most important tuber crops cultivated worldwide due to its high nutritional value and versatility in human diets. It is believed to have originated in the Andean region of South America, particularly in present-day Peru and Bolivia. The crop was introduced to India by Portuguese traders from Europe during the early 17th century. Botanically, potato belongs to the family Solanaceae (commonly known as the nightshade family) and is classified as *Solanum tuberosum*. Potatoes are widely consumed in various forms such as boiled, baked, or fried, and are commonly served as a staple food, side dish, or snack. Popular processed products derived from potatoes include French fries, potato chips, and potato flour.

The nutritional composition of potato is dominated by carbohydrates, mainly in the form of starch, which constitutes about 60–80% of its dry weight. A 100 g serving of boiled potato typically contains approximately 77 g water, 87 kcal of energy, 1.87 g protein, 0.1 g fat, 20.1 g carbohydrates, 1.8 g dietary fiber, 5 mg calcium, and 13 mg vitamin C (Anonymous, 2019).

Asia contributes nearly half of the global potato production, with China and India together accounting for about 38% of the total output. Global potato production has shown a steady increase, rising from 354.8 million tonnes to 359.07 million tonnes in recent years. In India, potato is primarily grown during the winter season, with sowing typically carried out between October and November. During 2020–2021, the area under potato cultivation in India was approximately 22.48 lakh hectares, producing about 542.3 lakh tonnes. The major potato-producing states include Uttar Pradesh, West Bengal, Bihar, Punjab, and Gujarat (Anonymous, 2022).

Potato is highly sensitive to climatic conditions. Factors such as low temperature, high light intensity, and short-day length promote early tuber formation and development (Das *et al.*, 2014). Therefore, the development of heat-tolerant varieties and their adaptation to different agro-climatic regions is essential for enhancing

productivity, especially in subtropical and warmer climates (Singh *et al.*, 2008). Since potato is cultivated across diverse environments ranging from plains to mountainous regions and from humid to dry areas, region-specific varietal improvement is necessary to achieve optimal yields (Kolech *et al.*, 2015). Farmers require potato varieties that not only provide high yields but also exhibit stability across varying environmental conditions and seasons. Over the years, several varieties with diverse yield potentials and quality traits have been developed (Marwaha *et al.*, 2010). The Central Potato Research Institute has released more than 50 improved varieties suitable for different agro-climatic zones of India (Kumar *et al.*, 2014).

Previous studies have highlighted the performance of various potato varieties. Kufri Pushkar and Kufri Chipsona-1 have shown higher germination rates, while Kufri Chipsona-1 also recorded superior dry matter accumulation. Kufri Pukhraj demonstrated higher water-use efficiency. In terms of yield and economic returns, varieties such as Kufri Pukhraj, Kufri Khyati, and Kufri Pushkar performed significantly better. Kufri Chipsona-1 has been identified as suitable for processing purposes, whereas Kufri Pukhraj, Kufri Khyati, and Kufri Pushkar are recommended for table consumption (Sadawarti *et al.*, 2018).

In another study, Kufri Surya, Kufri Khyati, and Kufri Chipsona-3 were found suitable for cultivation in the Northern Telangana Zone, with Kufri Surya producing the highest tuber yield and fresh weight (Preetham and Pavan, 2018). However, varietal susceptibility to pests varies; for instance, Kufri Chipsona-1 showed lower damage from soil-dwelling insect pests, whereas Kufri Surya was more affected (Tudu *et al.*, 2019).

Review of literature

Potato varietal improvement has played a significant role in enhancing productivity and adaptability under diverse agro-climatic conditions of Uttar Pradesh. Several studies have evaluated the performance of different potato cultivars with respect to yield, maturity, stress tolerance, and processing quality.

Kufri Bahar has been identified as a good general combiner for tuber yield, particularly under early planting conditions in the plains of Uttar Pradesh. Developed by the Central Potato Research Institute (CPRI), it is an early-maturing and widely adapted variety known for its high yield potential and suitability to northern plains. The variety produces large, round to oval tubers and matures within 100–110 days, yielding approximately 45 t/ha under favorable conditions. Its adaptability and consistent performance have made it one of the most popular cultivars in the region.

Kufri Anand, released in 1999, has shown promising performance in the north-western and west-central plains of Uttar Pradesh under the All India Coordinated Potato Improvement Programme (AICPIP). It is a medium-maturing variety derived from a cross between PJ-376 and PH/F-1430. The variety is characterized by tall and vigorous plants, white long-oval tubers, and resistance to late blight along with tolerance to frost. It has a yield potential of 35–40 t/ha and performs well under optimum agronomic conditions.

The adoption of high-yielding, early-maturing, and stress-tolerant varieties is considered an effective strategy to cope with climatic challenges such as drought and heat stress. Kufri Pukhraj is one such variety that has gained immense popularity in India, covering nearly one-third of the total potato cultivation area. It is an early-bulking, drought-tolerant variety with moderate resistance to late blight. Economic analyses over a 41-year period (1978–2018) have demonstrated that investment in this variety has generated substantial economic returns, benefiting both producers and consumers. Its widespread adoption highlights its importance in ensuring productivity and profitability under varying climatic conditions.

Kufri Sindhuri is a traditional late-maturing variety developed for the Indo-Gangetic plains. It is known for its stable performance under low-input conditions and adaptability to diverse environments. The variety produces red-skinned tubers with white flesh and has good storage quality. Although it shows moderate resistance to early blight and tolerance to leaf roll virus, it is susceptible to late blight. Despite the availability of improved cultivars, Kufri Sindhuri remains popular due to its reliability and consumer acceptance.

Processing-oriented varieties have also gained importance with the expansion of the potato processing industry. Kufri Chipsona-1 is a notable processing variety characterized by high dry matter content (22–24%) and low reducing sugars, which are essential for producing high-quality chips. It exhibits high yield potential (around 294 q/ha) and a high proportion of processing-grade tubers. Although it has some limitations in storage and tuber size uniformity, it has significantly contributed to improving processing efficiency and farmer income.

Kufri Chandramukhi, one of the earliest released varieties in India, is known for its early maturity, high yield, and wide adaptability. It produces medium to large, smooth tubers with good culinary quality. Studies indicate that its growth and yield respond positively to favorable environmental conditions, although stress factors may affect productivity. Its nutritional value and versatility have sustained its importance in potato cultivation.

Kufri Surya has been developed as a heat-tolerant and early-maturing variety suitable for early planting and warmer regions. It produces oblong tubers with good processing quality, including low reducing sugars and adequate dry matter content. The variety performs well under high-temperature conditions and produces a high proportion of large-sized tubers, making it suitable for processing into chips and French fries.

Kufri Jyoti is another widely cultivated variety known for its adaptability across different agro-climatic regions, including plains and hills. It is a medium-maturing variety with moderate resistance to early and late blight and good storage quality. With a yield potential of 250–300 q/ha, it has contributed significantly to potato production in India. Its stable performance and consumer acceptability have maintained its popularity over time.

Comparative studies of potato varieties indicate that varietal performance varies significantly depending on environmental conditions, maturity duration, and resistance to biotic and abiotic stresses. Early-maturing varieties such as Kufri Pukhraj provide quick returns and fit well into intensive cropping systems, whereas medium- and late-maturing varieties like Kufri Bahar and Kufri Jyoti generally produce higher yields under favorable conditions.

Processing varieties like Kufri Chipsona-1 are preferred for industrial use due to their high dry matter content, while table varieties are selected based on taste and texture. Overall, the literature suggests that the selection of appropriate potato varieties according to specific agro-climatic zones is essential for maximizing productivity, ensuring stability, and improving economic returns. This highlights the importance of comparative evaluation of major potato varieties under different agro-climatic conditions of Uttar Pradesh.

Comparative performance of potato varieties

Potato varieties differ widely in yield, maturity period, quality, and resistance to pests and diseases. Early-maturing varieties like Kufri Pukhraj and Kufri Ashoka are suitable for short-duration cropping systems and provide quick returns, though their total yield is comparatively moderate. Mid- to late-maturing varieties such as Kufri Jyoti and Kufri Bahar generally produce higher yields and better tuber size under favorable conditions. Varieties with resistance to diseases (especially late blight) show more stable performance in humid and high-risk areas. Processing varieties (e.g., those with high dry matter) are preferred for chips and fries, while table varieties focus on taste and texture. Overall, varietal performance depends on climate, soil conditions, and crop management, making region-specific selection essential for maximizing productivity (Pandey S. K. *et al.*, 2008).

Top 8 Potato Varieties in UP

1. Kufri Bahar (3797)
2. Kufri Pukhraj
3. Kufri Sindhuri
4. Kufri Chipsona-1
5. Kufri Chandramukhi
6. Kufri Anand
7. Kufri Surya
8. Kufri Jyoti

Kufri Bahar 3797—Major growing states of this variety are Haryana, Uttar Pradesh, Himachal Pradesh and Jammu Kashmir. Tubers are large and round-oval in shape with medium deep eyes. This potato crop matures approximately in 100–110 days. Average yield of this potato is about 45 tonnes per hectare.

Kufri Bahar is a widely cultivated potato (*Solanum tuberosum* L.) variety in India, developed by the Central Potato Research Institute (CPRI), Shimla, and released in 1980 as a selection from Kufri Red. It is particularly adapted to the northern plains and has gained popularity due to its early maturity, high yield potential, and suitability for table consumption. The variety is characterized by a semi-compact plant type with oval tubers having smooth, light yellow to cream skin, white flesh, and shallow eyes, making it convenient for peeling and household use. Agronomically, Kufri Bahar is considered an early maturing and high-yielding variety, producing uniform, medium-sized tubers with firm texture and good culinary quality, suitable for boiling, baking, and frying. It also demonstrates good storage ability, which enhances its market value and suitability for distribution in fresh markets. Studies have reported that this variety exhibits strong vegetative vigor and relatively higher dry matter and starch content compared to some other Kufri varieties, contributing to its desirable cooking and nutritional qualities. Additionally, research on its starch properties indicates that Kufri Bahar possesses functional characteristics such as resistant starch with potential prebiotic effects, further highlighting its nutritional importance (Mishra *et al.*, 2025).

Despite these advantages, the variety shows only moderate resistance to diseases and may require proper crop management practices for optimal performance. Overall, Kufri Bahar remains an important potato cultivar in India due to its adaptability, productivity, and consumer preference, and it continues to play a significant role in both cultivation and research programs.

Kufri Pukhraj—Most popular potato variety of Bihar, Punjab, Haryana, Uttar Pradesh, Maharashtra, Himachal Pradesh, Madhya Pradesh, Orissa and West Bengal. Tubers are characterized by large size, oval shape, slightly depressed fleet eye and flesh with yellowish in color. Maturity period of this variety ranges between 70–90 days and with an average yield of 40 tonnes per hectare. This variety shows good resistance against early blight as well as moderate resistance against late blight disease.

The potato variety Kufri Pukhraj is a widely cultivated, high-yielding cultivar developed by the Central Potato Research Institute and released in 1998 for Indian agro-climatic conditions. It is characterized as an early-maturing and early-bulking variety, capable of producing marketable yields within about 60–70 days, making it

particularly suitable for the North Indian plains and short cropping systems. The variety exhibits medium-to-large, oval to oblong tubers with smooth, light yellow to golden skin and shallow eyes, while the flesh is yellow, firm, and waxy, contributing to good table quality and consumer acceptance. Agronomically, Kufri Pukhraj has a semi-compact plant canopy, white flowers, and moderate tolerance to drought and late blight, although it can be somewhat sensitive to heat stress under certain conditions. It is primarily grown for table purposes rather than processing due to relatively higher reducing sugars, which affect frying quality. The variety has achieved remarkable adoption, covering nearly one-third of India's potato cultivation area and contributing significantly to farmer income and national food security through its high productivity and adaptability (Pandey *et al.*, 2022). Overall, Kufri Pukhraj represents a successful example of varietal improvement in potato, combining early maturity, good yield, and wide adaptability, thereby playing a crucial role in Indian potato production systems.

Kufri Sindhuri—It is mainly cultivated in Bihar, Gujarat, Maharashtra, Punjab, Uttar Pradesh, Karnataka, and Jammu Kashmir. This variety requires 110–120 days to mature. It is suitable for cultivating in the regions having high temperature and water stress and this variety is also known for preparing different processed food.

Kufri Sindhuri is a widely cultivated potato variety developed by the Central Potato Research Institute, Shimla, and released in 1966 for commercial cultivation in the Indo-Gangetic plains of India. It originated from a cross between Kufri Red and Kufri Kundan, aiming to produce a variety with improved adaptability and consumer preference. The tubers of Kufri Sindhuri are characterized by their distinct red skin and white flesh, with a round to oval shape and shallow eyes, which facilitates peeling and enhances market acceptability. The variety is late maturing and performs well under the agro-climatic conditions of North India, particularly in states like Uttar Pradesh, Punjab, and Bihar.

From an agronomic perspective, Kufri Sindhuri exhibits moderate resistance to early blight and some tolerance to leaf roll viruses, although it remains susceptible to late blight, which can significantly affect yield under humid conditions. Despite these limitations, it is known for its stable yield performance under low-input farming systems and its relatively good storage capability compared to many modern cultivars. The variety produces medium to large-sized tubers with acceptable uniformity and has remained popular among farmers due to its adaptability and resilience across varying environmental conditions.

In terms of utilization, Kufri Sindhuri is considered a multipurpose potato variety suitable for common household cooking methods such as boiling, baking, and frying. Its firm texture and mild flavor make it desirable for table purposes, though it is not typically preferred for processing industries that require high dry matter content. Although newer high-yielding and disease-resistant varieties have been introduced, Kufri Sindhuri continues to be cultivated in several regions due to its dependable performance, consumer preference, and storability.

Kufri Chipsona -1—Kufri Chipsona-1 is an important potato (*Solanum tuberosum* L.) processing variety developed by the Central Potato Research Institute (CPRI), India, and released in the late 1990s to meet the growing demand of the potato chips industry. It is characterized by medium maturity, high yield potential, and suitability for cultivation in the North Indian plains. The tubers are oval to oblong with smooth, light-colored skin, shallow eyes, and white flesh, making them ideal for industrial peeling and processing. A key distinguishing feature of this variety is its high dry matter content (around 22–24%) and low reducing sugar levels, which are essential for producing light-colored, good-quality chips with minimal browning during frying. Studies have reported that Kufri Chipsona-1 can produce high total tuber yields (around 294 q/ha) and a high proportion of processing-grade tubers, along with chip recovery exceeding 27% and acceptable chip color indices. Additionally, it exhibits low phenolic content and reduced enzymatic discoloration, further enhancing its processing quality. Economically, despite slightly higher cultivation costs, the variety provides higher net returns and a better benefit–cost ratio compared to many traditional varieties, making it profitable for farmers. However, some limitations such as the occurrence of undersized tubers and relatively lower suitability for long-term storage under

certain conditions have also been noted. Overall, Kufri Chipsona-1 represents a significant advancement in India's potato breeding program, contributing to the expansion of the processing sector and improving farmer income (Marwaha *et al.*, 2007).

Kufri Chandramukhi—Cultivating states of this variety are Bihar, Gujarat, Haryana, Punjab, Madhya Pradesh, Himachal Pradesh, Uttar Pradesh, Orissa, and West Bengal. Approximately 80–90 days are required for the development of the variety. Mature tubers are large, round, white with flattened eyes, and dull white flesh. Average yield capacity of this variety is 25 tonnes per acre. This is one of the suitable variety for preparing chips and instant flakes.

Kufri Chandramukhi is one of the earliest and most widely cultivated potato (*Solanum tuberosum* L.) varieties developed in India by the Central Potato Research Institute (CPRI) and released in 1966. It is an early-maturing, high-yielding cultivar known for its adaptability across diverse agro-climatic regions of India, particularly in the northern plains. The variety produces medium to large, oval to oblong tubers with smooth, light brown skin and creamy white flesh, which makes it suitable for a range of culinary purposes including boiling, frying, and processing. Its waxy texture and mild flavor contribute to its consumer acceptability and versatility in cooking. Agronomically, Kufri Chandramukhi is valued for its high yield potential and relatively good resistance to certain diseases and pests, reducing dependency on chemical plant protection measures. Studies have shown that it can produce significantly higher tuber yields compared to several other cultivars and is also relatively rich in essential minerals such as potassium, zinc, and copper. Additionally, its growth and productivity are influenced by environmental factors such as carbon dioxide and ozone levels, with elevated CO₂ conditions enhancing biomass and tuber yield. Due to these characteristics early maturity, high productivity, desirable tuber quality, and moderate resistance traits Kufri Chandramukhi has remained an important variety in Indian potato cultivation, although it is gradually being replaced in some regions by newer improved cultivars with enhanced disease resistance and yield stability (Rai *et al.*, 2014).

Kufri Anand—Mainly cultivated in the plains Bihar and Uttar Pradesh. Main features are medium size, oval to long, fleet eye, smooth rind and white core. Period required for tuber maturity ranges between 100–110 days and 35–40 tonnes per hectare tuber yield can be obtained by growing this variety. French fries are mainly prepared from this potato variety.

Kufri Anand is an improved potato variety developed by the Central Potato Research Institute (CPRI), Shimla, and released in 1999 as a selection from Kufri Ashoka. It is particularly suited to the North Indian plains and performs well under spring cultivation conditions. The variety is characterized by medium maturity and a semi-compact plant canopy with green stems showing slight purple pigmentation. Tubers are oval, medium to large in size, with smooth white to cream skin, shallow eyes, and white flesh, which enhances its consumer appeal and ease of processing. Kufri Anand is valued for its high yield potential, typically ranging from 350–400 quintals per hectare under optimal management. It also exhibits moderate resistance to late blight and immunity to wart disease, although it may be susceptible to certain other pathogens such as charcoal rot. Agronomically, it shows tolerance to environmental stresses like frost and hopper burn, contributing to its stability in variable climatic conditions. In comparative varietal evaluations, Kufri Anand has demonstrated superior vegetative growth, including increased plant height and leaf number, indicating strong vigor and adaptability. The tubers possess good cooking quality, with a floury texture, mild flavor, and absence of discoloration after cooking, making them suitable for boiling, baking, and frying. Additionally, the variety has acceptable storage characteristics, supporting its use in both fresh markets and short-term storage systems. Overall, Kufri Anand remains an important cultivar in Indian potato farming due to its balanced combination of yield, quality, and adaptability (R.P. *et al.*, 2025).

Kufri Surya—Kufri Surya is a widely recognized potato variety developed in India for its adaptability to high-temperature conditions and early planting systems. It is an early maturing cultivar with strong vegetative vigor, capable of producing high yields comparable to popular varieties such as Kufri Bahar. The tubers are typically oblong to oval in shape, with smooth white to light yellow skin, shallow eyes, and pale yellow to white flesh, making them suitable for both table consumption and industrial processing. One of the key features of

Kufri Surya is its tolerance to heat stress and resistance to hopper burn, enabling successful cultivation in warmer regions and during early planting seasons when other varieties may fail. Studies have shown that this variety produces a high proportion of large-sized, defect-free tubers, which are particularly desirable for processing into products like French fries and chips. Additionally, Kufri Surya exhibits good dry matter and starch content, contributing to improved processing quality and consumer acceptability. Field evaluations have demonstrated its superior performance under stress conditions, with yields ranging from about 25 to 31 tonnes per hectare depending on agro-climatic conditions. Its moderate resistance to diseases such as late blight and good storage characteristics further enhances its suitability for commercial cultivation. Overall, Kufri Surya represents a climate-resilient and economically viable potato variety that supports both fresh market supply and the growing processing sector in India (Minhas *et al.*, 2006).

Kufri Jyoti- The main producing states are Bihar, Maharashtra, Gujarat, Haryana, Punjab, Uttar Pradesh, Karnataka, and West Bengal. The eyes are small and swift, and the flesh is white. This potato has an average yield of 20 tonnes per acre. This variety is moderately resistant to early and late blight disease.

Kufri Jyoti is a significant potato variety developed by the Central Potato Research Institute (CPRI), India, and released in 1968 for cultivation across diverse agro-climatic conditions. The variety is characterized by a compact plant canopy, green stems with red-brown pigmentation, ovate leaflets, and white flowers. Its tubers are ovoid, white to cream in color with shallow eyes and cream flesh, making them attractive for market and consumption purposes. Kufri Jyoti is a medium-duration variety with broad adaptability to hills, plains, and plateau regions, which has contributed to its widespread adoption among Indian farmers.

From an agronomic perspective, Kufri Jyoti has an average yield potential of 250–300 quintals per hectare under optimal conditions and demonstrates good keeping quality during storage. Studies have also highlighted its suitability for post-harvest handling and storage, where practices like precooling can significantly enhance shelf life and maintain tuber quality. In terms of disease response, the variety shows moderate resistance to early and late blight but is susceptible to viral diseases and cyst nematodes, which can affect yield under adverse conditions. Nevertheless, it is immune to wart disease, providing a distinct advantage in certain regions.

Quality-wise, Kufri Jyoti is preferred as a table potato due to its waxy texture, mild flavor, and absence of after-cooking discoloration. Biochemical studies indicate that it also contains appreciable levels of phenolic compounds and ascorbic acid, contributing to its nutritional value. Despite the introduction of newer high-yielding and disease-resistant varieties, Kufri Jyoti continues to be cultivated due to its stable performance, adaptability, and consumer acceptance. Thus, it remains a historically and agronomically important potato variety in India.

Conclusion

The comparative evaluation of major potato (*Solanum tuberosum* L.) varieties across different agro-climatic zones of Uttar Pradesh demonstrates that varietal performance is significantly influenced by the interaction between genotype and environment. Uttar Pradesh, being the leading potato-producing state of India, encompasses diverse agro-climatic regions ranging from the Western Plains and Central Plains to the Eastern Plains and Bundelkhand region. These regions differ considerably in soil characteristics, temperature regimes, rainfall patterns, and irrigation availability, thereby affecting the growth, yield, quality, and adaptability of potato varieties. The reviewed studies reveal substantial variations among widely cultivated potato varieties such as Kufri Uday, Kufri Surya, Kufri Bahar, Kufri Anand, Kufri Khyati, Kufri Kiran, Kufri Chipsona series, and Kufri Fryom. Varieties such as Kufri Uday and Kufri Khyati have consistently exhibited superior tuber yield and wider adaptability under favorable growing conditions, whereas Kufri Surya and Kufri Bahar have demonstrated better tolerance to heat stress and suitability for regions experiencing higher temperatures. Similarly, processing varieties belonging to the Kufri Chipsona series have shown higher dry matter content, lower reducing sugar levels, and enhanced suitability for chip and French fry production.

In addition to genetic factors, agronomic practices including

planting date, seed quality, fertilizer management, irrigation scheduling, and harvesting time significantly influence varietal performance. Studies have shown that timely planting and optimum crop management enhance tuber development, improve yield attributes, and maximize economic returns. Therefore, the selection of an appropriate variety must be complemented by suitable agronomic interventions to achieve optimum productivity.

The development and dissemination of improved potato varieties by institutions such as the ICAR–Central Potato Research Institute have contributed substantially to enhancing potato production in Uttar Pradesh. New varieties possessing high yield potential, disease resistance, heat tolerance, and superior processing qualities offer significant opportunities for increasing farm profitability and ensuring sustainable potato cultivation under changing climatic conditions.

Overall, the study emphasizes that no single potato variety can be considered universally superior across all agro-climatic zones of Uttar Pradesh. Region-specific varietal recommendations based on local environmental conditions, production objectives, and market requirements are essential for maximizing productivity and profitability. Future research should focus on the development of climate-resilient, resource-efficient, and disease-resistant potato varieties, along with precision crop management strategies, to address emerging challenges associated with climate change and resource constraints. In conclusion, the sustainable growth of potato production in Uttar Pradesh depends on the adoption of suitable varieties tailored to specific agro-climatic zones, supported by improved cultivation practices and continuous varietal improvement programs. Such an integrated approach will enhance productivity, profitability, and resilience of potato-based farming systems while contributing to food security and agricultural development in the state.

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