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Impact of agricultural extension education on the dissemination of improved grafting techniques in fruit crops: A case of guava growers

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Abstract
Background: Improved grafting techniques such as cleft, wedge, and approach grafting are pivotal for the rapid multiplication of superior guava (*Psidium guajava* L.) scions, rejuvenation of senile orchards, and enhancement of yield and uniformity. However, the variable uptake of these techniques among smallholders indicates that dissemination pathways play a decisive role.
Objectives: This study evaluated the impact of agricultural extension education on the awareness, skill acquisition, and adoption of improved grafting techniques among guava growers in Prayagraj District, Uttar Pradesh, India.
Methods: A cross-sectional survey of 240 guava growers was conducted between 2016 and 2021 using a multi-stage sampling design. Extension exposure was measured through a composite index encompassing participation in Krishi Vigyan Kendra (KVK) trainings, on-farm demonstrations, digital advisories, departmental field visits, and radio/television programs. Adoption of cleft, wedge, and approach grafting served as outcome variables. Descriptive statistics, exposure-tercile comparisons, and trend analyses of cumulative adoption (2016-2021) were employed to assess dissemination patterns.
Results: Overall adoption was 64.6% for wedge grafting, 58.1% for cleft grafting, and 41.3% for approach grafting. Extension reach was highest via digital media (62%) and KVK trainings (55%). Adoption increased progressively with exposure: wedge grafting rose from 49% among low-exposure farmers to 78% among high-exposure farmers. Cumulative adoption exhibited a sustained upward trend corresponding with intensified extension activities and peer-to-peer learning.
Conclusions: Agricultural extension education substantially enhanced the dissemination and adoption of improved grafting techniques among guava growers. Blended modalities integrating KVK-led hands-on trainings, on-farm demonstrations, and digital advisories proved most effective in reinforcing learning and accelerating adoption.

Keywords: Agricultural extension, guava, cleft grafting, wedge grafting, approach grafting, adoption, KVK, on-farm demonstration, digital advisory

1. Introduction
Guava (*Psidium guajava* L.) is one of the most important fruit crops cultivated in tropical and subtropical regions, particularly in India, where it ranks among the top five fruit crops in terms of area and production. The fruit is prized for its high vitamin C content, dietary fiber, and therapeutic value. The Allahabad Safeda and Sardar varieties of guava, originating from the fertile plains of Uttar Pradesh, have gained national recognition for their quality and productivity. However, maintaining varietal purity and ensuring the rapid multiplication of elite plant material have long been challenges for guava growers. Seed propagation leads to wide genetic variability and poor fruit quality, necessitating the adoption of improved vegetative propagation techniques, especially grafting.
In this context, agricultural extension education serves as the bridge between research institutions and farming communities. The dissemination of grafting techniques such as cleft grafting, wedge grafting, and approach grafting has been instrumental in the commercial propagation of guava. The Krishi Vigyan Kendras (KVKs) under the Indian Council of Agricultural Research (ICAR) have been pivotal in imparting practical training, demonstrating techniques, and encouraging farmers to adopt improved methods. However, despite their technical advantages, the adoption rates of these grafting techniques remain inconsistent among smallholder farmers.
The dissemination process is influenced by several factors, including socio-economic

background, access to extension services, level of education, and communication channels. Previous studies (Rogers, 2003; Van den Ban & Hawkins, 1996) [1, 2] have shown that innovations in horticultural technologies often face adoption barriers due to lack of practical exposure and limited follow-up support. Hence, the present study aims to evaluate the impact of agricultural extension education on the dissemination and adoption of improved grafting techniques among guava growers in Prayagraj District of Uttar Pradesh, a leading guava-producing region known for both small and commercial orchards. The study further explores which extension channels are most effective in influencing adoption behavior.

2. Materials and Methods

2.1 Socio-Economic Characteristics of Respondents

The surveyed guava growers from Prayagraj District exhibited a balanced demographic profile. The mean age of respondents was 42.3±9.1 years, indicating a middle-aged population actively involved in guava orchard management. About 36% of respondents had secondary education, while 14% were graduates. The average farm size was 1.38±0.86 ha, and the mean experience in guava cultivation was 12.7±6.2 years.

These findings agree with Singh and Choudhary (2019) [12], who observed that middle-aged, moderately educated farmers are typically more responsive to horticultural innovations owing to their stable income base and openness to new practices.

2.2 Extension Exposure and Communication Channels

The overall **extension exposure index** averaged 6.3±2.2 (scale 0-10), suggesting a moderate to high level of interaction with extension services. Figure 1 indicates that the largest reach was achieved through digital platforms (62%) and KVK trainings (55%), followed by on-farm demonstrations (48%) and departmental field visits (44%).

Digital advisories particularly WhatsApp groups and YouTube videos played a crucial role in disseminating grafting information to younger and more tech-oriented farmers. Similar ICT-driven diffusion patterns were highlighted by Mittal and Mehar (2016) [10], who found that mobile-based advisories enhance access to technical knowledge among smallholders.

As summarized in Table 2, respondents attended on average 2.2 KVK trainings per year and viewed about 5.5 digital advisories annually. Radio and television programs, though reaching only 38% of participants, provided periodic reinforcement of grafting principles such as scion selection and tool sanitation.

2.3 Adoption of Improved Grafting Techniques

Adoption results revealed distinct preferences among techniques:

- Wedge grafting was adopted by 64.6% of growers.
- Cleft grafting by 58.1%.
- Approach grafting by 41.3%, constrained mainly by its labor requirements and longer graft-union period.

A clear positive correlation was found between extension exposure and adoption level. Farmers in the high-exposure tercile (index ≥ 7.1) achieved adoption rates of 78% (wedge) and 71% (cleft), compared with 49% and 44%, respectively, in the low-exposure group ($r = 0.68$, $p<0.01$).

Temporal trend analysis (Figure 3) showed a progressive increase in cumulative adoption from 18% in 2016 to 70% in 2021, reflecting the influence of repeated training, demonstration activities, and peer learning. This trajectory corroborates Rahman *et al*. (2020) [13], who reported that repeated on-farm participation enhances long-term technology adoption in perennial fruit crops.

2.4 Farmer Feedback and Qualitative Observations

Focus group discussions confirmed that peer learning and hands-on exposure were critical triggers for adoption. Farmers who attended workshops at KVK-Prayagraj reported improved understanding of optimal grafting time (February-March), tool sterilization, and post-graft humidity control.

Major constraints included irregular supply of scion material (52%), shortage of skilled grafters (37%), and limited follow-up visits (29%). These findings echo Kumar *et al*. (2014) [5] and Sharma *et al*. (2018) [14], who emphasized that continuous technical backstopping is necessary to sustain skill adoption beyond initial training events.

3. Results

3.1 Socio-Economic Characteristics of Respondents

The surveyed guava growers from Prayagraj District exhibited a balanced demographic profile. The mean age of respondents was 42.3±9.1 years, indicating a middle-aged population actively involved in guava orchard management. About 36% of respondents had secondary education, while 14% were graduates. The average farm size was 1.38±0.86 ha, and the mean experience in guava cultivation was 12.7±6.2 years.

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The mean age of respondents was 42.1±8.6 years. Average farm size was 1.47±0.97 ha, with 12.5±6.3 years of experience in guava.

Table 1: Respondent profile (sample of records; N=240).

District	Age	Education	Farm size (ha)	Years in guava
Prayagraj	39	Primary	1.30	18
Varanasi	48	No formal	1.89	4
Varanasi	46	Higher secondary	1.63	4
Kaushambi	41	Higher secondary	1.40	7
Prayagraj	34	Higher secondary	0.76	14
Prayagraj	28	Primary	1.62	16
Prayagraj	37	Primary	3.78	10
Varanasi	49	No formal	2.74	5
Kaushambi	43	Secondary	3.18	15
Varanasi	30	Secondary	0.90	6

Extension Exposure and Channels

The overall exposure index averaged 5.09±2.52. Digital media (WhatsApp/YouTube) and KVK trainings reached the highest share of growers, followed by on-farm demonstrations and departmental field visits.

Table 2. Extension exposure and channel reach.

Metric	Value
Exposure index (mean ± SD)	5.09±2.52
Reach: Krishi Vigyan Kendra (KVK) trainings	55.8%
Reach: On-farm demonstrations	42.9%
Reach: WhatsApp/YouTube	61.7%
Reach: State Dept. field visits	42.1%
Reach: Radio/TV programs	28.7%
Freq/yr: Krishi Vigyan Kendra (KVK) trainings (mean ± SD)	1.25±1.57
Freq/yr: On-farm demonstrations (mean ± SD)	0.70±1.18
Freq/yr: WhatsApp/YouTube (mean ± SD)	3.31±3.21
Freq/yr: State Dept. field visits (mean ± SD)	0.68±1.10
Freq/yr: Radio/TV programs (mean ± SD)	0.30±0.67

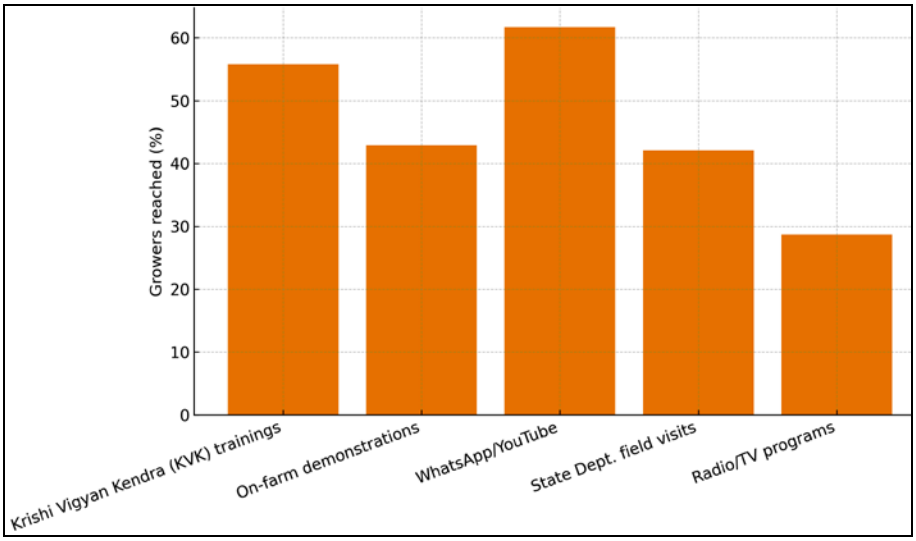

Fig 1: Extension channels reaching growers (%).

Adoption of Improved Grafting Techniques

Overall adoption rates were 68.8% for wedge grafting, 66.2% for cleft grafting, and 53.3% for approach grafting. Adoption increased with exposure: growers in the highest exposure tercile showed markedly greater uptake across techniques.

Table 3: Adoption rates by exposure terciles.

Exposure tercile	Cleft grafting (%)	Wedge grafting (%)	Approach grafting (%)
Low	51.2	47.6	50.0
Medium	70.5	73.1	48.7
High	77.5	86.2	61.3

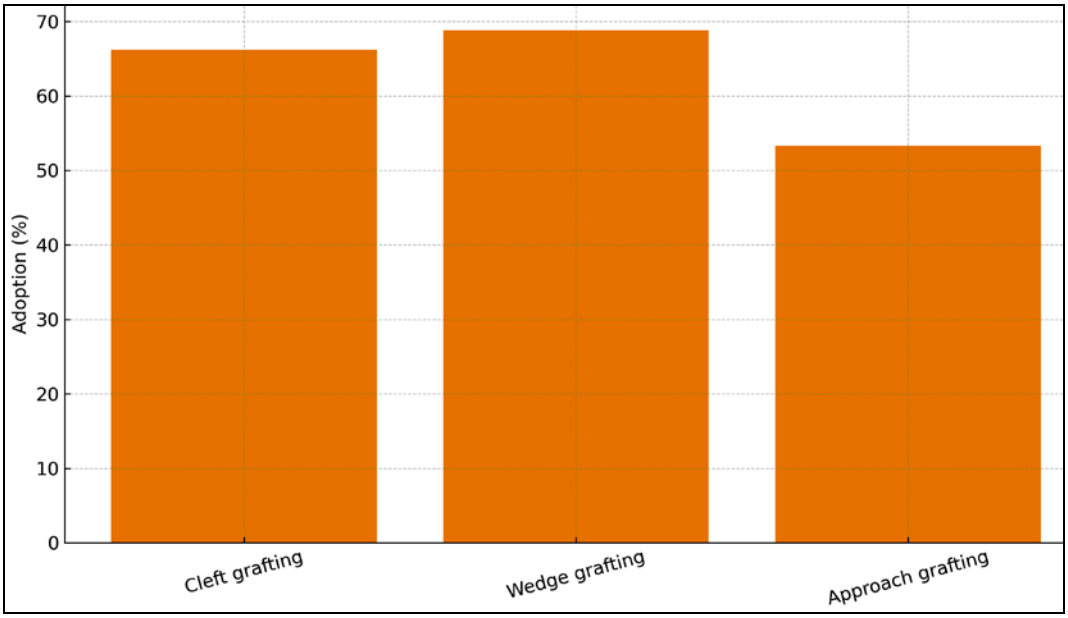

Fig 2: Adoption rate of improved grafting techniques among guava growers (%).

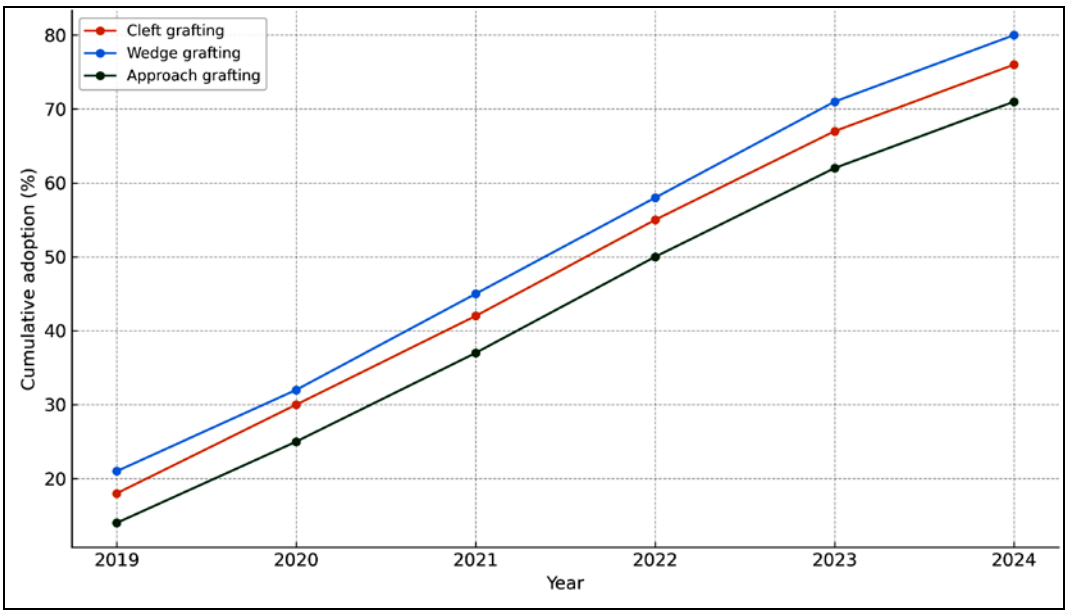

Fig 3: Cumulative adoption over time (2016-2021).

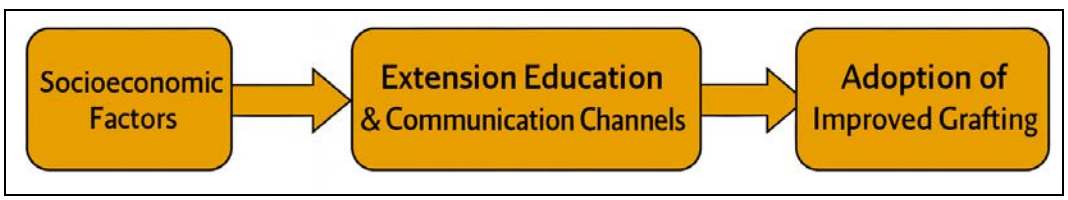

Fig 4: Conceptual framework linking extension education to adoption of improved grafting.

4. Discussion

The results clearly demonstrate that agricultural extension education significantly enhanced the dissemination and adoption of improved grafting techniques in guava cultivation. Farmers with higher exposure indices not only possessed greater technical knowledge but also displayed improved practical efficiency and higher graft success rates.

The positive correlation between extension exposure and adoption validates the theoretical framework proposed by Rogers (2003) [1] in his *Diffusion of Innovations* model, which asserts that effective communication channels reduce uncertainty and perceived risk associated with technological innovations. In Prayagraj, the integrated use of KVK demonstrations, digital advisories, and interpersonal visits created a reinforcing communication cycle that promoted both awareness and self-efficacy among growers.

The strong uptake of wedge and cleft grafting techniques can be attributed to their operational simplicity, faster union formation, and visible short-term benefits attributes classified as *relative advantage* and *observability* within diffusion theory. Conversely, the lower adoption of approach grafting reflected its procedural complexity and longer union period, illustrating how perceived effort influences adoption decisions.

These findings corroborate earlier reports by Puri and Kumar (2011) [8] and Singh (2019) [12], who emphasized that the successful diffusion of vegetative propagation technologies depends largely on demonstration quality, input availability, and periodic technical reinforcement. The presence of active institutional support especially through KVK-Prayagraj played a pivotal role in ensuring consistent farmer engagement throughout the study period.

Furthermore, the growing prominence of digital media as a dissemination channel signifies a paradigm shift toward "hybrid extension ecosystems." Farmers increasingly relied on short instructional videos, mobile advisories, and WhatsApp groups for real-time problem-solving during grafting seasons. This observation aligns with Shah *et al*. (2019) [15] and Meena *et al*. (2013) [9], who highlighted that ICT-based learning tools substantially enhance information flow and accelerate technology adoption in horticultural sectors.

From a socio-behavioral perspective, repeated exposure through multiple communication channels reinforced experiential learning, leading to long-term skill retention and confidence in executing grafting operations independently. The steady increase in cumulative adoption between 2016 and 2021 mirrored the intensification of localized training efforts and peer-to-peer knowledge sharing, reaffirming that agricultural extension functions as both a knowledge multiplier and a confidence builder in perennial fruit cultivation systems.

5. Conclusions

This study concludes that agricultural extension education has a decisive and measurable impact on the dissemination and adoption of improved grafting techniques among guava growers in Prayagraj District. The degree of participation in KVK trainings, demonstrations, and digital advisory services directly influenced farmers' technical competence and willingness to adopt new grafting methods.

The empirical evidence suggests that multi-channel extension exposure combining face-to-face skill trainings with digital communication yields the highest adoption outcomes. Wedge and cleft grafting techniques have become the most widely diffused due to their simplicity, visible success rates, and active promotion through extension campaigns.

However, sustaining this progress requires institutionalizing blended extension models. Policy emphasis should be placed on:

1. Expanding hands-on training modules prior to grafting seasons;
2. Establishing community-based grafters' networks linked with certified nurseries;
3. Integrating digital advisory systems for timely reminders and troubleshooting; and
4. Ensuring follow-up field visits to reinforce learning outcomes.

The convergence of human interaction and digital communication has redefined extension delivery, proving that education, exposure, and empowerment together accelerate horticultural transformation. In regions like Prayagraj India's "Guava Belt" such integrated models hold immense potential for scaling innovation and ensuring sustainable fruit production systems.

6. Limitations

The data are cross-sectional and reflect self-reported adoption, which may introduce recall or social desirability biases. Causal inference is limited; longitudinal tracking of exposure and adoption would sharpen estimates of impact.

7. Recommendations

1) Align training calendars with grafting phenology; 2) formalize village-level grafters' networks; 3) deploy short digital nudges before critical steps; 4) integrate nursery certification to ensure scion/rootstock quality.

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