ANNUAL RESEARCH REPORT 2010-2011

NARI

Nimbkar Agricultural Research Institute,
P.O. Box 44, PHALTAN-415523,
Maharashtra

August 2011

Nimbkar Agricultural Research Institute (NARI), Phaltan

ANNUAL RESEARCH REPORT 2010-11

Report of the President

I am very happy to place the annual research report 2010-11 of NARI before our readers. Significant research progress at NARI has been presented in brief. For more details of any subject, readers are encouraged to visit our website and/or write an e-mail to us.

Presently we are in the process of planning for the 12th five-year plan which commences from April 2012. Inputs from our readers to make our research more effective are always welcome.

In 2010 we recorded the highest total rainfall of 1038 mm since 1983, the year when data started being recorded at the Tambmal research farm of NARI. Previous record was of 923 mm in 1998. In 2010 not only was the amount of rainfall high but it continued through November delaying all our post-rainy season sowings in sorghum and safflower. This had an adverse effect on the seed yields. Also the number of rainy days was much fewer than normal making the rainfall intensity quite high.

Finally the construction work of the Bajaj Centre for Sustainable Development (BCSD) was completed during this year. It was inaugurated on 12 April 2011 by Shri. Madhur Bajaj (Vice Chairman of Bajaj Auto Ltd.) in the presence of Shri. Sanjay Kirloskar (Chairman and Managing Director of Kirloskar Brothers Ltd.), Shri. Zia Quraishi (Chairman and Managing Director of Nimbkar Seeds Pvt. Ltd.), Shri. Pradeep Bhargava (Managing Director, Cummins Generator Technologies Ltd.), Mr. Jayant Sapre (Director, Kirloskar Brothers Ltd.) and Shri. Dinesh Castellino (Vice President, Cummins India Ltd.). We thank the large number of friends and well-wishers of NARI who attended the function.

The center is expected to serve as a training and research facility for interaction between the corporate sector, civil society and local residents to produce high tech solutions for rural problems. I am sure under the dynamic leadership of NARI director Dr. Anil K. Rajvanshi this center has a bright future.

I wish to congratulate Dr. Chanda Nimbkar, Director, Animal Husbandry Division for her appointment as a member of GALVmed (Global Alliance for Livestock Veterinary Medicines) Regional Advisory Committee, South Asia chapter. Mandate of GALVmed is to make livestock vaccines, diagnostics and medicines accessible and affordable in the developing countries.

Finally, I wish to gratefully acknowledge the generous donations of Rs. 10,00,000 from Cummins Diesel India Foundation, Pune and Rs. 2,40,000 from Kirloskar Engines India Ltd., Pune for BCSD.

We also acknowledge donations of Rs. 2,50,000 from Mr. B. V. Nimbkar, Rs. 2,00,000 from Dr. Chanda Nimbkar, Rs. 1,15,000 from Raut Scientific and General Traders, Pune, Rs. 55,000 from Prof. Abdullah Allowaimer, Saudi Arabia and Rs. 50,000 from Smt. Hemlata Rajvanshi for various research projects. We are extremely grateful to all the donors for their kindness.

Dr. N. Nimbkar
President

August 31, 2011

AGRICULTURAL RESEARCH

SAFFLOWER

All India Coordinated Research Project on Oilseeds (Safflower)

Funding agency : Indian Council of Agricultural Research (ICAR), New Delhi

NARI is one of the centers of All India Coordinated Research Project (AICRP) for safflower Research under limited irrigation since 1980. The major objectives of safflower improvement at NARI have been to develop high-yielding and high oil-producing spiny and non-spiny varieties and hybrids with in-built resistance to wilt (*Fusarium oxysporum*), in addition to development of suitable agro-production and crop protection technologies for growing safflower under limited irrigated conditions.

Research highlights :

I. **BREEDING** :

The major highlight of safflower programme during 2010-11 was the granting of non-exclusive licence for commercial production of newly developed high oil-containing and high yielding safflower variety NARI-57 and non-spiny hybrid NARI-NH-1 to Marico, Mumbai. Marico is a well-known company which is a leader in marketing products such as "Saffola"-a brand name for refined safflower oil. Marico has planned to promote NARI-57 and NARI-NH-1 in their contract farming programme of safflower, which according to them has nearly 1 lakh farmers registered with it.

1. **Development of a short and simple technique to study chromosomes from leaf tissues in safflower** : Investigations of chromosomes from root tissues obtained from seeds germinated in petri dishes which are usually carried out are lengthy and cumbersome. It is a laborious process to collect root tips from a grown-up plant standing in the field especially one having a taproot system like safflower. Breeders are always keen to know the ploidy of a phenotypically distinct plant whenever they encounter it in the field. The ploidy of such a plant can be determined by studying the meiosis in the reproductive organs, however, major hurdle in doing so is that on many occasions the reproductive phase of such plants is shorter than normal and is often associated with abnormalities. The tissue processing technique developed for examining the meiosis in normal plants does not always suit the phenotypically distinct plants and needs modifications. By the time modified techniques are evolved, the reproductive phase is over. Therefore such plants are often left unstudied and an opportunity is wasted. Thus important information which may be useful for the improvement of the crop is lost. Therefore, in view of the above it was envisaged to develop a technique to process the leaf tissues for chromosome investigations since leaves are an integral part of a plant and are produced continuously throughout the period of plant growth. The efforts made in this direction resulted in the development of a suitable technique to study chromosomes from a young leaf in safflower.

The processing of leaf tissue for chromosomal investigations by this method includes the fixing of freshly excised pieces from a young leaf of about 1.5 cm length in a regular fixative for a period of four hours, followed by 4-5 washings with water and then staining with acetoorcein for a period of 20-30 minutes. In short, the leaf processing enables chromosome analysis in a period of 6-7 hours as compared to a period of 96 to 100 hours required for processing of root tissues with the usual method. Thus the development of the leaf tissue processing technique provides an opportunity to analyse the chroromosomes of a standing plant any time during its entire vegetative phase of growth. Fig. A shows the safflower leaf chromosomes.

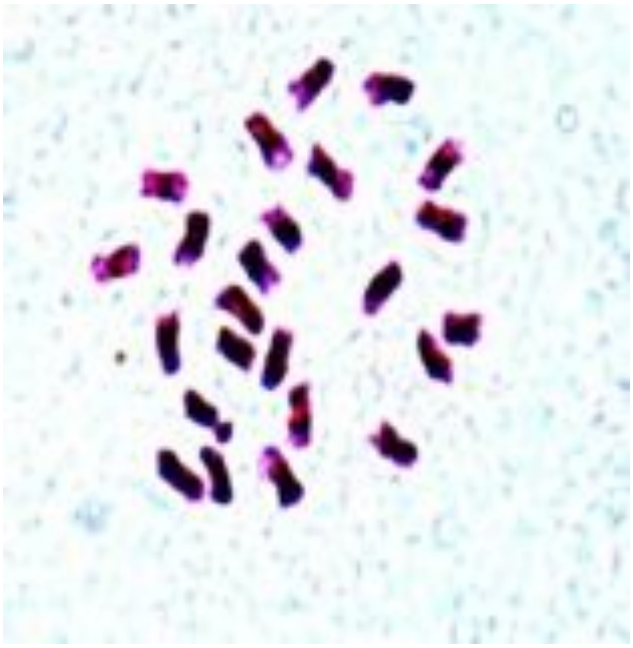


Fig. A. Safflower leaf chromosomes

2. **Development of cytoplasmic male sterility (CMS) through interspecific crossing and CMS induction by treatment with streptomycin :** The cytoplasmic male steriles in safflower developed through interspecific crossing as well as induced by streptomycin treatment at NARI were crossed with fertile sib-counterparts which had shown high male sterility in their progenies in rabi 2009-10. During rabi 2010-11, about 69 pairwise crosses made with sib-pollinator parents were screened to identify the genotypes maintaining male sterility of the sterile cytoplasm. However, none of the crosses raised gave 100% male sterility to the sterile cytoplasm.

3. **Evaluation of CMS-based crosses** : Twenty six diverse genotypes were crossed with the CMS lines in order to identify the genotypes which could become male sterility maintainer or fertility restorer to the CMS lines in safflower. Each of these 26 CMS-based crosses were sown along with their pollinators in two rows of 5 m length during rabi 2010-11. The evaluation of these crosses for sterility/fertility during flowering of the crop revealed that none of the 26 crosses evaluated showed complete maintenance of male sterility in the male sterile cytoplasm. However, three of them viz. CMS X NARI-47-6, CMS X NARI-47 and CMS X JLSF-94 exhibited complete restoration of fertility to the male sterile cytoplasm.

4. **Evaluation of thermosensitive genetic male sterility (TGMS)-based hybrids in safflower** :

Thirty seven TGMS-based hybrids produced in rabi 2009-10, were evaluated along with their parents and two hybrid checks viz. NARI-NH-1 and NARI-H-15 under rainfed conditions during rabi 2010-11. The trial was planted in a randomized block design with two replications on September 15, 2010 with a plot size of 0.9 X 5 m^2 for each entry. Standard agronomic practices as described under the head agronomic practices were followed to raise a good crop. Observations were recorded on five random plants of each entry for physiological traits, whereas the whole plot was utilized for recording seed yield and final plant stands for each entry.

Evaluation of the TGMS-based hybrids for sterility/fertility during the flowering of the crop showed that all the 37 hybrids exhibited complete fertility in them thereby indicating usefulness of TGMS system for hybrid development in safflower. The assessment of the TGMS hybrids for yielding ability showed that 10 hybrids out of 37 gave significantly higher seed yield than the best check NARI-NH-1. The highest seed yield of 1952 kg/ha was recorded by the hybrid TGMS-H-277 which was 43.42% higher than that of the best check NARI-NH-1. This was followed by the hybrids TGMS-H-273 (1874 kg/ha), TGMS-H-294 (1678 kg/ha), TGMS-H-271 (1662 kg/ha) and TGMS-H-275 (1657 kg/ha). The details of the TGMS hybrids recording significantly higher seed yield than the best check NARI-NH-1 are furnished below :

Promising TGMS-based hybrids

Sr. No.	Hybrids	Seed yield (Kg/ha)	% increase over NARI-NH-1
1.	TGMS-H-269	1563	14.84
2.	TGMS-H-271	1662	22.12
3.	TGMS-H-273	1874	37.69
4.	TGMS-H-275	1657	21.75
5.	TGMS-H-277	1952	43.42
6.	TGMS-H-278	1501	10.29
7.	TGMS-H-283	1444	6.10
8.	TGMS-H-289	1507	10.73
9.	TGMS-H-293	1436	5.51
10.	TGMS-H-294	1678	23.29
11.	NARI-NH-1 (Check)	1361	-
12.	CD at 0.05	525.7	-
13.	CV%	24.57	-

5. **Evaluation of TGMS, CMS and GMS lines at different dates of sowing** :

A trial comprising of nine TGMS lines, two CMS lines (obtained from Dr. A. B. Hill, USA) and two GMS lines was laid out at four dates of sowing viz. 15th September, 2nd October, 15th October and 30th October to study the effect of different dates of sowing on expression of male sterility in different male sterility systems in order to identify the most appropriate time of sowing for inducing 100% male sterility in them so that they could be harnessed for hybrid seed production. Each entry was sown in a plot size of 3.6 X 5 m area. Standard agronomic practices were followed to raise a good crop. Observations on

days to capitula (button) formation, days to 50% flowering, male sterility % and days to maturity were recorded on whole plot basis, while the physiological traits like plant height, no. of primary branches/plant, no. of capitula/plant and capitulum diameter were recorded on five random plants. A daily record of minimum and maximum temperatures was also maintained from capitulum formation to full flowering of the crop.

The results of the trial showed that days to button (capitula) formation in different male sterile lines was recorded to be the minimum in the crop sown on September 15 and was followed by the crop sown on October 2. The crops sown on October 15 and 30 recorded similar days to button formation and which were observed to be the maximum. Surprisingly different dates of sowing had no effect on days to 50% flowering of the entries tested since sowing at different dates gave similar days to 50% flowering. The male sterility percentage of the entries tested was recorded to be the highest in the crop sown on October 30 and which was closely followed by the crops sown on October 2 and 15. The male sterility percentage in the crop sown on September 15, in general, was recorded to be the lowest. The results of the male sterility percentages at different dates of sowing suggested that the sowing of hybrid seed production in safflower can be done at any time in the month of October.

Among the different systems of male sterility tested, the TGMS and CMS systems behaved alike and gave similar estimates for male sterility for all the dates of sowing. This clearly suggests that the TGMS system developed indigenously is at par with the CMS system developed in US as far as expression of male sterility at different dates of sowing is concerned. However, GMS system in general gave lower percentage of sterility at the sowings carried out on October 2 and 15 as compared to the sowings carried out on September 15 and October 30. Among the TGMS lines screened, the entry TMS-3-6-7-9 recorded 100% male sterility in all the dates of sowing except the sowing carried out on October 2, where it was observed to be 99.7%. Thus this line showed very high stability for expression of male sterility across the sowing dates and hence can be sown for seed production any time from September 15 to October 30. The entry TMS-3-6-11-5 also showed 100% male sterility at all the dates of sowing except for sowings on September 15 and October 2, where it showed the male sterility of 98.6 and 99.6% respectively. Entry TMS-3-4-2-12 too exhibited high male sterility percentages of 99.4, 99.5, 100 and 99.7% at the four dates of sowing. All the three TGMS lines viz. TMS-3-6-7-9, TMS-3-6-11-5 and TMS-3-4-2-12 recorded higher expression of male sterility than both the CMS lines viz. EC675847 and EC675848 at all the sowing dates. The results of the trial revealed that sowing of hybrid seed production using the TGMS lines identified as above can be done at any time in the month of October.

Evaluation of male sterility systems at different date of sowing.

Sr. no.	Entry	D1				D2				D3				D4			
		Total plants	sterile plants	fertile plants	sterility %	Total plants	sterile plants	fertile plants	sterility %	Total plants	sterile plants	fertile plants	sterility %	Total plants	sterile plants	fertile plants	sterility %
1	TMS-3-6-7-10	211	199	12	94.3	321	319	2	99.4	285	284	1	99.6	402	397	5	98.8
2	TMS-3-6-11-3	206	196	10	95.1	304	304	0	100.0	221	219	2	99.1	383	378	5	98.7
3	TMS-6-5-3-1	289	269	20	93.1	351	351	0	100.0	203	200	3	98.5	331	317	14	95.8
4	TMS-3-6-11-5	221	218	3	98.6	274	273	1	99.6	277	277	0	100.0	413	413	0	100.0
5	TMS-6-1-5-1	254	252	2	99.2	342	342	0	100.0	304	303	1	99.7	328	319	9	97.3
6	TMS-6-5-3-4	198	165	33	83.3	356	279	77	78.4	267	238	29	89.1	335	307	28	91.6
7	TMS-3-6-7-9	197	197	0	100.0	352	351	1	99.7	230	230	0	100.0	365	365	0	100.0
8	TMS-3-4-2-12	176	175	1	99.4	202	201	1	99.5	198	198	0	100.0	301	300	1	99.7
9	TMS-3-1-4-13	214	196	18	91.6	332	326	6	98.2	296	290	6	98.0	436	435	1	99.8
10	EC-675847	247	245	2	99.2	168	167	1	99.4	115	114	1	99.1	-	-	-	-
11	EC-675858	251	246	5	98.0	149	148	1	99.3	120	118	2	98.3	44	43	1	97.7
12	MMS white	121	44	77	36.4	231	62	169	26.8	465	69	396	14.8	416	168	248	40.4
13	MSV-10-1-5	314	147	167	46.8	496	230	266	46.4	325	135	190	41.5	558	314	244	56.3

Sr. no.	Entry	Days to button formation					Range of temperature during vegetative phase of capitula development								Male sterility %				
		D1	D2	D3	D4	Mean	D1		D2		D3		D4		D1	D2	D3	D4	Mean
							Max	Min	Max	Min	Max	Min	Max	Min					
1	TMS-3-6-7-10	40	44	46	46	44	26.5	9.0	26.0	8.0	26.0	8.0	26.0	8.0	94.3	99.4	99.6	98.8	98.0
2	TMS-3-6-11-3	41	42	47	45	44	to	to	to	to	to	to	to	to	95.1	100.0	99.1	98.7	98.2
3	TMS-6-5-3-1	46	44	48	44	46	33.0	23.0	33.5	22.0	34.5	19.5	35.0	17.5	93.1	100.0	98.5	95.8	96.8
4	TMS-3-6-11-5	40	42	46	45	43									98.6	99.6	100.0	100.0	99.6
5	TMS-6-1-5-1	42	43	46	46	44									99.2	100.0	99.7	97.3	99.0
6	TMS-6-5-3-4	44	44	47	47	46									83.3	78.4	89.1	91.6	85.6
7	TMS-3-6-7-9	44	42	47	44	44									100.0	99.7	100.0	100.0	99.9
8	TMS-3-4-2-12	44	45	49	48	47									99.4	99.5	100.0	99.7	99.6
9	TMS-3-1-4-13	44	43	46	46	45									91.6	98.2	98.0	99.8	96.9
10	EC-675847	46	47	52	-	48									99.2	99.4	99.1	-	99.2
11	EC-675858	46	48	49	50	48									98.0	99.3	98.3	97.7	98.3
12	MMS white	60	45	50	50	51									36.4	26.8	14.8	40.4	29.6
13	MSV-10-1-5	54	41	49	43	47									46.8	46.4	41.5	56.3	47.7

Note: D1=sowing on September 15, 2010, D2= sowing on October 2, 2010, D3= sowing on October 15, 2010 and D4= sowing on October 30, 2010.

6. **Crossing programme** : Sixty crosses were attempted using four TGMS lines of NARI and two CMS lines obtained from Mr. A. B. Hill of SAFFTECH, Davis, California, USA as females and 10 promising genotypes as males to produce TGMS and CMS-based hybrids in safflower.

7. **Early and advanced generation selections** :

   (a) One hundred ninety nine high oil-containing F_3 families were examined for seed yield and other traits during the season. Of them 50 families recorded higher seed yield than the respective checks in different trials.

   (b) Two hundred thirty seven F_4 populations and 17 F_6 selections were screened for seed yield and its components. This resulted in identification of 47 F_4 populations and 5 F_6 selections giving higher seed yield than the best checks in the concerned trials.

8. **Development of high seed and oil-yielding safflower cultivars** : Twenty four out of the 230 high oil-containing entries evaluated in the preliminary varietal trials recorded higher seed yield than the best checks in the respective trials. High yielding safflower variety NARI-63 which was evaluated in AVT-I during 2009-10 recorded 7.6 and 13.5% increase in oil yield under rainfed and irrigated conditions respectively over the best check A-1 across the locations and was promoted to AVT-II for third year of evaluation. In addition two hybrids based on thermosensitive genetic male sterility viz. NARI-H-21 and NARI-H-23 which were evaluated in Initial Hybrid Trial during rabi 2009-10 gave an increase of 23.2 and 5.8 % in seed yield and 30.4 and 16.3% in oil yield respectively over the best check NARI-H-15 across the locations under rainfed conditions. Both the hybrids were promoted to IAHT for second year of multilocation evaluation during rabi 2010-11.

9. **Coordinated varietal trials** : Among the three coordinated varietal trials, out of 23 entries in IVT, none could record higher seed yield than the local check NARI-38 (1948 kg/ha). In IAHT-I, entry NARI-H-21 recorded the maximum seed yield of 1844 kg/ha which was followed by the entries DSH-185 (1609 kg/ha) and NARI-H-24 (1426 kg/ha). In AVT-I and -II, entry NARI-63 recorded the maximum seed yield of 1967 kg/ha which was followed by the local check NARI-38 (1907 kg/ha).

   The center has produced 700 kg breeder seed of safflower variety NARI-6, 300 kg seed of MMS, the female parent of non-spiny hybrid NARI-NH-1, and 5 kg breeder seed of MSV-10-1-5 the female parent of spiny hybrid NARI-H-15. In addition, 250 kg hybrid seed of NARI-H-15 was also produced during the season.

II. **AGRONOMY** :

1. **Yield maximization in safflower** : The non-spiny hybrid NARI-NH-1 was grown by following the recommended package of practices for maximizing its seed yield. The incessant rains after the germination of the crop adversely affected the plant stand in the trial which in turn affected the seed yield. Consequently a low seed yield of 1223 kg/ha and net returns of Rs. 12705/ha were obtained from the trial.

2. **Response of AVT-II entries to fertilizer application** : The results of this trial showed that differences due to fertilizer levels (main plots) were significant for seed yield, gross returns, net returns and benefit cost ratio. Differences due to varieties (sub plots) were

significant for seed yield, biological yield, gross returns, net returns and benefit cost ratio. The entry PBNS-12 recorded the significantly highest seed yield, biological yield, gross returns, net returns and benefit-cost ratio. The application of 150% recommended dose of fertilizers gave the maximum seed yield in the trial which was on par with the application of 50 and 100% recommended fertilizer doses. Therefore, there is no advantage in giving higher than 30:15:15 kg/ha of $N:P_2O_5:K_2O$.

3. **Evaluation of AVT-II entries under different sowing dates (Irrigated)** : The results of the trial exhibited differences due to sowing dates (main plots) and varieties (sub plots) to be significant for seed yield, biological yield, gross returns, net returns, harvest index (%) and benefit cost ratio except for harvest index in case of varieties. The entries PBNS-12 and SSF-733 recorded significantly higher seed yield than the remaining entries and were observed to be at par with each other. Both the planting dates in October gave significantly higher seed yields than those in September and November.

4. **Assessment of fertilizer recommendations for safflower** : The results of the trial showed differences due to fertilizer levels to be non-significant for seed yield, gross returns, net returns and benefit cost ratio. However, they were significant for biological yield, number of capitula/plant, number of seeds/capitulum and capitulum diameter. The highest seed yield of 2352 kg/ha was recorded for the application of 60:80:40 kg/ha of $N:P_2O_5:K_2O$.

5. **Comparative assessment of yield gain from safflower hybrids in relation to fertilizer inputs** : The results of the trial indicated that the differences due to fertilizer levels (main plots) and varieties (sub plots) were significant for seed yield, gross returns, net returns, benefit cost ratio, plant height, number of capitula/plant and number of seeds/capitulum. Among the cultivars evaluated, safflower variety A-1 recorded the significantly highest average seed yield of 1581 kg/ha across the fertilizer dosages applied. The increasing levels of fertilizer showed increased seed yields. The application of 150% recommended dose of fertilizers gave the significantly highest mean seed yield. Same trend was observed for gross returns, net returns and benefit cost ratio.

III. PATHOLOGY :

Under the plant pathology programme, 90 farmers' fields were surveyed in two talukas in Satara district, four talukas from Sangli district and one taluka in Pune district. The *Cercospora* leaf spot disease intensity varied from 1 to 50% while *Alternaria* leaf spot and wilt disease intensity was less than 1%.

None of the 350 germplasm entries and 40 elite entries screened against *Alternaria* leaf spot were found to be tolerant to it.

Among the 10 germplasm and 11 breeding lines screened against *Fusarium* wilt, two were moderately resistant and five were tolerant. Among the 40 elite entries screened against wilt, eight were found to be moderately resistant and nine were tolerant.

Seven different fungicides were evaluated for their efficacy against *Alternaria* leaf spot. Plots treated with Difenconazole @ 0.05%, Propiconazole @ 0.1% and SAAF @ 0.2% were found to have significantly lowest disease severity.

Five fungal isolates were screened in dual culture studies against root rot fungus *Macrophomina phaseolina* of safflower. Out of them two *Trichoderma viride* isolates (F-10) and (F-12) gave 48% and 45.5% inhibition of *M. Phaseolina* and seed dressing with the isolates gave high seed germination in pot studies.

SWEET SORGHUM

All India Coordinated Sorghum Improvement Project (Sweet Sorghum)

Funding agency : Indian Council of Agricultural Research (ICAR), New Delhi

NARI is one of the centres of All India Coordinated Sorghum Improvement Project (AICSIP) for sweet sorghum research since 2009. The major objective of sweet sorghum improvement programme at NARI has been to develop high biomass and high sugar-yielding varieties and hybrids.

Objectives : The objectives of the research work on sweet sorghum at the center are :

1. Development of sweet sorghum varieties and hybrids for both monsoon and post-monsoon seasons.
2. Development of high brix CMS lines.
3. Identification of promising lines for syrup production.
4. Quality improvement of syrup and also enhancing its shelf-life.

Research highlights :

The investigations undertaken in the project are described below.

Kharif (Rainy season) 2010 :

1. In continuing sweet sorghum CMS-line development programme, we made 168 backcrosses. The CMS lines being considered for improvement are NARI-SS-5A, NARI-SS-6A and NARI-SS-11A.

2. Out of 23 F_5 generation lines tested, two lines F_5 (DC-24)-27-1 (78.9 T/ha) and F_5 (DC-24)-40-1 (77.54 T/ha) recorded fresh biomass on par with hybrid Madhura (79.64 T/ha). F_5 (DC-24)-7 recorded significantly highest brix (19%).

3. Among 22 F_5 generation lines tested, F_5 (DC-19)-18 recorded fresh biomass (67.88 T/ha) on par with hybrid Madhura (75.16 T/ha). F_5 (DC-26)-12 recorded significantly highest brix (21%).

4. Out of 25 F_5 generation lines tested, F_5 (DC-32)-47 and F_5 (DC-32)-17 recorded significantly highest fresh biomass of 68.44 T/ha and 66.79 T/ha, respectively. F_5 (DC-33)-33 recorded significantly highest juice yield of 27.74 T/ha.

5. Among 25 F_5 generation lines tested, F_5 (DC-34)-27 (63.88 T/ha) and F_5 (DC-34)-29 (63.72 T/ha) recorded fresh biomass yield on par with hybrid Madhura (76 T/ha). F_5 (DC-34)-27 also recorded highest juice yield of 25.48 T/ha.

6. Out of 18 F_5 generation lines tested, F_5 (DC-49)-47 recorded highest fresh biomass yield of 58.49 T/ha which was on par with that of hybrid Madhura (70.02 T/ha). F_5 (DC-49)-19 recorded highest juice yield of 24.27 T/ha.

7. Among 43 F_5 generation lines tested, F_5 (D-158)-20 recorded highest biomass yield and juice yield of 71.12 and 25.77 T/ha, respectively.

8. Out of 44 F_5 generation lines tested, F_5 (DC-91)-46 recorded biomass yield of 66.73 T/ha which was on par with that of hybrid Madhura (71.04 T/ha). It also recorded significantly highest stripped stalk yield and juice yield of 54.45 and 26.12 T/ha, respectively.

9. Among 43 F_5 generation lines tested, significantly highest fresh biomass yield and stripped stalk yield of 80.39 and 64.31, respectively was recorded for F_5 (D-169)-75. Highest juice yield of 29.97 T/ha was recorded for F_5 (D-92)-53.

10. Out of 28 F_6 generation lines tested, F_6 (D-94)-14 recorded highest fresh biomass, stripped stalk weight and brix and these were 82.94 T/ha, 59.63 T/ha and 18.25%, respectively.

11. Among 25 F_6 generation lines tested, F_6 (D-102)-3 recorded highest fresh biomass yield of 76.7 T/ha. However, F_6 (D-118)-64 recorded significantly highest stripped stalk weight and juice yield of 60.02 T/ha and 24.59 T/ha, respectively.

12. Out of 23 F_7 generation lines tested, F_7 (D-81)-14-2 recorded significantly highest fresh biomass yield, stripped stalk weight and juice yield and these were 64.07 T/ha, 53.99 T/ha and 24.9 T/ha, respectively.

13. Among 20 F_6 generation lines tested, F_6 (DC-87)-17 recorded significantly highest fresh biomass, stripped stalk weight and juice yield which were 62.61 T/ha, 48.07 T/ha and 21.44 T/ha respectively.

14. Center also conducted four AICSIP trials on Sweet Sorghum during Kharif 2010. The details are as follows :

    a. **Effect of staggered planting on stalk yield, sugar content and ethanol yield of sweet sorghum for increased harvest window :** CSH-22 SS (1^{st}, 2^{nd}, 3^{rd} and 5^{th} date of sowing) and SSV-74 (4^{th} date of sowing) have been found to be the best for ethanol yield and total sugar index.

    b. **Characterizing and identification of new sorghum sources (Photoperiod sensitive) for high biomass for second generation biofuels traits :** SSRG-222, SSRV-43 and SSRV-44 have been found to be the best entries for ethanol yield and total sugar index.

    c. **Assessment of sweet sorghum for post harvest deterioration of stalk and juice quality** : V2T1, V2T2 and V2T4 have been found to be the best treatment combinations for high ethanol yield and total sugar index. Thus CSH-22 SS is definitely superior to SSV-84 even 72 hours after harvest.

(V1 : SSV-84 and V2 : CSH-22 SS. T1 : Juice and stalk weight and quality assessment at harvest (0 hr), T2 : Juice and stalk weight and quality assessment at 24 hr after harvest and T4 : Juice and stalk weight and quality assessment at 72 hr after harvest).

d. **IAVHT Trial** : SSRV 1 (DSR), SSRV 2 (DSR), RSSV 209 (MPKV), ICSV 25272 (ICRISAT), ICSSH 58 (ICRISAT), RSSV 192 (MPKV) and NARI-SSH-1 (NARI) have shown shoot fly tolerance.

NSSV 261 (DSR), ICSSH 70 (ICRISAT), RSSV 192 (MPKV) and ICSSH 58 (ICRISAT) have been found to be the best entries on the basis of IPS, FPS, biomass, brix %, juice yield and grain yield.

Rabi (Post-rainy season) 2010-11 :

1. In continuing sweet sorghum CMS-line development programme, we have made backcrosses in 248 progenies. The CMS lines being considered for improvement are NARI-SS-5A, NARI-SS-6A and NARI-SS-11A. These backcrosses are currently in BC_3 and BC_2 stages.

2. Out of 15 F_5 generation lines evaluated, F_5 (D-141)-33 recorded highest fresh biomass yield and stripped stalk weight which were 59.28 T/ha and 42.52 T/ha, respectively. It was followed by F_5 (D-141)-34 whose fresh biomass and stripped stalk yields were 49.09 T/ha and 33.51 T/ha, respectively. Total sugar index of the two lines was 2.88 and 2.25 T/ha, respectively.

3. Among 45 F_5 generation lines tested for high biomass and high sugar yield, F5 (D-91)-30 recorded 44.61 T/ha fresh biomass yield, 29.39 T/ha stripped stalk yield and 2.31 T/ha total sugar index.

4. Of 35 advanced generation lines tested, F_7 (D-34)-11-1 recorded highest fresh biomass, stripped stalk weight and total sugar index which were 33.86 T/ha, 22.61 T/ha and 1.74 T/ha, respectively. Currently we have 35 promising high biomass and high sugar yielding lines in advanced generations.

5. F_3 and F_4 selections of different crosses were evaluated for developing maintainers giving high biomass and high sugar yield and we have 27 potential maintainers which have been selected for further evaluation.

6. F_3 progenies were evaluated for developing high biomass and high sugar-yielding shoot fly tolerant restorers and 95 potential restorers have been selected which have greater than 15% brix.

7. F_3 progenies were evaluated for developing high biomass and high sugar-yielding shoot fly-tolerant maintainers and more than 500 individual plant selections have been made which have greater than 15% brix.

8. More than 250 germplasm lines were maintained by the center during Rabi 2010-11.

9. More than 250 AB lines were maintained by the center during Rabi 2010-11.

10. Seed production of four promising CMS-based hybrids *viz.,* NARI-NFSSH-35, NARI-NFSSH-44, SKH-67 and SKH-81 was undertaken. Sufficient amounts of seed of these hybrids were obtained for conducting an evaluation trial.

Sweet Sorghum Hybrid "NARI-NFSSH-44"
developed by Nimbkar Agricultural Research Institute

11. Seed production of 17 CMS-based sweet sorghum hybrids was undertaken on small scale. These hybrids will be evaluated during Kharif 2011.

12. Seed production of two promising selections *viz.,* NARI-LC-07-5 and NARI-SS-233 was undertaken. These selections were tested in AICSIP trials during Kharif 2010 and have been promoted for testing in advanced trials.

13. Center also conducted three AICSIP trials during Rabi 2010-11. The details are as follows:

    a. **IVHT-SS Trial (Evaluation of grain sorghum entries on shallow soils)** : RSV 1345 (Rahuri) and BJV 85 (Bijapur) have shown shoot fly tolerance. AKSV 205R (Akola), RSV 1345 (Rahuri) and AKSV 203R have shown stem borer tolerance.

    b. **AVHT-SS Trial (Evaluation of grain sorghum entries on shallow soils)** : SPV 1901 (Solapur), RSV 1098 (Rahuri), Phule Anuradha, SPV 1831 (Rahuri) and SPV 1892 (Rahuri) have shown shoot fly tolerance. Phule Anuradha and BJV 44 (Bijapur) showed no incidence of stem borer. SPV 1829 (Solapur), SPV 1892 (Rahuri), RSH 1010 (Rahuri), SPV 1901 (Solapur), SPV 1893 (Rahuri), SPV 1806 (Rahuri) and Mauli have shown stem borer tolerance.

c. **Sweet sorghum evaluation for stalk yield, biomass, juice yield quality (sugar traits) and winter season adaptation** : SSRV-45 and SSRV-10 were found to be the best as these varieties have yielded high TSI which was 1.51 and 0.98 T/ha respectively. SSRV-45 and SSRV-10 have also yielded maximum ethanol yield which was 867.15 and 519.95 L/ha, respectively.

Project staff : N. Nimbkar, Ph.D.; D. R. Bapat, Ph.D. (Consultant); V. Singh, Ph.D.; R. Sharma, Ph.D.; A. Siddique, Ph.D.; M. B. Deshpande, M.Sc.; S. V. Burungale, M.Sc.; V. A. Bhagwat, M.Sc.; A. M. Ranaware, M.Sc.; C. S. Khore, M.Sc.; B. R. Waghmode, M.Sc.; A. V. Godase, M.Sc.; S. V. Choudhari, B.Sc.; A. A. Chavan, M.Sc.; R. K. Andhalkar; D. S. Awati; A. M. Nale; A. R. Gholap; M. G. Shirke

RENEWABLE ENERGY RESEARCH

The following activities took place during 2010-11. (1) development of kerosene lanstove; (2) development of solar-powered water disinfection system and (3) the construction of Bajaj Center for Sustainable Development (BCSD).

Project 1. Kerosene lanstove

Funding agency : Self-funded.

In 2009 NARI received the Globe forum award in Sweden for its alcohol lanstove design. Lanstove is a device which simultaneously provides light and cooks a complete meal for a family of five. It was planned to spread lanstove in rural areas. However, because of archaic and stringent excise laws regarding use of alcohol this was not possible. Hence it was decided to develop a kerosene lanstove, since the kerosene fuel is available and is already used for rural household purposes.

The main criteria in design and development of this lanstove were :

(1) It should be completely smokeless and with least particulate emissions.
(2) It should be very easy to light and be safe.
(3) It should be cost-effective.

All these criteria were fulfilled by the kerosene lanstove. It has been tested in about 40 huts which never had electricity and the user response has been tremendous. A trademark registration for ‘Lanstove’ has been filed.

Lanstove to the best of our knowledge is the first device which provides very bright light (equivalent to that from a 200-300 W incandescent bulb), cooks a complete meal (including chapatti and bhakari) for a family

of five and also boils 10 liters of water.

The mass media have covered this invention extensively both in print (DNA, Mail Today) and electronically (CNN-IBN). The details of the lanstove are at this site.

A paper on the lanstove was sent to the International Indoor Air Pollution Conference which took place in June 2011 in Texas, U.S.A.

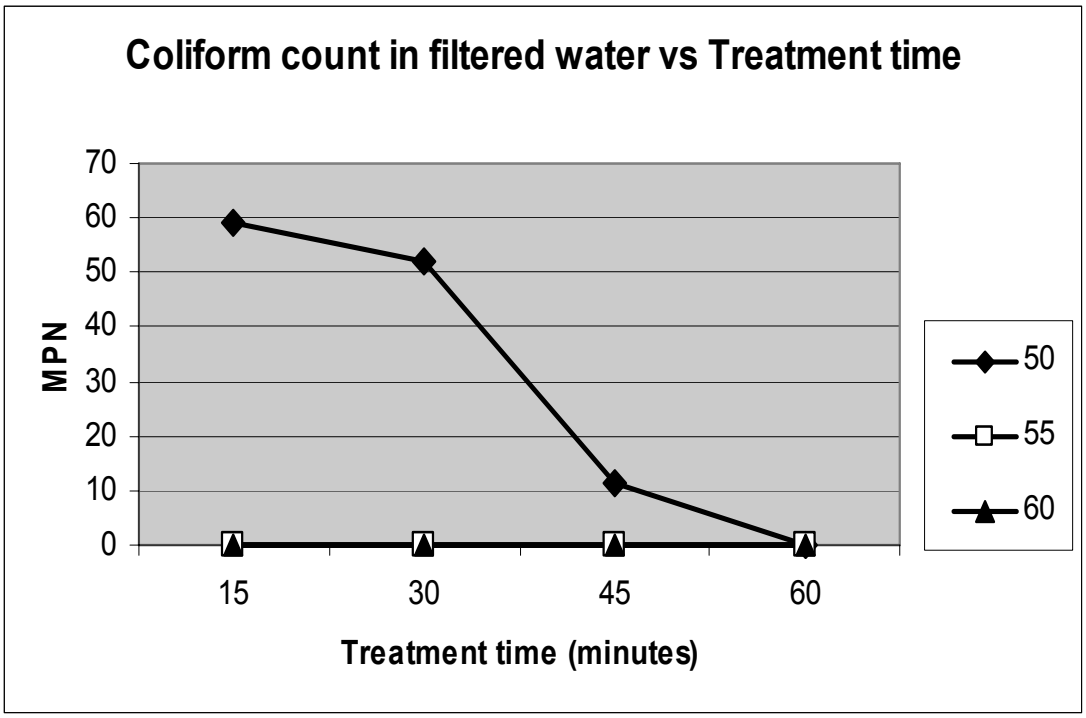
Project 2. Solar disinfection of water

Funding agency : Self-funded.

According to WHO about 1.5 million deaths in India take place every year because of drinking contaminated water. The quality of drinking water in urban and rural areas leaves much to be desired. Presently the preferred method for disinfection of water is UV treatment, Reverse Osmosis (RO) filters and other types filters which mostly use electricity.

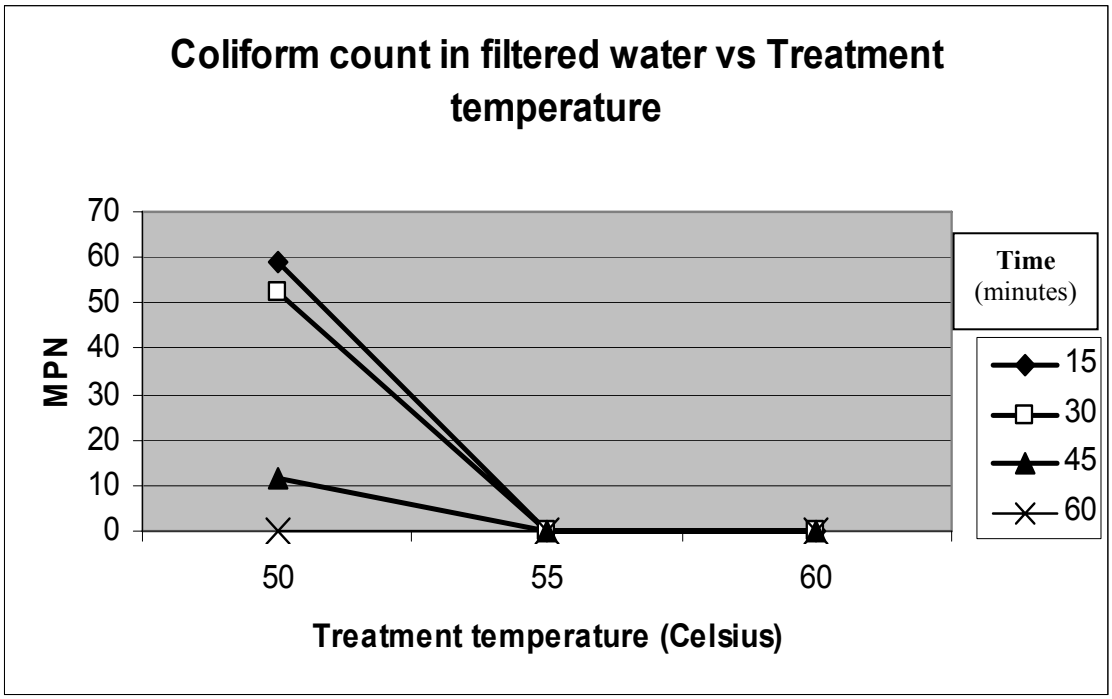
There was therefore a need to develop a simple thermal device which does not use electricity, uses solar thermal energy directly and is simple to use.

Hence a strategy was developed whereby the contaminated water was first filtered through four layers of a cotton sari and then put in the solar boiler. Around 10-15 liters of water was heated in a double-glazed solar boiler. The water in a simple solar collector is easily heated to 60^0C even on cloudy days. Lab tests showed that water heated to 60^0C for 1 hour deactivated all coliforms (Table 1, Fig. 1, Fig. 2). Thus a simple solar water system to disinfect water has been developed.



*** MPN values are mean of 3 replications.**

Figure 1: Coliform Count (MPN) in filtered water vs. Treatment Time



*** MPN values are mean of 3 replications.**

Figure 2: Coliform Count (MPN) in filtered water vs. Treatment Temperature

Table 1 Comparative data of Most Probable Number (MPN) and Colony Forming Units (CFU) of coliforms in cotton sari-filtered water

Sr. No.	Sample		MPN	CFU count	Remarks
1	Raw water		350 - 920	125	Untreated canal water
2	Raw water filtered with double-folded cotton sari cloth		215- 825	97	Coliform count declines
3	Raw water filtered with double-folded cotton sari cloth and heated				
	50°C	15 min	14-130	55	Coliforms in water sample inactivated after heating for minimum 60 min
		30 min	3.7-130	32	
		45 min	3.7-23	2	
		60 min	0	0	
	55°C	15 min	0	3	Coliforms in water sample inactivated after heating for minimum 45 min
		30 min	0	1	
		45 min	0	0	
		60 min	0	0	
	60°C	15 min	0	0	Coliforms in water sample inactivated after heating for 15 min or more.
		30 min	0	0	
		45 min	0	0	
		60 min	0	0	

Project 3. Sustainable Development Center

Funding agencies : Various as given below.

The 1200 m^2 Bajaj Center for Sustainable Development was finally constructed and inaugurated on 12th April 2011 by Shri. Madhur Bajaj, Shri. Sanjay Kirloskar and Shri. Zia Quraishi. Generous donations from Nimbkar Seeds Pvt. Ltd., Bajaj Foundation, Cummins Foundation, Kirloskar Brothers etc. made it possible to construct this center.

The center is a residential training and research facility with 10 room (double occupancy) hostel, two suites for visiting faculty, a large auditorium, offices, spacious dining room and kitchen facilities.

The center was designed by two U.S. architect interns Megan Cook and Ross Karsen. It contains very innovative renewable energy features like solar water heating system (wood boiler as backup) for hostel; solar PV unit to pump water from the borewell to the overhead tank, rain water harvesting and recycling of all kitchen waste into compost. The waste water from the building both from the toilets and the kitchen goes to the NARI farms. Hence almost all the waste products are recycled.

The center is cooled by passive cooling of the roof, where the solar pump enables the water to be sprayed on the roof to soak the gunny sacs. The evaporating water from the gunny sacs cools the roof and hence the rooms.

The facility has been found to be very useful for holding seminars, workshops and hosting lectures and discussions with visiting students, farmers and visitors from all over the country and abroad.

Project staff : Anil K. Rajvanshi, Ph.D.; V. J. Chopade, M.Tech.; S. M. Patil; R. S. Bale; A. M. Pawar; D. B. Gadhave

Animal Husbandry

Project 1. Increasing profitability of sheep production by genetic improvement using the *FecB* (Booroola) mutation and improved management

Funding agency : Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India.

Collaborating Institute : National Bureau of Animal Genetic Resources of the Indian Council of Agricultural Research

Duration : 2009-12

This project is a follow-on project to the project funded by the Australian Centre for International Agricultural Research (ACIAR) for 10 years from 1998-2007.

Progress made against targets (including methodologies used and discussion)

Objective 1 : Multiplication of *FecB* carrier animals in the nucleus flock

Two artificial insemination programmes of ewes were carried out at NARI in October-November 2010 and April-May 2011 in order to achieve fast multiplication of *FecB* carrier animals in the nucleus flock. Each program lasted for one month, roughly covering two oestrus cycles. Details are in Table 1 below. Ewes were inseminated in natural oestrus detected by vasectomized teaser rams. All ewes were inseminated cervically once, about 12 hours after oestrus detection, with fresh, diluted semen of the allotted rams. The composition of the semen diluent was based on one suggested by Evans and Maxwell (1987) and modified for local conditions. It was a synthetic diluent containing Tris buffer, D Glucose, citric acid and the antibiotics Benzyl penicillin and Streptomycin sulphate. Adequate numbers of unrelated breeding rams were used to keep inbreeding under control. Sophisticated genetic analysis was used to estimate breeding values. An advanced ‘mate allocation’ program was used to maximize genetic merit while keeping inbreeding below a predetermined level.

Deccani and Madgyal rams are being used to improve the physical appearance and conformation of crosses in such a way as to make them more desirable to local smallholder sheep owners. Madgyal or Vijapuri is a breed from southern Maharashtra which is a tall breed with a faster growth rate than Deccani and is preferred by shepherds in the Phaltan area and many other areas of Maharashtra. The overall conception rate ranged from 75 to 89 per cent for ewes of different *FecB* genotypes. The number of lambs born in April 2011 was 198.

Table 1. Details of AI programs carried out during 2010 and first half of 2011

Dates of AI	15 October 2010 to 15 November 2010				11 April 2011 to 16 May 2011			
Particulars	*FecB*^{BB}	*FecB*$^{B+}$	*FecB*$^{++}$	Total	*FecB*^{BB}	*FecB*$^{B+}$	*FecB*$^{++}$	Total
Ewes available for breeding	45	82	65	192	38	101	39	178
Ewes that exhibited oestrus and were inseminated artificially (AI)	45	78	64	187	31	90	31	152
Ewes given natural service (NS)	0	0	0	0	0	0	0	0
Total number of first and second AI	47	82	73	202	34	94	34	162
Ewes that returned to oestrus	8	5	9	22	1	0	0	1
Ewes conceived	37	73	55	165	Ewes will be scanned ultrasonically.			
Overall conception rate	79%	89%	75%	82%				
Ewes aborted / foetus absorbed	0	5	1	6				
Pregnant ewes died / culled	1	3	3	7	Ewes will lamb in September-October 2011			
Ewes lambed	36	66	50	152				

Objective 2 : Dissemination of *FecB* and monitoring progeny performance

Three homozygous and one heterozygous *FecB* carrier rams were supplied by NARI in April 2011 to the Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar, Jammu & Kashmir as per the recommendations of the Animal Biotechnology Task Force of DBT during its meeting in December 2010.

Since 2004, 85 *FecB* carrier rams (38 homozygous and 47 heterozygous) and 148 *FecB* carrier ewes have been supplied to 26 parties including SKUAST-K, Sheep Husbandry Department of Jammu & Kashmir Government, Bangalore Veterinary College of the Karnataka Veterinary, Animal and Fisheries Sciences University, College of Agriculture, Dapoli, Maharashtra, Bombay Veterinary College, two NGOs in Andhra Pradesh, four private companies in Maharashtra, Karnataka, Rajasthan and Tamil Nadu, private organized farm owners in Maharashtra, Karnataka, Rajasthan, Tamil Nadu and Andhra Pradesh, 12 traditional shepherds from the Dhangar community in Maharashtra and one Krishi Vigyan Kendra at Namakkal, Tamil Nadu under the Tamil Nadu Veterinary and Animal Science University. We have recently mailed questionnaires to these sheep rearers and organizations requesting information on the ewes mated by the rams, their progeny and progeny performance.

FecB carrier NARI Suwarna rams disseminated to smallholder shepherds in Bhadali Khurd, Tal. Phaltan

In addition, two *FecB* carrier rams are currently in two shepherds' flocks for breeding at Wadgaon in Satara district (Shri Nandakumar Awate) and at Kamone in Solapur district (Shri Digambar Kharat) in Maharashtra.

Ninety four heterozygous ($FecB^{B+}$) ewes were disseminated on 13 January 2010 to 12 smallholder sheep owners who are members of the Birdev Farmer Shepherds' Club in Bhadali village in the rainfed area of Phaltan taluka, south of Phaltan town. There are now three homozygous, 98 heterozygous *FecB* carrier and 224 non-carrier ewes in 10 smallholder shepherd flocks which are being performance-recorded by NARI's extension workers. All ewes and their lambs have ear tags for individual identification. Tables 6 and 7 under Objective 4 below give the details of 172 lambings of heterozygous ewes and 377 lambings of non-carrier ewes belonging to shepherds over the last two years (June 2009-May 2011). Shepherds are gaining substantial benefit from the twinning ability of *FecB* carrier ewes. The 172 lambings of heterozygous ewes in their flocks produced 273 lambs.

One homozygous ram was given to the Agricultural Development Trust at Baramati to use for breeding in their stall-fed flock of *FecB* carrier ewes. In a study we made of *FecB* heterozygous carrier and non-carrier ewes in this flock, it was found that there was an annual net loss of Rs.74 per non-carrier ewe while there was a net profit of Rs.115 per *FecB* heterozygous carrier ewe after accounting for all expenses in the stall-fed flock. The number of 6-month old saleable lambs per heterozygous ewe was 1.4 which was 74% higher than 0.94 per non-carrier ewe. This study was published in an article in a Marathi agricultural monthly magazine.

Objective 3 : **Establish PCR-RFLP DNA test for detection of *FecB* mutation**

3A. DNA test conducted to detect the *FecB* mutation : A molecular biology laboratory was established at NARI for which all the basic equipment was purchased and the PCR-RFLP DNA test for detection of the *FecB* mutation was established successfully in the first year. All lambs born at NARI and in shepherds' flocks that are likely to be *FecB* carriers are genotyped using their blood samples taken on FTA paper. Table 2 below gives details of the sheep genotyped in the NARI laboratory from November 2010 to May 2011.

Table 2. *FecB* genotypes of sheep tested using the PCR-RFLP test at the NARI laboratory from November 2010 to May 2011

Breed	Sheep genotyped	*FecB*^{BB}	*FecB*$^{B+}$	*FecB*$^{++}$
Sheep belonging to NARI				
Garole	23	22	1	0
Crossbred lambs	350	87	204	59
Awassi and crosses	3	0	1	2
Sheep belonging to smallholder shepherds, KVK, Baramati and KVK, Namakkal, Tamil Nadu				
Crossbred lambs	68	4	35	29
Total	**444**	**113**	**241**	**90**

The samples where the genotypes were doubtful were retested. *FecB* genotypes of 93% of the samples were obtained at the first test and the remaining 7% after a repeat test.

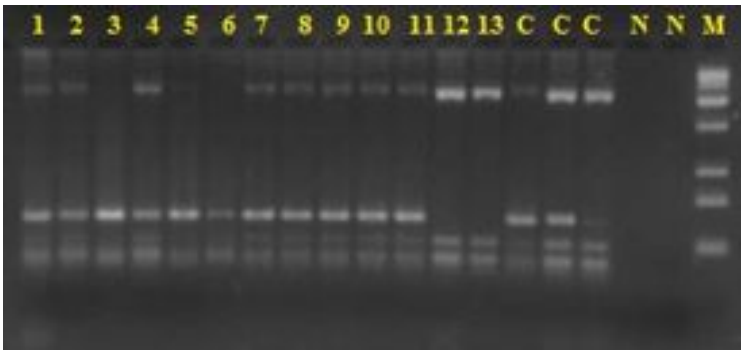
3B. Establishment of an ARMS PCR test at NARI for the *FecB* mutation : A tetra-primer ARMS PCR method was established at NARI for the detection of the BMPR-IB mutation. The ARMS-PCR protocol we established is a modified form of the ARMS-PCR test described by Polley *et al.* (2009). The protocol was modified to save on time and cost and to suit large-scale genotyping at the *FecB* locus. The PCR-RFLP procedure requires two full days for 96 samples while an ARMS-PCR test can be carried out in one day and the cost of the restriction enzyme digestion reaction does not have to be incurred. The ARMS-PCR amplifications yielded two bands of molecular weight 1100 bp (wild type allele product) and 136 bp (mutant allele product). The ARMS-PCR test reduces false negative results due to incompletely digested PCR products which can be a problem with the PCR-RFLP test.

Table 3. *FecB* genotypes of sheep tested at the NARI laboratory using the ARMS PCR test from November 2010 to May 2011

Breed	No. of sheep genotyped	*FecB*^{BB}	*FecB*$^{B+}$	*FecB*$^{++}$
Crossbred lambs	43	14	23	6
Breeding rams	62	18	42	2
	105	32	65	8

Eighty nine out of the 105 sheep genotyped by ARMS-PCR were already genotyped by PCR-RFLP and the *FecB* genotypes of only two of these sheep turned out to be different from the PCR-RFLP results. Thus 97.7% of the results from the two tests matched.

Fig. 1. Agarose gel photo of a *FecB* genotyping test performed by ARMS-PCR method at NARI



Lane 3 : *Fec*B carrier homozygous ($FecB^{B}$/ $FecB^{B}$) with one band at 136 bp
Lane 4 : *FecB* heterozygous ($FecB^{B}$/ $FecB^{+}$) with two bands at 1100 bp and 136 bp
Lane 12 : *FecB* non-carrier homozygous ($FecB^{+}$/ $FecB^{+}$) with one band at 1100 bp
Lane C : Positive controls. Genomic DNA samples of known *FecB* genotypes
Lane N : Negative controls with only PCR cocktail and no DNA template.
Lane M : DNA molecular weight marker ladder : Genei^{TM} Low Range DNA Ruler.

3C. Ovine Prolactin (PRL) gene polymorphism detection in *FecB* carrier and non-carrier ewes with known litter sizes : Prolactin is an anterior pituitary hormone involved in many reproductive pathways (Vincent and Rothschild, 1997). Prolactin has a crucial role in uterine preparation for embryo implantation and stimulation of ovarian production of progesterone. Members of the lactogenic hormone family stimulate endometrial gland development and function during pregnancy to facilitate implantation and placentation of the conceptus.

Investigation of PRL gene polymorphism in *FecB* carrier ewes was considered important because of the role of PRL in uterine function and capacity. In order to maximize the profit from *FecB* carrier prolific ewes, it is going to be necessary to carry out selection for improved uterine function and capacity. It would be easier to select ewes for uterine capacity if an association can be established between the existence of a polymorphism and lamb survival at birth.

Introduction :

There exist two variants in the ovine *PRL* gene that have been distinguished based on *Hae*III digestions of PCR products, as first described by Vincent and Rothschild (1997), although the precise genetic nature of these forms had until now remained uncharacterized. Recently a simplified, rapid, and cost-effective method of genotyping a prolactin gene polymorphism of the ovine prolactin gene was developed. By direct DNA sequencing of PCR products generated from AA and BB homozygous animals, it was reported that the B allele is the result of a deletion in the region flanked by 2 *Hae*III sites. This finding facilitated the design of new primers flanking the deletion; therefore, genotyping of the two alleles is possible by using a simplified PCR assay, based solely on the size of a short PCR product without the need for digestions. Using this modified assay, we genotyped an experimental flock of 100 sheep of three breeds and their crosses and carried out association studies.

Animals tested

Genomic DNA was extracted from whole blood samples of three sheep breeds and their crosses. Venous jugular blood samples (10 ml per ewe) were collected from 100 ewes having data of their previous lambings. In this study, blood samples (100 animals) were initially taken from Garole (n = 48; 13 males and 35 females), Deccani (n = 9 females), Awassi (n = 2 females) and Crossbred (n = 41 females) [with contributions from Garole, Deccani and Awassi breeds] sheep from Animal Husbandry Division of the Nimbkar Agricultural Research Institute. Blood was collected using BD vacutainers and subsequently their DNA contents were salted out and extracted at NBAGR in January 2010. Genomic DNA was extracted from whole blood by phenol–chloroform method as described by Sambrook and Russell (2001), and then dissolved in TE buffer and kept at -20°C.

Table 4. **Animals used for the detection of *PRL* polymorphism and their *FecB* genotypes**

Sheep Breed	*FecB* genotypes			Total
	$FecB^{B}/FecB^{B}$	$FecB^{B}/FecB^{+}$	$FecB^{+}/FecB^{+}$	
Garole	35	13	0	48
Deccani	0	0	9	9
Crossbred*	19	20	2	41
Awassi	0	0	2	2
Total	54	33	13	100

* Crossbred ewes had 12.5-25% contribution of Garole breed and 75-87.5% contribution of Deccani breed in their breed composition.

Materials and methods

Primer sequences :

One pair of primers described in the literature was used to amplify the concerned region of the ovine *PRL* gene. Expected fragment sizes were as follows: A variant: 213 bp; B variant: 190 bp.

PCR amplification :

Amplifications were performed in a final volume of 25 µl using 10 ng of genomic DNA, 2.5 m*M* $MgCl_2$, 0.4 µ*M* *PRL*Del-F, 0.4 µ*M* *PRL*Del-R, and 1 U of Taq DNA polymerase (Genei). Following an initial 5-min denaturation step at 94°C, the PCR reactions were subject to 30 cycles of 94°C for 30 s, 56°C for 30 s, 72°C for 30 s, and a final elongation step for 5 min at 72°C. Clear, high intensity bands of the expected size (213 bp for the A allele and 190 bp for the B allele) could be resolved on 2% agarose gels run for 60 min. Genomic DNA of 100 sheep of three breeds and their crosses (Table 4) genotyped by PCR and allele sizes were compared to a 100-bp DNA ladder (Fig. 2).

Genomic DNA of 100 sheep of three breeds and their crosses (Table 4) was amplified. PCR products were detected by running a 2% agarose gel electrophoresis. The amplified product was consistent with the target fragment and had good specificity. (Fig. 2).

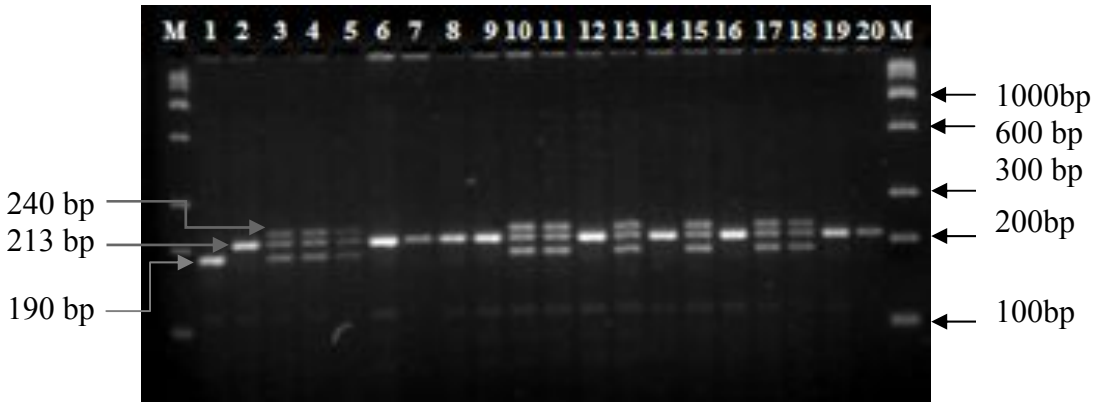
Results

PCR amplification :

Three genotypes (AA, BB and AB) were detected. Single, clean PCR bands of the expected sizes (213 bp for A allele and 190 bp for B allele) were generated from AA and BB homozygous animals. An additional higher molecular weight (240 bp) band also appeared for heterozygous samples (Fig. 2). However, as discussed in the literature, its presence does not appear to affect in any way the correct genotyping of heterozygous animals and it is likely to comprise mixed signals generated from both alleles, possibly due to the formation of heteroduplexes because of a loop structure in the area of deletion.

Among the tested sheep population, maximum proportion (20/48 or 0.42) of heterozygous *PRL* variants were found in Garole ewes followed by Deccani (2/9 or 0.22) and crossbred ewes (7/41 or 0.17).

Fig 2. Agarose gel electrophoresis (2%) of PCR product.



Lane 1 : Amplification of mutant B variant (BB) (190 bp product)
Lane 3-5, 10, 11, 13, 15, 17, 18 : Amplification of heterozygous (AB variant) having both 213 bp and 190 bp products
Lanes 2, 6-9, 12, 14, 16, 19, 20 : Amplification of wild type A allele (AA) (213 bp product)
Lane M : DNA molecular weight marker (Genei^{TM} Low Range DNA Ruler).

In summary, identification of polymorphism in the ovine prolactin gene in sheep showed a high frequency of the wild type A allele (Garole: 0.78; Deccani: 0.89 and Crossbred: 0.91). In tested sheep population (100), frequency of the mutated B allele was 0.22 in Garole; 0.11 in Deccani and 0.09 in Crossbred. The PRL mutation did not exist in either of the Awassi ewes. Since only 17% of the 41 crossbred ewes were found to carry the mutation, it appears that this polymorphism was originally present in the Garole breed and was transmitted to the crosses from the Garole. However, we need to confirm this by genotyping more samples and also confirming the mutation by sequencing of fragments generated for the presence of the 23 bp deletion.

Association studies of polymorphism in the second intron of prolactin gene.

Among 35 Garole ewes, one was homozygous (BB) for the mutation, 14 were heterozygous (AB) and 20 were wild type homozygous (AA) for *PRL* gene. When we checked for the lamb mortality at birth in these ewes; we observed that the mortality of lambs at birth (stillbirth / lambs died soon after birth) was 0% in the homozygous BB ewe, 4.6% in heterozygous ewes and 13% in homozygous AA ewes.

Out of 41 crossbred ewes, 7 were heterozygous variants (AB) of the *PRL* mutation and 34 were homozygous AA variants. Lamb mortality at birth was 7.9% in heterozygous variants (AB) while in case of AA variants, it was 21.6%. In case of Deccani and Awassi ewes, no lamb mortality at birth was seen either in heterozygous AB or homozygous AA variants.

Table 5. Lamb mortality at birth in 170 lambings of 87 ewes of different breeds and three genotypes of *PRL* gene mutation

	Total number of Lambings			Number of lambs born					
PRL mutation genotypes	BB	AB	AA	BB		AB		AA	
Ewe breed				Live	Dead	Live	Dead	Live	Dead
Garole	5	40	55	7	0 (0%)	62	3 (4.6%)*	80	12 (13.0%)
Crossbred	-	21	115	-	-	35	3 (7.9%)	156	43 (21.6%)
Deccani	-	7	18	-	-	7	0	20	0
Awassi	-	-	8	-	-	-	-	8	0

* Numbers in brackets denote percent lamb mortality.

From these preliminary observations, we can say that the ewes having one or two alleles of the mutation (homozygous BB and heterozygous AB ewes) have less lamb mortality at birth than homozygous AA variants. Hence we can say that the *PRL* deletion mutation appears to have an association with uterine capacity and therefore lamb survival at birth. More samples of ewes with lambing records need to be tested to arrive at a firm conclusion.

3D. Genomic DNA extraction : NARI purchased a high speed cooling refrigerated centrifuge from the specific grant approved by the Task Force. The standard protocol (proteinase-SDS digestion followed by phenol-chloroform extraction) for genomic DNA extraction from whole blood (Sambrook and Russell, 2001) was established and DNA of 16 sheep has been extracted so far. The purity and concentration of DNA samples was estimated using a UV-visible range spectrophotometer at the Department of Microbiology, Sharadabai Pawar Mahila Mahavidyalaya, Sharadanagar near Baramati. All the DNA samples had the 260/280 OD ratios in the range of 1.8 to 2, indicating high purity. DNA was also examined by loading samples on 0.8% agarose gel and visualizing the band under gel documentation system. As we carry out detailed phenotypic recording of all sheep at the NARI farm and in some shepherds' flocks, it would be important from the potential of association studies and genomic selection, to extract and store genomic DNA samples of as many of the recorded sheep as possible.

Objective 4 : Estimation of the effect of one and two copies of the *FecB* mutation

During 2009-11, average live litter size of *FecB* homozygous ewes that lambed at four different times at NARI ranged from 1.5 to 1.7 while that of *FecB* heterozygous ewes ranged from 1.3 to 1.7. Ten to 25% homozygous and 4 to 13% heterozygous ewes had triplets while 3 to 20% homozygous and less than 2% heterozygous ewes gave birth to quadruplets. There was variation in total and live litter size in ewes of the same *FecB* genotype. Some ewes in each *FecB* carrier genotype had a 'low' live litter size (mostly singles and an occasional twin) consistently for at least three lambings while some had a 'high' average litter size (mostly $\geq$2 with the highest of 4 and an occasional single). Table 6 below gives the average litter size in all lambings over the last two years, of ewes of the three *FecB* genotypes in NARI's and shepherds' flocks. The table shows that 54% and 56% of the lambings of heterozygous ewes in NARI's and shepherds' flocks produced twins and 8% and 1% of the lambings produced triplets respectively. Forty three per cent of the 214 lambings of homozygous ewes in NARI's flock produced twins, 16% produced triplets and 11% produced quadruplets.

Table 6. Classification according to litter size of all lambings (with at least one live lamb) of ewes of three *FecB* genotypes from 25 June 2009 to 28 April 2011 in NARI and shepherds' flocks

	NARI Flock							Shepherds' flocks				
Litter size	***FecB*^{BB}**		***FecB*$^{B+}$**		***FecB*$^{++}$**		**Total**	***FecB*$^{B+}$**		***FecB*$^{++}$**		**Total**
	No.	%	No.	%	No.	%		No.	%	No.	%	
Single	64	30	177	37	248	93	489	73	43	361	96	434
Twin	92	43	258	54	19	7	369	97	56	16	4	113
Triplet	35	16	41	8	-	-	76	2	1	0	0	2
Quadruplet	23	11	3	1	-	-	26	0	0	0	0	0
Total	214	100	479	100	267	100	960	172	100	377	100	549

Only 1% of lambings of heterozygous ewes in shepherds' flocks producing triplets is acceptable from the point of view of ewe and lamb management but the comparatively high proportion (27%) of lambings of homozygous ewes with triplets and quadruplets is a matter of concern as such ewes and lambs need special care. The proportion of triplet and quadruplet lambings needs to be reduced by limiting the quantity of supplementary feed given to ewes at breeding, thereby limiting the number of ovulations.

Three month weight records of 373 lambs born at NARI in April and November 2010 were analyzed. The fixed effects that were found to be statistically significant were season of birth (lambs born in the summer being about 1 kg. heavier than lambs born in the winter), sex (males being 1.5 kg heavier than females), proportion of Garole and Awassi breeds in the lambs' breed composition (increase in the Garole proportion reduces lamb weight while increase in Awassi proportion increases lamb weight), weight of the dam at breeding (heavier dams have heavier lambs) and type of birth of the lamb. *FecB* genotype of the lamb was not significant. This is contrary to some of the literature reports which have reported that *FecB* carrier lambs are lighter than non-carrier lambs. Least squares means for different birth types are given in Table 7 below.

Table 7. Least squares means of 3-month weights of crossbred lambs of different types of birth

Lamb's type of birth	Lamb's *FecB* genotype		
	$FecB^{BB}$	$FecB^{B+}$	$FecB^{++}$
Single	15.1 ± 0.6 (14)*	15.7 ± 0.2 (77)	15.4 ± 0.4 (33)
Twin	12.1 ± 0.3 (47)	12.0 ± 0.2 (108)	11.7 ± 0.5 (22)
Triplet	9.2 ± 0.6 (14)	10.9 ± 0.4 (34)	9.4 ± 0.9 (6)
Quadruplet	11.7 ± 1.0 (7)	10.6 ± 0.7 (10)	No records

* (Numbers in brackets are the numbers of lambs.)

Objective 5 : Analysis of expression profile of candidate/regulatory genes associated with fecundity

Animals and sampling :

Sheep belonging to different breeds (Garole/Deccani/crossbred) and *FecB* genotypes (carriers and non-carriers) were included from which the collection of ovaries and Graafian follicles had already been accomplished. The sampling was done at NARI-Sheep Farm, Phaltan following standard laparoscopy surgical procedure after estrus synchronization of ewes of different genotypes/litter size and breeds as explained earlier. Gene expression analysis using ovary and follicle samples from these ewes was carried out at NBAGR.

Laparoscopic examination of ewe ovaries before sampling for RNA isolation and gene expression analysis

Gene expression analysis :

Mutations that increase the ovulation rate in ewes have been discovered in the *BMPRIB, GDF9 and BMP15* genes and others known to exist from the expressed inheritance patterns (Moore et al., 2004; Chu et al., 2006). Other genes implicated in the process include various *SMAD*s and transcription factors *viz. STAT5*. Role of these latter in increased ovulation rate need to be verified. Several BMPs like BMP4, BMP7, belonging to the transforming growth

factor β (TGFβ) superfamily, are known to have effects on reproduction. Genes regulating the ovulation process through different pathways were selected for expression analysis to establish their role in increased or decreased rates of folliculogenesis.

Primer designing :

Primers were designed for the genes regulating the ovulation rate *BMPRIB, BMP15, STAT5, SMAD5, SMAD9, FSHR, GDF9, LHCGR, BMP4, BMP7, SMAD4, BMPRIA* and *TGFβR1* from the sheep and cattle sequences available in the GenBank database for quantitative real-time PCR analysis. Primer pairs were designed for *LHCGR* and *SMAD4* gene transcripts using bovine sequences while for the rest of the genes including *GAPDH*, homologous sheep primer pairs were designed with the help of PrimerSelect program of Lasergene (DNASTAR Inc.).

RNA isolation and quality assessment :

Total RNA from ovary tissue and Graafian follicles collected from ewes of different genotypes/litter sizes was extracted by TRIzol method. In brief, the tissue samples were homogenized by adding 1 ml TRIzol per 100 mg of tissue with the help of GlassCol homogenizer. After centrifugation at 12000 x g for 10 min to the supernatant, 200µl of chloroform per ml of TRIzol was added and shaken vigorously. The mixture was centrifuged at 12000 x g for 15 min after leaving the samples at room temperature for 15 min. Supernatant was collected into a fresh tube and RNA was precipitated by adding 0.5 ml isopropanol. This was followed by incubation at room temperature for 30 min. The samples were then centrifuged at 12000 x g for 15 min to pellet the RNA. The pellet was washed with 75% ethanol and re-suspended in 30-50µl of RNA storage solution and stored at -80º C till used. On column DNase treatment was done for all the samples while purifying further using RNAeasy mini kit (Qiagen). RNA quantity and quality was assessed by Nanodrop spectrophotometer and also using Experion bio-analyzer (BioRad) system.

Analysis of genes from subtracted cDNA libraries :

In order to analyze the differentially expressed genes across the ewes of different *FecB* genotypes and litter sizes clones from the previously constructed subtracted cDNA libraries viz. Forward [Garole ($FecB^{B}$/ $FecB^{B}$) Vs Deccani ($FecB^{+}$/ $FecB^{+}$)] and reverse [Deccani ($FecB^{+}$/ $FecB^{+}$) Vs Garole ($FecB^{B}$/ $FecB^{B}$)] were sent for sequencing. The sequence data generated on 100 clones each from forward and reverse subtracted library were sequenced and analysed by BLASTN for similarity to the reported genes and also classified based on their sub-cellular location and biological functions.

Results :

RNA isolation from ovarian tissue :

Total RNA extracted from ovary tissue and Graafian follicles was first evaluated for its integrity and quantity. The concentration of all the samples as measured by Nanodrop ND1000 varied from 500-2000 ng/µl. The OD ratio of 260 and 280 nm for all of the RNA samples was in the range of 1.9-2.0 indicating purity of the respective samples. The results indicated good quality of RNA samples to proceed further.

Real-time PCR :

Salient findings are as follows :

- Significant difference in the levels of *GDF9* and *BMP15* mRNAs in the ovaries and Graafian follicles of the high and low fecundity groups within same BB genotypes of

Garole and crossbred possibly suggest that differences in their expression levels could influence ovulation rate as reported in Chinese sheep.

- For *BMPRIB, LHCGR* and *SMAD9,* expression was similar across different litter size groups.
- Further the mRNA expression level of *BMP4* and *FSHR* was found to be significantly higher in low litter size BB crossbred but in BB Garole and B/+ crossbred their expression was high in high litter size ewes.
- STAT5 expression was high in low litter size BB crossbred only and was static across all other genotypes and litter size animals.
- *BMP7* expression was higher in low litter size BB Garole animals.
- The expression of BMPRIA was high in high litter size Garole.
- Crossbred B/+ ewes did not show significant differences in the expression of any of the genes except for FSHR, which was high in high litter size animals.

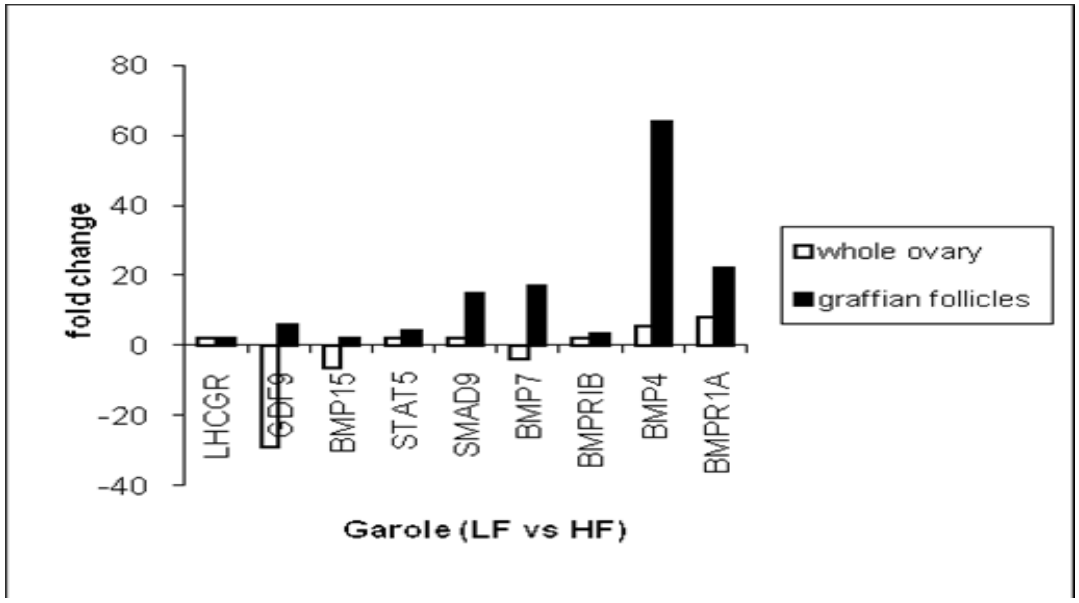


Fig. 3. Fold change expression of various genes in ovaries and Graafian follicles of low (LF) and high (HF fecundity Garole ewes. (Bars below 0 indicate higher expression in LF and above 0 are for higher expression of genes in HF animals).

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Summary

Artificial insemination of *FecB* carrier and non-carrier ewes was carried out twice during the last 6 months at NARI with a conception rate of 82% in October 2010. One hundred ninety-eight lambs were born in April 2011 out of which 134 were genotyped at the *FecB* locus and 108 found to be *FecB* carriers. One hundred fifty-two ewes were inseminated in April 2011. Ewes in 10 smallholder shepherd flocks (3 homozygous, 98 heterozygous *FecB* carrier and 224 non-carrier ewes) are being performance recorded. Heterozygous ewes in shepherds' flocks gave birth to 59% more lambs and weaned 53% more lambs than non-carrier ewes, thus bringing substantially higher profits to the shepherds who managed them well. 444 ram and ewe lambs belonging to NARI and shepherds were genotyped at the *FecB* locus using the PCR-RFLP DNA test at NARI. 105 sheep including 62 breeding rams were genotyped at the *FecB* locus using a tetra-primer ARMS PCR method to confirm the validity of the RFLP method. 100 *FecB* carrier and non-carrier sheep were tested for the detection of a deletion mutation in the PRL gene and its association with uterine function and capacity was studied. Results showed that ewes carrying one or two copies of the mutation had significantly lower lamb mortality at birth than ewes not carrying the mutation. The standard protocol for genomic DNA extraction was established at NARI using the equipment newly sanctioned by the Task Force. The 3-month weight of single born lambs at NARI was 15.4 kg, that of twin-born lambs 11.9 kg and triplet and quadruplet-born lambs was 10.2 and 10.8 kg respectively.

The expression profile of ten fecundity-related genes in whole ovarian tissue and Graafian follicles in *FecB* carrier ewes with different levels of prolificacy was studied by quantitative real-time PCR. The expression of *GDF9* and *BMP15* genes that are negative regulators of ovulation was higher in BB Garole ewes having a low litter size. The expression of *LHCGR*, *BMPRIB*, *STAT5* and *SMAD9* genes in the ovaries of BB Garole sheep was similar across ewes of varying litter sizes. However, the expression of *STAT5, SMAD9, BMP7, BMPRIB, BMP4* and *BMPRIA* genes in Graafian follicles was higher in high litter size BB Garole ewes. Different fragments of sheep *PRL* gene and *BMPRIB* promoter have been amplified and *FecB*-genotyped animals screened for polymorphism and SNP discovery. A contig of ~ 1.7 kb generated for *BMPRIB* had a total of 12 SNPs, two of which were found to be present in the transcription factors binding sites, which may have implications in gene expression.

Achievements

- Artificial insemination was carried out twice at NARI in October 2010 and April 2011 for fast multiplication of *FecB* carrier animals in the nucleus flock. 198 lambs (108 of which were *FecB* carrier) were born in April 2010. One hundred fifty-two ewes were inseminated in April 2011. Overall conception rate achieved was 82%.

- Since 2004, 85 *FecB* carrier rams (38 homozygous and 47 heterozygous) and 148 *FecB* carrier ewes were supplied to 26 parties including institutions and individuals.
- Three homozygous and one heterozygous *FecB* carrier rams were supplied by NARI in April 2011 to the Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar, Jammu & Kashmir as per the recommendations of the Animal Biotechnology Task Force of DBT during its meeting in December 2010.
- Three *FecB* homozygous, 98 heterozygous and 224 non-carrier ewes in 10 smallholder shepherds' flocks are being performance-recorded. Heterozygous ewes in shepherds' flocks gave birth to 59% more lambs and weaned 53% more lambs than non-carrier ewes.
- In shepherds' flocks, the weight of lamb weaned per single-bearing ewe was about 11.6 kg while that per twin-bearing ewe was 20.0 kg. which was a 72% increase caused by the phenomenon of twinning combined with better management.
- 444 ram and ewe lambs were genotyped at the *FecB* locus using the PCR-RFLP DNA test in the molecular biology laboratory established at NARI under the DBT project.
- 105 sheep including 62 breeding rams were genotyped at the *FecB* locus using a tetra-primer ARMS PCR method to confirm the validity of the RFLP method. 97.7% of the results were the same in both tests.
- 100 *FecB* carrier and non-carrier sheep were tested for the detection of a mutation in the Prolactin (PRL) gene and its association with uterine function and capacity was studied. The frequency of the mutated B allele was 0.22 in Garole; 0.11 in Deccani and 0.09 in crossbred sheep. Since only 17% of the 41 crossbred ewes were found to carry the mutation, it appears that this polymorphism was originally present in the Garole breed and was transmitted to the crosses from the Garole.
- Results showed that ewes carrying one or two copies of the PRL mutation had significantly lower lamb mortality at birth than non-carriers of the mutation (4.6% vs. 13% in Garole ewes and 7.9% vs. 21.6% in crossbred ewes), indicating superior uterine capacity.
- The standard protocol for genomic DNA extraction was established at NARI using the equipment newly sanctioned by the Task Force and high quality DNA was extracted from sheep whole blood.
- The 3-month weight of single-born lambs at NARI was 15.4 kg; that of twin-born lambs 11.9 kg and triplet and quadruplet-born lambs was 10.2 and 10.8 kg respectively. This indicates that the combined weight of twin-born lambs was 23.8 kg which was 54% higher than that of single lambs.
- The expression profile of ten fecundity related genes in whole ovarian tissue and Graafian follicles in *FecB* carrier ewes with different levels of prolificacy was studied by quantitative real-time PCR. The expression of *GDF9* and *BMP15* genes that are negative regulators of ovulation was higher in BB Garole ewes having a low litter size.
- The expression of *LHCGR*, *BMPRIB*, *STAT5* and *SMAD9* genes in the ovaries of BB Garole sheep was similar across ewes of varying litter sizes. However, the expression of *STAT5, SMAD9, BMP7, BMPRIB, BMP4* and *BMPRIA* genes in Graafian follicles was higher in high litter size BB Garole ewes.
- *BMP7* expression was higher in low litter size BB Garole animals. The expression of *BMPRIA* was high in high litter size Garole. Crossbred B/+ ewes did not show significant differences in the expression of any of the genes except for *FSHR*, which was high in high litter size animals.
- Analysis of genes from forward and reverse cDNA subtraction revealed higher expression of genes related to signal transduction and enzymatic activity in the ovaries of *FecB* carrier animals.

- Different fragments of sheep *PRL* gene and *BMPRIB* promoter have been amplified and *FecB*-genotyped animals screened for polymorphism and SNP discovery. A contig of ~1.7 kb generated for *BMPRIB* had a total of 12 SNPs, two of which were found to be present in the transcription factors binding sites, which may have implications in gene expression.
- A total of eight SNPs were found to be present in various regions of analyzed sheep PRLR introns and exons screened.
- Genotyping protocols are being developed for the selected SNPs for their role in fecundity in sheep.

Principal Investigators :

1. Dr. Chanda Nimbkar, Director, AHD, NARI
2. Dr. B. P. Mishra, NBAGR, Karnal (up to 20 March 2011)
3. Dr. R. S. Kataria, NBAGR, Karnal (from 21 March 2011)

Co-investigators :

1. Dr. Pradip Ghalsasi, Associate Director, AHD, NARI
2. Dr. R. S. Kataria, NBAGR, Karnal (up to 20 March 2011)
3. Dr. B. K. Joshi, NBAGR, Karnal

Project staff : Ms. Sonali Saste, Ms. Padmaja Ghalsasi, Mr. Rupchand Khanvilkar, Mr. Dilip Bhandari, Mr. Ashok Magar, eight shepherd men and women and seven farm labourers.

Project 2. Osmanabadi Goat Field Unit under the All India Coordinated Research Project on Goat Improvement.

Funding agency : Indian Council of Agricultural Research (ICAR), Government of India

Executive summary

Objective 1. To assess the production performance of goat breeds in farmers' flocks under village management system and improve the germplasm through selection

1. An Osmanabadi goat field unit was established at NARI in April 2009 under the AICRP on Goat Improvement. The first centre under this unit was established in Satara district in Bibi and Wadgaon villages, 25 km from Phaltan town. The second centre was established in Kalamb taluka of Osmanabad district in July 2010, in collaboration with the NGO Paryay. The third centre was established in Karmala taluka of Solapur district in October 2010 in collaboration with the NGO Mahatma Phule Samaj Seva Mandal. Fourth centre will be established in Ahmadnagar district.

2. Seven hundred and forty eight adult does (269, 179 and 300 adult female goats in Satara, Osmanabad and Solapur districts respectively) are being recorded. Detailed periodic recording has been done of their body weight, milk yield, reproduction, mortality, morbidity, cost incurred for goat rearing and income earned.

3. 1026 kids were born to 626 does in total (in all project villages) from 1 April 2010 to 1 April 2011. Of these, 281 does were in Satara district, 180 in Osmanabd district and 165 in Solapur district. The average litter size over all districts was 1.64. The average litter size was higher (1.77) in Osmanabad district.

4. The average kidding interval of 155 Osmanabadi does (3 kidding records of 21 does and 2 kidding records of 134 does) in Phaltan taluka where at least two subsequent kidding dates were known with certainty, was calculated. It was found to be 289 days indicating about 1.3 kiddings per doe per year.

5. The major breeding season of Osmanabadi does was from May to July, followed by a secondary season from August to October. A small proportion of does bred from October to March also.

6. The least squares mean three month weight of single-born kids (95 records) was 12.2 $\pm$ 0.4 kg and that of twin-born kids (185 records) was 10.0 $\pm$ 0.3 kg. Thus does giving birth to twin kids weaned almost 64% more kid weight than does giving birth to single kids. Three month weights of Osmanabadi kids in this study were higher than the ~ 7 kg given in the report of the Network Project on Osmanabadi Goats, MPKV, Rahuri (1995-99).

7. The 100-day milk yield of does that had given birth to single, twin and triplet kids was 52.4 kg, 74.8 kg and 83.4 kg respectively. There was large variation in kid weight and milk yield, indicating a potential for selection.

8. Overall mortality over all age groups was 3.7 to 9.8 per cent in different project villages. In project villages in Osmanabad district, it was 8-12 per cent in the below 12 months age group. Most of these deaths were due to twice the average rainfall which led to starvation and increased vulnerability to infections. Mortality was lower in the below 12 months age group in Satara and Solapur districts i.e. 2-5% and 2.5-7% respectively.

9. NARI has purchased 23 bucks for dissemination since 2009. The six month weights of these are 20 to 25 kg. These are 10 to 15 kg higher than the mean weights reported under the ‘Network Project on Osmanabadi Goats’ (1995-99).

10. NARI has disseminated 10 Osmanabadi breeding bucks – five in Phaltan taluka, three in Kalamb taluka and two in Karmala taluka since there is a severe shortage of breeding bucks and there was persistent demand for bucks from goat keepers. The goat keepers of these villages appreciate having these bucks available for breeding their goats. The performance of the progeny of these bucks will be monitored. The remaining 13 bucks are less than one year old and are being reared on the NARI farm.

11. We have frozen semen of eight Osmanabadi bucks in pellet form and of three Osmanabadi bucks in straws and now have 395 Osmanabadi buck frozen semen pellets and more than 100 straws available for submission to NBAGR. The post-thaw progressive motility of this frozen semen is > 60%. Each dose contains 180 to 200 million spermatozoa. We plan to freeze more semen in straws in the near future.

AHD staff members weighing kids in a goat keeper's flock in Bibi village under the Osmanabadi field unit of AICRP – Goat improvement

Objective 2. To evaluate the socio-economic status of goat breeders and the economics of goat production in farmers' flocks

12. Overall 38% of the goats and kids recorded under the project in six villages were sold. Out of 885 males, 479 or 54% were sold and out of 1739 females, 523 or 30% were sold. The majority of the animals sold (38-65% in different centres) belonged to the age group 3 to 6 months. Forty two percent of the male kids aged 3-6 months were sold and 53% of the male kids aged 6-12 months were sold.

13. The average price of a 3-6 months old kid was Rs.1750 in Phaltan taluka, Rs. 2250 in Kalamb taluka and Rs. 2550 in Karmala taluka. The average sale price per kg was thus more than Rs. 100 per kg live weight. Considering an average litter size of 1.64, a kidding interval of 9.5 months and 5% kid mortality, the minimum gross income of a goat keeper per doe per year is likely to be Rs. 3000.

Objective 3. To disseminate the pro-poor goat-based technologies under field conditions and assess their impact on goat production

14. Two information leaflets were published in Marathi on 'Vaccination of goats' and 'First-aid treatment in goats'. Copies of these are distributed free in project villages.

15. We have started using a new effective method of training of goat keepers in practical goat management. This is a weekly 1.5 hour evening training session with a group of interested goat keepers in a village. This has resulted in improving the confidence of goat keepers in their ability to detect sick goats and administer powder and liquid medicines to them safely. The group is called 'Jai Malhar Pashumitra Samiti'. We consider this group as the first step towards formation of a society of goat keepers in the village.

16. Awareness has been created among goat keepers about

- Weight of sale goats and expected market rate
- Disadvantages of early breeding of young does
- Importance of immediate treatment to save the lives of sick goats
- Importance of identification of goats and keeping records

- Better prices fetched by improved animals
- Reduced mortality by regular vaccination, deworming and spraying

Principal Investigator : Dr. Chanda Nimbkar

Project staff : Mr. Kaniya Chavan, Dr. Kiran Unaune, Mr. Popat Shinde, Mr. Swanand Joshi

Project 3. Assessment of green and dry matter yield and quality of NARI Nirbeeja (KX2 or *Leucaena leucocephala x Leucaena pallida*) planted on a farm bund and grown without direct irrigation after the first 9 months and without fertilizer for use as fodder for ruminants.

Duration : August 2008 to December 2011

Funding agency : self-funded

Objectives :

1) To assess yield of NARI Nirbeeja trees harvested at intervals of 12 weeks during the year.
2) To compare the difference in yield of leaves for cutting heights of 1 m and 0.5 m from the ground.
3) To assess the nutritive value of NARI Nirbeeja leaves – Crude protein, ADF and NDF.

Material and methods : Five trees were always cut at a height of 1.0 m and five trees at 0.5 m from the ground at every 12 weeks.

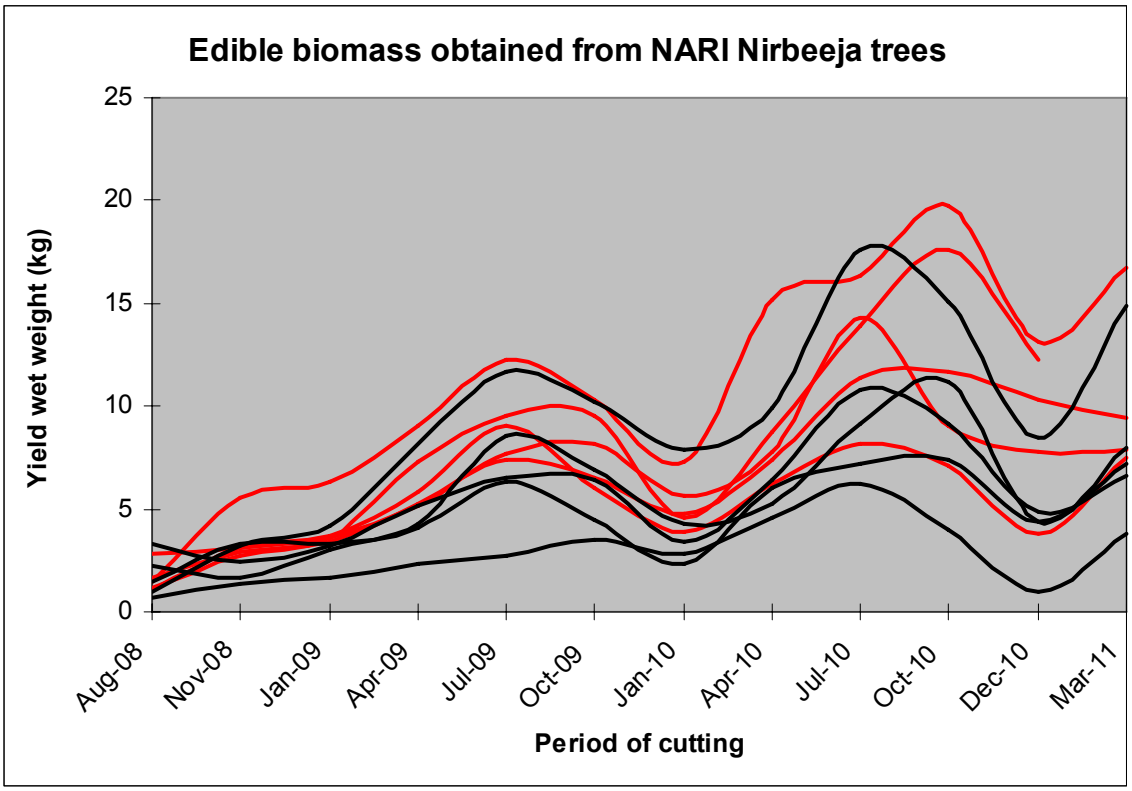
Research findings :

1. The edible biomass yield and wood yield of trees almost doubled in the second year compared to the first year.
2. We compared the yield of the trees cut at 1.0 m and 0.5 m from the ground over two years (Aug. 2008–Oct. 2010). The five trees cut at 1.0 m from the ground yielded a total edible biomass wet weight of 366 kg compared to 276 kg from five trees cut at 0.5 m from the ground. Thus the trees cut at 1.0 m from the ground yielded 33% more edible biomass in the first two years. The trees cut at 1.0 m height yielded 216.5 kg wet wood i.e. about 21% more compared to 179.5 kg yielded by trees cut at 0.5 m height.
3. At the 12^{th} cut on 30 March 2011, the trees cut at 1 m still yielded more edible biomass and wood than the trees cut at 0.5 m but the difference in yield reduced to 25%.
4. The dry matter percentage of pooled stems and leaves was 35% and the crude protein percentage was 30%.
5. The trees did not bear any seed pods and there was no psyllid attack on the trees.
6. There is a lot of individual variation among the trees which can be seen in Fig.4 below.

Project advisers : B. V. Nimbkar, Dr. N. Nimbkar, Dr. A. Siddique, Dr. P. M. Ghalsasi and Dr. C. Nimbkar

Project staff : P. P. Ghalsasi, A. H. Magar and R. R. Jadhav

Fig. 4 The yield obtained from 10 individual trees over two years.

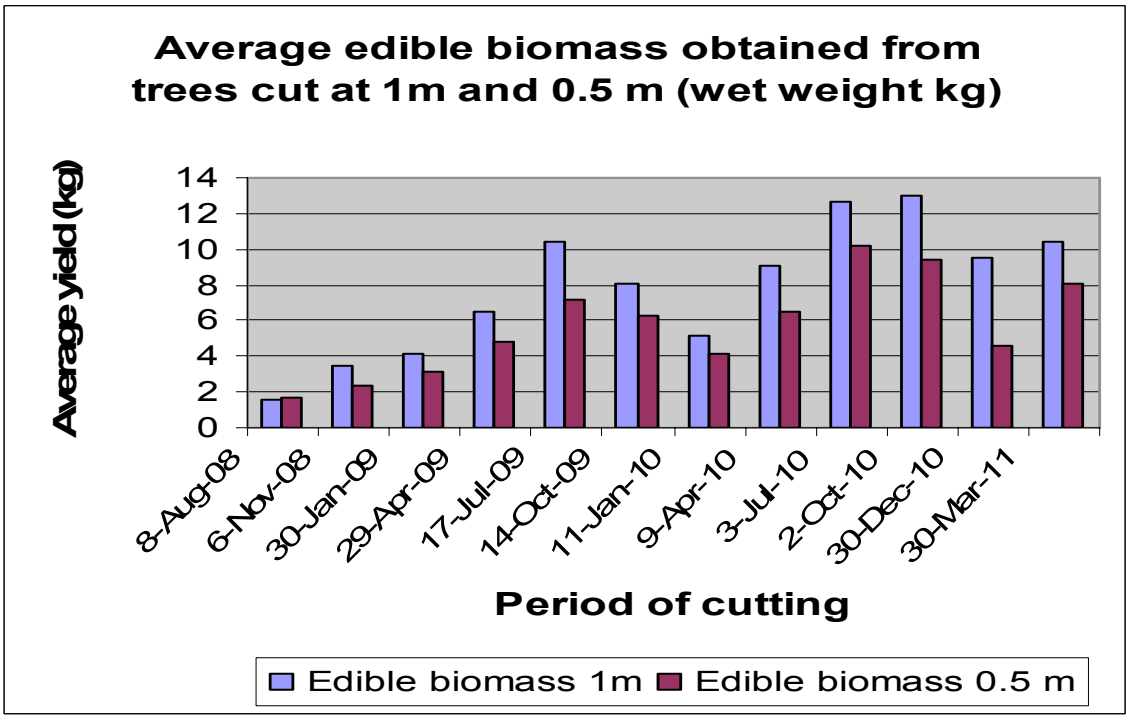


* One of the trees cut at 1.0 m from the base could not be cut in March 2011 because of a bee hive on it.

Trees cut at 0.5m height from ground

Trees cut at 1.0m height from ground

Fig. 5 Average edible biomass yield from trees cut at different heights.



Project 4. Research in veterinary parasitology with special reference to sheep and goats

Funding agency : self-funded

During the year, we monitored the gastro-intestinal (GI) worm burden under natural infection of NARI's sheep and goat flocks and of goat keepers' flocks participating in NARI's projects. Gastro-intestinal worm burdens of sheep and goat flocks of the shepherds from Phaltan and Malshiras talukas associated with the NGO Anthra, Pune were also assessed. Pooled faecal samples of sheep from these flocks were brought to NARI by representatives of Anthra to know the worm infection and to seek advice on drenching. NARI provided them detailed reports with appropriate advice on anthelmintic administration.

Research findings :

1. In NARI's flocks, Garole sheep were again found to have natural worm resistance and did not require much drenching compared to the other breeds. In July 2010, only three Garole rams out of 11 tested were positive with FEC range 200-700 epg while 50% of the crossbred rams grazing with them were positive with range of 0-1200. Crossbred rams had to be drenched in August 2010 with Closantel while Garole rams did not require drenching. Out of the 22 Garole ewes that lambed in Dec 2010-Jan 2011 only one ewe showed the peri-parturient relaxation in immunity (PPRI) with an FEC of 2100 epg. 54% of the Garole ewes had zero FEC and the remaining 46% had low FEC of 100-700 epg.

2. NARI has been mainly using the anthelmintics of Benzimidazole class along with other classes successfully for the past 15 years. It was used as single, in combination or alternately with other classes of anthelmintics. However, in 2010 it was confirmed that on one of our farms and in a village goat flock of participatory farmers, anthelmintic resistance (AR) to Benzimidazole was emerging in worms (viz. *Haemonchus contortus* and *Trichostrongylus colubriformis*).

3. We have now therefore made the following changes to our drenching policy.

    - Discontinue anthelmintics of Benzimidazole class for at least the next three years.
    - Increase the FEC threshold limit for drenching from 1000 epg to 2000 epg to minimize the use of anthelmintics.
    - Use the drug only when necessary such as in post-parturient and young animals.
    - Instead of mass drenching (i.e. drenching all animals in the flock), carry out individual drenching as far as possible.

4. For the shepherd flocks associated with Anthra, FEC was measured by pooled faecal sampling method. Larval species identification was performed by faecal culture examination. Total 27 flocks were tested. We found that some of the shepherd groups had drenched their flocks prior to testing. The FEC range for such groups was 0 to 420 epg. Those flocks which were not drenched had FEC ranging from 810 to 3540 epg. These FEC ranges were quite similar to those seen in NARI's flocks or village flocks. Fifteen flocks with predominantly *Haemonchus* species were advised to drench using Closantel. In three flocks there was less worm infection with FEC range 120-310 epg and in one flock the FEC was 2830 epg but the larval differentiation showed predominance of *Trichostrongylus* worm species. Hence they were advised to drench using Albendazole.

In eight flocks the worm burden was not seen as the shepherds had drenched their flocks just prior to testing. Hence they were advised not to drench again.

Project 5. Detection of emerging Benzimidazole resistance in gastrointestinal nematodes in sheep and goats in NARI flock and in village goats of Bibi in Phaltan taluka.

Funding agency : Partly under the Osmanabadi Field Unit of the AICRP on goat improvement, partly self-funded

The post-drench Faecal Worm Egg Counts (FEC) of treated animals are always measured in NARI's sheep and goat flocks to ensure the efficacy of the anthelmintics used. Albendazole was found to be 100% effective during 1996-2000. From 2001 to 2004, Closantel and inj. Levamisole were used instead of Albendazole. From 2005 to 2009 Albendazole was used again alternately or in combination with other classes of anthelmintics and found to be 100% effective. NARI animals periodically graze on pastures in the institute's premises in addition to stall feeding. In November 2009, FEC of 46 crossbred rams in NARI flocks were measured by McMaster technique for routine monitoring .The mean FEC was 504 eggs per gram of faeces (epg). Fourteen rams with FEC > 500 epg were drenched with Albendazole @ 10mg/kg body weight. Post treatment FEC on day 12 showed that half of the rams had positive FEC. The FEC Reduction Test (FECRT) showed a reduction of 74% (upper confidence limit (CL) 91% and lower CL 24%) (WAAVP, 1992). Use of Benzimidazole was discontinued subsequently.

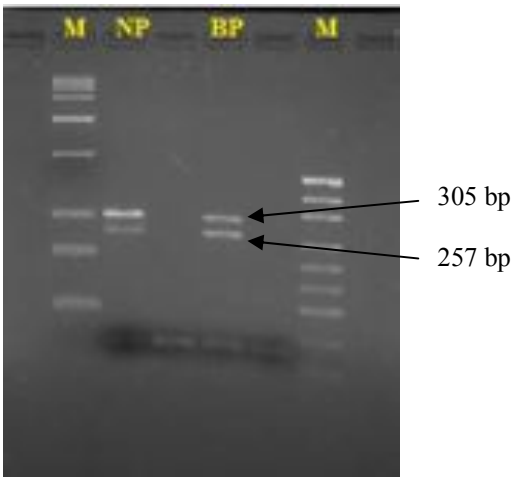
In October 2010, to confirm anthelmintic resistance, FEC of 24 crossbred rams, 28 Garole breed lambs and 19 crossbred goats were measured. Their mean FEC were 308, 400 and 837 epg respectively. Two rams, three Garole lambs and six goats with FEC > 1000 epg were drenched with Albendazole @ 10mg/kg body weight. Post-treatment FEC of two crossbred rams was zero epg, one Garole lamb was 400 epg and four does was 100-500 epg. The FECRT showed a reduction of 91% (upper CL 97% and lower CL 77%). The Garole lamb and one doe were redrenched with Albendazole and again had positive FEC on day 10 (400 and 600 epg).

NARI started performance recording of goats belonging to smallholder goat owners in Bibi and Wadgaon village near Phaltan in 2009. The goats and kids are grazed on common pastures near the villages. After measuring FEC, all the goats and kids were drenched with oral Ivermectin @ 0.25 ml per kg body weight in August 2009. FEC of these goats were measured again in October 2010. Sixty four adult does out of 226 and eight kids out of 180 in Bibi were sampled. The mean FEC was 1705 epg. All the does and kids were drenched with Albendazole @10 mg/kg body weight. Forty eight goats of Bibi with pre-drench FEC measurements and 22 goats of Wadgaon were tested on day 10 post-drench. Half of the goats from Bibi had positive FEC while none of the goats from Wadgaon had positive FEC. The FEC reduction in Bibi goats was 89% (upper CL 96% and lower CL 78%). Seven goats from Bibi with positive FEC were re-drenched with Albendazole. They all again had positive FEC on day 10 (100-600 epg).

The larval species of the nematodes in NARI and village post-drench culture were identified as *H. contortus* and *T. colubriformis*. The proportion of these two species was 95% and 5% respectively in NARI flocks and 97% and 3% respectively in village goats. Resistance to Benzimidazole thus appears to be emerging in NARI and smallholder flocks.

The Albendazole-resistant larvae were obtained by culturing the faeces of only those animals drenched twice with Albendazole. DNA was extracted from the preserved larvae and a PCR-RFLP test performed which detected the mutation at codon 200 of the *B*-tubulin isotype I gene which causes resistance to Benzimidazole (Tiwari *et al*., 2007). Both *H. contortus* and *T. colubriformis* larvae were found to be heterozygous for the mutation.

Fig. 6. Detection of the mutation at codon 200 of B tubulin isotype I gene (which causes resistance to Benzimidazole) in DNA of *Haemonchus contortus* and *Trichostrongylus* species larvae



Lane M : DNA molecular weight marker (Genei™ Ruler).
Lane NP : DNA from pooled larvae from faecal samples of NARI sheep and goats
Lane BP : DNA from pooled larvae from faecal samples of Bibi goat flock
Lane M : DNA molecular weight marker (Genei™ pUC19).

Amplification at **305 base** pairs indicates presence of the wild type allele of the concerned mutation indicating susceptibility to Benzimidazole.

Amplification at **257 base** pairs indicates presence of the mutated allele of the concerned mutation indicating resistance to Benzimidazole.

Project staff : P. P. Ghalsasi, S. R. Saste, Manisha Kulkarni

Project advisers : P. M. Ghalsasi, C. Nimbkar

Research Collaboration

1. A Memorandum of Understanding between NARI-AHD and Bombay Veterinary College, Mumbai was signed on 29 March 2010 to cooperate in conducting collaborative research on "Isolation and molecular characterization of *Listeria* spp from sheep and goats with reproductive disorder or spontaneous abortion and its public health significance."

   Under this collaboration

   - A post graduate student of Bombay veterinary college, Ms. Shilpa Katkar visited AHD on 8-9 April 2010 to collect samples for her thesis work. She collected 194 clinical samples (blood, urine, milk, vaginal swabs and faeces) from 58 sheep, goats

and humans who were in direct contact with sheep and goats on AHD farms. These samples were analyzed at Bombay veterinary college for presence of *Listeria* spp. by performing microbiological tests.

Four animal samples were found positive for Listeriosis. The infected animals were treated successfully. One human case that was found positive was treated with antibiotics successfully; a repeat sample was tested after treatment and confirmed to be negative.

Due to excellent cooperation of Bombay Veterinary College, this was a successful collaborative project of NARI. The AHD technicians are now confident to perform the test at NARI whenever required.

- Ms. Padmaja Ghalsasi and Ms. Sonali Saste visited Bombay Veterinary College on 21-23 April 2010 to learn and practise the isolation, identification and culture techniques of *Listeria* bacteria, from clinical samples.

2) A Memorandum of Understanding between NARI and Maharashtra Animal and Fishery Sciences University, Nagpur was signed on 18 April 2010 for a period of three years to carry out collaborative research and development to enhance animal productivity, to promote technology, research interactions and cooperation in education and research.

3) A Memorandum of Understanding between NARI and Vidya Pratishthan's School of Biotechnology, Baramati (VSBT) was signed on 10 September 2010 for a collaborative project 'To develop a micro-propagation technique and protocols for hybrid Leucaena KX2 NARI Nirbeeja (*Leucaena leucocephala X Leucaena pallida*)'. The time period planned for this collaboration was September 2010 to February 2011. The required planting material (cuttings) was supplied by AHD to VSBT. However, due to technical difficulties at VSBT, the micro-propagation protocol was not developed. Another trial has been started in June 2011.

   The objective of propagation of the Leucaena KX2 hybrid through tissue culture is to achieve mass production of KX2 plants to make them available to the farmers in large numbers at a reasonable cost. The other technique for propagation of KX2 at present is wedge-grafting on K8 Leucaena seedlings in plastic bags or directly on the field which takes 6-7 months for a plant to be ready.

New Project sanctioned :

Project title : "Setting up a State of Art A.I. Centre for sheep and goats" under Central Sector Scheme" Integrated Development of Small Ruminants and Rabbits".

Funding agency : Ministry of Agriculture, Department of Animal Husbandry and Fisheries, Government of India

Total amount : Rs. 199.73 lakh

Date of sanction : 24 November 2010

The first installment of Rs. 50 lakh was released by the Government of India in November 2010. However, the work on this project could not be started because the funds were not

released directly to NARI. The Government of India sent the funds to the Department of Animal Husbandry, Dairying and Fisheries (ADF) of Government of Maharashtra. The Maharashtra Govt. has still not released the funds to NARI because of lengthy administrative procedures and delays. We have been constantly following up with them. Finally they were able to obtain an account head from the Finance Dept. and got the release of the funds sanctioned by both houses of the State Assembly in the recent monsoon session. We expect to receive the funds in the first half of September 2011.

This will be the first centre in Maharashtra producing high quality frozen semen of superior bucks of the Osmanabadi and Boer breeds to disseminate all over India.

I. PUBLICATIONS (In Alphabetical Order)

Refereed publications

1. Aggarwal J., Kataria R. S., **Ghalsasi P. M., Nimbkar C**., Joshi B. K. and Mishra B. P. 2010. Expression analysis of fecundity related genes in *FecB* carrier and non-carrier ewes by semi-quantitative PCR. Journal of Livestock Biodiversity 2 : 15-19.

2. **Nimbkar, C.** 2010. Indian initiatives to promote sustainable use of animal genetic resources. Proceedings 9th World Congress on Genetics Applied to Livestock Production. Leipzig, Germany. August 1-6, 2010. CD ROM Communication No. ID026.

3. **Rajvanshi, A. K.** 2010. Sustainable development - the Gandhian way. In : Timeless Inspirator – Reliving Gandhi (Ed. R. A. Mashelkar). Sakal Papers Ltd., Pune.

4. **Rajvanshi, A. K.** 2010. Sustainable development for the rural poor. *In* : Global and local polemics of development. Vol. II Sustainable development and inclusive growth : Histories, institutions, ideologies and praxes (Ed. : Prasenjit Maiti). Concept Publishing Company Pvt. Ltd., New Delhi. 271 pp.

5. **Ranaware, A., Singh, V. and Nimbkar, N.** 2010. In vitro antifungal study of the efficacy of some plant extracts for inhibition of *Alternaria carthami* fungus. Indian J. Nat. Prod. Resour., 1 (3) : 384-86.

6. **Saste, S. R., Ghalsasi, P. M.**, Kataria, R. S., Joshi, B. K., Mishra, B. P. and **Nimbkar, C.** 2011. ARMS-PCR as an alternative cost-effective method for detection of *FecB* genotype in sheep. Submitted to Indian Journal of Biotechnology.

7. **Singh, V., Akade J. H. and Nimbkar, N.** 2010. Inheritance of stem fasciation and twin/multi-embryonic seed and genetic linkage between them in safflower. Indian J. Genet. 70 (3) : 281-87.

Non-refereed publications

1. **Ghalsasi, P. M. and Nimbkar, C.** 2010. Use of laparoscopy as a management tool in goat farming. Abstract submitted to the 10th International Goat Conference held at Recife, Brazil on 19-23 September 2010.

2. **Ghalsasi, P. M., Ghalsasi, P. P. and Nimbkar, C.** 2011. Detection of emerging Benzimidazole resistance in gastrointestinal nematodes in sheep and goats in organised farm and smallholder flocks in Phaltan taluka, Maharashtra. Compendium-cum-Souvenir. XXI National Congress of Veterinary Parasitology of the Indian Association for the Advancement of Veterinary Parasitology, organized by the Department of Veterinary Parasitology, Bombay Veterinary College, Mumbai on 5-7 January 2011. p. 44.

3. **Nimbkar, C.** and van Arendonk, J. 2010. Recent trends in the global organization of animal breeding. Paper for the International Technical Expert Workshop on "Exploring the need for specific measures for access and benefit-sharing of animal genetic resources for food and agriculture" held at Wageningen, The Netherlands on 8-10 December 2010.

http://documents.plant.wur.nl/cgn/seminars/Worshop20100812/Nimbkar%20and%20Arendonk%20doc.pdf

4. **Rajvanshi, A. K.** 2010. On an ego trip. Editorial article in Speaking Tree, Times of India. 28 June.

5. **Rajvanshi, A. K.** 2010. Cloud computing and reincarnation. Editorial article in Speaking Tree, Times of India. 13 July.

6. **Rajvanshi, A. K.** 2010. The Future is after mimicking nature (interview). Innovation Trends Newsletter (Russia) issue 4, 25 December. Institute of Public Planning, Moscow.

7. **Saste S. R., Ghalsasi P. M.,** Kataria R. S., Mishra B. P. and **Nimbkar C.** 2010. Improving reproduction and productivity of Deccani sheep through introgression of *FecB* gene from prolific Garole sheep. In 'A compilation of abstracts, International symposium on "Biotechnologies for optimization of reproductive efficiency of farm and companion animals to improve global food security and human health" and XXVI Annual convention of Indian Society for the Study of Animal Reproduction'. College of Veterinary and Animal Sciences, Pantnagar, Uttarakhand. 10-12 November 2010. p. 143.

8. **Unaune, K. P., Chavan, K. M., Ghalsasi, P. M. and Nimbkar, C.** 2010. Goat rearing in two Indian villages: a low-input occupation to boost incomes and nutrition. Abstract submitted to the 10th International Goat Conference held at Recife, Brazil on 19-23 September 2010.

Reports

1. Nimbkar C. April 2010. Evaluation report of the project proposal 'Development of Sangamneri goat embryos in vitro and their transfer by using laparoscopic technique' submitted for funding to the Department of Biotechnolgy, Ministry of Science and Technology, Govt. of India by the Dept of Animal Reproduction, Gynaecology and Obstetrics, Krantisinh Nana Patil College of Veterinary Science, Shirval, Maharashtra.

2. Sharma, R. March 2011. Annual Progress Report of All India Coordinated Sorghum Improvement Project. Submitted to the Directorate of Sorghum Research (DSR), Hyderabad. 91 pp.

3. Singh, V. June 2010. Annual Progress Report of All India Coordinated Research Project on Oilseeds (Safflower). Submitted to the Directorate of Oilseeds Research (DOR), Hyderabad, 200 pp.

4. Singh, V. June 2010. Annual Progress Report of Frontline Demonstrations in Safflower. Submitted to the Directorate of Oilseeds Research (DOR), Hyderabad, 72 pp.

5. April 2010. A new hybrid Leucaena NARI Nirbeeja (KX2) more productive and more resistant to the psyllid (*Heteropsylla cubana)* than the prevailing K8 strain. A write-up for 'Good Practices on Small Ruminant (Goat and Sheep) Rearing'. Submitted to South Asia Pro Poor Livestock Policy Program (a joint venture of NDDB and FAO).

6. April 2010. Progress report of the collaborative project between National Bureau of Animal Genetic Resources (NBAGR) and NARI funded by the Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India entitled 'Increasing profitability of sheep production by genetic improvement using the *FecB* (Booroola) mutation and improved management' for the period November 2009 to February 2010.

7. May 2010. First Annual Report of 'Osmanabadi Goat Field Unit at NARI' under the All India Coordinated Research Project (AICRP) on Goat Improvement of Indian Council for Agricultural Research (ICAR) for the period 1 April 2009 to 31 March 2010.

8. October 2010. Progress report of 'Osmanabadi Goat Field Unit at NARI' under the AICRP on Goat Improvement of ICAR for the period 1 April to 1 August 2010.

9. November 2010. Progress report of the collaborative project between NBAGR and NARI funded by DBT entitled 'Increasing profitability of sheep production by genetic improvement using the *FecB* (Booroola) mutation and improved management' for the period February 2010 to October 2010.

Educational Marathi booklets published by NARI on practical sheep and goat management

1. June 2010. Leaflet on vaccination in goats and sheep (shelya-mendhyanmadhil lasikaran). Nimbkar Agricultural Research Institute, Animal Husbandry Division. pp. 4.

2. November 2010. Leaflet on first aid in goats and sheep (shelya-mendhyanmadhil prathamopchar). Dr. P. M. Ghalsasi, Shri K. M. Chavan, Dr. Chanda Nimbkar. Nimbkar Agricultural Research Institute, Animal Husbandry Division. pp. 6.

3. March 2011. Training manual for livestock caretakers on first aid in goats and sheep (pashumitra / pashusakhinsathi shelya-mendhyanmadhil prathamopchar prashikshan pustika). Nimbkar Agricultural Research Institute, Animal Husbandry Division. pp. 9.

II. CONFERENCES/SEMINARS/MEETINGS/WORKSHOPS ATTENDED BY STAFF AND LECTURES GIVEN

(In Chronological Order)

1. Dr. Anil K. Rajvanshi gave a Homi Bhabha Centenary celebration lecture titled "Rocket Science for Rural Development" at Tata Institute of Fundamental Research (TIFR) on 30 April 2010.

2. Mr. V. A. Bhagwat attended a writeshop on 12 and 13 May 2010 entitled "Reviving rainfed crops with a focus on millets-understanding experiences and designing future strategies". It was arranged by Watershed Support Services and Activities Network (WASSAN) – an NGO based in Secunderabad and took place in the Central Research Institute for Dryland Agriculture (CRIDA), Santoshnagar.

3. Dr. Anil K. Rajvanshi attended the Jamnalal Bajaj Award selection committee meeting on 14 May 2010 in Mumbai. This meeting was for selection of the candidate for 2010 award for application of science and technology for rural development.

4. Dr. Anil K. Rajvanshi was a chief guest on occasion of International Environment Day at Sardarkrushinagar Dantiwada Agricultural University (SDAU), Gujarat on 5 June 2010 and gave a speech entitled "High Tech Agriculture for prosperous India".

5. Aravind Netralaya evaluation meeting took place in Madurai on 10-12 June 2010. Dr. Rajvanshi was asked by Jamnalal Bajaj Awards Committee to evaluate the work of Arvind Netralaya for a possible award.

6. Dr. Anil K. Rajvanshi gave an IITK Golden Jubilee Celebration lecture entitled "Happiness through social entrepreneurship" in Infosys Campus, Bangalore on 20 June 2010.

7. Dr. Rajvanshi had a meeting with the Gasification group of General Electric (GE) in Bangalore in June 2010. GE had invited Dr. Rajvanshi to explore the possibility of buying NARI gasifier technology.

8. Dr. Anil K. Rajvanshi was the guest of honor in a function at Motilal Jhunjhunwalla College of Arts, Commerce and Science, Mumbai on 30 June 2010 and gave a speech entitled "Reviving Patriotism – Nation Building and Happiness".

9. Dr. Chanda Nimbkar and Dr. Nandini Nimbkar attended the scientific advisory committee meeting of the Krishi Vigyan Kendra at Sharadanagar, Baramati held on 10 July 2010.

10. Dr. Chanda Nimbkar attended the '9th World Congress on Genetics Applied to Livestock Production' held at Leipzig, Germany on 1-6 August 2010. She was invited to this conference by the Food and Agriculture Organization of the United Nations (FAO), Rome to give an invited lecture on the topic "Indian initiatives to promote sustainable use of animal genetic resources". Her travel and accommodation cost was paid by the FAO.

11. Dr. V. Singh, Mr. M. B. Deshpande and Mr. A. M. Ranaware attended the annual group meeting of safflower and linseed workers held at Mahatma Phule Agricultural University, Rahuri from 19-21 August, 2010 and presented the progress reports of the work carried out in safflower AICRP during Rabi 2009-10.

12. Dr. Rajvanshi and Dr. N. Nimbkar had a meeting with the personnel of Cummins Foundation in Pune regarding Bajaj Centre for Sustainable Development on 27 August, 2010. Dr. Rajvanshi gave a presentation on how BCSD could be used for sensitizing corporates and members of civil society on different developmental issues. Persons present were Mr. Dinesh Castellino (Vice-president), Mr. Lokesh Agrawal (Cummins R & T Centre and Ipsita Thakur (ABO-HR). It was decided to explore some joint projects based on NARI's research.

13. Shri. K. M. Chavan attended the seminar on 'Promotion of goat rearing in Maharashtra' organized by the BOSCO Gramin Vikas Kendra, Kedgaon, Ahmedngar in collaboration with Sir Dorabji Tata Trust and Allied Trusts on 28 August 2010. He gave a presentation

on 'Progress of Osmanabadi goat field unit of NARI under All India Coordinated Research Project (AICRP) on goat improvement of Indian Council of Agricultural Research (ICAR)'.

14. Dr. Chanda Nimbkar attended the Brain Storming Session on 'Field Data Recording and Information Management Systems for Conservation and Improvement of Goats' held at the Central Institute for Research on Goats (CIRG), Makhdoom, U.P. on 30 August 2010 as a consequence of her correspondence with the Director, CIRG. Dr. Nimbkar was co-chairperson of the session which was organized under the AICRP on goat improvement of ICAR. Dr. Nimbkar gave a presentation on the data base developed at the AHD, NARI for the Osmanabadi Field Unit under the AICRP.

15. Shri. B. V. Nimbkar participated in the FAO e-conference on 'Successes and failures with animal nutrition practices and technologies in developing countries' organized by the Livestock Production Systems Branch (AGAS), FAO, Rome, Italy for the period 1-30 September 2010.

16. Shri. B. V. Nimbkar attended the Second meeting of the State Level Sanctioning and Monitoring Committee (SLMC) of Maharashtra State established for the implementation of the Central Sector Scheme 'Integrated Development of Small Ruminants and Rabbits' of Ministry of Agriculture, Dept of Animal Husbandry, Dairying and Fisheries, Govt. of India as a non-Government member on 8 September 2010.

17. Dr. Chanda Nimbkar attended the Board of Management meeting (as a member of the Board) of National Dairy Research Institute, Karnal, Haryana held on 25 October 2010.

18. Ms. Sonali Saste attended the 'International symposium on biotechnologies for optimization of reproductive efficiency of farm and companion animals to improve global food security and human health' and XXVI Annual convention of ISSAR organized by the Department of Animal Reproduction, Gynaecology and Obstetrics, College of Veterinary and Animal Sciences, Pantnagar, Uttarakhand on 10-12 November 2010. She presented a research paper 'Improving reproduction and productivity of Deccani sheep through introgression of *FecB* gene from prolific Garole sheep'.

19. Dr. Anil K. Rajvanshi participated in a teleconference with National Collegiate Inventors Alliance (NCIIA) staff and advisors in Boston, USA regarding project evaluation in November 2010. Dr. Rajvanshi has been evaluating NCIIA project proposals from various U.S. universities. Each grantee whose proposal is accepted gets $ 50,000 grant for work in developing countries.

20. Dr. Rajvanshi had a meeting with Shri. Sam Pitroda, Advisor to P.M. on infrastructure and Chairman, National Innovation Council in November 2010 in Mumbai. Mr. Pitroda had requested this meeting to discuss a note prepared by Dr. Rajvanshi regarding Rural Development.

21. Dr. Chanda Nimbkar attended the International Technical Expert Workshop "Exploring the need for specific measures for access and benefit-sharing of animal genetic resources for food and agriculture" held at Centre for Genetic Resources (CGN), Wageningen, the Netherlands on 8-10 December 2010. She gave a presentation on 'Recent trends in the

global organisation of animal breeding. Roles of the public and private sectors and of civil society'.

22. Dr. Anil K. Rajvanshi presented "Innovations for Sustainable Development of Bottom Billions" - a plenary lecture in International Conference on Environment (ICENV), 2010 in Pulau Pinang, Malaysia. This conference was organized by Universiti Sains Malaysia (USM) on 13-15 December 2010.

23. Dr. Chanda Nimbkar attended the GALVmed (Global Alliance for Livestock Veterinary Medicines) South Asia Regional Advisory Committee Workshop organised by GALVmed at New Delhi on 13-14 December 2010.

24. Dr. Chanda Nimbkar attended the meeting of the Task Force on Animal Biotechnology-I of Ministry of Science and Technology, Department of Biotechnology (DBT), Government of India held at Delhi on 14 December 2010. She presented the progress report for February-October 2010 of the ongoing project funded by DBT titled 'Increasing profitability of sheep production by genetic improvement using the *FecB* (Booroola) mutation and improved management'.

25. Ms. Padmaja Ghalsasi attended the XXI National Congress of Veterinary Parasitology organized by the Department of Veterinary Parasitology, Bombay Veterinary College, Mumbai on 5-7 January 2011. She presented the paper 'Detection of emerging Benzimidazole resistance in gastrointestinal nematodes in sheep and goats in organised farm and smallholder flocks in Phaltan taluka, Maharashtra'.

26. Dr. Chanda Nimbkar attended the National Conference on 'New Horizons in Animal Breeding Technologies for Accelerating Livestock Production and Health' organized by Indian Society of Animal Genetics and Breeding and Division of Animal Genetics, Indian Veterinary Research Institute at Izatnagar, U.P. on 20-21 January 2011. She presented a paper 'Use of biotechnology for sustainable intensification of sheep production on the Deccan plateau'.

27. Dr. Anil K. Rajvanshi gave a keynote speech entitled "Renewable Energy for Rural Development" at the International Conference on Recent Trends in Renewable Energy Resources at Indian Institute of Chemical Technology (IICT), Hyderabad on 28 January 2011.

28. Dr. Chanda Nimbkar and Ms. Nadia Qureshi attended the Mid-term review meeting of AICRP on Goat Improvement held at Central Institute for Research on Goats, Makhdoom, U.P. on 29 January 2011. Dr. Chanda Nimbkar was made Co-chairman and presented the progress report of the Osmanabadi field unit at NARI.

29. Dr. Anil K. Rajvanshi gave an institute lecture entitled "Nation Building, IITians and Happiness" at IIT Kharagpur on 28 February 2011.

30. A brain-storming meeting was held in Gangtok, Sikkim on 5 March 2011 with Shri. P. D. Rai, Member of Parliament and several NGOs in Sikkim regarding setting up of Sikkim Innovation Council. Dr. Rajvanshi and Dr. N. Nimbkar participated in the meeting.

31. Maharashtra Electricity Regulatory Commission (MERC) meeting was held on 25 March 2011 in Mumbai and was attended by Dr. Anil K. Rajvanshi who is a member of their advisory committee.

32. Dr. Anil K. Rajvanshi participated in the brainstorming workshop organized by US based X-Prize on 30 March 2011 in Delhi. NARI's work on lanstove and energy from agricultural residues was accepted as possible X-prize entries in this workshop organized by the foundation and IIT, Delhi.

33. Dr. Chanda Nimbkar as a member of the Governing Body of ICAR attended the meetings of Indian Council of Agricultural Research (ICAR) at New Delhi during the year.

III. TRAINING AND EXTENSION ACTIVITIES

Training

1. NARI-AHD conducted a one-day training program for 11 Farm Managers of the Punyashlok Ahilyadevi Maharashtra Mendhi Va Sheli Vikas Mahamandal Ltd., Maharashtra on 29 April 2010. This program was organized at the request of the Managing Director of the Mahamandal, on instructions from the Secretary, Animal Husbandry, Govt. of Maharashtra. They were given lectures and demonstrations on record keeping, *FecB* genotyping test, semen collection and artificial insemination in sheep and goats and sustainable worm control in sheep and goats. They were also taken for a visit of the Boer goat farm of Nimbkar Seeds Pvt. Ltd. and sheep breeding activities of NARI-AHD at Lundy farm, Rajale.

2. AHD supplied 24 fresh sheep placentas to Dr. Natraj Dravid, Physician from Satara in April 2010 for his research. These placenta samples were used to conduct trials to prepare a medicine against leucoderma in humans.

3. Dr. Ranjit S. Kataria, Senior, Scientist, DNA Fingerprinting Unit, National Bureau of Animal Genetic Resources, Karnal, Haryana collected blood samples of Boer goats on AHD farm on 15-18 July 2010. These samples were collected for genomic DNA isolation and for polymorphism analysis of candidate immune response genes.

4. Shri. Harke, Research Fellow from Department of Veterinary Parasitology, College of Veterinary and Animal Sciences, Parbhani of the Maharashtra Animal and Fishery Sciences University collected insects from sheep and goats, in the vicinity of and in the animal houses/sheds at AHD's farm on 29 July 2010 for the survey and study of livestock disease vectors.

5. Prof. H. S. Birade and his three colleagues Dr. D. M. Chavan, Dr. S. M. Gaikwad, and Dr. R. R. Shelar, all from the K.N.P. Veterinary College, Shirwal, visited AHD's sheep farm at Rajale on 2 August 2010 to learn the technique of semen collection and artificial insemination in sheep and obtain information about the sheep breeding program.

6. Nopalitos (pads) of five accessions of *Opuntia ficus-indica* were supplied to Mr. Maheshkumar L. Shinde-a student in the Department of Pharmacology, KLE University's

College of Pharmacy, Belgaum on 5 August 2010. He is going to analyze their pharmacological properties.

7. Twenty five shepherds (17 men and 8 women) of Birdev Shetkari Mendhpal Mandal, Bhadali Kh., Tal. Phaltan participated in a training program on 'Importance of vaccination in sheep and goats' organized by AHD on 18 August 2010. A leaflet giving details of diseases and related vaccines published by NARI was distributed to the participants.

8. Four candidates from the NGO 'Paryay' working in Osmanabad District of Maharashtra and two of AHD's staff members were trained in 'First aid treatment in goats and sheep' by Shri. K. M. Chavan of AHD on 11-13 January 2011.

9. Twenty candidates were trained in three training courses on 'Artificial insemination in goats' conducted at AHD on 20-22 April 2010, 18-20 October 2010 and 17-19 January 2011. (There were 13 candidates from Maharashtra, 3 from Karnataka, 2 from Andhra Pradesh and 2 from Madhya Pradesh).

10. Professor Abdullah Alowaimar Nasser from Department of Animal Production, College of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia visited AHD on 13-15 January 2011 and was given training in laparoscopic insemination in sheep by Dr. P. M. Ghalsasi of AHD. He was also given consultancy on the appropriate breeding program for *FecB* gene introgression by Dr. Ghalsasi and Dr. C. Nimbkar.

11. On 16 and 29 March 2011, Shri. Tauseef Ansari, a student of AISSMS College of Engineering, Pune was supplied samples of sweet sorghum juice for fermentation studies.

12. Under the AICRP on goat improvement, Osmanabadi Field Unit at NARI, nine goat rearers of village Bibi in Phaltan taluka are being given training in 'Goat management and nutrition' one evening a week. The AHD's staff members Mr. Sachin Rajput and Mr. K. M. Chavan visit Bibi and conduct this programme with support from Dr. Kiran Unaune and Mr. Shyam Kulkarni.

Extension

A. Dissemination of seed and other products

During this year about 60 Kg 'Madhura' sweet sorghum syrup was test-marketed. About 20 Kg dried safflower flowers were test-marketed as herbal health tea and also supplied to Agharkar Research Institute, Marico, Kancor etc. for trials and testing. About 160 Kg seed of Madhura sweet sorghum hybrid was distributed to farmers all over India. More than 400 Kg seed of safflower varieties (NARI-38, NARI-52, NARI-57 and NARI-6), hybrids (NARI-NH-1 and NARI-H-15) and parents of NARI-H-15 (GMU-2369, MSV-10-1-5) were disseminated during the year.

B. Frontline demonstrations in safflower

Twenty five frontline demonstrations on farmers' fields were organized to demonstrate the latest technologies developed in safflower. Timely adoption of plant protection measures resulted in seed yield increase of 60% under rainfed and 40% under irrigated conditions.

Application of recommended doses of fertilizers gave 48.63% increase in seed yield as compared to the fertilizer levels applied by the farmers in the region.

C. Dissemination of animals

The following *FecB* gene carrier rams and ewes were supplied for breeding during the year.

Seven homozygous (BB) and thirteen heterozygous (BW) rams were supplied to Mr. N. Samson, Director, Gram Abhuday Mandali, Dharmaram, Andhra Pradesh on 27 April 2010 for distribution to shepherds in Andhra Pradesh.

Two homozygous (BB) rams were supplied to Shri Santosh Venkatappa, Bangalore on 19 October 2010.

One heterozygous (BW) ram was supplied to Shri Dilip Pandurang Deokar, Pune on 7 December 2010.

Two heterozygous (BW) rams and two heterozygous (BW) ewes were supplied to Associate Dean, Bombay Veterinary College, Mumbai on 24 March 2011.

Four homozygous (BB), six heterozygous (BW) rams and nineteen heterozygous (BW) ewes were supplied to Mr. L. Ranganath, Yennegere, Karnataka.on 26 March 2011.

D. *FecB* genotyping

FecB genotyping of the following sheep blood samples belonging to different NGOs was done in the Molecular Genetics Laboratory of AHD. The results along with the gel photographs were sent to the owners. Advice for future breeding program was also given.

1. Forty six sheep blood samples received from Mr. N. Samson, Director, Gram Abhudaya Mandali, Dharmaram, Andhra Pradesh tested in April and August 2010.
2. Four sheep blood samples received from Krishi Vigyan Kendra, Sharadanagar, Baramati tested in December 2010.

Dissemination of NARI Nirbeeja hybrid *Leucaena* grafts

During this year 76 'NARI Nirbeeja' (hybrid subabhool) grafted plants were supplied to various institutions and farmers. The following were the customers who purchased more than two grafted plants.

Mr. N. Samson, Gram Abhuday Mandali, Andhra Pradesh – 7 plants

Samridha Jeevan Foods India Ltd., Pune – 20 plants

'Paryay', Aurangabad – 10 plants

Shri Jagannath Kenjale, Pimpode, Dist. Satara – 6 plants

Smt. Mayabai Amrut Patil, Chamgaon, Dist. Jalgaon – 4 plants

IV. TRAINING RECEIVED BY NARI STAFF

1. A refresher training course in 'Mechanical sheep shearing' was organized by AHD on 20-30 August 2010 for hands on experience to AHD's staff members who were trained in

this technique last year. The Government of India, Ministry of Agriculture's Central Sheep Breeding Farm (CSBF), Hisar, Haryana deputed two trainers Mr. Maljeet Singh and Rai Singh for the course. M/s. Jatin Chemicals and Pharma Private Limited, New Delhi (dealer in India of Lister Ltd.) made available one shearing machine for this refresher course.

2. Shri. D. S. Randive participated in a workshop on 'Book keeping and Accounting for Public Trusts and Societies' organized by SOSVA Training and Promotion Institute, Pune on 9-10 June 2010.

3. On 14 June 2010, Mr. M. M. Khetan of Indostat Services, Hyderabad trained all the crop scientists on the use of software for statistical analysis of experimental data. We have recently purchased this software from Indostat.

4. Eleven Livestock Supervisors of AHD and Nimbkar Seeds Pvt. Ltd., Phaltan participated in a one day training program on 'Symptoms and treatment of goats and sheep' conducted by Dr. P. M. Ghalsasi at AHD on 8 September 2010.

5. Shri. K. M. Chavan, Extension Coordinator at AHD successfully completed a six months' Certificate course of the Yashwantrao Chavan Mukta Vidyapeeth, 'Swayamsahayyata Bachat Gat Prerak' held during August to November 2010 at Chaitanya Sanstha, Khed, Dist. Rajgurunagar, a centre of the open university. He stood first in the Pune centre and second in Maharashtra in the final examination.

6. Dr. Rishika Sharma obtained training at ICRISAT, Patancheru, Andhra Pradesh from 7-11 February 2011 on "Sorghum hybrid parents and hybrids development and production".

7. Ms. Bharati Pawar participated in a two-day workshop on 'Women's Voice Empowerment Training for Trainers' organized by Appropriate Rural Technology Institute (ARTI), Phaltan on 13-14 March 2011. Dr. Beth Osnes, Professor of Theatre, Colorado State University, USA conducted the workshop and Ms. Pawar acted as a translator.

8. Shri. Popat Shinde, Livestock Supervisor received training in mechanical sheep shearing at the Government of India's Central Sheep Breeding Farm, Hissar, Haryana on 22-30 March 2011. He was trained methodically in all aspects of machine shearing and maintenance of the machine.

V. VISITORS TO THE INSTITUTE

1. Shri. Sanjay Kirloskar, Chairman and Managing Director, Kirloskar Brothers Ltd. visited the Institute and discussed the issues regarding Center for Sustainable Development on 2 April 2010.

2. Mr. N. Samson, Director, Gram Abhuday Mandali, Dharmaram, Andhra Pradesh and Shri Bhaskar Mitra, Senior Program Officer, Sir Dorabji Tata Trust and Allied Trusts, Mumbai visited AHD on 3 April 2010. This visit was to give information about their collaborative goat project in Andhra Pradesh and to discuss about the expertise that NARI can provide to them. Dr. Chanda Nimbkar gave them information about the research and development activities of AHD. They were also shown the *FecB* gene carrier ewes at AHD's farm at Rajale and Boer goats at Nimbkar Seeds Pvt. Ltd., Phaltan.

3. Shri. Atul Kirloskar, Chairman and Managing Director, Kirloskar Oil Engines Ltd. and his team visited the Institute to discuss issues of mutual interest on renewable energy on 5 April 2010.

4. Dr. A. Ninawe, Vice-chancellor, Maharashtra Animal and Fishery Sciences University (MAFSU), Nagpur visited AHD on 18 April 2010 together with Dr. S. Z. Ali and Dr. A. H. Ulemale to familiarize themselves with the AHD's research and development work in sheep and goats. An MOU was signed between MAFSU and NARI to facilitate future collaboration.

5. Mr. Suresh Bhadrannavar and Mr. G. S. Baravani of the Karnataka Antibiotics and Pharmaceuticals Ltd. visited on 20 April 2010 to familiarize themselves with NARI's research.

6. Dr. Shyam Bhaskar from Bengaluru and Mr. Matthew Adebayo from Princeton, New Jersey visited on 24 April 2010 to discuss issues regarding mutual collaboration.

7. Mr. Nitin Kathuria, Buying Manager and his colleague Mr. Vaibhav Kulkarni from Marico visited on 1 June and 12 August 2010 to discuss large scale dissemination of NARI safflower varieties and hybrids and their seed production in rabi 2010-11.

8. Shri. Vishwanath Todkar, Secretary, Paryay, Kalamb, Dist. Osmanabad visited AHD on 16 June 2010 to discuss the collaboration between NARI and Paryay to set up a centre of the Osmanabadi field unit in Kalamb taluka of Osmanabad district under the AICRP on goat improvement.

9. Dr. A. K. Rawat, Joint Director, Government of India, Ministry of Science and Technology, Dept. of Biotechnology (DBT), Dr. B. P. Mishra, Principal Scientist, DNA Fingerprinting Unit, National Bureau of Animal Genetic Resources (NBAGR) and Dr. R. S. Kataria, Senior Scientist, NBAGR Karnal, Haryana visited AHD on 16-18 July 2010.

10. Dr. S. N. Bagade, Managing Director, Punyashlok Ahilyadevi Maharashtra Mendhi va Sheli Vikas Mahamandal Ltd., Pune visited AHD on 5 August 2010 with Dr. Tekade from the Mahamandal to familiarize themselves with the research and development work in sheep and goats carried out at AHD. Shri B.V. Nimbkar, Smt. Padmaja Ghalsasi and Ms. Bharati Pawar gave them information about the AHD's activities.

11. Dr. B. A. Chopade, Director Institute of Bioinformatics & Biotechnology and professor of Microbiology, University of Pune and his Ph.D. student Smt. Suchitra Mokashi visited on 23 August 2010 regarding the sweet sorghum syrup production technology at NARI. They want to use it to prepare syrup from nira (juice from toddy palm).

12. Dr. Yoganand Barve, Manager-Energy Agro Solutions in Praj Industries Ltd. and his colleague Mr. J. H. Akade visited on 28 August 2010 regarding purchase of NARI safflower hybrids.

13. Shri. Ajitrao Ghorpade, former Minister of State for Irrigation, Govt. of Maharashtra and now an MLA from Kavathemahankal, Dist. Sangli and Krishi Bhushan Shri P. S. Thakur, Retired Dy. Director, Agriculture, Sangli visited AHD on 9 September 2010. They had discussions with Dr. Chanda Nimbkar about developing goat rearing and improvement activities in Kavathemahankal taluka.

14. On 29 September 2010 a monitoring team consisting of Dr. S. S. Rao and Dr. Subba Ryudu from DSR, Hyderabad and Dr. Biradar from Bijapur visited NARI to evaluate kharif 2010 sweet sorghum research programme.

15. Shri. Pramod Zinjade, Chairman, Mahatma Phule Samaj Seva Mandal, Karmala, Dist. Solapur and his colleagues visited AHD on 3 November 2010 to get information about the AHD's activities and to discuss about setting up a centre of the Osmanabadi Field Unit in Karmala taluka.

16. Dr. D. Venkateshwarlu, Managing Director, Andhra Pradesh Sheep and Goat Development Federation with a Technical Team of the federation visited AHD on 15 November 2010 to study impact of the *FecB* gene on Deccani sheep. They had discussions with Dr. Chanda Nimbkar about introduction of the *FecB* gene into the Nellore Brown and Nellore Jodipi breeds of sheep in Andhra Pradesh.

17. Dr. R. K. Ravikumar of National Innovation Foundation, Ahmedabad visited on 27 November 2010 to familiarize himself with innovative research at NARI.

18. Dr. M. Gunasekar, Chief Scientist – Research and Innovation at Kancor Ingredients Ltd., Ernakulam and his colleague Mr. Arjun Matthew visited on 21 December 2010 regarding extract preparation from safflower flowers. They procured samples to study the feasibility of large scale use.

19. A monitoring team consisting of Dr. P. Padmavathi, Sr. Scientist, DOR, Hyderabad and Dr. S. K. Shinde and Dr. V. B. Akashe from AICRP, Solapur visited NARI on 11 January 2011 to evaluate its safflower research program of rabi 2010-11.

20. A monitoring team consisting of Dr. V. R. Bhagwat, Principal Scientist and Dr. I. K. Das, Senior Scientist from DSR, Hyderabad, Dr. O. G. Lokhande, Agronomist, MAU, Parbhani and Dr. Deshmukh from PDKV, Akola visited NARI on 11 January 2011 to evaluate its rabi 2010-11 sorghum research programme.

21. Dr. Sanjeev Kumar, Managing Trustee, The Goat Trust, Lucknow visited AHD on 18-19 January 2011 to take information about AHD's activities with regard to goat and sheep development.

22. Three professors Dr. S. M. Bhokare, Dr. S. H. Surkar and Dr. Khanvilkar from Krantisinh Nana Patil College of Veterinary Sciences, Shirval, Dist. Satara visited AHD on 20 January 2011.

23. Dr. Henning Mündel, a scientist from Canada who worked at NARI in the late sixties as a safflower breeder and his wife Bev Mündel visited NARI on 18-20 February 2011. In remembrance of his earlier days in Phaltan he gave a presentation on his stay and work at NARI, which was attended by many of his former colleagues at NARI. He also visited the safflower trials in the field.

24. Prof. Nilesh Nalawade, Baramati Agricultural College Baramati with two international program officers I (Ingrid) De Vries, Senior Advisor, Marketing and International Relations and Ir. J. M. J. M. (Jos) Leeters, International Horticulture and Marketing, International Relations, University of Applied Sciences Van Hall Larenstein, Part of Wageningen University in The Netherlands visited AHD on 13 March 2011.

25. Mr. Sachin Joshi, Pune and Mr. John Hatch, USA visited NARI on 17 March 2011 to see its renewable energy program and discuss with Dr. Rajvanshi regarding possible collaboration.

26. Mr. S. Sasheendran and Mr. Bijo Varghese of Kancor Ingredients Ltd., Ernakulam visited NARI on 17 March 2011 regarding further discussions with Dr. Singh and Dr. Nimbkar regarding procurement of safflower flowers.

27. Dr. M. P. Ravindra, Vice Chancellor. and Dr. Murli, Director of Research Manipal Institute of Technology, Bangalore visited the Institute on 18 March, 2011 and had detailed discussions with Dr. Rajvanshi regarding collaboration of NARI with Manipal Group for training in engineering.

28. Dr. Gaur, former Professor of IIT Delhi visited on 22 March 2011 as a representative of DST to evaluate lanstove for possible funding of the project by DST.

29. Dr. Nadeem Fairoze, Professor and Head, Dept. of Livestock Products Technology and four PhD students from Veterinary College, Hebbal Bangalore visited AHD on 25-26 March 2011. Dr. Fairoze wanted to show the students the AHD's sheep and goat farms so as to help them in their assignment to manage new sheep and goat units to be set up in their college. Two of the students were taken to visit a shepherd's flock having *FecB* carrier ewes.

Visits by groups during the year

1. Twenty five students from Dr. Sukhatme Institute of Agricultural and Research Centre, Phaltan visited AHD on 26 April 2010.

2. Award Institute, Satara brought 15 representatives of various institutes such as Kisan Clubs, SHGs, REDPs to get information about AHD's work on 5 August 2010.

3. Agricultural Department, Tal. Palghar, Dist. Thane organised a study tour of 50 woman members of Self Help Groups to AHD on 1 September 2010.

4. Shri. Ramdas Jadhav, T.A.O., Guhagar, Dist. Ratnagiri visited with 30 farmers on 1 November 2010.

5. Dr. H. S. Patil from Vidya Pratisthan, Baramati brought a tour of 10 botany students on 7 December 2010.

6. Shri. Vitthalrao Karche and Smt. Shobha Kulkarni of Phaltan regional centre of Prajapita Bramhakumari Ishwareeya Vishwavidyalaya, Mount Abu visited with six of their colleagues to discuss sustainable yogic agriculture with NARI staff on 9 December 2010.

7. Shri. Dilip Patel and Dr. Bansilal Choudhari accompanied six other members of Shri. Dattaprabhu Krishi Vidnyan Mandal, Shirpur, Dist. Dhule on an agricultural visit on 18 December 2010.

8. Shri. Pisal and Shri. Lonkar of Sou Venutai Chavan College for Girls, Phaltan brought 18 of their students for an educational visit on 11 March 2011.

9. Smt. Poonam Jagdale of Yashvantrao Chavan School of Social Work, Jakatwadi, Dist. Satara brought nine students on an educational tour on 11 March 2011.

10. Office of the Veterinary Services, Durg, Chattisgarh organised a visit of 32 farmers and 3 veterinary officers to AHD under Rashtriya Krishi Vikas Yojana on 28 March 2011.

11. Under refresher training program of Livestock Development Officers of Animal Husbandry Department, Maharashtra conducted by Krantisinh Nana Patil College of Veterinary Sciences, Shirval, Dist. Satara three batches of total 62 Livestock Development Officers visited AHD in February and March 2011.

VI. VISITS BY STAFF

1. Dr. Chanda Nimbkar visited Punyashlok Ahilyadevi Maharashtra Mendhi Va Sheli Mahamandal's sheep and goat farm at Mukhed, Tal. Ambejogai on 21 June 2010.

2. Dr. Chanda Nimbkar visited Gram Abhuday Mandali at Dharmaram, Dist. Nizamabad, Andhra Pradesh on 20-23 June 2010 to give them recommendations on their *FecB* carrier sheep breeding and dissemination program. She visited the flocks of shepherds in Lokeshwar Mandal of Adilabad district where the 20 *FecB* carrier rams supplied by NARI have been disseminated.

3. Dr. Chanda Nimbkar visited the Osmanabadi goat unit at College of Veterinary and Animal Sciences, Udgir on 23 June 2010.

4. Dr. Anil K. Rajvanshi and Dr. N. Nimbkar attended a presentation on 27 August 2010 at MCCIA, Pune on Varunyantra 2010 (An experiment in harvesting sky water using ground-based fires). It was given by Dr. Shreehari (Raja) Marathe of Rashtrasant Tukdoji Maharaj Swayampoornata Kendra, Sujelgaon, Dist. Nanded.

5. Dr. Anil K. Rajvanshi and Dr. N. Nimbkar attended the function to launch the book "Timeless Inspirator-Reliving Gandhi" edited by Raghunath Mashelkar on 2 October 2010 at Aga Khan Palace, Pune. The ceremony was organized by Sakal Papers Ltd.

6. Dr. Chanda Nimbkar and Shri K. M. Chavan visited the office of the NGO 'Mahatma Phule Samaj Seva Mandal' (MPSSM) at village Kamone, Tal. Karmala, Dist. Solapur on 27 October 2010 with regard to setting up a field centre of the Osmanabadi goat unit in Karmala taluka in collaboration with MPSSM.

7. Dr. Chanda Nimbkar and Dr. P. M. Ghalsasi visited the exhibition 'Baramati Agri Expo Haritkranti 2010' on 3 November 2010 organised by Agricultural Produce Market Committee at Baramati.

8. Dr. P. M. Ghalsasi visited Kerala Livestock Development Board's semen freezing laboratory and bull station located at Dhoni Farm, Palakkad in Kerala on 4-7 January 2011.

9. Dr. Chanda Nimbkar accompanied the Hon. Union Minister for Agriculture, Shri. Sharad Pawar, on his invitation, on a visit to the Central Institute for Research on Goats, Makhdoom, U.P. on 24 January 2011. She gave a lecture in Hindi at the 'Farmers' and Scientists' Joint meeting' organized there.

10. Dr. Vrijendra Singh visited All India Coordinated Research Programmes on Safflower at Indore and Raipur centres on 12-14 February, 2011. He was a member of the monitoring team assigned to evaluate the breeding programme by Directorate of Oilseeds Reseearch (DOR), Hyderabad.

11. Dr. Vrijendra Singh visited the seed production of NARI-H-15 organized by Marico Ltd. on the farm of Basant Agro Tech (India) Ltd., Akola on 15 February 2011.

12. Dr. Vrijendra Singh attended the Safflower Germplasm Field Day on 5 March 2011 held at Rajendranagar farm of DOR, Hyderabad. He observed the various indigenous and oxotic germplasm accessions and identified the promising ones possessing different desirable traits.

13. Shri. Kanhaiya Chavan, Smt. Nadia Qureshi and Shri Santosh Londhe who are working under the AICRP on goat improvement, Osmanabadi field unit at NARI visited the Sirohi field unit at Udaipur, Rajasthan on 3-8 March 2011 to get information about the unit.

VII. HONOURS RECEIVED BY STAFF

1. The first prize 'Best Article on complementary activities to agriculture - 2010' of 'Baliraja' magazine was given to the Marathi article on 'Stallfed or partly stallfed rearing of 'NARI Suwarna' sheep: A supplementary occupation to crop farming to increase income and obtain organic manure' ('NARI Suwarna' sankarit mendhyanche bandista / ardhabandista mendhipalan: shetkaryanna adhik utpannasathi wa sendriya khatasathi jod dhanda) written by Dr. Chanda Nimbkar, Shri K. M. Chavan and Shri A.H. Magar. It was published in the March 2010 issue of the magazine.

2. Ms. Sonali Saste received the 'best oral presentation' award in the 'young scientist' category for her presentation of the paper 'Improving reproduction and productivity of Deccani sheep through introgression of *FecB* gene from prolific Garole sheep' at the 'International symposium on biotechnologies for optimization of reproductive efficiency of farm and companion animals to improve global food security and human health' held at College of Veterinary and Animal Sciences, Pantanagar, Uttarakhand on 10-12 November 2010.

3. Dr. Anil K. Rajvanshi was interviewed by Russian magazine "Innovation Trends Newsletter" in November 2010.

4. Ms. Padmaja Ghalsasi received the 'best presentation' and the 'best abstract' awards in the 'Ruminant parasitology' category at the XXI National Congress of Veterinary Parasitology organized at Mumbai by the Department of Veterinary Parasitology, Bombay Veterinary College, Mumbai on 5-7 January 2011 for the abstract 'Detection of emerging Benzimidazole resistance in gastrointestinal nematodes in sheep and goats in organised farm and smallholder flocks in Phaltan taluka, Maharashtra'.

5. Dr. Anil K Rajvanshi was interviewed by Shri. Jayraman and DNA newspaper team on Lanstove. A major story on lanstove appeared in many newspapers and on CNN IBN live. DNA story appeared as headline news in DNA newspaper on 24 February 2011.

6. Dr. Anil K. Rajvanshi was interviewed for the Sci Dev net in March 2011 regarding 2011-12 central government budget for renewable energy.

VIII. OTHER ACTIVITIES

1. NARI is registered with the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) of the Ministry of Environment and Forests, Animal Welfare Division, Government of India. As per the rules of CPCSEA Animal House facility of the Institute was inspected on 11 November 2010. Members of the inspection team were Dr. K. Nachimuthu, Expert Consultant, CPCSEA from Chennai, Dr. S. Harinarayana Rao, Research Director, Reliance Life Sciences Pvt. Ltd., Navi Mumbai and Dr. Dhananjay Manjramkar, Scientist-C and Head, Department of Lab Animals, National Institute for Research in Reproductive Health, Mumbai nominated by CPCSEA and Dr. N. V. Tandale, Retired Additional Director, Animal Husbandry, Maharashtra State nominated by NARI.

   The team inspected animal house facilities of sheep at Wadjal and Rajale farm of the Institute and checked records of the animals. Dr. Nachimuthu prepared a report in consultation with other team members and submitted the report to CPCSEA in December 2010. The facility was approved by CPCSEA members in the meeting held at New Delhi on 1 March 2011. (Ref. Letter from the CPCSEA No. 25/31/2011-AWD dated 23 March 2011, issued on 29 March 2011).

2. A meeting of the Institutional Animal Ethics Committee of NARI formulated under the CPCSEA was held at the AHD's office on 1 January 2011.

IX. STAFF APPOINTMENTS TO PRESTIGIOUS POSITIONS

Dr. Chanda Nimbkar was appointed in August 2010 as a member of the GALVmed (Global Alliance for Livestock Veterinary Medicines) Regional Advisory Committee, South Asia chapter. GALVmed is a not-for-profit global alliance of public, private and government partners. Its mandate is to protect livestock and save human lives and livelihoods by making livestock vaccines, diagnostics and medicines accessible and affordable to the millions in developing countries for whom livestock is a lifeline.