

On-farm conservation of traditional mango varieties by custodian farmers in Uttar Pradesh

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Farmers in Uttar Pradesh play a crucial role as guardians of the state's diverse mango heritage, actively contributing to the evolution and on-farm conservation of numerous varieties. This extensive study across 23 key mango-growing districts in Uttar Pradesh sought to identify custodian farmers employing Indigenous Technical Knowledge (ITK) to conserve a minimum of ten mango varieties within their orchards. District-wise analysis unveiled a concentration of custodian farmers, with Lucknow district standing out at 31.68%, showcasing their dedication to maintaining the highest number of traditional varieties. Across districts, substantial variations were noted in fruit maturity, suitability, color (peel and pulp), size, quality, and fiber content. Saharanpur district emerged as a notable area where custodian farmers dedicated significant orchard space to mango cultivation. The discovery of a 250-year-old orchard in Bulandshahr district adds a historical dimension to the custodian farmers' commitment. Malihabad nurseries in Lucknow took center stage as primary sources for planting materials of traditional varieties, highlighting their pivotal role in supporting on-farm conservation efforts. This emphasizes the synergy between custodian farmers and local nurseries, both rooted in ITK practices. The study identified a strong correlation ($r=0.997$), emphasizing that the number of traditional varieties significantly contributes to on-farm conservation, underscoring the importance of preserving mango diversity. This research illuminates the proactive measures taken by Uttar Pradesh farmers, providing insights with potential implications for sustainable agriculture and biodiversity conservation.

Keyword: Custodian farmer, Diversity, Mango, Nursery, Traditional mango variety

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India's cultural and agricultural tapestry is interwoven with a vast array of traditional mango varieties, and Uttar Pradesh stands at the forefront of nurturing this rich heritage. As the global leader in mango production, India, particularly Uttar Pradesh, has not only cultivated numerous commercial mango varieties within its borders but has also influenced neighboring Pakistan. Key regions, such as the Lucknow-Saharanpur belt in Uttar Pradesh, the Murshidabad area of West Bengal, and the Hyderabad area of Andhra Pradesh, have emerged as centers of diverse mango collections, contributing significantly to genetic diversity and broader mango conservation^{1,2}.

Amidst the evolution and conservation of hundreds of mango varieties in these regions, including the Lucknow-Saharanpur belt, it is crucial to acknowledge the collective efforts of local farmers, nurserymen, and landlords. Their pivotal roles in enhancing genetic diversity and preserving traditional mango varieties underscore the

Lucknow-Saharanpur belt's significance in mango variety development³.

Despite the prevalence of commercial varieties in new orchards, and the replacement of old orchards with these varieties, farmers in various parts of the country, especially in Uttar Pradesh, remain dedicated to conserving and cultivating traditional or heirloom mango varieties. These varieties, rooted in seedlings and specific to particular regions, continue to thrive as embodiments of enduring agricultural practices^{4,5}.

While changing preferences have led to a reduction in diversity due to the widespread adoption of a few leading commercial varieties, Uttar Pradesh farmers persist in conserving a significant number of traditional mango varieties. This study focuses on custodian farmers across 23 districts of Uttar Pradesh actively maintaining at least 10 mango varieties in their orchards or homesteads. The objectives of present study include analyzing the association of commercial and non-commercial varieties with orchard characteristics, understanding the contribution of nurseries in on-farm mango diversity conservation,

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and exploring various hypotheses related to variety origin, distribution, district importance, maintenance criteria, and the role of nurseries in sustaining Uttar Pradesh's rich mango heritage⁶.

Materials and Methods

Locale for the Study

The study focused on major mango diversity-rich districts in Uttar Pradesh, encompassing areas with significant mango cultivation and those where commercial production is comparatively lower but diversity is actively maintained by farmers. The selected districts included Aligarh, Amethi, Amroha, Bagpat, Balrampur, Bulandshahr, Faizabad, Gonda, Jaunpur, Kannauj, Kasganj, Lakhimpur Kheri, Lucknow, Mau, Meerut, Muzaffarnagar, Saharanpur, Sant Kabir Nagar, Shamli, Shravasti, Siddharthanagar, Sitapur, and Varanasi (Table 1). A total of 101 farmers participated in the survey, comprising 99 males and 2 females, with ages ranging from 24 to 79 years. Prior informed consent was diligently obtained from all participating farmers before conducting any data collection or interviews. The process involved comprehensive explanations of the study objectives, procedures, and potential implications, ensuring that

the farmers fully understood their participation and its implications.

Data collection

To ensure a comprehensive representation of Custodian Farmers (CFs) dispersed throughout mango-growing regions, a systematic sampling strategy was employed. This approach aimed to cover more than 90% of farmers within each district or location, minimizing bias in participant selection.

Custodian farmers were defined as individuals conserving 10 or more varieties on their farms. To augment our dataset, information about these farmers was also sourced from annual state and national mango diversity exhibitions held in Lucknow and New Delhi. Detailed information about custodian farmers was acquired in the field during diversity fairs, where individuals were identified and their data collected. Farmers were further identified using passport data available in the action register of the national field gene bank.

By adopting this multi-faceted approach, our goal was to assemble a diverse and representative sample of custodian farmers. This approach aimed to provide a more holistic insight into the practices employed for mango diversity conservation across the selected districts.

Table 1 — Selected districts and areas for the collection of information on custodian farmers

Districts	Study Area
Aligarh	Billona (Billona Chitrasi)
Amethi	Thauri
Amroha	Sihali Jagir (Block -Gajraula), Salempur (Hemnagar), Keshavpur, Sekhupura Jhakari
Bagpat	Rataul
Balrampur	Chirraiya, Phulveria Birahimpur
Bulandshahr	Alipur (Pahanshu), Bharkaow (Block- Unchagaon, Tehsil- Siyana), Bhoranshi (Nawab Chhatari, Block- Pahanshu), Patti Hazari (Siyana), Siyana
Faizabad	Sariyawa, Masodha
Gonda	Pure Chain Kunwar, Sahjanwa-Rupaideeh
Jaunpur	Mai (Buxa), Barauli (Badlapur), Kuddupur, Purew
Kannauj	Gadanpur Baddu
Kasganj	Mahawar, Dehari, Nagla Amber (Inayati), Lodhipur
Lakhimpur Kheri	Hindustan Farm
Lucknow	Gopramau, Sarsanda, Kasmandi Kalan, Mohammed Nagar Talukedari, Nabipanah, Nadan Mahal Road, Malihabad, Narauna, Tiwari Kheda, Naubasta, Mall, Gosaiganj, Godwa, Para Bandrahi
Mau	Galib Pur, Muhammadabad Gohna
Meerut	Kithore
Muzaffarnagar	Pinna, Purkazi
Saharanpur	Behat, Kheda Afgan, Nandi Firojpur, Toli, Kashipur
Sant Kabir Nagar	Harraiya
Shamli	Babri, Gazipur
Shravasti	Labeledpur
Siddharthanagar	Dhanghata
Sitapur	Achra Mau, Barsandhiya, Nighuwa Mau, Rehamabad, Dharwa Garhi, Revankala Garhi, Kala Bagahiya, Kesharipur Kothar, Sita Rasoi- Sidhau, Indraul, Maholi Block, Ambarpur Biswan, Biswa
Varanasi	Chiraigaon, Barbaspur, Barai-Umaraha, Sultanpur, Pilkhini, Kibli Bhtsar

Statistical analysis

Statistical analyses were conducted to explore potential correlations between orchard age and the number of CVs and TVs conserved by CFs. Correlation coefficients were calculated to quantify the strength and direction of these relationships. Pearson's correlation calculation, SPSS Version 25 was used⁷.

Results and Discussion

A comprehensive survey spanning 23 districts in Uttar Pradesh (UP) identified a total of 101 custodian farmers actively engaged in on-farm conservation efforts. The distribution of custodian farmers varied across districts, with the highest concentration observed in Lucknow (32) and Sitapur (13). Conversely, Amethi, Faizabad, Gonda, Lakhimpur Kheri, Mau, Sant Kabir Nagar, Shravasti, and Siddharthnagar each had one custodian farmer, representing the lowest count in each respective district (Table 2). It is noteworthy that previous reports on UP custodian farmers were limited in scope, focusing solely on enumerating custodian farmers in Malihabad^{6,8}. In contrast, our present study stands out for its extensive survey, encompassing nearly all major mango-growing areas and districts within the state. This broader scope

enhances the overall understanding of custodian farmer contributions to on-farm conservation in Uttar Pradesh.

Orchard characteristics

Custodian farmers in Uttar Pradesh (UP) were found to be actively conserving and maintaining a diverse array of mango varieties within their orchards. Notably, the majority of conserved varieties originated from seedlings, while the sources for grafted varieties remained unknown. The district of Lucknow stood out for maintaining the highest number of commercial varieties (15), contrasting with seven custodian farmers in the same district who continued to prioritize traditional mango varieties over commercial ones. The surveyed custodian farmers exhibited a wide range of Traditional Varieties (TVs) in their orchards, with some individuals conserving more than 100 varieties, and one farmer from Lucknow amassing an impressive collection of over 250 varieties. The total number of Traditional Varieties conserved ranged from 5 to 257 across different districts, while Cultural Varieties (CVs) were found in the range of 0-15 (Table 2). Earlier reports from Malihabad highlighted custodian farmers conserving 40-135 mango varieties^{1,8}.

Table 2 — Custodian farmers, number of commercial & traditional (heirloom) varieties, area under mango diversity conservation (both commercial and traditional varieties) and orchard age in selected districts

Districts	Custodian farmers (no.)	Commercial varieties (no.)			Traditional (heirloom) varieties (no.)			Area (ha)			Orchard age (year)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Aligarh	2	4	4	4.0	9	35	22.0	2.4	4.4	3.4	22	30	26.0
Amethi	1	3	3	3.0	8	8	8.0	1.0	1	1.0	30	30	30.0
Amroha	5	3	5	3.6	8	18	12.2	0.8	15	9.9	20	60	36.0
Bagpat	3	5	5	5.0	20	100	47.3	5.0	12	9.7	60	100	80.0
Balrampur	2	3	5	4.0	7	28	17.5	2.5	4	3.3	10	50	30.0
Bulandshahr	5	4	5	4.6	7	16	11.0	2.8	103	38.2	18	250	99.6
Faizabad	1	3	3	3.0	8	8	8.0	12.0	12	12.0	50	50	50.0
Gonda	1	4	4	4.0	6	6	6.0	0.4	0.4	0.4	20	20	20.0
Jaunpur	3	4	5	4.3	5	7	6.0	1.0	22.6	9.1	35	200	98.3
Kannauj	2	3	5	4.0	9	50	29.5	10.5	23	16.8	50	75	62.5
Kasganj	4	3	5	3.5	8	15	10.8	2.0	9	4.0	35	50	43.0
Lakhimpur Kheri	1	4	4	4.0	6	6	6.0	2.0	2	2.0	16	16	16.0
Lucknow	32	0	15	3.5	6	257	33.3	0.3	25	4.1	25	100	43.9
Mau	1	4	4	4.0	20	20	20.0	1.0	1	1.0	30	30	30.0
Meerut	4	2	4	3.0	7	22	15.5	2.0	51	30.0	40	60	48.8
Muzaffarnagar	2	4	4	4.0	14	100	57.0	25.0	29	27.0	75	75	75.0
Saharanpur	8	4	10	7.0	7	70	27.5	2.5	154	52.6	25	80	52.5
Sant Kabir Nagar	1	4	4	4.0	8	8	8.0	16.0	16	16.0	20	20	20.0
Shamli	3	4	6	5.3	10	15	11.7	16.0	128	69.3	50	60	56.7
Shravasti	1	10	10	10.0	70	70	70.0	14.0	14	14.0	5	5	5.0
Siddharthanagar	1	5	5	5.0	5	5	5.0	0.4	0.4	0.4	20	20	20.0
Sitapur	13	3	7	4.7	6	50	12.2	0.4	30	5.1	18	150	49.2
Varanasi	5	3	5	4.4	5	7	6.0	0.5	4	1.6	50	100	68.0

The study identified motivational factors such as self-interest, self-use, social prestige, and income as significant contributors to custodian farmers' commitment to variety conservation. Additionally, personal, social, cultural, natural, and biological factors played pivotal roles in encouraging custodian farmers to conserve diversity⁵. The number of varieties maintained by custodian farmers was influenced by factors such as emotional attachment to ancestral orchards, family heritage, social prestige, the desire to conserve rare varieties, unique taste preferences, and income. Similar motivations were reported in previous studies regarding the maintenance of old mango trees⁶.

Contrary to expectations, orchard area did not emerge as a decisive factor for the number of traditional or commercial varieties. Large orchards exceeding 150 hectares exhibited limited numbers of Traditional Varieties, while smaller orchards, less

than 20 hectares in size, were capable of conserving more than 60 varieties (Fig. 1A). The number of commercial varieties also displayed no association with orchard size (Fig. 1B).

The study also provided insights into the age distribution of mango orchards, ranging from the oldest orchard in Bulandshahr (250 years) to the newest in Shravasti (5 years). Notably, older orchards were predominantly established by previous generations, with the average age of mango orchards in Jaunpur, Faizabad, Azamgarh, and Sultanpur ranging from 60 to 70 years, planted during the 1940s-50s and 1960s-1970s. A Lucknow custodian farmer maintained a 100-year-old orchard. Interestingly, our investigation revealed that the maintenance of cultural and traditional varieties by custodian farmers was not correlated with the age of their orchards, as illustrated in Figure 2A and Figure 2B. Custodian farmers predominantly conserved more

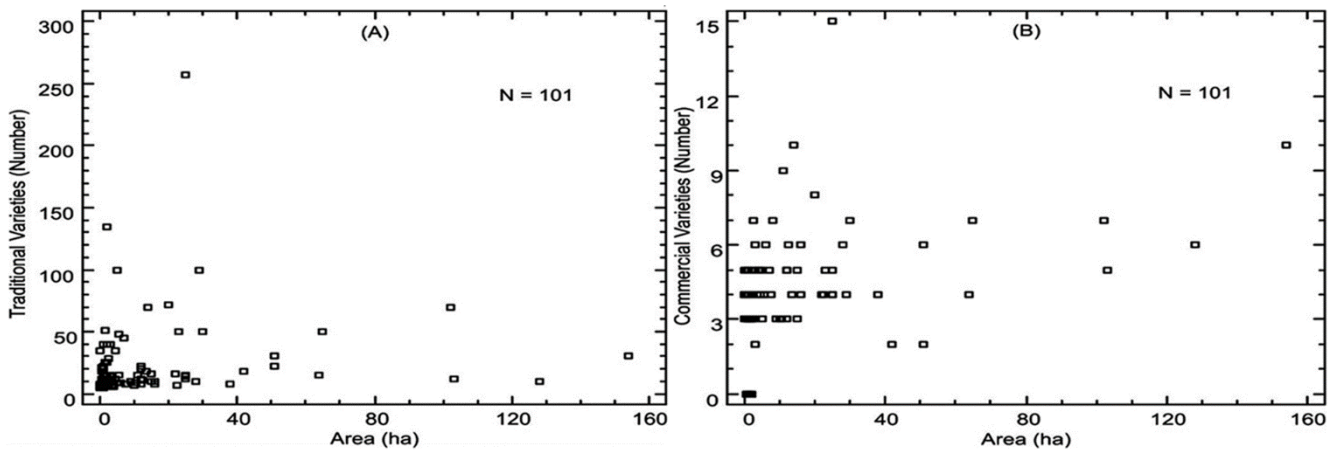


Fig. 1 — Illustrations: A-Scatter plot of area vs traditional variety, B-scatter plot of area vs commercial variety

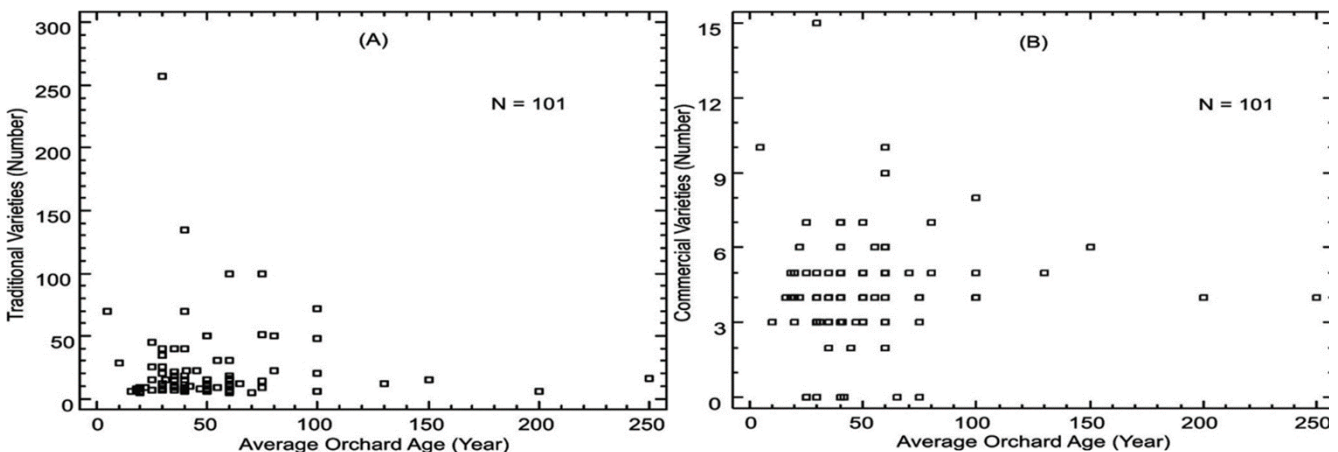


Fig. 2 — Illustrations: A-Scatter plot of average orchard age (year) vs traditional variety (number), B-scatter plot of average orchard age (year) vs commercial variety (number)

traditional varieties compared to commercial ones (Fig. 3), and traditional varieties significantly contributed to the overall variety count maintained by custodian farmers ($r=0.997$) (Fig. 4).

Fruit character diversity in traditional varieties

Lucknow emerged as a district rich in both traditional and commercial mango varieties, boasting the highest varietal diversity among all surveyed districts. Following Lucknow, Sitapur and Saharanpur were identified as the second and third districts with the most extensive varietal collections. Traditional varieties such as Benzeer, Desi Gola, Hushnara, Jard Amin, Surkha, and Taimuriya were found to be distributed across two or more districts. These heirloom varieties exhibited distinct characteristics, including variations in maturity time, color, and fruit size. Maturity time, in particular, played a crucial role in traditional variety conservation, with farmers expressing interest in both early and late-maturing varieties. However, the availability of such varieties

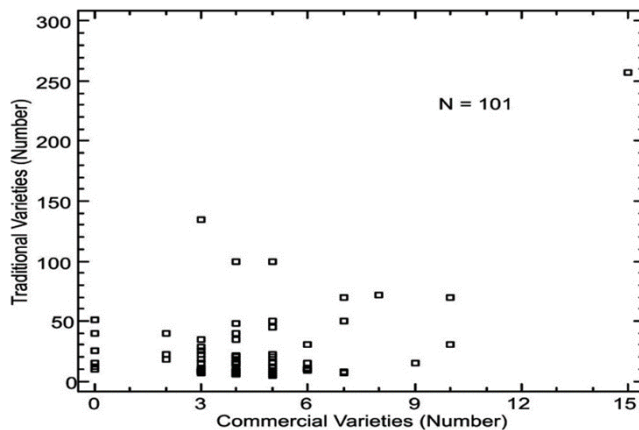


Fig. 3 — Association of commercial varieties and traditional varieties (number)

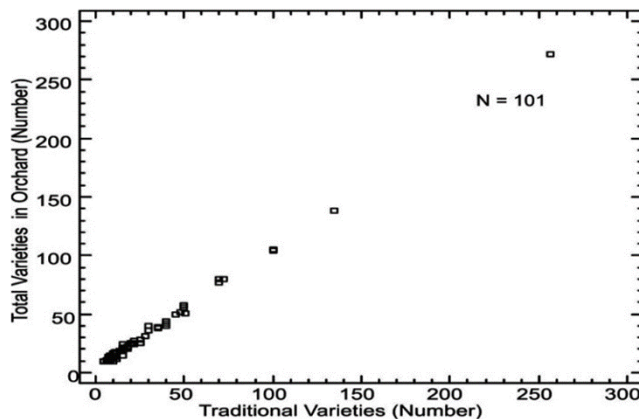


Fig. 4 — Relationship between number of traditional varieties and total number of varieties in orchard

was limited, resulting in medium (56.5%) and late-maturing (34.8%) traditional varieties being more prevalent (Fig. 5A).

Farmers expressed a keen interest in varieties suitable for pickle making or consumption. A majority of farmers (72.5%) believed that most varieties could be transformed into mango pickles (Fig. 5B). Notably, certain traditional varieties with high acidity and fiber content were considered more suitable for pickle making, especially those not ripening shortly after harvest. Traditional methods and recipes for pickling mangoes in India, such as the highly aromatic Appemidi of Karnataka, were highlighted, underscoring the demand for these varieties in preparing pickles, chutneys, and other traditional dishes^{9,10}.

Custodian farmers actively participated in the dissemination of their knowledge and the outcomes of their conservation efforts. Their enthusiasm was directed towards promoting activities that could document their efforts and establish their significance in the field of mango variety conservation. The importance of the use-value of diversity in food and processing within the context of mangoes has been previously documented by Vasudeva *et al.*¹¹.

Peel color analysis revealed that the majority of traditional varieties exhibited an attractive orange-yellow peel color (33.3%). However, yellow-colored pulp was more prevalent (47.8%) in these varieties (Fig. 5C & D). Traditional mango varieties played a pivotal role in conserving diversity in various shades of peel and pulp color. Indigenous varieties from South Gujarat, for instance, displayed green, yellow, greenish-yellow, and greenish-red peel colors¹². Additionally, variations were observed in fruit size, quality, and the presence of fibers. Most traditional varieties were fibrous (69.6%), medium-sized (53.6%), and of excellent quality (69.6%) (Fig. 5E, F & G). The preference for yellow-golden and red-colored traditional mango varieties, as well as diversity in size, fibers, and quality, aligns with findings from previous studies¹³.

Source of traditional varieties

The age distribution of orchards exhibiting varietal diversity in traditional mango varieties ranged from 5 to 250 years. Several orchards, some dating back up to 250 years, were reported to have been planted by forefathers, with the present owners often unaware of the collection source due to the historical nature of the orchards. This practice of inheriting unique varieties

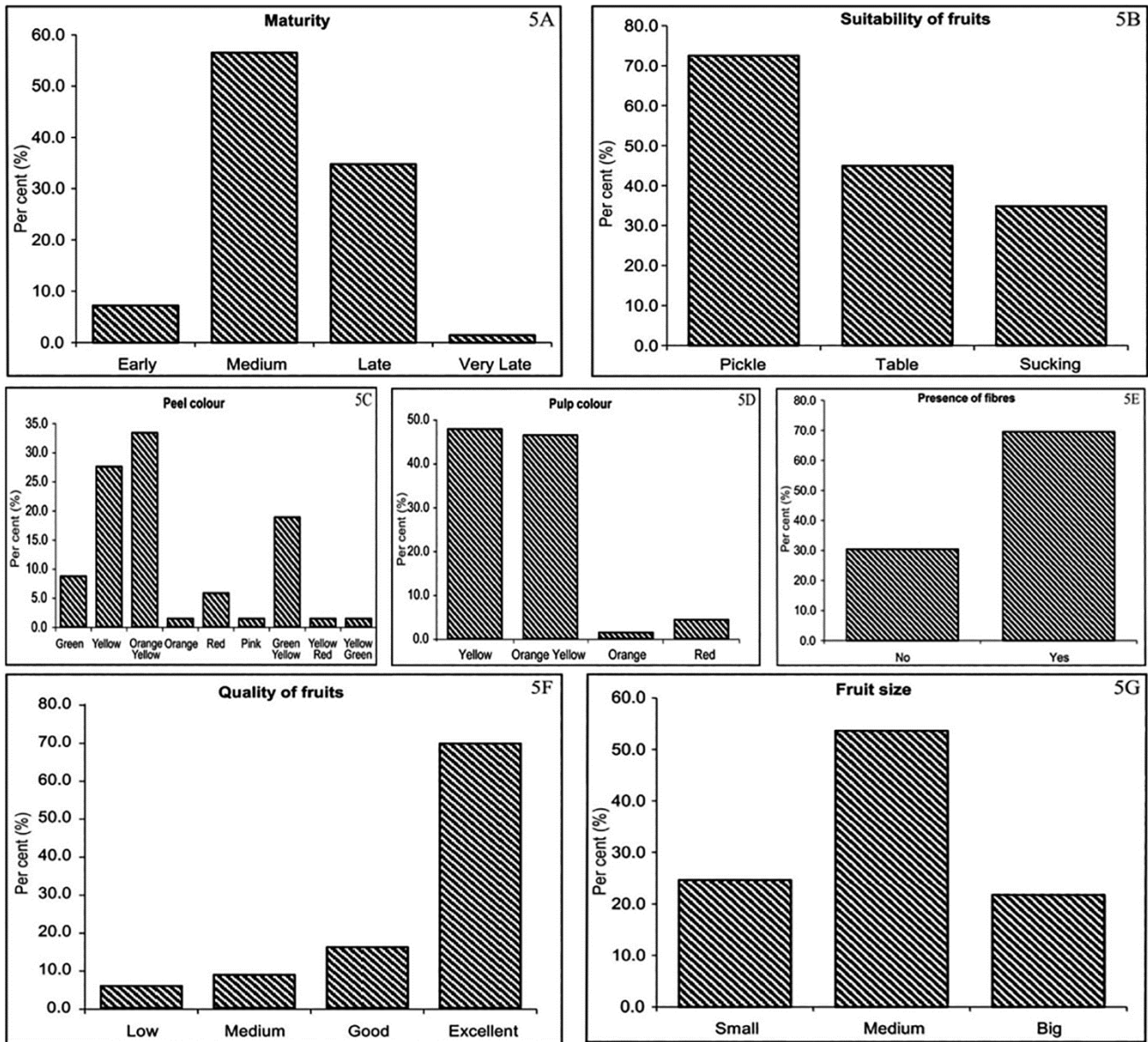


Fig. 5 — Illustrations: A-Maturity time of traditional mango varieties, B- Traditional mango varieties suitable for pickle making, table and sucking purposes, C- Peel colour of traditional varieties, D- Pulp colour of traditional varieties, E- Presence of fibers in different traditional varieties, F- Fruit quality of traditional varieties, G-Size of traditional varieties

and orchards from forefathers has been documented in previous studies^{14,15}. The majority of the varieties in these orchards originated from seedlings, and while farmers did not actively multiply the plants, certain varieties were commonly found in multi-varietal orchards across the state. In Uttar Pradesh (UP), the lack of synonyms for varieties and the consistent use of vernacular names can be attributed to the predominant introduction of varieties from the Malihabad area. Despite the potential for variations in names when varieties are transported over long

distances to regions with different dialects and languages, the prevalence of Hindi-Urdu speaking farmers in UP has contributed to a relative consistency in vernacular nomenclature.

Many Custodian Farmers expressed interest not only in local traditional varieties but also in commercial varieties from other regions. Some farmers were particularly keen on planting renowned varieties such as Alphonso and Neelum. In recent years, while establishing new orchards, farmers have introduced new varieties as a hobby, for personal consumption,

and for the exchange of fruits, showcasing the evolving diversity in their orchards. Decades ago, nurseries in Malihabad were favored by Custodian Farmers for acquiring mango saplings of various varieties, with 59 out of 101 Custodian Farmers from 15 districts having collected mango varieties from Malihabad nurseries. Presently, Malihabad continues to host nurseries with a diverse array of mango varieties, managed by individuals recognized as custodians of mango diversity across generations.

Apart from local nurseries, farmers from Lucknow, Sitapur, and Balrampur districts also sought mango

varieties from the ICAR-Central Institute for Subtropical Horticulture (ICAR-CISH) in Lucknow, known for maintaining one of the richest genebank of traditional mango varieties. Despite being a preferred source for planting material for farmers from other districts, custodian farmers in Lucknow also engaged in collecting varieties from various places, such as Malihabad, Shahabad, Sandila, ICAR-CISH, Bhopal, Raebareli, Kankaha, Saharanpur, Barabanki, Sahjahanpur, and State Government Nurseries, for enrichment in both nurseries and orchards (Fig. 6).

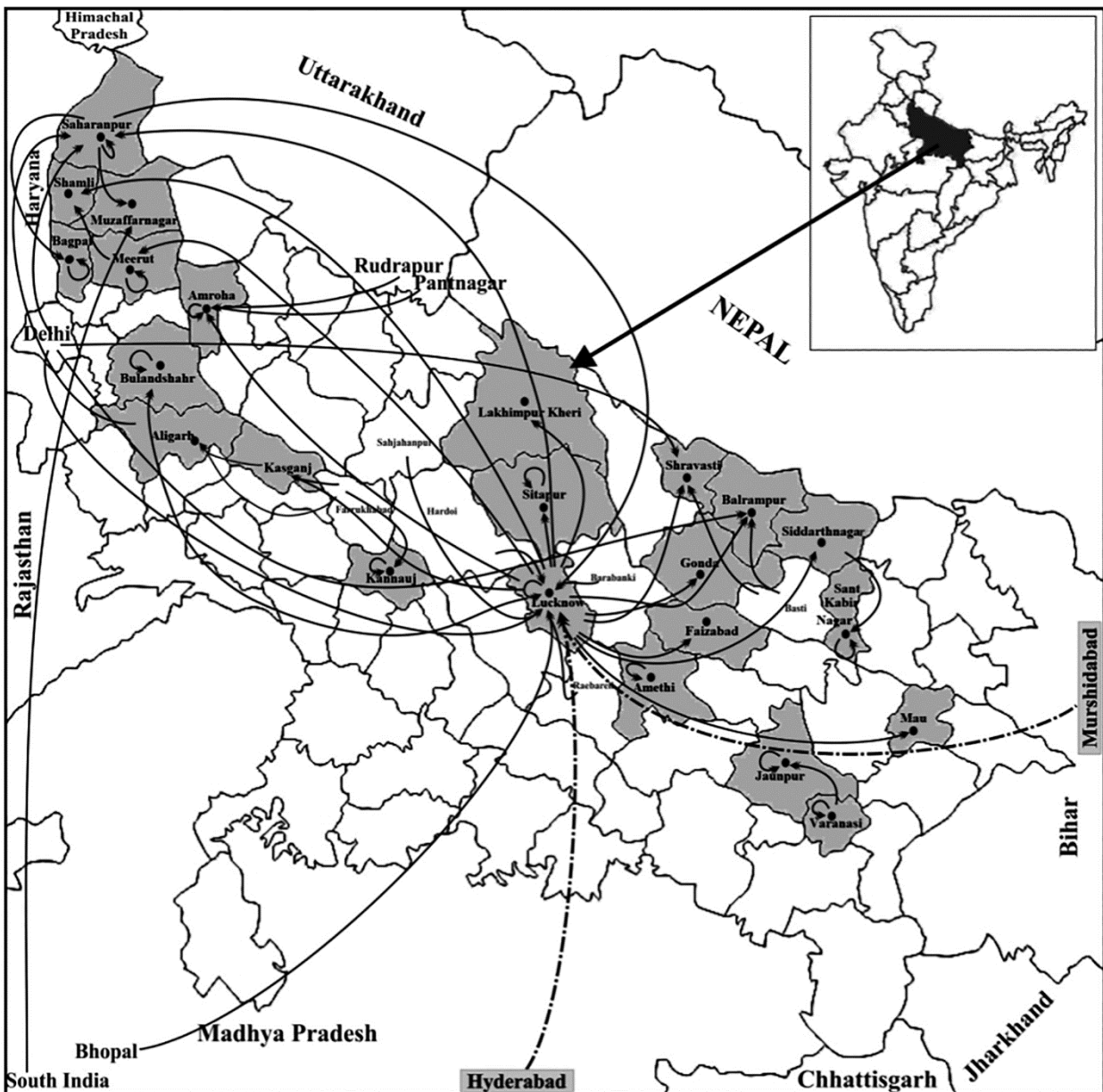


Fig. 6 — Diversity flow from nurseries to custodian farmers

The traditional or heirloom mango varieties of Malihabad are renowned for their unique characteristics, often originating as open-pollinated seedlings from varieties introduced from different parts of the country and selected as superior seedlings^{1,16}. Described as old commercial varieties or antiques, these heirloom varieties, although not grown on a commercial scale, are limited to a select few in orchards¹⁷. In addition to collecting planting materials from various sources, farmers are actively involved in the multiplication of desired varieties from their own orchards and also engage in the exchange of scions with fellow farmers. This practice of exchanging planting materials is an established tradition among mango farmers in Malihabad, contributing to the propagation and preservation of diverse mango varieties.

Conclusion

The survey across 23 districts in Uttar Pradesh highlights the pivotal role of 101 custodian farmers in mango variety conservation. Beyond conventional perspectives, this study emphasizes the non-linear relationship between orchard characteristics and variety conservation. Custodian farmers, driven by Indigenous Technical Knowledge (ITK), showcase a dynamic interplay of tradition and innovation. Fruit character diversity reflects ITK-driven choices, with custodian farmers actively disseminating knowledge through traditional methods. The collaboration with local nurseries, particularly in Malihabad, and the pursuit of diverse sources signify an ITK-rich approach to mango variety enrichment. In essence, custodian farmers, rooted in ITK, embody the guardians of a rich mango legacy. This study sheds light on their vital role in preserving and evolving mango varieties in Uttar Pradesh.

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Conflict of Interests

There is no conflict of interest among the authors.

Author Contributions

SR conceptualize the idea of *i.e.*, survey identified study districts, planned methods and procedures to conduct the survey, supervised execution of this study, analyzed data, edited and finalized the manuscript. PKM collected data from study area, drafted the manuscript, assisted in data analysis and prepared diversity flow map, KA collected data from study areas, PS & VS assisted in compilation of data collected from different districts. All the authors have approved the manuscript prior to submission.

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