

ANNUAL RESEARCH REPORT

(2025-2026)



Nimbkar Agricultural Research Institute

SEPTEMBER 2026

Report of the President

I have the pleasure of presenting to you the NARI annual research report for 2025-26. Some significant events of the year were as follows:

1. The Drinking Water Technology (DWT) system funded by Tata Group was inaugurated in the school at Nandal in Phaltan taluka. So far similar systems have been installed in three rural schools in Phaltan Taluka. A [technical paper on it has been published.](#)
2. A 20-kW rooftop Solar PV system has been installed at the head office at NARI. It faced a lot of teething troubles for nearly one year because of shoddy and unprofessional work by the original contractor but is now functioning well. It does not have any battery storage and is able to meet the electricity demand of the whole institute during sunshine hours and the excess energy produced is exported to the MSEDCL grid.
3. The long pending matter of rewriting and updating the PTR of the institute at the Assistant Charity Commissioner's office in Satara was resolved. We are grateful to The Charity Commissioner Shri. Amogh Kaloti for all his help in the matter.
4. One of our trustees Ms. [Madhura Rajvanshi](#) received the "[Bhashabhyasak Jaywant Chuneekar Prayogsheel Marathi Shikshak Puraskar](#)" in Mumbai on 1 March 2026.
5. Dr. Rajvanshi was honoured by PANIIT USA at the IIT2026 Global Conference in Long Beach, California where he was given the [Ron Gupta Memorial Global Pan IIT Social Impact award.](#)
6. A nice [half an hour film was made by a private film producer on the work done by Dr. Anil K. Rajvanshi.](#)

7. Dr. Rajvanshi gave a prestigious [keynote address at Tech HR India 2025 – Asia’s largest HR and Work Tech Conference](#) organized by People Matters. This event held in New Delhi hosted 5000 + attendees.
8. Dr. Rajvanshi was the [chief guest on 3rd January at the Jyoti-Savitri International School in Khanavdi village](#), Purandar taluka – the first CBSE-affiliated public-private partnership Zilla Parishad School. Five women who had excelled in their chosen fields were felicitated by him on occasion of the 195th birth anniversary of Savitribai Phule. He gave an inspirational lecture to the school students.
9. Dr. Rajvanshi was invited to address the [students at Golden Jubilee School, Jalna](#). It is an English-medium school affiliated to CBSE. He also gave an invited lecture to the research staff of [Mahyco Private Ltd.](#) at Dawalwadi. Both these events were on the invitation of Shri Rajendra Barwale, Chairman of Mahyco.
10. Dr. Anil Rajvanshi’s latest book (8th book) [“Deep Science in Ancient Indian Philosophical Thought”](#) has been published by Motilal Banarsidass (MLBD). Since 1903 MLBD have been publishing books on Indian philosophy and heritage.
11. A nice [story on Dr. Rajvanshi’s work at NARI appeared in University of Florida Engineer 2026](#) as a part of Alumni spotlight series.
12. Dr. Rajvanshi was the [chief guest at IIT Bombay for the inauguration of the book “Social Entrepreneurship in India : Theory and Cases”](#) written by Dr. Nisha Pandey and Dr. Ashish Pandey, Professors at Shailesh J. Mehta School of Management, IIT Bombay.
13. [Shri. Shreyas Desai](#), Assistant Vice President of Tata Sons Ltd. who leads the Tata Affirmative Action Programme (TAAP) was inducted as an honorary member of NARI.

14. I congratulate Dr. Chanda Nimbkar, Director, A.H. Division of NARI and her colleagues for the excellent research and development work done by them during the year. It can be seen from the highlights of the year and the full report of A.H. Division.
15. Finally, I would like to thank Ms. Sanika Pawar for all her diligent work in putting this year's annual report together.



September 2026



Dr. Nandini Nimbkar
President

Contents

	Page No.
Agricultural Research	6
Weather Data	72
Visitors during the year (HO)	73
Publications	74
Animal Husbandry Research (full report)	77
Annual Fact Sheet	100
Governing Council / Trustees	101

Agricultural Research

Farming carbon credit possibilities for small farmers

Ms. Sweta Kumari a doctoral researcher from Department of law at the Central University of Punjab, Bathinda carried out her internship at NARI from 3 January to 4 April 2026. She was involved in understanding and framing carbon credit possibilities for small farmers in Western Maharashtra.

Data were collected from the literature for 15 different crops including grain crops (Sorghum-dual and sweet, pearl millet, maize, wheat), legumes (Pigeonpea, cowpea, black/green gram), Oilseeds (soybean, safflower, sunflower, castor), fodder crops (Leucaena, cenchrus grass, napier grass) and sugarcane. Highest carbon sequestration (t CO₂e/ha/year) was recorded for sugarcane (8-12), fodder crops (4-15) and among field crops pigeonpea (2.5-5).

All the data collected (carbon sequestration, yield, recommended spacing, water requirement, fertilizer strategy, organic/Bio fertilizer options, residue management, best sowing time and carbon fixation mechanism) along with the references are given in Table 1 in the Appendix 1.

Ms. Sweta Kumari's work included:

- a. Collecting soil samples from NARI agricultural plots and getting them analyzed for soil organic carbon (SOC).
- b. Compilation of data related to crops generally grown in western Maharashtra, their water use and residue management.
- c. Interaction with local farmers for collection and compilation of farmer-level data.
- d. Preparation of material for a possible research proposal on carbon credit to be submitted to a funding agency.

Her internship report is given in Appendix 2.

An agricultural soil carbon credit framework which could be implemented for Indian smallholder farmers especially those in semi-arid areas was prepared by Ms. Sweta Kumari. This framework integrates six core research objectives. Viz.

1. Developing a reliable measurement and verification system suited to Indian farming condition.
2. Creating income opportunities through carbon credit programmes.
3. Establishing baseline data on soil organic carbon and health indicators.
4. Implementing and evaluating soil management practices.
5. Measuring seasonal and long-term changes in soil organic carbon and
6. Developing practical monitoring guidelines.

By combining technological innovation with farmer-centric service delivery models, this framework aims to transform Indian smallholder agriculture into a viable carbon sequestration sector while improving farmers' livelihoods and soil health. Successful implementation of this framework could transform Indian smallholder agriculture into a significant carbon sequestration sector while improving, farmers' livelihoods. If even 10% of smallholder farmers participate, sequestering an average of 0.5 t carbon per hectare per year, India could sequester over 7 million t of C annually. The full research paper prepared by Ms. Sweta Kumari is given in Appendix 3.

Sweet Corn

In order to evaluate the possibility of producing syrup from the juice of the sweet corn stalk three sweet corn varieties were compared for various parameters. All observations are averages of three plants.

This idea came after reading some reports from USA on the internet that yield of syrup from corn stalks was comparable to that from sweet sorghum stalks when the stalks were cut before maturity at the stage of roasting ears.

Mahyco experimental sweet corn hybrid was found to be the earliest among the three tested. The juice from its stalks had a brix of 6.2 two months after planting and the highest brix of 10 was obtained three months after planting. The highest juice brix of 15.1 was obtained for Syngenta sugar-75 about four months after planting. It also maintained the high brix throughout the growing season unlike the other two varieties.

The highest juice extraction percentage of 40 was given by the Mahyco experimental hybrid two months after planting. However, it was rapidly reduced to about 9% three months after planting. The highest juice extraction of 32% was obtained four months after sowing for Syngenta sugar-75. Ankur sweet-16 maintained its extraction % of about 20 throughout the growing season with a high of 39% at earhead maturity.

The average plant height of Ankur Sweet-16 at 233 cm was the greatest among the three varieties compared. It also gave the highest biomass weight of 3.8 Kg on day 105. The highest biomass weight of Syngenta sugar-75 was 3.3 Kg recorded on day 84 and for Mahyco experimental hybrid it was 1.8 Kg, recorded two months after sowing.

However, in our trial the juice extraction percentage and brix in juice of sweet corn was about half that for sweet sorghum. Also brix and juice extraction were rapidly reduced especially in Mahyco experimental hybrid about 90 days after planting, so it may not be possible to harvest the mature earheads and then use the stalks for syrup production. Ankur Sweet-16 is probably the most suitable cultivar for this purpose followed by Syngenta sugar-75 as the juice extraction percentage was relatively high throughout the growing season and appears to increase after earhead maturity, as does the juice brix.

Further studies will be required by testing more sweet corn varieties planted during different times of the year to determine if sweet corn stalks can be used for syrup production profitably.

Details of the data recorded are given in Appendix 4.



Sweet corn hybrid Trial

Sweet Sorghum

Data are given in Appendix 5.

1. Sweet Sorghum station germplasm evaluation trial

The differences between the eight station germplasm lines and the three controls viz.

Madhura-1, 2 and 3 were non-significant except for days to 50% flowering. Madhura-3, NARI-LC-7-38, Madhura-1, Madhura-2, NARI-SS-360 and NARI-LC-7-29-1 were found to be significantly earlier than the remaining entries.

Due to the very high seed yields obtained the juice brix values were quite low.

The most promising entries were as follows:

Sr. No.	Entry	Characteristics for which promising
1.	NARI-LC-7-29-1	Plant height, % juice extraction
2.	NARI-LC-7-38	Shootfly tolerance
3.	NARI-SS-228	Stripped stalk weight, stripping %, juice brix
4.	NARI-SS-235	Panicle weight, shootfly tolerance
5.	NARI-SS-260	Shootfly tolerance
6.	Madhura-2	Stem diameter, biomass weight
7.	Madhura-3	Final plant stand, seed yield

2. Maintenance and evaluation of germplasm lines

A total of 26 sweet sorghum lines in NARI collection were sown for maintenance and evaluation.

The most promising germplasm lines were as follows:

Sr. No.	Characteristics	Lines
1.	Plant stand	NARI-SS-56, NARI-LC-07-12, NARI-LC-07-12-1
2.	Plant height	NARI-SS-228
3.	Stem diameter	NARI-SS-222
4.	Biomass	NARI-23-1
5.	Stripped stalk weight	NARI-LC-07-79
6.	Panicle weight	NARI-SS-144
7.	Juice weight	NARI-SS-228
8.	Days to 50% flowering (earliness)	NARI-SS-130, NARI-SS-135
9.	Shootfly tolerance	NARI-LC-07-08, NARI-LC-07-36
10.	Stripping %	NARI-LC-07-12
11.	Juice extraction %	NARI-LC-07-91
12.	Juice brix	NARI-SS-228
13.	Seed yield	NARI-SS-227

Stem borer attack was very low and 19 of the lines were found to be completely tolerant to stem borer.

Soil Analysis

Soil samples from eight different plots at NARI Tambmal farm were drawn and sent for analysis to Shreemant Shivajiraje College of Horticulture, Phaltan and the Krishi Vigyan Kendra, Phaltan.

All organic carbon and copper values resulting from KVK analysis were higher than those from the analysis carried out at college of horticulture. All phosphorus, iron, manganese and zinc values were higher in analysis of college of horticulture than those from KVK analysis. The soil analysis data are presented in Appendix 6. The tables below give the range of percentages by which the higher values were greater than the lower values.

Since the soil analysis values for different parameters in many cases vary quite a lot between KVK and college of horticulture with very high percentage differences, it is extremely difficult to decide on their reliability.

Range of percentages by which KVK analysis values were higher than the college of horticulture values.

Sr. No.	Parameter	Range of percent difference
1.	Organic carbon	60-271
2.	Copper	61-1425

Range of percentages by which college of horticulture values were higher than the KVK values.

Sr. No.	Parameter	Range of percent difference
1.	Phosphorus	91-336
2.	Iron	578-2746
3.	Manganese	742-2567
4.	Zinc	400-833

In most of the cases pH values (0.37-3.68% difference) and available potassium (4.65-74.94% difference) were found to be higher in KVK analysis than that done at college of horticulture. Similarly, electrical conductivity (25-75% difference) and nitrogen (92-188% difference) values were mostly higher in analysis done at college of horticulture than that at KVK. Analysis of sodium, free lime, Sulphur and boron was carried out only at KVK.

ARTI trials

Appropriate Rural Technology Institute (ARTI), has produced a strained, sterilized, dehydrated culture of a consortium of soil bacteria from the slurry left after production of biogas through its generators. A trial was conducted on Daikon radish to test the efficacy of this ARTI bio-fertilizer. Since there was a severe attack of wilt on this trial, it was repeated on a hybrid maize crop. The organic fertilizer was applied at a dosage of 1, 2, 3 or 4 g/Sq.m., and compared with an untreated control and chemical control (30 g per Sq.m. of 15:15:15::N:P:K). No statistically significant differences between the treatments were found for any of the parameters.

Another trial was conducted also on hybrid maize to test the use of urea as a supplier of nitrogen and carbon to soil bacteria to raise the bacterial count about a week before sowing the seed. This was expected to substitute the application of recommended basal dose of chemical fertilizers. This trial had a total of seven treatments consisting of five different dosages of urea (4, 8, 12, 16 and 20 g/4 m²), an untreated control, and a chemical control (120 g of 15:15: 15:: N:P: K/4 m²). Here also differences between all the parameters measured were non-significant except for the 10 plant fresh weight.

Significantly higher fresh plant weight was recorded for plots given 12, 16 or 20 g urea/4 m², chemical control and untreated control compared to plots given 4 or 8 g urea/4 m² . Therefore, it may be possible to completely do away with the basal fertilizer dose by applying a small quantity of urea about a week before sowing. The data for both the ARTI trials are given in Appendix 7.

Organic Fertilizer trial on hybrid Maize



Urea testing trial on hybrid Maize



Crop yields at Tambmal farm

Yields of different crops grown on NARI farms at Tambmal over last 25-30 years were compared. The yields plotted were those for pearl millet, wheat, soybean and sugarcane. The data and graphs are given in Appendix 8.

Pearl millet: Yields were mainly reduced by sowing early i.e. in June and also due to rainfall of returning monsoon coinciding with the harvest time.

Wheat: Fluctuations in wheat yields from year to year could not be attributed to any specific cause. However, it needs to be checked if it can be correlated to the air temperature during the growing season.

Soybean: A fair amount of fluctuation in seed yield was observed from year to year, but its cause could not be ascertained.

Sugarcane: Wherever the yields of plant crop were high, the ratoons were also found to be high-yielding.

Vegetable Crops

During COVID lockdown it was difficult to buy vegetables in the market, so from April 2020 we have been attempting to grow different vegetables on small scale at the institute. We are growing the vegetables without using any conventional pesticides. The 'organic' pesticide alternatives were found to be mostly quite ineffective in controlling the pests. During the year 2025 the vegetables were grown on a 250 Sq.m. plot.

Main problems encountered in vegetable growing

Problem	Planting month
Pests and diseases. Ineffective control with organic pesticides	Throughout the year
Poor germination due to low temperatures	January, February
Water stress (esp. as the soil was light lateritic)	March, April, May
Foliage scorching due to high temperatures (especially leafy vegetables)	March, April, May



Ineffective Pest and disease control in tomato



Sticky pad for sucking pest control

Amounts of different vegetables harvested during 2025

Sr. No.	Vegetable	Amount [Kg (W) or number of bunches (B) or fruits (F) or roots (R)]
1.	Fennel	24 (B)
2.	Fenugreek	21 (B)
3.	Coriander	44 (B)
4.	Spinach	36 (B)
5.	Chakvat (<i>Chenopodium</i> sp.)	2 (B)
6.	Tandulja (<i>Amaranthus</i>)	7 (B)
7.	Safflower	15 (B)
8.	Chuka (Green sorrel)	3 (B)
9.	Scallions	8 (B)
10.	Mustard leaves	6 (B)
11.	Pathri (<i>Launea</i>)	2 (B)
12.	Daikon radish	18 (R)
13.	Bottle gourd	27 (F)
14.	Beet	3 (R)
15.	Eggplant	15.37 (W)
16.	Bitter gourd	7.15 (W)
17.	Ridge gourd	4.50 (W)
18.	Cucumber	1.25 (W)
19.	Tomato	6.5 (W)
20.	Green broad beans	2.4 (W)
21.	Okra	2.0 (W)
22.	Green pepper	0.85 (W)
23.	Cowpea	0.5 (W)

Wheat

Half of the plot received foliar spray+ micronutrients and the other half did not. Two 1m² areas from each of the plots were harvested for assessing biomass and grain yield.

Date of sowing: 23-11-2025

Date of Foliar spray I

(19:19:19): 27-12-2025

Date of Foliar spray II

(00:52:34): 16-01-2026

Date of Harvesting: 14-03-2026

For micronutrients Rexolin CXK-EDTA microgranules micronutrient mixture of PR Agro Nutri Pvt. Ltd. was used. It contains 3.4 % Fe, 3.2 % Mn, 4.2 % Zn, 0.05 % Mo, 1.5 % B, and 1.2 % Mg. Ltd.

Plot 4	Biomass wt./sqm.(kg)		Mean	Grain wt./sqm (kg)		Mean
	RI	RII		RI	RII	
Foliar spraying 19:19:19 & 00:52:34	1.832	1.540	1.686	0.725	0.626	0.6755
Without foliar spraying	1.526	1.851	1.689	0.634	0.620	0.627

Plot 11	Biomass wt./sqm (kg)		Mean	Grain wt./sqm (kg)		Mean
	RI	RII		RI	RII	
Foliar spraying 19:19:19 & 00:52:34	1.382	1.378	1.38	0.593	0.558	0.5755
Without foliar spraying	1.396	1.056	1.226	0.528	0.482	0.505
	Plot - 4		Plot - 11		Plot-4 & 11	
	Biomass wt. (kg/ha)	Grain wt. (kg/ha)	Biomass wt. (kg/ha)	Grain wt. (kg/ha)	Net profit (Rs/ ha)	
Foliar spraying 19:19:19 & 00:52:34	16860	6760	13800	5760	32474	
Without foliar spraying	16890	6270	12260	5050	34902	

The government-sponsored Mahavistar ai app for farmers recommends the following:

- (1) 100 g 19:19:19::N:P:K and 70 g micronutrients in 15 l water should be sprayed at stem elongation.
- (2) 70 g 00:52:34::N:P:K and 50 g micronutrients in 15 l water should be sprayed at booting or heading.

To find out if these measures are effective in increasing grain yield we carried out the spraying on half the area of the two plots on which wheat was planted.

We recorded 7-14% increase in grain yield due to the foliar spraying. However, the net profit was decreased by about 7% as the cost of spraying was more than the benefit accrued by the foliar spraying.

Scientists: Anil K. Rajvanshi, Nandini Nimbkar, Sweta Kumari, Sharad Choudhari

Technical assistants: S. G. Dighe, Anita Gholap, Sarika Pawar, Maruti Shirke

Appendix 1

Crop	Carbon Sequestration (t CO ₂ e/ha/year)	Yield Year 1 (t/ha)	Yield Year 2–3 (t/ha)	Recommended Spacing	Water Requirement (mm/year)	Fertilizer Strategy
Sorghum (dual/sweet)	1.5–3.5	2.5–3.5	3–4	45×15 cm	450–650	Reduce N 20–25%
Pearl Millet (Bajra)	1.2–3.0	2–3	2.5–3.5	45×10–15 cm	350–500	Reduce N 30%
Maize	2.0–4.0	3–5	4–6	60×20 cm	500–800	Reduce N 20–25%
Wheat (residue retained)	1.0–2.5	3–4	4–5	22.5 cm rows	450–650	Reduce N 15–20%
Pigeonpea	2.5–5.0	1–1.5	1.5–2	90×20 cm	600–800	No chemical N
Soybean	1.8–3.5	2–3	2.5–3.5	45×5–7 cm	500–700	No chemical N
Cowpea	1.5–3.0	1.2–1.8	1.5–2	45×20 cm	400–600	No chemical N
Black/Green gram	1.2–2.8	0.8–1.2	1.2–1.5	30×10 cm	350–500	No chemical N
Safflower	1.0–2.2	1–1.5	1.2–1.8	45×20 cm	300–500	Reduce N 15–20%
Sunflower	1.8–3.5	1.5–2.5	2–3	60×30 cm	500–700	Reduce N 20%
Castor	2.0–4.0	1.5–2.5	2–3	90×45 cm	600–800	Reduce N 20%
Sugarcane	8–12	70–90	60–80	90×30 cm	1500–2500	Reduce N 25–30%
Leucaena	6–12	—	—	1×1 m	600–900	No chemical fertilizer
Cenchrus grass	4–8	8–12	10–15	50×50 cm	300–500	Organic manure once
Napier grass	10–15	60–80	100–150	60×60 cm	1200–1800	Organic manure

Appendix 1 (Continued)

Crop	Organic / Bio-fertilizer Option	Residue Management / Fertilizer Use	Best Sowing Time	Carbon Fixation Mechanism	Scientific References
Sorghum (dual/sweet)	Compost + Azotobacter	Stover composting, mulching, biochar	June–July	Deep roots + stover	ICRISAT; ICAR AICRP; FAO Drylands
Pearl Millet (Bajra)	FYM + PSB	Mulching, composting	June	Fast biomass	ICAR Millet Handbook; ICRISAT
Maize	Vermicompost + PSB	Residue incorporation, compost	June–July	High residue	ICAR Maize Manual; FAO
Wheat (residue retained)	Compost + Biofertilizer	Straw mulching, zero till	Nov	Straw SOC	ICAR Wheat System; CIMMYT
Pigeonpea	Rhizobium + PSB	Leaf litter, root biomass	June	Deep root carbon	ICRISAT Pulses; ICAR
Soybean	Rhizobium + PSB	Residue incorporation, compost	June–July	Root + residue	ICAR Soybean Research
Cowpea	Rhizobium + Compost	Green manuring, mulching	June/Sept	Living cover	FAO Legume Crops; ICAR
Black/Green gram	Rhizobium	Green manure, compost	June	Fast OM	ICAR Pulses; FAO
Safflower	Compost	Residue incorporation	Oct	Taproot	ICAR Oilseeds
Sunflower	PSB + Compost	Residue composting	June/Jan	Root biomass	ICAR Oilseeds; FAO
Castor	FYM	Stalk composting	June	Drought biomass	ICAR Castor Research
Sugarcane	Press-mud + Biofertilizer	Trash mulching, bio-compost	Jan/Oct	Maximum biomass	Indian Sugar Research Institute; FAO
Leucaena	Leaf litter	Leaf litter, fodder residue compost	Monsoon	Permanent sink	ICAR Agroforestry; FAO
Cenchrus grass	Compost	Mulching, grazing residue	June	Dense roots	ICAR Grasslands; FAO
Napier grass	Compost + slurry	Silage, compost, vermicompost	June	Continuous biomass	FAO Forage Crops; TNAU

Appendix 2

Enhancing and Monitoring Soil Carbon Sequestration through Residue-Based Soil Management in Irrigated Semi-Arid Agricultural Systems: A Pilot Study at NARI

Objectives

1. To develop an agricultural soil carbon credit framework suited to Indian farming conditions and smallholder farmers that supports reliable measurement and verification of soil carbon. It should enable farmers to participate in carbon credit programs and carbon markets.
2. To create opportunities for farmers to earn additional income through carbon credit programs by employing practices that promote soil carbon sequestration.
3. To establish baseline data on soil organic carbon, bulk density, and important soil health indicators under irrigated semi-arid farming conditions.
4. To implement and evaluate soil management practices such as crop residue retention and compost application for increasing soil organic carbon.
5. To measure seasonal and long-term changes in soil organic carbon under improved soil management practices and evaluate their impact on soil health.
6. To develop simple and practical guidelines for monitoring soil carbon so that farmers can record soil carbon improvements and participate in carbon credit programs.

To achieve these objectives, NARI has undertaken a series of field-based activities, data analysis, and pilot interventions, as described in the following sections.

Advancing Soil Carbon Research and Carbon Credit Readiness at NARI

The Nimbkar Agricultural Research Institute (NARI), Phaltan, is expanding its work in sustainable agriculture through soil carbon research and the exploration of carbon credit mechanisms in Indian farming systems.

Building a New Direction in Agricultural Research

Agriculture in India faces increasing challenges due to climate change, soil degradation, and declining resource efficiency. In response, NARI has initiated a programme focused on Soil Organic Carbon (SOC) as a central element of sustainable agriculture. Unlike conventional approaches that treat soil health and climate mitigation separately, NARI integrates both within a unified framework. This approach is grounded in long-term field data and practical farming conditions in irrigated semi-arid agriculture.

Long-Term Data as a Scientific Foundation

One of the key strengths of NARI's initiative is the availability of long-term soil and cropping data across multiple plots. These datasets, spanning nearly two decades, provide valuable insights into soil carbon behaviour under varying cropping systems and management practices. Analysis indicates that vegetated and perennial systems retain more carbon, whereas conventional practices often result in unstable or declining levels. This evidence supports the development of scientifically grounded strategies to enhance soil carbon.

From Soil Fertility to Carbon Accounting

A major shift in NARI's work is the transition from traditional soil fertility assessment to structured carbon accounting readiness. While soil testing has been routinely conducted for agronomic purposes, efforts are now directed towards aligning this data with carbon credit requirements. This includes standardising soil sampling methods, improving measurement consistency, and developing monitoring and documentation systems. Such standardisation is essential for ensuring accuracy, consistency, and long-term verification in carbon frameworks.

As part of this transition, green manure practices were implemented to enhance soil organic carbon levels. The stages of crop growth and incorporation are illustrated below.

Figure 1: Growth stage of green manure (Sunhemp) crop under field conditions



Figure 2: Incorporation of green manure (Sunhemp) into soil to improve organic carbon



The incorporation of green manure provides organic inputs to the soil, thereby improving soil structure, nutrient cycling, and carbon sequestration.

Pilot-Level Field Implementation

To translate research into practice, NARI initiated pilot-level field activities focused on soil carbon monitoring and improvement. These included baseline soil sampling, green manuring, improved crop rotations and residue management, and reduction of bare fallow periods. Field-level documentation formats such as activity records and photo logs were also

developed. Field-level soil sampling and testing procedures were carried out to establish baseline parameters and support data-driven analysis, as shown below.

Figure 3: Soil sampling process showing the collection of soil samples and the measurement of sampling depth for accurate analysis



Figure 4: Processed soil samples prepared for testing and analysis



These procedures ensured consistency and reliability in soil data collection.

Understanding Farmer Realities

An important component of the initiative involves field engagement with farmers. Surveys and field visits in nearby villages have provided valuable insights into current farming practices. The findings indicate that farmers primarily make decisions based on market conditions, rainfall, and risk; soil testing is not widely practised; residue management practices vary; and there is openness to adopting improved methods when economic benefits are clear. These insights are critical in designing carbon-related interventions that are practical, scalable, and farmer-friendly.

Developing Institutional Carbon Readiness

NARI is working towards establishing itself as an institutional model for carbon credit implementation in agriculture. This includes identifying eligible plots, assessing data gaps, developing Project Design Documents (PDDs), and creating monitoring and reporting

frameworks. The focus is on ensuring that future carbon projects are scientifically robust and aligned with recognised standards. The current work is positioned as a research and readiness initiative rather than a commercial project, ensuring scientific credibility. The following table has been developed by integrating crop-specific data from field observations, existing datasets, and relevant agronomic references for semi-arid conditions. It compares crops based on their potential contribution to soil carbon along with yield, water requirements, and management practices. Carbon potential reflects estimated sequestration based on biomass production, root contribution, and residue return, while water and management parameters ensure alignment with local farming conditions.

Table 1: Integrated Crop–Carbon–Water Dataset for Analysis of Soil Carbon Dynamics

Crop	Carbon Potential (Mt CO ₂ e/ha/yr)	Yield (Mt/ha)	Water Requirement (mm)	Fertilizer Strategy	Residue Management	Carbon Mechanism
Sorghum	1.5–3.5	3–4 (Grain)	450–650	Reduce N (20–25%)	Mulching, green manure	Root residue +
Pearl Millet	1.2–3.0	2.5–3.5 (Grain)	350–500	Reduce N (30%)	Green manure	Fast biomass
Maize	2.0–4.0	4–6 (Grain)	500–800	Reduce N (20–25%)	Residue incorporation	High residue
Wheat	1.0–2.5	4–5 (Grain)	450–650	Reduce N (15–20%)	Straw mulching	SOC stabilisation
Pigeonpea	2.5–5.0	1.5–2 (Grain)	600–800	No chemical N	Leaf litter	Deep taproot
Soybean	1.8–3.5	2.5–3.5 (Grain)	500–700	No chemical N	Residue incorporation	Root residue +
Cowpea	1.5–3.0	1.5–2 (Grain)	400–600	No chemical N	Green manure	Living cover
Safflower	1.0–2.2	1.2–1.8 (Grain)	300–500	Reduce N (25–30%)	Residue incorporation	Deep taproot
Sugarcane	8–12	High biomass	1500–2500	Reduce N (25–30%)	Trash mulching	High biomass
Leucaena	6–12	High biomass	600–900	Organic	Leaf litter	Permanent carbon sink
Cenchrus grass	4–8	High biomass	300–500	Organic	Mulching	Dense roots

The table shows a clear variation in carbon contribution across crops. High-biomass systems such as sugarcane, leucaena, and perennial grasses exhibit greater carbon potential due to continuous organic matter input. In the case of sugarcane, yield is indicated qualitatively as ‘high’ because the focus is on total biomass contribution rather than grain yield. In perennial systems such as Cenchrus grass, mulching involves leaving cut biomass on the soil surface, which helps retain moisture and adds organic matter. In contrast, ‘organic’ fertiliser indicates the use of compost or green manure rather than chemical inputs.

Annual crops such as cereals and pulses provide moderate carbon inputs, which can be enhanced through residue management and intercropping. Pearl millet is described as ‘fast biomass’ due to its rapid growth and ability to generate biomass quickly within a short period. In wheat, ‘SOC stabilisation’ refers to maintaining existing soil organic carbon levels through practices such as residue retention rather than increasing them rapidly. Leguminous crops additionally support nitrogen fixation, improving overall soil health. Overall, the table shows that carbon outcomes depend on both crop selection and management practices.

In addition to crop-level analysis, the following table has been developed using plot-wise soil data, including soil organic carbon (SOC) levels and water availability, along with field observations and crop suitability analysis. The data is derived from soil testing records, field monitoring, and existing cropping patterns at NARI. Based on these parameters, each plot was assigned a primary and alternative crop along with a carbon strategy, considering biomass potential, residue contribution, and suitability to local conditions. This approach ensures that crop planning is aligned with soil carbon improvement objectives while maintaining practical feasibility.

Table 2: Plot-wise Crop Planning and Carbon Enhancement Strategy

Plot No.	SOC (%)	Water Category	Primary Crop	Alternate Crop	Carbon Strategy
1	1.70	Low–Medium	Leucaena	Cenchrus grass	Maintain a perennial carbon sink
2	0.51	Low	Pearl millet	Sweet sorghum	Fast biomass for low SOC
3	0.54	Low–Medium	Sweet sorghum	Safflower	Residue-based carbon build-up
4	0.41	Low	Pearl millet	Sweet sorghum	Drought-resilient carbon system
5	0.50	Low–Medium	Sweet sorghum	Cowpea	Cover crop for SOC increase
6	0.46	Low	Sweet sorghum	Pearl millet	Seasonal biomass improvement
7	1.30	Medium	Sesbania (Dhaincha)	Soybean	Nitrogen enrichment
8	0.80	High	Sugarcane	Maize	High biomass carbon system

Plot No.	SOC (%)	Water Category	Primary Crop	Alternate Crop	Carbon Strategy
9A	1.70	Medium	Eucalyptus	Leucaena	Long-term carbon storage
10	0.55	Medium	Sorghum	Soybean	Balanced carbon-yield system
11	0.80	Medium	Sweet sorghum	Wheat	SOC stabilisation
12	—	Low	Eucalyptus	Perennial grasses	Carbon benchmark plot

The table shows that crop selection and management strategies vary depending on soil conditions and resource availability. Plots with low SOC are assigned crops with faster biomass production and greater residue contribution to support carbon build-up. In contrast, plots with moderate SOC are managed with balanced crop systems to maintain productivity and improve soil health. Plots with higher SOC or perennial systems, such as Leucaena and Eucalyptus, are maintained as long-term carbon sinks to ensure carbon stability. Water availability further influences crop selection, with drought-resilient crops assigned to low-water plots. Overall, the table reflects a targeted, data-driven approach in which crop choice and management strategies are adapted to specific plot conditions to optimise soil carbon outcomes.

Proposed DST-Supported Research Project

NARI is developing a research proposal for possible submission to the Department of Science and Technology (DST) to establish a field-based framework for soil carbon enhancement and participation in carbon credit programs under Indian agricultural conditions, particularly for smallholder farmers. The proposal builds on on-going field activities, data analysis, and pilot interventions carried out at NARI.

Strengthening Technical Capacity

As part of this initiative, efforts are also being made to strengthen technical infrastructure and knowledge systems. This includes understanding soil-testing laboratory requirements, documenting instruments and procedures, and gaining practical experience with laboratory-based soil analysis methods.

A Scalable Model for the Future

NARI's work in soil carbon and carbon credit readiness is expected to represent a significant step towards climate-resilient agriculture in India. By combining long-term data, field validation, farmer engagement, and institutional planning, the institute wants to develop a model that can be replicated in similar agro-climatic regions.

Conclusion

Through its on-going work, NARI is positioning itself at the intersection of agriculture, climate science, and emerging carbon markets. The institute's approach reflects a shift

towards data-driven, field-based, and system-oriented research that aligns environmental sustainability with agricultural development.

Appendix 3

An Agricultural Soil Carbon Credit Framework for Indian Smallholder Farmers: Integrating Low-Cost Measurement Technologies and Farmer-Centric Incentive Mechanisms

Abstract

Indian agriculture faces the dual challenge of enhancing soil health while mitigating climate change. This research paper presents a comprehensive agricultural soil carbon credit framework specifically designed for Indian smallholder farmers operating under semi-arid conditions. The framework integrates six core research objectives: (1) developing a reliable measurement and verification system suited to Indian farming conditions, (2) creating income opportunities through carbon credit programs, (3) establishing baseline data on soil organic carbon and health indicators, (4) implementing and evaluating soil management practices, (5) measuring seasonal and long-term changes in soil organic carbon, and (6) developing practical monitoring guidelines. We propose innovative solutions, including affordable low-cost measurement technologies (portable NIR spectroscopy, handheld sensors, smartphone-based tools), a Small Local Carbon Service Organisation (SLCSO) model for accessible carbon measurement services, green incentives with fast remuneration mechanisms featuring tiered payment systems, and a "Carbon Check First" mechanism providing free or subsidised initial baseline assessments. This framework addresses critical barriers preventing smallholder farmer participation in carbon markets, including high measurement costs, complex procedures, and delayed payments. By combining technological innovation with farmer-centric service delivery models, this research aims to transform Indian smallholder agriculture into a viable carbon-sequestration sector while improving farmers' livelihoods and soil health.

Keywords: Soil Carbon Sequestration, Carbon Credit Markets, Smallholder Farmers, Sustainable Agriculture, Low-Cost Soil Measurement Technologies, Carbon Farming Framework.

1. Introduction

India's agricultural sector, dominated by smallholder farmers cultivating fragmented landholdings, faces unprecedented challenges from climate change, soil degradation, and economic vulnerability. Agricultural soils in India are severely depleted in soil organic carbon (SOC), with concentrations often below 1 g kg^{-1} or barely $10\text{--}15 \text{ Mg C ha}^{-1}$ at a depth of 40 cm (Lal, 2015). This depletion results from decades of extractive farming practices, threatening both food security and farmer livelihoods. Simultaneously, India's agriculture sector presents significant potential for climate change mitigation through soil carbon sequestration, with the capacity to reduce annual emissions by 84% from 2019 to 2070 through sustainable farming practices (Khurana et al., 2024).

Carbon farming, the practice of managing agricultural lands to sequester atmospheric carbon dioxide in soils and biomass, offers a promising dual solution: enhancing soil health while creating new income streams for farmers through carbon credit markets (Sharma et al., 2024). The global carbon credit market is projected to reach \$97.1 billion by 2033, presenting substantial opportunities for Indian agriculture. However, existing carbon credit projects in India reveal systematic exclusion of small and marginalised farmers, with approximately 99% of participating farmers receiving no monetary benefit (Krishna et al., 2024). This exclusion stems from multiple barriers: prohibitively expensive soil testing procedures, complex verification requirements, high transaction costs, delayed payments, and a lack of accessible measurement infrastructure.

Current carbon credit frameworks fail to address the unique constraints of Indian smallholder farmers, who typically operate on landholdings of less than 2 hectares under resource-constrained conditions. Traditional soil carbon measurement relies on laboratory-based methods involving soil sampling, transportation, and dry combustion analysis, which are time-consuming, labour-intensive, and costly, often exceeding €44 per sample (Kohl et al., 2025). These costs create insurmountable barriers for smallholder farmers seeking to participate in carbon markets. Furthermore, the convoluted and unpredictable nature of receiving offset credits discourages farmer participation (Barbato et al., 2023).

This research paper addresses these critical gaps by developing an integrated agricultural soil carbon credit framework specifically tailored to Indian smallholder farmers. Our framework combines technological innovation in low-cost measurement equipment, institutional innovation through locally run service organisations, and financial innovation via simplified incentive mechanisms. By proposing and testing mechanisms to help farmers first conduct carbon baseline assessments and then proceed with the full carbon credit process, this research aims to democratise access to carbon markets and transform Indian smallholder agriculture into a viable carbon-sequestration sector.

2. Research Objectives

This study is guided by six interrelated objectives that address the technical, institutional, and economic barriers to smallholder participation in carbon credit programmes in India. It develops a context-specific soil carbon credit framework for semi-arid farming systems, integrating affordable measurement technologies, simplified verification procedures, and accessible service delivery models. The study further examines the potential for enhancing farmer income through carbon sequestration practices, with evidence suggesting that agroforestry-based carbon finance can increase income by 40–50%, potentially generating up to Rs. 25,000 per hectare annually (Singh et al., 2024), while also considering mechanisms for equitable benefit distribution. It establishes baseline data on soil organic carbon, bulk density, and key soil health indicators to ensure accurate measurement and additionality, a critical requirement for carbon credit eligibility (Cariappa et al., 2024). In addition, it assesses the effectiveness of sustainable soil management practices, such as crop residue retention and organic amendments, which have demonstrated the potential to increase soil organic carbon stocks by up to 36% in the topsoil layer (Jat et al., 2022). The study also analyses seasonal and long-term variations in soil organic carbon to support reliable monitoring and verification, recognising that continuous monitoring is essential for ensuring permanence and measurement accuracy (Maho, 2023). Finally, it proposes simplified, farmer-friendly monitoring guidelines that balance scientific rigour with practical accessibility, addressing the complexity of existing systems that often limit smallholder participation (Krishna et al., 2024).

3. Proposed Framework

Our proposed agricultural soil carbon credit framework integrates four key components: (1) accessible measurement infrastructure, (2) simplified verification procedures, (3) farmer-centric service delivery, and (4) streamlined payment mechanisms. This framework is designed to overcome the systematic barriers that currently exclude smallholder farmers from carbon markets. The framework begins with the "Carbon Check First" mechanism, which provides farmers with free or subsidised initial baseline assessments to eliminate upfront financial barriers. Following baseline establishment, farmers receive guidance on implementing carbon-positive practices, including conservation agriculture, crop residue retention, compost application, and integrated nutrient management. These practices have been demonstrated to enhance soil organic carbon while improving soil health indicators, including water retention, nutrient cycling, and microbial diversity (Sharma et al., 2024).

Measurement and verification are conducted using low-cost portable technologies operated by Small Local Carbon Service Organisations (SLCSOs), eliminating the need for expensive laboratory analysis. The framework employs a hybrid approach combining direct soil measurements with modelling, similar to the Soil Enrichment Protocol, which has

demonstrated effectiveness in reducing data collection burdens while maintaining scientific rigour (Hammond et al., 2021). Field-level baselines and dynamic modelling enable accurate carbon stock estimation with as few as 0.5 samples per hectare (Maho, 2023). The verification process is simplified through tiered payment systems that provide quick initial payments based on practice adoption, followed by payments based on verified carbon sequestration. This hybrid payment approach addresses the challenge of delayed remuneration while maintaining additionality requirements (Raina et al., 2024). Local monitoring organisations aggregate farmer contributions, reducing transaction costs that can range from 3% to 85% of total credit value (OECD, 2023). The framework emphasises inclusivity through differential pricing mechanisms that incentivise participation of small and marginalised farmers (Krishna et al., 2024). By addressing technical, economic, and institutional barriers simultaneously, this integrated framework creates a viable pathway for smallholder farmers to participate in carbon markets while improving soil health and farm productivity.

4. Proposed Technologies and Equipment

The success of our framework depends critically on affordable, accurate, and farmer-accessible measurement technologies. We propose a suite of low-cost technologies that replace expensive traditional laboratory methods while maintaining sufficient accuracy for carbon credit verification.

Portable Near-Infrared (NIR) Spectroscopy

Portable NIR spectroscopy represents the most promising technology for field-based soil carbon measurement. Handheld NIR devices operating in the 350-2500 nm wavelength range can predict soil organic carbon with good accuracy ($R^2 = 0.85$, RMSE = 0.47) under field conditions, comparable to laboratory methods (England et al., 2018). The visible-near-infrared portable (vis-NIRp) spectrometer has been identified as the most cost-effective option for SOC estimation of ≤ 2 mm samples due to its low cost, high accuracy, and large measurement capacity (Li et al., n.d.). These devices are significantly cheaper than traditional laboratory analysis, with measurement costs of approximately €3-4 per sample compared to €44 for laboratory analysis (Kohl et al., 2025). Recent advances have produced increasingly affordable NIR spectrometers. The NanoQuest FT-NIR spectrometer, a compact and lightweight alternative to bulky research-grade instruments, demonstrates satisfactory SOC estimation (R^2 : 0.17 to 0.70, RMSE: 5 to 9.2 g C kg⁻¹) at variable moisture contents (Murad et al., 2023). Portable vis-NIR spectrometers can cost less than AUD 10,000 to over AUD 100,000, with costs continually decreasing as smaller micro-electromechanical systems (MEMS) spectrometers emerge (England et al., 2018).

Handheld Sensors and Multi-Parameter Probes

Multi-sensor approaches offer a comprehensive soil health assessment beyond carbon measurement. The Stenon FarmLab multi-sensor probe provides portable, in-field SOC monitoring at approximately €3-4 per measurement, facilitating dense spatial sampling (Kohl et al., 2025). Novel sensor-in-field probes for real-time monitoring of soil health indicators, including total soil carbon, have demonstrated coefficients of variation below 20% and accuracy comparable to traditional laboratory analysis (Dhamu et al., 2025). Self-developed sensor systems based on simultaneous reflectance measurements at 660 and 940 nm

wavelengths offer even lower running costs. These systems, incorporating built-in GPS units for mapping, make soil carbon research "much cheaper and faster" than laboratory tests, with strong correlations ($R^2 = 0.73$) between sensor values and reference measurements (Béni et al., 2021).

Smartphone-Based Tools and Colour Sensors

Smartphone-based technologies represent the most accessible and affordable option for smallholder farmers. The Nix Pro™ colour sensor, priced at \$349, serves as a low-cost alternative to traditional colourimeters for soil organic carbon determination (Stiglitz, 2017). Controlled via Bluetooth and a mobile application, this device provides rapid and reliable colour analysis using linear regression models, achieving an R^2 of 0.7978 for dry soils. The accompanying Soil Scanner app enables GPS location recording, photo capture, and crowd-sourcing of soil data. Emerging technologies leverage Wi-Fi and optical signals for cost-effective soil carbon sensing. The Scarf system uses Wi-Fi signals to detect carbon content without dedicated hardware, achieving accuracy comparable to state-of-the-art techniques costing thousands of dollars (Ding et al., 2024). Prototype handheld devices that integrate measurements of soil colour, texture, moisture, bulk density, and NIR reflectance, with cloud storage via Wi-Fi, offer integrated, data-driven approaches to overcome the expense of traditional techniques (Acharya et al., 2022).

Laser-Induced Breakdown Spectroscopy (LIBS)

For higher-throughput applications, laser-induced breakdown spectroscopy offers a scalable solution. The commercially available LaserAg-Quantum analyser achieves an average limit of quantification of 0.75% carbon with 4.10% precision, providing a robust alternative to time-consuming, energy-intensive traditional methods (Morais et al., 2024).

Technology Selection Criteria

For the proposed framework, we recommend a tiered technology approach: (1) smartphone-based color sensors for initial screening and farmer self-monitoring (cost: \$300-400), (2) portable NIR spectrometers for SLCSO-operated baseline and verification measurements (cost: \$5,000-15,000), and (3) multi-sensor probes for comprehensive soil health assessment in research and validation contexts (cost: \$10,000-30,000). This tiered approach balances affordability, accuracy, and accessibility while maintaining scientific rigour for carbon credit verification.

5. Small Local Carbon Service Organisation (SLCSO)

The Small Local Carbon Service Organisation (SLCSO) model represents a critical institutional innovation that bridges the gap between smallholder farmers and carbon credit markets. SLCSOs are community-based organisations that provide affordable, accessible carbon measurement and verification services at the local level, addressing the infrastructure and expertise barriers that currently exclude smallholder farmers from carbon programs.

Organisational Structure and Functions

SLCSOs operate as locally-run entities staffed by trained technicians from farming communities who understand local agricultural practices, languages, and socio-economic contexts. Each SLCSO serves a cluster of villages or a defined geographic area, typically

covering 500-1000 smallholder farmers. Core functions include: (1) conducting initial "Carbon Check First" baseline assessments, (2) providing technical guidance on carbon-positive farming practices, (3) performing periodic soil carbon monitoring using portable equipment, (4) maintaining farmer records and documentation, (5) aggregating farmer data for carbon credit verification, and (6) facilitating communication between farmers and carbon credit buyers. The SLCSO model draws on successful precedents set by intermediary organisations in agricultural carbon finance. Research demonstrates that intermediaries at the meso-level, including external agencies and local units such as farmer groups, effectively influence and incentivise production decisions while bridging micro-level farmers with macro-level buyers (Clements et al., 2015). Third-party intermediaries can aggregate contracts and reduce transaction costs, particularly for small farms (Antle et al., 2003).

Equipment and Capacity Building

Each SLCSO is equipped with portable NIR spectrometers, handheld multi-sensor probes, GPS-enabled tablets for data recording, and soil sampling equipment. Initial capital investment for equipment ranges from \$15,000 to \$ 25,000 per SLCSO and can be subsidised through government programs, corporate social responsibility funds, or carbon credit advance payments. SLCSO technicians receive comprehensive training in soil sampling protocols, equipment operation, data management, and farmer communication. Training programs developed in partnership with agricultural universities and research institutions emphasise practical skills and local-language instruction.

Service Delivery Model

SLCSOs operate on a fee-for-service model with subsidised rates for smallholder farmers. The "Carbon Check First" baseline assessment is provided free or at minimal cost (Rs. 50-100 per farmer) to eliminate entry barriers. Subsequent monitoring visits are charged at affordable rates (Rs. 200-500 per visit), significantly lower than commercial laboratory costs. Revenue is generated through: (1) farmer service fees, (2) commissions from carbon credit sales (typically 5-10% of credit value), (3) government subsidies for soil health monitoring, and (4) corporate sponsorships.

Community Engagement and Trust

Trust is a critical factor in farmer participation in carbon credit projects (Mallappa et al., n.d.). SLCSOs build trust through: (1) local staffing with community members, (2) transparent payment tracking and reporting, (3) regular farmer meetings and training sessions, (4) demonstration plots showcasing carbon-positive practices, and (5) farmer-to-farmer knowledge exchange. Community engagement in monitoring can significantly reduce project costs while increasing farmer ownership (Okoli et al., 2024).

Aggregation and Transaction Cost Reduction

A key function of SLCSOs is aggregating contributions from multiple smallholder farmers to achieve economies of scale. Individual smallholder farms typically sequester small amounts of carbon, making direct participation in carbon markets economically unviable due to high transaction costs. By aggregating 500-1000 farmers, SLCSOs create carbon credit volumes sufficient to attract buyers while distributing transaction costs across many participants. This

aggregation model has proven effective in reducing per-farmer costs from prohibitive levels to manageable amounts (Antle et al., 2003).

Integration with Existing Institutions

SLCSOs are designed to integrate with existing agricultural institutions, including farmer-producer organisations (FPOs), self-help groups (SHGs), Krishi Vigyan Kendras (KVKs), and agricultural extension services. This integration leverages existing social capital, infrastructure, and farmer networks while avoiding duplication of services. Policy tools should offer targeted incentives, such as equipment subsidies and training through SHGs, to support the establishment of SLCSOs (Patil et al., 2025).

6. Green Incentives and Fast Remuneration

Current carbon credit payment systems suffer from complexity, delays, and unpredictability that discourage smallholder farmer participation. Farmers express concerns about the convoluted and burdensome nature of receiving offset credits, with payments often delayed by years (Barbato et al., 2023). Our framework proposes innovative "green incentives" and "fast remuneration" mechanisms to simplify procedures and accelerate payments.

Tiered Payment System

We propose a three-tier payment structure that provides progressive remuneration aligned with farmer actions and verified outcomes:

Tier 1: Practice Adoption Payments (Action-Based)

Farmers receive quick initial payments (Rs. 2,000-5,000 per hectare) upon verified adoption of carbon-positive practices such as zero tillage, crop residue retention, or compost application. These action-based payments are simpler to administer, require lower monitoring intensity, and can be paid upfront or shortly after practice implementation (Raina et al., 2024). This tier addresses immediate farmer cash flow needs and provides confidence-building early returns.

Tier 2: Interim Verification Payments (Hybrid)

After 6-12 months of practice implementation, farmers receive interim payments (Rs. 3,000-8,000 per hectare) based on preliminary soil carbon measurements and modelling estimates. This hybrid approach combines low-risk guaranteed payments with early result-based incentives, reducing farmer uncertainty while maintaining carbon sequestration verification (Raina et al., 2024).

Tier 3: Full Carbon Credit Payments (Result-Based)

Upon complete verification of carbon sequestration after 2-3 years, farmers receive full carbon credit payments based on verified carbon stocks. At current market rates of Rs. 780-2,000 per carbon credit, with potential for higher prices from corporate buyers (Singh et al., n.d.), farmers can earn Rs. 8,000-15,000 per hectare depending on sequestration rates and market conditions.

Carbon Loan Program

To address capital market imperfections and payment delays, we propose a "carbon loan" program that finances upfront investments by paying the capitalised value of expected carbon credits in advance (Antle et al., 2003). Farmers receive advance payments (50-70% of the

projected carbon credit value) to invest in necessary inputs such as compost, cover crop seeds, or equipment. These advances are reconciled against the actual carbon credits generated, with any surplus returned to farmers and any deficits carried forward. This mechanism addresses the critical constraint that farmers often lack the capital to implement carbon-positive practices while waiting years for carbon credit payments.

Simplified Verification Procedures

Traditional carbon credit verification involves complex monitoring, reporting, and verification (MRV) processes that are time-consuming and costly. Our framework simplifies verification through: (1) standardised protocols for common practices (zero tillage, residue retention, compost application), (2) remote sensing integration to reduce field visits, (3) risk-based sampling where high-performing farmers receive less frequent monitoring, and (4) group verification where clusters of farmers implementing similar practices are verified collectively rather than individually.

Digital Payment Infrastructure

Fast remuneration requires an efficient payment infrastructure. We propose leveraging India's digital payment systems (UPI, Aadhaar-linked bank accounts) to enable direct, transparent, and rapid payments to farmers. SLCSOs maintain digital records of farmer participation, practice adoption, and carbon measurements, enabling automated payment triggers when verification milestones are achieved. Blockchain-based systems can provide transparent tracking of carbon credits from generation to sale, building farmer trust through payment transparency (Mallappa et al., n.d.).

Differential Pricing for Inclusivity

To ensure small and marginalised farmers benefit equitably, we propose differential pricing mechanisms that give smaller landholdings premium rates per unit of carbon sequestered. This addresses the systematic exclusion observed in existing projects where 99% of farmers receive no monetary benefit (Krishna et al., 2024). Premium pricing (20-30% above standard rates) for farmers with less than 1-hectare landholdings compensates for higher per-hectare transaction costs while incentivising inclusive participation.

Corporate and Government Co-Financing

Green incentives can be enhanced through corporate social responsibility (CSR) funds and government subsidies. Corporations can support carbon credits through CSR funds, paying market prices as incentives (Singh et al., 2024). Government programs such as the Soil Health Card scheme, Pradhan Mantri Krishi Sinchayee Yojana, and National Mission for Sustainable Agriculture can integrate carbon credit support, providing co-financing for practice adoption payments and SLCSO infrastructure.

7. Carbon Check First Mechanism

The "Carbon Check First" mechanism represents a paradigm shift in how farmers engage with carbon credit programs. Rather than requiring farmers to commit to complex, long-term contracts before understanding their baseline carbon status, this mechanism provides free or heavily subsidised initial carbon baseline assessments, eliminating upfront financial and informational barriers.

Rationale and Design

Current carbon credit programs require farmers to invest time, money, and effort before knowing whether their soils have carbon sequestration potential or whether participation will be economically viable. This uncertainty deters risk-averse smallholder farmers. The Carbon Check First mechanism reverses this sequence: farmers first receive a comprehensive baseline assessment of their soil carbon status, sequestration potential, and projected income from carbon credits, enabling informed decision-making before committing to the program. The mechanism operates through SLCSOs, which conduct initial baseline assessments covering: (1) soil organic carbon concentration and stocks (0-30 cm depth), (2) bulk density, (3) key soil health indicators (pH, available nitrogen, phosphorus, potassium), (4) soil texture and moisture, and (5) current management practices. These assessments utilise portable NIR spectroscopy and handheld sensors, providing results within 24-48 hours rather than the weeks required for laboratory analysis.

Subsidy Structure

The Carbon Check First assessment is provided free to farmers with landholdings of less than 2 hectares, subsidised at 75% for farmers with 2-5 hectares, and at market rates for farmers with 5+ hectares. Subsidies are funded through: (1) government soil health monitoring programs, (2) carbon credit advance payments from buyers, (3) corporate CSR funds, and (4) international climate finance mechanisms. The cost per baseline assessment is approximately Rs. 500-800 per farmer using portable technologies, making universal coverage economically feasible.

Farmer Decision Support

Following the baseline assessment, farmers receive a personalized report in local language detailing: (1) current soil carbon status compared to regional averages, (2) estimated carbon sequestration potential based on soil type and climate, (3) recommended carbon-positive practices suited to their farming system, (4) projected income from carbon credits over 3-5 years under different scenarios, (5) required investments and practice changes, and (6) comparison of carbon credit income with alternative income sources. This decision support empowers farmers to make informed choices about participation. Research indicates that farmers implement practices primarily for business and sustainability reasons, with carbon payments seen as "gravity on top" (Barbato et al., 2023). By clearly demonstrating both soil health benefits and income potential, the Carbon Check First mechanism aligns carbon credit participation with farmers' existing motivations.

Baseline Database Development

The Carbon Check First mechanism simultaneously addresses Research Objective 3 by establishing a comprehensive baseline database of soil organic carbon and health indicators across semi-arid farming systems. This database serves multiple purposes: (1) regional benchmarking for carbon credit additionality verification, (2) identification of high-potential areas for targeted interventions, (3) research on soil carbon dynamics under diverse management systems, and (4) policy development for soil health programs. Baseline data collection follows standardised protocols, ensuring comparability across regions and time periods. Soil samples are collected at 0-15 cm and 15-30 cm depths using systematic sampling designs. GPS coordinates, land use history, current management practices, and farmer socio-

economic data are recorded. This comprehensive baseline enables accurate measurement of carbon stock changes and ensures additionality, a critical requirement for carbon credit eligibility (Cariappa et al., 2024).

Transition to Full Program

Farmers who choose to proceed after the Carbon Check First assessment transition seamlessly to the full carbon credit program. They receive: (1) technical training on recommended practices, (2) access to inputs and equipment through SLCSOs or farmer cooperatives, (3) Tier 1 practice adoption payments upon implementation, (4) ongoing monitoring and support from SLCSO technicians, and (5) entry into the tiered payment system. This smooth transition reduces friction and maintains farmer engagement.

Scalability and Replication

The Carbon Check First mechanism is designed for rapid scalability. Each SLCSO can conduct 10-15 baseline assessments per day using portable equipment, covering 500-1000 farmers within 2-3 months. The mechanism can be replicated across diverse agro-ecological zones with minimal adaptation, requiring only regional calibration of measurement equipment and adjustments to practice recommendations based on local conditions. Successful implementation in pilot regions can demonstrate viability and attract additional funding for expansion.

8. Discussion

This research paper presents an integrated framework to address the multifaceted barriers that prevent Indian smallholder farmers from participating in carbon credit markets. By combining technological innovation (low-cost measurement equipment), institutional innovation (SLCSOs), and financial innovation (tiered payments and Carbon Check First), the framework creates a viable pathway to transform Indian agriculture into a carbon-sequestration sector while improving farmer livelihoods and soil health.

Addressing Systematic Exclusion

Current carbon credit projects in India systematically exclude small and marginalised farmers, with 99% receiving no monetary benefit (Krishna et al., 2024). Our framework directly addresses this exclusion through: (1) eliminating upfront costs via Carbon Check First, (2) reducing measurement costs by 90% through portable technologies, (3) aggregating farmers through SLCSOs to achieve economies of scale, (4) providing quick initial payments to address cash flow constraints, and (5) implementing differential pricing to incentivize inclusive participation. These mechanisms collectively remove the financial, technical, and institutional barriers that currently prevent smallholder farmers from participating.

Balancing Rigour and Accessibility

A critical challenge is maintaining scientific rigour for carbon credit verification while ensuring accessibility for resource-constrained farmers. Our framework achieves this balance through: (1) validated portable measurement technologies with accuracy comparable to laboratory

methods (England et al., 2018), (2) hybrid measurement-modeling approaches that reduce sampling intensity while maintaining precision (Maho, 2023), (3) standardized protocols for common practices that simplify verification, and (4) risk-based monitoring that focuses resources on verification-critical aspects. Research demonstrates that the precision of farm carbon stocks below 5% is achievable with as few as 0.5 samples per hectare using appropriate methods (Maho, 2023).

Additionality and Permanence

Carbon credit programs must demonstrate additionality (carbon sequestration would not have occurred without the program) and permanence (sequestered carbon remains stored long-term). Our framework addresses additionality through comprehensive baseline data establishing pre-intervention carbon stocks and regional adoption rates of carbon-positive practices. Eligibility criteria similar to those proposed by Cariappa et al. (2024), baseline adoption rates below 20%, no yield decreases exceeding 5%, and fertiliser reductions exceeding 5% ensure additionality. Permanence is addressed through: (1) long-term monitoring protocols, (2) farmer education on practice maintenance, (3) economic incentives for continued practice adoption, and (4) insurance mechanisms to address disadoption risks. The high disadoption rate (28%) observed in existing projects (Krishna et al., 2024) highlights the importance of ongoing support and incentives.

Soil Health Co-Benefits

Beyond carbon sequestration, the proposed practices deliver substantial co-benefits for soil health. Conservation agriculture practices enhance soil physical, chemical, and biological properties, boosting natural resource availability and nutrient cycling (Mrudula et al., 2025). Integrated management practices, including biochar application, optimised irrigation, and fertiliser management, improve yields (maize yields increased over 30%) while increasing SOC levels (Gv et al., 2025). These co-benefits provide immediate value to farmers, independent of carbon credit payments, addressing the concern that farmers implement practices primarily for business and sustainability reasons rather than solely for financial incentives (Barbato et al., 2023).

Policy Integration

Successful implementation requires supportive policy frameworks. Policy interventions should promote the adoption of best management practices through payments for ecosystem services, with improved governance and strong political will (Lal, 2015). Integration with existing government schemes such as the Soil Health Card, the National Mission for Sustainable Agriculture, and the Pradhan Mantri Fasal Bima Yojana can provide co-financing and institutional support. A National Carbon Registry for agriculture, as proposed by Gokhale et al. (2024), would facilitate the development of carbon credits and corporate investment. Policy tools should offer targeted incentives such as equipment subsidies, community-scale biochar production, and composting training through self-help groups (Patil et al., 2025).

Limitations and Challenges

Several challenges require careful consideration. First, portable measurement technologies, while significantly cheaper than laboratory analysis, still require initial capital investment and technical expertise. Second, carbon credit markets remain volatile, with prices subject to

supply-demand dynamics and policy changes. Third, smallholder farmers face multiple competing demands on their time and resources, potentially limiting the adoption of new practices. Fourth, verification of carbon sequestration requires multi-year monitoring, creating temporal gaps between the adoption of practices and full payment. Fifth, land tenure insecurity in some regions may discourage long-term investments in soil carbon sequestration.

Research and Validation Needs

This paper outlines mechanisms requiring rigorous testing and validation. Key research needs include: (1) field validation of portable measurement technologies under diverse Indian soil conditions, (2) calibration of measurement equipment for regional soil types, (3) quantification of carbon sequestration rates under different management practices and agro-ecological zones, (4) assessment of farmer adoption rates and barriers under different incentive structures, (5) evaluation of SLCSO operational efficiency and financial sustainability, (6) long-term monitoring of practice permanence and carbon stock changes, and (7) economic analysis of cost-effectiveness compared to alternative carbon sequestration approaches.

9. Conclusion

This research paper presents a comprehensive agricultural soil carbon credit framework specifically designed to enable Indian smallholder farmers to participate in carbon markets while improving soil health and farm productivity. By integrating low-cost measurement technologies (portable NIR spectroscopy, handheld sensors, smartphone-based tools), farmer-centric service delivery through Small Local Carbon Service Organisations, simplified incentive mechanisms with tiered payments, and the innovative Carbon Check First mechanism, this framework addresses the systematic barriers that currently exclude smallholder farmers from carbon credit programs.

The six research objectives provide a structured approach to the development, implementation, and validation of the framework. Establishing baseline data on soil organic carbon and health indicators under semi-arid conditions will create a foundation for measuring carbon sequestration and ensuring additionality. Implementing and evaluating soil management practices, such as crop residue retention and compost application, will quantify the potential for carbon sequestration while delivering co-benefits for soil health. Measuring seasonal and long-term changes in soil organic carbon will enable verification of permanence and temporal dynamics. Developing practical monitoring guidelines will empower farmers to record soil carbon improvements and participate actively in carbon credit programs.

This research framework transforms the current paradigm where farmers face upfront costs, complex procedures, and delayed payments. Instead, farmers receive free baseline assessments, affordable ongoing monitoring through local service organisations, quick initial payments for practice adoption, and transparent tracking of carbon credit generation and sales. This farmer-centric approach aligns carbon credit participation with farmers' existing motivations for improving soil health and farm sustainability.

Successful implementation of this framework could transform Indian smallholder agriculture into a significant carbon-sequestration sector while improving farmers' livelihoods. With over 146 million agricultural holdings in India, predominantly smallholder farms, the potential

impact is substantial. If even 10% of smallholder farmers participate, sequestering an average of 0.5 tonnes of carbon per hectare per year, India could sequester over 7 million tonnes of carbon annually while improving soil health across millions of hectares.

This research paper tests different mechanisms to help farmers first conduct carbon baseline assessments and then proceed with the full carbon credit process. By demonstrating viability through pilot implementation, rigorous monitoring, and transparent reporting, this research aims to create a replicable model for agricultural carbon credit programs in India and other developing countries with similar smallholder farming systems. The integration of technological, institutional, and financial innovations provides a holistic solution to the complex challenge of enabling smallholder farmer participation in carbon markets while advancing climate change mitigation and sustainable agriculture goals.

References

- Acharya, U., Daigh, A. L., & Oduor, P. G. (2022). Data-driven approach to in-situ soil carbon measurement. **Carbon Management**, 13(1), 441-451. <https://doi.org/10.1080/17583004.2022.2106310>
- Antle, J. M., Capalbo, S. M., Mooney, S., Elliott, E. T., & Paustian, K. H. (2003). Creating incentives for the adoption of sustainable agricultural practices in developing countries: The role of soil carbon sequestration. **American Journal of Agricultural Economics**, 85(5), 1178-1184. <https://doi.org/10.1111/J.0092-5853.2003.00526.X>
- Barbato, M., Comerford, E., Ewing, P., Gattinger, A., Jones, S. K., Tayleur, C., & zu Ermgassen, S. O. S. E. (2023). Farmer perspectives on carbon markets incentivizing agricultural soil carbon sequestration. **Communications Earth & Environment**, 4, 324. <https://doi.org/10.1038/s44168-023-00055-4>
- Béni, Á., Lajtos, D., Kovács, Z., Mucsi, M., & Pósa, B. (2021). Development of soil organic matter measurement system. **Soil and Water Research**, 16(4), 198-202. <https://doi.org/10.17221/18/2021-SWR>
- Cariappa, A. G. A., Chandel, B. S., Birthal, P. S., & Mishra, A. K. (2024). Evaluating the potential and eligibility of conservation agriculture practices for carbon credits. **Scientific Reports**, 14, 10159. <https://doi.org/10.1038/s41598-024-59262-6>
- Clements, T., Suon, S., Wilkie, D. S., & Milner-Gulland, E. J. (2015). Exploring the meso-level of agricultural carbon finance projects. In **Reducing Emissions from Deforestation and Forest Degradation (REDD): A Casebook of On-the-Ground Experience** (pp. 433-448). Springer. https://doi.org/10.1007/978-3-319-09360-4_26

Dhamu, V. N., Gopal, R., Srinivasan, R., Jayaraman, S., Muthukumar, S., & Prasad, S. (2025). SODS: Soil health on-demand sensors—A multi parameter field study with temporal monitoring. **Sensors**, 25(11), 3505. <https://doi.org/10.3390/s25113505>

Ding, J., Xiong, J., Wang, H., Zhao, J., Gao, S., Chen, L., & Zhang, D. (2024). Cost-effective soil carbon sensing with Wi-Fi and optical signals. **Proceedings of the 30th Annual International Conference on Mobile Computing and Networking**, 675-690. <https://doi.org/10.1145/3636534.3690675>

England, J. R., Viscarra Rossel, R. A., Chappell, A., Lorimer, M., & Nawar, S. (2018). Proximal sensing for soil carbon accounting. **SOIL**, 4(2), 101-122. <https://doi.org/10.5194/SOIL-4-101-2018>

Gokhale, Y., Nair, A., Nair, P. K. R., & Nair, V. D. (2024). Enhancing farmer's income and achieving net neutrality through agroforestry: A proposal for India. **Climate Change and Environmental Sustainability**, 12(1), 21-30. <https://doi.org/10.5958/2320-642x.2024.00003.8>

Goodwin, N., Armston, J., Muir, J., & Stiller, I. (2022). Can low-cost, handheld spectroscopy tools coupled with remote sensing accurately estimate soil organic carbon in semi-arid grazing lands? **Soil Systems**, 6(2), 38. <https://doi.org/10.3390/soilsystems6020038>

Gv, S., Srinivasan, R., Hegde, R., Singh, S. K., & Kundu, D. K. (2025). Integrating carbon sequestration and yield optimization in Indian cropping systems. **Sustainable Futures**, 9, 101293. <https://doi.org/10.1016/j.sftr.2025.101293>

Hammond, J., Sieber, S., Rosenstock, T., Falconnier, G., Fraval, S., van Wijk, M., Pagella, T., Carpena, P., Sander, B. O., & Schueler, C. (2021). Implementing the soil enrichment protocol at scale: Opportunities for an agricultural carbon market. **Frontiers in Climate**, 3, 686440. <https://doi.org/10.3389/FCLIM.2021.686440>

Jat, H. S., Datta, A., Choudhary, M., Yadav, A. K., Choudhary, V., Sharma, P. C., Gathala, M. K., Jat, M. L., & McDonald, A. (2022). Carbon sequestration potential, challenges, and strategies towards climate action in smallholder agricultural systems of South Asia. **Crop and Environment**, 1(2), 120-132. <https://doi.org/10.1016/j.crope.2022.03.005>

Khurana, I., Jain, A., Rasul, G., Khadka, M., & Dhyani, S. (2024). Shaping India's climate future: A perspective on harnessing carbon credits from agriculture. **Outlook on Agriculture**, 53(2), 147-158. <https://doi.org/10.1177/00307270241240778>

Kohl, L., Philipp, M., Wiesmeier, M., & Rumpel, C. (2025). Field evaluation of a portable multi-sensor soil carbon analyzer under real-world farming conditions: Performance, precision, and limitations. **Preprints**. <https://doi.org/10.20944/preprints202505.0591.v1>

Krishna, V. V., Keil, A., Aravindakshan, S., Meena, P. C., Ajay, A., & Grovermann, C. (2024). Carbon farming in India: Are the existing projects inclusive, additional, and permanent? Figshare. <https://doi.org/10.6084/m9.figshare.27264256>

Lal, R. (2013). Climate-resilient agriculture and soil organic carbon. **Indian Journal of Agronomy**, 58(4), 440-450.

- Lal, R. (2015). Soil carbon sequestration in agroecosystems of India. **Journal of the Indian Society of Soil Science**, 63(2), 125-143.
- Li, B., Xie, W., Huang, J., Tang, G., Zhang, S., & Shi, Z. (n.d.). The cost-effectiveness of reflectance spectroscopy for estimating soil organic carbon. **European Journal of Soil Science**, 73(1), e13202. <https://doi.org/10.1111/ejss.13202>
- Maho, A. (2023). Enabling carbon farming: A robust, affordable and scalable approach leveraging remote and proximal sensing. **EGU General Assembly 2023**. <https://doi.org/10.5194/egusphere-egu23-13552>
- Mallappa, M., Manjunatha, A. V., Biradar, N., & Patil, B. L. (n.d.). Understanding farmers' trust in stakeholders of carbon credit projects: A perception-based analysis. [Manuscript in preparation].
- Morais, C. L. M., Lima, K. M. G., Silla, J. M., Tavares, T. R., Cherubin, M. R., & Martin, F. L. (2024). Scalable solution for agricultural soil organic carbon measurements using laser-induced breakdown spectroscopy. **Scientific Reports**, 14, 15304. <https://doi.org/10.1038/s41598-024-65904-6>
- Mrudula, K., Prasad, P. V. V., & Prasad, J. V. N. S. (2025). Nurturing soil health through conservation agriculture practices. In **Sustainable Agriculture and the Environment** (pp. 1-24). IntechOpen. <https://doi.org/10.5772/intechopen.1006472>
- Murad, M. O. F., Jones, E. J., Minasny, B., McBratney, A. B., Wijewardane, N., & Ge, Y. (2023). Estimating soil organic carbon content at variable moisture contents using a low-cost spectrometer. **SSRN Electronic Journal**. <https://doi.org/10.2139/ssrn.4571122>
- OECD. (2023). Pursuing higher environmental goals for agriculture in an interconnected world. **OECD Food, Agriculture and Fisheries Working Papers**, 197. <https://doi.org/10.1787/99d917ab-en>
- Okoli, C., Wortmann, M., Kaaya, L. T., Korir, H., Sila, A., & Shepherd, K. (2024). Monitoring soil carbon in smallholder carbon projects: Insights from Kenya. **Research Square**. <https://doi.org/10.21203/rs.3.rs-4191055/v1>
- Patil, S., Saha, A., Krupnik, T. J., Choudhary, K. K., Kakraliya, S. K., Kumar, V., Jat, H. S., Jat, M. L., & Sapkota, T. B. (2025). Differential impacts of regenerative agriculture practices on soil organic carbon: A meta-analysis of studies from India. **Scientific Reports**, 15, 2149. <https://doi.org/10.1038/s41598-025-12149-6>
- Raina, G., Sinha, A., Wadhwa, S., Dutta, S., & Krishna, V. V. (2024). Incentive mechanisms of carbon farming contracts: A systematic mapping study. **Journal of Environmental Management**, 354, 120126. <https://doi.org/10.1016/j.jenvman.2024.120126>
- Sharma, R., Thakur, M., Sharma, S., & Sharma, P. (2024). Carbon farming: Its emerging role in soil health and climate mitigation with special reference to hill agriculture. **Environment & Social Lens**, 5(2), 18-25. <https://doi.org/10.51470/esl.2024.5.2.18>
- Singh, A., Chaturvedi, O. P., Kaushal, R., Tewari, S., Raizada, A., & Gupta, A. (2024). Incentivising agroforestry through carbon revenue: Augmenting farmers' income in India. **Agricultural Science Digest**, 44(5), 721-728. <https://doi.org/10.18805/ag.d-6066>

Singh, P., Nedumaran, S., Boote, K. J., Gaur, P. M., Srinivas, K., & Bantilan, M. C. S. (n.d.). Carbon farming: A circular framework to augment CO₂ sinks and to combat climate change. **Environmental Science: Advances**, 3(3), 296-311. <https://doi.org/10.1039/d3va00296a>

Stiglitz, R. Y. (2017). Application of low-cost color sensor technology in soil data collection and soil science education. [Doctoral dissertation, University of Vermont].

Appendix 4

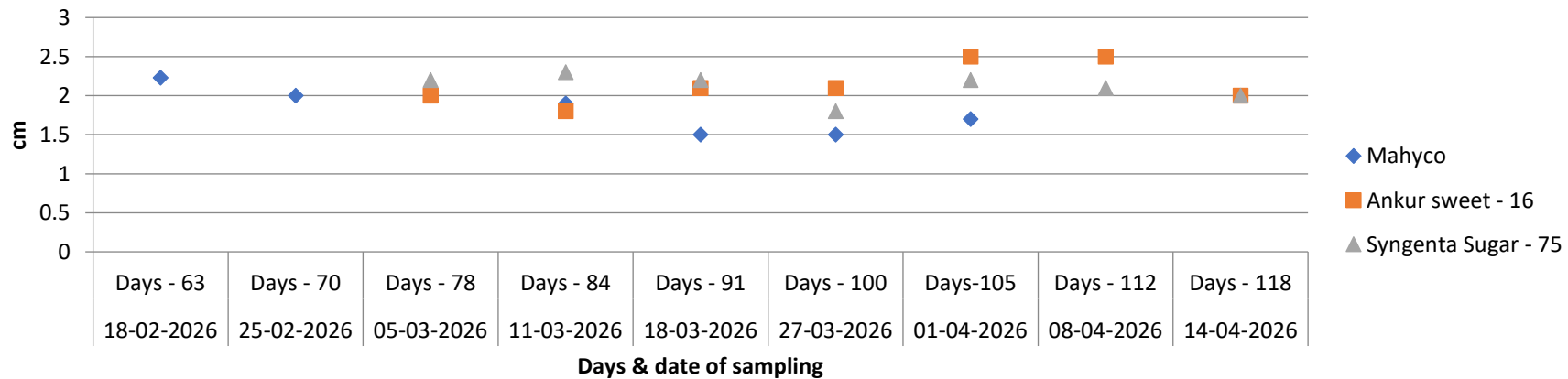
Date of sowing-10-12-25

Sweet corn varieties in plot-3

1.Plant Height (cm)

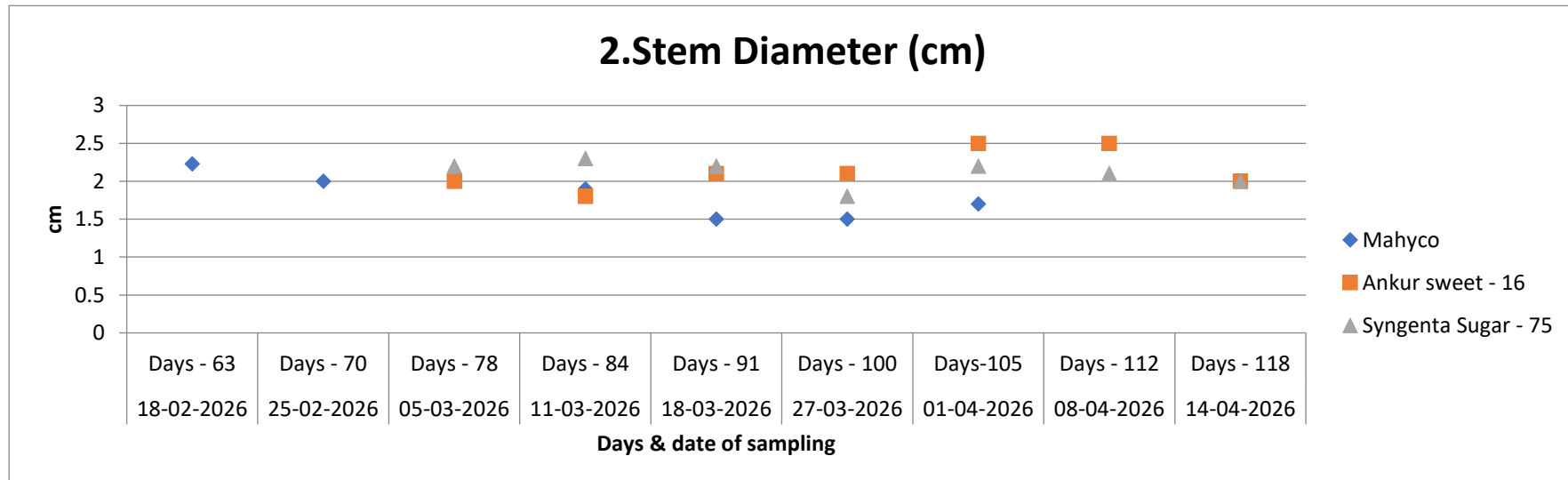
	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026	Mean	S.D	C.V %
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118			
Mahyco	164.3	161.7	166.4	155.6	166.2	168	187.8			167.1	9.26	5.5
Ankur sweet - 16			231.1	244.7	233.9	244.6	224.4	224.4	228.9	233.1	7.93	3.4
Syngenta Sugar -75			192.8	202.8	196.7	206.2	169.4	197.2	197.2	194.6	11.07	5.7

2.Stem Diameter (cm)



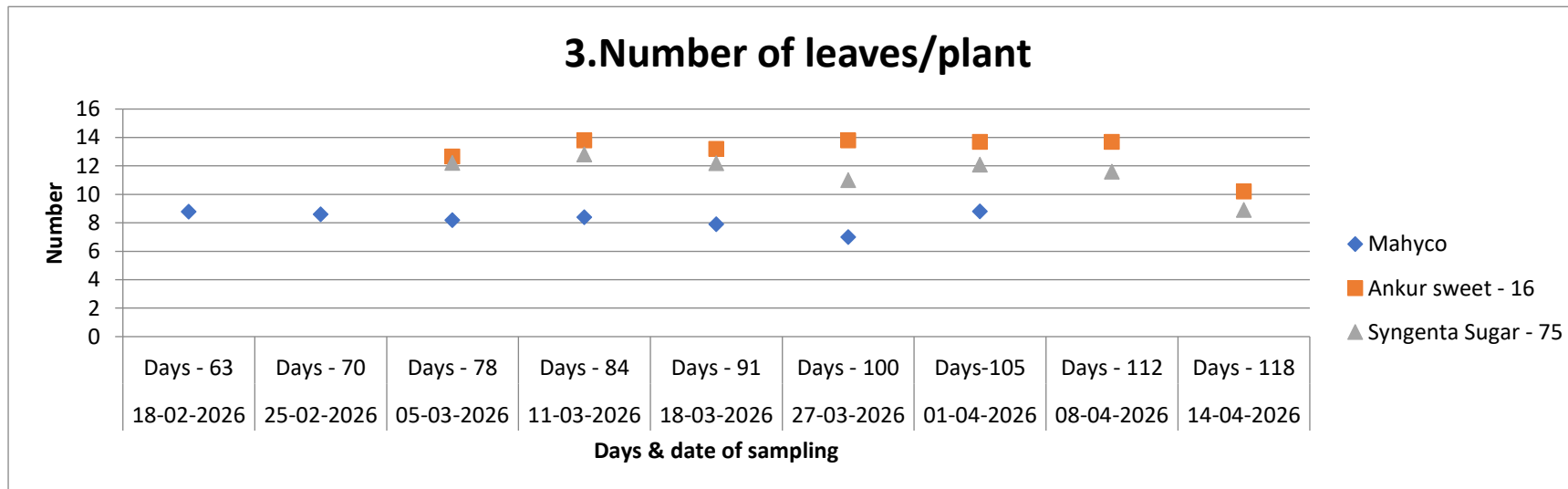
2.Stem Diameter (cm)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026	Mean	S.D	C.V %
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118			
Mahyco	2.23	2.0	2.0	1.9	1.5	1.5	1.7			1.83	0.25	13.97
Ankur sweet - 16			2.0	1.8	2.1	2.1	2.5	2.5	2.0	2.14	0.24	11.41
Syngenta Sugar - 75			2.2	2.3	2.2	1.8	2.2	2.1	2.0	2.11	0.15	7.35



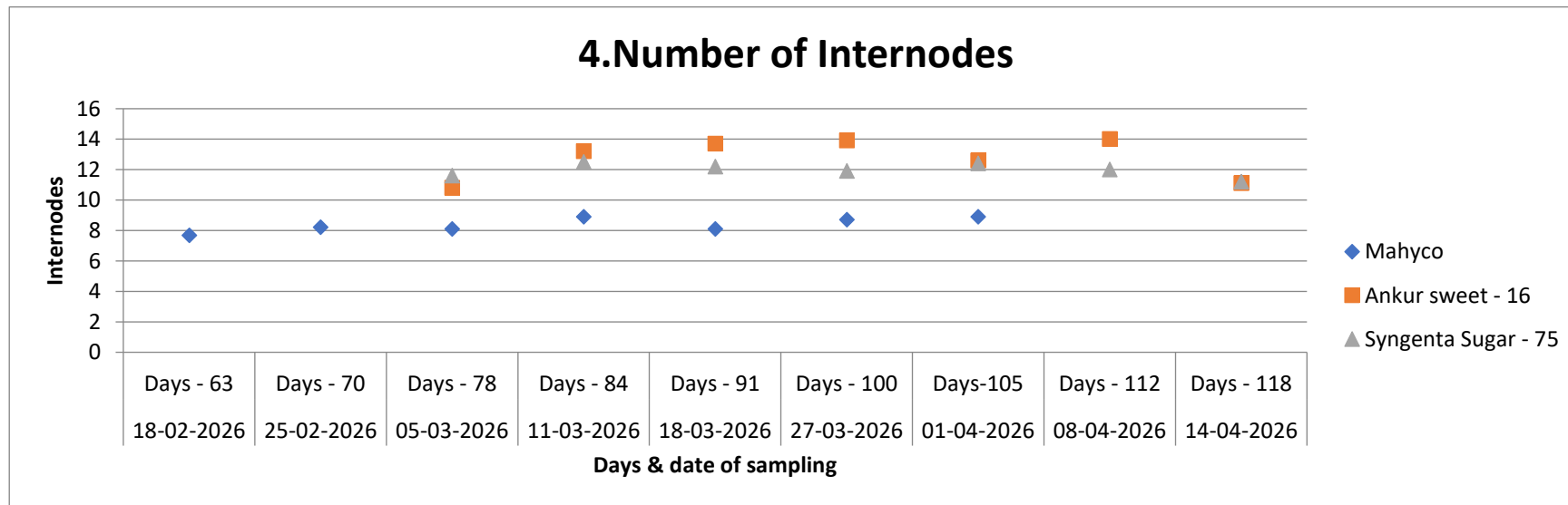
3.No. of leaves

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026	Mean	S.D	C.V %
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118			
Mahyco	8.78	8.6	8.2	8.4	7.9	7	8.8			8.24	0.59	7.13
Ankur sweet - 16			12.67	13.8	13.2	13.8	13.7	13.7	10.2	13.01	1.21	9.3
Syngenta Sugar - 75			12.22	12.8	12.2	11	12.1	11.6	8.9	11.54	1.2	10.39



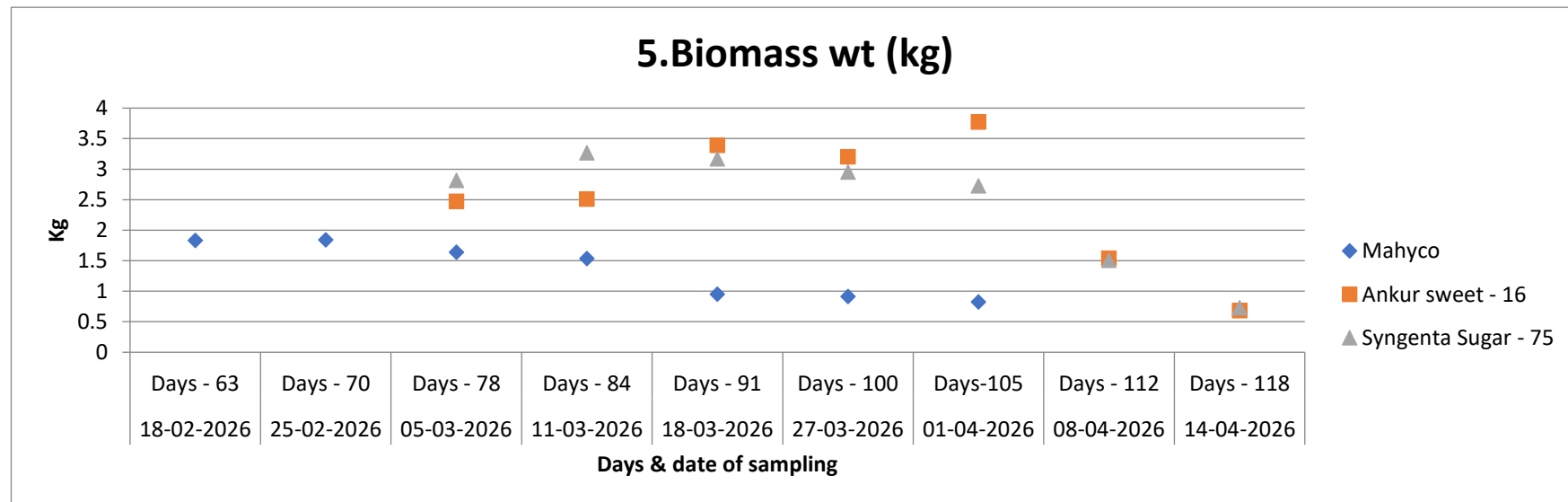
4.Number of Internodes

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026	Mean	S.D	C.V %
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118			
Mahyco	7.67	8.2	8.1	8.9	8.1	8.7	8.9			8.37	0.44	5.22
Ankur sweet - 16			10.8	13.2	13.7	13.9	12.6	14	11.1	12.76	1.23	9.61
Syngenta Sugar - 75			11.6	12.5	12.2	11.9	12.4	12	11.2	11.98	0.44	3.69



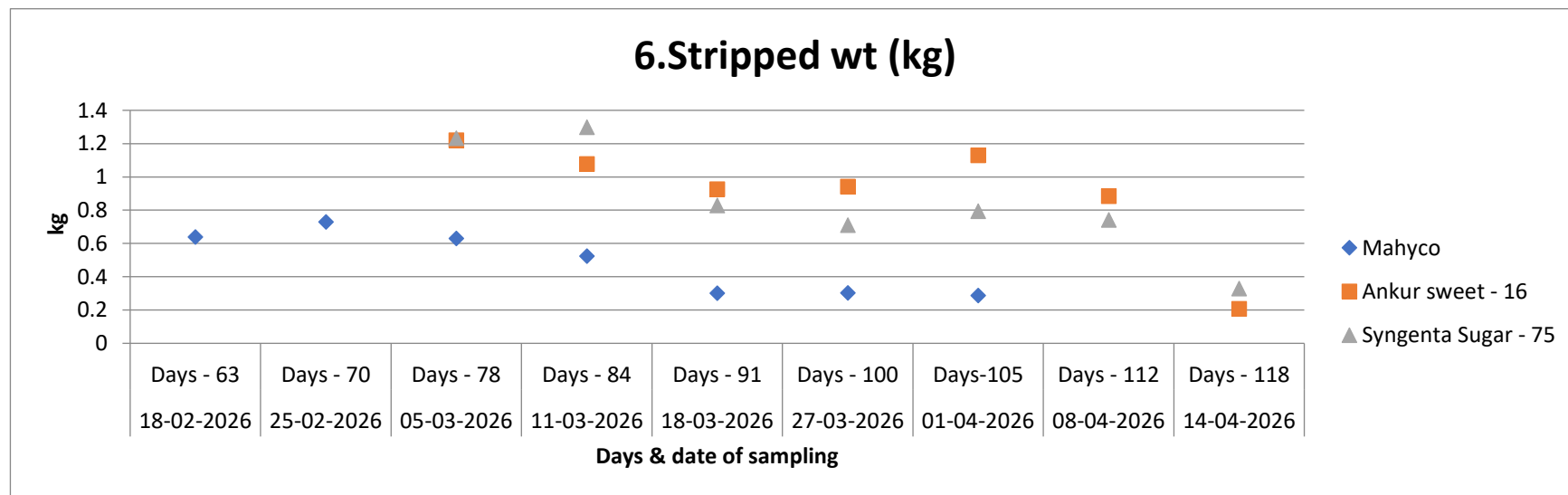
5.Biomass wt (kg)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118
Mahyco	1.83	1.839	1.637	1.533	0.948	0.91	0.821		
Ankur sweet - 16			2.47	2.51	3.39	3.202	3.769	1.537	0.682
Syngenta Sugar - 75			2.816	3.267	3.169	2.951	2.725	1.503	0.726



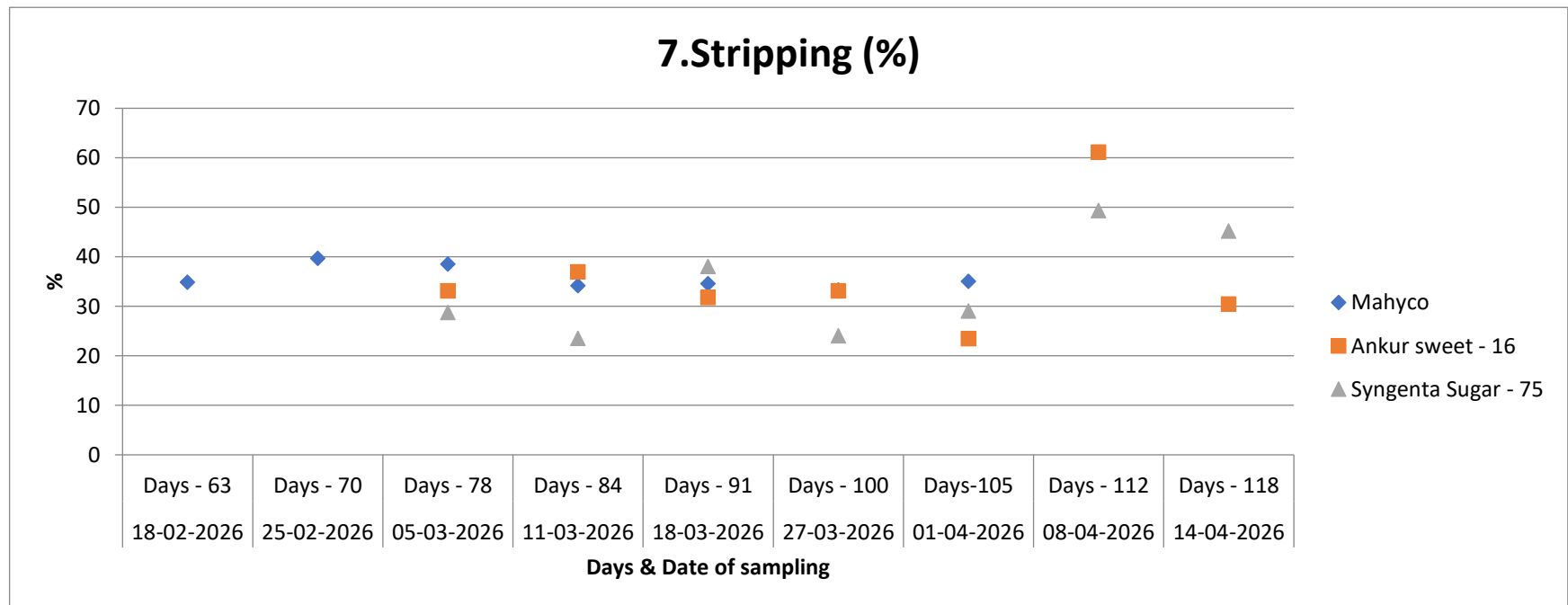
6.Stripped wt (kg)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118
Mahyco	0.639	0.730	0.631	0.524	0.301	0.303	0.288		
Ankur sweet - 16			1.221	1.077	0.927	0.942	1.129	0.884	0.208
Syngenta Sugar - 75			1.233	1.299	0.828	0.71	0.793	0.742	0.329



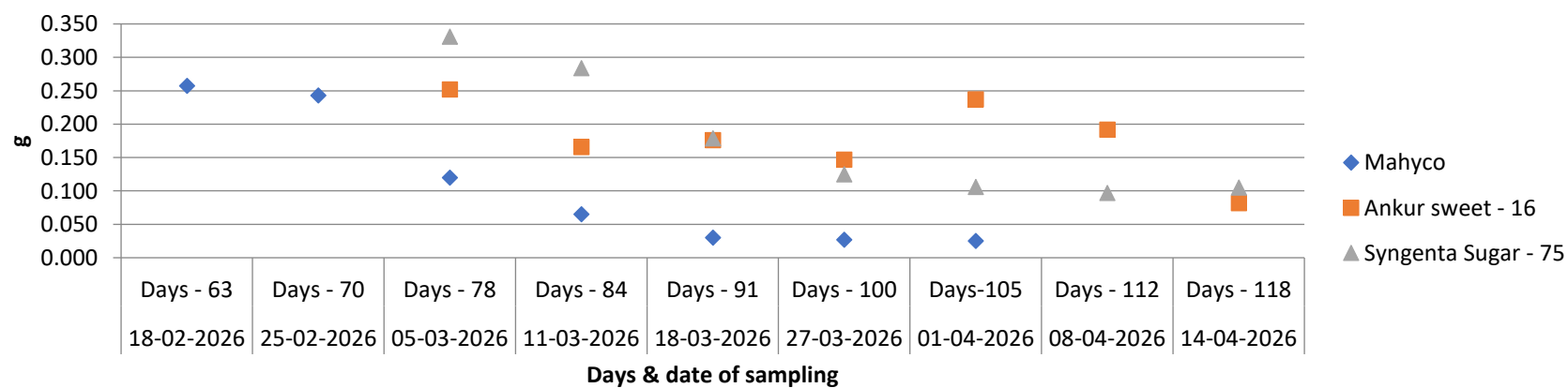
7.Stripping (%)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026	Mean	S.D	C.V %
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118			
Mahyco	34.92	39.7	38.55	34.18	31.75	33.3	35.08			35.35	2.62	7.4
Ankur sweet - 16			49.43	42.91	27.34	29.42	29.95	57.51	30.5	38.15	10.98	28.8
Syngenta Sugar - 75			43.78	39.76	26.13	24.06	29.1	49.37	45.32	36.79	9.44	25.6



8.Juice wt (g)

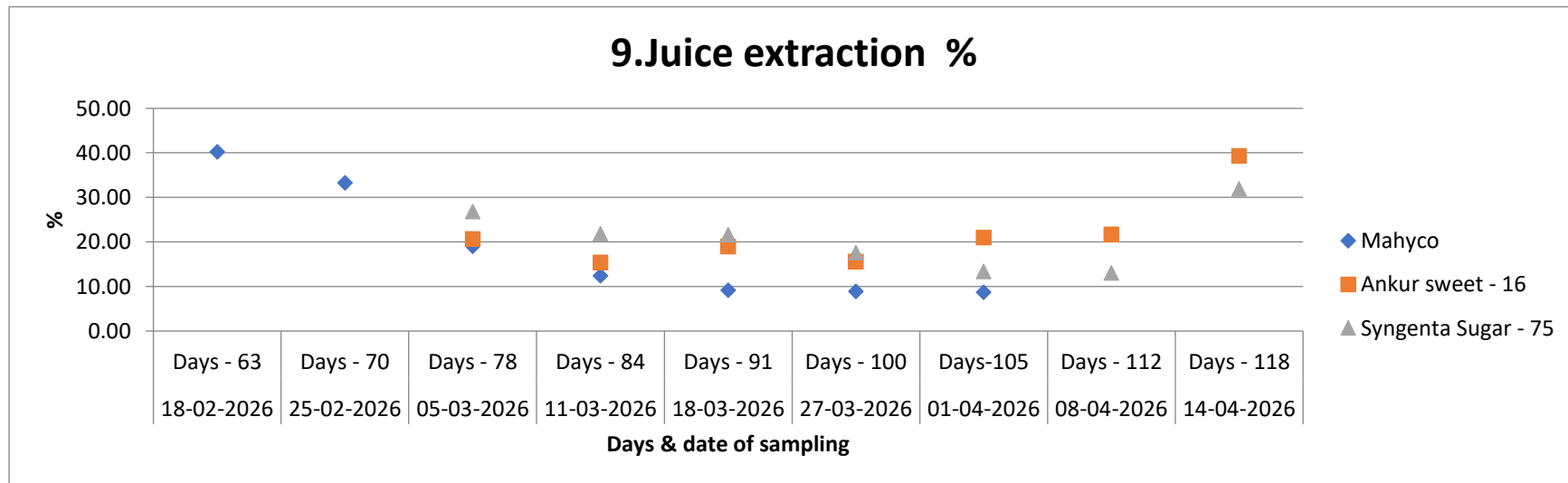
	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118
Mahyco	0.257	0.243	0.12	0.065	0.030	0.027	0.025		
Ankur sweet - 16			0.252	0.166	0.176	0.147	0.237	0.192	0.082
Syngenta Sugar - 75			0.331	0.284	0.179	0.125	0.106	0.097	0.105

8.Juice wt (g)

9.Juice extraction %

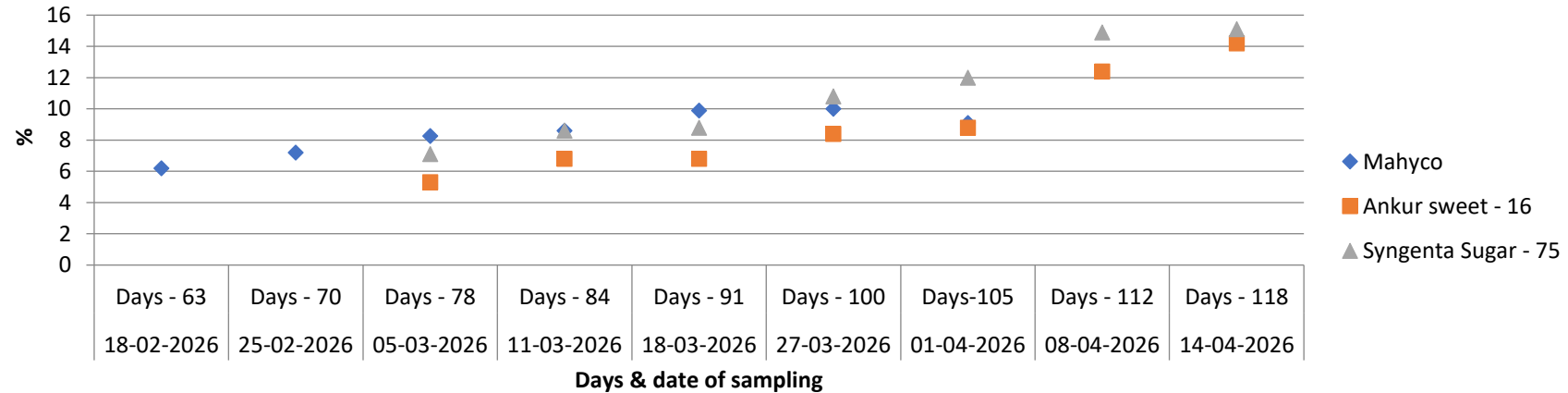
)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118
Mahyco	40.22	33.29	19.02	12.4	9.15	8.91	8.68		
Ankur sweet - 16			20.64	15.41	18.99	15.60	20.99	21.72	39.33
Syngenta Sugar - 75			26.84	21.86	21.62	17.6	13.37	13.07	31.91



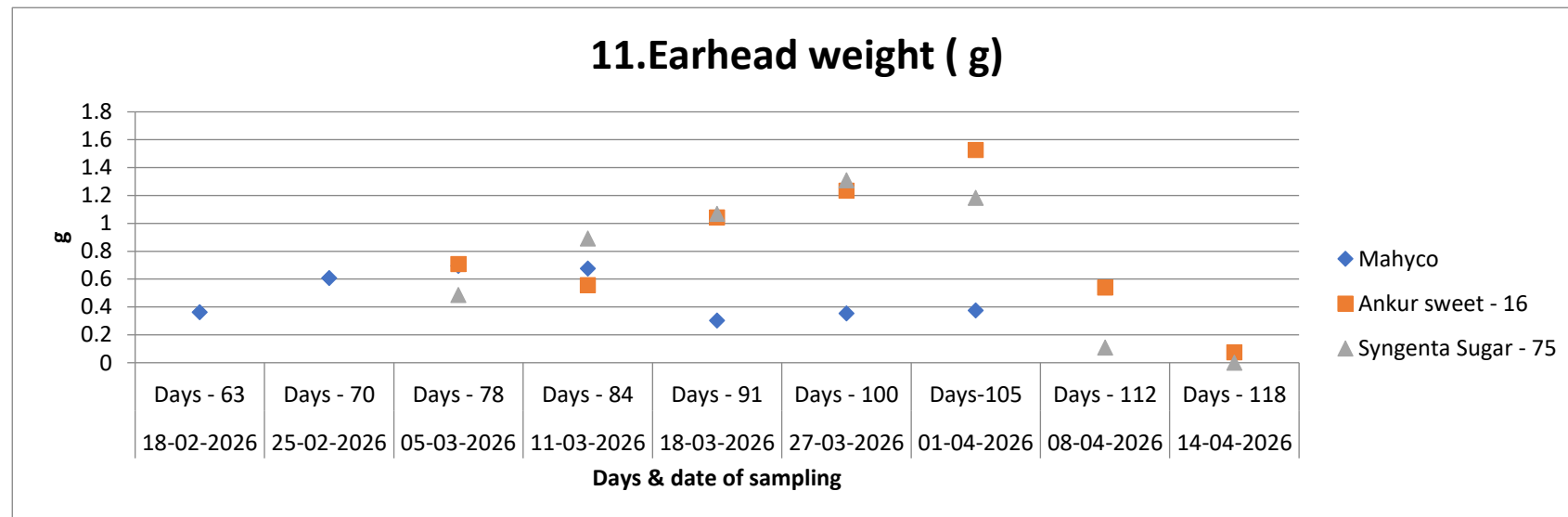
10. Stalk juice Brix (%)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118
Mahyco	6.2	7.2	8.27	8.6	9.9	10	9.1		
Ankur sweet - 16			5.3	6.8	6.8	8.4	8.8	12.4	14.2
Syngenta Sugar - 75			7.1	8.6	8.8	10.8	12	14.9	15.1

10. Stalk juice Brix (%)

11.Earhead weight (g)

	18-02-2026	25-02-2026	05-03-2026	11-03-2026	18-03-2026	27-03-2026	01-04-2026	08-04-2026	14-04-2026
	Days - 63	Days - 70	Days - 78	Days - 84	Days - 91	Days - 100	Days-105	Days - 112	Days - 118
Mahyco	0.362	0.607	0.694	0.676	0.303	0.353	0.374		
Ankur sweet - 16			0.707	0.556	1.042	1.234	1.527	0.539	0.074
Syngenta Sugar - 75			0.485	0.890	1.068	1.309	1.183	0.108	0



Appendix 5

Basic information of Sweet Sorghum Rabi trial -2025-26 in plot-19

Sr.no	Field operation	Date
1	Double Cultivation	01-09-2025
2	Furrow opening	01-09-2025
3	Mending of furrows	14-11-2025 ,16-11-2025
4	Sowing	18-11-2025
5	Thinning	29-11-2025
6	Spraying Rogor (Dimethoate) & Hamla(Chlorpyrifos+ Cypermethrin)	03-12-2025,16-12-2025, 30-12-2025,05-01-2026
7	Fertilizer application	18-11-2025, 12-12-2025
8	Weeding	11-12-2025,31-01-2026,
9	Irrigation given	18-11-2025,12-12-2025,19-01-2026, 10-02-2026,
10	Selfing (covering earheads with nylon net)	05-02-2026,12-02-2026,
11	Sampling of 5 plants	18-03-2026, 20-03-2026
12	Harvesting	21-03-2026, (22-03-2026,24-03-2026-border)
13	Threshing	28-03-2026,30-03-2026, 31-03-2026,01-04-2026

Selfing- Panicle covered by a brown paper bag before anthesis

Plot size-0.9 x 1x 4 meter long

Maintenance Evaluation of Station germplasm

Sr.no	Entry	Final plant stand /ha	Plant height (cm)	Stem diameter (cm)	Days to 50% flowering	5 plant biomasses (kg)	5 plant stripped stalk wt (kg)	Stripping%	5 Plant Juice wt (g)	Juice extraction%	Juice Brix	5 plant Panicle weight (g)	Seed yield (kg/ha)	Shoot fly damage %	Stem borer damage %
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	NARI-LC-7-29-1	79167	269.5	1.2	81	1.415	0.740	52	269	36	10	33	5674	6	0
2	NARI-LC-7-38	84722	264.4	1.1	78	1.143	0.498	43	105	22	11	36	4674	3	0
3	NARI-SS-48	77778	245.0	1.1	82	1.502	0.880	58	18	22	12	35	4342	7	0
4	NARI-SS-141	65278	175.0	1.4	87	1.462	0.541	37	121	23	11	44	5074	10	0
5	NARI-SS-203	80556	235.3	1.1	82	0.879	0.423	49	70	17	8	25	5524	9	0
6	NARI-SS-228	70833	268.0	1.3	83	1.756	1.094	72	142	13	13	33	3886	7	0
7	NARI-SS-235	63889	253.0	1.3	87	1.417	0.940	68	199	21	12	48	5190	3	0
8	NARI-SS-260	80556	255.6	1.4	80	1.455	0.897	62	219	25	11	43	7832	3	0
9	Madhura-1(C)	79167	259.3	1.2	79	1.237	0.652	53	145	22	9	37	7265	7	0
10	Madhura-2(C)	84722	267.0	1.5	80	1.801	0.756	42	169	22	9	33	8367	9	0
11	Madhura-3 (C)	95833	231.0	1.2	76	1.22	0.693	55	229	35	11	37	11347	13	0
	General Mean	78416.7	247.5	1.25	81.00	1.39	0.740	53.7	170	23.43	10.63	37	6277.77	6.86	-
	C.D. (0.05)	NS	NS	NS	5.69	NS	NS	NS	NS	NS	NS	NS	NS	NS	-
	SEM $\pm$	10722.2	10.1	0.09	1.81	0.15	0.11	6.75	0.04	4.73	1.25	0.07	1888.89	1.91	-
	C.V. %	19.4	5.77	10.56	3.15	15.71	20.77	17.78	31.36	28.58	16.61	26.75	42.60	39.44	-

(C)= Control

Sr.no	Entry	Final plant stand /ha	Plant height (cm)	Stem diameter (cm)	Days to 50% flowering	5 plant biomass (kg)	5 plant stripped stalk wt (kg)	Stripping%	5 Plant Juice wt (g)	Juice extraction%	Juice Brix	5 plant Panicle weight (g)	Seed yield (kg/plot)	Seed yield (kg/ha)	Shoot fly damage %	Stem borer damage %
1	NARI-SS-22	41667	275	1.2	81	1.079	0.427	40	29	7	11	376	0.839	2331	12	0
2	NARI-SS-56	94444	223	1.5	81	1.590	0.937	59	81	9	16	271	1.203	3342	7	2
3	NARI-SS-58	66667	248	1.2	81	1.440	0.735	51	78	11	14	140	0.752	2089	11	0
4	NARI-SS-130	83333	280	1.4	76	1.085	0.567	52	41	7	13	277	0.782	2172	16	0
5	NARI-SS-131	47222	259	0.9	85	0.888	0.487	55	12	2	14	129	0.626	1739	8	1
6	NARI-SS-135	69444	225	1.2	76	0.960	0.551	57	49	9	15	96	1.224	3400	10	1
7	NARI-SS-144	88889	263	1.2	81	0.838	0.469	56	19	4	13	600	1.127	3131	9	0
8	NARI-SS-150	77778	247	1	78	0.91	0.494	54	16	3	12	315	0.665	1847	10	1
9	NARI-SS-180	52778	265	1.3	88	0.986	0.703	71	62	9	9	380	0.784	2178	14	0
10	NARI-SS-180-1	75000	260	1.4	88	1.652	0.878	53	98	11	14	368	1.348	3744	8	3
11	NARI-SS-222	61111	247	1.3	84	1.490	0.721	48	34	5	11	483	1.235	3431	16	0
12	NARI-SS-222-1	72222	242	1.7	88	1.05	0.435	41	11	3	14	346	2.073	5758	28	2
13	NARI-SS-227	69444	232	1.2	78	1.606	0.896	56	48	8	17	290	2.463	6842	8	0
14	NARI-SS-228	77778	265	1.3	84	1.856	1.203	65	143	12	18	242	0.745	2069	23	0
15	NARI-SS-228-1	47222	297	1.3	88	1.184	0.701	59	17	2	13	245	0.852	2367	14	1
16	NARI-SS-233	86111	284	1.2	85	1.609	0.914	57	56	6	15	250	1.358	3772	5	0
17	NARI-23-1	80556	241	1.3	81	2.093	0.888	42	95	11	12	242	1.196	3322	10	0
18	NARI-LC-07-08	72222	245	0.7	78	1.025	0.466	45	15	3	9	92	0.881	2447	4	0
19	NARI-LC-07-12	94444	239	1.4	78	1.315	0.672	51	45	7	13	217	1.718	4772	9	0
20	NARI-LC-07-121	94444	257	1.2	78	1.008	0.676	67	35	5	14	215	0.703	1953	6	0
21	NARI-LC-07-18	80556	262.6	1.4	78	1.385	0.764	55	94	12	13	77	0.408	1133	7	0
22	NARI-LC-07-36	86111	240	1.4	78	1.79	0.865	48	14	2	14	212	0.768	2133	4	0
23	NARI-LC-07-64	88889	247	1.2	78	1.259	0.66	52	94	14	13	255	1.784	4956	8	0
24	NARI-LC-07-76	91667	247	1.4	78	1.543	0.743	48	28	4	10	290	1.052	2922	7	0
25	NARI-LC-07-79	77778	275	1.2	78	1.829	1.002	55	138	14	13	348	0.397	1103	5	0
26	NARI-LC-07-91	80556	258	1	78	0.947	0.416	44	107	26	11	248	0.864	2400	9	0

Appendix 6

Comparison of soil analysis data of NARI Farm carried out at KVK Baramati and College of horticulture, Phaltan

	KVK Baramati	Horticultural college Phaltan	KVK Baramati	Horticultural college Phaltan	KVK Baramati	Horticultural college Phaltan	KVK Baramati	Horticultural college Phaltan	KVK Baramati	Horticultural college Phaltan
	Plot no-2		Plot no-5		Plot no-6		Plot no-8		Plot no-9B	
Acidity / Alkalinity (pH)	8.16	8.27	8.21	8.18	8.30	8.19	8.44	8.14	8.14	8.22
Alkalinity (EC) (deciSym/m)	0.20	0.35	0.21	0.28	0.20	0.3	0.20	0.25	0.71	0.29
Organic Carbon (%)	1.11	0.44	0.93	0.45	1.14	0.47	1.32	0.48	1.44	0.5
Available Nitrogen (N) (kg/ha)	113	326.1	138.00	313.6	125.00	301.1	150.00	288.5	347	276
Available Phosphorus (P) (kg/ha)	12.81	40.32	9.76	42.56	10.30	33.6	11.20	31.36	19.89	38.08
Available Potassium (K) (kg/ha)	632	372.7	273.00	334.9	387.00	369.8	652.00	372.7	427.00	381.5
Sodium (Na) (meq/L)	3.94	-	4.22	-	4.79	-	3.04	-	2.73	-
Free Lime (Ca) (%)	19.50	-	23.00	-	20.00	-	23.50	-	22.00	-
Iron (Fe) (ppm)	0.20	3.64	0.53	3.96	0.31	3.76	0.26	3.3	0.46	3.12
Manganese (Mn) (ppm)	0.05	1.12	0.10	1.74	0.19	1.7	0.09	1.68	0.19	1.6
Zinc (Zn) (ppm)	0.05	0.46	0.09	0.5	0.06	0.56	0.07	0.48	0.06	0.4
Copper (Cu) (ppm)	0.61	0.04	1.03	0.08	0.76	0.16	0.73	0.14	0.29	0.18
Sulphur (S) (ppm)	8.51	-	7.46	-	10.27	-	8.37	-	13.27	-
Boron (B) (ppm)	0.12	-	0.09	-	0.10	-	0.14	-	0.10	-

Comparison of soil analysis data of NARI Farm carried out at KVK Baramati and College of horticulture, Phaltan (contd.)

	KVK Baramati	Horticultural college Phaltan	KVK Baramati	Horticultural college Phaltan	KVK Baramati	Horticultural college Phaltan
	Plot no-23		Plot no-24 A		Plot no-24 B	
Acidity / Alkalinity (pH)	8.39	8.24	8.28	8.1	8.33	8.11
Alkalinity (EC) (decSym/m)	0.20	0.32	0.19	0.19	0.18	0.22
Organic Carbon (%)	0.90	0.41	0.78	0.39	1.56	0.42
Available Nitrogen (N) (kg/ha)	125 .0	351.2	138 .0	376.3	113 .0	301.1
Available Phosphorus (P) (kg/ha)	11.02	35.84	11.37	38.08	11.11	44.8
Available Potassium (K) (kg/ha)	355 .0	384.4	615 .0	378.6	356 .0	364
Sodium (Na) (meq/L)	4.78	-	1.72	-	4.20	-
Free Lime (Ca) (%)	17 .0	-	16 .5	-	17 .5	-
Iron (Fe) (ppm)	0.41	3.54	0.13	3.7	0.30	3.64
Manganese (Mn) (ppm)	0.10	1.5	0.08	1.56	0.06	1.6
Zinc (Zn) (ppm)	0.07	0.52	0.05	0.34	0.06	0.3
Copper (Cu) (ppm)	0.50	0.2	0.49	0.12	0.58	0.1
Sulphur (S) (ppm)	11.97	-	12.41	-	9.45	-
Boron (B) (ppm)	0.10	-	0.13	-	0.11	-

Appendix 7

Testing of ARTI organic fertilizer on hybrid maize at NARI, Tambmal, Phaltan

Basic information	
Plot size:	4 sqm (gross)
Replications:	4
Treatments:	6
Weeding (fallow furrows)	11-07-2025
Sowing & organic fertilizer application	15-07-2025
Irrigation	16-07-2025,4-08-25,13-08-25,29-08-25
Spraying (Dimethoate)	22-07-2025
Spraying (Chlorpyriphos 50% + Cypermethrin 5 % EC)	25-07-2025,6-8-25
Date of weeding	24-07-2025,9-08-25,12-08-25,25-08-25
Dsate of harvesting	06-11-2025

Trial 1: Testing of ARTI organic fertilizer on hybrid maize at NARI ,Tambmal, Phaltan

Sr.No.	Treatment	Initial plant stand/ gross plot	Final plant stand/ net plot	Plant height (cm) on 18-08-2025. Mean of of 5 plants	Plant height (cm) on 22-08-2025. Mean of 10 plants	Fresh weight /10 plants (Kg) Recorded on 6-11-2025	Earhead weight /10 plants (Kg) Recorded on 6-11-2025	Seed weight / net plot (kg)	Seed yield (kg/ha)
1	Untreated control	46	21	77.50	94.33	3.60	1.39	1.707	8534
2	Chemical control 300 kg/ha (30 g per sq.m) of 15:15:15)	45	19	82.50	100.39	3.86	1.78	1.977	9884
3	Organic fertilizer = 1 g / sq.m	41	20	83.50	95.15	4.09	2.20	1.921	9605
4	Organic fertilizer = 2 g / sq.m	48	19	78.00	98.63	4.08	1.66	1.479	7393
5	Organic fertilizer = 3 g / sq.m	46	22	78.50	99.68	3.73	1.72	1.705	8524
6	Organic fertilizer = 4 g / sq.m	45	21	79.25	103.20	3.91	1.84	1.769	8843
	General Mean	44.92	20.25	79.88	98.56	3.88	1.77	1.76	8800
	C.D. (0.05)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	SEM $\pm$	2.40	1.30	2.64	2.25	0.19	0.17	0.23	1150
	C.V. %	9.96	12.87	6.61	4.57	9.80	19.07	26.04	26.04

Trial 2 : Urea testing trial on hybrid maize at NARI ,Tambmal, Phaltan

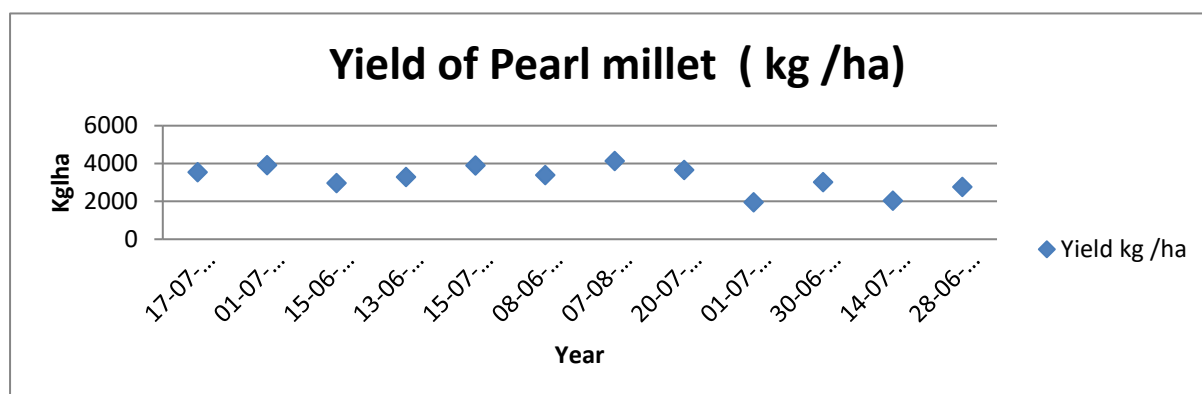
	Treatment	Initial plant stand/ gross plot	Final Plant Stand/ net plot	Plant height (cm) on 18-08-2025 Mean of 5 plants	Plant height (cm) on 22-08-2025 Mean of 10 plant	Fresh weight /10 plants (Kg)Recorded on 6-11-2025	Earhead weight /10 Plants (Kg)Recorded on -6-11-2025	Seed weight / net plot (kg)	Seed weight (kg/ha)
1	Untreated control	44	21	60.75	81.73	4.633	1.899	1.639	8193
2	Chemical control = (120 g of 15:15: 15 per gross plot)	43	21	59.25	84.33	4.952	2.320	2.539	12694
3	4 g urea /gross plot	45	20	58.50	85.60	4.068	1.681	1.919	9595
4	8 g urea/ gross plot	45	22	55.75	76.45	3.935	1.811	1.499	7495
5	12 g urea/ gross plot	42	18	61.00	77.58	4.616	2.111	1.793	8963
6	16 g urea/gross plot	45	22	62.25	80.20	4.363	2.002	2.050	10248
7	20 g urea/gross plot	44	22	56.00	81.23	5.113	2.244	2.254	11268
	General Mean	43.89	21.04	59.07	81.01	4.53	2.01	1.96	9800
	C.D. (0.05)	N.S	N.S	N.S	N.S	0.76	N.S	N.S	N.S
	SEM +	1.32	1.68	3.79	3.69	0.25	0.21	0.16	800
	C.V. %	6.03	15.99	12.83	9.11	11.23	21.30	16.84	16.84

Gross plot size = 4 sq.m

Appendix 8

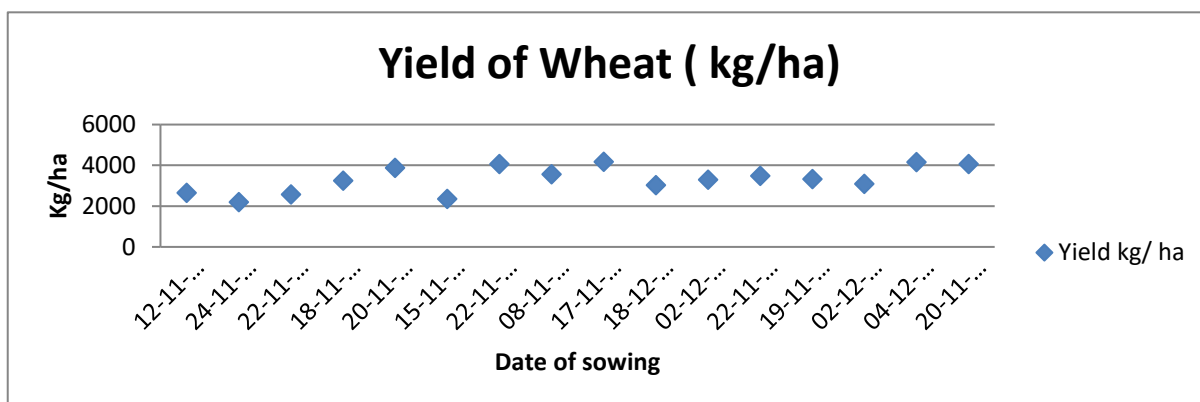
Crop	plot no	Area (ha)	Date of Sowing	Seed yield (kg/plot)	Seed yield (kg /ha)	Variety
Pearl millet	11	0.4	17-07-1998	1417.5	3544	Mahyco-267
Pearl millet	21,22,23	3.4	01-07-1999	13317.5	3917	Mahyco-267
Pearl millet	14	2.8	15-06-2000	8295	2963	Mahyco-204 (Calibre)
Pearl millet	20,22,27	1.3	13-06-2004	4277	3290	Mahyco-2210
Pearl millet	12,14,25	2.8	15-07-2005	10913	3898	Mahyco-204 (Calibre)
Pearl millet	14	0.8	08-06-2006	2710	3388	Mahyco-204 (Calibre)
Pearl millet	3,7,8	1.6	07-08-2016	6614.5	4134	Mahyco-204 (Calibre)
Pearl millet	19	1.2	20-07-2018	4403	3669	Sujalam-68
Pearl millet	5,7	1.4	01-07-2019	2729	1949	Mahyco-204
Pearl millet	4,10	1.6	30-06-2020	4844	3028	Mahyco-204
Pearl millet	24	1	14-07-2023	2035	2035	Mahyco-204
Pearl millet	5	0.5	28-06-2024	1385	2770	Mahyco-204
Mean					3215.42	
S.D.					673.63	
C.V. %					20.95	
Range					1949-3917	

Note: In 2019 and 2023 due to the very heavy rainfall of returning monsoon in September the seed yields were low.



Appendix 8 (Continued)

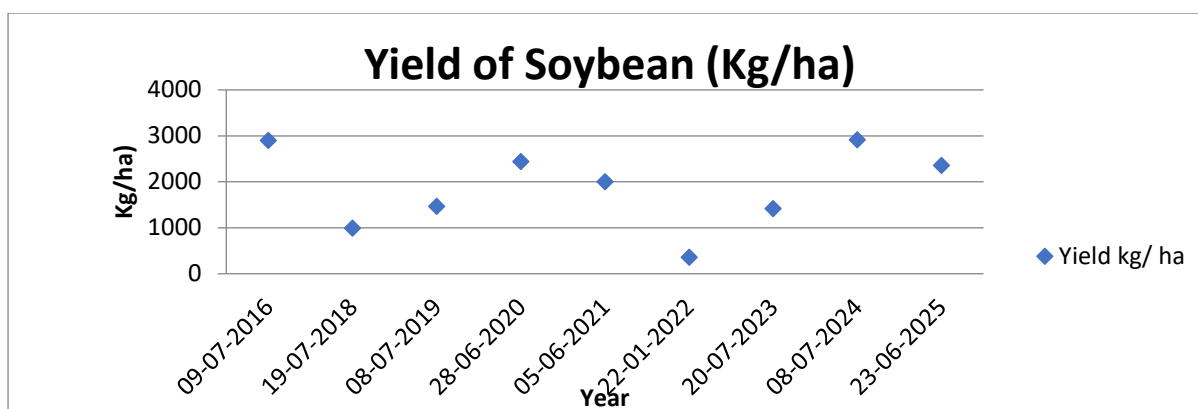
	plot no	Area (ha)	Date of Sowing	Seed yield (kg/plot)	Seed yield (kg /ha)	Variety
Wheat	21	1.6	12-11-1997	4250	2656	Gold-23
Wheat	23	3.1	24-11-1999	6843.5	2208	Gold-24
Wheat	19	0.4	22-11-2001	1028.11	2570	Gold-25
Wheat	2	0.4	18-11-2005	1301	3253	Mahalaxmi HD-2189
Wheat	3	0.8	20-11-2005	3107	3884	ANKUR-2189
Wheat	3,4	0.9	15-11-2011	2123	2359	Gold- 23
Wheat	16B	0.8	22-11-2013	3256.5	4071	Gold- 23
Wheat	16A,18	2.4	08-11-2014	8544	3560	Gold- 23
Wheat	19,24	3.2	17-11-2018	13382.5	4182	Gold- 23
Wheat	2,10	2.2	18-12-2019	6678	3035	Gold- 23
Wheat	5,7,18	2.2	02-12-2020	7267.5	3303	Gold- 71
Wheat	18	1.2	22-11-2022	4184	3487	Gold- 23
Wheat	10	1.2	19-11-2023	4000	3333	Gold- 23
Wheat	19	1	02-12-2024	3100	3100	Gold- 23
Wheat	2	0.6	04-12-2024	2500	4167	Shriram
Wheat	4,10,11	1.6	20-11-2025	6558	4073	Gold- 23
Mean					3327.56	
S.D.					627.10	
C.V. %					18.85	
Range					2208-4182	



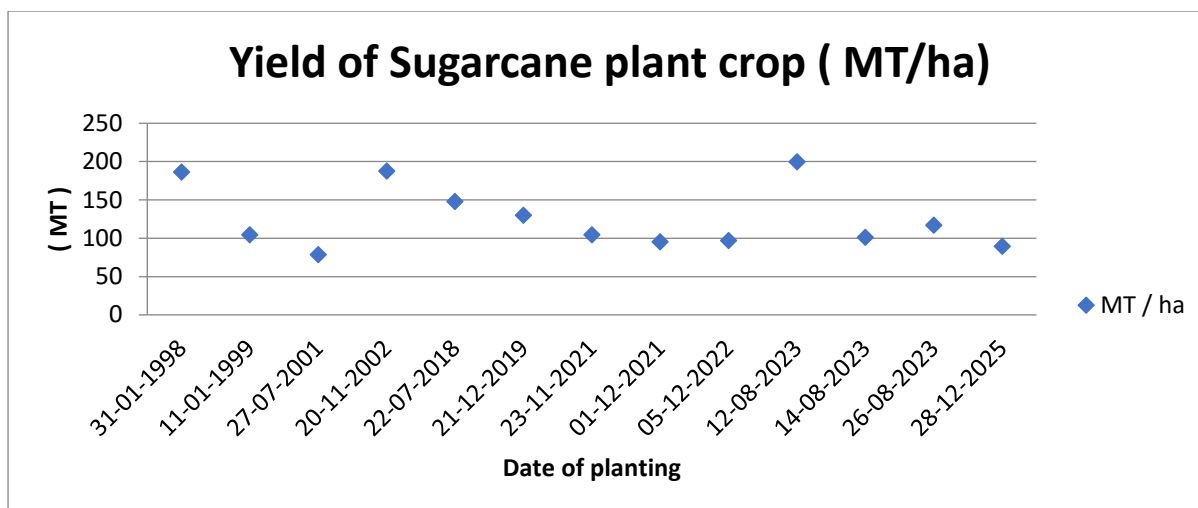
Appendix 8 (Continued)

Crop	plot no	Area (ha)	Date of Sowing	Seed yield (kg/plot)	Seed yield (kg /ha)	Variety	
Soybean	24	1.2	09-07-2016	3481	2901	MACS-1188	(Agharkar Research Institute)
Soybean	2	1	19-07-2018	996	996	GOLD 306	(Green Gold seeds Ltd.)
Soybean	10	1.2	08-07-2019	1763	1469	MACS-1188	
Soyabean	24	1	28-06-2020	2438	2438	MACS-1188	
Soybean	4	0.4	05-06-2021	800	2000	MACS-1188	
Soybean	10	0.8	22-01-2022	288	360	MACS 1281	
Soybean	19	1.2	20-07-2023	1700	1417	Phule Sangam	(Fule seeds)
Soybean	16A	0.8	08-07-2024	2330	2913	Yashoda-9041	(Yashoda Hybrid seeds Pvt.Ltd.)
Soybean	24	1	23-06-2025	2361	2361	Phule Sangam	
Mean					1872.78		
S.D.					826.06		
C.V. %					44.11		
Range					996-2913		

Note : January planting was carried out in 2022 to find out if Soybean can be planted during summer .
However, the performance was very poor. It can be used as a green manure crop in summer.

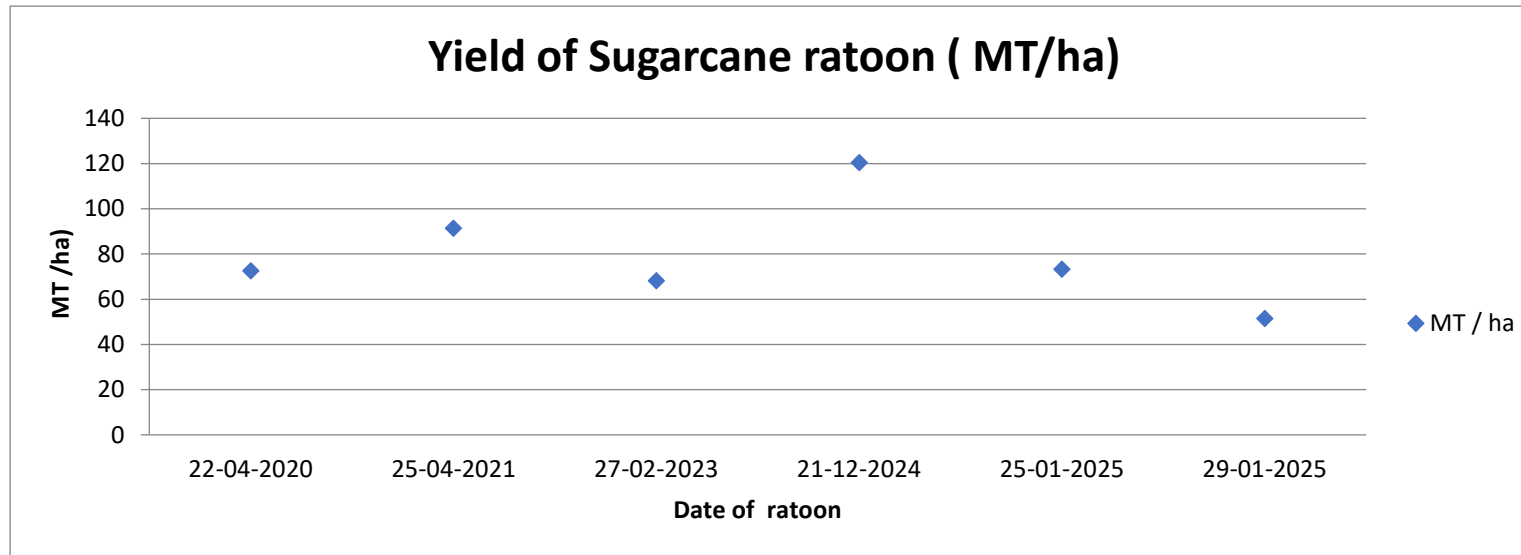


Crop		Area (sq.m)	Plot No	Date of Sowing	Variety	Total yield (MT/plot)	Yield (MT /ha)
Sugarcane		8000	18	31-01-1998	Co-7219	149	186.25
Sugarcane		12000	18	11-01-1999	Co-740	125	104.49
Sugarcane		8000	3	27-07-2001	Co-86032	62.85	78.57
Sugarcane		8000	7	20-11-2002	Co-86032	150	187.50
Sugarcane		12000	24	22-07-2018	Co-265	177.62	148.02
Sugarcane		4000	9	21-12-2019	Co-86032	52	130.00
Sugarcane		8000	16A	23-11-2021	Co-86032	83.59	104.49
Sugarcane		3000	6	01-12-2021	Co-86032	28.63	95.43
Sugarcane		10000	24	05-12-2022	Co-86032	97.129	97.13
Sugarcane		8000	23	12-08-2023	Co-86032	159.803	199.75
Sugarcane		2000	9	14-08-2023	Co-86032	20.271	101.36
Sugarcane		4000	8	26-08-2023	Co-86032	46.783	116.96
Sugarcane		8000	16A	28-12-2025	Co-86032	71 .577	89.47
Mean							126.11
S.D.							39.53
C.V. %							31.35
Range							78.6-199.7



	Area (ha)	Plot No	Date of ratooning	Variety	Stalk yield (MT/plot)	Stalk yield (MT /ha)
Sugarcane (ratoon)	1.2	24	22-04-2020	Co-265	87.01	73
Sugarcane (ratoon)	0.4	9	25-04-2021	Co- 86032	36.542	91
Sugarcane (Ratoon)	0.8	16A	27-02-2023	Co- 86032	54.499	68
Sugarcane (Ratoon)	0.8	23	21-12-2024	Co- 86032	96.298	120
Sugarcane (Ratoon)	0.4	8	25-01-2025	Co- 86032	29.294	73.24
Sugarcane (Ratoon)	0.2	9	29-01-2025	Co- 86032	10.286	51
Mean						79.37
S.D.						21.60
C.V. %						27.21
Range						51-120

Plot-No-9 Water accumulated due to poor drainage. Also Eucalyptus plantation next to it caused yield reduction due to shading and tree roots.



Sugarcane plant + ratoon crop yields

Area (Sq.m.)	Plot No.	Date of sowing	Variety	Total stalk yield (Plant crop + ratoon) MT/ha
12000	24	22-07-2018	CO-86032	148 + 73 = 221
4000	9	21-12-2019	CO-86032	130 + 91 = 221
8000	16A	23-11-2021	CO-86032	104 + 68 = 172
8000	23	12-08-2023	CO-86032	200 + 120 = 320
2000	9	14-08-2023	CO-86032	101 + 51 = 152
4000	8	25-01-2025	CO-86032	117 + 73 = 190
Mean				212.67
S.D.				54.02
C.V. %				25.4
Range				172-320

SUMMARY SHEET OF WEATHER DATA. 2025 -2026

Nimbkar Agricultural Research Institute (NARI) PHALTAN-415523

Month	Air Temperature (°C)		Rainfall (mm)	Rainy days	Pan evaporation mm/day	Wind Direction	Relative humidity (%)		Relative humidity (%)		Nature of sky Octa grade (0-8)	
	Max	Min					Max	Min	8 a.m.	2 p.m.	Morning	Evening
April	44.15	20.93	3.30	0.00	7.87	SW	77.90	26.73	77.80	31.63	0.37	1.90
May	37.94	21.74	396.10	11	5.36	NE	94.35	57.65	94.00	60.00	2.94	5.03
June	34.10	21.95	93.50	13	3.37	NE	100.00	72.77	100.00	75.77	2.83	4.63
July	32.25	21.26	22.40	10	2.91	SW	100.00	77.06	100.00	79.97	2.74	3.58
August	32.81	21.10	67.80	14	2.49	NE	100.00	71.45	100.00	73.94	3.16	4.35
September	33.4	20.38	135.70	9	2.99	SE	100.00	74.3	100.00	76.20	3.17	3.50
October	35.18	19.92	83.20	7	3.18	SE	99.23	56.39	99.23	59.29	1.19	1.45
November	33.67	13.92	1.60	1	2.91	NW	100.00	40.37	99.77	42.30	1.40	1.40
December	32.35	9.21	0	0	2.69	NW	97.00	33.77	97.00	35.61	0.00	0.10
January	33.10	12.82	0.55	1	2.89	NW	97.42	38.65	97.35	40.61	0.16	0.55
February	36.27	14.32	0	0	4.24	NW	95.21	34.29	95.18	36.36	0.00	0.21
March	40.44	17.52	15.10	2	5.92	SE	87.39	29.81	87.16	32.29	0.03	0.39
Mean	35.47	17.92	819.25	68.00	3.90	SE	96	51	96	54	1	2

Visitors during the year (HO)

Visits by groups during the year to learn about NARI's work

Date	No. of persons in group	Type of group	Place
29/8/2025	6 students	B.Sc. (Hons) Agri.	Lokmangal College of Agriculture, Wadala, Dist. Solapur
2/3/2026	19 students	B.Sc. (Horti.)	Shrimant Shivajiraje College of Horticulture, Phaltan (RAWE programme)

Visits during the year to NARI

Date	Name of visitor	Organization	Purpose of visit
18/10/2025	Shantanu, Nitin and Sumit Devkar and Nitin Shinde	Dahiwadi	To learn about institute activities
21-22/11/2025	Sriram Gangadhar	Bio-India Biologicals Corporation, Hyderabad	To learn about safflower cultivation practices for growing safflower in Telangana for flower production.
27/12/2025	Suraj Ashok Shinde	Phaltan	To learn about Opuntia cultivation and take planting material
12/1/2026	Shrikant and Manasi Palkar	Dharma Civilization Foundation, Seattle, Washington, USA	To invite Dr. Rajvanshi to give a keynote speech at the Dharma in Digital Age Conference in Houston.

Publications, videos and podcasts

1. [Motivating India's youth: Why students remain largely disconnected from the India story](#). Published in South Asia Monitor. 2 April 2025.
2. A nice story on our work of providing clean drinking water to rural schools was [published in Better India, 3 April 2025](#).
3. [Science behind Pranayama](#). April 2025.
4. [A tribute to my dear friend Madhur Bajaj](#) who passed away on 11 April 2025. It was also [published in South Asia Monitor, 11 April 2025](#).
5. [What is Death and can we reduce its fear](#). May 2025. [Audio of the file is here](#).
6. [How Spirituality Helps the Discovery Process](#). Published in [South Asia Monitor, 10 June 2025](#).
7. [Why we Sleep and Dream?](#) A neurobiological basis of sleep and dreams. Also [published in South Asia Monitor, 7th July 2025](#).
8. [AI Tools are great – Yet no match to human ingenuity](#). An article on what deep AI research can and cannot do. Also [published in South Asia Monitor, 21 August 2025](#).
9. [Student suicides in India](#). Published in [South Asia Monitor, 8 September 2025](#).
10. [Caring for Young and Sensitive Hearts](#). Op-ed article in Times of India, 10 September 2025.
11. [My Vision of India](#). A vision document released on Gandhi Jayanti, 2 October 2025.
12. [What is Death and Can we Reduce Its Fear?](#) A detailed article on the nature of death, as explained via neurobiological and physical basis, and fear associated with it. October 2025
13. [How to Live a Good and Meaningful Life – Art of Living](#). Distillation of my writings on this subject. October 2025.
14. [2025 Economics Nobel Prize: Can India Offer Its Own Development Model?](#) Published in South Asia Monitor, 23 October 2025.

15. [Cloud Seeding – Scientist’s Nightmare: Politicians Delight](#). Published in [South Asia Monitor](#), 3 November 2025.
16. [Planting Trees in City is like Planting Clean Air](#). Published in [The Tribune](#), 9 November 2025.
17. [Ancient Indian Philosophers understood Time just like modern physicists do](#). Published in [South Asia Monitor](#), 20 November 2025 and a shorter version appeared as [Op-ed in Times of India](#). 17 December 2025
18. [Untold Story of Sweet Sorghum Research at NARI](#). Human interest story of sweet sorghum R&D at NARI from 1970s. December 2025. [Published in Boloji](#) 20 December 2025.
19. [Schools as Shrines of Knowledge](#). Article published in [The Tribune](#), 12 February 2026.
20. [Romance of Innovation: How to Live a Meaningful Life in Rural India](#). Published in [South Asia Monitor](#), 13 February 2026.
21. [Learning from nature: The power of biomimicry in engineering design](#). An article published in [The Tribune](#), 18 February 2026. The [original article with the links is here](#).
22. [AI and Children: Proper Teaching of AI in Schools a Must to Fire Creativity](#). [South Asia Monitor](#), March 16, 2026.

Videos

1. [Connected to the story of India – Life lessons from a Spiritual Engineer](#). A short film about the life and work of Anil Rajvanshi. July 2025.
2. [Innovating for a Self-Reliant Rural India: Challenges, Frugality, and Scale in R&D](#). Anil Rajvanshi’s Interview with Mr. Aroop Zutshi of Frost & Sullivan Institute. July 2025.
3. Anil K Rajvanshi participated in [People Matters HR Tech India](#) 2025 in Delhi as one of the keynote speakers. HR 25 was one of the largest HR events in Asia. The [video of the fireside chat is here](#). [People Matters also put out a nice story on the event](#). August 2025.

4. [An Epidemic of Suicides in India](#). An interview Of Anil Rajvanshi conducted by Mayank Chhaya. 19 September 2025.

Books

E-book: Anil K. Rajvanshi [“Deep Science in Ancient Indian Philosophical Thought.”](#) November 2025. Also [available in Kindle stores](#).

Podcasts

[Life Lessons from a Spiritual Engineer](#). Podcast of Anil K Rajvanshi. June 2025.

Animal Husbandry Division
Nimbkar Agricultural Research Institute
Annual Report
1 April 2025 to 31 March 2026

Highlights of the year

- a. Our unique and highly successful breeding program of **NARI Suwarna sheep** carrying the *FecB* gene for prolificacy is now in its third decade. The breed became very popular in Karnataka over the last 20 years and now it is becoming popular in Maharashtra. We supplied 82 NARI Suwarna sheep in 2025-26 (38 rams and 44 ewes); 46 in Maharashtra, 31 in Karnataka and 5 in Gujarat (for the first time). We were able to supply this number with only about 230 breeding ewes, which indicates their high productivity. The popularity of NARI Suwarna among sheep owners also proves their productivity and resilience which can be attributed to the careful breeding practices we have followed over the years. As an example of appreciation of the breed by sheep owners, we quote below from an email message received on 31 May 2026 from Mr. Sufi Samiullah of Srinagar, Kashmir.

“I am writing to express my profound admiration and deep regards for the incredible, pioneering work your institution has been doing in the field of agricultural and livestock research. The dedication and scientific excellence displayed by NARI have truly transformed livestock farming across the country.

I am particularly captivated by the Nari Suwarna sheep breed. Having closely followed its development, impressive twinning rates, and overall resilience, I am truly fascinated with this breed and its massive potential. It is my passion and vision to establish an authentic Nari Suwarna breed farm right here in Srinagar, Kashmir. To turn this vision into reality, I am looking to establish a foundational flock and would deeply appreciate your guidance on procuring authentic, high-quality male and female Nari Suwarna sheep directly from your institution.”

NARI Suwarna ewes with their 2.5 months old twin lambs



We do not select for colour uniformity although some buyers prefer white sheep.



5 months old NARI Suwarna lambs with Lundy farm supervisors and workers

- b. **Another highlight of our NARI Suwarna breeding program** was the prestigious fellowship training program at AHD-NARI on 6 to 17 October 2025, of Dr. Amadou Traore from Burkina Faso (Africa) to learn about all aspects of the development and dissemination of NARI Suwarna sheep. Dr. Traore works at the Institute for Environmental and Agricultural Research in Ouagadougou and is the National Liaison Officer for Animal Genetic Resources for Burkina Faso. This fellowship was sponsored by the International Atomic Energy Agency (IAEA), Vienna under their technical cooperation program which provides assistance to developing countries. Dr. Pradip Ghalsasi and Mrs. Padmaja Ghalsasi played a significant role with his training. It is a matter of great significance for AHD-NARI that IAEA should select us for the fellowship program. The ICAR-Central Sheep and Wool Research Institute has also developed a breed carrying the *FecB* gene. But IAEA preferred AHD-NARI over them.



Padmaja Ghalsasi with Dr. Traore in the lab



Dr. Traore learning laparoscopy from Dr. Ghalsasi

c. Technical support to the project ‘Climate change mitigation initiatives managed and led by women farmers’ (CCMI-MWF):

Dr. Chanda Nimbkar and Dr. Pradip Ghalsasi of the Animal Husbandry Division of NARI provided technical support to field teams from local grantee organizations, tribal goat keepers and *pashu sakhis* under the Sir Dorabji Tata Trust-funded CCMI-MWF project over the year in the southern Aravali region of southern Rajasthan and northern Gujarat as well as to sheep rearers in two districts of Andhra Pradesh, adjoining Karnataka.

Through this project, AHD-NARI is further establishing its expertise (after giving technical support to Project Mesha in Bihar from 2018 to 2023) in this comparatively new but important field in India, of Community-based Small Ruminant Breeding Programs (CBBPs). During 2025-26, together with other organizations involved in the project (i.e. AbacusBio Ltd, NZ, Centre for Micro-Finance (CmF), Rajasthan, Collectives for Integrated Livelihood Initiatives (CInI), Gujarat and Vijayavahini Charitable Foundation (VCF), Andhra Pradesh), NARI-AHD completed the first draft of a ‘Technical Guide to Implementation of Women-led Community based Goat Breeding Programs in Low Input Systems in India’. This was presented in two State-level workshops, one in Udaipur, Rajasthan and the second in Ahmedabad, Gujarat to civil society organizations working in this area, government agencies and scientific communities with Dr. Nimbkar giving presentations on the principles, rationale and practice of CBBPs. The audience of about 100+ at each workshop appreciated this strategy of genetic improvement of local goats with active participation of village goat keepers as it ensures advances in goat productivity while conserving diversity and also empowerment of local women.



Dr. Chanda Nimbkar giving a talk at the Rajasthan state workshop in Udaipur on 12 Feb. 2026



Dr. Pradip Ghalsasi on a field visit in Gujarat with Dr. Sushmita Parai of Tata Trusts

d. Low methane genetics expansion to small ruminants in Africa and Asia

A new 2-year research project has started at the AHD-NARI in collaboration with AbacusBio, NZ and the CGIAR institute International Centre for Agricultural Research in the Dry Areas (ICARDA), the agreement for which was signed with AbacusBio Ltd. on 18 March 2026 for the total grant amount of US\$103,000 over two years. This is a part of the new project “Low-methane genetics expansion to small ruminants in Africa and Asia,” funded by and facilitated through the Global Methane Hub. This work is bringing to life a shared ambition: identifying sheep and goats that are productive, efficient, and lower-emitting—and using them to drive sustainable genetic improvement for smallholder systems. Early work has focused on building the foundations for success. Historic performance and pedigree data from NARI’s *FecB* gene carrier ‘NARI Suwarna’ nucleus sheep flock are being integrated into the DTreo platform, enabling structured data capture and future genetic evaluation.

At the same time, partners have been designing methane measurement systems suited to local conditions, including the use of portable accumulation chambers (PAC) and standardised protocols for animal recording.

Under this project, AHD-NARI will record methane emissions on at least 2000 sheep and goats in India, at least 3 times on each animal. This is probably the first time such recording will be done in India. Another remarkable aspect of this work is that apart from AHD-NARI’s own sheep and goats, methane emissions will be recorded on Osmanabadi goats belonging to smallholders under the Osmanabadi Field Unit of the ICAR-AICRP on Goat Improvement being operated at AHD-NARI since 2009. DNA of a sample of recorded animals will be extracted and used for further studies conducted in India to identify genomic regions responsible for low methane emissions. Field visits and exchanges between technical teams have started and supported implementation, ensuring that global measurement approaches are adapted to local production systems and realities. This is an innovative component of the wider project run concomitantly in Ethiopia, India, Mongolia, and Tunisia. This type of information hasn’t yet been collected in scale in smallholder systems. This is a great learning opportunity for AHD-NARI and also an opportunity to be part of international climate change mitigation research networks.



*Dr. Claire Payne
of AbacusBio with
NARI Suwarna
sheep flock at
Lundy farm*



Discussions: Drs. Payne, Ghalsasi and Nimbkar

e. The Osmanabadi Goat Field Unit under the ICAR-All India Coordinated Research Project on Goat Improvement

This unit at NARI is one of 24 units working on different goat breeds all over India, from Kerala to Ladakh. During 2025-26, 2058 adult Osmanabadi goat does and their progeny belonging to 216 goat keepers are being recorded by AHD-NARI under this project in villages in six districts of Maharashtra.

AHD-NARI has established a model of bringing about genetic improvement by performance recording of village goats and kids and selection of outstanding young breeding bucks and disseminating the improvement through artificial insemination (AI) of local goat does. We have been freezing the semen of these selected bucks since 2012 in the laboratory set up with a grant for equipment from the Government of India. AHD-NARI has trained close to 100 community animal health workers (*pashu sakhis*) of the Mann Deshi Foundation, Mhaswad, Tal. Phaltan, Dist. Satara in goat management and AI. Currently 42 *pashu sakhis* are doing AI in six districts of Maharashtra. During 2025-26, they procured buck frozen semen from AHD-NARI and inseminated 2700 local does with Osmanabadi buck semen, 1500 does with Boer and 300 does with Damascus breed semen with a conception rate of about 55%. Thus the benefits of genetic improvement are reaching the goat keepers directly.



*Selected
Osmanabadi buck
and doe*



f. Article published in the ‘Animal Frontiers’ journal

A perspective paper by Dr. C. Nimbkar and Dr. P. Amer of AbacusBio Ltd., NZ, “Indian *pashu sakhis*: excelling against all odds” was published as an invited submission in 2025 in the special issue No.15(6) of ‘Animal Frontiers’, the prestigious official journal of the professional animal science societies, ASAS, the American Society of Animal Science, EAAP, the European Federation of Animal Science, AMSA, the American Meat Science Association and WAAP, World

Association of Animal Production. *Animal Frontiers* provides a novel forum for innovative and timely perspectives that have relevance to understanding the complex dynamics at work through animal agriculture. The journal has an impact factor of 7.8. The paper is based on the work of talented and hard-working women ‘community animal health workers’ trained and guided by Dr. Nimbkar in collaboration with grassroots organizations in Bihar, Rajasthan and Gujarat. The conclusion of the paper is “Effective community-based breeding programs (CBBPs) can be developed by building the capacity of local, poorly educated women (over 250 pashu sakhis in Project Mesha, Bihar) to collect and record data on goats using the Dtreo platform. CBBPs can be powerful means of improving goat productivity, raising incomes of goat keepers and conserving indigenous goat breeds.”

Info-graphic included in the article in Animal Frontiers



g. Educational goat and sheep management booklets published by AHD-NARI.

During 2025-26, AHD-NARI hit a record number of 2100 copies of 20 information booklets and charts on goat and sheep management supplied to goat keepers. The subjects of the booklets range from ‘Misconceptions and superstitions in livestock treatment’ to a ‘Goat anaemia guide chart’. It is especially important in this digital age that people still value these booklets written in simple Marathi/Hindi/English to gain knowledge on scientific goat and sheep management.

Goat and sheep rearing is becoming ever more important as a profitable occupation in rural areas and people are hungry for high quality, evidence-based knowledge.

Details of Research and Development Projects.

Project I. Osmanabadi Goat Field Unit of the Indian Council for Agricultural Research (ICAR)-All India Coordinated Research Project (AICRP) on Goat Improvement

Funding agency: Indian Council of Agricultural Research (ICAR), Government of India, New Delhi, administered by the Central Institute for Research on Goats, Makhdoom, Via Mathura, U.P.

Scientists: Dr. Chanda Nimbkar, Dr. Pradip Ghalsasi,

Technical staff: Mr. Navnath Patange, Mr. Sagar Shinde, Mr. S.L. Nimbalkar (from 9 June 2025), Mr. V. N. Shedage (from 19 January 2026)

Ms. Minakshi Ghorpade (in Dhakale, Tal. Baramati, Dist. Pune),

Mrs. Prajakta Lahane (Sakat, Tal. Jamkhed Dist. A'Nagar)

Executive summary for 2025-26

An Osmanabadi goat field unit was established at NARI in April 2009 under the AICRP on Goat Improvement. NARI is the only non-government organization (registered public charitable trust and society) running a field unit in the history of AICRP. During the period 1 April 2025 to 31 March 2026, the production performance of goats in farmers' flocks was assessed in the low rainfall, drought-prone Deccan plateau regions of Six districts in Maharashtra State. Viz. Ahmednagar, Beed, Pune, Latur, Satara and Solapur districts.

Litter size: 2025-26: 1.65

During 1 April 2025 to 31 March 2026, **in 924 kiddings, 1520 kids were born** making the average litter size per kidding 1.65. Many does had two kiddings in the calendar year and so the average litter size per doe kidded per year was 1.84.

Milk yield at 90 days (least squares mean): 115.35±4.4 (57 records)

Top 50% of the recorded does had a 90-day milk yield of 136 litres. Out of 239 milk records collected in 2024-25, 55 does had a test-day yield of 1 to 1.5 litres, 25 gave 1.5 to 2 litres while 12 does gave >2 litres milk per day.

Selection differential of 2.7 to 3.0 standard deviations was achieved in the purchase of 6-9 months old and 1.4 years old bucks.

- We are procuring twin-born, true-to-type Osmanabadi bucks with high body weights from the field; e.g. six-months old bucks weighing 24 to 28 kg, 1.3 to 1.5 years old bucks weighing 45 to 57 kg. Such high weights are due to both the high genetic potential of the bucks and good management and **using these for breeding will certainly bring about genetic gain in body weight in the next generation.** Genetic gain is also expected in goat milk yield as the dams of these selected bucks must have high milk yields for the bucks to attain such high body weights.
- Five outstanding Osmanabadi bucks were purchased for a total outlay of Rs.72,475 during 2025-26, thus making a total of 108 bucks purchased as breeding bucks since 2009.
- **We established a new cluster in Renapur taluka of Latur district.** Thus we started working in Latur district for the first time and have registered 10 SC community goat

keepers and their 164 goats. This is the sixth district/cluster of the Osmanabadi Goat Field Unit. **We are thus expanding further into the area considered the core tract for the Osmanabadi breed.**

- Additionally, during 2025-26, we registered 83 new goat keepers and their 635 goats in the five existing clusters i.e. Ahilyanagar, Beed, Pune, Satara and Solapur.
- **During 2025-26, 2,807 straws of 37 Osmanabadi bucks were frozen and 2,704 straws were supplied to Mannideshi Foundation** and local A.I. technicians, farmers and entrepreneurs for breeding Osmanabadi goats. The Mannideshi Foundation pashu sakhis do artificial insemination of goats in over 30 villages in six districts of Maharashtra. Conception rates reported by them are 50-55%. Thus the genetic superiority and diversity of selected Osmanabadi bucks is being disseminated over a wide area.
- **Income/goat/year:** The income/doe/year is estimated as follows. It will change if the parameters used in the estimation change.
 Average No. of kiddings per doe per year = 1.4
 Average litter size 2025-26: 1.60
 $\therefore$ No. of kids produced per doe per year = $1.4 \times 1.60 = 2.2$
 $\therefore$ Kid sale proceeds realized/doe/year = $2.2 \times \text{Price per kid Rs.5,250} = 11,550$
Thus maximum gross income earned per doe per year is about Rs.11,000 in a flock of 7 to 10 adult does.
However, very few flocks have ideal management. Therefore usually the income per adult doe per year is Rs.8,000.

Improvement in performance traits: 0.5 SD improvement in 3 months' weight (11.3 to 13.0 kg) and 6 months' weight (16.1 to 16.9 kg).

Project II. Increasing profitability of sheep production by genetic improvement using the *FecB* (Booroola) mutation and improved

Scientists: Dr. Chanda Nimbkar, Dr. Pradip Ghalsasi

Technical staff: Mr. Anil Chavan, Mr. Dattatray Mulik, Mr. Dilip Bhandare, Mr. Sagar Shinde and Mr. Vikram Shedge along with 7 men and 5 women labourers on 3 farms

This successful breeding programme has continued to be self-sustaining since 2012, by generating income mainly from the sale of breeding rams and ewes and secondarily from the sale of surplus lambs and cull sheep.

A. Breeding programme

A new strain of Deccani sheep has been developed, called 'NARI Suwarna' which gives about 40-50% higher lamb production due to a 50% higher litter size compared to local Deccani sheep. The growth rate, mothering ability and conformation of the new breed were improved by the introduction of the Madgyal and Awassi breeds and continuous selection is being carried out to improve these traits further. The breed has been disseminated to shepherds in Maharashtra, Karnataka, Telangan and Andhra Pradesh and they are profiting from its use. **Total 1021 breeding rams and 1598 breeding ewes have been supplied.** Out of these, 38 rams and 44 ewes were supplied during 2025-26. These rams and ewes were purchased by sheep keepers from Karnataka, Maharashtra and Telangana.

All ewes are bred by artificial insemination (AI) in order to use a large number of breeding

rams to maintain diversity and control inbreeding and maintain accurate pedigree records. Each of the three AI programmes in 2024-25 went on for one month, roughly covering two oestrus cycles. Ewes were inseminated in natural oestrus detected by vasectomised teaser rams. All ewes were inseminated cervically once, about 5-6 hours after oestrus detection. Ewes were inseminated with fresh, diluted semen of the allotted rams. The overall conception rate of 79.9% (slightly less than the previous year) indicates the high standard of practices used for the AI programme and the good condition of ewes and rams. Genetic analysis was used to estimate breeding values.

One of the NARI Suwarna flocks grazing at Lundy farm, Rajale



Table 1. Results of Four AI Breeding Programs carried out at NARI's Lundy farm, Rajale in November 2024, March, June and October 2025

Particulars	Ewe's <i>FecB</i> genotype			
	<i>FecB^{BB}</i>	<i>FecB^{B+}</i>	<i>FecB⁺⁺</i>	Overall
Ewes inseminated artificially (AI)	100	147	12	259
Ewes conceived (first and second AI)	77	129	9	215
Conception rate to first AI (%)	72.0	85.7	75.0	79.9
Pregnant ewes died	2	0	0	2
Ewes aborted	9	10	1	20
Ewes lambed with at least one live lamb	62	109	8	179
Ewes lambed with all lambs stillborn (perhaps due to dystocia) or died soon	4	10	0	14
Total live lambs born	91	171	9	271
Live lambs born per ewe lambed with at least one live lamb	1.47	1.57	1.13	1.51
Live lambs born per ewe conceived and present at lambing	1.21	1.33	1.00	1.27

271 lambs were born during the year compared to 227 lambs born during 2024-25. The number of live lambs born per ewe lambd increased from 1.34 to 1.47 for $FecB^{BB}$ ewes and from 1.51 to 1.57 for $FecB^{B+}$ ewes. The number of lambs born per ewe conceived also increased from 1.07 to 1.21 and 1.27 to 1.33 respectively for homozygous and heterozygous ewes. Abortions reduced to 9.3% from 11% the previous year. During 2026-27, we have been able to reduce the abortions even further.

A. Genotyping of sheep DNA at the *FecB* locus

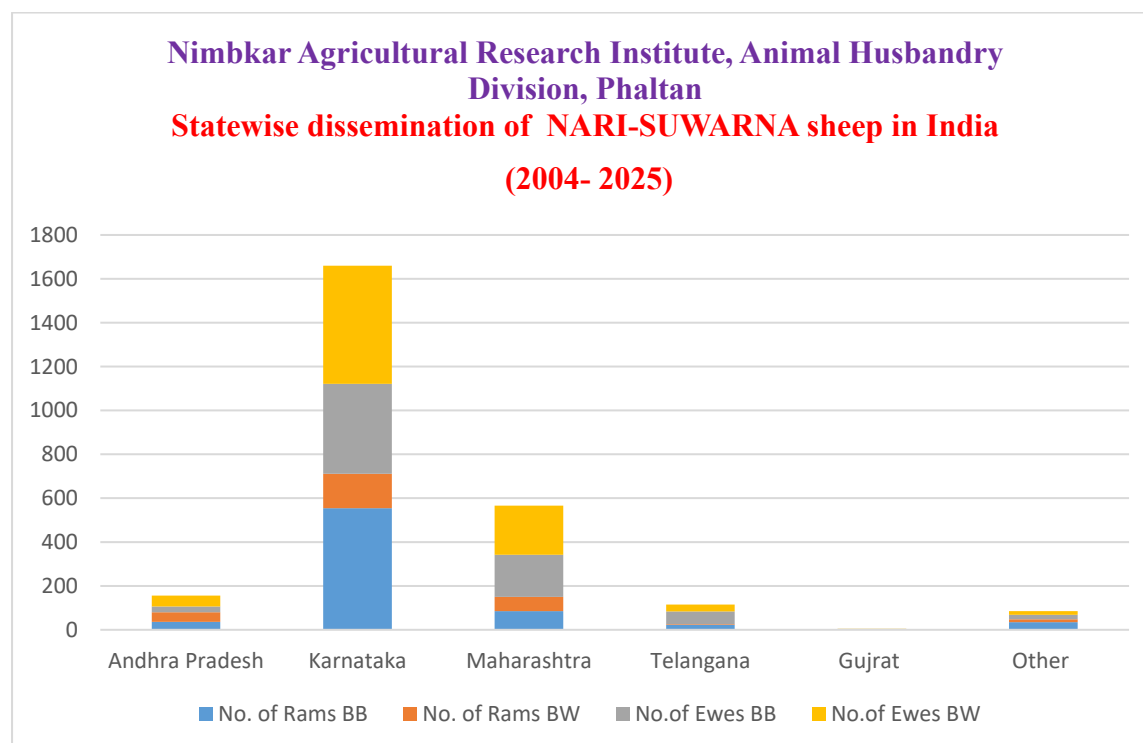
Table 2. *FecB* genotypes of AHD-NARI's sheep tested at the AHD laboratory during 2025-26

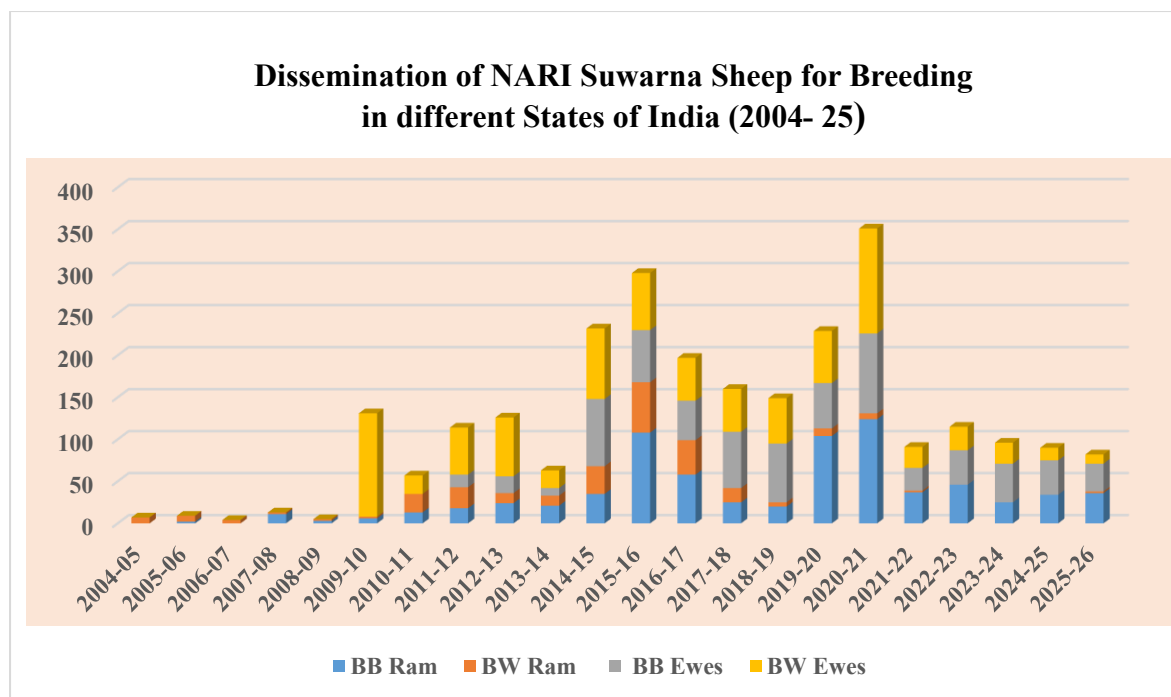
Breed	Number of animals genotyped	$FecB^{BB}$	$FecB^{B+}$	$FecB^{++}$
NARI Suwarna lambs	154	78	76	0

The *FecB* genotyping protocol is now **fine-tuned and cost-effective** and **100%** results were obtained at the first go in all the genotyping tests conducted this year also.

We would like to thank Mrs. Padmaja Ghalsasi, our retired Technical Officer, who was most gracious and helpful to come from Pune and carry out all the genotyping. We are extremely grateful to her.

We acknowledge the valuable help and guidance of Mrs. Sheetal Ranade who is our consultant and adviser for the *FecB* DNA test.





Project III. Climate change mitigation initiative managed and led by women farmers (CCMI-MLWF)

Funding agency: Sir Dorabji Tata Trust, Mumbai

Scientists: Dr. Chanda Nimbkar, Dr. Pradip Ghalsasi

Collaborating organizations:

Centre for MicroFinance (CmF), Rajasthan

Centre for Integrated livelihood Initiatives (CInI), Gujarat

Vijayavahini Charitable Foundation (VCF), Andhra Pradesh

AbacusBio Ltd., New Zealand

The project got under way in May 2024.

The project aims to establish community based goat breeding (genetic improvement) programs (CBBP) through capacity building of women goat keepers and introducing innovative strategies in villages of Rajasthan and Gujarat states where the collaborating organizations CmF and CInI have organized households into primary institutions. Genetic improvement in animal performance is permanent and cumulative and is therefore an attractive method of productivity improvement of goats belonging to resource poor rearers located in remote villages. The objective of the CBBPs is to improve the goat genetic resources owned by women to improve their livelihoods and possibly, at a later stage, to promote business in sale of breeding bucks and does. This will be ultimately achieved through selection of genetically superior offspring for breeding leading to continuous genetic improvement in a goat population. Goat rearer participation is being ensured from inception to implementation gaining an understanding of goat rearer needs, perception and decisions when developing the program. The overarching objective is to add value to the sustainable production, management and marketing of goats belonging to smallholder village communities using community focused interventions. The objective is also to use this as a proof of concept for adoption of

women-led community based small ruminant breeding approaches by the GOI/AHD and shall be showcased to them as best practice initiatives to influence policy.

During July to September 2025, Drs. Nimbkar and Ghalsasi contributed extensively to the **development of the breeding buck selection merit score and also the climate adaptation score**, making collective decisions about the composition and structure of the score, to be incorporated in the DTreo software being used in the project. We then participated in two meetings of the technical committee comprising of team members from CmF and CInI to explain the score to them and further incorporate their preferences in it. This process was delayed considerably because of slow progress in the field and requisite weights of male and female kids not being available in the software to include the predictions of weights in the selection merit score.

Dr. Chanda Nimbkar and Dr. Pradip Ghalsasi visited the Vijayvahini Charitable Trust (VCF) field areas in Andhra Pradesh on 24 to 28 October 2025. We visited the three villages (one each in three selected Mandals) where VCF has decided to start tagging and recording sheep. We observed sheep flocks in each village and held discussions with sheep owners to understand the production system, constraints and challenges. We gave advice on sheep management. We gave a one-day training session to VCF staff, program associates and Jeeva mithras on the principles of CBBPs, benefits of systematic genetic improvement carried out through CBBPs, permanent and cumulative nature of genetic improvement, need to use breeding rams selected according to community-preferred criteria and castrate all others, necessity of periodic ram-rotation, need for performance-recording to aid in ram selection, the DTreo software, how to estimate the age of sheep based on dentition and how to work out their birth dates and necessary first-aid medicines for goats and sheep. Finally, we drew up an action plan for the VCF team to follow to start the proposed CBBP.

Evening visit to a Nellore Brown sheep flock in Galiveedu Mandal, Dist. Annamayya, Andhra Pradesh and discussion with sheep owners





Drs. Ghalsasi and Nimbkar with the jeeva mithras and VCF staff to whom they gave a one-day training session

Documentation of SOP: On 28 November 2025, Dr. Chanda Nimbkar submitted the first draft of the "Blueprint for women-led community based genetic improvement of local goat breeds" to all project partners and to the Tata Trusts program coordinator. On 18 December 2025, she submitted the second draft of the document after incorporating the feedback and comments from project partners. This was the key output indicator for NARI with 25% weightage according to the Log Frame Analysis specified by Tata Trusts. Thus NARI has now fulfilled three key performance indicators assigned to it worth 45% weightage in the CCMI-MLWF project (i.e. setting up of breeding goals and parameters for selection (10% weightage), training of pashu sakhis in Rajasthan and Gujarat (10% weightage) and process document for women led CBBP (25% weightage). The cover of the document is given on the next page.

A technical guide to implementation of women-led community-based goat breeding programs in low input systems in India



Project III. Setting up a State of the Art A.I. Centre for sheep and goats under the National Livestock Mission Scheme under the component of ‘Interventions towards productivity enhancement’. (This project was originally sanctioned under the Central Sector Scheme – Integrated Development of Small Ruminants and Rabbits).

The project was submitted to the Government of India, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries under Central Sector Scheme – Integrated Development of Small Ruminants and Rabbits on 21 August 2010 through Commissioner, Animal Husbandry Maharashtra State. The proposal was approved for 100% Central Government assistance by the Government of India, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries vide their administrative approval letter No. 48-51/2010-TS/Sheep dated 24 November 2010. The total project amount was received in five installments from October 2011 to August 2016. An audited utilization certificate of the last installment was submitted to the Deputy Commissioner, Satara District, Animal Husbandry, Maharashtra State on 28 April 2017.

- 1. Date of commissioning of the semen freezing lab: 2 January 2012**
- 2. Production and utilization of buck frozen semen doses during the period January 2012 to 31 March 2026.**

We established a standard protocol for freezing of buck semen and started producing frozen semen straws since June 2012. These straws are regularly supplied to State Governments and private customers and excellent conception rates of average 50% are being achieved.

Table 4. Number of buck frozen semen straws produced and used (2012 to March 2026)

Type of buck semen doses	Breed of buck					Total
	Boer	Osmanabadi	Damascus cross	Alpine and Saanen X Beetal	Beetal	
Frozen	48,101	64,582	7,893	1477	440	1,22,493
Supplied	41,227	62,280	6,998	1453	343	1,12,301
Used for AI of NARI and MGSRDI Farm and local goat keepers' goats and given free to AI technicians for trial	5,150	933	479	24	5	6,608
In storage	1,724	1,369	416	0	92	3,584

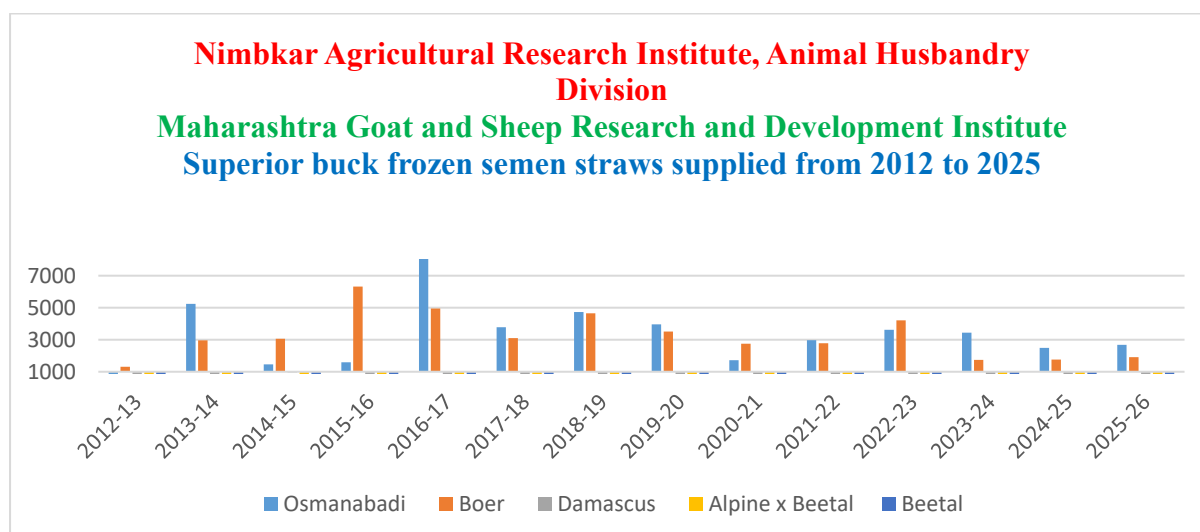
Table 5. Number of buck frozen semen straws produced and supplied during the year 1 April 2025 to 31 March 2026

Type of buck semen doses	Breed of buck			
	Boer	Osmanabadi	Damascus cross	Total
Frozen	1248	2935	235	4418
Supplied	1908	2682	453	5043
Used for AI of NARI and MGSARDI Farm and local goat keepers' goats brought to NARI	11	20	38	69

Goat keepers from nearby villages bring their goats in oestrus to the AHD-NARI farm for cervical AI. During the year 2025-26, 32 goat does belonging to local goat keepers were inseminated, out of which 22 could be followed up and 14 kidded. Thus the conception rate to A.I. was 64%. This is a high conception rate and reflects the high semen quality as well as the skill of our farm supervisors/inseminators. It also shows that goat keepers can detect the signs of oestrus in their goat does properly.

Table 6. Results of AI of farmers' goats using frozen buck semen on NARI farms

Farm / Field	No. of goats inseminated	No. of goats monitored	No. of does conceived	Conception rate (%)
AHD-NARI Farms (2025-26)	32	22	14	64%
AHD-NARI farms (2012-2026)	1,536	1,181	614	52%



2016-17: 20,000 Osmanabadi semen straws supplied to Government of Karnataka.

Training courses in goat and sheep production and management and artificial insemination (AI) conducted by NARI-AHD

During the year, we held two 3-day training courses on goat management and A.I. – one for 24 *sheli sakhis* from the Mann Deshi Foundation and one for 15 *pashu sakhis* and livestock assistants from the Centre for MicroFinance, working in Rajasthan.

Table 7. Training courses and classification of participants (2007- March 2026)

Topic of training	No. of training courses	No. of participants			Total
		Vets	Para-vets and <i>pashu/sheli sakhis</i>	Farmers	
Goat Artificial insemination (AI)	73	306	210	251	767
Goat and sheep production and management	16	57	52	87	196
Goat and sheep management including AI	34	138	184	161	483
Total	123	501	446	499	1446



We wish to place on record our gratitude to Mr. K.M. Chavan (seen in the above picture, teaching the trainees from Rajasthan), our former staff member who still carries out the role of the main trainer during our training courses now.

Project IV. Research in veterinary parasitology with special reference to sheep and goats.

Funding agency: Internally funded

Scientists: Dr. Chanda Nimbkar, Dr. Pradip Ghalsasi

Technical staff: Ms. Shraddha Khot, Mr. Dilip Bhandare, Mr. Datta Mulik, Mr. Sagar Shinde, Mr. Anil Chavan.

We monitored faecal worm egg counts (FEC) and FAMACHA scores of our sheep and goat flocks to assess the gastro-intestinal nematode (GIN) worm burden under natural infection. We have been studying internal parasite burdens and parasite epidemiology in sheep and goats for more than 23 years. During the last 14 years, we have also included FAMACHA score monitoring as a part of our sustainable GIN control strategy. FAMACHA chart is an anaemia guide which indicates the seriousness of the burden of infection with blood sucking parasites. It can be effectively used especially when laboratory facilities are not available. Anaemia in sheep and goats is mainly caused by the parasite *Haemonchus contortus* which is the predominant species in our area. The anthelmintic *Closantel* is a selective drug used against *H. contortus* only. We often use it. We tested its efficacy by measuring the FEC of drenched sheep on days 14, 28 and 42 after drenching. It was found to be fully effective up to day 42.

AHD maintains sheep and goats on three farms - Wadjal, Dhuldeo and Lundy farm (Rajale). All sheep and goats at Wadjal farm are stall-fed and therefore, during the year, only a few animals needed to be drenched individually. Selected Osmanabadi bucks which are placed in villages for breeding, are brought back to this farm and they are likely to bring worm infestation on to the farm.

At Lundy farm, Rajale, four cohorts of lambed ewes were mass dewormed after lambing as lambed ewes have reduced immunity and are more vulnerable to worm infections.

On Dhuldeo farm, early pregnant ewes were mass drenched twice and stall-fed goats and kids were drenched twice.

We have minimized the use of dewormers by maintaining good feeding and management. This reduces the possibility of the development of anthelmintic resistance.

Project V. Low-methane genetics expansion to small ruminants in Africa and Asia

Progress report up to 30 March 2026

Date	Activity
3 October 2025	Online meeting with AbacusBio personnel including Peter Amer and Jolene van Tonder about integrating NARI's NARI Suwarna sheep flock data into the CBBP database in the DTreo platform. - AbacusBio provided an overview of the Global Methane Hub project, which focuses on measuring methane emissions in small ruminants in Ethiopia, India, Mongolia, and Tunisia. The project evolved from an initial application for funding that was redirected to a larger initiative led by ICARDA. A postdoc will oversee the implementation across the countries, with designated coordinators in each location to ensure consistency in data collection and protocol adherence. - AbacusBio outlined the procedure for measuring emissions from animals using specialized boxes that are hermetically sealed. There was discussion on this and practicalities of implementation in India.

	- Jolene from AbacusBio explained the functionalities of the DTreo platform, focusing on the dashboard that summarizes information about villages, flocks, and animal breeds. It was noted that the platform allows for interactive data exploration and the ability to export bulk animal information. - It was decided that Chanda would share data with Jolene for incorporation into the CBBP tenant in DTreo.
30 October 2025	Online meeting with Jolene of AbacusBio about sending NARI Suwarna sheep data.
November 2025	Further correspondence with Jolene about NARI sheep data.
18 December 2025	Online meeting with Chanda and Pradip from NARI and Peter and Claire from AbacusBio. Claire and Peter explained the details of the methane emissions measurement procedure using PACs, where PACs could be placed for measurement, PAC dimensions used in Australia (Length 1.23 m, width 0.5 m. height 1.24 m), measurements to be done at 15, 30 and 45 min. after putting animal into chamber or at 20 and 40 min., interval between two measurements of the same animal could be one or two weeks, that cylinder/s with three gases are needed (O ₂ , CO ₂ and CH ₄), that minimum 4 well-trained people are needed for measurements, measurements to be done only after weaning, animals to be weighed before measurements, good records have to be kept even of the time animal goes into chamber, time of measurement and time animal comes out of chamber.
23 Dec 2025	Draft agreement with fine print received from AbacusBio
12 to 30 Jan 2026	Emails with Hannah Farr and Peter Amer about NARI's concerns about the agreement and budget which were all resolved amicably.
6 Jan 2026	Sent the first large data file of NARI Suwarna sheep to Jolene.
30 Jan 2026	Online meeting with Jolene about Review and clarify the current status of the NARI sheep data for the DTreo project, address specific questions regarding the data file structure and content, and align on next steps for data integration and analysis. - Clarifications on certain aspects of the data. - Mapping the columns from the file to the columns we have in the CBBP tenant in DTreo. - Questions regarding the data in the SQL database file.
13 Feb 2026	Online meeting with NARI, AbacusBio and ICARDA personnel. Discussions included topics such as PAC chamber types and sourcing, methane measurement device and sourcing, RFID ear tag sourcing, iPads sourcing . NARI requested ICARDA for methane measurement protocols, data recording formats and training material to create awareness among goat keepers. This has not been received up to 30 April 2026.
16-17 Feb 2026	Visit by Claire Payne of AbacusBio to NARI (report attached separately). Claire saw NARI's farms, animals and facilities and visited village facilities and had extensive discussions with Pradip and Chanda about specifics of carrying out methane measurements.

23 Feb 2026	Sent to Joram Mwacharo of ICARDA a list of 10 items needed for effective operation of PACs. These are to be purchased through the ICARDA India office and delivered to NARI.
18 March 2026	Agreement with AbacusBio signed by Chanda Nimbkar
23 March 2026	Claire Payne helped to prepare a job advertisement for the project manager's position at NARI.

(URLs for the blogs about the project in different countries on the ICARDA web site:

<https://icarda.org/media/news/advancing-low-methane-sheep-and-goat-production-india>

<https://icarda.org/media/news/unlocking-genetic-potential-sheep-and-goats-low-methane-emission-and-high-productivity>)

Publications

1. Nimbkar, C., Ghalsasi, P., Parai, S., Rao, C. S., Patel, H., Vaghani, V., Schurink, A., Bjelland, D. and Amer, P. 2025. Community based breeding programs – opportunity for smallholder goat genetic improvement and increased incomes. Compendium of abstracts. ICAR Annual Conference and IDF/ISO Analytical Week 2025. NDDB Anand, Gujarat, India. 29 March to 4 April 2025. p. 44.
2. Schurink, A., Bjelland, D., **Nimbkar, C.**, Kumar, N., Parai, S., Singh, C. Vaghani, V., Haigh, M., Santos, B. and Amer, P. 2025. The last data point – experience with Dtreo data capture for impact in smallholder ruminant systems. Compendium of abstracts. ICAR Annual Conference and IDF/ISO Analytical Week 2025. NDDB Anand, Gujarat, India. 29 March to 4 April 2025. p. 45.
3. Amer, P., Schurink, A., Bjelland, D., Haigh, M. and **Nimbkar, C.** 2025. Simple phenotypic indexes can bring data recording to life for smallholder farmers. Compendium of abstracts. ICAR Annual Conference and IDF/ISO Analytical Week 2025. NDDB Anand, Gujarat, India. 29 March to 4 April 2025. p. 48.
4. Abeykoon, S. Amer, P., Wilcox, P. and **Nimbkar, C.** 2025. A comparison of progeny of selected and unselected sires within the setting of a community based breeding programme catering to women smallholder goat rearers in Bihar India. *Proc. Assoc. Advmt. Anim. Breed. Genet.* 26:295-298.
5. **Nimbkar, C.** and Amer, P. 2025. Indian *pashu sakhis*: excelling against all odds. *Animal Frontiers*. 15(6):15-19. <https://doi.org/10.1093/af/vfaf044>
6. Amer, P., Santos, B., Schurink, A., **Nimbkar, C.**, Haile, A., Wurzinger, M., Soelkner, J., Getachew, T., Rekik, M., Mueller, J., Bjelland, D. and Rischkowsky, B. 2025. Learnings from community based breeding programs for small ruminants in small holder systems. Poster presented at the Fifth TropAg Conference held in Brisbane, Australia on 11-13 November 2025.

NARI, AbacusBio, CmF, CInI, VCF. 2026. A technical guide to implementation of women-led community-based goat breeding programs in low input systems in India. 2026. pp.46. Tata Trusts.

Report.

Nimbkar, C. and the AICRP Osmanabadi Field Unit Team. 2026. Annual Report of the Osmanabadi Field Unit of the ICAR-AICRP Goat Improvement. 2025-26. p. 47.

List of booklets published by AHD-NARI:

1. First aid treatment in sheep and goats – one booklet and one folded leaflet
2. Vaccination in sheep and goats - folded leaflet
3. Abortions in sheep and goats: prevention, treatment, care and precautions to be taken to avoid infection to humans
4. Misconceptions and superstitions in livestock treatment
5. Adverse effects of early breeding of young does: consequences and prevention
6. Sustainable worm control in sheep and goats
7. Goat rearing package of practices for small holders (in Marathi and English)
8. Training material for a training course in small ruminant (goat and sheep) production technology. (p. 89).
9. Package of practices for goat artificial insemination (AI)
10. Economics of stall-fed goat production
11. Goat kid management
12. Training manual on goat artificial insemination (in English also)
13. Sheep and goat management (Hindi)
14. Four-page folder on the Osmanabadi breed (English)
15. Contagious ecthyma in goats (Marathi)
16. Goat Nutrition in Marathi and English
17. Sheep and goat management (Hindi)

Educational Videos prepared

1. Age determination of goats based on dentition
2. Assessment of worm infestation using a FAMACHA card prepared by NARI
3. Ear-tagging of goats for identification
4. Weighing of goats and kids
5. Measurement of length, chest girth and height of goats
6. Measurement of body temperature of goats
7. Castration of bucks using a Burdizzo's baby castrator
8. Artificial insemination in goats
9. Dressing of abscesses due to Caseous lymphadenitis in goats

**Major frozen semen straw buyers of Boer, Damascus and Osmanabadi bucks from
MGSARDI and AHD-NARI
during 1 April 2025 to 31 March 2026**

Sr. No.	Name and Address of Straw Buyer	Osmanabadi	Boer	Damascus	Total
1	Manndeshi Foundation, Mhaswad, Vaduj, Lonand, Satara, Nashik branches, Maharashtra	2,591	1,522	420	4,533
2	Gopal Kundu, Kolkata, West Bengal	—	250	—	250
3	Aryaman Shrey, Bangalore, Karnataka	—	100	—	100
4	Vinayak Kare, Phaltan, Dist. Satara	19	20	26	65
5	S. S. Botheekar, Phaltan, Satara	20	11	4	35
6	Deepak Yadav, Rajale, Tal. Phaltan, Dist. Satara	20	5	—	25
7	Aniket Pakhale, Phaltan, Dist. Satara	16	—	3	19
8	Deepak Mathapati, Phaltan, Dist. Satara	16	—	—	16
Total		2,682	1,908	453	5,043

Scientific presentations made by Dr. Chanda Nimbkar in conferences during the year

Date	Name of conference	Place	Topic of presentation
3 April 2025	Annual Conference of the International Committee on Animal Recording	NDDB, Anand, Gujarat	Community based breeding programs – opportunity for smallholder goat genetic improvement and increased incomes
12 February 2026	Women-led community goat breeding program for climate resilience	Udaipur, Rajasthan	Technical guide for community managed goat breeding program
14 February 2026	Business Strategy meeting - Allanasons	Aurangabad, Maharashtra	Community farming and genetics experience
18 February 2026	‘Living lightly’ Consultation with pastoral communities of India. (Understanding pastoralism, facilitating mobility)	Zapurza, Pune, Maharashtra	Building a charter – Updating of the 2019 manifesto
27 February 2026	Reimagining goat breeding systems: Integrating data, genetics and communities for women led climate resilient livelihoods	Ahmedabad, Gujarat	Steps to establish a Community-based Breeding Program

Conferences and meetings attended by Drs. Ghalsasi and Nimbkar

Date	Name of conference	Place	Organizer
16 April 2025	Herding hope: National Goat Summit	New Delhi. (Attended on-line)	GIZ, Passing Gifts
14 February 2026	Business strategy meeting	Aurangabad, Maharashtra	Allanasons Ltd.

I. Visitors during the year to AHD-NARI

Date	Name of visitor	Organization	Purpose of visit
22 January 2026	L.Venkat ram Reddy, Hyderabad, Telangana	Retired Commissioner	To learn about AHD-NARI activities

II. Visits by groups during the year to learn about AHD-NARI's work

Sr. No.	Date	Particulars	Type of group	Organized by	
		No. of people	From place		
	11 Aug. and				
1	25 Nov. 2025	6	Pune	NGO	Nirman Sanstha, Pune
2	28 Sept. 2025	23	Karad	Farmers and goat keepers	Krushiksha Va Gramin Prashikshan Sanstha, Malkapur
3	25 Nov. 2025	50	Dahiwadi	Farmers and Sheep keepers	Afarm, Dahiwadi branch
4	27 Nov. 2025	46	Pune	6 th std. students	Aksharnandan School
5	10 Feb, 2026	18	Rajale, Tal. Phaltan	Women Farmers	Sajag Mahila Gramsangh

Additionally, 117 farmers and goat/sheep rearers visited AHD-NARI during the year in 52 groups. Also, 131 women self-help group members visited in 5 groups through the Mann Deshi Foundation.

Annual Fact Sheets

Total Sales

- 5043 frozen semen straws of Osmanabadi, Boer and Damascus cross
- 250 MT of sugarcane
- 96 MT of firewood
- 5 MT of food grains and oilseeds (wheat, soybean, sorghum, maize)
- 18 MT fodder (sweet sorghum biomass, leucaena leaves)
- 517 Kg food products (sweet sorghum and sugarcane syrup, jaggery, safflower, mustard, sesame and groundnut oil, safflower herbal tea)
- 109 Kg seed of different varieties of sweet sorghum, safflower, leucaena, stylosanthes and Desmanthus)
- 13 Kg opuntia pads

Publications

- 28 articles and papers in journal, magazines and newspapers
- 17 booklets
- 1 book
- 1 report
- 1 technical guide
- 13 videos
- 7 podcasts

Visitors

- 6 visitors from government and private institutions and farming community
- 64 groups of farmers, students and sheep and goat keepers



Governing Council (2023-2026)

Dr. Nandini Nimbkar, Ph.D., Permanent President, NARI

Dr. Chanda Nimbkar, Ph.D., Director, Animal Husbandry Division, NARI

Noorie Rajvanshi, Ph.D., US Head of Environmental Sustainability at Siemens, U.S.A.

Dr. Anil K. Rajvanshi, Ph.D., Padma Shree Awardee, Director and Hon. Secretary, NARI,

Ms. Madhura Rajvanshi, MA, Fulbright Scholar, Trustee, Pragat Shikshan Sanstha, Phaltan.

Prof. P. Balaram, Padma Bhushan Awardee, Ph.D., Former Director of Indian Institute of Science, Bengaluru.

Trustees

Dr. Nandini Nimbkar, Ph.D., Permanent President, NARI

Dr. Chanda Nimbkar, Ph.D., Director, Animal Husbandry Division, NARI

Dr. Anil K. Rajvanshi, Ph.D., Padma Shree Awardee, Director and Hon. Secretary, NARI,

Noorie Rajvanshi, Ph.D., US Head of Environmental Sustainability at Siemens, U.S.A

Dr. Manjiri Nimbkar, M.B.B.S., Vice president, Pragat Shikshan Sanstha, Phaltan.

Dr. Priyadarshini Karve, Ph.D., Director, Samuchit Enviro Tech, Pune

Smt. Jai Nimbkar, M.A., Founder Trustee