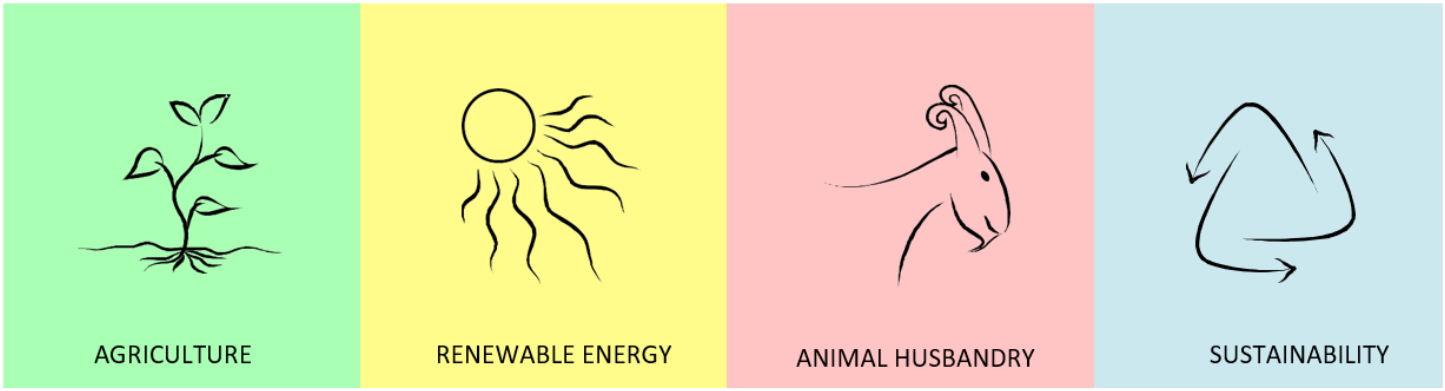
Annual Research Report (2021-22)



Nimbkar Agricultural Research Institute
Lonand Road, Phaltan, Maharashtra

NARI

Report of the President

I have the pleasure of presenting to you the NARI annual research report for 2021-22. Some significant events of this year were as follows:

Dr. Anil K. Rajvanshi, the Director and Honorary Secretary of NARI was conferred with Padma Shri - the fourth highest civilian award of the Republic of India, this year. He was chosen in the science and engineering category. All of us at NARI are proud of his achievements for which he received this honour and heartily congratulate him for his achievement.

Mr. B. V. Nimbkar, the founder and first president of NARI was selected for this award in 2006. Unfortunately, he passed away a year ago. I feel this is probably the first time when two Padma awards have been given to persons in such a small institute. This should offer an encouragement to grassroots workers and show them that good research can be done on a shoestring budget under trying circumstances.

I would also like to congratulate Dr. Chanda Nimbkar, the director of NARI's animal husbandry division for receiving two honours this year. Firstly, Chanda has been nominated to be featured in the second book dedicated to 75 Indian women in the fields of Science, Technology, Engineering, Arts and Mathematics (STEAM) on the occasion of India's 75th anniversary of independence. The aim of the series is to showcase women role models, make visible the leadership by women and generate interest in the SDGs.

Secondly, Chanda was nominated as a member of the Board of Governors of the Gujarat Biotechnology University, a new, autonomous, state-funded university being established in Gandhinagar, in partnership with the University of Edinburgh.

We gratefully acknowledge the generous donation to the corpus by Dr. Stuart Winter, MD – a pediatric hematologist/oncologist at the University of New Mexico in Albuquerque, U.S.A.

Dr. Winter recently published his 100th scientific paper on childhood leukemia, which is his niche of expertise. He was an intern at NARI in 1983 and worked with me and Mr. B. V. Nimbkar. He wrote his first research paper/report at that time and so wanted to recognize the impact working at NARI had on his life and thus donated more than Rs. 1,00,000 to further our research mission.

Over the years we have had scores of interns from all around the world working on various projects at NARI. In recent times we have been getting interns only from India. They are a great help as it is very difficult to get anybody to come and work in a small institute in a rural area. We are always happy to welcome anybody who wants to spend a few months/years at our institute and help out in our work. We offer them a free accommodation and if required a small stipend.

We also thank C. V. Manjunath and Amol Inamdar for their donations of Rs. 2,000 and Rs. 1,000, respectively for research in our animal husbandry division. Also during the past year Rs. 6,00,000 were donated by Dr. Anil Rajvanshi and Rs. 3,50,000 by Dr. Nandini Nimbkar. All these donations make it possible for us to continue our research and development work.

Date

August 27, 2022

Dr. Nandini Nimbkar

President

Contents

Sweet sorghum (SS)

a. SS trials

Basic information: Kharif 2021

Table 1: Basic information of sweet sorghum evaluation trials Kharif 2021.

Operation	Date
Single cultivation	01 Jun, 2021
Furrow opening	04 Jun, 2021
Mending of furrows	08 Jun, 2021
Sowing & fertilizer application (50: 50: 50 kg/ha N:P: K)	23 Jun, 2021
Irrigation	24 Jun, 2021 17 Aug, 2021 01 Sep, 2021
Spraying of Hamla (Chlorpyrifos 50% + Cypermethrin 5% EC)	01 Jul, 2021
Weeding & thinning	08 Jul, 2021 17 Jul, 2021 03 Aug, 2021
Top dressing (50 kg/ha N) & Spraying of Hamla (Chlorpyrifos 50% + Cypermethrin 5% EC)	16 Jul, 2021
Sampling of 5 plants	13 Sep, 2021

Note: All trials got lodged due to heavy rain.

The trials were sown in a randomized complete block design with two replications. The plot size was 0.9 m X 4.0 m.

Evaluation of sweet sorghum germ plasm lines: Kharif 2021

Thirty germ plasm lines were evaluated along with three checks (Madhura-1, Madhura-2 and Madhura-3).

The following data was collected:

(a) Plant height (cm)
(b) Stem diameter (cm)
(c) Final plant stand (000^s /ha)
(d) 5 Plant biomass weight (kg)
(e) 5 Plant stripped stalk weight (kg)
(f) 5 Plant juice weight (kg)
(g) 5 Plant panicle weight (kg)
(h) Juice extraction (% w/w juice by stripped stalk)
(i) Stripping (% w/w stripped stalk by biomass)

(j) Juice Brix (°)
(k) Biomass (T/ha)
(l) Days to 50% flowering
(m) Shoot-fly damage (%) @21 days
(n) Stem borer damage (%) @45 days

To determine the best performing varieties, the varieties were evaluated on parameters (a), (b), (g), (h), (i), (j), (k), (l), (m), (n). As all the plants in the trial got lodged due to rains, seed yield data is not available. Maximum relative weightage is given to biomass and juice Brix (25% each), followed by (inverse of) shoot-fly damage and stem borer damage (10% each). All the remaining parameters are given equal weightage among themselves. Ten best-performing station germ plasm lines so determined are given in Table 2. Overall, Madhura-1 and Madhura-3 were found to be the best. Among the germ plasm entries NARI-SS-135 and NARI-SS-130 performed better than others and were like the check Madhura-2.

Evaluation of sweet sorghum land races: Kharif 2021

Eighteen land races were also evaluated in Kharif 2021 along with the same three checks. The evaluation method was the same as that for the station germ plasm. Ten best-performing land races so determined are given in Table 3. In this trial Madhura-1 gave the best overall performance followed by the land races NARI-LC-07-38 NARI-LC-07-64.

Basic information: Rabi 2021-22

Table 4: Basic information of sweet sorghum evaluation trials Rabi 2021-22.

Operation	**Date**
Single cultivation	19 Oct, 2021
Furrow opening & mending of furrows	22 Oct, 2021
Sowing & fertilizer application (50: 50: 50 kg/ha N:P: K)	22 Nov, 2021
Irrigation	23 Nov, 2021 14 Dec, 2021 03 Jan, 2022 18 Jan, 2022 31 Jan, 2022
Thinning	06 Dec, 2021
Spraying (Dimethoate)	09 Dec, 2021
Weeding	11 Dec, 2021
Top dressing (50 kg/ha N)	14 Dec, 2021
Selfing (Covering panicles with bags for bird protection)	04 Mar, 2022
Sampling for Brix analysis	01 Apr, 2022
Panicle cutting	11 – 12 Apr, 2022
Threshing panicles	28 – 30 Apr, 2022

The trials were sown in a randomized complete block design with two replications. The plot size was 0.9 X 4.0 m.

Evaluation of sweet sorghum germ plasm lines: Rabi 2021-22

Twenty-seven germ plasm lines were evaluated along with three checks (Madhura-1, Madhura-2 and Madhura-3).

The data collected was the same as that for the germ plasm trial in Kharif 2021, except the additional data of seed yield (kg/ha) for the Rabi trial.

To determine the best performing varieties, maximum relative weightage was given to biomass, juice Brix and seed yield (20% each), followed by (inverse of) shoot-fly damage and stem borer damage (7.5% each). Equal weightage was assigned to the rest of the parameters. Ten best-performing station germplasm lines so determined are given in Table 5. Overall performance of NARI-SS-233 and NARI-SS-225 was found to be the best and was like that of the checks Madhura-1 and Madhura -3. Out of these 10, NARI-SS-225, NARI-SS-205, NARI-SS-222, NARI-SS-45 and NARI-SS-141 had performed well in Rabi 2020-21 also.

Evaluation of sweet sorghum land races: Rabi 2021-22

Seventeen land races were also evaluated in Rabi 2021-22 along with the same three checks. Ten best-performing station land races so determined are given in Table 6. Overall performance of NARI-LC-07-38 and NARI-LC-07-9-8 Was the best and like that of Madhura-3. These were followed by the entries NARI-LC-07-29-1, NARI-LC-07-1 and NARI-LC-07-83. Out of these, NARI-LC-07-38, NARI-LC-07-83, NARI-LC-07-42, NARI-LC-07-91, NARI-LC-07-64 and NARI-LC-07-56 had also performed well in Rabi 2020-21.

Table 7: Germplasm entries that performed well in Rabi 2020-21 and 2021-22.

Table 8: Land races that performed well in Rabi 2020-21 and 2021-22.

Table 9: Germplasm entries that performed well in Kharif 2021 and Rabi 2021-22.

Table 10: Land races that performed well in Kharif 2021 and Rabi 2021-22.

Tables 9 and 10 show that in general for both germ plasm entries and land races in Kharif season higher values of all the parameters were recorded. Only seed yields were higher in the Rabi season. In Kharif seed production is practically non-existent due to the attack of pests like midge and bird predation. The damage to plants due to shoot fly and stem borer attack was nearly double during the Kharif compared to that in Rabi.

Funding agency: Internally funded.

Scientists: Dr. Nandini Nimbkar.

Technical staff: Mr. Sharad Choudhari, Ms. Sonali Khalate, Ms. Anita Gholap and Mr. Maruti Shirke.

b. Brix analysis

The yearlong data of the juice Brix measurements across different varieties, plots and seasons was collected. The chief objective of Brix data collection is to identify the seasons appropriate for sowing and harvesting of the SS crop, to get the best quality syrup.

Variation in Brix content of the juice of five varieties of sweet sorghum grown at NARI with time is plotted below in Figure 1 through Figure 5.

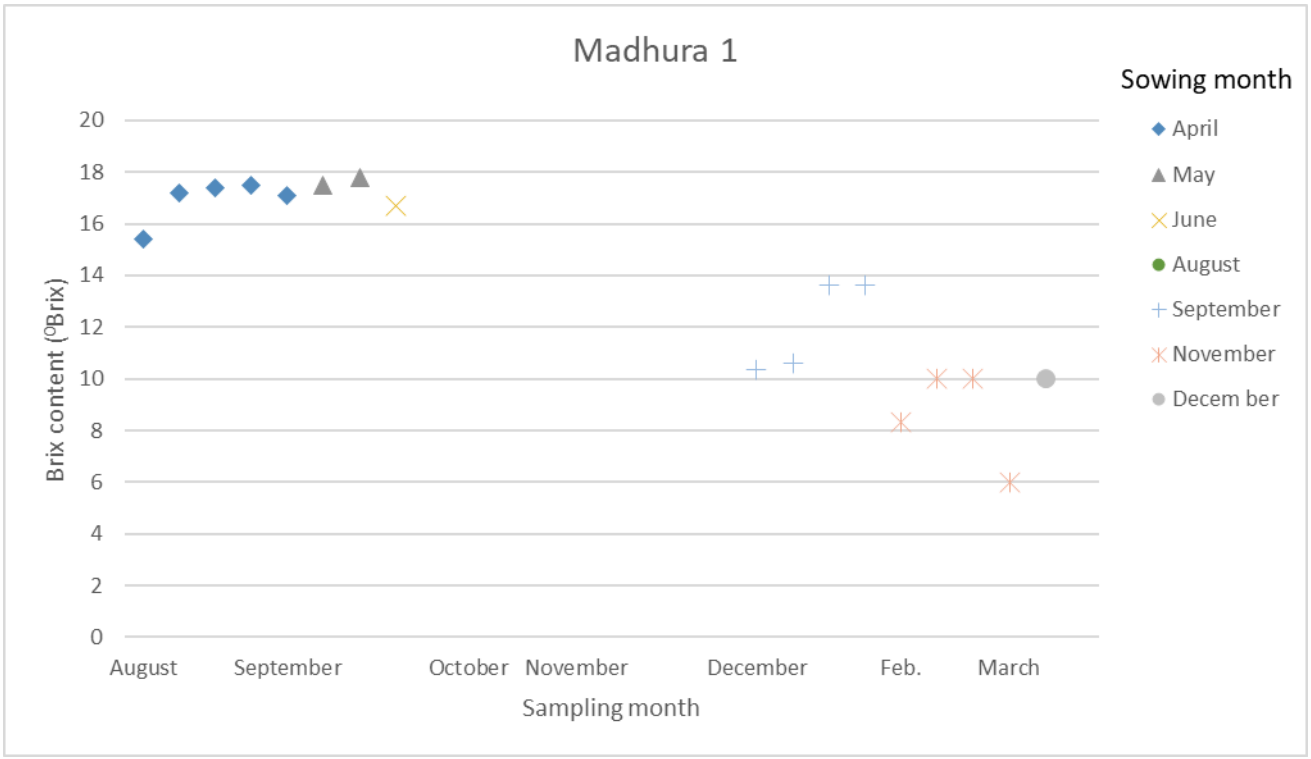


Figure 1: Variation in Brix content of Madhura 1 variety through the year 2021-22. The sowing month is indicated by markers on the panel at the right-hand side.

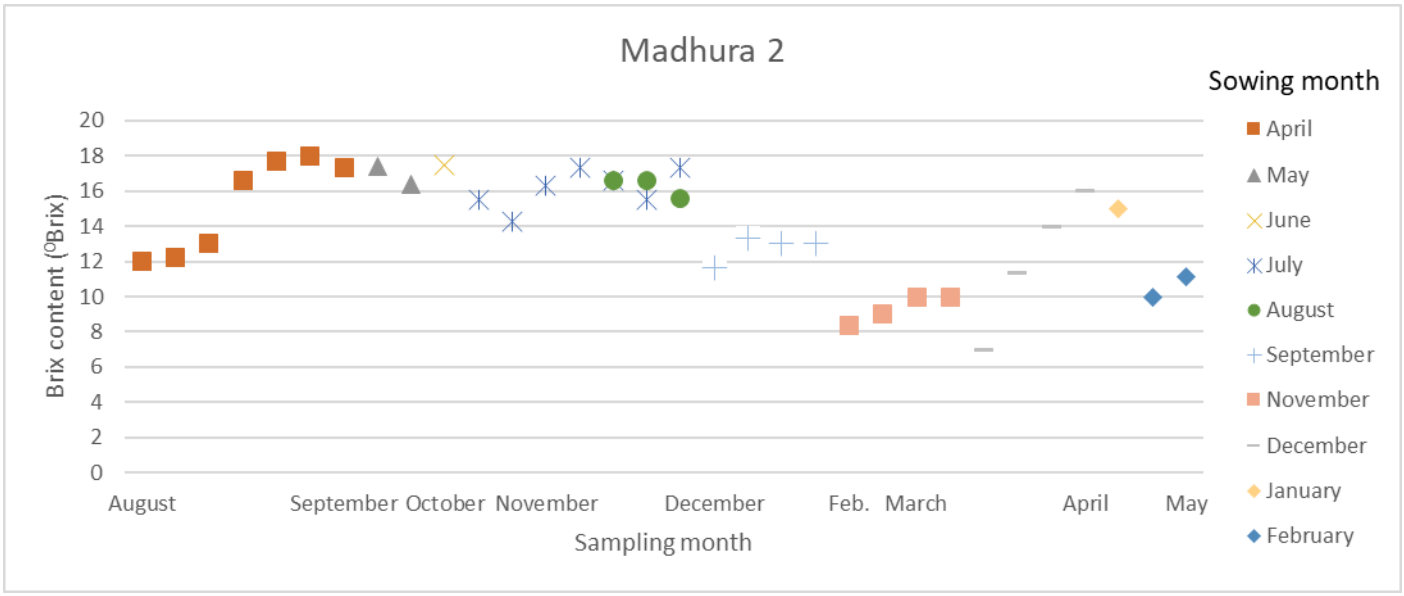


Figure 2: Variation in Brix content of Madhura 2 variety through the year 2021-22. The sowing month is indicated by markers on the panel at the right-hand side.

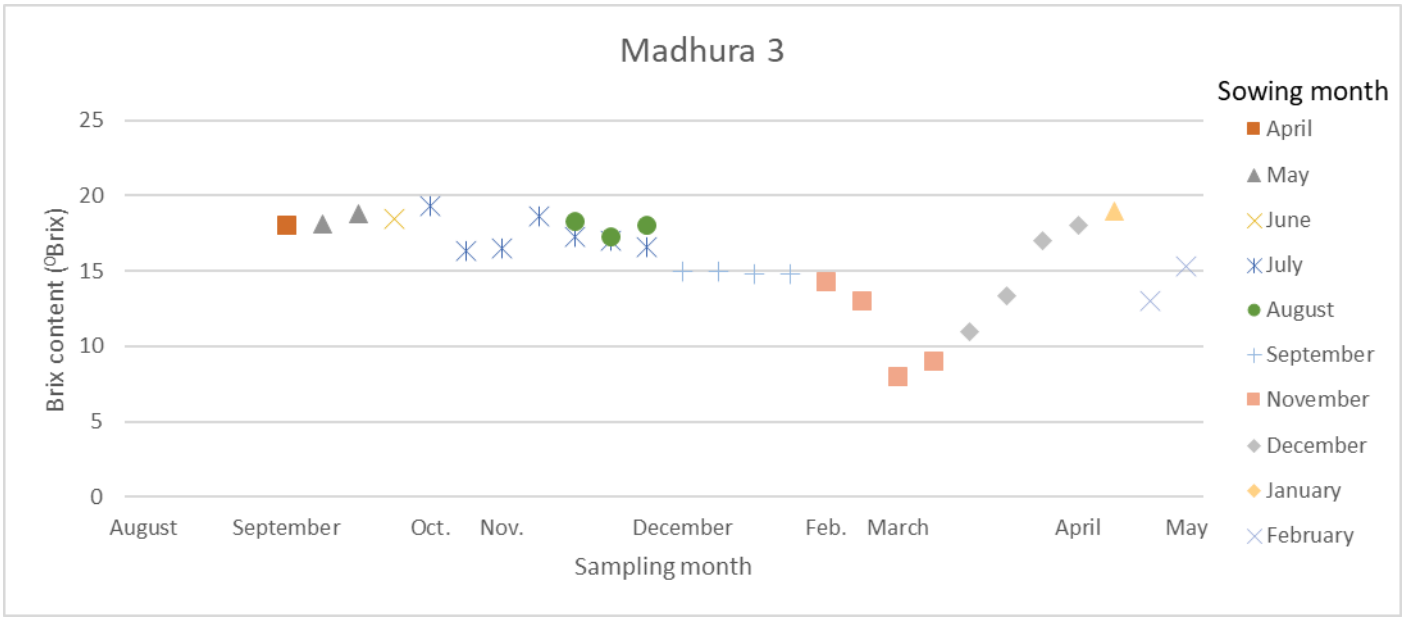


Figure 3: Variation in Brix content of Madhura 3 variety through the year 2021-22. The sowing month is indicated by markers on the panel at the right-hand side.

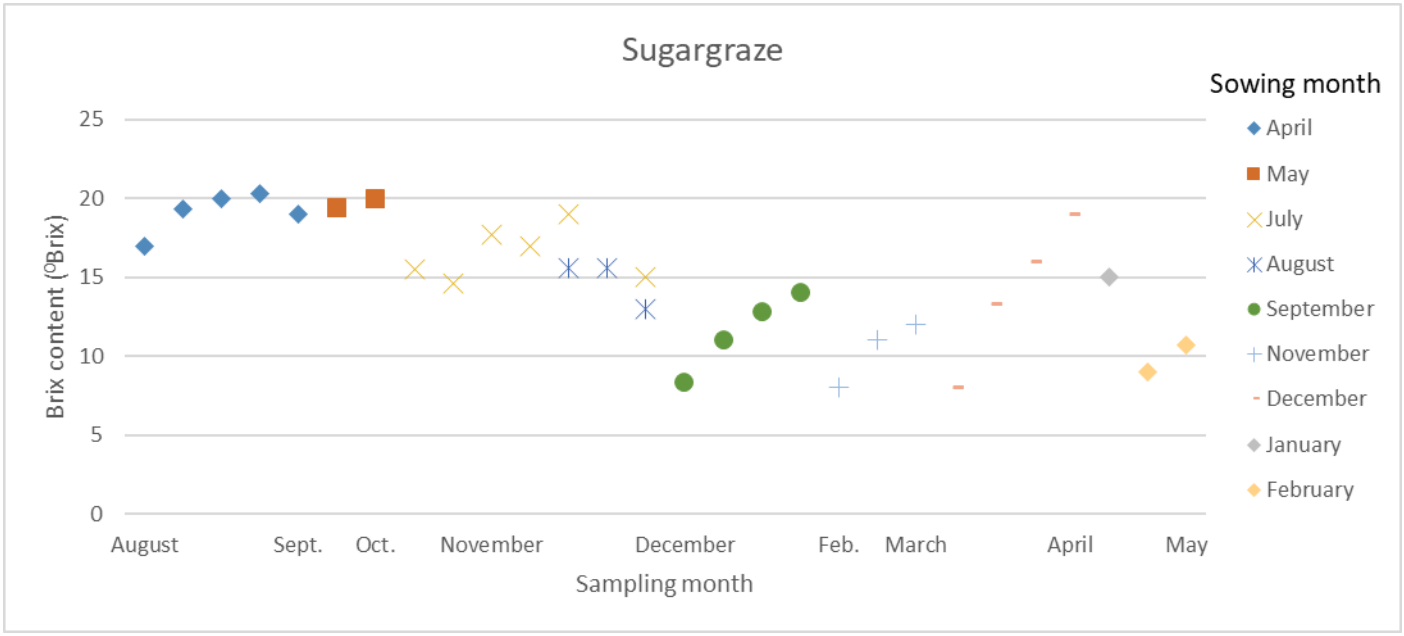


Figure 4: Variation in Brix content of Sugargraze variety through the year 2021-22. The sowing month is indicated by markers on the panel at the right-hand side.

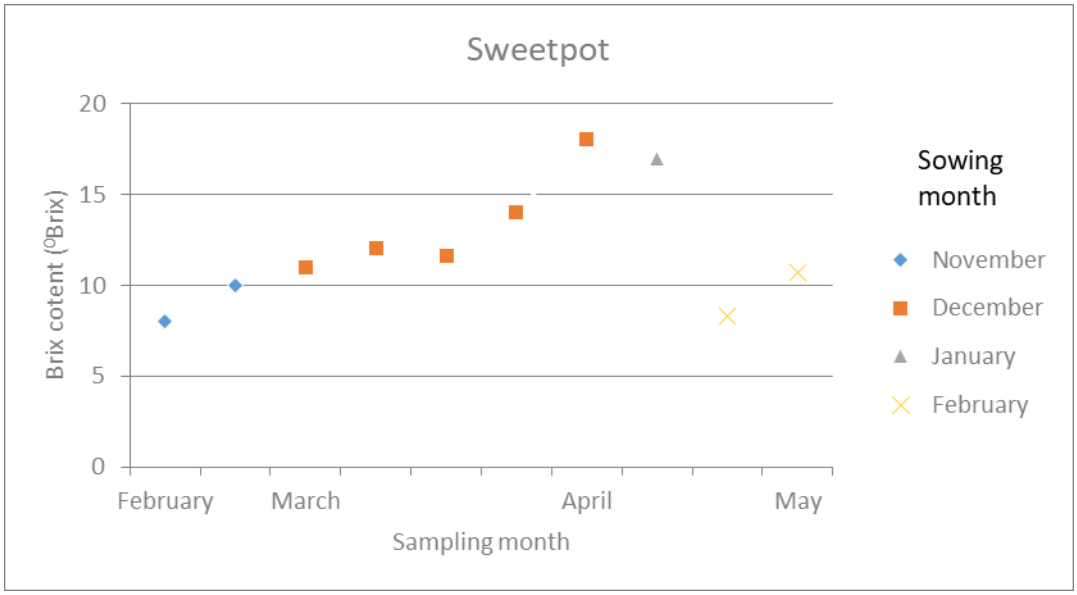


Figure 5: Variation in Brix content of Sweetpot variety through the year 2021-22. The sowing month is indicated by markers on the panel at the right-hand side.

Conclusions

Overall, January, April, May and December appear to be the most suitable months for sowing SS in order to get the highest Brix of juice. This was followed by June, July and August.

Madhura-3 is the most adaptable variety as it gave high Brix of juice when planted during any month of the year except November.

These conclusions are based on one year's data and data should be collected for at least one more year to increase their reliability.

Funding agency: Internally funded.

Scientists: Dr. Nandini Nimbkar.

Technical staff: Mr. Sharad Choudhari, Ms. Sonali Khalate, Ms. Anita Gholap and Mr. Maruti Shirke.

c. Sweet sorghum syrup project

Department of Science and Technology (DST), Government of India, has sanctioned the sweet sorghum project proposal titled 'Development of a fully mechanized plant to produce syrup from sweet sorghum'. This two-year project commenced on September 1, 2020. The objectives of this project are:

1. Designing, modelling and fabrication of a fully mechanized pilot plant to produce syrup from sweet sorghum (SS) juice at NARI.
2. Integration and optimization of all the sub-processes and the respective machinery to produce 150 kg of syrup per day.
3. Standardizing the quality of the syrup produced.
4. Popularizing the syrup produced (and thereby, the SS cultivation) among the farmers through demonstrations/workshops.

Highlights of the work done

For ease of bookkeeping, the complete process of syrup making can be divided into four sections: (a) harvesting and stripping of stalks, (b) crushing of stalk and settling of juice, (c) heating of juice, and (d) cooling and storage of syrup. A schematic illustrating the whole process, clearly depicting these four sections, is shown below.

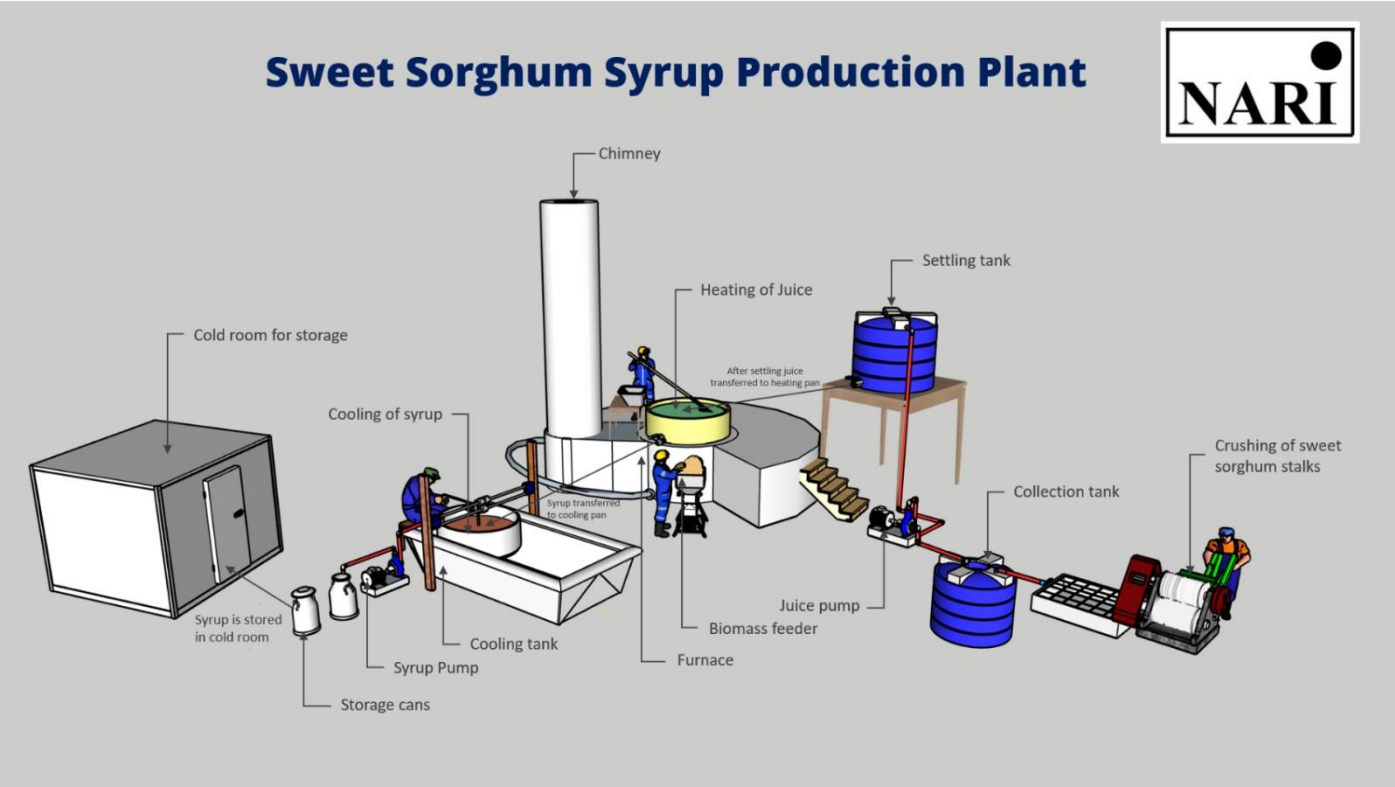


Figure 6: A schematic of the sweet sorghum syrup production process.

A summary of all the work that has been done in these four sections, and its key impact, is provided in the table below. Besides, work carried out towards dissemination of this technology has also been presented in the table.

Summary of the work done from September 1, 2021 to June 30, 2022.

Work	Key impact
Section: crushing of stalk and settling of juice	
Determined optimum settling time through lab experiments	Reduction in scum
Modified crusher outlet to collect bagasse using carts	Requires only one laborer (compared to two previously) with enhanced convenience
Modified filtration assembly at crusher juice outlet; shifted finest filter to heating stage	No choking of filter
Installed new juice transfer pump	Faster juice transfer from collection to settling tank
Section: heating of juice	

Switched to continuous bagasse feeding	Enhancement in efficiency and heating rate, and reduction in smoke
Purchased new shredder	Reduction in chute choking
Determined optimum furnace height	Enhancement in furnace efficiency
Fabricated bigger primary air inlet	Lesser stoking required, reduction in backpressure
Installed new blower, added non-return valve	Occupies less space, is less noisy and consumes less power
Fabricated fuel feeding cart	Convenient fuel feeding
Modified furnace design to improve heat transfer	Enhancement in efficiency and heating rate
Made design modifications to prevent ash particles from going into juice while heating	Cleaner syrup
Developed a conveyor mechanism for continuous fuel feeding	Convenient fuel feeding
Explored different pan sealing mechanisms	Reduction in smoke; and enhanced efficiency
Fabricated a thermocouple wire mounting frame	Accurate and convenient syrup temperature measurement
Installed alarms in temperature measuring instrument	Precise estimation of syrup endpoint
Fabricated scum collector	Reduction in juice loss
Fabricated bigger scum removal ladle	Reduction in number of laborers required with enhanced convenience
Constructed new furnace	Enhancement in efficiency and ease of scum removal
Fabricated a syrup filter (while transferring from heating to cooling pan)	Filtration of impurities introduced during heating
Section: cooling and storage of syrup	
Determined dominant mode of cooling	Helped us build an appropriate device
Developed a semi-mechanical cooling mechanism	Reduction in cooling time and effort
Installed syrup pump	Convenient transfer from cooling pan to storage can
Installed pan cleaning pump	Convenient and better cleaning of pans; and saving of water
Correlated syrup Brix with flowability	Objective evaluation of syrup flowability
Correlated syrup clarity with light transmittance	Objective evaluation of syrup clarity
Section: popularization & dissemination of technology	
Made syrup making manuals in English, Hindi & Marathi	Enable rural farmers to make syrup in the right manner
Installed syrup banner in front of the institute	Increase awareness about SS syrup
Put up a stall in front of the institute during the time of the annual pilgrimage to Pandharpur	-do-

Demonstrated to farmers syrup making process	Get farmers interested in planting SS and producing syrup from it
Did cost-benefit analysis of SS syrup production	Justification for producing SS syrup
Carried out economic analysis of sugarcane v/s sweet sorghum	-do-

Funding Agencies: DST and Bajaj Finserv CSR.

Scientists: Dr. Anil Rajvanshi, Dr. Nandini Nimbkar and Dr. Sankalp Tiwari.

Technical staff: Mr. Sharad Choudhari, Mr. Shivam Patange, Mr. Rivaan Jadav, Ms. Rezeena Chinthamalla and Mr. Santosh Adsul.

Safflower (*Carthamus tinctorius*)

Safflower evaluation trials: Safflower entries provided by the Department of Botany, University of Delhi were sown for evaluation at NARI farms. Two different trials were carried out. The details of the trials are given below.

Trial-1

Introduction

Safflower was sown in Plot-19 in four blocks shown in the schematic below in Figure 7. Each block was divided into six plots, and in each plot, there were 20 rows. In each row, 10 seeds of a given entry were sown. In this way, 1200 seeds of 120 entries were sown in each block. Timeline of major activities carried out for this trial is given in Table 11. Some entries did not germinate and many plants also died at the seedling stage, so the trial was resown at the same place 74 days after the initial sowing.

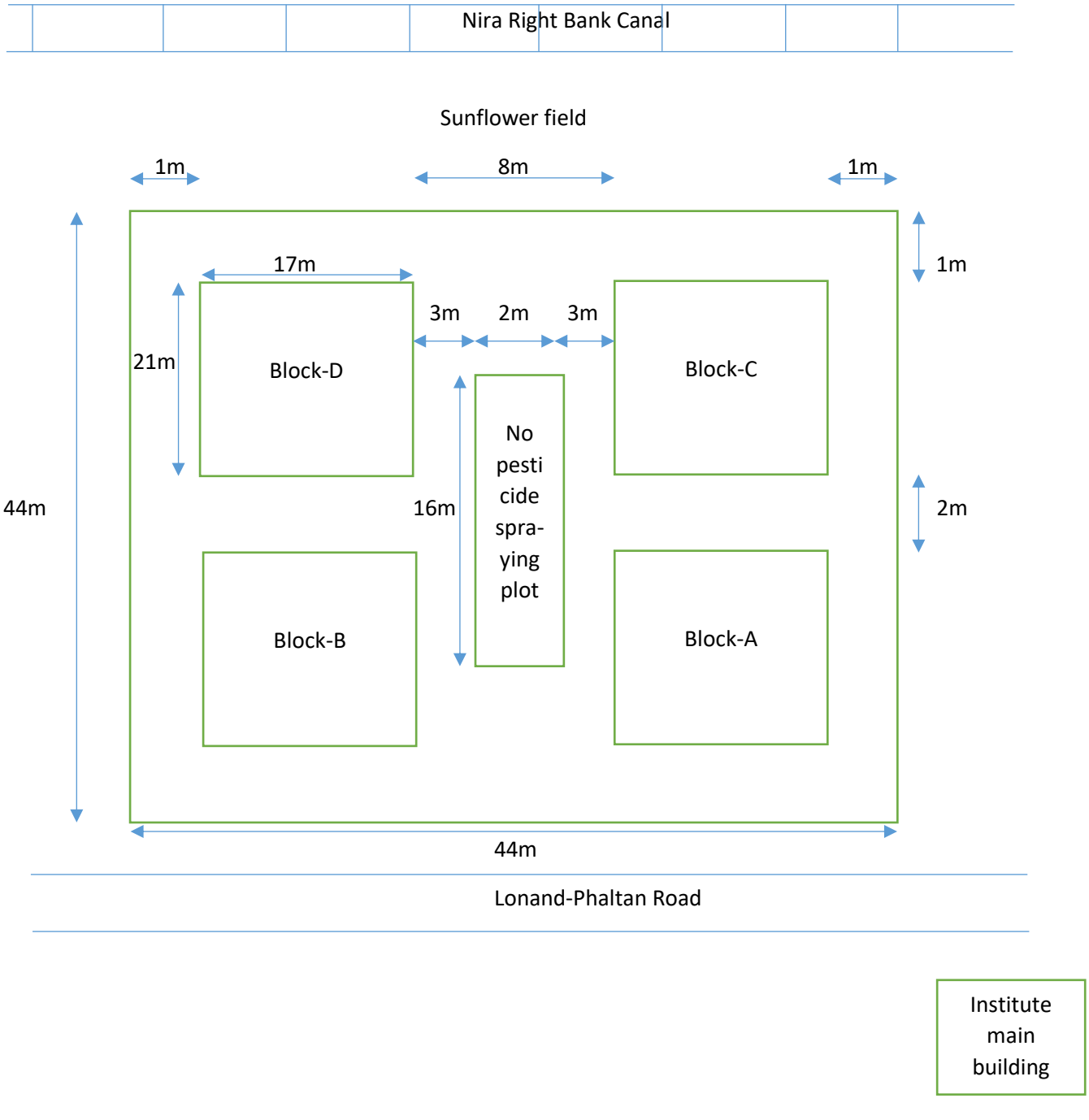


Figure 7: Block diagram of safflower trial-1.

Table 11: Timeline of safflower trial-1.

Date	Work done
20 Oct, 2021	Double cultivation
22 Oct, 2021	Making of beds by small tractor
25 Oct, 2021	First dose of fertilizer & irrigation
29 Oct, 2021	Sowing & water-spraying
3 Nov, 2021	Water spraying on beds
10 to 13 Nov, 2021	Weeding
17 Nov, 2021	Rainfall (17.5 mm)
18 Nov, 2021	Second dose of fertilizer
25 Nov, 2021	Spraying (Carbendazim + Dimethoate)
2 Dec, 2021	Rainfall (62.79 mm)
4 Dec, 2021	Rainfall (8.5 mm)
8-9 Dec, 2021	Weeding in remaining beds
8 Jan, 2022	Received seeds for resowing
10 Jan, 2022	Weeding in all beds before sowing
11 Jan, 2022	Resowing
12 Jan, 2022	Irrigation & fertilizer application
24 Jan, 2022	Irrigation
2 Feb, 2022	Spraying (Carbendazim + Dimethoate)
12 Feb, 2022	Spraying of Dimethoate
16 Feb, 2022	Spraying of Dimethoate
17 Feb, 2022	Irrigation & fertilizer application
24 Feb, 2022	Selfing by net bags
17 Mar, 2022	Weeding
21 Mar, 2022	Irrigation & fertilizer application
16-17 Mar, 2022	Weeding
12-14 Apr, 2022	Start harvesting, threshing
15 Apr, 2022	Selfing by net bags on resown entries

Photos

Figure 8: Safflower trial-1 photos. Top-left: preparation of flat beds; top-right: prepared beds being irrigated; mid-left: sowing of seeds; mid-right: water-spraying; bottom-left: germination; bottom-right: growing plant.

Methodology

The following data was collected:

(a) Germination count (recorded two times: 12 and 44 days after sowing).
(b) Plant height.
(c) Location of first branch from the soil surface: base (B), middle (M) and top (T).
(d) Diameter of capitula.
(e) Number of primary branches per plant.
(f) Number of capitula per plant.
(g) Spininess (non-spiny, spiny and very spiny).
(h) Days to 50% flowering.
(i) Seed weight.

To determine the best performing entries, they were evaluated on all the above criteria except (a), (c) and (g). Maximum relative weightage was given to seed weight criterion since it is the most crucial output for a farmer so far as his/her income is considered. To that end, the relative weight assigned to the seed weight criterion was equal to the sum of all the others, which were equal among themselves.

Results

The top ten entries of trial-1 are given in Table 12: Ten best-performing entries in trial-1.

Trial-2

Introduction

Safflower was sown in Plot-19 in nine plots (P1 to P9) shown in the schematic below in Figure 9. In each plot, there were 100 to 115 lines. In each line, ten seeds of a given variety were sown. Sharda variety was sown as a check. Timeline of major activities carried out for this trial is given in Table 13.

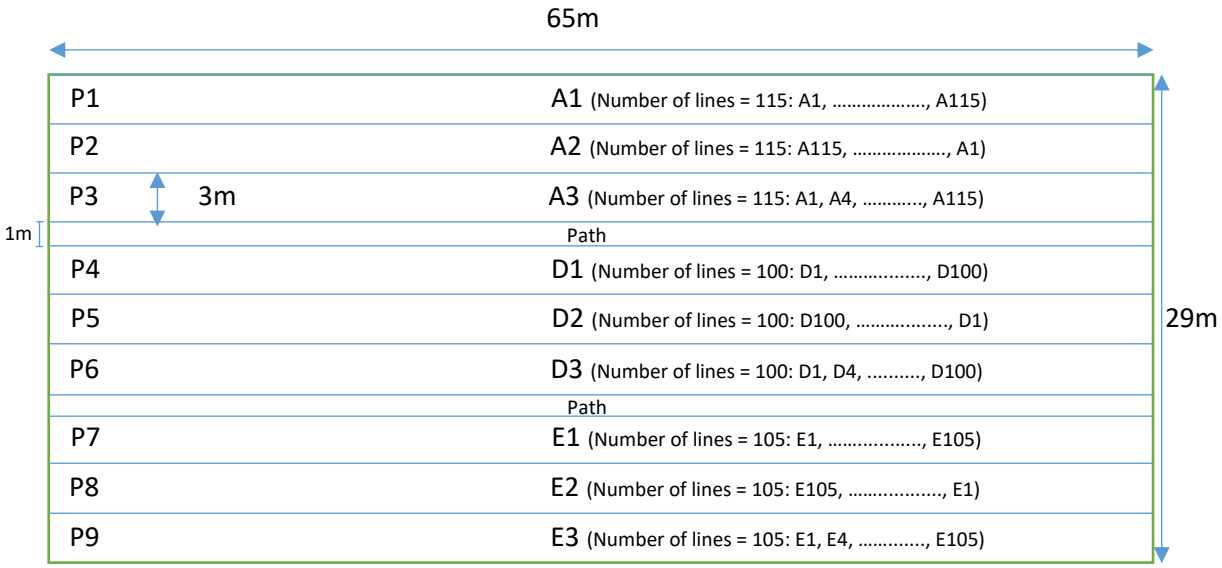


Figure 9: Block diagram of safflower trial-2.

Table 13: Timeline of safflower trial-2.

Date	Work done
20 Oct, 2021	Double cultivation
22 Oct, 2021	Making of beds with small tractor
30 Oct, 2021	Mending of beds
8 Nov, 2021	First dose of fertilizer & irrigation
13 Nov, 2021	Marking of 60 cm rows
14 Nov, 2021	Marking of 60 cm rows & spraying (Carbendazim + Dimethoate)
16 Nov, 2021	Sowing & water-spraying
17 Nov, 2021	Rainfall (17.5 mm)
24 Nov, 2021	Spraying (Carbendazim + Dimethoate)
24-26 Nov, 2021	Weeding
2 Dec, 2021	Rainfall (62.79 mm)
4 Dec, 2021	Rainfall (8.5 mm)
9 Dec, 2021	Spraying (Carbendazim + Dimethoate)
28 Dec, 2021	Second fertilizer dose (urea) & irrigation
8 Jan, 2022	Spraying (Dimethoate)
20 Jan, 2022	Spraying (Dimethoate)
24 Jan, 2022	Irrigation
2 Feb, 2022	Spraying of Hamla (Chlorpyriphos 50% + Cypermethrin 5% EC)

14 Feb, 2022	Spraying of Hamla (Chlorpyriphos 50% + Cypermethrin 5% EC)
15 Mar, 2022	Spraying of Dimethoate on a few entries.
28 Feb-30 Mar, 2022	Bird watching
6-11 Apr, 2022	Harvesting, threshing

Photos

Figure 10: Safflower trial-2 photos. Top-left: irrigation of flat beds; top-right: germination; mid-left, mid-right, bottom-left, bottom-right: various stages of growth before flowering.

Figure 11: Various stages of growth after flowering.

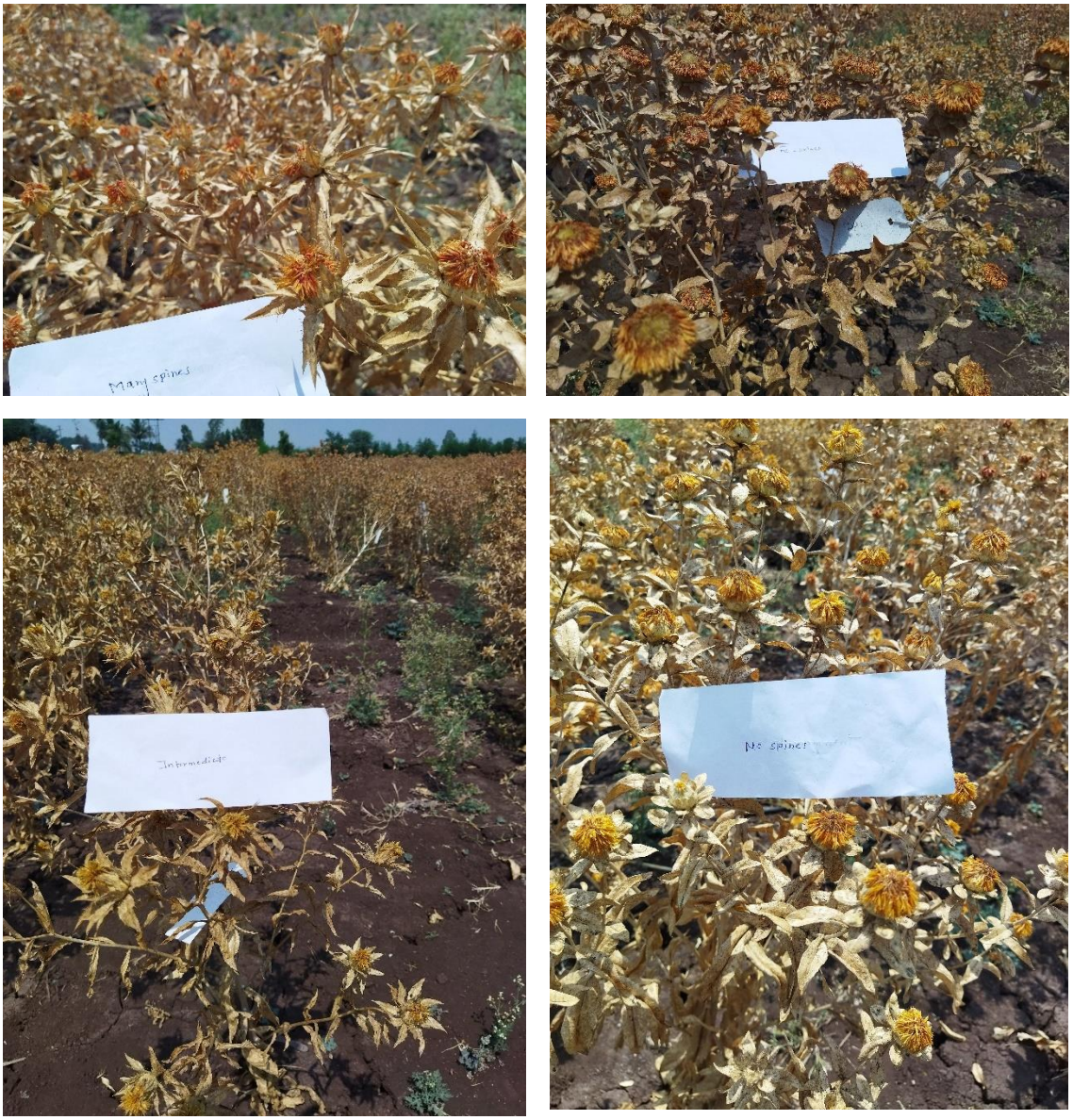


Figure 12: Tags for characterization of spininess. Top-left: many spines; top-right: few spines; bottom-left: intermediate; bottom-right: no spines.

Methodology

The following data was collected:

(a) Germination count (10 days after sowing).
(b) Final plantstand per plot.
(c) Plant height.
(d) Number of primary branches per plant.
(e) Location of first branch from the soil surface: base (B), middle (M) and top (T).
(f) Number of capitula per plant.
(g) Diameter of capitulum.
(h) Spininess (no spines, few spines, intermediate and many spines).
(i) Days to 50% flowering.
(j) Flower colour.
(k) Seed yield per plot.
(l) Weight of 100 seeds.

To determine the best performing entries, they were evaluated on all the above criteria except (e), (h) and (j). Maximum relative weightage was given to seed yield criterion since it is the most crucial output for a farmer so far as his/her income is considered. To that end, the relative weight assigned to the seed yield criterion was equal to the sum of all the others, which were equal among themselves.

Results

The top ten entries of trial-2 are given in Table 14: Ten best-performing entries in trial-2.

Funding agency: Department of Botany, University of Delhi. [Concerned scientists: Trial 1 - Dr. Ani Elias, Scientist D on Ramalingaswami fellowship, Institute of Forest Genetics and Tree Breeding, ·Coimbatore, Tamil Nadu. (Earlier at University of Delhi). Project entitled "Develop prediction models for forestry and agricultural crop improvement programs using genomic and image data".

Trial 2 - Dr. Arun Jagannath, Professor, Department of Botany, University of Delhi].

Scientist: Dr. Nandini Nimbkar.

Technical staff: Mr. Sharad Choudhari, Ms. Sonali Khalate, Ms. Anita Gholap and Mr. Maruti Shirke.

Biofertilizer trial

Biofertilizers provided by Bomlife Private Limited, Kolkata (https://bomlife.in/) were used to grow soybean, sweet sorghum, sunflower and sugarcane. The details of the trials except those for sugarcane are given below. Sugarcane will be harvested next year, when the data will be recorded.

Soybean trial

Basic information

Table 15: Basic information of soybean trial.

Operation	Date
Sowing (MACS-1281) by tractor	17/01/2022
Mending of beds	18/01/2022
Irrigation	18/01/2022 03/02/2022 29/02/2022 21/03/2022 31/03/2022 11/04/2022
Weedicide spraying (Sodium Acifluorfen 16.5% + Clodinafop Propargyl 8%)	10/02/2022
Spraying Bom Knight-1	15/02/2022 14/03/2022
Spraying Bom Tonic	24/02/2022
Spraying Bom Knight-2	28/02/2022 28/03/2022
Weeding	28/02/2022
Spreading compost(150 kg) with Bom Biomics(30 kg)	29/02/2022
Spraying Bom Shield	07/03/2022
Spreading compost-50 kg with Bom Biomics-10 kg	21/03/2022
Harvesting	05/05/2022- 06/05/2022
Collecting dried soybean plants from the field	11/05/2022
Threshing	11/05/2022
Sun drying the seeds	13/05/2022- 14/05/2022
Cleaning	16/05/2022

Results

Fertilizer	Area in sqm	Seed yield/plot (kg)	Seed yield (kg/ha)	Remarks
Organic fertilizer	4000	251	627.5	One extra irrigation was given
Without Fertilizer	4000	160	400	

Note: Generally, no fertilizer application is carried out in soybeans.

Soybean crop responded quite well to the application of the organic fertilizers, but with the extra cost of the biofertilizers and their application it has to be assessed if the cost benefit analysis will be favourable.

Photos

Figure 13: Soybean trial photos. Top-left: Spraying; Top-right: Application of compost fertilizer; Bottom-left: Application of organic fertilizer Bom Biomics; Bottom-right: Soybean crop.

Sweet sorghum trial

Basic information

Table 16: Basic information of sweet sorghum trial.

Operation	Date
Irrigation given to fallow furrows	09/02/2022 16/02/2022
Spreading compost (150 kg) with Bom Biomics (30 kg)	14/02/2022
Sowing (Madhura-3) & seed treatment	16/02/2022
Irrigation	17/02/2022 24/02/2022 16/03/2022 30/03/2022 31/03/2022 18/04/2022 03/05/2022
Thinning	02/03/2022
Weeding	15/03/2022
Spraying Bom Knight-2	19/03/2022
Spraying Bom Tonic	23/03/2022

Spreading compost (50kg) + Bom Biomics (10 kg)	15/04/2022
Harvesting for large scale syrup production	30/05/2022

Photos

Figure 14: Sweet sorghum trial photos. Top-left: Seed treatment; Top-right: Sowing; Bottom-left: Irrigated field; Bottom-right: Sorghum crop.

Results

Table 17: Average of observations of 10 plants. (Range of the recorded values is given in bracket)

Fertilizer	Total plant height (cm)	Stem diameter (cm)	Number of leaves / plant	Number of internodes / plant	Biomass weight (g)	Juice brix (%)	Juice weight (g)	Weight of insect - damaged plants (g)	Panicle weight (g)
Organic fertilizer	224 [145-270]	1.5 [1.2-2.0]	8 [5-11]	9 [6-9]	434.4	18.1	55.7	40.3	73.0
Chemical fertilizer (100: 50: 50 kg/ha N:P:K)	236 [210-270]	2.0 [1.3-2.5]	9 [5-11]	8 [7-9]	424.4	18.7	64.3	26.1	93.0

Table 18: Overall results.

Fertilizer	Area in sqm	Biomass/plot (kg)	Biomass (MT/ha)
Organic fertilizer	205	460	22.4
Chemical fertilizer (100: 50: 50 kg/ha N:P: K)	205	545	26.5

Note: Seed yield could not be recorded as very little seed was produced due to bird predation.

No advantage of organic fertilizer compared to standard chemical fertilizer application was observed.

Sunflower trial

Basic information

Table 19: Basic information of sunflower trial.

Operation	Date
Broadcasting compost (150 kg) + Bom Biomics(30 kg)	21/02/2022
Sowing (Hybrid NSH-10) with seed treatment	22/02/2022
Irrigation	23/02/2022 02/03/2022 17/03/2022 31/03/2022 19/04/2022 02/05/2022
Spraying Bom Knight-2	09/03/2022
Weeding	15/03/2022
Spraying Bom Tonic	15/03/2022 21/03/2022
Spraying Bom Knight-1	30/03/2022 07/04/2022
Spraying Bom Shield	08/04/2022
Bird watching	10/05/2022 – 21/05/2022
Harvesting	21/05/2022 – 22/05/2022
Threshing	23/05/2022 – 26/05/2022
Cleaning	28/05/2022

Results

Table 20: Average of observations of 10 plants and results.

Fertilizer	Plant height (cm)	Capitulum diameter (cm)	Plot area (sqm)	Seed yield/plot (kg)	Seed yield (kg/ha)
Organic fertilizer	144 [120-170]	4.3 [3.0-6.0]	2340	230	982
Chemical fertilizer (100: 50:50 kg/ha N:P: K)	156 [135-175]	5.3 [4.0-6.0]	468	53	1132

Note: Sunflower plants in plot to which organic fertilizer was applied flowered about 10 days later than those in plot to which chemical fertilizer was applied.
At its best organic fertilizer was on par with the chemical fertilizer treatment.

Photos

Figure 15: Sunflower trial photos. Top-left: Sowing Top-right: Application of compost and Bom Biomics; Bottom-left: Left part of the image shows the plot grown with organic fertilizers in which late flowering was observed, on the right part chemical fertilizers were used and early flowering can be seen; Bottom-right: Sunflower crop.

Funding agency: Bomlife Private Limited, Kolkata.

Scientists: Dr. Nandini Nimbkar.

Technical staff: Mr. Sharad Choudhari, Ms. Sonali Khalate, Ms. Anita Gholap and Mr. Maruti Shirke.

Indoor agriculture (Funded by Bajaj Finserv CSR)

Introduction

Hydroponics is the technique of growing plants without soil and without the limitations of space and climate. In the traditional farming system, plants obtain all the nutrients needed for their growth from soil. In contrast, a hydroponic garden provides all these nutrients without involving sunlight and soil. Setting up a hydroponic plant may be expensive and unfeasible for farmers. Our aim at NARI is to develop strategies for setting up a hydroponic system with cheaper environment control. Once this aim is achieved, we plan on training farmers and leasing the developed technology to them so that they can benefit from it.

Objectives

1. To develop an efficient and low-cost indoor agriculture technology to produce green fodder and vegetables year-round.
2. Disseminate the developed technology to the local farmers by leasing them some of the developed indoor agriculture units.

Highlights of the work done

Data monitoring

This year, only lettuce was planted in our hydroponic set-up. It was planted in two batches: (1) November 2021 end to February 2022 beginning (Batch-1) and (2) Mid-February 2022 to April 2022 beginning (Batch-2). The temperature and humidity of the greenhouse was measured six times between 9:30 am and 5:00 pm each day. These parameters are plotted in Figure 16 to Figure 19 below.

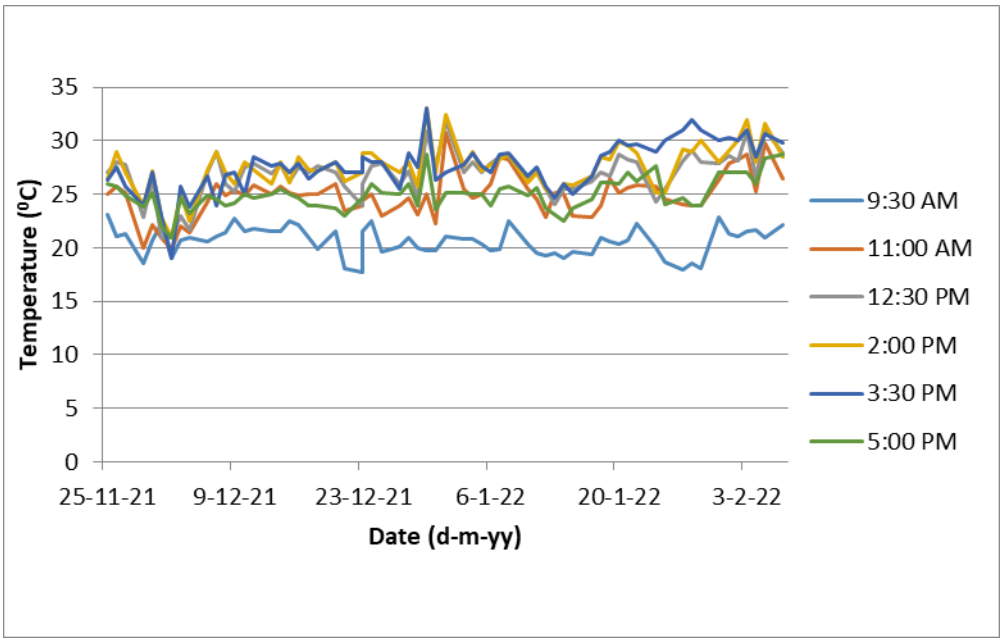


Figure 16: Variation in temperature for Batch-1 from November end to February beginning at different times of the day. Note that the data was taken on all the days during this period and only a few X-axis entries have been shown here for brevity; the same applies for figures that follow.

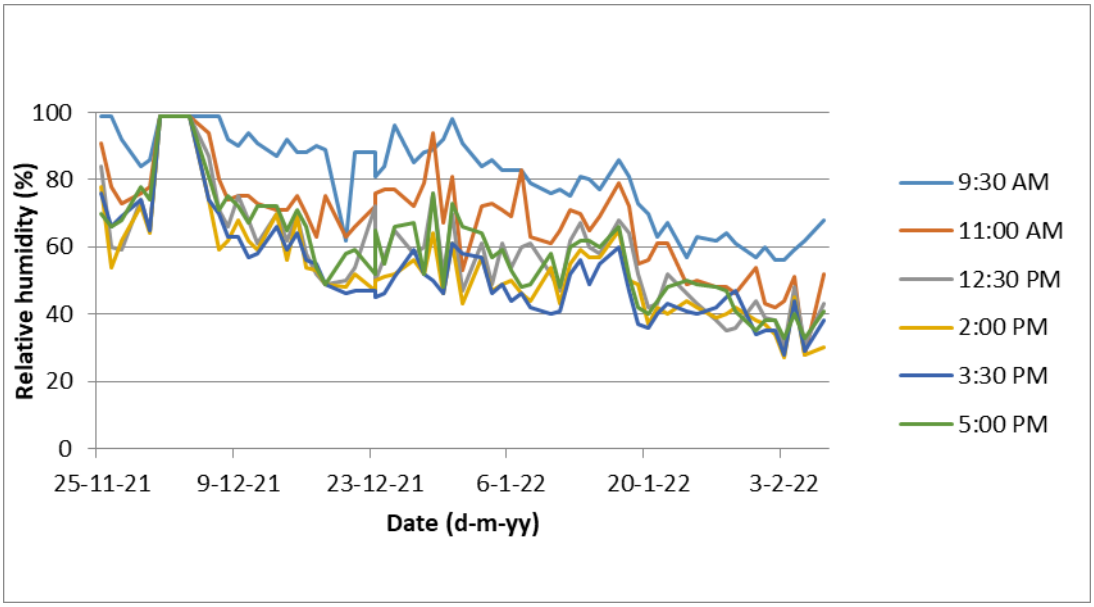


Figure 17: Variation in relative humidity for Batch-1 from November end to February beginning at different times of the day.

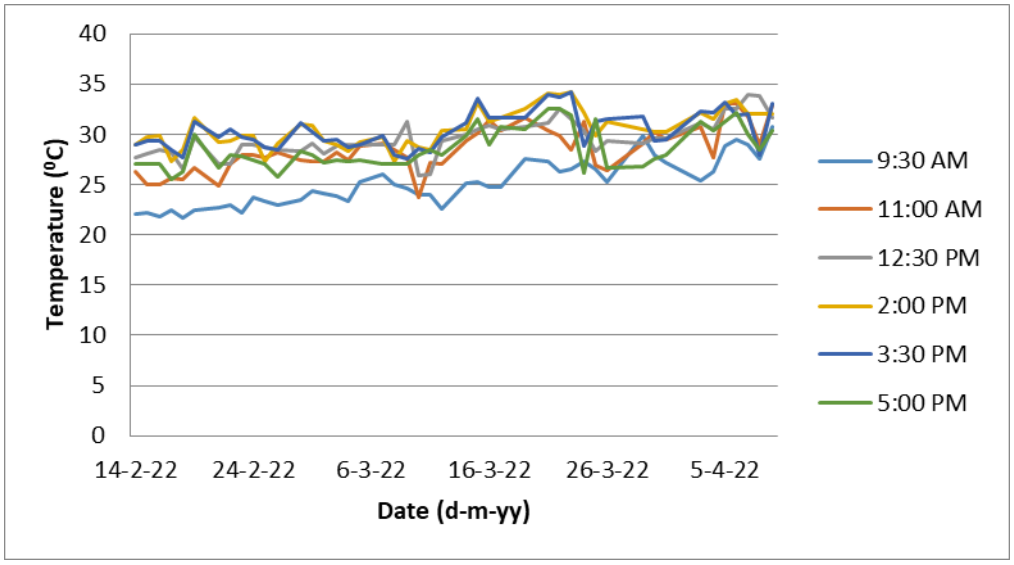


Figure 18: Variation in temperature of Batch-2 from mid-February to April beginning at different times of the day.

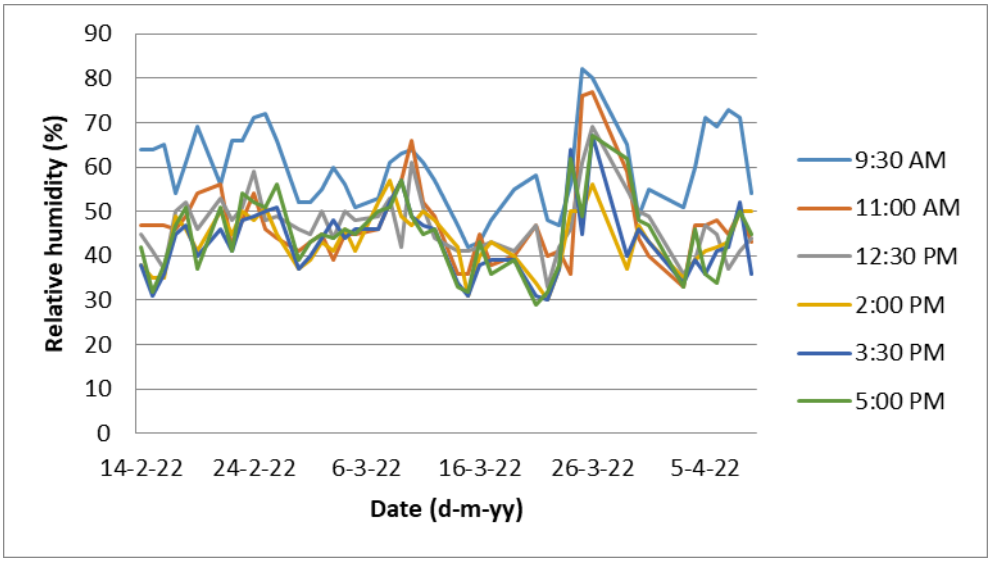


Figure 19: Variation in relative humidity for Batch-2 from mid-February mid to April beginning at different times of the day.

Yield results

The ideal temperature required for lettuce seed germination is in the range of 18–20°C, while that for subsequent growth is around 23°C [1]. On the other hand, the average minimum and maximum temperatures in the greenhouse in Batch-1 were around 20.6 and 27.6°C respectively, which were slightly higher than desired. Similarly, ideal relative humidity is between 50-70%[2], while the average minimum and maximum relative humidity observed were 54 and 81% respectively, which is again higher than desired. An average lettuce leaf yield of 3.13 g/plant (yield range was 1.42 to 4.08 g/plant) was obtained, while the expected yield was around 280 g/plant.

In Batch-2, the average minimum and maximum temperatures were around 25.1 and 30.3°C respectively, the average minimum and maximum relative humidity were around 43 and 60% respectively, and the average lettuce leaf yield was a paltry 2.02 g/plant (yield range was 1.54 to 3.33 g/plant) .

Electricity and water consumption

Electricity and water consumption data in Batch-2 was collected each day to perform a cost-benefit analysis. The electricity consumption on each day, as noted from the electricity meter, is plotted in Figure 20. The water consumed through fogger each day is plotted in Figure 21**Error! Reference source not found.**. The water consumed through air cooler each day is plotted in Figure 22. The fogger and air cooler together were found to consume 500 liters of water per day, which is quite substantial.

[1] Source: https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/hydrolettuce.pdf.
[2] Source: https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/8/8824/files/2019/06/Cornell-CEA-Lettuce-Handbook-.pdf.

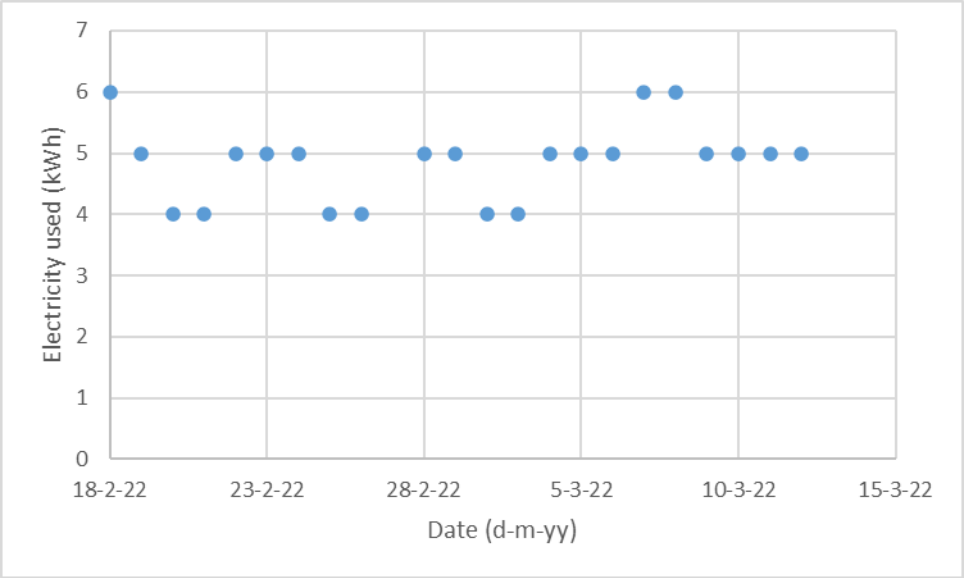


Figure 20: Electricity consumption per day for Batch-2 setup.

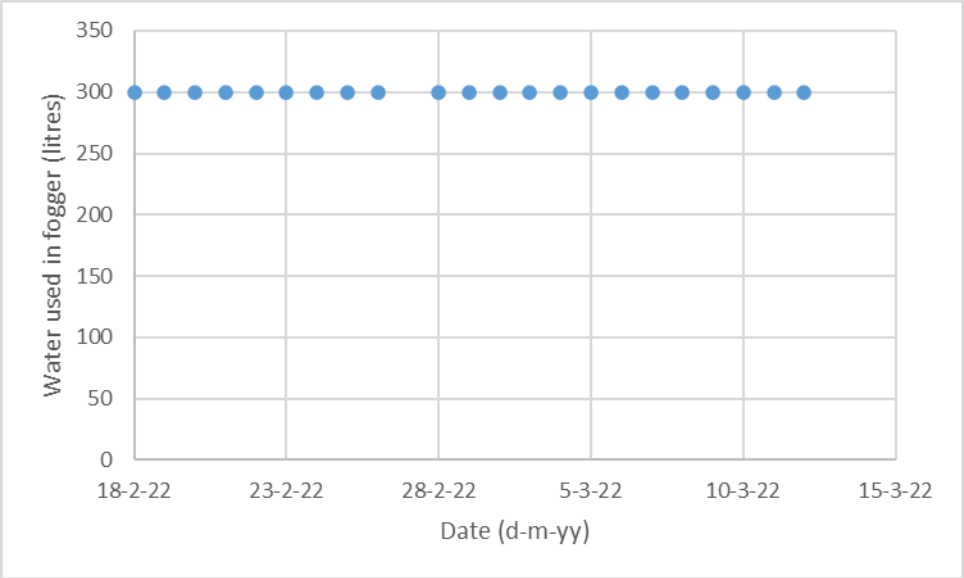


Figure 21: Water consumption per day for fogger usage in Batch-2 setup.

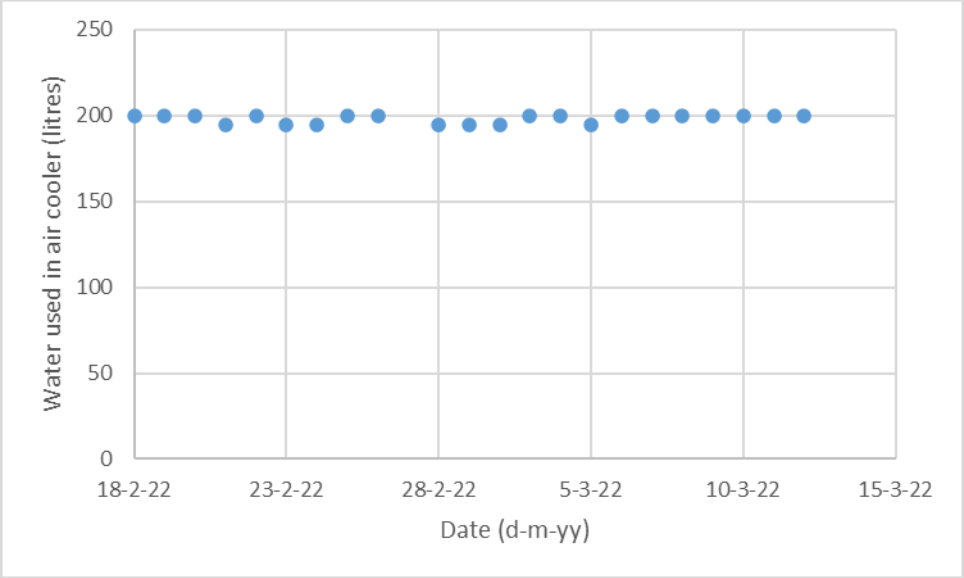


Figure 22: Water consumption per day for air cooler usage in Batch-2 setup.

Funding Agency: Bajaj Finserv CSR.

Scientists: Dr. Anil Rajvanshi and Dr. Nandini Nimbkar.

Technical staff: Mr. Sharad Choudhari and Ms. Anita Gholap.

Drinking water technology

Introduction

In the year 2019-20, a complete low-cost drinking water technology (DWT) was developed, and a prototype was installed at the NARI campus. The technology consists of two chief components: harvesting of rainwater and its purification through solar energy. Illustrations summarizing how DWT works and actual unit components can be seen in Figure 23 to Figure 25.

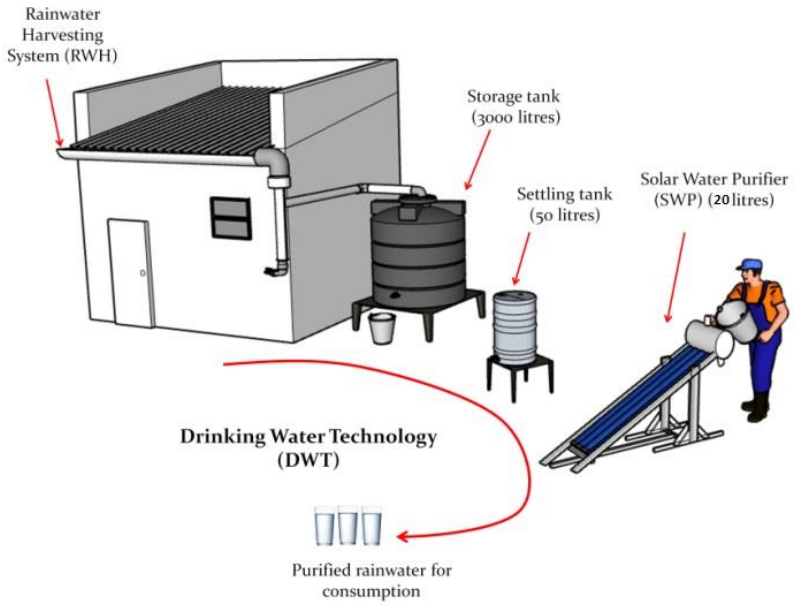


Figure 23: A schematic of the DWT unit developed by NARI.

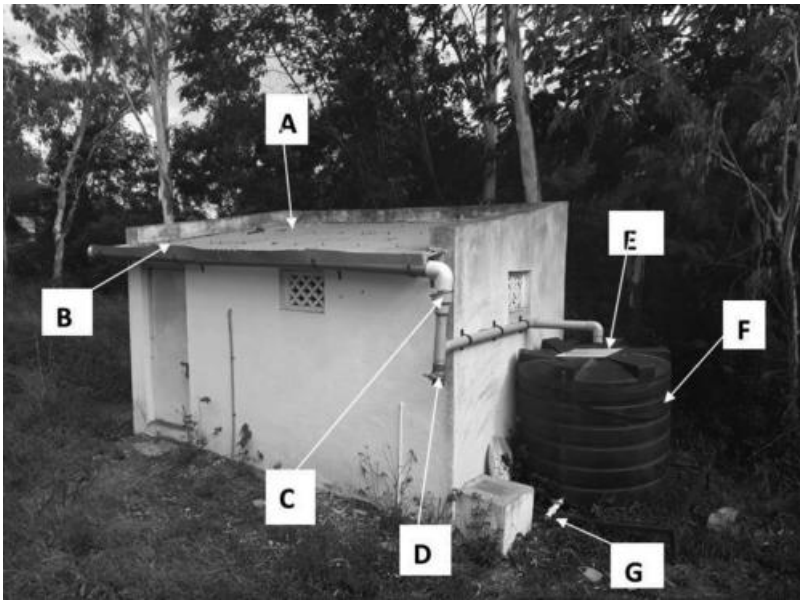


Figure 24: Installed RWH setup for an average-sized dwelling. A, Corrugated GI roof; B, Collection channel; C, SS mesh screen; D, First rainwater diverter valve; E, Cloth filter; F, Storage tank; G, Tap for drawing rainwater.

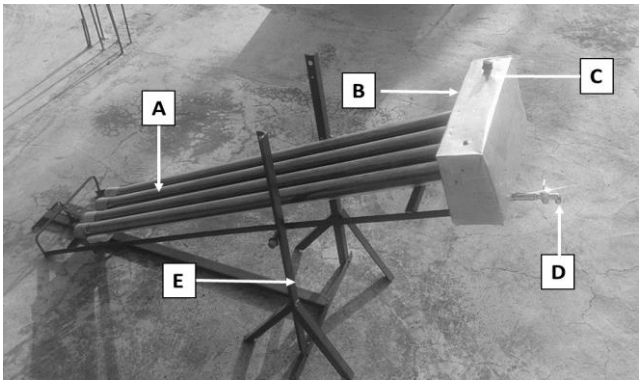


Figure 25: Four tube SWP unit at NARI. A, tubular solar collectors; B, stainless steel manifold; C, inlet port; D, tap (outlet port); E, mild steel supporting frame.

The salient features of this DWT are as follows.

- DWT offers a unique solution to address drinking water scarcity by harvesting the freely and abundantly available natural resources: rainwater and solar energy.
- The DWT unit ensures supply of clean drinking water *throughout* the year.
- In principle, no electricity is required in DWT.
- DWT rarely requires replacement parts (except for accidental breakages of glass tubes in the SWP unit).
- There is no water wastage in the SWP unit (unlike RO systems which discard about 80% water).

Highlights of the work done

The next step is to install this DWT in rural schools to address the issue of unavailability of potable water in such schools, as reported by many technical and mass-print studies. To that end, a detailed plan has been sketched and a proposal has been written up for CSR funding. The objectives of the proposal are as follows:

i.	Development of an automated, easy-to-use DWT unit based on RWH and SWP technologies developed at NARI.
ii.	Making the DWT unit fool-proof and economically viable through R&D.
iii.	Installing the DWT units in two rural schools of different sizes in Phaltan region.
iv.	Training students on water testing and DWT unit maintenance by developing an instruction manual.
v.	Popularizing DWT through videos, reports, and electronic media.

The work plan of the proposed project is shown below in Figure 26.

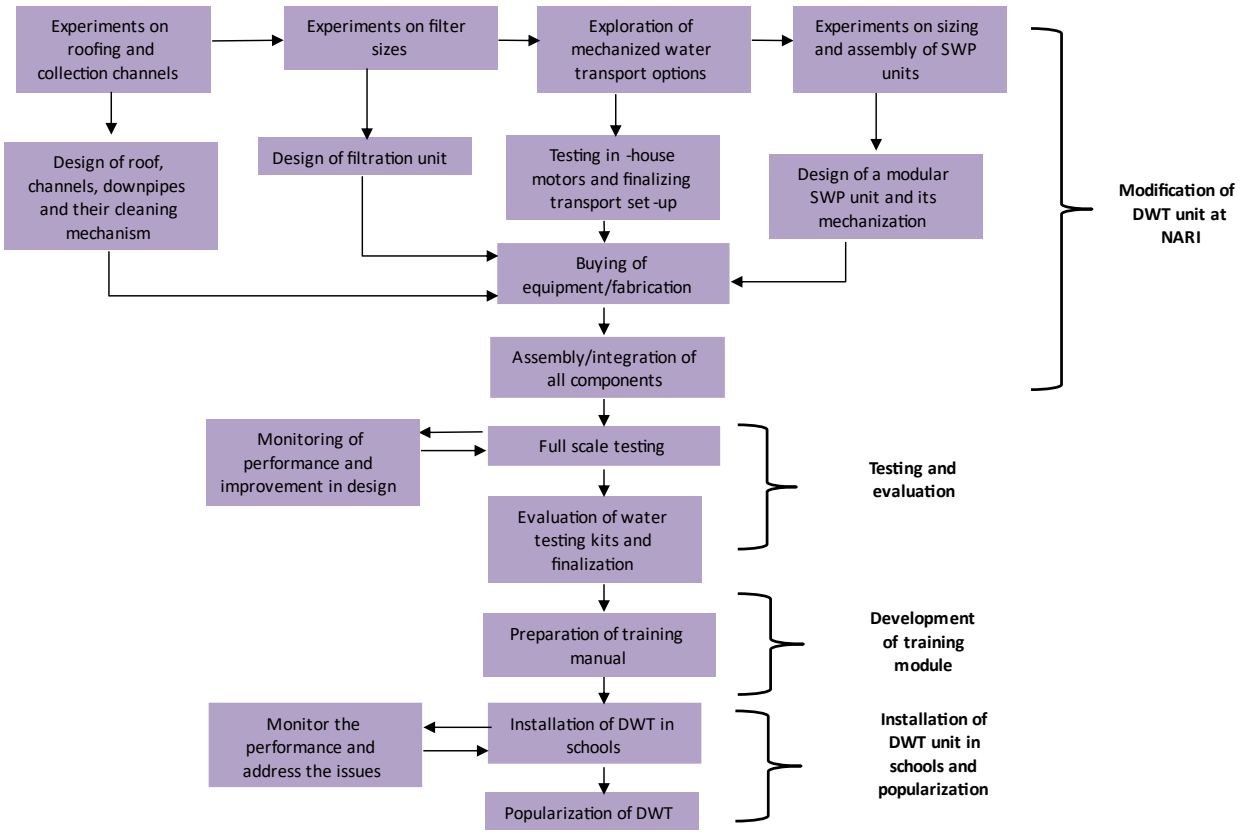


Figure 26: Work plan of the proposed DWT project.

Funding Agency: Partially funded by Bajaj Finserv CSR.

Scientists: Dr. Anil Rajvanshi and Dr. Sankalp Tiwari.

Technical staff: Mr. Shivam Patange.

Summary sheet of weather data

2021-22 (April 2021 to March 2022)

Nimbkar Agricultural Research Institute (NARI) PHALTAN-415523

Month	Average air temperature^{0}C		Rainfall (mm)	No. of 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 2021	39.88	21.00	46.03	4	6.08	NW	82.27	28.17	81.23	30.67	1.23	2.20
May	38.74	23.63	22.80	2	5.42	NW	89.29	39.10	88.32	42.61	2.71	4.23
June	33.40	22.48	68.10	13	3.21	NW	95.47	60.47	95.40	63.80	3.97	4.37
July	31.73	22.48	137.45	20	3.06	NW	97.13	68.16	97.13	72.00	5.00	5.42
August	30.44	21.82	28.20	12	2.91	NW	95.77	64.35	95.65	68.71	4.35	4.71
September	31.37	22.02	41.75	9	2.78	NW	97.53	61.83	97.47	64.03	4.53	5.20
October	32.90	19.81	127.70	8	2.68	NW	93.68	47.16	93.58	48.97	1.45	1.55
November	31.02	19.58	26.95	3	1.88	NW	94.87	55.47	94.77	77.67	2.37	2.57
December	28.16	15.73	77.40	3	1.31	SE	98.65	53.58	97.94	57.55	1.58	1.39
January 2022	28.56	13.63	0	0	5.20	NW	96.23	40.65	95.03	44.94	1.16	0.94
February	33.18	14.84	0	0	3.40	NW	66.82	29.36	64.39	34.14	0.39	0.71
March	38.21	19.76	0	0	5.05	NW	71.52	28.87	69.71	32.90	0.97	1.70
Mean	**33.13**	**19.73**	**576.38**	**82.00**	**3.58**	**NW**	**89.94**	**48.09**	**89.22**	**53.16**	**2.48**	**2.92**

Note: During this year, the highest maximum temperature of 42^0C was recorded on 7 April 2021, 29 March 2022 and 31 March 2022. The lowest minimum temperature of 10^0C was recorded on 29 January 2022. The highest one-day rainfall of 60.75 mm was recorded on 2 December 2021.

Animal Husbandry Research

Highlights

- Dr. Chanda Nimbkar, Director, AHD, NARI was nominated to be featured in the second book dedicated to 75 Indian women in the fields of Science, Technology, Engineering, Arts and Mathematics (STEAM), on the occasion of India's 75th Anniversary of Independence. The book series is being brought out by the Red Dot Foundation in partnership with the Office of the Principal Scientific Adviser to the Government of India. The aim of the series is to showcase women role models, make visible the leadership by women and generate interest in the SDGs.
- On 4th January 2022 Dr. Chanda Nimbkar had the honour of being nominated as a member of the Board of Governors of the Gujarat Biotechnology University (GBU), a new, autonomous, state-funded university being established in Gandhinagar, in partnership with the University of Edinburgh (UoE). UoE signed an agreement with GBU in December 2020 to co-create a research led, post graduate biotechnology university, with a focus on translation with a deep international partnership at its core. The GBU-UoE partnership has five strands (i) high level curriculum development for five MSc programmes – Animal, Environmental, Industrial, Medical and Plant Biotechnology (ii) faculty development & pedagogical training (iii) visiting faculty from UoE to GBU (iv) competitive student placements at UoE and (v) academic leadership and mentorship across the establishment of GBU.
- The organization Teplu Digital Farmers, which produces training videos on livestock management, approached the AHD. Dr. Pradip Ghalsasi gave lectures on various topics in sheep and goat management and allowed them to videograph the lectures. These videos will be used in NARI-AHD training programs and made available for the use of other agencies.
- NARI-AHD bought a new IMV Technologies ultrasound machine Ovi-Scan 6 with a 3.5" probe, worth Rs 23.6 lakh. With this machine, we will be able to determine the number of fetuses a pregnant NARI Suwarna ewe is carrying so that we can ensure its adequate nutritional intake. We are complying with all the provisions of the Pre-Conception and Pre-natal Diagnostic Techniques (Regulation and Prevention of Misuse) Act, 1994 (57 of 1994) and the Pre-natal Diagnostic Techniques (Regulation and Prevention of Misuse) rules, 1996. We intend to do research to find out the factors influencing the number of live lambs born in relation to the number of fetuses carried by ewes of the three different *FecB* genotypes.

Dr. Pradip Ghalsasi using the new ultrasound machine for scanning of a NARI Suwarna ewe

- On 9th August 2021 Hon'ble Shri. Sunil Kedar, Minister of Animal Husbandry, Dairy Development, Sports and Youth Welfare, Government of Maharashtra visited NARI AHD. Hon. Shri Ramraje Naik Nimbalkar, Chairman of the Maharashtra Legislative Council and Chairman of the Governing Council of the Maharashtra Goat and Sheep Research and Development Institute was also present on the occasion. Dr. Chanda Nimbkar and Dr. Pradip Ghalsasi informed the visitors about the activities of NARI-AHD and had discussions on genetic improvement of goats and sheep in Maharashtra. Dr. Ghalsasi showed them the buck and ram frozen semen lab and the buck semen freezing protocol standardized at NARI-AHD. They were highly impressed with the set up and research and development work going on at the AHD.
  Hon'ble Shri. Sunil Kedar wrote in the Visitors Register that 'It was really an amazing experience for me. NARI AHD is working hard with latest technology which will be really useful for public. I really appreciate the devotion and passion towards research in this field. As the Minister for Animal Husbandry I assure that government will always support your research activities and work in future and I wish you all the best'.


Visit by Hon'ble Shri. Sunil Kedar, Minister of Animal Husbandry and Hon. Shri Ramraje Naik Nimbalkar, Chairman, Legislative Council, Government of Maharashtra

- The Minister then arranged the procurement of **1100 frozen semen straws of Osmanabadi bucks** and **550 frozen semen straws of Damascus bucks** for the genetic improvement of goats belonging to the Punyashlok Ahilyadevi Mendhi Va Sheli Vikas Prakshetra, Ranjani, Sangali, and Maharashtra Animal and Fishery Sciences University, Nagpur.
- Some more evidence of the recognition of Dr. Chanda Nimbkar's expertise by the Government of India, Ministry of Fisheries, Animal Husbandry and Dairying came when she was requested to evaluate the research proposal entitled "Upliftment of farmers' livelihood through multifaceted approaches to increase production and reproduction ability of sheep and goats" submitted by the ICAR-National Institute of Animal Nutrition and Physiology Adugodi, Bengaluru, Karnataka, which was received for funding under the National Livestock Mission. She submitted her review to the government.
- On 28 August 2021. Dr.N. Vijaya Lakshmi, IAS, Principal Secretary, Animal and Fisheries Resources *Department*, Government of Bihar visited NARI AHD. Dr. Chanda Nimbkar and Dr. Pradip Ghalsasi gave her information about NARI AHD. The purpose of visit was to see the facilities of NARI AHD and discuss how the Bihar government can use it.


Visit of Dr. N. Vijaya Lakshmi to NARI AHD farm and Molecular Biology lab

- On 19 October 2021, professors and officers from the Maharashtra Animal and Fisheries Sciences University (MAFSU), Nagpur visited NARI-AHD to see the set-up for goat semen freezing and artificial insemination. They were, Dr. A. U. Bhikane, Director of Extension Education, Dr. D. S. Raghuwanshi, Professor and Head, Animal Reproduction,

Dr. J. P. Korde, Professor and Head, Physiology, Dr. A. P. Dhok, Assistant Professor, Animal Nutrition and Technical Officer to the Hon'ble Vice-Chancellor.

Visit of MAFSU professors and officials to NARI AHD

Project I. Osmanabadi Goat Field Unit of the ICAR-All India Coordinated Research Project 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. Kanhaiyya Chavan, Mr. Navnath Patange, Ms. Karishma Shaikh, Mr. Dilip Dhaigude (until 30 September 2021), Mr. Sagar Shinde (from 27 January 2022), Ms. Minakshi Ghorpade (in Dhakale, Tal. Baramati, Dist. Pune), Mr. Mithu Garje (Sakat and Gandhanwadi, Tal. Jamkhed and Patoda, Dist. Ahmednagar and Beed respectively).

Executive summary:

i. 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 2021 to 31 March 2022, the production performance of goats in farmers' flocks was assessed in the low rainfall, drought-prone, dry, Deccan plateau regions of five districts in Maharashtra State. Viz. Ahmednagar, Beed, Pune, Satara and Solapur districts.

ii. Six hundred adult does (110 in Ahmednagar, 29 in Beed, 159 in Pune, 31 in Satara and 271 in Solapur districts respectively) are being recorded. These belong to 126 goat keepers, indicating that the average number of adult does reared per household is 4.76. Detailed periodic recording has been done of their body weight, milk yield, reproduction, kid weights, mortality, morbidity, cost incurred for goat rearing and income earned.

iii. In 552 kiddings, 882 Kids were born during 1 April 2021 to 31 March 2022, making the average litter size 1.60. The closing balance is 1258 goats in total (comprising 325 males and 933 females). Overall mortality was 2.8%.

iv. The total number of superior Osmanabadi bucks purchased since 2009 is 92, 23 of which were sired by selected breeding bucks provided by the Osmanabadi Field Unit. Four Osmanabadi bucks were purchased during the period 1 April 2021 to 31 March 2022 out of which, three are sired by the superior Osmanabadi bucks disseminated by the Osmanabadi Field Unit.

v. Total 50,765 Straws (0.25 ml French mini straws) of frozen semen of 74 Osmanabadi bucks have been produced so far in NARI's Buck Semen Freezing Laboratory from January 2012 to 31 March 2022. From 1 April 2021 to 31 March 2022, total 3008 Osmanabadi buck straws were supplied to A.I. technicians, farmers and entrepreneurs for breeding Osmanabadi goats. Conception rates reported by field AI technicians are 50-55%.

vi. The average 3, 6, 9 and 12-months weights of Osmanabadi kids born during April 2021 to March 2022 under the Field Unit are 12.12 kg, 16.01 kg, 19.70 kg and 23.0 kg respectively. These average weights are very high and reflect the good genetic quality of the animals as well as the high standards of feeding and management because of the efforts taken by NARI over the last 10 years.

vii. The Osmanabadi Field Unit has established the least squares mean 90-day milk yield of Osmanabadi does to be 102.4 kg with 1644 records. This was measured using the

weigh-suckle-weigh method. This establishes the Osmanabadi breed to be among the top five dairy goat breeds in India. The least squares mean 90-day milk yields of does having singles, twins and triplets were 68.1, 103.4 and 135.8 kg respectively, indicating that milk yield increases with the number of kids. The heritability of 90-day milk yield was estimated to be 0.17±0.04

viii. During 2021-22, there were periodic lock-downs and micro containment zones declared in adopted villages from time to time due to the Covid19 pandemic. Our extension staff still managed to remain unaffected by Covid with due care, made attempts to complete the project work and could achieve almost all targets.

ix. We have published 16 information booklets/leaflets in Marathi language to give information to goat keepers on better goat management practices.

x. Preventive health care of goats was undertaken in all villages and vaccinations, deworming and spraying against ecto-parasites was regularly carried out in all participating villages.

xi. Goat keepers were trained in preventive health care of goats and first-aid treatment so that they can care for their goats themselves instead of having to rely on others especially during the Covid19 pandemic period. There are 33 Goat owners (13 from Morochi, 2 from Gosaviwadi, 11 from Dhakale, 5 from Sakat and 2 from Gandhanwadi.) who can undertake preventive health care of goats and first-aid treatment. There were 17 goat keepers trained in first aid treatment during 2021-22.

xii. Goat keepers are benefiting from castration of males unwanted for breeding, carried out by Project staff. This has reduced undesirable accidental mating and has also solved the problem of very early breeding of young does.

Salient Achievements

i. **Development of a FAMACHA chart for Osmanabadi goats**: NARI has developed a standardized FAMACHA chart for Osmanabadi goats. Goat keepers can use this chart for detection of anaemia and therefore blood-sucking worm (*H. contortus*) load in their goats. If the score is found to be above 3, rapid action can be taken to prevent further adverse consequences.

ii. **Performance recording of more than 10,000 Osmanabadi goat does and their progeny over the last 11 years** has led to selection of fast-growing twin- or triplet-born males produced by high milk-yielding does with superior reproductive performance. **Breeding values of bucks for 6 to 9-month weights are now estimated** based on weights of 15 to 40 progeny per buck. High breeding value unrelated males are used for breeding in project villages and frozen semen of high breeding value progeny-tested bucks is disseminated in areas outside the project through a network of AI technicians. The **Osmanabadi Field Unit has thus established an effective model of genetic improvement** and its dissemination which can be considered the first in the country.

iii. After seeing the results of the project such as excellent, fast growing kids and drastic reduction in mortality and morbidity, some **goat keepers** earlier opposed to ear tags, have enthusiastically embraced ear tags and are **taking interest in the recording and weights of their kids**. A few goat keepers have started keeping records in notebooks or on a calendar in their house. This helps them to check predicted kidding dates and weight gain in kids.

iv. A **success story of Mrs. Ranjana Kokare from Morochi in Solapur district whose annual income almost doubled from 2018-19 to 2020-21,** was sent to the ICAR HQ as per the suggestion of the DDG (AGB), ICAR during the ARM for the year 2020-21.

v. Local butchers mention that **meat quality of kids born to NARI's superior bucks is better and consumers prefer this meat**. This could be due to higher live weight and higher proportion of meat compared to bones. They also mention about healthy carcass and this could be due to regular vaccination and timely treatment.

vi. **Seventy goat keepers out of 126 (55%) have started feeding their goats using feeders**. This has helped in reducing feed wastage and goats receive unsoiled fodder.

vii. NARI's **continuous public awareness creation for feeding nutritious fodder to goats** has resulted in most goat keepers starting to make silage. The number of goat keepers who make silage and feed it to goats is **62 out of 126** (39 out of 39 in Morochi, 14 out of 44 in Dhakale, 6 out of 33 in Sakat and 3 out of 9 in Gosaviwadi)**.** This has increased from 53 in the previous year. Almost all participating goat keepers have planted Super Napier fodder to feed their goats.

viii. **The proportion of Osmanabadi true-to-type goats in the Project villages has increased to 95% now**. Goat keepers have retained for breeding the good does sired by the improved bucks in the project. Goat keepers have stopped using Sirohi or other local bucks for breeding their goats. They have thus started contributing to the genetic improvement of Osmanabadi goats, which is the main objective of the AICRP Goat Improvement.

ix. There is **substantial improvement in the incomes of goat keepers** due to reduced mortality, better health of goats and kids and consequently less expenditure on health care and knowledge of kid weights which enables calculation of the expected sale price.

x. There were **no village fares and slaughter of animals in 2021-22 due to the Covid19 pandemic**. It was therefore not possible to collect data on meat yield. Similarly **market surveys could not be done as all agricultural produce markets were closed** during the reporting period.

Castration of buck

Measurement

Vaccination

Weighing

Project II. Increasing profitability of sheep production by genetic improvement using the *FecB* (Booroola) mutation and improved management in conjunction with the Project for Dissemination of *FecB* carrier sheep to Karnataka.

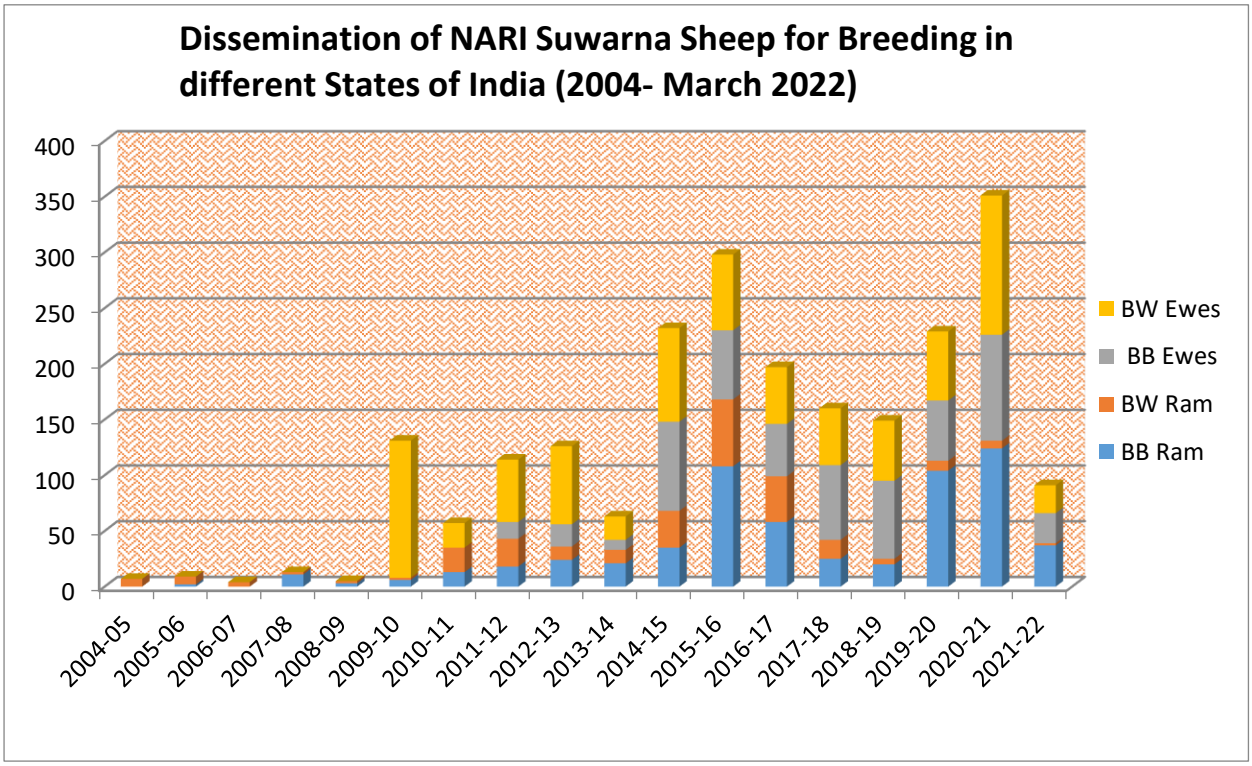
Scientists: Dr. Chanda Nimbkar, Dr. Pradip Ghalsasi

Technical staff: Mr. Kanhaiyya Chavan, Mr. Anil Chavan, Mr. Dattatray Mulik, Mr. Vikram Shedge (until 8 December 2021), Mr. Dilip Dhaigude (until 30 September 2021), Mr. Dilip Bhandare (from 10 October 2021), Mr.Sagar Shinde (from 27 January 2022) and Ms. Karishma Shaikh

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 and Andhra Pradesh and they are profiting from its use. Total **877** breeding rams and **1359** breeding ewes have been supplied. Out of these, **39** rams and **52** ewes were supplied during April 2021 to 31 March 2022. Majority of the rams and ewes were purchased by sheep keepers from Karnataka, a few from Maharashtra and two from 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 **2021-22** 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 82.21% 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.

Table 1. Results of three AI programs carried out at NARI's Lundy farm, Rajale in December 2020, March 2021 and July 2021.

	Ewe's *FecB* genotype			
Particulars	*FecB*^{BB}	*FecB*$^{B+}$	*FecB*$^{++}$	Overall
Ewes inseminated artificially (AI)	101	129	23	253
Ewes conceived (first and second AI)	75	110	23	208
Conception rate to first AI (%)	74.26	85.27	100	82.21
Pregnant ewes died	0	2	0	2
Ewes aborted	15	15	5	35
Ewes lambed with at least one live lamb	56	90	17	163
Ewes lambed with all lambs stillborn (dystocia?) or died soon	4	3	1	8
Total live lambs born	86	128	17	231
Live lambs born per ewe lambed with at least one live lamb	1.53	1.42	1	1.42
Live lambs born per ewe conceived	1.15	1.16	0.74	1.11

The conception rate to artificial insemination of 82.21% was slightly higher than last year. The table shows that the average litter size of *FecB* carrier ewes was 42 to 53% higher than that of non-carrier ewes but this advantage declined to 16% because of the higher proportion of stillbirths among *FecB* carrier ewes. There was a decrease in the number of live lambs born per ewe conceived from 1.31 to 1.15 this year. Abortions due to infectious causes cannot be ruled out. Investigations need to be made to diagnose such causes. We are making improvements in the management of pregnant ewes to reduce abortions and embryonic mortality. The advantage of twin-bearing ewes over single-bearing ewes can, however, be clearly seen as the range of weight of lambs weaned by twin-bearing ewes (when both lambs survived to weaning age) was 32.2 to 43.5 kg at 4 months age compared to 18.5 to 26 kg for single-bearing ewes. This year, the management of ewes suffered due to labour scarcity at both Lundy farm, Rajale and Dhuldeo farm of the Maharashtra Goat and Sheep Research and Development Institute.

There is evidence that our selection strategy is also working. We now have a number of top class ewes that have twin lambs and rear them to 16 kg weight each by the age of three months. The popularity of the NARI Suwarna breed among sheep owners in Karnataka also indicates the superior productivity of the breed.

NARI Suwarna flock and a NARI Suwarna ewe with twins at AHD's sheep farm at Rajale

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

Table 2. *FecB* genotypes of NARI-AHD's sheep tested at the AHD laboratory during April 2021 to 31st March 2022.

Breed	Number of animals genotyped	$FecB^{BB}$	$FecB^{B+}$	$FecB^{++}$
Crossbred NARI Suwarna lambs	231	125	100	6
Awassi lambs	16	-	12	4
Confirmation of genotypes initially determined on pedigree	6	5	1	-
Re-genotyping of parent on obtaining a non-matching genotype in the progeny*	2	-	1	1
Total	**255**	**130**	**114**	**11**

*One ewe had initially been genotyped as $FecB^{BB}$; on re-genotyping **it was found to be $FecB^{B+}$.** The discrepancies were sorted out. Another ewe was not genotyped but assumed to be $FecB^{BB}$ based on its pedigree. However, it gave only one lamb consistently and was therefore genotyped to find that it was a $FecB^{++}$**.**

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.

Acknowledgements: We acknowledge the excellent cooperation given by Mrs. Padmaja Ghalsasi in training and then observing the new molecular biology technical officer Ms. Karishma Shaikh and helping her to avoid mistakes so that Ms. Shaikh has become very good at carrying out the *FecB* DNA test. Mrs. Ghalsasi visited NARI-AHD whenever necessary to observe the *FecB* test.

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

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 2022.**

   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.

Semen freezing team of NARI AHD

Table 3. Number of buck frozen semen straws produced and used during June 2012 to 31 March 2022.

	Breed of buck					
Type of buck semen doses	**Boer**	**Osmanabadi**	**Damascus cross**	**Alpine and Saanen X Beetal**	**Beetal**	**Total**

Frozen	35596	50186	6058	1477	440	93757
Supplied	30319	48199	5259	1453	343	85573
Used for AI of NARI and MGSRDI Farm and local goat keepers' goats brought to NARI and given free to AI technicians for trial	5088	813	349	24	5	6279
In storage	189	1174	450	0	92	1905

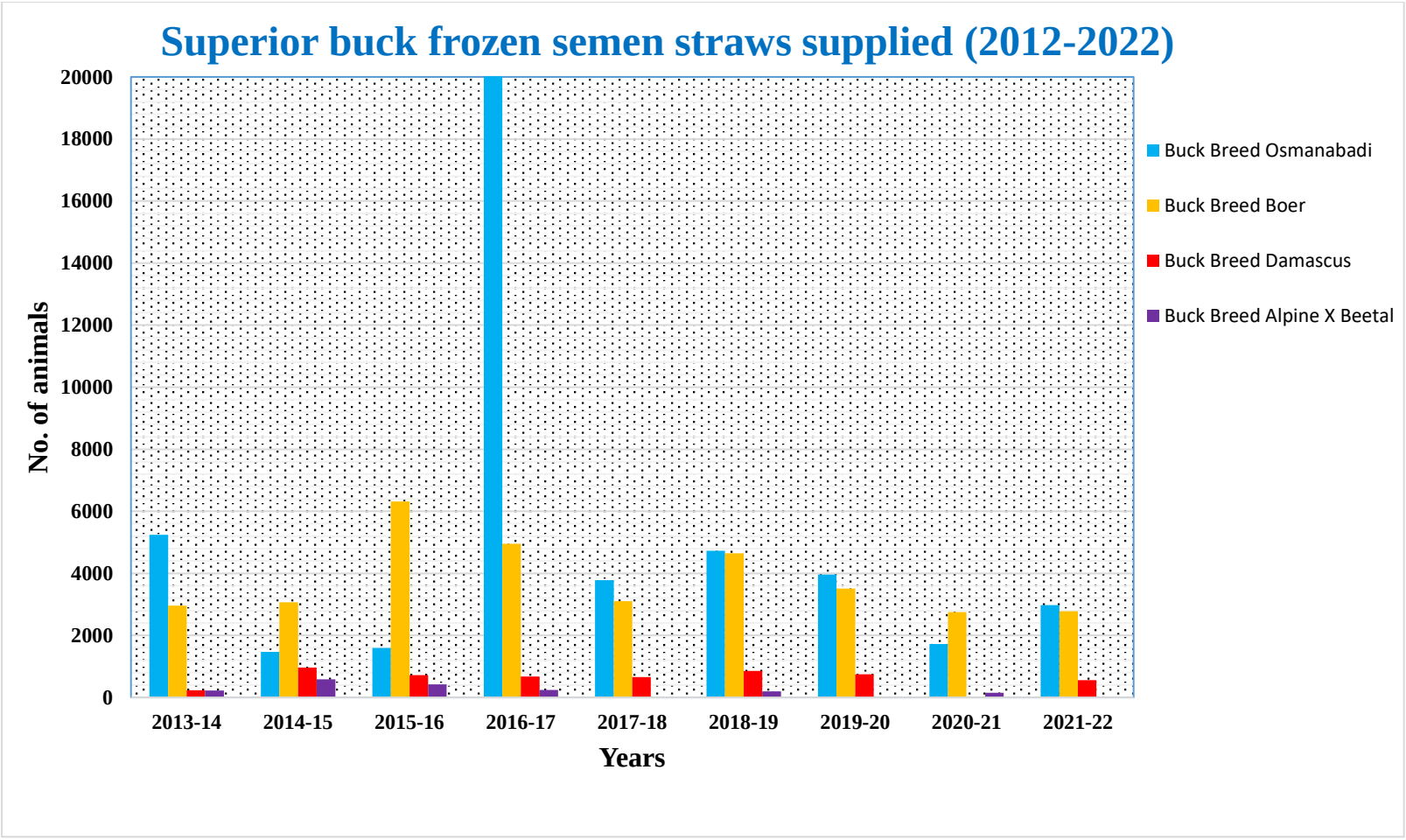
- 500 frozen semen straws of Osmanabadi bucks were given for breed conservation to the National Bureau of Animal Genetic Resources (NBAGR), Karnal, Haryana under the technical programme of the Osmanabadi field unit at NARI-AHD under the ICAR-All India Coordinated Research Project on Goat Improvement.
- 2677 goats belonging to farmers from surrounding villages and 3,602 goats of the Institute have so far been artificially inseminated using these frozen semen straws.
- Goat keepers from nearby villages bring their goats in oestrus to NARI farm for cervical AI. AI technicians who used to carry out AI of only cows and buffaloes belonging to farmers, have started to take buck frozen semen from NARI and carry out AI of does at the farmers' door. During the year 2021-22, (1 October 2020 to 30 September 2021) 72 goat does belonging to local goat keepers were inseminated, out of which 51 could be followed up and 29 kidded. Thus the conception rate to A.I. was 56.7%. This is a high conception rate and reflects the high semen quality as well as the skill of our farm supervisors/inseminators. Conception rate results for the last ten years (2012-22) are given in Table 4.

Artificial insemination of local goat keeper's goat at AHD farm, Wadjal

Table 4. 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 goats conceived	Conception rate (%)
NARI Farms (2021-22)	72	51	29	56.9
NARI farms	1,339	1,064	529	49.7

(2012-22)				



1. 2016-17: 20,000 Osmanabadi semen straws supplied to Government of Karnataka.
2. 2020-21: Straw procurement reduced due to the Covid19 pandemic

Training in goat artificial insemination

During the year one course was conducted for Pashusakhis of Manndeshi Foundation, Mhaswad, Taluka Mann, Dist. Satara. Eighteen participants were given a three days' refresher intensive training course (including theory and practicals) on 'First aid in goats and artificial insemination'. The Pashusakhis came from different villages of Satara, Nashik, Latur, Solapur and Kolhapur districts. After completion of the training course we took an examination. All Pashusakhis passed and 80% Pashusakhis got distinction. The Pashusakhis presented a street-play on the last day, based on their learning during the course. Mr. Kanhaiyya Chavan conducted the training under the guidance of Dr. Pradip Ghalsasi.

Training conducted for Pashusakhis of Manndeshi Foundation,
Mhaswad, Taluka Mann, Dist. Satara.

This year NARI-AHD hosted the **Internship Training Programme** of Fourth year students of the Bachelor's degree in Veterinary Science from the Baramati Animal Husbandry College. The training period was 17 July to 14 August 2021. Four students attended the internship programme. They were given training and hands-on experience in various aspects of sheep and goat management and on subjects such as Parasitology, Nutrition, Reproduction and Health. They were also given training in village level extension by having them participate in the field work of the ICAR-AICRP's Osmanabadi Goat Field Unit.

Training courses

Table 5. Training courses conducted and number and classification of participants (2007-March 2022)

Topic of training	No. of training courses	No. of participants			Total
		Vets	Para-vets and pashu/sheli sakhis	Farmers	
Goat Artificial insemination (AI)	71	306	175	251	732
Goat and sheep production and management	16	57	52	87	196
Goat and sheep management including AI	22	138	51	3	192
Goat and sheep first-aid including AI	10	0	81	156	237
Total	119	501	360	497	1358

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

Funding agency: Internally funded

Scientists: Dr. Chanda Nimbkar, Dr. Pradip Ghalsasi

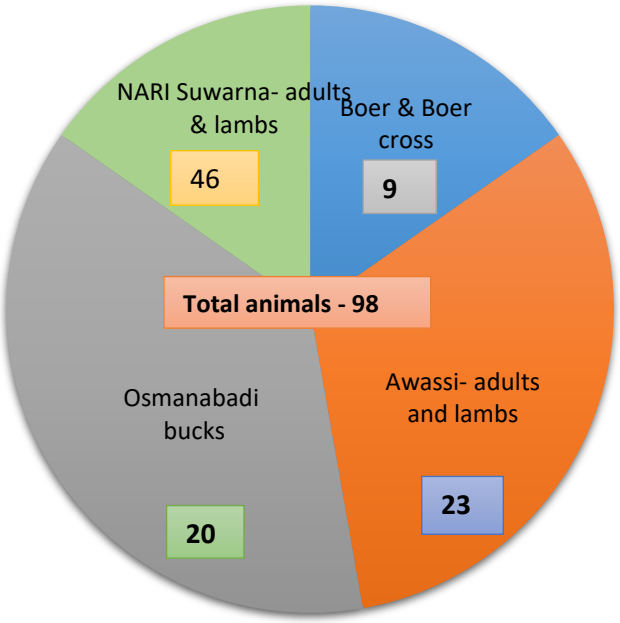
Technical staff: Ms. Karishma Shaikh, Ms. Sanyogita Kumbhar.

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. However, we could not monitor samples of goat flocks of goat keepers participating in the Osmanabadi Goat Field Unit under the ICAR-AICRP Goat Improvement project as the field visits were limited due to the Covid19 pandemic. We have been studying internal parasite burdens and parasite epidemiology in sheep and goats for more than 21 years. During the last 11 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 rainfall had major impact on prevalence of internal and external parasites. Worm infection was found to be heavy during the monsoon.

AHD maintains sheep and goats on three farms - Wadjal, Dhuldeo and Lundy farm (Rajale).

Wadjal Farm
Breed & numbers of animals
(April 2021 to 31st March 2022)



Information about farm:

All animals are stallfed. 

Rainfall during the year - 552 mm 

During the year, FEC of all animals was measured four times and the observations are given below.

1) Osmanabadi Bucks-
FEC average: 350 epg
FEC range: 0-1000 epg
(only 40 % bucks whose FEC was >1000 epg needed to be drenched individually . Those were mostly transferred from outside villages to our farm.)

2**) Awassi -** FEC average: 300 epg
FEC range: 0-1100 epg
(In Awassi lambed ewes periparturient rise in FEC was not seen but tapeworm infection was, so they weredrenched with Fentas Plus.)

3) NARI Suwarna Rams -
FEC average: 273 epg
FEC range: 0-1100 epg
(only 25% NARI Suwarna rams needed to be drenched individually.)

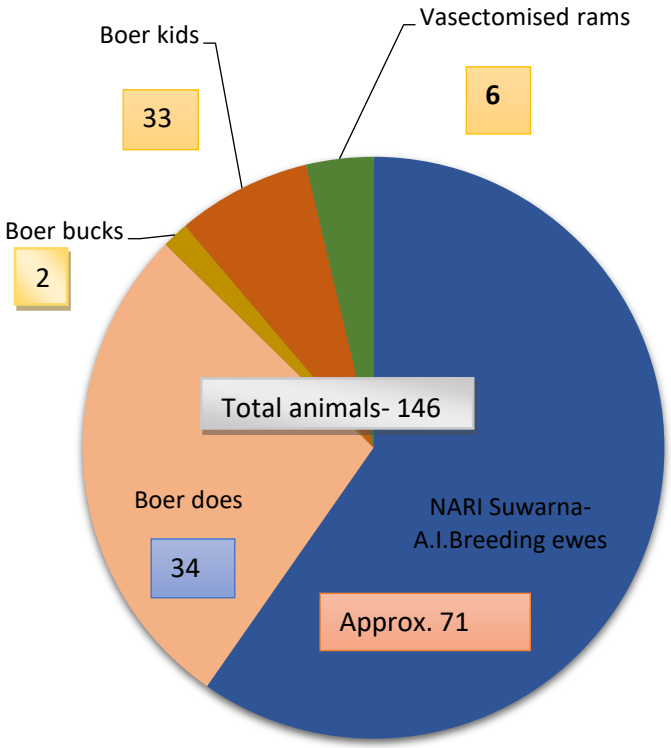
Overall the worm burden was not so high; maybe due to the dry climate, good nutrition, good management and all animals being stall-fed.

FAMACHA score : 2 to 2.5
Body Condition score : 2.5 to 3

Dhuldeo Farm

Breed and numbers of animals

(April 2021 to 31st March 2022)



Information about farm:

Goats are stall-fed. 

Ewes are allowed to graze. 

Rainfall during the year - 577 mm 

During the year, FEC of all animals was measured four times and the observations are given below.

1) Goats - FEC average: 1912 epg
FEC range: 0-3400 epg
(Mass drenching required only once .)

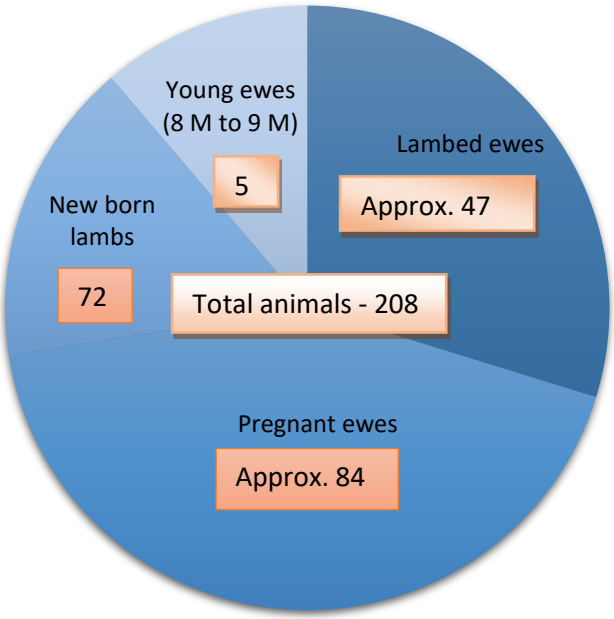
Only individual drenching of 2 goats in January and 8 goats in March 2022 whose FEC was >1000 epg was carried out **.**

2) 3.5 M & 7.5 M Kids - Tapeworm observed, so drenched with Fentas Plus in June 2021.

3) NARI Suwarna Pregnant Ewes-
FEC average : 445 epg
FEC range: 0-1900 epg
(only 25% pregnant ewes needed to be drenched individually)

FAMACHA Score: 2 to 2.5
Body Condition Score: 2.5 to 3

Lundy Farm
NARI Suwarna breed
(April 2021 to 31st March 2022)



Information about farm:

All animals are allowed to graze.

Total Rainfall - 574 mm

During the year, FEC was measured five times and the observations are given below.

1) 53 Lambed Ewes -
FEC average: 1672 epg
FEC range: 500-3200 epg

2) 76 Pregnant Ewes (1 week before lambing) - FEC average: 2327 epg
FEC range: 100-10500 epg

3) 68 Lambed Ewes -(15 days after lambing) - FEC average: 3794 epg
FEC range: 100-22600 epg

4) 64 Pregnant and Lambed ewes-
FEC average : 2596 epg
FEC range: 0-5900 epg

(Each group of ewes was mass drenched once just after lambing with Closantel and once with Albendazole. Worm infection rises due to reduction in progesterone levels and the stress associated with lambing and suckling of lambs).

Only individual drenching of 11 empty ewes in October 2021 and 11 pregnant ewes whose FEC was >1500 epg in March 2022 was carried out.
Lambs were mass drenched with Fentas Plus only once for tapeworm infection.

FAMACHA Score: 2 to 3
Body Condition Score : 2 to 3

- We check the FAMACHA scores of all animals every month at the time of weighing of animals and observed that no animal had a FAMACHA score above 3, which shows the good management and feeding.
- Those lambed and pregnant ewes with FAMACHA score of 2.5 to 3 as well as high FEC were drenched individually and also given an iron injection.
- FEC reduction test was performed and it was found that Ivermectin (Hitek) was 91% effective which is not up to the mark.
- The immediate and sustained activity of Closantel which is long acting and narrow spectrum was tested at day 14, 28, 42 and 55 post-drench and it was found that Closantel was fully effective up to 55 days.
- To ensure that the feeding is going on correctly, all the animals were **weighed every fortnight**. When there was weight loss, the feeding was altered. This year too the

management gave incentives to the workers of those farms where animals in all the groups gained weight during a particular month. And all the three farms got incentives which means our management is improving day by day.

- Ecto-parasite infection was observed in sheep and goats during rainy season. Amitraz was used to treat this.
- Larval culture: The overall predominant larval species (almost 85%) in all the sheep and goat flocks identified from pooled faecal samples was *Haemonchus contortus* followed by *Trichostrongylus* species (12%) and *Oesophagostomum* species (3%).

Acknowledgements: We wish to acknowledge the excellent training given by Mrs. Padmaja Ghalsasi, retired staff member of NARI-AHD, to Ms. Karishma Shaikh, our present parasitology technical officer.

Annual Fact Sheet

Publications

- 3 publications in refereed/non-refereed journals
- 27 magazine/newspaper/popular articles
- 10 videos
- 1 reports
- 1 leaflet

Visitors to NARI

- 10 dignitaries from national organizations
- 4 student and women-trainee groups

Visits by NARI staff

- 20 invited lectures/talks/seminars attended
- 12 meetings attended
- 1 jaggery production unit visited

Total sales

- 5,960 buck semen straws supplied in bulk
- 91 NARI Suwarna sheep disseminated for breeding
- 1,507 kg food products (Sweet sorghum syrup/Jaggery/Safflower oil/Mustard oil/Safflower herbal tea/Vegetables) sold
- 212 kg seeds of different varieties of sweet sorghum, safflower, *Leucaena, Stylosanthes, Desmanthus and Cenchrus* sold
- 5,668 kg of foodgrains (wheat, soybean, sorghum) sold
- 49,975 kg of firewood, poles and fodder sold

Awards and recognition

Other activities

Governing Council (2020-2023)

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

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

Anil K. Rajvanshi, Ph.D., Director and Hon. Secretary, NARI

Noorie Rajvanshi, Ph.D., Staff Scientist, Siemens, USA

Madhura Rajvanshi, MA, Trustee, Pragat Shikshan Sanstha, Phaltan

S. K. Jha, I.R.S., Retired Chief Commissioner of Income Tax (CCIT), Pune

Niraj Chandra, BA, Industrialist, Satara