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RESEARCH PAPER

Evaluation of Potato (*Solanum tuberosum* L.) Cultivars for Adaptability and Productivity in a Non-traditional Potato-Growing Region of Rajasthan

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ABSTRACT

The present study evaluated sixteen potato cultivars for different physical, morphological, growth and yield attributes and yield to find out the suitable alternative crops for enhancing the farm productivity in non-traditional areas of potato in Rajasthan. The experiment was conducted in a randomized block design with four replications. Significant varietal differences were observed for most of the evaluated traits. Morphological assessment revealed considerable diversity in tuber shape, skin and flesh colour, eye depth, and skin texture. Most cultivars produced oval to round tubers with shallow eyes and cream to yellow flesh, traits desirable for commercial processing. Emergence ranged from 87.17 to 95.87%, with Kufri Bahar recording the highest emergence (95.87%). Chlorophyll content (SPAD) varied from 37.63 to 44.58; while plant height ranged from 30.63 to 54.08 cm. Kufri Bahar exhibited the lowest disease incidence (10.71%), indicating better field tolerance. Tuber quality parameters also differed significantly among cultivars. Moisture content ranged from 77.52 to 82.56%, whereas dry matter content varied from 17.44 to 22.48%, with Kufri Neelkanth recording the highest dry matter (22.48%) and specific processing suitability. Total soluble solids ranged from 5.88 to 7.23 °Brix, with the maximum value observed in Kufri Bahar. Tuber yield ranged from 25.96 to 35.60 t ha^{-1}, with Kufri Bahar producing the highest yield (35.60 t ha^{-1}), followed by Kufri Bhaskar (33.53 t ha^{-1}), Kufri Lalit (33.22 t ha^{-1}), and Kufri Sukhyati (32.96 t ha^{-1}). All principal components accounted for 54.60% of the variation across all attributes. PC1 contributes 35.90% of total variance, followed by PC2 which contributes 18.70%. PCA results showed that Kufri Bahar, Kufri Bhaskar and Kufri Lalit are the highly diverse genotypes. Overall, Kufri Bahar, Kufri Bhaskar and Kufri Lalit demonstrated superior agronomic performance by combining high emergence, greater chlorophyll content, lower disease incidence, excellent processing attributes, and the highest yield, whereas Kufri Neelkanth exhibited outstanding tuber quality due to its high dry matter content. These cultivars are promising candidates for commercial cultivation and potato processing industries in the non-traditional potato-growing regions of Rajasthan.

HIGHLIGHTS

- Sixteen potato cultivars evaluated for adaptability in non-traditional potato growing area.
- Kufri Bhar, K. Bhaskar, K. Lalit and K. Sukhyati found suitable for this region.
- Kufri Bhar recorded highest yield.
- Kufri Neelkanth exhibited outstanding tuber quality.

Keywords: Potato cultivars, morphological, yield attributes, farm productivity, diversity

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Potato (*Solanum tuberosum* L.) is one of the most important vegetable and food crops cultivated throughout the world. In India, it is the most significant tuber crop and recognized as the "*king of vegetables*". It is widely consumed due to its high nutritional value, adaptability and higher yield potential. Potato tubers are good source of carbohydrates, vitamins, minerals and dietary fiber, making them an important component of the human diet. In recent years, the demand for processed potato products such as chips, French fries and dehydrated products has increased rapidly because of changing food habits and expansion of the food processing industry (Wang *et al.* 2023). Therefore, identification of suitable potato varieties for the purpose of cultivation in new area and fulfil the demand of the processing industries become essential. Tuber traits such as shape, eye depth, skin texture, flesh colour and number of eyes influence peeling efficiency, appearance and consumer preference.

Varieties having shallow eyes, smooth skin and uniform tuber shape are preferred for industrial use because they minimize processing losses (Rahman *et al.* 2017). Similarly, quality parameters such as dry matter content, total soluble solids and moisture content play an important role in determining the suitability of potatoes for chips, french fry production and many other products (Islam *et al.* 2022). Tuber dry matter content and TSS are critical trait that influences processing quality, nutritional value and marketability. Disease incidence and yield performance are also important considerations in selecting potato varieties for introduction of crop in new area and commercial processing purposes. The physical, morphological, yield and processing attributes of potato varieties are largely unidentified in non-traditional area of potato specially newly introduced or release varieties. It is important to know the adaptability of these varieties in non-traditional areas and soil to meet the domestic demand of consumers and consumer requirements for its various uses.

Despite the release of several improved potato cultivars in recent years, comprehensive information on their adaptation, agronomic performance, tuber quality, and processing suitability under the non-traditional potato-growing conditions of Rajasthan remains limited. Most previous studies have primarily focused on yield evaluation in traditional potato-growing regions, with comparatively less attention given to the integrated assessment of morphological characteristics, growth attributes, tuber quality parameters, and yield under the semi-arid agro-climatic conditions of northwestern India. We hypothesized that significant genotypic variation exists among potato cultivars in their adaptation, growth performance, tuber quality, and yield under the non-traditional agroecosystems of Rajasthan, enabling the identification of superior cultivars suitable for commercial cultivation and processing. Therefore, the present study was undertaken with the following objectives: (i) to evaluate the morphological, growth, physiological, and tuber quality characteristics of sixteen potato cultivars under the non-traditional potato-growing conditions of Rajasthan; and (ii) to identify high-performing cultivars with superior yield and processing attributes for commercial cultivation and industrial utilization in the region.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at Rajasthan Agricultural Research Institute, Durgapura (28°5808600 N; 81°6607300 E; 43 m above MSL), Jaipur. The experiment was conducted during two growing rabi seasons (2024-2025 and 2025-2026). This area is characterised by low and erratic rainfall and long winter. In general, the cool climatic condition during December-January months was favourable for tuber formation and development.

Experimental Treatments and Design

Sixteen potato varieties (Kufri Pukhraj, Kufri Lima, Kufri Bahar, Kufri Lohit, Kufri Thar-3, Kufri Lalit, Kufri Bhaskar, Kufri Jamunia, Kufri Mohan, Kufri Neelkanth, Kufri Sukhyati, Kufri Khyati, Kufri Ganga, Kufri Surya, Kufri Sangam and Kufri Thar-2) were taken in the experiment. The experiment was laid out in a randomised block design (RBD); each variety replicated in four with a ridge plot size of 2.10 m × 0.6 m. The land was thoroughly prepared and tubers of each variety were planted on ridges spaced at 50 cm, with a plant-to-plant distance of 30 cm.

The field was fertilised with 100 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1} and 80 kg K_2O ha^{-1} in the form of urea, single super phosphate and muriate of potash, respectively. Out of these nutrient doses, ½ of nitrogen and a full dose of P_2O_5 and K_2O were applied as basal on the date of planting of tubers. The rest half of nitrogen was applied in two equal splits, first top dressing at 20 days after planting (DAP) and the remaining portion of N was applied as the second top dressing during 40 DAP. During the entire crop production cycle, cultural practices including hoeing, hilling and irrigation were carried out uniformly on all plots. 1% spray of potassium sulphate were also done at 50 DAP and 70 DAP in all varieties. Ten days before harvesting the haulm was removed using sickles and the tubers were harvested by splitting the ridges with plough.

Data Collection

Observations were recorded on tuber morphological characteristics, crop establishment, physiological and growth attributes disease incidence, tuber dimensions, quality parameters, and tuber yield.

(a) Morphological characterization of potato tubers

The morphological characteristics of tubers from the sixteen potato cultivars were evaluated after harvesting. The recorded characteristics included tuber shape, eye depth, skin colour, flesh colour, presence or absence of scars, skin texture, and number of eyes per tuber. Ten representative and marketable tubers were randomly selected from each plot for morphological characterization. Tuber shape, eye depth, skin colour, flesh colour, and skin texture were recorded through visual assessment following the descriptors prescribed under the Distinctness, Uniformity and Stability guidelines for potato. The total number of eyes present on each selected tuber was counted manually, and the mean number of eyes per tuber was calculated for each cultivar.

(b) Crop establishment and physiological attributes

Tuber emergence was recorded at 30 days after planting (DAP) by counting the number of emerged plants in each plot. Emergence percentage was calculated in relation to the total number of seed tubers planted using Eq. (1). Leaf chlorophyll concentration was estimated at 60 DAP using a portable SPAD chlorophyll meter. Readings were recorded from fully expanded and physiologically active leaves of five randomly selected plants from each plot.

(c) Plant growth and disease incidence

Plant height was recorded at 60 DAP from five randomly selected plants in each experimental plot. Disease incidence was assessed at 90 DAP by counting the number of plants showing visible disease symptoms in relation to the total number of plants examined in each plot. Disease incidence was calculated using Eq. (2). Cultivars with lower disease incidence were considered relatively more tolerant under the prevailing field conditions.

(d) Measurement of tuber dimensions, moisture and dry matter contents

The polar or vertical diameter and equatorial or horizontal diameter of ten randomly selected marketable tubers from each plot were measured using a digital Vernier calliper with a resolution of 0.1 mm. Polar diameter was measured along the longest longitudinal axis of the tuber, whereas equatorial diameter was measured across the widest transverse portion. The average values were expressed in millimetres. Representative tubers were randomly collected from each experimental plot immediately after harvesting. The tubers were washed thoroughly to remove adhering soil, surface-dried, and cut into slices approximately 1–2 mm thick. A known fresh weight of the sliced tuber sample was recorded using an electronic balance. The samples were subsequently dried in a hot-air oven at 70 °C for 48 h or until a constant weight was attained. After drying, the samples were cooled in a desiccator and weighed immediately. Tuber moisture and dry matter contents were calculated on a fresh-weight basis using Eqs. (3) and (4), respectively.

(e) Determination of total soluble solids

Total soluble solids in the tubers were determined at harvest using a portable hand-held refractometer. Representative tubers were cut and homogenized, and a small quantity of extracted juice was placed on the prism of the refractometer. The refractometer was calibrated with distilled water before measurement. Total soluble solids were recorded at room temperature and expressed as °Brix. Multiple readings were taken from each tuber, and their mean was used for statistical analysis.

(f) Measurement of ash content

The ground potatoes were ashed at 550 °C for 5 h in a muffle furnace for determination of ash content in each potato varieties. The ash content is calculated as the weight of the residue (ash) divided by the weight of the original sample, multiplied by 100 to express the result as a percentage.

(g) Tuber yield

Potato tubers were harvested separately from each experimental plot after haulm removal and attainment of physiological maturity. Harvested tubers were cleaned, graded, and separated into marketable and non-marketable categories. Healthy tubers weighing more than 30 g and free from visible defects, disease symptoms, greening, cracking, and mechanical injury were considered marketable. The marketable tubers collected from each plot were weighed, and the plot yield was converted to tonnes per hectare using Eq. (6).

Calculation of derived parameters

The following equations were used to calculate crop establishment, disease incidence, tuber quality parameters and yield.

$$\textit{Plant emergence (\%)} = (\textit{Number of emerged plants / Total number of seed tubers planted}) \times 100 \quad \text{...Eq. (1)}$$

$$\textit{Disease incidence (\%)} = (\textit{Number of diseased plants / Total number of plants observed}) \times 100 \quad \text{...Eq. (2)}$$

$$\textit{Moisture content (\%)} = [(\textit{Fresh weight} - \textit{Dry weight}) / \textit{Fresh weight}] \times 100 \quad \text{...Eq. (3)}$$

$$\textit{Dry matter content (\%)} = (\textit{Dry weight / Fresh weight}) \times 100 \quad \text{...Eq. (4)}$$

$$\textit{Ash content (\%)} = \textit{Weight of ash residue/weight of dry tuber} \times 100 \quad \text{...Eq.(5)}$$

$$\textit{Marketable yield (t ha}^{-1}\textit{)} = [\textit{Marketable tuber weight per plot} \times 10] / \textit{Net plot area} \quad \text{...Eq. (6)}$$

Statistical analysis

The experiment was conducted in a randomized block design with sixteen potato cultivars and four replications. The plot-wise data collected during the two growing seasons were subjected to analysis of variance to determine the significance of cultivar effects. Principal component analysis (PCA) was performed using the past (v.4.14) program to identify the proper relationships between various features.

RESULTS AND DISCUSSION

Physical/morphological characteristics of tuber of different potato

During the study period many potato cultivars showed great diversity in their shape, eye depth, skin and flesh colour, tuber skin type and number of eyes (Table 1). Kufri Bahar, Kufri Lohit, Kufri Jamunia, Kufri Neelkanth, Kufri Sukhyati, Kufri Khyati, Kufri Ganga, Kufri Surya and Kufri Sangam were oval to round; Kufri Pukhraj and Kufri Lima were oval, Kufri Thar-2 and Kufri Thar-3 were oval to long oval while Kufri Mohan produced round shape tuber. Majority of potato showed shallow eye depth except Kufri Lalit showed medium deep eyes. The skin red colour observed Kufri Lohit and Kufri Lalit, other were yellow in colour (Table 1 and Fig. 1). Alom *et al.* (2003) and Bandana *et al.* (2025) find out different colours and shape in different potatoes.

Mean number of eyes ranged from 3.0 to 8.0 with least in Kufri Sangam and highest in Kufri Sukhyati followed by Kufri Lohit, Kufri Lalit and Kufri Neelkanth (Table 1). Potato varieties shallow, medium and deep eyes (Rahman *et al.* 2017). The flesh of 7 potato such as, Kufri Pukhraj, Kufri Lima, Kufri Lohit, Kufri Thar-3, Kufri Khyati, Kufri Ganga and Kufri Sangam were creamy, while white in case of 2, namely Kufri Bahar and Kufri Mohan. On the other hand, 6 such as, Kufri Lalit, Kufri Bhaskar, Kufri Neelkanth, Kufri Sukhyati, Kufri Surya and Kufri Thar-2 had yellow flesh colour while Kufri Jamunia had purple flesh colour (Table 1). The colour of the flesh of a tuber greatly influences its economic worth as it is a highly prized characteristic

Table 1: Morphological diversity among sixteen potato cultivars based on tuber shape, eye depth, skin colour, flesh colour, skin texture, and number of eyes.

Variety	Shape	Eye depth	Skin colour	Flesh colour	Skin texture	Eyes (No.)
Kufri Pukhraj	Oval	Shallow	Yellow	Creamy	Light rough–smooth	5
Kufri Lima	Oval	Shallow	White cream	Pale cream	Smooth	6
Kufri Bahar	Oval–Round	Shallow	Light yellow	Creamy white	Smooth	6
Kufri Lohit	Oval–Round	Shallow	Red	Creamy white	Smooth	7
Kufri Thar-3	Oval–Long oval	Shallow	Yellow	Creamy	Rough–smooth	4
Kufri Lalit	Oval–Round	Medium	Red	Yellow cream	Smooth	7
Kufri Bhaskar	Oval–Round	Shallow	Yellow	Creamy yellow	Smooth	4
Kufri Jamunia	Oblong	Shallow	Purple	Purple	Rough–smooth	4
Kufri Mohan	Round	Shallow	Whitish yellow	White	Rough	5
Kufri Neelkanth	Oval–Round	Shallow	Purple	Creamy yellow	Rough–smooth	7
Kufri Sukhyati	Oval–Round	Shallow	Yellow	Creamy yellow	Smooth	8
Kufri Khyati	Oval–Round	Shallow	Yellow	White cream	Smooth	4
Kufri Ganga	Ovoid	Shallow	Yellow	Cream	Rough–smooth	5
Kufri Surya	Oval–Round (Oblong)	Shallow	Whitish yellow	Yellow	Rough–smooth	4
Kufri Sangam	Ovoid	Shallow	Light cream	Cream	Smooth	3
Kufri Thar-2	Oval–Long oval (ovoid)	Shallow	Light yellow	Light yellow	Rough	4

Fig. 1: An overview of tuber shape, eye depth, skin and flesh colour variation of potato cultivars

in the processing sector and similar variations in flesh colour (Rahman *et al.* 2017; Bandana *et al.* 2025).

Emergence, chlorophyll concentration, plant height and disease incidence

The potato varieties exhibited significant differences in growth, physiological, and health-related parameters, whereas tuber emergence remained statistically comparable among varieties (Table 2). Tuber emergence at 30 DAP ranged from 92.30% to 97.43%, with the highest emergence recorded in Kufri Bahar (97.43%), followed by Kufri Lima (94.87%) and Kufri Pukhraj (92.30%). However, the differences were non-significant, indicating that all evaluated varieties possessed good germination potential under the experimental conditions. Similar non-significant differences in emergence among potato cultivars have been reported by Deshmukh *et al.* (2018) and Patel *et al.* (2024), suggesting that varietal effects on emergence are generally minimal when healthy seed tubers are planted under favourable field conditions.

Significant varietal variation was observed in leaf chlorophyll concentration (SPAD values), reflecting differences in photosynthetic capacity and physiological vigour (Table 2). The highest SPAD value was recorded in Kufri Bahar (44.58), followed by Kufri Pukhraj (42.32) and Kufri Lima (41.64), whereas Kufri Mohan, Kufri Thar-2 and Kufri Sangam exhibited significantly lower chlorophyll concentrations. Higher SPAD readings indicate greater chlorophyll accumulation and enhanced photosynthetic efficiency, which may contribute to improved biomass production and yield potential. These findings agree with Diana *et al.* (2025), who also reported significant varietal differences in chlorophyll concentration among potato cultivars.

Plant height differed significantly among the tested varieties (Table 2). The tallest plants were recorded in Kufri Pukhraj (54.08 cm), followed by Kufri Lima (53.21 cm), whereas the shortest plants were observed in Kufri Thar-3 (30.63 cm). Plant height is a varietal trait influenced by genetic potential together with environmental factors, nutrient availability, and crop management practices. Vigorous vegetative growth in Kufri Pukhraj and Kufri Lima suggests better adaptability and resource utilization under the prevailing agro-climatic conditions. Similar significant differences in plant height among potato varieties have been reported by Dhaliwal *et al.* (2025a) and Giri *et al.* (2023).

Disease incidences at 90 DAP also varied significantly among the potato varieties (Table 2). Kufri Bahar recorded the lowest disease incidence (10.71%), indicating superior field tolerance or resistance to prevailing diseases, while other varieties exhibited comparatively higher disease levels. Lower disease incidence in Kufri Bahar may have contributed to its better physiological performance and overall crop health. Comparable findings were reported by Jeevalatha *et al.* (2017), who observed lower seed degeneration and minimal leaf curl symptoms in Kufri Bahar, confirming its relatively better disease resistance under field conditions. Overall, the combined assessment of emergence, chlorophyll concentration, plant height, and disease incidence suggests that Kufri Bahar demonstrated superior physiological performance and plant health, while Kufri Pukhraj and Kufri Lima exhibited greater vegetative vigour, highlighting distinct varietal strengths that can be exploited for cultivar selection under similar agro-ecological conditions.

Moisture and dry matter content:

The moisture content was found minimum in Kufri Neelkanth (77.52%) and Kufri Bahar (77.93%) and maximum by Kufri Jamunia (82.56%) (Table 3). The observed disparity in moisture content may be attributed to the distinct varietal traits. High moisture content in potato tubers is an undesirable trait as it affects shelf life of tubers, less recovery of dry matter in processing industry, etc. The moisture contents of potato tubers from various varieties align with results published by Dhaliwal *et al.* (2025b). Dry matter content of different tubers was recorded and presented in table 3. The dry matter content of tubers was significantly affected due to different potato genotype. It ranged from 17.44 per cent (Kufri Jamunia) to 22.48 per cent (Kufri Neelkanth) with an overall mean of 20.19 per cent. The highest dry matter content of tubers was found in genotype Kufri Neelkanth (22.48 per cent) which was noted statistically at par with Kufri bahar (21.85 percent), Kufri Sangam (21.60 per cent), Kufri Lalit (21.50 per cent), Kufri Bashkar (21.35 per cent), Kufri Sukhyati (21.20 per cent) and Kufri Mohan (20.69 per cent) and significantly superior over rest of the potato.

Table 2: Performance of potato varieties on various attributes (Pooled of two years)

Treatment	Emergence (%) at 30 DAP	SPAD Value at 60 DAP	Plant height (cm) at 60 DAP	% Disease incidence at 90 DAP	Polar diameter (mm)	Equatorial diameter (mm)
Kufri Pukhraj	94.08	42.32	54.08	12.50	78.36	43.23
Kufri Lima	92.30	41.64	53.21	16.07	78.49	44.99
Kufri Bahar	95.87	44.58	43.30	10.71	77.91	43.34
Kufri Lohit	90.74	40.48	44.96	16.07	81.08	41.20
Kufri Thar-3	86.38	40.28	30.63	19.64	68.77	44.22
Kufri Lalit	95.09	43.53	50.68	12.50	62.08	45.24
Kufri Bhaskar	91.29	43.85	43.15	14.29	74.33	44.68
Kufri Jamunia	92.52	43.41	44.38	14.29	67.50	36.04
Kufri Mohan	89.55	37.63	43.14	14.29	76.38	50.71
Kufri Neelkanth	92.30	40.87	49.74	14.29	72.38	40.05
Kufri Sukhyati	93.30	40.85	48.01	19.64	75.24	45.61
Kufri Khyati	88.17	39.98	42.14	16.07	77.75	44.13
Kufri Ganga	88.95	40.29	47.23	14.29	81.03	46.91
Kufri Surya	90.29	40.88	42.26	19.64	84.10	48.03
Kufri Sangam	87.17	38.86	43.66	17.86	72.34	43.98
Kufri Thar-2	90.29	38.13	40.98	19.64	79.16	43.34
SEm±	5.31	1.61	2.05	6.16	3.35	2.35
CD(p=0.05)	NS	4.51	5.76	17.32	9.41	6.62

Table 3: Quality parameters of potato varieties and yield (Pooled of two years)

Treatment	Moisture content in tuber (%)	Tuber dry matter (%)	Total soluble solids (°Brix)	Ash content (%)	Yield (t/ha)
Kufri Pukhraj	81.30	18.70	6.25	4.57	32.22
Kufri Lima	79.79	20.21	6.95	4.92	30.61
Kufri Bahar	77.93	21.85	7.23	5.77	35.60
Kufri Lohit	80.69	19.31	6.93	5.07	32.79
Kufri Thar-3	81.18	18.82	5.88	4.77	30.30
Kufri Lalit	78.50	21.50	6.60	4.69	33.23
Kufri Bhaskar	78.65	21.35	6.80	4.94	33.53
Kufri Jamunia	82.56	17.44	6.63	4.59	28.29
Kufri Mohan	79.31	20.69	6.58	5.14	31.46
Kufri Neelkanth	77.52	22.48	6.38	4.84	27.49
Kufri Sukhyati	78.80	21.20	6.35	4.08	32.96
Kufri Khyati	80.70	19.30	6.55	4.78	31.73
Kufri Ganga	80.12	19.88	6.98	4.82	30.58
Kufri Surya	80.49	19.51	6.25	4.28	29.21
Kufri Sangam	78.40	21.60	6.88	4.49	26.20
Kufri Thar-2	80.79	19.21	6.75	4.35	25.96
SEm±	1.07	1.06	0.26	0.21	1.31
CD(p=0.05)	2.99	2.96	0.72	0.59	3.67

However, the lowest dry weight of tuber was found in genotype Kufri Jamunia (17.44 per cent). The results are close refers with the finding of Jatav *et al.* (2023). The dry matter content of potatoes is a crucial factor in potato processing. There is a significant degree of variation across cultivars when it comes to the quantity of dry matter that is present in tubers, as stated by Abbas *et al.* (2011). Amin *et al.* 2021 also stated that potato genotypes had a direct influence on dry matter content. 20% dry matter content in tuber is essential for processing industries (Kaur *et al.* 2025).

Tuber quality attributes and yield

Significant varietal differences were observed in tuber quality attributes, including total soluble solids (TSS), tuber dimensions, ash content, and marketable yield (Tables 2 and 3). Total soluble solids (TSS) ranged from 5.88 to 7.23 °Brix, with the highest value recorded in Kufri Bahar (7.23 °Brix) and the lowest in Kufri Thar-3 (5.88 °Brix) (Table 2). Higher TSS values indicate greater accumulation of soluble sugars and other dissolved solids, which contribute to improved tuber quality and processing characteristics. The increased TSS may be attributed to higher concentrations of soluble carbohydrates, proteins, and vitamins. The TSS values recorded in the present study were slightly higher than those reported by Singh *et al.* (2025) and Dhaliwal *et al.* (2025).

Significant variation was also observed in tuber size among the evaluated cultivars (Table 2). The maximum polar (vertical) diameter was recorded in Kufri Surya (84.23 mm), followed by Kufri Lohit (81.03 mm), whereas the minimum was observed in Kufri Lalit (65.08 mm). In contrast, the highest equatorial (horizontal) diameter was recorded in Kufri Mohan (50.71 mm), while Kufri Jamunia (36.04 mm) produced the smallest tubers in terms of equatorial diameter. These differences reflect the inherent genetic variability among cultivars governing tuber shape and size, traits that are important for consumer preference and processing suitability. Ash content also differed significantly among potato cultivars (Table 3), indicating variation in mineral accumulation. The highest ash content was recorded in Kufri Bahar (5.77%), followed by other high-performing cultivars, whereas the lowest value was observed in Kufri Sukhyati (4.08%). Although significant varietal differences were evident, the ash content values obtained in the present study were generally lower than those reported by Gautam *et al.* (2024).

Marketable tuber yield varied significantly among the tested potato varieties (Table 3). The highest yield was obtained with Kufri Bahar (35.60 t ha^{-1}), followed by Kufri Bhaskar (33.53 t ha^{-1}), Kufri Lalit (33.22 t ha^{-1}), and Kufri Sukhyati (32.96 t ha^{-1}), whereas the lowest yield was recorded in Kufri Thar-2 (25.96 t ha^{-1}). The superior yield performance of Kufri Bahar can be attributed to its favourable combination of higher chlorophyll content, lower disease incidence, desirable tuber quality attributes, and efficient partitioning of assimilates towards tuber development. The observed differences among cultivars demonstrate the importance of genotype in determining productivity under the prevailing agro-climatic conditions. Similar varietal variation in tuber yield has also been reported by Singh *et al.* (2025). Overall, the results indicate that Kufri Bahar consistently outperformed the other cultivars in terms of tuber quality and productivity, making it a promising variety for cultivation under the experimental conditions.

Multivalent analysis of potato cultivars

Principal component analysis (PCA) was performed using eleven quantitative traits to elucidate the overall variability among the sixteen potato cultivars (Fig. 3). The first two principal components explained 54.60% of the total variation, with PC1 accounting for 35.90% and PC2 for 18.70%. PC1 was mainly associated with tuber quality and productivity traits, whereas PC2 represented variation related to growth attributes and tuber morphology. The PCA biplot clearly differentiated the cultivars according to their agronomic and quality characteristics. Kufri Bahar was positioned in association with higher yield, SPAD value, total soluble solids, and emergence percentage, indicating its superior overall performance. Kufri Neelkanth was closely associated with dry matter content, confirming its suitability for processing purposes. Conversely, cultivars such as Kufri Thar-2, Kufri Sangam, and Kufri Jamunia were positioned away from the yield-associated vectors, reflecting comparatively lower agronomic performance.

Fig. 2: General view of the different potato varieties

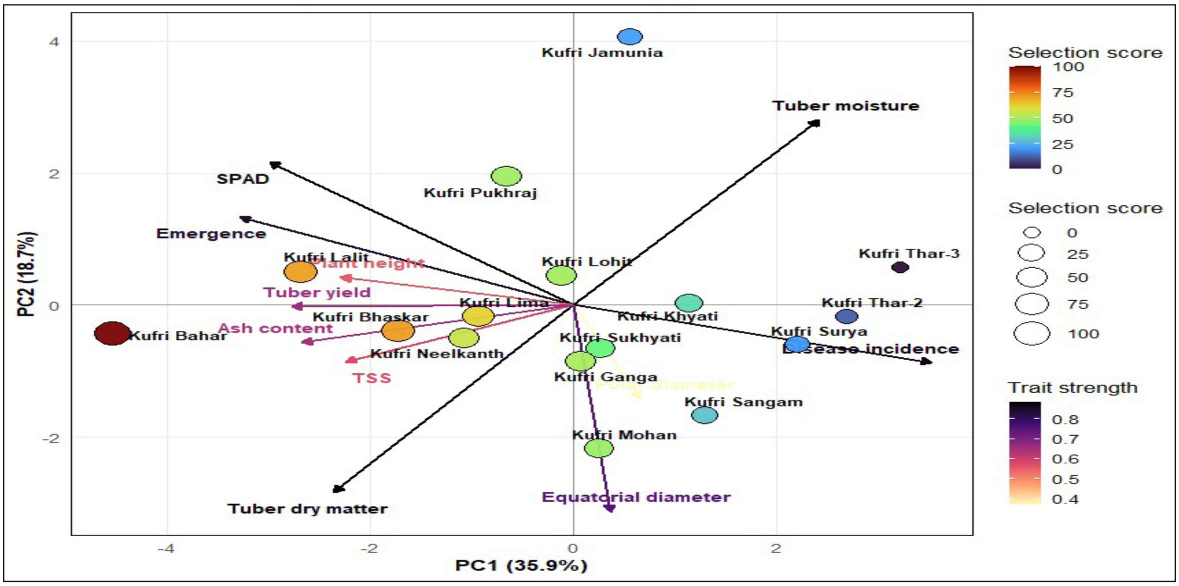

Fig. 3: Principal component analysis biplot showing the relationships among sixteen potato cultivars and growth, physiological, tuber-quality, disease, and yield traits

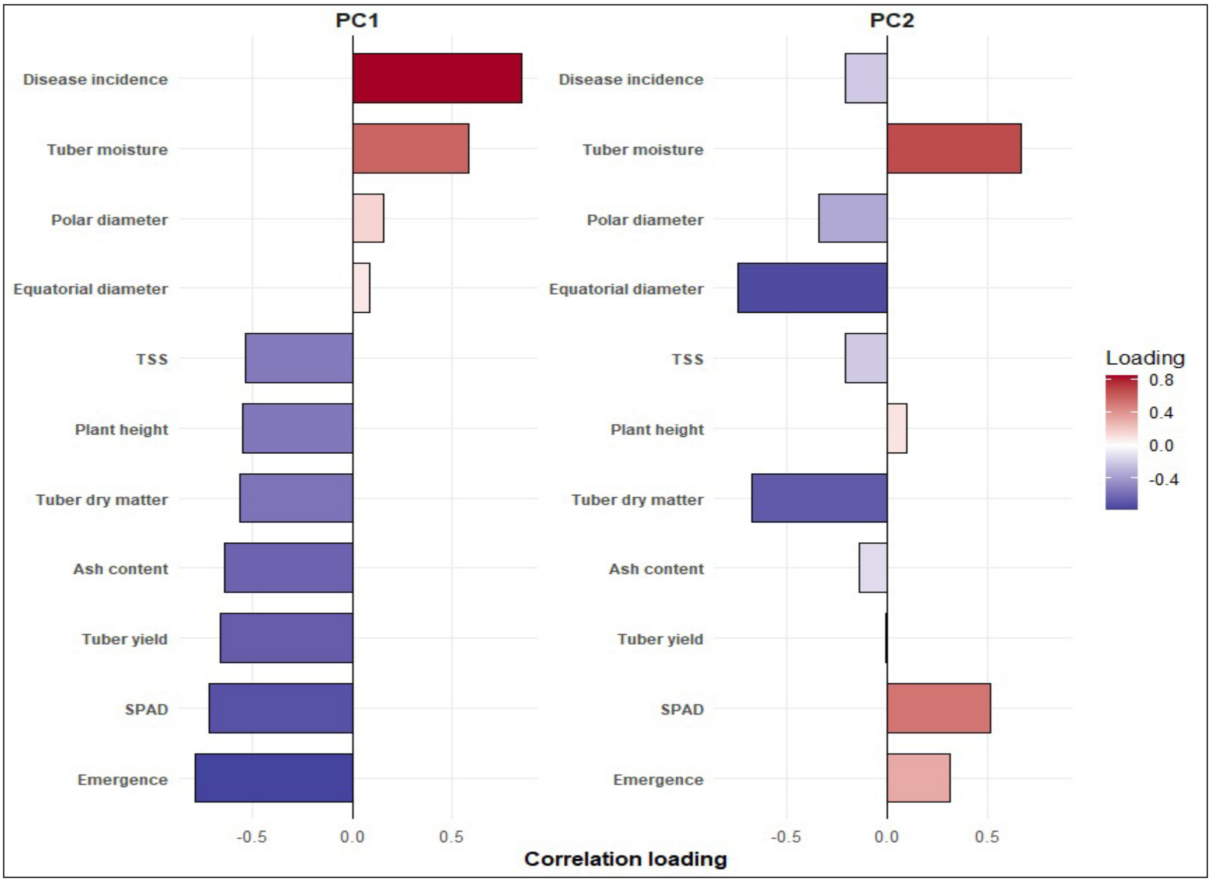

Fig. 4: Loadings of the measured traits on the first two principal components (PC1 and PC2)

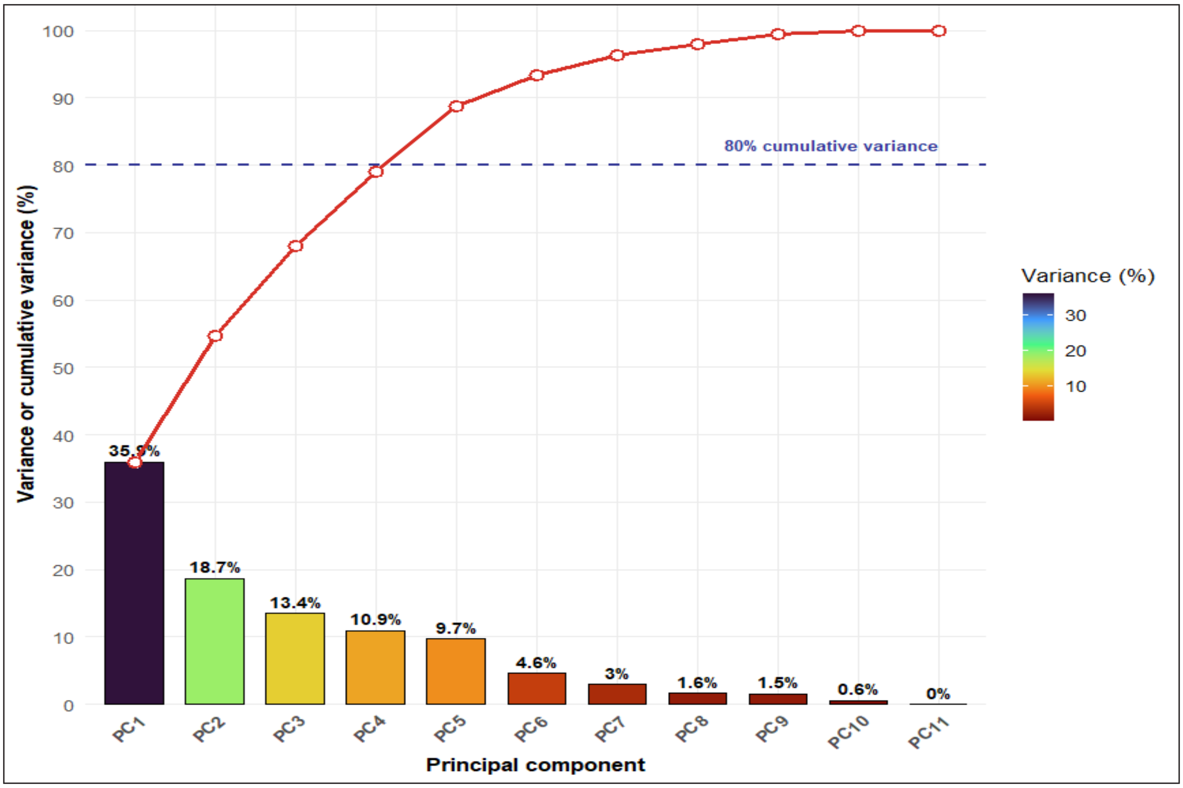

Fig. 5: Principal components illustrating the cumulative variance of eleven traits

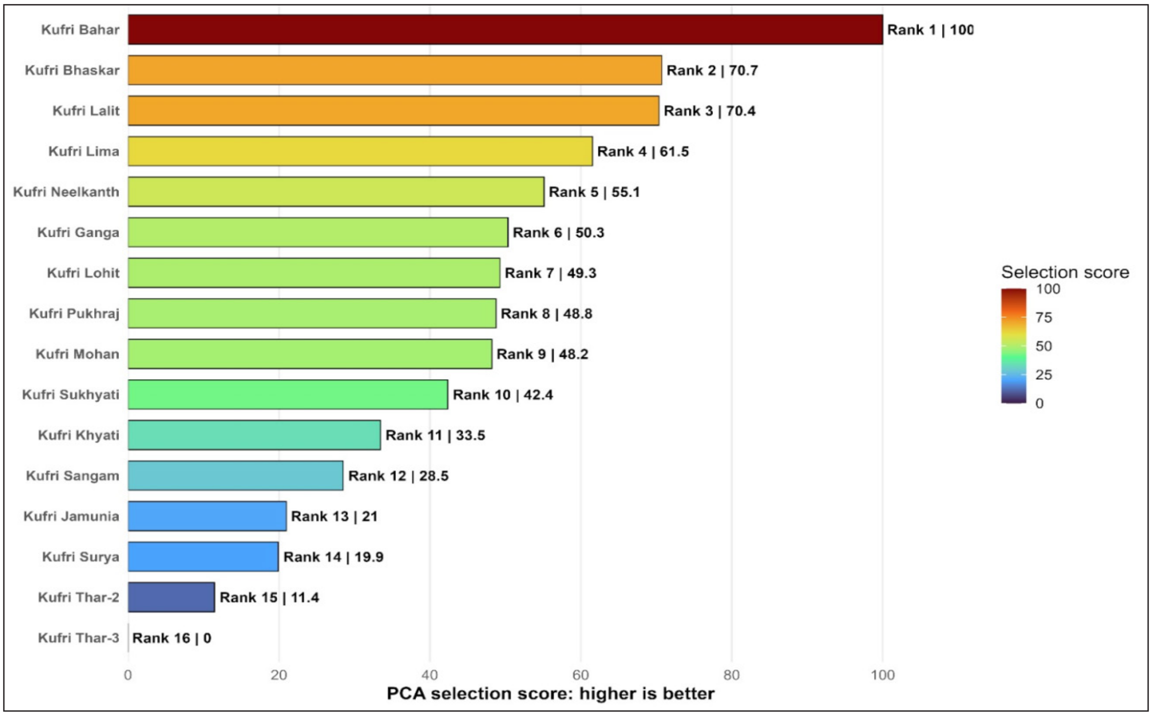

Fig. 6: Ranking of potato cultivars based on PCA scores

The loading vectors further revealed that tuber yield was positively associated with emergence percentage, chlorophyll content, and total soluble solids, whereas disease incidence showed an opposite trend (Fig. 4). The PCA of total eleven traits of potato cultivars revealed that the first 5 PCs accounted for 88.70% of the total standard variation. PC1 explained 35.90% of the total variance, followed by PC2 (18.70%), PC3 (13.4%), PC4 (10.9%), and PC5 (9.70%). Thus, the first 5 PCs were considered sufficient to explain the major variability among the evaluated cultivars (Fig. 5). PCA based figure 6 showed that among the tested cultivars, Kufri Bahar recorded the highest positive scores (100), indicating superior overall performance, followed by Kufri Bhaskar (70.7), Kufri Lalit (70.4), Kufri Lima (61.4), Kufri Neelkanth (55.1) and Kufri Ganga (50.3). These cultivars exhibited desirable combinations of higher emergence, growth and yield attributing characters and quality parameter making them suitable for cultivation under the non-traditional potato-growing conditions of Rajasthan.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

CONCLUSION

Different potato varieties show considerable variation in growth, quality and yield under similar environmental condition. The plant height of these ranged from 30.63 cm (Kufri Thar-3) to 54.08 cm (Kufri Pukhraj), moisture content ranged from 77.52 to 82.56 %, dry matter content ranged from 17.44% to 22.48%. The high dry matter contents were observed in Kufri Neelkanth (22.48 %) followed by Kufri Bahar (21.85%). The Overall, most of the potato cultivars produced tubers with a dry matter content greater and among the tested varieties, Kufri Bahar (35.60 tha^{-1}), Kufri Bhaskar (33.53 tha^{-1}), Kufri Lalit (33.22 tha^{-1}) and Kufri Sukhyati (32.96 tha^{-1}) were produce good tuber yield under non-traditional potato growing area. The principal component analysis showed first five components explain 88.70% of total variability. PCA based ranking identified Kufri Bahar as most suitable cultivar followed by K. Bhaskar, K. Lalit, K. Lima, K. Neelkanth and K. Ganga for cultivation in the non-traditional potato-growing region of Rajasthan.

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