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Comparative study on the growth, yield and storability of potato genotypes propagated through apical rooted cuttings

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Abstract
Potato (*Solanum tuberosum* L.) is a globally significant crop for food security and economic growth. Traditional cultivation using seed tubers poses challenges such as disease transmission, bulky seed material and high storage costs. Apical rooted cuttings (ARCs) have emerged as a promising alternative propagation method, offering potential advantages such as disease-free planting material and reduced seed volume. This study aimed to compare the performance of potato genotypes propagated through ARCs in terms of growth, yield and post-harvest storability. The field experiment, conducted at the University of Agricultural Sciences, Dharwad, involved eight potato genotypes under Randomized Block Design. Key growth parameters like plant height, shoot number, leaf count and tuber yield were measured. The results revealed that tuber-propagated plants, particularly Kufri Jyoti, exhibited superior growth and yield, while ARC-propagated plants showed reduced performance in most parameters. Storage evaluations highlighted that tuber-propagated plants had lower physiological losses and rotting percentages compared to ARC plants. These findings suggest that while ARCs can be cost-effective, traditional seed tubers remain more efficient for maximizing yield and storability, particularly in certain genotypes. The research provides valuable insights for optimizing potato propagation methods to enhance productivity and reduce costs.

Keywords: Apical rooted cuttings, post-harvest storability, potato, seed tubers, growth, storage

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important staple crops worldwide, playing a crucial role in ensuring food security and generating economic value. Traditional potato cultivation largely relies on seed tubers, which involve planting whole or cut tubers for propagation. While this method is effective in terms of genetic uniformity and yield potential, it has certain drawbacks, such as high disease transmission rates, bulky seed material and higher storage costs. In response to these challenges, alternative propagation methods, such as apical rooted cuttings (ARCs), have emerged as a potential solution to enhance potato production efficiency, reduce disease risk and lower the costs associated with seed storage.

Apical rooted cuttings involve the use of stem cuttings with growing tips, which are rooted in a controlled environment and later transplanted into the field. This method can produce disease-free planting material, reduce the volume of seed material required and offer a more cost-effective propagation method, especially for smallholder farmers. However, the performance of ARCs in terms of growth, yield and storability has not been as widely studied as traditional seed tubers, which are known for their reliability in ensuring high yields and consistent quality. Understanding how these two methods compare in different growth conditions and with various genotypes is crucial for optimizing potato cultivation.

This study aims to conduct a comparative analysis of the growth, yield and storability of potato genotypes propagated through apical rooted cuttings and traditional seed tubers. By assessing key parameters such as plant height, tuber size, total yield and post-harvest storage qualities, this research seeks to determine the viability and advantages of ARC propagation compared to conventional tuber-based methods.

The results of this study will provide valuable insights for farmers, researchers and agricultural policymakers in selecting the most effective propagation methods to enhance productivity and reduce production costs.

Materials and Methods

The field experiment was conducted during the *Kharif* season of 2023 at the University of Agricultural Sciences, Dharwad to study the performance of potato genotypes propagated through apical rooted cuttings. The experimental site was characterized by deep black soils (vertisols) rich in phosphorus and iron. The experiment was laid out in a Randomized Block Design (RBD) with eight potato genotypes, including seven propagated through apical rooted cuttings and one control propagated through tubers (Kufri Jyoti). Each treatment was replicated three times. The crop was planted on ridges with a spacing of 60 cm x 20 cm and standard agronomic practices, including earthing up, weed management and pest control, were followed throughout the cropping period.

Growth parameters such as plant height, number of shoots per plant, number of compound leaves per plant and diameter of the main stem were recorded at different growth stages. Five plants were randomly selected and tagged in each plot for observation. Plant height was measured from the base to the tip of the tallest stem, while the number of shoots and compound leaves per plant was recorded manually. The diameter of the main stem was measured at the base using a vernier caliper. Data were collected at regular intervals to assess the impact of propagation methods on vegetative growth and development.

After harvest, yield parameters such as the number of tubers per plant, tuber weight per plant, average tuber weight, total yield per plot and marketable yield per plot were recorded. Tubers were weighed and the average number and weight of tubers were calculated for each genotype. Post-harvest storage parameters, including physiological loss in weight, rotting percentage and sprouting percentage, were monitored over a specified storage period. These observations were critical in evaluating the storage potential of tubers propagated through apical rooted cuttings. Statistical analysis was performed using analysis of variance (ANOVA) to test the significance of differences between treatments.

Results and Discussion

The plant height, number of shoots per plant, number of compound leaves per plant, diameter of main stem, number of tubers per plant, weight of tubers per plant, average weight of tuber per plant, total yield per plot, total yield per hectare, marketable yield per plot and marketable yield per hectare, Physiological loss in weight, weight loss due to rottage, total weight loss, rotting percent and sprouting percent for several potato genotypes was calculated. The data regarding growth and yield parameters is presented in Table 1, 2 and 3.

Plant Height

The plant height ranged from 35.24 cm to 46.82 cm. The highest plant height was recorded in Kufri Jyoti (46.82 cm) propagated through tubers, followed by Kufri Lima (45.97 cm) and Kufri Sangam (45.56 cm). The lowest height was observed in Kufri Jyoti propagated through apical rooted cuttings (35.24 cm). The significant variation in plant height among the potato genotypes highlights the influence of propagation methods on vegetative growth. Kufri Jyoti, propagated through tubers recorded the maximum height (46.82 cm), indicating its vigorous growth when using traditional seed tubers. This could be attributed to better initial nutrient reserves and root development. In contrast, Kufri Jyoti propagated through apical rooted cuttings (ARC) showed the lowest plant height (35.24 cm), which suggests that ARCs may experience slower initial growth due to delayed root establishment. These findings are consistent with previous studies that indicate slower growth in ARC-propagated plants during early stages. Similar variations in plant height with respect to potato genotypes was noticed by Abdalla *et al.* (2022) [3] and Kumar and Amruta (2023) [13].

Number of Primary Shoots Per Plant

The number of primary shoots varied from 1.89 to 4.99. Kufri Jyoti propagated through tubers recorded the highest number of shoots (4.99), while the lowest was in Kufri Jyoti propagated through apical rooted cuttings (1.89). The number of primary shoots per plant is crucial for determining the plant's ability to produce tubers. Kufri Jyoti propagated through tubers had the highest number of shoots (4.99), reflecting its superior vegetative capacity. However, Kufri Jyoti propagated through ARCs recorded the lowest (1.89), which is likely a result of limited shoot development in ARCs compared to tubers. This suggests that tuber propagation provides a better environment for shoot initiation due to the presence of auxiliary buds and stored energy in the tubers. Similar variations in number of primary shoots/plant with respect to potato genotypes was observed by Ranalli *et al.* (1994) [18] and Rajegowda *et al.* (2021) [17].

Number of Compound Leaves Per Plant

The number of compound leaves ranged between 25.11 and 41.84. Kufri Jyoti (41.84) propagated through tubers showed the highest leaf count, on par with Kufri Lima (38.54), while Kufri Jyoti propagated through apical rooted cuttings (25.11) recorded the lowest. The number of compound leaves is directly related to the photosynthetic potential of the plant. Kufri Jyoti (tuber) showed the highest number of compound leaves (41.84), which may have contributed to its higher yield by providing more surface area for photosynthesis. The lower leaf count in Kufri Jyoti propagated through ARCs (25.11) indicates reduced vegetative growth, which aligns with the slower shoot and root development observed in ARC-propagated plants. These differences suggest that propagation methods significantly affect foliage development. Similar differences in number of compound leaves/plant were reported with respect to potato genotypes by Sharma *et al.* (2020) [19] and Kumar and Singh (2021) [12].

Diameter of Main Stem

Stem diameter ranged from 0.75 cm to 1.24 cm, with Kufri Jyoti (tuber) showing the highest diameter (1.24 cm), followed by Kufri Lima (1.19 cm), while Kufri Jyoti (ARC) and Kufri Karan (ARC) had the lowest (0.75 cm). The diameter of the main stem reflects the overall strength and vigor of the plant. Kufri Jyoti propagated through tubers had the thickest stem (1.24 cm), indicating robust growth and efficient nutrient transport. In contrast, Kufri Jyoti and Kufri Karan propagated through ARCs had the thinnest stem (0.75 cm), reflecting weaker structural development. This reinforces the notion that ARC propagation may lead to slower or less vigorous initial growth compared to tuber propagation. Similar variations in diameter of main stem with respect to potato genotypes were observed by Aarakit (2021) [1].

Number of Tubers Per Plant: The number of tubers per plant varied from 1.93 to 6.80. The highest was recorded in Kufri Jyoti (6.80) propagated through tubers, while the lowest was observed in Kufri Karan (1.93) propagated through apical rooted cuttings. Kufri Jyoti (tuber) recorded the highest number of tubers per plant (6.80), demonstrating that tuber propagation promotes superior reproductive growth. The lowest number of tubers was observed in Kufri Karan (1.93) propagated through ARCs, which suggests that ARC propagation may limit tuber formation in some genotypes. This could be due to reduced early growth, affecting the plant's capacity to develop multiple tubers. Similar variations in number of tubers per plant was observed by Rajegowda *et al.* (2021) [17], Sharma *et al.* (2020) [19] and Patel and Rao (2019) [16].

Weight of Tubers Per Plant

Tubers' weight ranged between 70.04 g and 290.15 g. Kufri Jyoti (290.15 g) propagated through tubers recorded the highest tuber weight, while Kufri Chipsona-4 (70.04 g) had the lowest. The weight of tubers per plant varied significantly, with Kufri Jyoti propagated through tubers recording the highest (290.15 g). This result highlights the advantage of tuber propagation in enhancing tuber development and overall biomass. The lowest tuber weight was found in Kufri Chipsona-4 (70.04 g), suggesting poor tuber growth in this genotype under the given conditions, possibly due to genetic limitations. The findings are consistent with those revealed by Giri *et al.* (2023) [8] and Kumar and Amruta (2023) [13].

Average Weight of Tubers

The average tuber weight ranged from 32.86 g to 42.67 g. Kufri Jyoti (42.67 g) propagated through tubers recorded the maximum, while Kufri Himalini (32.86 g) propagated through apical rooted cuttings had the lowest. Kufri Jyoti propagated through tubers also had the highest average tuber weight (42.67 g), further supporting the effectiveness of this propagation method in promoting larger tubers. In contrast, Kufri Himalini propagated through ARCs had the smallest average tuber weight (32.86 g), indicating that ARC propagation may not be as effective in achieving optimal tuber size in certain genotypes which is consistent with Namugga *et al.* (2024) [15] and Khan *et al.* (2020) [11] observations.

Total Yield Per Plot

Total yield ranged from 1.75 kg/plot to 7.70 kg/plot. The highest yield was recorded in Kufri Jyoti (7.70 kg/plot) propagated through tubers, while Kufri Karan (1.75 kg/plot) had the lowest. Kufri Jyoti (tuber) achieved the highest total yield per plot (7.70 kg), significantly outperforming other genotypes. This can be attributed to its superior growth and tuber production capabilities. Kufri Karan, propagated through ARCs, had the lowest yield (1.75 kg), which highlights the challenges associated with ARC propagation in certain genotypes, particularly in terms of yield potential. Similar variations were observed by Handayani *et al.* (2023) [10].

Total Yield Per Hectare

Total yield per hectare varied from 3.74 t/ha to 16.45 t/ha. Kufri Jyoti (16.45 t/ha) propagated through tubers produced the highest yield, while Kufri Karan (3.74 t/ha) yielded the least. The total yield per hectare showed a similar trend, with Kufri Jyoti propagated through tubers achieving the highest yield (16.45 t/ha). This confirms the advantage of tuber propagation for large-scale production. The lowest yield was recorded for Kufri Karan (3.74 t/ha), reflecting its poor performance under ARC propagation. These results suggest that while ARCs may reduce seed costs, they may not consistently match the yield potential of tubers in all genotypes. Similar variations were observed by Sushil *et al.* (2018) [20].

Marketable Yield Per Plot

Marketable yield per plot ranged between 0.63 kg/plot and 16.63 kg/plot. The highest marketable yield was from Kufri Jyoti (16.63 kg/plot) propagated through tubers, while Kufri Karan (0.63 kg/plot) had the lowest. Marketable yield is a key indicator of economic viability. Kufri Jyoti propagated through tubers had the highest marketable yield per plot (6.63 kg), emphasizing its efficiency in producing high-quality tubers suitable for the market. On the other hand, Kufri Karan (0.63 kg) had the lowest marketable yield, indicating that this genotype may not be well-suited for ARC propagation in terms of marketable output. Potato genotypes showed similar variability in the marketable yield noticed by Aarakit *et al.* (2021) [1].

Marketable Yield Per Hectare

Marketable yield per hectare ranged from 1.35 t/ha to 14.17 t/ha. Kufri Jyoti (14.17 t/ha) propagated through tubers recorded the highest, while Kufri Karan (1.35 t/ha) had the lowest. The marketable yield per hectare was highest in Kufri Jyoti propagated through tubers (14.17 t/ha), reinforcing its potential for commercial cultivation. The lowest marketable yield was observed in Kufri Karan (1.35 t/ha), which further highlights the limitations of ARC propagation for this genotype. Overall, tuber propagation consistently outperformed ARC propagation in terms of both total and marketable yield, suggesting that while ARCs offer certain advantages, tuber propagation remains the most reliable method for achieving high productivity in potato cultivation. Potato genotypes showed similar variability in the marketable yield noticed by Benz *et al*. (1995) [4].

Physiological Loss in Weight after Storage

The physiological loss in weight varied significantly among the genotypes, ranging from 4.00% to 32.00%. The highest loss was recorded in Kufri Karan (32.00%) propagated through apical rooted cuttings, while Kufri Sangam had the lowest physiological loss (4.00%). Kufri Jyoti propagated through tubers recorded a moderate loss of 12%. The study revealed significant variation in physiological weight loss among different potato genotypes. Kufri Karan, propagated through apical rooted cuttings, exhibited the highest loss, suggesting a potential genetic predisposition or susceptibility to physiological decay. In contrast, Kufri Sangam, also propagated through apical rooted cuttings, demonstrated the lowest loss, indicating its superior tolerance to physiological weight loss. The check variety, Kufri Jyoti, displayed intermediate loss, further emphasizing the genotypic differences in this trait. These findings highlight the importance of genotype selection in potato cultivation to minimize postharvest losses and ensure optimal storage longevity. Bisognin *et al.* (2015) [5] observed the similar variations for physiological loss in weight with respect to potato genotypes.

Weight Loss Due to Rottage

Weight loss due to rottage ranged from 3.20% to 24.00%. Kufri Karan exhibited the highest rottage (24.00%), while Kufri Jyoti propagated through tubers showed the least rottage (3.20%). Other genotypes like Kufri Jyoti (ARC) and Kufri Himalini had higher rottage percentages of 16.80% and 16.80%, respectively. The findings showed that various potato genotypes varied significantly in the amount of weight lost as a result of rotting. Several variables can be linked to this discrepancy. Propagated by apical rooted cuttings, the genotype Kufri Karan showed the greatest physiological weight loss, perhaps because of its vulnerability to rot-causing pathogens. Compared to genotypes produced via tuber, apical rooted cuttings can have weaker root systems, which would make them more susceptible to infections. On the other hand, the genotype Kufri Jyoti, which is propagated via tubers, showed the least amount of weight loss. Because of their extensive root system and nutrients that are retained, tubers may be more resistant to rot-causing pathogens. Furthermore, each genotype's vulnerability to rot is largely determined by its genetic composition. These results emphasize how crucial it is to choose potato genotypes that are naturally resistant to rot for sustainable agricultural practices. Similar differences in weight loss due to rottage were noted by Gajurel *et al.* (2024) [7] in relation to potato genotypes.

Total Weight Loss after Storage

Total weight loss after storage ranged from 10.00% to 56.00%. Kufri Karan had the highest total weight loss (56.00%), followed by Kufri Himalini (40.73%). Kufri Sangam had the lowest total weight loss (10.00%), indicating its better storage performance. The findings show that there is a significant difference in the overall weight loss between the various potato genotypes, which is probably caused by a mix of genetic and propagation variables. Propagated using apical rooted cuttings, the Kufri Karan genotype showed the greatest weight loss, indicating that this genotype may have innate characteristics that make it more prone to weight loss. Reduced weight loss in Kufri Sangam, which is propagated by tubers, may be caused by physiological processes or protective chemicals found in plants grown from tubers that counteract weight loss. These results highlight how crucial genotype selection and propagation techniques are in influencing a potato cultivar's overall performance, especially with regard to weight loss after harvest. Daniels-Lake *et al.* (2014) [6] found similar variations in total weight loss with respect to potato genotypes.

Rotting Percentage after Storage

Rotting percentages ranged from 1.41% to 5.63%, with Kufri Karan showing the highest rotting percentage (5.63%) and Kufri Jyoti propagated through tubers showing the lowest (1.41%). Kufri Jyoti (ARC) and Kufri Himalini exhibited higher rotting percentages of 4.93% and 4.23%, respectively. The findings show a considerable difference in rotting percentages among potato genotypes. Kufri Karan, produced by apical rooted cuttings, had the highest sensitivity to rotting, most likely because to an intrinsic genetic predisposition and the probable vulnerability of apical cuttings to infections. Kufri Jyoti and Kufri Himalini, which were similarly produced using apical rooted cuttings, had modest rotting percentages, presumably due to similar causes. Kufri Mohan and Kufri Chipsona-4, which were produced using apical rooted cuttings, rotted at a slower pace, indicating a stronger resilience to rot-causing pathogens. Interestingly, Kufri Jyoti grown by tubers had the lowest rotting percentage, suggesting that tuber-based propagation may provide superior tolerance to rot-inducing conditions. These findings emphasize the significance of genotype selection and propagation methods in decreasing post-harvest losses due to rotting in potato. Haider *et al.* (2022) [9] discovered comparable variances in rotting percent across potato genotypes.

Sprouting Percentage after Storage

Sprouting percentages varied from 3.52% to 8.45%. Kufri Karan had the highest sprouting percentage (8.45%), while Kufri Jyoti propagated through tubers had the lowest (3.52%). Kufri Chipsona-4 (7.75%) and Kufri Himalini (7.37%) also showed higher sprouting rates. The study found significant variations in sprouting percentages among potato genotypes, with Kufri Karan having the greatest sprouting rate (8.45%) when propagated using apical rooted cuttings. Other genotypes, like Kufri Chipsona-4 and Kufri Himalini, showed good sprouting potential. However, Kufri Jyoti produced by tuber had the lowest sprouting rate (3.52%), indicating that the mode of propagation has a substantial impact on sprouting. The observed disparities in sprouting rates can be linked to genetic variables, physiological parameters and the propagation strategy used. These findings provide useful information for selecting potato genotypes and propagation procedures that improve sprouting and subsequent crop establishment. Wurr *et al.* (1979) [21] discovered comparable variances in sprouting percent across potato genotypes.

Table 1: Mean performance of different potato genotypes for growth parameters

Sl. No.	Genotypes	Plant height (cm)	Number of shoots per plant	Number of compound leaves per plant	Diameter of main stem
		75 DAT			
1	Kufri Mohan	41.48	2.97	28.95	0.96
2	Kufri Chipsona-4	40.80	2.78	37.06	0.82
3	Kufri Sangam	45.56	2.19	36.28	0.98
4	Kufri Karan	40.35	2.31	32.95	0.75
5	Kufri Jyoti	35.24	1.89	25.11	0.75
6	Kufri Lima	45.97	3.97	38.54	1.19
7	Kufri Himalini	41.07	2.54	33.42	1.10
8	Kufri Jyoti (Tuber) (Check)	46.82	4.99	41.84	1.24
Mean		42.16	2.96	34.27	0.97
S.Em ±		1.89	0.14	1.52	0.05
C.D. @ 5%		5.73	0.44	4.62	0.14

Table 2: Mean performance of different potato genotypes for yield parameters

Sl. No.	Genotypes	Number of tubers per plant	Weight of tubers per plant (g plant^{-1})	Average weight of tubers (g tuber^{-1})	Total tuber yield per plot (kg/plot)	Total tuber yield per hectare (tons/ha)	Marketable tuber yield per plot (kg/plot)	Marketable tuber yield per hectare (tons/ha)
1	Kufri Mohan	2.53	94.34	37.29	3.51	7.49	2.63	5.62
2	Kufri Chipsona-4	1.98	70.04	35.37	2.97	6.35	1.64	3.50
3	Kufri Sangam	3.27	120.22	36.76	4.05	8.65	3.26	6.97
4	Kufri Karan	1.93	70.09	36.32	1.75	3.74	0.63	1.35
5	Kufri Jyoti	2.10	74.05	35.26	2.51	5.35	1.25	2.67
6	Kufri Lima	3.78	141.23	37.36	4.47	9.56	3.32	7.09
7	Kufri Himalini	2.89	94.96	32.86	3.46	7.39	2.25	4.81
8	Kufri Jyoti (Tuber) (Check)	6.80	290.15	42.67	7.70	16.45	6.63	14.17
Mean		3.16	119.39	30.04	3.80	8.12	2.70	5.77
S.Em ±		0.15	6.00	1.38	0.27	0.40	0.15	0.31
C.D. @ 5%		0.47	18.19	4.19	0.83	1.22	0.44	0.94

Table 3: Mean performance of different potato genotypes for storage behavior

Sl. No.	Genotypes	Physiological loss in weight after storage (%)	Weight loss due to rottage after storage (%)	Total weight loss after storage (%)	Rotting percent after storage (%)	Sprouting percent after storage (%)	Marketable tuber yield per plot (kg/plot)
1	Kufri Mohan	17.00	15.25	32.25	3.71	5.63	2.63
2	Kufri Chipsona-4	12.40	10.40	22.80	2.82	7.75	1.64
3	Kufri Sangam	4.00	6.00	10.00	2.11	4.93	3.26
4	Kufri Karan	32.00	24.00	56.00	5.63	8.45	0.63
5	Kufri Jyoti	12.00	16.80	28.80	4.93	6.49	1.25
6	Kufri Lima	7.60	5.40	13.00	2.11	4.23	3.32
7	Kufri Himalini	24.00	16.80	40.73	4.23	7.37	2.25
8	Kufri Jyoti (Tuber) (Check)	12.00	3.20	15.20	1.41	3.52	6.63
Mean		15.13	12.23	27.35	3.37	6.05	2.70
S.Em ±		0.75	0.57	1.27	0.17	0.29	0.15
C.D. @ 5%		2.26	1.74	3.86	0.50	0.88	0.44

Conclusion

The study demonstrates that propagation methods significantly impact the growth performance of potato genotypes. Kufri Jyoti propagated through tubers consistently recorded superior results in plant height, number of primary shoots and compound leaves, highlighting its vigorous growth and robust shoot development. Tuber propagation generally resulted in thicker stem diameters and higher tuber numbers, emphasizing its effectiveness in enhancing vegetative and reproductive growth. In contrast, apical rooted cuttings (ARC) showed slower initial growth and reduced performance in most parameters, indicating their limitations in some genotypes. Overall, tuber propagation remains more efficient in maximizing potato productivity.

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