

Seedling Mango Diversity in Bihar: A Treasure Trove for Genetic Improvement and Conservation

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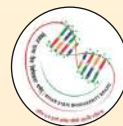


Collaborative Organization

Bihar State Biodiversity Board

(Dept. of Environment, Forest & Climate Change, Govt. of Bihar)

4th Floor, Bihar State Building Construction Corporation Limited Campus
Shastrinagar, Patna 800 013, Bihar



Lead Research Centre

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ICAR-Central Institute for Subtropical Horticulture
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Date: 3rd September 2025

FOREWORD

India is a hotspot for mango biodiversity, with over 1000 varieties, many of which are seedlings. These seedling-derived mangoes often referred to as "heirloom" or "farmer's varieties," represent a significant portion of the genetic diversity within the Indian mango gene pool. They offer a valuable resource for breeding programs and can be directly adopted for commercial cultivation.

The Bihar State Biodiversity Board (BSBB), Patna has called for research body support to community seeds banks like seedling originated mango of Bihar so that mango industry can be saved in climate-risked times. The BSBB, Patna celebrates the 'seed savers and community seed banks of Bihar including seedling mango in the recent past. ICAR-Central Institute for Subtropical Horticulture, Lucknow has called for formally recognizing and acknowledging farmers and communities who conserve traditional seedling [mango] varieties.

Maintaining enthusiasm among seedling mango savers requires both recognition and incentives. Without adequate value for their labour and knowledge, community participation is bound to decline. Farmers and communities who conserve traditional mango (seedling or heirloom) varieties should be formally acknowledged as 'custodians of biodiversity'. This could come in the form of official certification (as due recognition as Farmer's variety), public appreciation and inclusion in national seed and state biodiversity conservation plans. The BSBB, Patna and ICAR-CISH, Lucknow has already started collaborative research programme entitled "Evaluation of diversity and decline of indigenous seedling mango of Bihar and study for its conservation strategy" for mango growing districts of Bihar. Community seed banks in terms of seedling mango are not just about saving old mangoes; they are about saving culture, nutrition, and self-reliance. A farmer's personal seedling mango orchard is their insurance against hunger, inflation, and climate shocks. The ICAR- National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi has its own gene bank for the farmers, facilitating seed exchange among them. Government support through funding infrastructure and policy are essential conserving seedling diversity.

The orchard of seedling mango is decentralized grassroots initiatives (a form of gene banks) managed by local farmer groups, self-help groups, non-profits and women. Their primary purpose is to preserve indigenous and climate-resilient mango varieties and the knowledge around their use. The traditional seedling mango varieties are more resilient to extreme weather events.

The world is celebrating the International Day for Biological Diversity every year. While there is biodiversity all around us, what nourishes us is the biodiversity available on our plates. With their stash of local crop varieties and related knowledge, these seedling mangoes can support diversified farming systems and ensure food security.

The current publication provides information about the biodiversity and enables comprehensive overview of seedling mango biodiversity scenario in Bihar.

I complement the researcher from ICAR-CISH, Lucknow and BSBB, Patna for bringing out this publication that will serve as guiding force for conservation efforts (especially for seedling mango) in other parts of the country.



(Sanjay Kumar Singh)

भारत ज्योति
अध्यक्ष
Bharat Jyoti
Chairperson



बिहार राज्य जैव विविधता पर्वद्
(जैव विविधता अधिनियम-2002 के अंतर्गत गठित वैधानिक निकाय)

Bihar State Biodiversity Board

(Statutory Body under Biological Diversity Act 2002)



MESSAGE

The ICAR-CISH, Kakori, Lucknow has conducted rigorous survey in many districts of Bihar, covering the community *seedling-mango (Biju Aam)* growers and individuals to understand how the state is faring on preserving this resource, valuable in the context of native biodiversity and related aspects. This survey shows many orchardists have a well-developed system of seedling mango collection, preservation and distribution; a system that has stood the test of time. While there is an overall concern about the increasing unpredictability of weather and climate, preservers of these traditional seeding mango varieties say that these seeds are naturally adapted to these extreme conditions. The actual number of varieties might be higher. There is very little documentation on the seedling mango and only from a few organizations that have made the effort to document these varieties.

The Bihar State Biodiversity Board, Patna has supported this special study by the ICAR-Central Institute for Subtropical Horticulture, Lucknow, in consultation with experts and researchers involved in mango improvement Programme. The national agriculture research body i.e. ICAR has found that the horticulture farmers who have still retained the native varieties of especially the seed grown *Biju Aam*, face challenges related to funding, infrastructure and policy support. Other than these, they also need to deal with changing attitudes and declining interest in traditional seed grown mango (*Biju Aam*) and a preference towards hybrid and introduced varieties which are promoted as high-yielding and faster-growing. The younger farmers, in particular, view traditional mango as outdated and prefer commercial varieties that promise better profits.

We have to realize that a number of varieties of these seed grown mango (*Biju Aam*) has unique attributes, in contradistinction to the attributes of uniform quality and high productivity of the hybrids and introduced varieties, and they are repository of genetic wealth as well. Hence, the identified native varieties of *Biju Aam*, also need to be conserved and promoted in fair proportion. Towards this end, the farmers growing them have to be supported in appropriate manner. The biodiversity conservation agenda calls for better balance needs to be fostered by judicious blend of mango crop varieties with policy, market and consumers' support.

I hope this bulletin, that would be useful also for 15 other mango growing states across the country, will support the cause of biodiversity via promotion of the identified native varieties of *Biju Aam*, and awareness of the stakeholders about assessed seedling diversity available in Bihar, leading to fruitful actions and interventions.

Patna, 02 Sept., 2025

Bharat Jyoti

PREFACE

India is the centre of origin or diversity for several crops such as rice, sugarcane, coconut, arecanut, maize, mango, coffee etc. The long farming tradition, soil features, topography and rainfall variation have permitted the development of diverse agricultural ecosystems and enormous biodiversity of mango in the region. The list of agro-biodiversity hot spots in India has already been identified by the Protection of Plant Varieties and Farmers' Right Authority (PPV&FRA), New Delhi.

Biological resources of mango (especially seedling origin) nationally and globally are depleting at an alarming rate in the last few decades due to increased destructive anthropogenic factors causing distress to all biological forms and disrupting the ecosystems. Several of the seedling-types being grown as heirloom varieties, are conserved in farmers' orchards. Analyzing the genetic makeup of seedlings can help identify desirable traits and potential parents and its conservation [of indigenous germplasm] could play a role in any crop improvement programme. The large population of seedling germplasm located in the orchards, conservation and evaluation is important. This can help locate traits of interest, especially, biotic and abiotic-stress tolerance.

There are two broad approaches in conservation that are adopted to protect and maintain biodiversity viz. *In-situ* and *Ex-situ*. The mango is undoubtedly the most important fruit crop of India and has a long period of domestication in India resulting in high genetic variability. The majority of the commercial varieties of mango in India have originated as natural chance selections. Mango being a highly cross-pollinated and heterozygous fruit crop exhibits wide genetic variability in seedling population. Majority of cultivated mango varieties were developed through selection on the basis of fruit shape, size, colour, time of maturity, juice, content, TSS/acid blend, flavour, aroma, taste, etc. Presently, India harbours more than 1000 mango varieties/land races in regions of different diversity and represents the biggest mango gene-pool of the world, Bihar is one of them.

The large-scale screening under this project has helped to identify some varieties as tolerant to biotic and abiotic stresses, although this needs further confirmation. Registration of these varieties with PPV&FRA can result in conservation and, further, the farmer can also receive royalty for his sustained effort. Many seedling mango of Bihar is highly promising, many can be directly released as the variety and many can be used as breeding parents. This bulletin has identified promising lines among seedling population which will be useful for researchers, extension functionaries, development professionals and the entire stake holder involved in mango farming/improvement.

Authors

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1. INTRODUCTION

India is the world's largest mango producer; however, it exports less than 1% of its total production. The major mango exporting countries are UAE (56%), UK (11%) and Saudi Arabia (5%) though domestic exports are very less of its total output. In recent years, the percentage share of gulf countries has decreased, mainly due to a consistent decline in Saudi Arabia's share, and the space created has been occupied by Asian countries, but India has lagged far behind in maintaining or sustaining its position in the whole world. The high standards of the phytosanitary certification system (such as the presence of pesticides, pests, aflatoxin etc.) fixed by developed countries and the inability of Indian exporters to achieve these standards have resulted in India losing these premium markets. The exporters bear a huge amount of risk and harvest big profits on success to comply with the phytosanitary certification system. Adherence to safe export norms is very important to have credible sustainable export. Presently, only 36% of the Mango is being exported to foreign countries whose value is ₹ 44,548 lakhs. By considering the present data if the production can be enhanced by 20% through integrated approach of FPO and ODOP it may result in an increase of export up to 20%.

Mango (*Mangifera indica* L.) is tropical fruit widely cultivated and appreciated for its sweet and aromatic fruit. There is great diversity among mango cultivars for important fruit quality and agronomic traits that could be leveraged as part of a mango breeding program. Historically, most genetic improvement of this species has been the result of chance seedlings. The recent publication of multiple mango genomes and availability of genomic resources is facilitating the efficient breeding of mango, but controlled pollination of mango is challenging with only a few out of thousands of panicle-borne flowers developing into fruit. Therefore, genotyping open-pollinated seedlings could be a labour-saving method to select favourable hybrids in a breeding program.

Apart from 1000 varieties mango in Asia, there are 69 sp. of *Mangifera* in wild gene pools. Characterization and evaluation of mango germplasm is an imperative step for its utilization in breeding programs. Genetic resources have been used for conventional breeding mainly seedling selection and introgression of genes through hybridization. Therefore, the genetic resources are to be screened as donor for resistance genes against stresses.

Germplasm collections serve as an important source for the crop improvement, more so in fruit tree species like mango with long duration of juvenile period. The efforts have to be made to collect the germplasm and make utilize the total diversity existing for the species. Mango germplasm collections in India with an objective of searching for cultivars with better fruits started from the sixteenth century.

Most fruit-tree breeding projects utilize the selection of the best performing non juvenile seedlings, concerning agriculturally important traits. These seedlings are then

vegetatively propagated, usually by grafting, to allow a more thorough assessment. Since the first-stage selection is carried out on non-grafted seedlings. Obviously, much caution is needed at the seedling selection stage. Today, domestic production is focused on superior quality fruit with higher sweetness and aroma than that which is available from imported mangoes. The diversity of mango fruit quality metrics includes, varying levels of sweetness, acidity, and dominant aromas. Combining superior fruit quality with agronomic performance, including fruit size, yield, and disease resistance, is important for the future of the mango industry.



Fig. 1. (a) Elongated stem of seedling mango, (b) Farmer of Seedling mango at Lodhipur-Chandmari (Patna), (c) Concentrated seedling plantation at Bishanpur (Darbhanga) (d & e) Rari mango as seedling grown in Pandaul, Madhubani

2. DIVERSITY OF FRUIT CROPS IN DIFFERENT AGRO-ECOLOGICAL REGION OF BIHAR

Bihar is located between 24°20'10" N to 27°31'15" N latitude and 83°19'50" E to 88°17'40" E longitude. It has a geographical area of 9.416 million hectares and a population of 103.8 million (8.6% of all India) with population density of 1102 persons per sq. km and literacy rate of 63.82% (male: 73.89% and female: 53.33%) as per 2011 census.

Area wise, Bihar occupies 12th position in India. The state has 38 districts, having 101 subdivision and 534 blocks. The state falls under agro climatic zone IV (middle-gangetic plain region). The state is further divided into 3 agro-ecological zones. Bihar has a total area of 0.2614 million ha under fruit crops with highest under mango, followed by banana. The average productivity of fruit crops like banana, papaya and pineapple is higher in Bihar compared to that of Eastern region. On an average, Bihar has 19.824% area of Eastern region under fruit crops. Bihar ranks first among all the Eastern states so far in production of fruit crops were concerned. Of the total fruit production, Bihar contributes 25.612%, followed by West Bengal. Bihar ranks fourth in the list of mango-producing states, sharing > 8% of the total production in the country.

The Southern plains of Bihar covers the maximum area of the state (4.066 mha ha) having an annual rainfall of 1103 mm. The soil of the region is characterized as old alluvium to sandy loam clayey. The region comprises of districts like *Bhojpur, Rohtas, Buxar, Patna, Aurangabad, Gaya, Jehanabad, Banka, Nawada, Nalanda, Munger, Jamui, and Lakhisarai*. The main fruit crops of this region are mango, guava, banana, bael, jackfruit etc. However, area under fruit crops in this region is low. Bringing more area under HDP will help in increasing the production of fruit crops in the region. The region is known for distress sale of fruits like banana in *Vaishali* district, bael in *Gaya, Patna* and *Lakhisarai* districts, mango in *Patna, Munger* and *Jamui* districts.

Bihar's Northern plains covers an area of 3.261 ha, comprising of districts like *West Champaran, East Champaran, Gopalganj, Siwan, Saran, Vaishali, Muzaffarpur, Samastipur, Sitamarhi, Sheohar, Madhubani, and Darbhanga* etc. The average annual rainfall of the region is 1275 mm. The large area in this region remains under water also called, *Chaur, Maun & Tal* lands. The region is known for quality litchi production. Mango and Makhana are other specialty crops of this region. Setting up of cold storage and processing units of litchi at *Muzaffarpur* and *Samastipur* districts, and processing units of mango at *Madhubani, Muzaffarpur* and *Darbhangha*, and processing units of *Makhana* in *Darbhangha* district would be highly remunerative ventures. Setting up of AEZ for litchi in the *Hajipur* area has further given fillip to horticulture development in this region with following prophylactic measures to inhibit frost damage and PRSV (papaya ring spot virus). *Samastipur* region is also known for quality papaya production. Expansion of area under papaya can be effectively carried out in this district. Quality seed production

of papaya varieties in the region holds promise. Expansion of more area under *Makhana* and *Water chestnut* will help in proper utilization of the water congested areas and wet lands. The interspaces of old orchards of mango and litchi in this region can be effectively utilized by growing shade-tolerant crops like *ginger* and *turmeric*, while intensification of floriculture in *Muzaffarpur* area can also be taken up.

The North-East plains cover an area of 1.956 m ha comprising of districts like *Madhepura*, *Purnea*, *Katihar*, *Khagaria*, *Begusarai*, *Saharsa*, *Araria*, *Kishanganj* and *Bhagalpur*. The Soil is sandy to silty loam, medium to strongly acidic, large area in this region comprise of *Tal* and *Diara* lands. Mango, bael, banana, papaya, are the main fruit crops grown in this region. Expansion of area under HDP of different fruit crops can be taken up in this region. Setting up of processing facilities of banana, papaya, and mango in *Bhagalpur* and *Saharsa* district and for bael in *Begusarai* region could be highly profitable venture. Quality seed production of papaya crops holds promise in this region. Setting up of nursery for production of quality planting material of different fruit crops can also be a profitable venture. The natural water bodies can be utilized for production of *Makhana* and *Water chestnut*.



Fig. 2. Commercial variety of mango of Bihar (a) Kalkattia Malda, (b) Himsagar, (c) Bambaiya, (d) Jarda



Fig. 3. Local variety of mango (a&b) Pahadpur Sinduria (c) Kishanbhog, (d) Sukul



Fig. 4. Commercial variety of mango of Bihar (Jardalu, Gulabkhas, Kapuria, and Biju)



Fig. 5. Mango cultivars [(a) Maldah (syn. Langra) (b) Bathua, (c) Sipia] of Bihar



Fig. 6. Seedling of Langra Mango (individual fruit weight is > 540 g) at Mehshi, East Champaran



Fig. 7. 'Mallika' mango (Average fruit weight 720 g), conserved by Sri Anoj Kr. Rai, Malikaur, Samastipur (Bihar)

3. STATUS OF MANGO DIVERSITY IN BIHAR

The 38 districts of Bihar have been divided into four zones (Zone I, Zone II, Zone IIIA and Zone IIIB) which are mapped into high, medium, and low categories based on fruit productivity. Bihar is the 4th mango-producing states after UP, AP and Karnataka and contributed 8% of the total mango production in the country. The area under mango in Bihar is 1.6024 lakh hectare with production of 15.4997 lakh tons. The productivity of mango in Bihar is 9.67 tons per ha that exceeded the national productivity which is around 8.80 tons per ha.

Mango is an important fruit crop, and it is grown extensively in three districts in Bihar namely, *Bhagalpur*, *Madhepura*, and *Arwal*. Bihar is known for its wide variety of mangoes which include *Digha Maldah*, *Jardalu*, *Gulabkhas*, *Amrapali*, *Kishanbhog*, *Jarda*, *Chausa*, *Bombai*, *Safeda*, *Sepia* and *Shukul*. Among these, '*Jardalu*' has been given the Geographical Indication (GI) tag which is distinguished by its light yellow skin and distinct special aroma. '*Jarda*' (syn. *Gaurjeet* of eastern UP) needs to be covered under GI. The Mithilanchal region is one of India's biggest producers of mangoes, with thousands of mango varieties grown in the state.

"*Jardalu* variety of mango, which is mainly grown in Bhagalpur district and the *Dudhiya* variety of '*Maldah*' mango of Digha, Patna are not just sold in different parts of India, but also exported to other countries. By the Government of Bihar, many districts have been identified for particular mango variety like 1) West Champaran for '*Jarda*' (has demand to get its GI status); 2) Sitamarhi for '*Baimbaiya*'; 3) Darbhanga for '*Kalkattia Maldah*' (syn. *Dalma*); 4) Supaul for '*Gulabkhash*'; 5) Madhubani for '*Krishanbhog*'; 6) Madhepura and Katihar districts for '*Malda*' (syn. *Langra*); 7) Bhagalpur for '*Jardalu*' (GI obtained by Govt. of Bihar during 2018) 8) Munger for '*Churamba Malda*' 9) Samastipur for '*Bathua*' (syn. *Kanchan*), 10) Patna for '*Dudhia Malda*' (that needs to be addressed for its declining existing diversity) and 11) Buxer for '*Chausa*' mango. Apart from *Sukul* (most suited for pickle making in Bihar), *Lal Malda*, *Dudhia Malda* are also used for pickle making in Patna. *Jarda* and *Bombai* are main sucking varieties, *Malda* is the main table variety and *Sukul* and *Fazli* used as pickle varieties.

Bihar famous 'Sipia' Mango

One of Bihar's favourite mangoes, it's shaped like a sea shell and thus its name, '*Sipiya*' a local variety from the *Samastipur* district of Bihar, known for their natural sweetness and ripeness. *Sipiya* is highly regarded for its unique taste and is usually sought after for its natural sweetness. It's non-fibrous, making it a good pick for chutneys and other dishes. It has a thinner skin compared to others and at times people savour it along with its skin. The leaves of the *Sipiya* mango tree are slender and long. Most of the varieties showed flat leaves for all are curled on the sides. The average weight of a *Sipiya*

mango is between 100-200 g. When ripe, it achieves a yellow hue. What makes *Sipiya* a much sought-after mango is due to its late maturing? When all other varieties have lived their time: for it arrives during *Rakshabandhan*, which makes it special which happens to be in August.



Fig. 8. Participation of ICAR-CISH, Lucknow at Mango Diversity Show (17-18th June, 2023) at Gyan Bhavan, Patna



Fig. 9. Seedling mango Shri. Kaushal Kishore Singh, Dwarkanagar, Mushahari, Muzaffarpur, Jale (Darbhanga), Deep (Madhubani), Paterhi Belsar (Vaishali)

4. BIHAR STATE BIODIVERSITY BOARD (BSBB), PATNA: Motivator Behind Germplasm Conservation

Concerned with the sharp decline in the farming of seedling mangoes in certain districts of Bihar, the Govt. of Bihar has decided to conduct a study and formulate a conservation plan for increasing diverse variety of mangoes such as 'Jardalu', 'Gulabkhas', 'Amrapali' and 'Chausa' from seeds. In Bihar, the large seedling diversity of mango has not been fully evaluated and also there is sharp decline [in the recent past] in the seedling mangoes in many districts. Therefore, the Bihar State Biodiversity Board (BSBB), Patna (under Dept. of Environment, Forest & Climate Change, Govt. of Bihar) has signed a Memorandum of Understanding (MoU) with the Lucknow-based ICAR-Central Institute of Subtropical Horticulture (CISH) for the '*Evaluation of diversity and decline of indigenous seedling mangoes of Bihar and study for its conservation strategy*'. The major rationale of this collaborative programme was as follows:-

- 1) To know what is the status/or causes of decline of indigenous seedling mangoes in Bihar?
- 2) How drivers of climate changes effected distribution of seedling mango?
- 3) What is the genetic variability existing among mango seedlings?
- 4) Any conservation strategies have been adapted by mango growers to mitigate climate risks.
- 5) To identify any elite mango genotypes could be scaled up for its commercialization/ multiplication and its adaption and/or what could be its conservation plan.

The study was aimed to find out reasons for the decline of indigenous seedling mangoes of Bihar and further formulate a conservation plan. The study is expected to be completed within 3-4 year and after that, the authorities concerned will formulate a conservation plan. Initially the project was proposed for two years which was extended for another two years based on uniqueness in diversity available in the northern part of Bihar.

The major objective of the programme was

- a) To assess the decline of indigenous seedling mangoes;
- b) To develop a conservation plan for seedling mango in Bihar;
- c) To increase the farming of seedling mango in certain district of Bihar;
- d) To export indigenous seedling mango, and
- e) To study the diversity for their morpho-phenological traits as well as yield performance under the Bihar condition to evaluate its suitability for the other states.

Therefore, a survey was conducted in the 12 districts (of Bihar) in collaboration with Bihar State Biodiversity Board (BSBB), Patna. The evaluation of seedling diversity was carried out for morphological, yield, maturity and fruit quality traits in the northern and eastern part of Bihar in India. The rigorous study will be conducted in at least 25 districts. It will focus on crop improvement and post-harvest processing quality of seedling mango. The study will also provide the state with the approx. data on decline in the farming of seedling mangoes. The survey is done by frequent visits during bearing to the different mango growing areas of Bihar.

The selection of seedlings was based mainly on

- (i) Tree morphological characters,
- (ii) Bearing habit
- (iii) Fruit yield and quality, and
- (iv) Degree of susceptibility/tolerance for abiotic and biotic stress.

Ten fruits were collected from each of the selected elite trees from the farmer's field. The fruits were labelled after they were plucked from the tree. The peel colour, and pulp colour were noted following the Royal Horticultural Society (1986). Colour Chart and the quality of fruit were estimated following the standard methods. The physico-chemical characters were recorded. The different variability of characters was statistically analysed.

Later the selected clones will be vegetative propagated by veneer grafting and 4 of each clone will be planted at the Horticulture Research Farm either at ICAR-CISH, Lucknow, UP/RPCA, Pusa, Samastipur Bihar/BAU, Sabour, Bhagalpur, Bihar/Centre of Excellence for Fruits, Desri, Hajipur (Bihar).

The current study took place in Farmer's field. Character descriptors were used to collect data on morphological (qualitative) characters. Descriptors (mentioned in DUS guidelines on mango) were used to evaluate the requirements of Distinctiveness, Uniformity, and Stability. The descriptions describe a trait of the entire plant or a portion of it. These descriptors can be morphological, biochemical, molecular, or any other type of descriptor. In the present study the open pollinated seedling progenies which flowers were subjected to DUS descriptors viz., Different plant parts and traits, such as leaves, flowers and inflorescences, fruits, and general architecture, through which have been identified.



Fig. 10. Seedling mango planted on bund of commercial orchard of mango a) Hayaghat (Darbhanga) b) Rataura, Katihar c) Bishanpur (Darbhanga) and road side plantation of seedling mango at Bishanpur (Darbhanga), seedling of Kishanbhog at Mishrawlia Jagdish (Vaishali)



Fig. 11. Bunch bearing seedling at Manganpur (Vaishali), Brahampur, Jale (Darbhanga)

5. IMPORTANCE OF SEEDLING MANGO IN IMPROVEMENT PROGRAMME

The seedling mangoes include plants derived from both monoembryonic and polyembryonic mango stones. Almost all the mango cultivars are the result of selection from these seedlings. As compared to cultivars, seedling mangoes exhibit wide variability with regard to fruit and tree characters. In India and other parts of the world, the seedlings of monoembryonic cultivars are not much cared, but in places where the polyembryonic varieties are commercially grown, seedlings are important. A number of polyembryonic varieties have been reported in mango mostly from coastal areas, Bihar farmers lack such varieties in their orchard i.e. no commercial variety in North India is polyembryonic. In about 20 polyembryonic varieties (indigenous and exotic) available and except [globally] exotic *Kensington*, most of them have inferior fruit quality with some exceptions of Southeast Asian varieties.



Fig. 12. Commercial orchard of seedling mango at Parsa Babutola (West Champaran), Bishanpur-Manohar (Muzaffarpur), Maker (Saran) and Koiladewa (Gopalganj)

Most of the commercial cultivars of mango are the results of selections made from chance seedlings. Many of the present-day cultivars in Florida (USA) were selected from open-pollinated seedling progenies. The variety 'Haden' was found to be a seedling of 'Mulgoba' an Indian variety. The cultivars *Edward*, *Lippens*, *Tommy Atkins*, and *Zill* were found to have originated from 'Haden'. In Israel, the varieties 'Maya' & 'Nimrod' are a selection from open-pollinated seedlings of *Haden*. Likewise 'Dahar' was found to be a seedling of 'Irwin' and 'Naomi' is a seedling of 'Palmer'. Two selections MDCH-1 and STH-1 are dwarf, and flower within 1 year in Manipur, India.

Bihar farmer's perception about seedling mango

Many farmers express their view on benefit and motivational factor to conserve mango diversity on seedling mango in their orchard. The details are as follows:-

- Good source of income through selling of wood (a mango grower from Vill. Brahampur, Block: Jale, Darbhanga sold the wood of 35 seedling mango trees for Rs. 35.00 lakhs).
- Act as pollinizer for commercial variety.
- Stagger in harvesting/fruit's availability and source of rootstock, importance as heritage trees.
- Used as wind break in *Mithilanchal* region, prevent trespassing, plantation on bund reduced soil erosion.
- High yielder (yield may be recorded up to 12 q per tee), bunch bearer but start bearing in late (10-12 years of planting).
- Better self-life than commercial variety with little prone to fruit fly.
- Mostly fibrous, led to best for gastric patients, little bit sweeter, beneficial for diabetic patients.
- The people from downtrodden class prefer and consume more seedling mango.
- Tolerant to strong wind, fruit drop and resistant to biotic and abiotic stresses.
- Many senior citizens prefer to consume seedling mango over commercial ones.



Fig. 13. Dropped fruits of unattained seedling mango at Garaul (Vaishali)

6. EFFORTS TAKEN FOR CONSERVATION OF SEEDLING MANGO ACROSS GLOBE

Consumer's preferences are associated with changing market needs for fresh fruit and value added products thus making mango cultivation more or less commercial venture. Large-scale use of clonally multiplied mango cultivars has diminished the genetic variability and chances of seedling selection, a method which resulted development of countless varieties in western and eastern Hemisphere. Climate change and urbanization triggers the depletion of genetic diversity in the wild gene pool. Many workers have understood the value of biodiversity protection and its genetic potential. Several mango populations are endangered by habitat loss. Since, variability available in mango is still unexplored and many of the indigenous land races are threatened with extinction, collection of this diversity was suggested.

Although mango is most important fruit in Asia, there is a potential for competition between the cultivated and non-commercial varieties for arable land. The largest mango producing countries including India have the most potential for its cultivation to be displaced by other more profitable crops. India being a major centre of diversity in mango, there is also significant erosion of the gene pool owing to urbanization, industrialization and deforestation. Other *Mangifera* spp. have their centre of diversity and origin in Southeast Asia, a region that has accomplished great economic development in recent years at the cost of genetic erosion in wild relatives.

In Thailand, *M. indica* has narrow base of genetic variation which is the main cause of genetic erosion in mango cultivars. Few principal commercial varieties are grown for commercial purpose. The introduction of selected clonal varieties to replace seedling varieties is also causing genetic erosion in the cultivated mango.

In Indonesia, genetic diversity is still maintained by the villagers in the form of inferior cultivars around houses which is under the threat of extinction due to the need to build houses or clearing of land for growing other crops. *In situ* conservation efforts in Indonesia have been confined to some protected forests and National Forest Parks for the conservation of wild plants and animals but mango species are not given particular attention as yet.

In Bangladesh, many of the elite varieties (which are not commercial varieties) are in potential threat of erosion. The predominance of one major variety, the 'Carabao', is threatening the existence of the minor varieties in Philippines. 'Carabao', 'Pico', 'Pahutan', 'Binoboy', 'Dudol', 'Senora', 'Digos' and 'Mampalang' mangoes are the eight recognized local mango varieties. *Mangifera* species are also greatly.

For fruit crops, various germplasm conservation methods are followed such as field gene bank (FGBs), seed storage, *in vitro* storage and cryopreservation of shoot tips etc. In

mango, with current available knowledge, *ex-situ* FGBs and *on-farm* conservation have contributed the most. Nevertheless, inferior cultivars in the home gardens of farmers, especially [seedling mango] in the mango production centres may be under threat. Kostermans and Bompard (1993) recommended for both *ex situ* and *in situ* conservation of *Mangifera* spp. Although, *in situ* conservation has advantages, its big drawback is that the nature reserves in Asia may not be secure. There is an urgent need to conserve the diversity in the zone of natural variability. The objective of *on-farm* conservation is to allow natural genetic introgression between domesticated crop and its wild relatives and to maintain crop evolution in farmer's fields, farms, home gardens, and landscapes.

Wild seedling races are reported to occur almost throughout India in the natural forests of Tripura, Odisha, Jharkhand, and Western Ghats. In the forest of the north eastern India, many of the seedlings still have a lot of primitive features such as polyembryony and dwarf habit. Work with ecotypes in Bihar for wild mango trees reveals that primitive characteristics persist and out-crossing with commercial varieties has not taken place.

In India, *in situ* conservation of wild forms of *M. indica* was suggested in the hill region of Odisha, Chhotanagpur, and the plateau adjoining Madhya Pradesh, forests bordering Myanmar in Manipur valley and Western Ghat. *In situ* conservation of *Mangifera sylvatica* Roxb. is possible in one or several areas of greater Chittagong Hill Tracts (Bangladesh). It deserves urgent attention since forest is declining fast.

Earlier, considerable efforts under the Asian Development Bank (ADB) sponsored initiative were made to conserve the fruit genetic resources of ten countries, including India, China, Bangladesh, Indonesia, Malaysia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam, under the 2010 initiative '*Conservation and Use of Native Tropical Fruit Species and Biodiversity in Asia*'. In India, a significant number of accessions were collected and conserved in ICAR institutes under UNEP-Global Environment Agency (GEF) funded by project in five states Amravati (Maharashtra) and Chittoor (Andhra Pradesh), Malihabad (UP), Pusa (Bihar) and Sirsi (Karnataka) on the Mango. Actually custodian farmers have also been identified from selected sites who played an important role in *in situ* on-farm diversity conservation in mango. Custodian farmers are the farmers' actively supporting, adopting and promoting agricultural biodiversity and related knowledge over time, in the farms and communities. We have also identified > 100 custodian farmer from different districts of Bihar.

7. WAY OF ON-FARM CONSERVATION OF SEEDLING MANGO

In India, identification and documentation of tropical fruit tree traditional knowledge related to seedling mango was undertaken earlier also. There are several motivations to the farmers for *on-farm* [seedling mango] diversity conservation. The analysis in India (particularly in Bihar) showed that many farmers conserve rich variation with few rare, special fruit tree species or varieties, motivated mostly by conservation philosophy. Personal, social, cultural/religious, natural and biological traits also played important role in motivating the farmers for conserving the mango diversity apart from economic factor. 'National Fruit Catalogue of Tropical Fruit Diversity' was developed based on the identification of unique varieties along with details of custodian farmers. For *on-farm* conservation of cultivated/seedling and wild germplasm of fruit trees, awareness is required on diversity conservation.

Fruit Tree Diversity Fairs in India are being arranged for general awareness about the diversity of fruit trees as a participatory method to recognize indigenous varieties with different traits and encourage conservation. The diversity fairs also helped in recognizing the custodian farmers. The heirloom varieties have a significant diversity and the study was undertaken in India under UNEP-GEF TFT project for their identification and conservation. Such varieties may be directly used for commercial cultivation or as parents to add characteristics through breeding.

Although several edible *Mangifera* species exists, obsolete and old varieties are being maintained in home gardens in mango-growing countries of Asia but scientific backup for *on-farm* conservation is lacking. However, this program needs strengthening for the conservation of valuable diversity available in genus *Mangifera*. Since the conservation by this means require incentives to the farmers, it should be supported through international organizations. It is important to be aware of the complementarity of the different techniques in the conservation of gene pool. Conservation in field gene banks should be used as a backup in case material is lost *in situ*. Nevertheless, farmers are still keeping inferior cultivars in their home gardens, especially in the mango production centres because of their use value.

Field Gene Bank (FGB)

Presently, establishment of FGB is the most important way for the conservation of mango germplasm. The plants are conserved in the field as living inventory. It is easier to conserve in the field, characterize and use in breeding programs. However, FGBs may be subjected to pressure from land use, prevalent diseases and pests, which may result into germplasm depletion. In India, few decades back, germplasm of *M. indica* was collected and assembled as working collection in the FGBs at different locations with major emphasis to the accessions with desirable traits be exploited as variety or to

be used in breeding program. Live collections of the crops have long been maintained by many orchardists/govt. department and attempts have been made to systematically organize these collections into FGBs to conserve the variety of fruit crops that are multiplied vegetatively. The effort to collect and conserve local germplasm is not given a high priority as it is called for.

In Vitro Conservation

Germplasm maintenance of mango in FGBs has its own limitations because of large land and other resource requirements. The other possible way for the conservation of the gene pool through *in vitro* conservation is still in fancy because till date tissue culture technique in mango is not available. Pollen storage of important mango varieties may be used in hybridization program for gene transfer. Pollen storage can reduce the lag period which is required for grafted plants to attain flowering stage and pollen of desired parents could be exchanged for breeding.

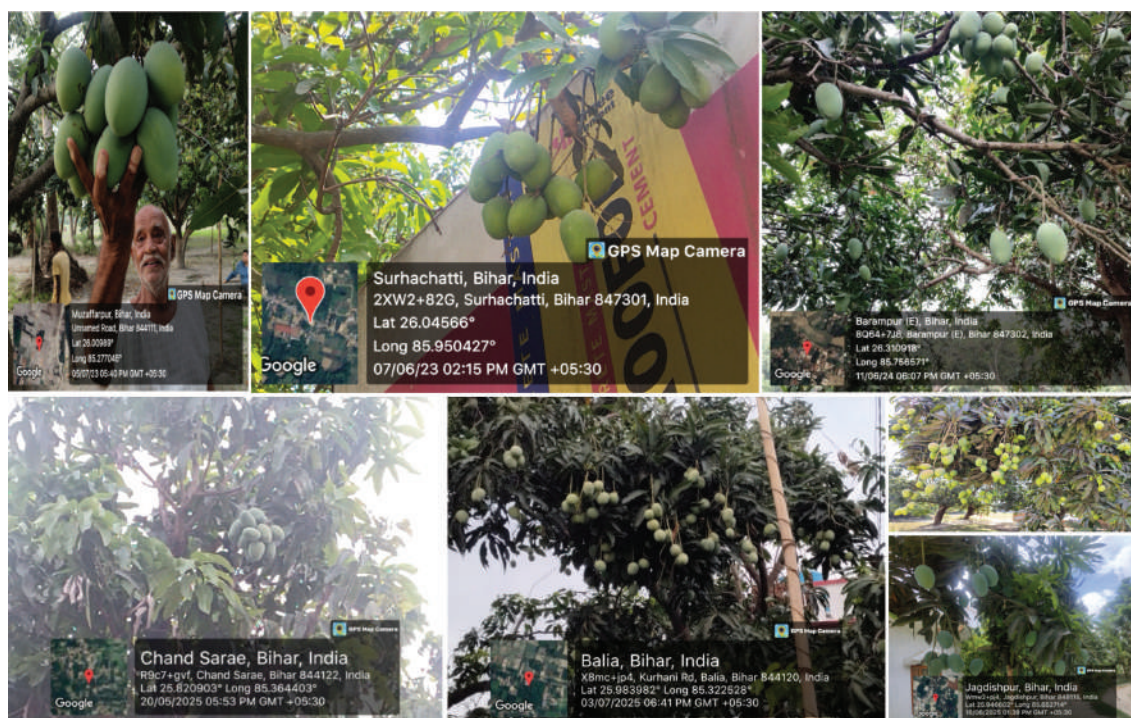


Fig. 14. Seedling mango bearing in bunches

8. UTILIZATION OF SEEDLING MANGO AS GENETIC RESOURCES

Characterization and evaluation of mango germplasm is an imperative step for its utilization in breeding programs. Available germplasm has been considerably characterized to identify desired traits mostly based on morphological and molecular markers. Moreover, germplasm conservation for future utilization also requires dependable information. Comprehensive details of mango cultivars, characterization of desired traits or genes and evaluation information on germplasm based on morphological as well as molecular markers will lead to better utilization.

Mango germplasm is being extensively used in breeding being conducted at different locations spread all over India. The main emphasis has been to develop regular bearing, coloured varieties and to avoid the formation of spongy tissue. As a result of massive hybridization programs, more than 45 mango varieties have been developed, including Amrapali (dwarf, regular bearing), Mallika (regular bearing, processing) and Ratna (regular bearing, free from spongy tissue), Sindhu (hybrid with papery and soft stone), Ambika (regular bearer and red colored) and Arunika (dwarfer than Amrapali, regular bearer and red colored), Elaichi (for incorporation of resistance against mango malformation). Few studies based on fruit traits have been conducted for selecting promising parents. Rootstocks response to soil salinity, a significant abiotic stress, restricts mango production worldwide.

Limitation of seedling mango for crop improvement programme

The utilization of high producing genotypes rather than poor yielding indigenous genotypes is critical for commercial mango production success. As a result, improving the genetics of this crop is critical for developing high-yielding genotypes. The first and most significant step in the description, classification, and characterization of germplasm collections is morphological characterization of trees and fruits. When screening genotypes for a specific region, the evaluation of genotypes is crucial. Although a cultivar may exhibit a distinct personality when grown in one location, it may not be able to maintain that personality when grown in another. Mango's genetic diversity provides a variety of opportunities to manipulate desirable traits using genomic resources. For effective conservation and exploitation of genetic resources for crop improvement programmes, it is critical to assess genetic variation within natural populations and among breeding lines. Growers will be able to select the best suitable and high yielding variety for their region based on location specific evaluation of varieties. The evaluation of germplasm also aids in the selection of parents for breeding programmes to increase production. So far, in Bihar >25 elite type germplasm amongst seedling population is identified under this project and it is under screening for molecular attributes.

9. PROBABLE APPROACHES FOR GENETIC RESOURCES MANAGEMENT OF MANGO FOR BIHAR

In the development of new varieties of mango, genetic resources play a significant role. In many of the FGB, the majority of mango germplasm plantations are old and traditional, planted at wider distances with dense canopy, which have led to a significant reduction in yields. Therefore strategies for conservation should be

- 1) Assessment of diversity to determine future gene donors by survey and collections from different districts of Bihar.
- 2) The germplasm, which can act as the basic material for the development of insect/disease-resistant varieties must be collected for biotic stress management.
- 3) Concerted studies are needed to identify climate-resistant seedling germplasm that can be used directly for cultivation or in breeding program.
- 4) Priorities must be reviewed and strategy must be prepared both for *in-situ* and *ex-situ* conservation.
- 5) Duplication of the accessions in FGBs increases the institution's burden and therefore it is necessary to analyse and reduce duplication to simplify conservation efforts in addition to helping to identify low-cost techniques.
- 6) Extensive surveys may be carried out in diversity-rich regions to identify and collect trait-specific mango germplasm.
- 7) Studies can also strengthen attempts to minimize threats to wild populations by collection and maintaining germplasm from rich areas of genetic diversity.
- 8) Extending opportunities to help local custodian farmers for *on-farm* conservation efforts which would provide safe livelihood choices for them.
- 9) Climate change has also made it difficult for crops in areas to explore the idea of creating conservation sites outside the current germplasm distribution. In order to manage diverse genetic trait-specific germplasm to achieve broad-based performance, core and mini-core collections need to be produced and evaluated.

10. HEIRLOOM VARIETIES OF MANGO IN BIHAR

Heirloom varieties are defined as local or regional varieties, passed down from generation to generation of gardeners/farmers, maintained by asexual means, also include old commercial varieties/antiques, presently not grown on commercial scale and limited to few orchards. Historically, these are important non-commercial varieties that do not limit or restrict to a particular family or community. Pre-occupation with few established commercial varieties might overlook and underestimate the potential of heirloom varieties. Conservation of genetic diversity is important for combating climate change challenges. Subsequently *on-farm* conservation of traditional varieties is being highly advocated. Heirloom varieties have been conserved and grown for various reasons. The farmers play an important role in the maintenance of crop genetic diversity, farmers do experiment with new plant materials and adopt them if they turn out to be superior to traditional varieties or landraces.

This is so in the case of old orchard of Bihar where traditional varieties of mango are still grown in spite of the lack of marginality. In this region, local mango varieties are advantageous because they are higher-yielding, resist infestation by pests, and are more tolerant to fruit drop. This is similar to the seedling originated mango varieties, which are being grown in spite of quality not very superior. However, farmers have varied uses for these varieties. The heirloom varieties are of seedling origin and most of them are regular bearers. These are observed to be growing as individual plants in several orchards of the mango-growing farmers. They have great potentiality as several of them have desirable traits *viz.* better keeping quality and high nutritive value.

Through PRA and interaction with mango growers, it was found that the unique local varieties which were conserved in the region as *Jalbanda* (large sized fruit with sweet at mature green stage), *Jalmarai* (uneven shape but very tasty with hard peel), *Bhastara* (syn. *Baramasi*, bearing twice in a year) *Sabja* (syn. *Bombaiya*, an early and sweet even at mature green stage), *Dalma* (syn. *Kalkatia Malda*, dark green peel, large sized), *Malda seedling* (fruit weigh up to 750 g, superior in taste and sweetness than grafted one), *Bhont* (thin stoned, papaya shaped and mid maturing), *Sinduria* (earliest maturity), *Raja* (sweet and easily digestible), *Kaveri*, *Bahadura*, *Balajee*, *Kerwa* (large sized fruit with banana shape), *Tairia* (heavy bearer with regularity), *Baelkhash* (leaves/fruits contains flavour of bael), *Chitrangan* (late maturity, taste like curd of buffalo milk) etc. '*Latkampu*' mango of *East Champaran*, '*Gaurjeet*, (good smelled and highly flavoured) of *West Champaran* has excellent market in the bordering area of Bihar, UP and Nepal. '*Hajipur Mithui*' (thick peel, better shelf life), '*Madhukupia*' and '*Baramasi*' of *Samastipur* were observed as unique mango variety in surveyed areas. Some unique mango which was identified of mango as *Mithua* (from *Patna*), *Sewaiaya*, *Bhont*, *Jalbanda* from *Saran* and *Baramasi* from *Samastipur* and *Jamui* district of Bihar (Table 1).

Table 1. Details of uniqueness of indigenous mango varieties (Heirloom) conserved by custodian farmers of mango across Bihar

Sl. No.	Name of unique varieties	Distinct attributes	District
1.	<i>Jalbanda</i>	Large sized fruit with sweet at mature green stage	Saran
2.	<i>Jalmarai</i>	- Very tasty with hard peel hard peel, better shelf life - Latest maturity (September) led to fruit fly attack - Shape is not uniform i.e. distorted	Purnea
3.	<i>Baramasi</i>	- Flowering thrice in a year; - June-July crop is sour in taste and October crop is sweet	Samastipur
4.	<i>Lamba Bahadur</i>	- Fruit is just like Fazli, shy bearer - Large sized fruit (1-1.25 kg per fruit) - Resistant to insect pest	Katihar
5.	<i>Hilsa Peti</i>	Heavy bearer, ideal sized fruit (4-5 in a kg).	
6.	<i>Bhastara (syn. Baramasi)</i>	Bearing twice in a year	Siwan
7.	<i>Sabja (syn. Bombaiya)</i>	An early and sweet even at mature green stage	East Champaran and Gopalganj
8.	<i>Dalma (syn. Kalkatia Malda)</i>	Dark greened, large sized	
9.	<i>Malda seedling</i>	- Fruit weigh up to 750 g - Superior in taste and sweetness than grafted one	Samastipur
10.	<i>Bhont</i>	Thin stoned, papaya shaped and mid maturing	Saran
11.	<i>Suraypuri</i>	- Regular bearer, scented, bunch bearer - Greenish while ripening with white pulp - Small sized fruit with prominent beak, thin peel - Sucking varieties, can be eaten as much as possible	Purnea
12.	<i>Raja</i>	Sweet and easily digestible	Gopalganj
13.	<i>Kaveri, Balajee</i>	Heavy bearer with regularity	
14.	<i>Esna</i>	- Ripening in September (latest to ripen) - Fibreless, and hgh yielder (4 quintal per tree) - Bangladeshis are fond of pickle out of it	Katihar
15.	<i>Baelkhash</i>	Leaves/ fruits contains flavour of Bael	Gopalganj
16.	<i>Chitrangan</i>	- Presumed to be cross of Chauria x Bombai - Very sweet (taste like curd of buffalo milk) - Tight skin with firm, yellow pulp - Thin stone, High shelf life, - Weight: 6-8 per kg - Fibreless, light-yellow peel - But milk sap is more and highly acidic - Matures in mid-June and - Fetch premium price - Resistant to insect pests	Katihar and Purnea

17.	<i>Gaurjeet</i>	• Good smelled and highly flavoured, has excellent market in the bordering area of Bihar, UP and Nepal	<i>West Champaran</i>
18.	<i>Kerwa</i>	• Long and big sized fruit, (banana shape) • A sucking variety Matures in late August, Small seed with 3 inch in length, red shoulder with fibre.	<i>Siwan</i>
19.	<i>Tairia</i>	• Heavily fruited, regular bearer, • Even un-ripe fruit and peels are also sweet	
20.	<i>Latkampu (Syn. Bahadura)</i>	• Big sized, matures in first week of July	<i>East Champaran, Gopalganj</i>
21.	<i>Hajipur Mithui'</i>	• Thick peel, better shelf life	<i>Samastipur</i>
22.	<i>Madhukupia</i>	• Pup taste like honey	
23.	<i>Paharpur Sinduria</i>	• Bears fruits in late July with firm pulp	
24.	<i>Rari mango</i>	• Small but very juicy and sucking variety liked by many locals	
25.	<i>Kapuria</i>	• Fibreless, firm pulp, red blush at shoulder • Matures in Late June, high yielder (3 quintal per tree with 10 year old)	
26.	<i>Hajipur Mithui</i>	• Big sized, yellow golden in colour, heavy bearer, • Very less fruit drop	
27.	<i>Ajgavi Sipia</i>	• Thin stoned, long fruited with thick shoulder	
28.	<i>Belwa</i>	• Fibreless, pulp consistency like <i>malda</i>, • Very sweet and ideal fruit sized, attractive red coloured • Thick skin, makes suitable for long distance transport	
29.	<i>Chauaria</i>	• Early maturity and sweet even at un-ripened	<i>Katihar</i>
30.	<i>Navras</i>	• Fibreless, with nine type of flavour, mid maturity	
31.	<i>Jethua</i>	• Earliest to mature, long and small fruit • Yellow pulp with scented aroma	<i>Purnea</i>
32.	<i>Kala Pahad</i>	• Big sized fruit with thin peel • Taste is better than Calcuttia malda	
33.	<i>Jing Jing</i>	• Sucking varieties, small sized with yellow pulp	

11. ROLE OF CUSTODIAN FARMERS IN CONSERVATION OF MANGO DIVERSITY

Bihar has enormous wealth of mango genotypes with respect to plant and fruit characteristics. The need has been felt to conserve the mango diversity at national and global levels. Due to shrinking land resources, smart strategies have to be developed for conservation of mango diversity. Different stages of conservation of mango diversity have been envisaged which include secret groves, forbidden orchards, cultivated orchards, field gene banks, diversity parks, homestead gardens and so on.

The '*custodian farmers*' refers to who dedicate time and effort to conserve mangoes and make maximum use of diversity for their livelihood security. Such custodian farmers maintain, adopt and disseminate the agro-biodiversity over time and in space. Research and development links with these custodian farmers should be maintained and to conserve mango diversity over time. Furthermore, while geneticists and plant breeders are particularly interested in diversity at the molecular level, farmers are more concerned about visible morphological and agronomic variation, which helps them to identify cultivars that are productive and do well in their location specific environment (this refers to narrow adaptation given that farmers are unfamiliar with the characteristics of the many different cultivars of mango).

Among almost 140 farmers of >20 blocks of seven districts of Bihar (*Darbhanga, Gopalganj Madhubani, Muzaffarpur, Samastipur, West Champaran and Vaishali*), the maximum varieties of mango is grown and maintained by Sri. Vinod Kumar Rai of *Jagdishpur, Samastipur* (36 in No.) and Sri Abdul Rahim of *Kumarbagh, West Champaran* (28 in No.). Sri Vijay Kumar Sharma of *Basuari, Samastipur* is maintaining 20 and Sri. Wasi Akhtar of *Dharmaparsa, Gopalganj, Sri. Harsh Ranjan of Hasanpur Vajhi, Muzaffarpur* and Mr. Sanjay Sharma of *Malinagar, Samastipur* are having 19 varieties each in their orchard. Till date we got maximum number of orchardists (25 in No.) from Darbhanga district having more than 10 varieties in their orchard, 13 orchardists, have more than 15 varieties in their orchard. Sri. Harendra Kumar Singh of *Makhdumpur, Bihta, Patna* has been identified as torch bearer for farmers who needs information on e-marketing, weather forecast, skilled grafter/budder and encourage farmers to grow Jamun and Datepalm. Sri. Anoj Kumar Rai of vill. *Malikaur, Pusa, Samastipur* growing > 10 number of mango variety in their orchard including recently developed varieties.



Fig. 15. Custodian Farmer of West Champaran



Fig. 16. Custodian Farmer of Gopalganj, Siwan, Katihar, Muzaffarpur and Samastipur



Fig. 17. Custodian Farmer of Jagdishpur, Mahmada (Samastipur), Jalhan (East Champaran) and Baha Chauki (Munger)

Table 2. List of custodian farmer conserving mango diversity

Sl. No.	Name of the farmers	Location of orchard ¹	Longitude	Latitude	Altitude (± m)	Total No. of trees	No. of Mango varieties conserved
1.	Sri. Kaushal Motani	Gamharia Farm, Chauhatta, Mainatand, (West Champaran)	N27°14'58.0"	E084°37'50.1"	2	2000	17
2.	Sri. Pankaj Kumar Singh	Jalhan, Khajuria, (East Champaran)	N26°28'50.0"	E084°43'21.6"	3	250	26
3.	Sri. Shailesh Pandey	Dhamsar, Lahladpur via Jantabazar, (Saran)	N26°03'19.7"	E084°37'40.8"	2	150	16
4.	Sri. Abdul Rahim	Kumarbag, Sadar, (West Champaran)	NA	NA	-	360	28
5.	Sri. Anuj Kumar Rai,	Malikaur, Pusa, (Samastipur)	N25°56'44.5"	E085°38'19.5"	2	150	21
6.	Sri. Vinod Kumar Rai	Jagdishpur, Pusa, (Samastipur)	N25°56'93.4"	E085°39'25.1"	34	300	36
7.	Sri. Vijay Kumar Sharma,	Basuari, Pusa, (Samastipur)	E 085°39.29"	N 26°00.19"	42	350	20
8.	Sri. Sanjay Sharma	Malinagar, Pusa, (Samastipur)	N26°00'28.5"	E085°40'58.5"	35	130	19
9.	Sri. Washi Akhtar	Dharmarsa, Manjha, (Gopalganj)	N26°21'30.6"	E084°29'23.3"	3	400	19
10.	Sri. Rajeev Nayan Tiwari	Dahibhata, Uchkagaon, (Gopalganj)	N26°28'42.7"	E084°22'40.3"	3	600	16
11.	Sri. Harsh Ranjan	Hasanpur Vajhi, Sakra, (Muzaffarpur)	N 26° 00' 5.16"	E085°33'2.7"	14	300	19
12.	Sri. Sudhir Kr. Pandey	Vishunpur Bakhari, Muraul, (Muzaffarpur)	NA	NA	-	100	16
13.	Sri. Amresh Kumar	Banwra Kothi, Sadar, (Katihar)	N25°36'30.9"	E087°34'45.6"	10	1500	17
14.	Sri. Kalidas Banerjee	Rautara, Kodha, (Katihar)	N25°39'37.5"	E087°31'57.9"	4	450	25
15.	Sri. Sameer Kumar Jha	Rampur Kamat, Hasanganj, (Katihar)	N25°37'50.2"	E087°33'55.7"	7	400	16
16.	Sri. Sanjeet Kumar	Chauhan Tola, Jalalgarh, (Purnea)	N25°56'57.0"	E087°31'30.2"	4	25	15
17.	Sri. Kumar Tarun		N25°56'54.4"	E087°31'37.6"	8	140	22
18.	Sri. Ashok Kr. Singh	Nagauali, Basantpur, (Siwan)	N26°09'41.6"	E084°40'26.0"	3	200	15

District's name is delineated in brackets under column 2.

[Note: all above farmers are conserving more than 10 varieties in their orchard, and standing near the tree of unique varieties they grow and conserve]

12. AREA COVERED FOR ASSESSMENT OF DIVERSITY OF SEEDLING MANGO

During year 2023, 12 districts were covered with 24 developmental blocks where we had collected 41 genotypes of seedling mango. Out of which 17 were found to be promising. The maximum diversity we got from *Darbhanga* (7) followed by *Muzaffarpur* (6), *Madhubani* (5), *East Champaran* (5) and *Vaishali* (5) district.

During the year 2024, 7 districts were covered with 14 developmental blocks where we had collected 38 genotypes of seedling mango. Out of which 13 were found to be promising. The maximum diversity we got from *Muzaffarpur* (12) followed by *Samastipur* (11), *Madhubani* (5) and *Vaishali* (4) district.

Table 3. Surveyed districts with blocks and no. of genotypes identified during 2023 and 2024

Sl. No.	Name of the Districts surveyed		Blocks		No. of elite type mango seedling (collected)		Total
	2023	2024	2023	2024	2023	2024	
1.	Muzaffarpur		Mushahari, Saraiya	Mushahari, Meenapur, Kanti	2 +1 +1 +2 = 6	5 +4 +1 +2 =12	18
2.	Darbhanga		Hayaghat, Bahadurpur	Jale	1 + 6 = 7	2	9
3.	Madhubani		Basopatti, Pandaul and Jhanjharpur	Rajnagar, Biraul, Jhanjharpur	2 +3 = 5	5	10
4.	Samastipur		Pusa, Sarayranjan	Pusa, Ujiarpur	1	5 +6 = 11	12
5.	East Champaran		Sangrampur, Mehsi, Kotwa	Mehsi, Kalyanpur	3 +2= 5	1+1+1= 3	8
6.	Vaishali		Paterhi-Belsar, Goraul	Bhagwanpur, Goraul	3 + 2 = 5	1 + 3 = 4	9
7.	Saran	-	Sonpur	-	3	-	3
2.	Sitamarhi	-	Bathnaha	-	-	1	1
3.	-	West Champaran	-	Majhauria	-	1	1
6.	Bhagalpur	-	Sadar, Pirpainti, Sultanganj, Sabour	-	2	-	2
7.	Banka	-	Rajaun	-	2	-	2
10.	Purnea	-	Jalalgarh, Sadar	-	-	-	-
11.	Katihar	-	Sadar Block	-	3	-	3
Total No. of elite type seedling identified for evaluation					41	38	79

Criteria for evaluation of mango seedling

The key characteristics of descriptors for seedling mangoes were distinctness, homogeneity, and stability. As we know the descriptors should be distinct, in the sense that the produced characters should distinguish each hybrid from the others, and the characters should not change after repeated propagation or at the end of each cycle. The descriptors should be stable; they should not vary between genotypes or under different environmental situations, and they should be uniform; each created descriptor should be consistent and unchanging. It was discovered that the seedling mango genotypes showed morphological differences from genotype to genotype based on the observations



Fig. 18. (a-e) Diversity of seedling mangoes from Bihar; (f) Fruiting in Seedling mangoes at Bhatsimar, Rajnagar (Madhubani)

gathered. These morphological changes have the ability to distinguish mango genotypes from one another; therefore they can be developed as descriptors. With the help of these descriptor, we can identify elite varieties as well as superior donor parents for different horticultural traits. The fruit characters were used for grouping the cultivars based on their performance and their region of adaption. The fruit characters further helped in selecting the promising parents using group constellation as well as for evaluation of cultivars for their per se performance. The fruit characters combined with several other traits were used in the classification of seedling mango for different attributes.

Table 4. List of elite type identified during 2023 taken for further evaluation with unique attributes

Attributes for mango genotype taken for consideration	No.	Source/Location
High yield (2500 fruit tree ⁻¹) + Bunch bearing (> 15 fruits) + Tolerant to fruit drop	01	Saraiya, Muzaffarpur
High yield (1000 fruit tree ⁻¹) + High fruit weight (477 g) + Late ripening (Last week of July)	01	Katarmala (Vaishali)
High fruit weight (417 g) + Bunch Bearer (3-4)	01	
High yield (2000 fruit tree ⁻¹) + high self-life (> 15 days)	01	Hayaghat (Darbhanga)
High fruit weight (543 g) (seedling of Langra) + high self-life and aromatic	01	Mehsi (East Champaran)
High yield (4 q tree ⁻¹ ; 10 q tree ⁻¹ ; 2-3 q tree ⁻¹)	01 (<i>Sipia</i>) + 01 (<i>Rajbhog</i>) + 01 (350 g, thin stone)	Paterhi Belsar (Vaishali); Deep (Madhubani); Rajaun (Banka)
High Yield (10 q tree ⁻¹) + Tolerant to fruit drop/biotic and abiotic stresses + Bunch bearer (30-40)	01	Manganpur (Vaishali)
Red Pulp	01	Bishanpur-Manohar (Muzaffarpur)
High Yield (6 q tree ⁻¹) + Anthracnose Tolerant	01	Dwarikanagar (Muzaffarpur)
High self life + Thick Peel	01	Katarmala (Vaishali)
Bunch bearing (> 20 fruits) + high yield (10 q tree ⁻¹) + late ripening (August)	01 (Rari)	Pandaul, (Madhubani)
Tolerant to abiotic and biotic stress	01	Mishrawalia (Vaishali)
Total plus type trees		14

Table 5. List of elite type seedling of mango identified during 2024 with unique attributes

Attributes for mango genotype taken for consideration	No.	Remarks
Coloured (Reddish yellow at ripening)	01	Shahbajpur (Muzaffarpur)
Coloured + Earliest to mature (mid-May)	01	Brahampur (Darbhanga)
Sucking type + late ripening (first fortnight of July) + Excellent shape + Shoulder red in colour + high yield (2.5 q tree ⁻¹)	01	Bhagwanpur Deshwa (Samastipur)
Peel sweet in taste + High yield (6 q tree ⁻¹) + High fruit weight (500 g)	01	
Sucking type + Red peel colour + High yielder (10 q tree ⁻¹)	01	Katarmala (Vaishali)
High Yield (2.5-3.0 q tree ⁻¹ ; 10 years old) + Late maturity + Tolerant to fruit drop	01	Bishanpur-Manohar (Muzaffarpur)
High fruit weight (500g) + High yield : 6 q tree ⁻¹ + Peel sweet in taste	01	
Sucking type + Red peel colour + Late ripening (15 th July) + High yielder (10 q tree ⁻¹ (50-year-old tree) + Tolerant to fruit drop + High Self Life (10 days)	01	Jagdishpur (Samastipur)
High yield (5 q tree ⁻¹ ; 5 q tree ⁻¹)	02	Jamin Mathia (Muzaffarpur)
High Yield: 3 q tree ⁻¹ (12-year-old) + Tolerant to Insect Pests and Diseases/ Fruit drop + Late ripening (after 15 th August)	01	Bhatsimar (Madhubani)
Gulab Khas with late maturity + high yield (6 q tree ⁻¹ (40 year old) + high fruit weight (330 g)	01	
Total plus type trees	12	



Fig. 19. Variability of seedling mangoes at Bhagwanpur Deshwa (Samastipur)

13. PROGRESS OF ASSESSMENT OF DIVERSITY OF SEEDLING MANGO

While investigation during 2023, we observed that existence of a great variability like *Chorbi* (sweet at unripe stage), *Nakubi* (with prominent beak), *Badwaria* (matures in August), *Piri* (Yellow at ripening), *Rajbhog* (high yielder with thin peel and stone), *Rari* (bearing even after 200 year old trees, bunch bearer, honey like taste), *Laru ka Mithua* (high yielder with less sweet), *Sajmania* (late maturity, high yielder). The superior characters were also recorded in the seedling of *Kishanbhog*, *Sipia*, *Langda*, *Dashehari* and the yield varies from 1000-3000 fruits per tree (200-500 kg per tree). The four seedling had average fruit weight of 500-750 g, two genotypes found having shelf life of 10 days, three were fibreless, one genotypes ripened in October besides two identified as *Baramasi* mango. The four genotypes were identified as bunch bearer.

During 2024, we revealed that existence of a great variability like 3 genotypes as sucking type, 3 as high yielder i.e. up to 10 q per tree. Two seedling mangoes were identified for tolerant to fruit drop/biotic and abiotic stresses. Three genotypes were screened out for red colour pulp with peel. Two mango seedlings had sweet peel at maturity, the two genotypes was identified for high self-life (> 10 days). Three genotypes were identified as bunch bearer.



Fig. 20. Ecotypes [seedling] of mango cv. Gulabkhas at Bhatsimar (Madhubani)

The data on other parameters for the collected genotypes are being analyzed however, for the last two years, 26 genotypes of seedling mango have been found promising for various attributes.

14. COMMERCIAL ORCHARD OF SEEDLING MANGO ACROSS BIHAR

We also observed 5 commercial orchard of seedling mango (rarely seen anywhere in Bihar). The list is as follows:-

Table 6. List of commercial orchard of seedling mango available in surveyed districts

Sl. No.	Name of the farmers	Location of the commercial orchard of seedling mango	No. of total trees on mango	No. of seedling [mango] trees	Approx. (%) seedling trees over total trees conserved and maintained by the farmers
1.	Shri. Deendayal Singh	Vill. Bishanpur Manohar, Block: Mushahari (Muzaffarpur)	340	300	90%
2.	Shri. Prabhakar Prasad Singh		110	60	55%
3.	Shri. Shailendra Kr. Shahi	Vill. Shahbajpur, Block: Kanti (Muzaffarpur)	150	100	67%
4.	Shri. Subhash Mishra	Vill. Bhatsimar (West), Block: Rajnagar (Madhubani)	50	50	50%
5.	Shri. Madhaw Kumar Thakur	Vill. Surhachatti, Block: Hayaghat, (Darbhanga)	2000	1000	50%
6.	Shri. Kalidas Banarjee	Vill. Rautara Block: Sadar (Katihar)	450	150	30%
7.	Shri. Kausal Prasad Singh	Vill. Bhagwanpur Deshwa Block: Ujiarpur (Samastipur)	350	100	30%
8.	Shri. Vinod Kumar Rai	Vill. Jagdishpur, Block: Pusa (Samastipur)	100	30	30%
9.	Shri. Rajnath Jha	Vill. Deep, Block: Jhanjharpur, (Madhubani)	1200	300	25%
10.	Shri. Amrendra Kumar Singh	Vill. Parsa Babu Tola, Block: Majhauria, (West Champaran)	400	100	25%
11.	Shri. Rajat Kumar Thakur	Vill. Brahampur, Block: Jale (Darbhanga)	320	80	25%
12.	Shri. Jagannath Pandey	Vill. Katarmala, Block: Goraul (Vaishali)	125	25	20%
13.	Shri. Ashotosh Thakur	Vill. Bhatsimar, Block: Rajnagar (Madhubani)	1500	300	20%
14.	Shri. Punit Singh Dangi	Vill. Bharpura Tola, Block: Sonpur (Saran)	24	5	20%
15.	Shri. Chandra Bhushan Prasad Singh	Vill. Manganpur, Block: Bhagwanpur (Vaishali)	400	80	20%
16.	Shri. Suman Kumar	Vill. Ballia Block: Kudhani (Muzaffarpur)	50	10	20%
17.	Shri. Kapildeo Prasad Singh	Vill. Jamin Mathia, Block: Meenapur (Muzaffarpur)	450	50	11%
18.	Shri. Bharat Mishra	Vill. Mishrawalia Afzalpur, Block: Paterhi Belsar, (Vaishali)	80	8	10%
19.	Shri. Awadh Kishore Singh	Vill. Baha Chauki, Block: Dharahara (Munger)	60	6	10%
20.	Shri. Anjani Kumar	Vill. Jarang Rampur, Block: Paterhi-Belsar (Vaishali)	50	6	12%
21.	Shri. Neel Kamal	Vill. Dighra, Block: Pusa (Samastipur)	78	12	15%
22.	Shri. Kedar Prasad Thakur	Vill. Baghnagari Block : Saraiya (Muzaffarpur)	100	15	15%
23.	Mr. Kapildeo Jha	Vill. Biraul, Block: Pandaul, (Madhubani)	3500	25	8%
24.	Shri. Awadh Kishore Pandey	Vill. Panchrukhi Block: Pirpanti (Bhagalpur)	6000	30	5%

SEEDLING ORCHARD AVAILABLE IN BIHAR



Fig. 21. Desua Bhagwanpur (Samastipur), Narkatiyaganj, Manganpur (Vaishali), Amma (Muzaffarpur), Deep (Madhubani), Majhauria (West Champaran)



Fig. 22. Fruit drop in commercial mango variety, declining seedling mango at Maker (Saran)

15. IDENTIFIED UNIQUE DIVERSITY OF SEEDLING MANGO

Table 7. List of farmers having unique seedling mango with distinct attributes

Sl. No.	Name of Farmer (Name of Unique Seedling)	Address of the Farmer	Details of unique seedling mango	Remarkable attributes of seedling
1.	Mr. Kapildeo Jha (Rari mango)	Vill. Biraul, Block: Pandaul, (Madhubani)	- Has 3500 mango trees (including 25 seedling) - Seedling of Rari (bearing even after 200 years) - Bunch bearer (20-25 per bunch), Late maturity - Yield : 10 q tree⁻¹. Honey like taste - Regular Bearer, Late maturity, Fibreless - Also growing <i>Nakubi</i> (prominent beak), <i>Bhadwaria</i> (matured in September month), <i>Chorbi</i> (sweet at maturity).	Rari mango (bearing even after 200 years), - Bunch bearer (20-25 per bunch), Late maturity Yield : 10 q tree⁻¹.
2.	Shri. Kedar Prasad Thakur (Biju mango)	Vill. Baghnagari, Block: Saraiya, (Muzaffarpur)	- Regular bearer (18 year old tree) - Highest yielder : 2,500 fruits t tree - Late maturity (third week of July) fibreless, yellow at ripening - Bunch bearers (15 fruits per bunch) - Tolerant to fruit drop - Average Fruit weight : 5 fruit per kg	- Highest yielder: 2,500 fruits per tree, - Bunch bearers (15 fruits per bunch), Tolerant to fruit drop
3.	Shri. Jagannath Pandey (Seedling of Malda)	Vill. Katarmala, Block: Goraul, (Vaishali)	- Has 125 mango trees (20% seedling) - Yield : 2.5 q per tree (15 year old) - Average Fruit Weight : 417.6 g - Fibreless, thin stone, - Tolerant to pests and diseases. - Bunch bearer : 3-4 fruits per bunch, TSS : 16.8 °B - Dark yellow at ripening - Pulp content : 85%	Yield : 2.5 q per tree (15 year old), Bigger sized fruit (417.6 g); Bunch bearer : 3- 4 fruits per bunch
4.	-----Seedling of Mallika-----		- Regular Bearer - Yield: 1 q tree⁻¹ (10-year-old) - Average fruit weight: 400 g - Thin stone with greenish yellow peel colour, fibreless - Tolerant to fruit drop	Tolerant to fruit drop, high yielder, large sized fruit
5.	Mr. Sugandh Raj S/o Shri. Ayodhya Das (Seedling of 'Kishanbhog)	Vill. Mishrawalia (Jagdish), Block: Paterhi Belsar, (Vaishali)	- Only had 5% seedling - Average Fruit weight : 281.96 g - TSS : 21.93 °B - Yield : 600-700 fruit per tree (15 year old) - Regular bearer, resistant to pest and diseases - Late maturity (July first week) - Dark yellow at ripening	TSS : 21.93 °B Yield : 600-700 fruit per tree (15 year old) Resistant to pest and diseases

6.	Mr. Arun Kumar Pandey (Seedling of 'Langra' Mango)		3 quintal per tree (1,000 fruits) - Regular bearer - Late maturity (Last week of July) - High fruit weight : 477.4 g - Thin stone with TSS : 21.10 °B - Dark yellow at ripening	3 quintal per tree (1,000 fruits) - Late maturity (Last week of July) - High fruit weight : 477.4 g - Thin stone with TSS : 21.10 °B
7.	Shri. Sanjay Kumar (Seedling of 'Langra' mango)	Vill. Mohabbat Chhapra, Block: Mehsi, (East Champaran)	- Average Fruit weight : 543 g - TSS : 17.20 °B - Yield : 300-400 fruit per tree (26 year old) - Regular bearer - Better aroma and higher shelf life than 'Langra' Mango - Mid maturity (last week of June) - Dark yellow at ripening	- Average Fruit weight : 543 g - Yield : 300-400 fruit per tree (26 year old) - Better aroma and higher shelf life than 'Langra' Mango
8.	Shri. Madhaw Kumar Thakur (Seedling of 'Dashahari')	Vill. Surhachatti, Block: Hayaghat, (Darbhanga)	50% seedling mango - Average fruit weight : 268.15 g - TSS: 18.65 °B - Regular bearer - Yield : 2,000 fruits trees⁻¹ - Late maturity (in last week of July) - Longer shelf life (15 days) - Bunch bearer (8-10 fruits per bunch)	- Yield : 2,000 fruits trees⁻¹ - Longer shelf life (15 days) - Bunch bearer (8-10 fruits per bunch)
9.	Mr. Udai Kumar S/O Shri. Shivshankar Mishra (Seedling of Sipia)	Vili. Mishrawalia Afzalpur, Block: Paterhi Belsar, (Vaishali)	- Yield : 4 quintal per tree - Bunch bearer - Size larger than 'Sipia' mango	Yield : 4 quintal per tree
10.	Shri. Kaushal Kishore Singh (Seedling of Langra)	Vill. Dwarikanagar, Block: Mushahari, (Muzaffarpur)	- Regular bearer (20 year old) - Yield : 6 quintal per tree - Thin stone with 80% pulp content - No anthracnose after harvest - Shelf life : 7 days	- Regular bearer (20 year old) - Yield : 6 quintal per tree - No anthracnose after harvest
11.	Shri. Rajnath Jha (Seedling of Rajbhog)	Vill. Deep, Block: Jhanjharpur, (Madhubani)	- Growing 35 variety of mango - Has 1,200 mango trees (including 25% seedling mango) - Seedling of Rajbhog (35 years old) - Mid maturity, thin peel and stone - Yield : 2,000 fruits tree⁻¹ /10 q tree⁻¹ - Average fruit weight : 300 g - Alternate Bearer	Yield : 2000 fruits tree⁻¹ i.e. 10 q tree⁻¹
12.	Mr. Narottam Mishra (Seedling mango)	Vill. Mohna, Block: Rajaun, (Banka)	- Regular bearer, mid maturity, light yellow at ripening - Average Fruit weight : 350 g - Yield : 2-3 q per tree (1,800 fruits per tree) - Thinnest Stone - Regular Bearer, Late maturity, Fibreless	- Yield : 2-3 q per tree (1,800 fruits per tree) - Thinnest Stone - Regular Bearer, Late maturity, Fibreless

13.	Shri. Alok Kumar (Seedling mango)	Vill. Manganpur, Block: Bhagwanpur, (Vaishali)	▪ Sucking type ▪ Yield: 10 quintal q tree⁻¹ (90-year-old trees) ▪ Bunch bearer (40-45 fruits per bunch) ▪ Tolerant to fruit drop, pest and diseases ▪ Alternate Bearer, Mid maturity, less fibrous (20%) ▪ Small fruits with small stones ▪ Average fruit weight: 100 g	o Sucking type o Bunch bearer (40-45 per bunch) o Yield: 10 q tree ⁻¹
14.	Shri. Shaktinath Jha (Rajbhog)	Vill. Deep, Block: Jhanjharpur (Madhubani)	▪ Thin stone, mid maturity ▪ Yield: 5 q tree⁻¹ (50-year-old) ▪ Fibreless with attractive colour ▪ Average fruit weight: 350 g	o High yielder (5 q tree ⁻¹ from 50-year-old)
15.	----Narayanbhog----		▪ Late ripening (after 15th June) ▪ High yielder: 4 q tree⁻¹ (50-year-old) ▪ Fibreless with average fruit weight: 320 g	o Yield: 4 q tree ⁻¹
16.	----Pahadpuri Kerwi----		▪ Yield: 5 q tree⁻¹ (50-year-old) ▪ Can be mixed with raw milk	o Yield: 5 q tree ⁻¹
17.	Shri. Prabhakar Prasad Singh (Seedling of Chausa)	Vill. Bishanpur Manohar Block: Mushahari (Muzaffarpur)	▪ Has 50% seedling mango ▪ Alternate Bearer, Late Maturity (last week of July) ▪ Average fruit weight: 500g ▪ Yield: 6 q tree⁻¹ ▪ Thin stone with more length ▪ Peel sweet in taste	o Peel sweet in taste o High yield (6 q tree ⁻¹)
18.	Shri. Shailendra Kr. Shahi	Vill. Shahbajpur, Block: Kanti (Muzaffarpur)	▪ Has 150 mango trees (67% seedling) ▪ Reddish yellow at ripening ▪ Yield: 1.25 q tree⁻¹ (15 years old) ▪ Average fruit weight: 250 g	o Coloured variety
19.	Shri. Deendayal Singh	Vill. Bishanpur Manohar, Block: Mushahari (Muzaffarpur)	▪ Has 340 mango trees (90% are seedling) ▪ Yield: 2.5-3.0 q tree⁻¹ (10 years old) ▪ Average fruit weight: 250 g ▪ Late maturity (second fortnight of July) ▪ Tolerant to fruit drop, table purpose ▪ Pulp and peel yellow at ripening ▪ Medium sized stone	o High yielder, tolerant to fruit drop
20.	Shri. Kausal Prasad Singh (Sucking type Biju)	Vill. Bhagwanpur Deshwa Block: Ujiarpur (Samastipur)	▪ Sucking type, late ripening (first fortnight of July) ▪ Average fruit weight: 200 g ▪ Yield: 2.5 q tree⁻¹ ▪ Peel: yellow but shoulder red in colour ▪ Excellent shape	o Coloured fruit with excellent shape

21.	Shri. Prabhat Kumar	Vill & PO. Dighra Block: Pusa (Samastipur)	- Average fruit Size : 250 g, less fibrous - Yield : 4 q tree⁻¹, regular bearer, - Late ripening (by mid-august) - Dark yellow at ripening - Thick peel led to shelf life of 6-7 days	o High self-life and very late maturity
22.	Shri. Awadh Kishor Singh (Sipiya Biju) (Sherha Biju) (Gulab Khas ka Biju)	Vill. & PO. Baha Chauki, Block Dharahara (Munger)	- Has 15 variety on one tree, - His <i>Sipiya</i> biju yields 5 q tree⁻¹ with early maturity (mid-June) <i>Sherha Biju</i> yields 5 q tree⁻¹ <i>Gulab Khas Biju</i> yields 3 q tree⁻¹ with average fruit weight 500g	o Has three seedling mango with yield higher than parent trees
23.	Shri. Neeraj Singh (Seedling mango for pickle purposes)	Vill. & PO. Dighra, Block Mushahari (Muzaffarpur)	- Regular bearer Very late ripening (later than <i>Shukul</i> mango) - Another seedling mango for pickle making purposes yielded 6 q tree⁻¹ - Another seedling mango has fruit weight : 500 g	o Pickle making genotype
24.	Shri. Pramod Kumar Sharma	Vill. Rampur Darp, Block: Maker (Saran)	- Scented seedling with high yield (6 q tree⁻¹ from 80 year old tree) - One sucking type seedling (fibrous pulp) is tolerant to fruit drop. - One seedling (with yield > 5 q tree⁻¹) he has having self-life of 15 days at room temperature.	o Seedling mango with 15 days self-life.
25.	Shri. Neel Kamal (Kelwa Biju)	Vill. & PO. Dighra, Block: Pusa, (Samastipur)	- Late Maturity (first fortnight of July), alternate bearer 100 year old tree, yield up to 3 q tree⁻¹ - Average fruit weight: 500 g; Dark yellow at ripening. - Self-life : 8-10 days	o Large fruits with high self-life and high yielder
26.	Shri. Suman Kumar	Vill. Ballia, Block: Kudhani (Muzaffarpur)	- Regular bearer, yield is recorded up to 5 q tree⁻¹. - Fruit weight : 300 g, late maturity, fibreless, thin stone	o High yielder with very late maturity
27.	Shri. Amarjeet Kumar Sinha	Vill. Lodipur-Chandmari Block: Danapur (Patna)	- Late maturity (30th July), fruit weight : 250 g - Thick peel led to tolerant to fruit fly - Fruit colour like <i>Safed Maldah</i>, light fibrous, pulp : > 85%. - Thinnest stone - He has sucking type mango also, sweeter than <i>Safed Maldah</i>	o Tolerant to fruit fly o Very sweet with very late maturity



Fig. 23. a) Seedling of ‘Dashahari’ mango at Darbhanga yield 1500 fruit per trees at Darbhanga, Bihar; b) Coloured seedling mango from Pirapinti, Bhagalpur, Bihar



Fig. 24. (a&b) Fruiting in bunches (8-10 fruits per bunch) in seedling mango at Saraiya, Muzaffarpur, (c&d) Thick peeled with 15 days shelf life of seedling mango of *Malda* at Goraul, Vaishali



Fig. 25. Seedling of *Kishanbhog* at Paterhi Belsar, Vaishali

Table 8. List of farmers where visits were made and information on seedling mango collected

Sl. No.	Name of farmers	Address of the farmers	Status of seedling mango	o Unique character to be validated
1.	Shri. Awadh Kishor Pandey	Vill. Panchrukhi, Block: Pirpanti (Bhagalpur)	Fibreless, mid maturity, thin stone with juicy	o Sucking type seedling
2.	Shri. Shyamanand Singh	Vill. Tilakpur, Block: Sultanganj (Bhagalpur)	- Fibreless, mid maturity - Yield up to 200 kg per tree (10 year old)	o Large sized fruit : 1 fruit per kg
3.	Shri. Tapeswar Thakur		- Average fruit weight : 250g, very tasty, mid maturity, yellow at ripening, - Thinnest stone and peel.	o Highest yield : 2,000 fruit per tree
4.	Shri. Balgovind Singh		Mid maturity, table, regular, average fruit weight : 150g	o Highest yielder : 5,000 fruits per tree o Sucking variety
5.	Shri. Subodh Sharma	Vill. Dharmagatpur Bathua, Block: Pusa (Samastipur)	- Have 20% seedling trees. - Table purposes, mid maturity, thin peel, dark black skin colour at maturity, Average fruit weight : 160 g	o Resistant to anthracnose
6.	Shri. Pramod Mishra (Seedling of Malda)	Vill. Mohna, Block: Rajaun, (Banka)	- Fruit weight : 250 g - Bunch bearer, regular bearing, light yellow at ripening, mid maturity. - Thinnest stone and peel	o Highest yield : 2,000 fruit per tree
7.	Shri. Pankaj Singh	Vill. Jalhan, Block: Sangrampur (East Champaran)	- Early and late maturity; both are available - Regular bearer - Sweet in taste at mature-green stage	o Ripened in August
8.	Shri. Binda Singh		- Ecotype of <i>Sipia</i> - Regular bearer, yellow pulp with fibreless	o Very late maturity (matures in September) o Yield : 3 quintal per tree (35 year old)
9.	Shri. Rajeev Ranjan	Vill. Belahi Jairam, Block: Bathnaha (Sitamarhi)	Chapra maldah, regular bearer, table purposes, light yellow in colour, late maturity	o High yielder (8 quintal per tree)
10.	Shri. Shambhunath Singh	Vill. Chachraha, Block : Basopatti, (Madhubani)	- Table purposes, regular (green at ripening), yield 1 q per tree (6 year old) - Average fruit size : 4 fruits per tree, fibreless	o Baramasi : 01 o Sajmania seedling : 3 fruits weight in one kg o Matures in July.
11.	Shri. Ajeetnath Mishra	Vill. Biraal Block: Pandaul (Madhubani)	Early in maturity, fibreless, regular bearer, reddish yellow at ripening, firm pulp	o Shelf Life : > 20 days o Yield upto 7-8 q per tree (30 year old)
12.	Shri. Rajeev Ranjan	Vill. Manika Bishanpur. Block: Mushahari (Muzaffarpur)	Mid maturity, fibreless, dark yellow skin colour, thin stone, alternate bearer.	o High yielder (8-9 quintal per tree)

13.	---do--- (Biju aam)		- Average Fruit weight : 500 g - Light read in colour, table purposes, large fruit size, alternate bearer - Yield : 1.5-2.0 quintal per tree	- o Very late maturity (in Mid August) - o Shelf life : 8 days
14.	Shri. Ranjeet Kumar (Seedling of Malda mango)	Vill. Chhapra Megh, Block: Mushahari (Muzaffarpur)	- Has 150 tree of mango - Average fruit weight : 400-500 g - Table purposes, shelf life is similar to langra	o Yield : 10 quintal per tree
15.	----Biju aam.....		- Table purposes, dark yellow colour, bunch bearer (3-4) - Yield : 2.5 quintal per tree (30-40 year old) - Cylindrical in shape	- o Large fruit (7 fruit per 5 kg) - o Ripened with 'Shukul' mango (last week of July) - o Sweeter than 'Chausa' mango
16.	Shri. Vijay Kumar Mishra	Vill. Mishrawalia Afzalpur, Block: Paterhi Belsar, (Vaishali)	- Has 200 mango tree (5% are seedling) - Regular bearer, fibreless, late ripening, - Bunch bearer (8-10 per bunch) - Dark yellow at ripening	- o Baramasi mango : 01 - o Yield: 2000 fruit per tree
17.	Shri. Bharat Mishra		- Has 80 mango trees with 10% are seedling) - Regular bearer, light yellow at ripening, - Bunch bearer, thin stone	- o Yield 500 fruits per tree (15 year old). - o Late ripening, Fibreless
18.	Shri. Vinay Kumar Thakur	Vill. Pokharbhinda, Block: Bahadurpur (Darbhanga)	Two unique seedlings he has i.e. Vill. <i>Chakka</i> and another at <i>Piri Mauje</i>	-
19.	Shri. Santosh Kumar Chaudhary	Vill. Bishanpur, Block: Bahadurpur (Darbhanga)	Has very late variety of seedling mango	-
20.	Shri. Ramesh Chaudhary		Has seedling of high yielder	-
21.	Shri. Shankar Chaudhary		Has large sized seedling	-
22.	Shri. Punit Singh Dangi (Seedling of Bathua)	Vill. Bharpura Tola, Block: Sonpur (Saran)	- Has 24 tree with 20% seedling mango - Sucking type - Mid-season maturity, Bunch bearer (405 per bunch) - Yield : 1,000 fruit per tree	o Sucking type
23.	Shri. Prem Singh Dangi	Vill. Pahadi Chak, Block: Sonpur (Saran)	- Table purpose, bunch bearer (4-5 per bunch) - Dark yellow in colour, fruit drop tolerant - Poor shelf life	- o Very Late Ripening (In mid-August) - o Average fruit weight : 750 g - o High peduncle strength
24.	Shri. Vijay Singh	Vill. Makhdumpur, Block: Sonpur (Saran)	- Round fruited, regular bearer, - Yellow colour like <i>Sipia</i> mango - Mid maturity	- o Yield : 4 q tree⁻¹ (35 years old) - o Shelf life : 10 days - o Has another sucking type mango

25.	Shri. Suman Kumar	Vill. Manganpur, Block: Bhagwanpur (Vaishali)	High self-life, thin peel like Langra, table purposes	o High Self life
26.	Shri. Janaki Raman Prasad Singh	Vill. Manika, Block: Mushahari (Muzaffarpur)	- Regular Bearer, Yellow pulp with reddish stone pulp - Thin stone, thin peel like Langra - Whitish fruit colour - Late maturity, tolerant to fruit drop	o Tolerant to fruit drop
27.	Shri. Prabhakar Prasad Singh	Vill. Bishanpur Manohar Block: Mushahari (Muzaffarpur)	- Has commercial orchard of seedling mango - Alternate Bearer, high average fruit weight: 350 g - Sucking type, thin Stone - Late maturity	o Sucking variety o Large sized fruit.
28.	 Seedling of Sipia.....		- Regular bearer, table purposes - Average fruit weight: 350g, - Late maturity (last week of June) - Yield: 5.50 q tree⁻¹, yellow at ripening, - Thinnest stone and peel.	o Yield: 5.50 q tree ⁻¹
29.	Lal Guda.....		- Table Purposes, red pulp with thin Peel - Thin and oblong stone - Regular bearer, High yield: 5 q tree⁻¹ (15-year-old) - Average fruit weight: 1000 g - Very late maturity (ripens in August)	o Red pulp with high yield o High fruit weight o Very late maturity (Mid-August)
30.	Shri Anand Singh (Seedling of Sinduria and Rohinia)	Vill. Samhauta, Block: Narkatiyaganj (West Champaran)	- Good yielder with better fruit size (250 g) - Rohinia biju has aroma like Zarda mango with more fruit length.	-
31.	Shri. Awadh Kishore Singh	Vill. Mani Chhapra, Block: Kalyanpur (East Champaran)	- Very Tasty - Peel colour red during maturity - Mid maturity, table purposes - Average fruit weight: 100 g	o Red peel colour
32.	Shri. Anoj Kumar Rai	Vill. Malikaur, Block: Pusa, (Samastipur)	- Table purposes, regular bearer, - mid maturity (Mid-June) - Small stone - Yield: 3-4 q tree⁻¹ (60-year-old tree) - Average Fruit weight: 300 g - Yellow at ripening, - Aroma develops after ripening	o Aromatic fruits

33.	Shri. Vinod Kumar Rai (Seedling of Shukul)	Vill. Jagdishpur, Block: Pusa, (Samastipur)	- Sucking type - Red peel colour, - Late ripening (15th July) - High yielder: 10 q tree⁻¹ (50-year-old tree) - Alternate bearer but tolerant to fruit drop - Self-life: 10 days	o High yielder with high self-life
34.	Seedling of Langra.....		- Average fruit weight: 300 g - Table purposes but fibrous - Late ripening (Early July) - Yield: 20 fruits (8-year-old tree), shy bearer	-
35.	Chinia.....		- Regular Bearer - Red peel colour with red pulp - Yield: 50 kg tree⁻¹ (12-year-old) - Average fruit weight: 200 g	o Red colour of peel and pulp
36.	Shri. Upendra Thakur	Vill. Brahampur, Block: Jale (Darbhanga)	- Bunch Bearer (5-6 fruits per bunch) - Yield: 1 q tree⁻¹ - Average fruit weight: 500 g - Regular bearer, table purpose with small stone	o Large fruit size (500 g)
37.	Shri. Manoj Thakur (Seedling of Langra)		- Yield: 4-5 q tree⁻¹ - Alternate bearer, Early maturity (Last week of May – First week of June) - Sucking type, light yellow at ripening - Thin stone	o High yielder (4-5 quintal per tree) with early maturity
38.	Seedling of Langra		- Average yield: 4-5 q tree⁻¹ - Late Ripening, alternate bearer, average fruit weight: 270 g - Thin stone, taste like Langra	o High yilder (5 q tree ⁻¹)
39.	Shri. Amrendra Kumar Singh	Vill. Parsa Babu Tola, Block: Majhulia, (West Champaran)	- Has 400 mango trees (25% are seedling) - Sucking type with thin stone - Average Yield: 2 q tree⁻¹ - Alternate bearer, matures in last week of June - Average fruit weight: 150 g	o Sucking type mango
40.	Shri. Kapildeo Prasad Singh	Vill. Jamin Mathia, Block: Meenapur (Muzaffarpur)	- Has 450 mango trees (11% seedling) Thin peel and stone - Average weight: 160 g - Yield: 2.5 q tree⁻¹ - Alternate bearer, late ripening and fibreless	o High yielder with thin peel

41.	Shri. Bada Vishun Pandey		- Table purposes, small stone - Yield: 5 q tree⁻¹, Alternate bearer - Average fruit weight: 250 g - Bunch bearer (4-6 fruits per bunch)	o High yielder (5 q tree ⁻¹)
42.	Seedling mango.....		- Average fruit weight: 250 g - Yield: 5 q tree⁻¹ (25-year-old) - Ripened during last week of June, - Thin peel	
43.	Shri. Rampukar Giri	Vill: Ratanpur, Block: Bhagwanpur (Vaishali)	- Yield: 3.50 q tree⁻¹ (15-year-old) - Regular bearer - Average fruit weight: 150 g	-
44.	Shri. Jagannath Pandey	Vill. Katarmala, Block: Goraul (Vaishali)	- Yield: 1.5 q tree⁻¹ (10-year-old) - Alternate bearer, complete yellow at ripening - Average fruit weight: 250 g - Tolerant to fruit drop - Fibreless with thin store	Tolerant to fruit drop
45.			- Small leaves like peach - Yield: 50 kg tree⁻¹ (6-7-year-old) - Average fruit weight: 150 g	-
46.	Shri. Mohan Chaudhary	Vill. Bishanpur, Block: Hayaghat (Darbhanga)	- Has Ganpati Bhog, Bajrang Bhog, Mohan Nhog and Rambhog as seedling mango. - Rambhog and Ganpati Bhog has taste like local maldah mango	-
47.	Shri. Prabhakar Prasad Singh (Lal Guda seedling)	Vill. Vishanpur, Manohar Block: Mushahari (Muzaffarpur)	- Has 110 trees (55% are seedling) - Yield: 1-1.15 q tree⁻¹ (10 years old) - Average fruit weight: 350-400 g - Alternate bearer, prone to black tip - Late maturity (last week of June) - Table purposes - Less fiber, thin stone, taste good, rich in aroma	-
48.	Seedling of Kerwa		- Yield: 2 q tree⁻¹ (10 years old) - Regular bearer, late maturity (first week of July) - Average fruit weight: 350g	-

49.	Shri. Kausal Prasad Singh	Vill. Bhagwanpur Deshwa Block: Ujiarpur (Samastipur)	- Has 350 mango trees (30% are seedling) - Table purposes, late ripening (first fortnight of July) - Yield: 1 q tree⁻¹, excellent shape - Average fruit weight: 300 g	o	Attractive and excellent shape
50.	Seedling of Calcuttia maldah...		- Yield: 2 q tree⁻¹ (25 years old) - Average fruit weight: 350 g - Remains green at ripening - Late ripening (first fortnight of July)	-	
51.	Sucking type biju		- Yield: 3.25 q tree⁻¹ (25 years old) - Sucking type with excellent shape - Shoulder : red with yellow skin colour - Fruit weight : 200 g	o	High yielder (3.50 q tree ⁻¹)
52.	Fazli biju		- Table purpose - Sweet at immature mango - Shoulder reddish, peel: dark yellow at ripening - Yield: 3 q tree⁻¹ (30-year-old trees) - Average fruit weight: 400 g - Firm pulp, thin peel, can be peeled with knife	o	High yield with large sized fruit
53.	Seedling of Fazli		- Yield: 1500 fruits tree⁻¹ - Immature fruits are sweet in taste - Average fruit weight: 330 g - Late ripening (end July) - Tolerant to fruit drop - Uneven surface	o	High yielder (1500 fruits tree ⁻¹)
54.	Shri. Ashotosh Thakur	Vill. Bhatsimar, Block: Rajnagar (Madhubani)	- Yield: 3 q tree⁻¹ (12-year-old) - Table purposes, like Langra - Tolerant to Insect Pests and Diseases - Late ripening (after 15th August) - Average fruit weight: 275 g - Tolerant to fruit drop	o o o	High Yield Tolerant biotic and abiotic stresses Late ripening
55.	---Seedling of Gulab Khas....		- Delayed maturity in comparison to Gulab Khas - Sweet taste at maturity	o	Better coloured than original Gulab Khas
56.	Shri. Subhash Mishra	Vill. Bhatsimar (West), Block: Rajnagar (Madhubani)	- Has 100 trees (50% seeding) - Regular bearer - High yielder: 5 q per tree (12-year-old)	o	High yielder (5 q tree ⁻¹)

57.	----- Seedling of Gulab Khas -----		▪ Delayed maturity in comparison to <i>Gulab Khas</i> ▪ Yield: 6 q tree⁻¹ (40 year old) ▪ Average fruit weight: 330 g ▪ Fibreless, coloured	o High yielder (6 q tree ⁻¹)
58.	 Belaha		▪ Regular bearer with better fruit size (> 350 g)	-
59.	Shri. Anand Tiwari	Vill. Mashrauli-Tola Fulwari via Koiladewa, Block: Hathua (Gopalganj)	▪ Has high yielder seedling mango with many promising Jamun and Jackfruit and aonla.	-
60.	Shri. Rajat Kumar Thakur	Vill. Brahampur, Block: Jale (Darbhang a)	▪ Has commercial orchard of seedling mango (25% seedling) ▪ Fibrous, sucking type with shoulder and peel colour red ▪ Alternate bearer, earliest to mature ▪ Yield: 4-5 q tree⁻¹ ▪ Average fruit weight: 250 g	o Earliest to mature (mid May)
61.	Shri. Kalidas Banarjee (Seedling of Fazli)	Vill. Rautara, Block: Sadar (Katihar)	▪ Earliest maturity (by 25th June) ▪ Regular bearer, yield (3 q tree⁻¹), less fibrous, reddish peel colour ▪ Fruit weight : 450 g,	o Ripe earlier than Fazli and testier than Fazli
62.	 Navras		▪ Regular bearer, 30 year old trees ▪ Earliest to ripening (by 20th June), yield : 1.25 q tree⁻¹ ▪ Table purposes, average fruit weight : 250 g ▪ Light yellow at ripening	o Early bearer
63.	Seedling mango		▪ Best shaped, uniform in shape ▪ High yielder : 6.0-7.5 q tree⁻¹ (60 year old trees)	o High yielder (7.5 q tree⁻¹ in 2023) o Early maturity (15th June)
64.	... Seedling of Kala Pahad		▪ Bigger size than <i>Kala Pahad</i> (average fruit weight 100 g) ▪ Black peel, hard pulp ▪ Average fruit weight: 150 g ▪ Yield : 10 q tree⁻¹	o High yielder : 10-12 q tree ⁻¹
65.	Shri. Rampukar Giri	Vill. Ratanpura, Block: Bhagwanpur (Vaishali)	▪ Regular bearer ▪ Yield up to 3.5 q tree⁻¹ (15 year old tree) ▪ Fruit weight (150 g)	-

16. VARIABILITY OF FRUIT WEIGHT/SIZE IN SEEDLING MANGO



Seedling Mango Diversity in Bihar: A Treasure Trove for Genetic Improvement and Conservation

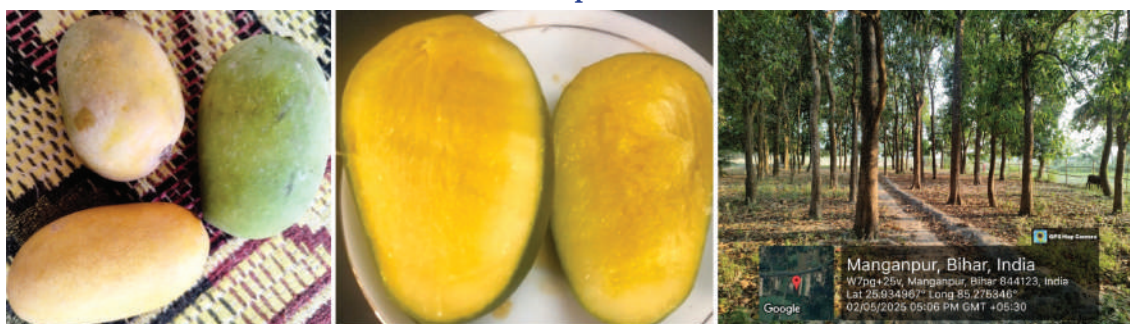




Fig. 26. Seedling of Langra Mango (individual fruit weight is > 475 g) at Paterhi Belsar, Vaishali



Fig. 27. Seedling of Langra Mango (individual fruit weight is > 540 g) at Mehshi, East Champaran



17. VARIABILITY IN SEEDLING MANGO FOR FRUIT COLOUR



19. VARIABILITY OF PULP COLOUR IN SEEDLING MANGO

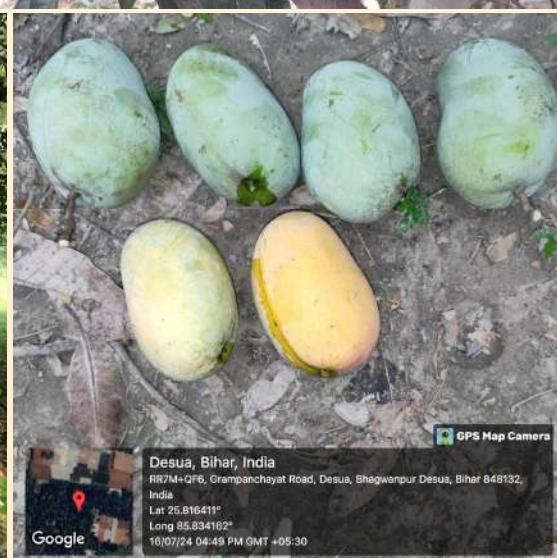


20. FARMERS WITH ELITE TYPE SEEDLING MANGO



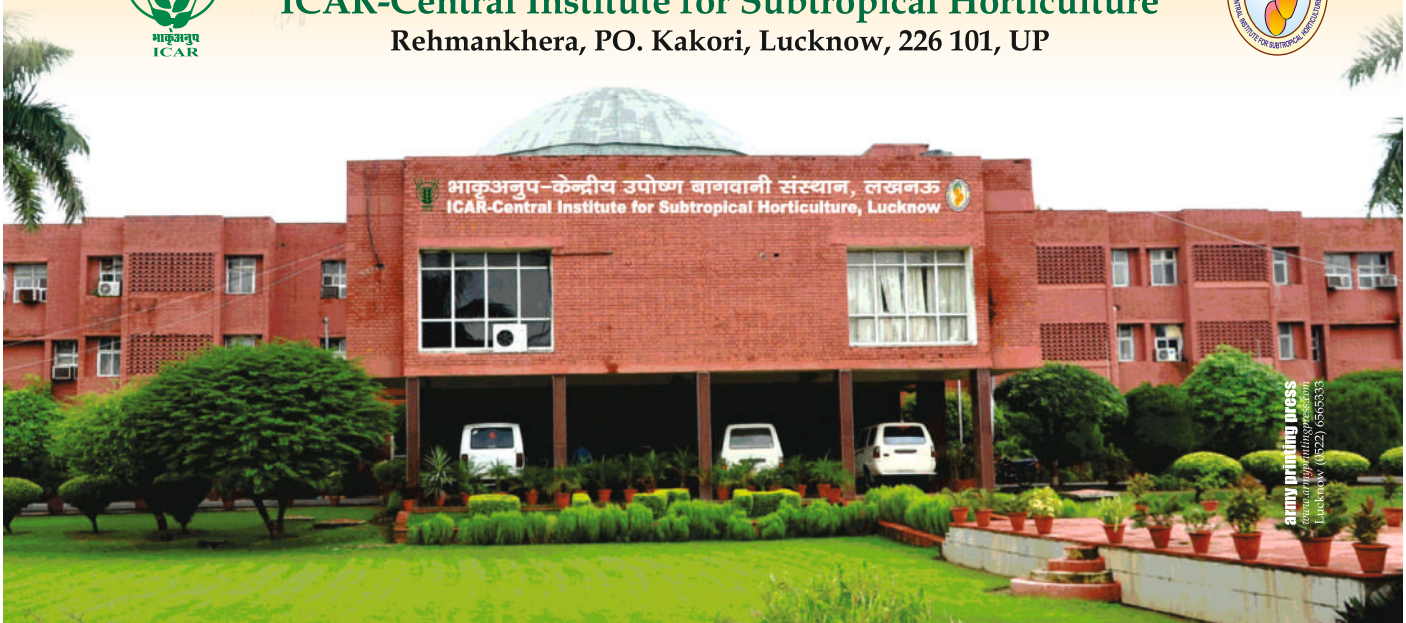
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