Comparative Study on Growth, Yield and Economics of Potato Production Propagated through Apical Rooted Cuttings

ABSTRACT

This study investigates the comparative growth, yield and economic performance of potato production propagated through apical rooted cuttings (ARCs) in the Northern Transitional Zone of Karnataka. Eight genotypes, including Kufri Jyoti, Kufri Lima and Kufri Sangam, were analyzed for key growth parameters such as plant height, number of primary shoots, number of compound leaves, stem diameter and tuber yield. Results showed that tuber propagation consistently outperformed ARCs, with Kufri Jyoti (tuber) recording the highest plant height (46.82 cm), number of tubers per plant (6.80) and total yield per hectare (16.45 t/ha). Among ARC-propagated genotypes, Kufri Lima performed best, with a yield of 9.56 t/ha. Economic analysis revealed that Kufri Jyoti (tuber) also achieved the highest net returns (₹ 256,146.72/ha) and benefit-cost ratio (2.65). While ARCs offer cost savings on seed material, they showed limitations in overall yield and profitability, particularly in genotypes like Kufri Karan. These findings provide crucial insights into optimizing potato production practices.

Keywords: Potato, Apical Rooted Cuttings, Tuber Propagation, Growth Parameters,Genotypes

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most widely cultivated and economically important food crops in the world, playing a crucial role in food security and the livelihoods of millions of farmers. In India, potato cultivation has expanded significantly, contributing to both subsistence and commercial agriculture. However, the traditional method of potato propagation through seed tubers comes with challenges such as high seed cost, susceptibility to diseases and the bulkiness of seed tubers, which makes storage and transportation difficult. To address these challenges, alternative propagation methods like apical rooted cuttings (ARCs) have been introduced, offering potential advantages in reducing seed costs and improving disease management.

Apical rooted cuttings are gaining attention as a viable alternative to tuber propagation due to their cost-effectiveness and potential to reduce disease transmission. Unlike seed tubers, ARCs involve using vegetative parts of the plant that are rooted and transplanted into the field. This method allows farmers to reduce the quantity of seed material required, thereby lowering input costs. Additionally, ARCs offer the potential for faster multiplication rates, making it easier for farmers to access high-quality planting material. However, despite these advantages, there is still limited research on how different potato genotypes perform when propagated through ARCs compared to traditional seed tubers in terms of growth, yield and economic returns.

This comparative study aims to evaluate the growth, yield and economics of various potato genotypes propagated through apical rooted cuttings and seed tubers. By analyzing key parameters such as plant height, number of shoots, tuber yield and marketable yield, this study seeks to determine the viability of ARCs as an alternative propagation method. Furthermore, the study will assess the economic implications of using ARCs versus seed tubers, providing valuable insights for farmers and stakeholders in optimizing potato production practices to improve both productivity and profitability.

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MATERIAL AND METHODS

The field experiment was conducted at the E-Block, Main Agricultural Research Station (MARS), Dharwad, during the Kharif season of 2023 to evaluate the performance of potato genotypes propagated through apical rooted cuttings (ARCs). The experimental setup followed a Randomized Block Design (RBD) with three replications. Eight potato genotypes were studied, including Kufri Jyoti, Kufri Lima, Kufri Chipsona-4 and Kufri Sangam, propagated through ARCs, while Kufri Jyoti propagated through tubers served as the check. The experimental plots were established with a spacing of 60 x 20 cm and each plot measured 3 m x 3 m.

For growth parameter analysis, key observations like plant height, the number of primary shoots, the diameter of the main stem and the number of compound leaves were recorded. Five plants were randomly selected and tagged in each plot and data were collected at different growth stages to assess the performance of each genotype. The tuber weight, average tuber weight and number of tubers per plant were measured after harvesting. All these parameters were used to assess the impact of different propagation methods on the vegetative and reproductive growth of potato plants.

Yield and economics data were also recorded post-harvest. Total tuber yield per plot and hectare, marketable yield per plot and hectare were calculated. Economic analysis involved determining the net returns and benefit-cost (B:C) ratio based on the cost of cultivation and marketable produce. The statistical analysis was performed using ANOVAto test the significance of differences between genotypes and propagation methods for each recorded parameter.

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RESULTS AND DISCUSSIONS

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, marketable yield per hectare, gross returns, net returns and benefit-cost ratio (B:C ratio) for several potato genotypes ~~was~~ werecalculated. 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 tubersrecorded 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) and Kumar and Amruta (2023).

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~~likely due to 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 topotato genotypes ~~was~~ wereobserved by Ranalli *et al.* (1994) and Rajegowda *et al.* (2021).

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 topotato genotypes by Sharma *et al.* (2020) and Kumar and Singh (2021).

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 topotato genotypes were observed by Aarakit (2021).

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), Sharma *et al.* (2020) and Patel and Rao (2019).

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) and Kumar and Amruta (2023).

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 genotypeswhich is consistent with Namugga *et al.* (2024) and Khan *et al.* (2020) 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).

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).

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).

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).

Gross returns

The genotype Kufri Jyoti propagated through tubers had the highest gross returns of 411146.72 Rs./ha. Among apical rooted cuttings propagated genotypes, Kufri Lima and Kufri Sangam, Kufri Mohan had higher gross returns of (239039.41 Rs./ha), (216136.75 Rs./ha) and (187364.32 Rs./ha). Kufri Karan propagated through apical rooted cuttings had the lowest gross returns (93482.91 Rs./ha). A similar trend was observed by Yadav *et al.* (2024) for gross returns, where Kufri Jyoti, propagated via tubers, outperformed all other genotypes, recording the highest gross returns at Rs. 411,146.72/ha. This reflects the direct correlation between high yield and economic returns. Among the genotypes propagated through apical rooted cuttings, Kufri Lima, Kufri Sangam and Kufri Mohan demonstrated relatively higher gross returns of Rs. 239,039.41/ha, Rs. 216,136.75/ha and Rs. 187,364.32/ha, respectively. Kufri Lima, once again, emerged as the top-performing genotype among those propagated through apical rooted cuttings. In contrast, Kufri Karan exhibited the lowest gross returns at Rs. 93,482.91/ha, indicating that the low yield led to unsatisfactory economic outcomes for this genotype.

Net returns

The genotype Kufri Jyoti propagated through tuber had the highest net returns (256146.72 Rs./ha). Among the apical rooted cuttings genotypes, Kufri Lima, Kufri Sangam and Kufri Mohan had the higher net returns (114039.41 Rs./ha), (91136.75 Rs./ha) and (62364.32 Rs./ha). The genotype with lowest net returns (-31517.09 Rs./ha) was Kufri Karan propagated through apical rooted cuttings. The net returns further emphasized the superiority of Kufri Jyoti propagated via tubers, with the highest net returns of Rs. 256,146.72/ha. The genotypes propagated through apical rooted cuttings followed a similar ranking, with Kufri Lima showing the highest net returns of Rs. 114,039.41/ha, followed by Kufri Sangam at Rs. 91,136.75/ha and Kufri Mohan at Rs. 62,364.32/ha. The most notable outcome, however, was the negative net returns of Kufri Karan (-Rs. 31,517.09/ha), propagated through apical rooted cuttings, which not only had the lowest yield but also failed to cover the production costs. This result underscores the economic risks associated with Kufri Karan when propagated through apical rooted cuttings. Similar variations with respect to net returns was observed by Sinha and Singh (2019) and Lal and Sharma (2006).

Benefit : Cost ratio (B:C ratio)

The genotype Kufri Jyoti propagated through tuber had the highest benefit : cost ratio (2.65). Among the apical rooted cuttings propagated genotypes, Kufri Lima, Kufri Sangam and Kufri Mohan had the higher benefit : cost ratio (1.91), (1.73) and (1.50). The genotype with lowest benefit : cost ratio (0.75) was Kufri Karan propagated through apical rooted cuttings. The benefit-cost ratio further solidified Kufri Jyoti's advantage, with the highest ratio of 2.65, indicating substantial profitability relative to its costs. The genotypes propagated through apical rooted cuttings—Kufri Lima, Kufri Sangam and Kufri Mohan—had B:C ratios of 1.91, 1.73 and 1.50, respectively, which are within acceptable profitability margins, with Kufri Lima emerging as the most economically viable among them. Conversely, Kufri Karan, with a B:C ratio of 0.75, demonstrated poor economic viability, as it failed to return a profit and resulted in losses. Similar variations with respect to benefit : cost ratio was observed by Subedi *et al.* (2019) and Chauhan *et al.* (2022).

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: Economics of potato production

Sl. No.	Genotypes	Yield per hectare (t/ha)	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	Benefit : Cost ratio (B:C ratio)
1	**Kufri Mohan**	7.49	187364.32	125000	62364.32	1.50
2	**Kufri Chipsona-4**	6.35	158668.80	125000	33668.80	1.27
3	**Kufri Sangam**	8.65	216136.75	125000	91136.75	1.73
4	**Kufri Karan**	3.74	93482.91	125000	-31517.09	0.75
5	**Kufri Jyoti**	5.35	133835.47	125000	8835.47	1.07
6	**Kufri Lima**	9.56	239039.41	125000	114039.41	1.91
7	**Kufri Himalini**	7.39	184867.52	125000	59867.52	1.48
8	**Kufri Jyoti (Tuber) (Check)**	16.45	411146.72	155000	256146.72	2.65

CONCLUSION

The study reveals significant differences in growth and yield parameters among various potato genotypes when propagated through apical rooted cuttings (ARCs). Tuber propagation consistently outperformed ARC propagation across metrics such as plant height, number of shoots, leaves, stem diameter and tuber yield, with Kufri Jyoti showing superior growth potential and economic viability for large-scale cultivation. While ARC propagation reduces seed costs, it exhibited limitations in yield and plant vigor, particularly for genotypes like Kufri Karan. Kufri Lima, however, performed well under ARC propagation, indicating its potential for alternative methods. Overall, tuber propagation proved to be a more reliable approach for maximizing yield and economic returns, particularly with Kufri Jyoti, while Kufri Karan demonstrated poor performance across all parameters under ARC propagation. These findings offer valuable insights for farmers and agricultural stakeholders in selecting appropriate genotypes and propagation methods to optimize productivity and profitability in potato cultivation.

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