Chapter - 4 **RESEARCH**

Research Activities in agricultural universities mainly focus on productivity, sustainability and thereby, the socio-economic conditions of farming community of the state. In order to fulfill this, various research projects have been functional at different research stations of Anand Agricultural University, Anand. These research projects are funded by various agencies like Govt. of Gujarat, Govt. of India, ICAR New Delhi, DBT, DST, NHM, RKVY and several private agencies.

There are eight (crop improvement, crop production, plant protection, social science, agricultural engineering and agricultural information technology, dairy science and food processing, animal production and animal health) Agricultural Research Sub-committees (AGRESCO) of different disciplines working on various aspects of agriculture. The recommendations/technologies emerged from AGRESCO meetings organized at respective SAUs and finalized at state level are recommended to the farmers as well as entrepreneurs.

Sincere efforts have been made by the scientists/ teachers of Anand Agricultural University associated with research in different disciplines to achieve the desired goals as per the objectives to make agriculture locally, regionally and globally competitive. This chapter highlights the research output carried out by the scientific community of Anand Agricultural University during the year 2016-17.

Seasonal weather features of 2016

During monsoon season, Gujarat state received 727 mm rainfall which is 91% receipt against long period average (797 mm). District wise rainfall received and percent against long period average (LPA) are depicted in Map 1 and Map 2, respectively. In middle Gujarat region, Ahmedabad district received the lowest rainfall (310-420 mm) which is 60-70% of LPA. Rainfall receipt of Anand, Kheda and Vadodara districts fell in the range of 420-590 mm (60-70% of LPA). Botad district also received rainfall quantum of same range with 90-100% of its long period average, while, Mahisagar, Panchmahal, Dahod and Chhotaudepur districts of middle Gujarat received rainfall in the range of 590-890 mm (70-120 % of LPA).

Onset of SW monsoon at Anand took place during the 26th meteorological standard week (MSW) with 39 mm rainfall (Table 1), followed by 13 mm rainfall in subsequent week. The onset was delayed by about 6 days from its normal onset; hence, the *kharif* crop sowing was delayed by one week. During the month of June, total rainfall was 42 mm in 2 rainy days against normal of 109 mm. There was wetspell period of well distributed rainfall till second week of August (26th to 32nd MSW). During July, rainfall receipt was 81 mm in 9 rainy days against the normal of 319 mm. Rainfall receipt during August was 231 mm, compared to 252 mm of normal but its temporal distribution (15 rainy days) was ideal for kharif crops. In September, rainfall receipt was 178 mm in 7 rainy days as compared to 115 mm normal rainfall. The *kharif* crops were favoured by well distributed rainfall, though the seasonal rainfall amount (587 mm) was below normal (68% of normal). The weekly distribution of weather parameters are presented in Table 2. The comparison between normal and actual of rainfall, temperature and relative humidity are presented in Fig. 1 to 3. The weekly maximum temperature was found to be higher than normal for most weeks during the year. Only a few weeks (38-42 MSW) during monsoon had lower maximum temperature than normal. Minimum temperature remained markedly higher then its normal till the end of June (5-25 MSW). Thereafter; it was close to normal during monsoon period. During post monsoon season, minimum temperature was consistently lower than normal. During winter season, morning relative humidity prevailed more compared to normal. Morning and evening relative humidity values were prominently higher than normal during monsoon season.



Map 1: Rainfall received during monsoon 2016







Fig. 1: Normal and actual rainfall during 2016



Fig. 2: Normal and actual temperatures during 2016



Fig. 3: Normal and actual relative humidity during 2016

Table 1. De	le nainfall	distribution	(during	Tumo to Se	ntombor	2016 of A	nond
Table 1. Da	ny rannan	uistiinuuon	(IIIII)	/ uur mg .	June to Se	eptember	2010 at A	IIanu

Date	June	July	August	September
1	0.0	0.0	12.6	7.6
2	0.0	4.6	0.0	3.0
3	0.0	0.0	0.0	8.2
4	0.0	0.0	25.8	0.0
5	0.0	8.6	34.8	0.0
6	0.0	0.0	2.2	0.0
7	0.0	0.0	11.2	0.0
8	0.0	0.0	19.0	0.0
9	0.0	0.0	41.4	0.0
10	0.0	0.0	21.0	0.0
11	0.0	0.0	2.0	0.0
12	0.0	20.0	0.0	0.0
13	0.0	10.4	2.8	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
17	0.0	2.2	0.0	52.0
18	0.0	0.0	0.0	7.8
19	0.0	2.6	0.0	12.8
20	0.0	11.8	0.6	0.0
21	0.0	1.2	3.6	0.0
22	0.0	0.0	5.6	86.4
23	3.4	0.0	4.0	0.6
24	0.0	0.0	6.0	0.0
25	1.8	0.0	18.4	0.0

26	33.2	0.0	11.4	0.0
27	0.8	5.2	5.4	0.0
28	0.0	10.4	0.0	0.0
29	1.8	3.6	1.6	0.0
30	0.8	0.0	0.8	0.0
31		0.0	1.2	
Total	41.8	80.6	231.4	178.4
Rainy Days	02	09	15	07

 Table 2: Weekly weather parameters during the year 2016 at Anand

Week	Evapo- ration (mm)	Bright sunshine (h)	Rain (mm)	Wind speed (kmph)	Max Tem- perature (C)	Min Tem- perature (C)	Relative humid- ity % (morn- ing)	Relative humidity % (afternoon)
1	2.8	9.1	0.0	1.4	31.9	10.7	94.1	36.4
2	3.1	9.0	0.0	1.9	30.0	10.4	92.3	39.4
3	3.2	7.4	0.0	2.5	27.5	10.2	90.3	44.0
4	3.2	9.6	0.0	2.0	28.2	6.6	93.9	33.4
5	3.4	9.2	0.0	2.5	30.4	13.2	88.0	40.4
6	4.2	10.0	0.0	2.5	29.9	11.1	76.7	31.1
7	4.0	8.5	0.0	3.2	29.8	14.7	80.4	33.6
8	5.2	8.9	0.0	3.3	33.0	15.4	79.0	38.4
9	5.5	9.3	0.0	3.1	36.0	18.5	66.8	31.5
10	6.4	9.9	0.0	3.6	35.2	19.1	70.7	26.1
11	6.3	9.7	0.0	3.7	34.9	19.8	71.7	28.7
12	8.2	9.8	0.0	4.2	38.4	19.9	66.1	20.3
13	6.9	9.1	0.0	3.4	38.9	19.8	73.7	22.1
14	7.2	9.1	0.0	4.6	37.2	23.5	70.6	29.2
15	9.3	10.4	0.0	4.9	38.6 39.0	24.1	60.5	22.7
16	8.3	10.6	0.0	5.1		23.9	58.6	28.9
17	7.4	9.1	0.0	4.6	37.7	24.4	66.3	30.7
18	8.7	9.2	0.0	4.7	40.2	25.1	75.4	32.1
19	8.4	10.6	10.3	5.1	40.5	26.9	73.1	32.3
20	10.5	11.2	0.0	5.6	43.3	27.1	70.4	27.0
21	10.0	10.8	0.0	10.5	39.7	28.2	76.6	42.3
22	10.3	11.2	0.0	8.6	39.7	28.0	74.9	38.0
23	10.5	11.2	0.0	7.4	41.9	28.1	74.3	34.0
24	10.3	9.6	0.0	11.0	39.1	28.1	71.7	37.6
25	7.4	4.5	3.4	7.0	37.7	28.5	77.6	50.4
26	4.8	6.4	38.4	6.0	36.3	26.2	89.4	61.4
27	4.5	3.2	13.2	7.4	34.4	26.0	89.0	69.7
28	3.7	2.4	30.4	6.1	33.4	26.2	91.1	71.4

Evano- Bright		Dwight		XX/:	Max	Min	Relative	Deletive	
Week	Evapo- ration (mm)	sunshine (h)	Rain (mm) speed (kmph)		Tem- perature (C)	Tem- perature (C)	ity % (morn- ing)	humidity % (afternoon)	
29	3.4	2.3	17.8	6.1	32.2	25.6	88.1	74.3	
30	3.5	2.3	19.2	4.8	33.5	25.6	91.4	72.1	
31	2.8	1.8	73.2	5.7	31.5	25.2	97.4	79.4	
32	2.5	1.0	96.8	6.0	30.0	24.5	95.6	85.0	
33	4.6	5.6	2.8	6.4	32.5	24.7	92.1	66.1	
34	1.8	1.1	49.6	5.5	29.5	24.9	94.7	90.1	
35	3.0	2.7	19.6	4.3	31.7	25.4	97.4	77.7	
36	4.9	8.8	8.2	5.8	32.4	23.7	94.6	60.4	
37	5.8	8.7	0.0	4.4	34.5	24.9	90.7	54.1	
38	3.4	4.1	159.6	4.0	32.3	23.7	93.6	76.9	
39	4.7	9.1	0.0	5.7	33.3	24.2	93.6	64.9	
40	3.1	3.6	44.2	4.2	32.1	24.0	98.3	79.9	
41	2.8	5.3	0.0	2.7	32.6	23.5	95.0	61.4	
42	4.5	9.0	0.0	2.3	35.0	19.6	89.0	35.4	
43	4.0	9.3	0.0	2.1	34.1	18.9	76.4	35.0	
44	3.5	9.3	0.0	1.9	34.4	15.1	89.3	28.3	
45	3.4	8.9	0.0	1.4	33.9	13.0	96.4	27.4	
46	3.6	9.4	0.0	2.2	32.6	13.2	89.6	30.6	
47	3.4	9.5	0.0	1.7	33.3	12.7	92.7	27.9	
48	3.4	9.8	0.0	1.8	33.0	12.8	87.4	29.7	
49	3.4	9.5	0.0	2.9	30.8	12.8	87.4	37.7	
50	3.0	9.6	0.0	1.8	31.3	11.5	92.6	36.1	
51	2.9	9.4	0.0	1.9	30.0	10.9	94.6	36.4	
52	3.1	9.0	0.0	2.0	30.0	10.4	93.1	33.9	

Research Council

The Research Council (as per following table) has been constituted as per the provision of Gujarat Agricultural Universities Act–5 of 2004, under section-26 and Common Statute for Agricultural Universities of Gujarat 2011, Section -26, S-27.

Sr.No.		Name, Designation & Address									
1	Dr. 1	Dr. N. C. Patel, Vice Chancellor, AAU, Anand Chairman									
2	Dean	Deans of the Faculties									
	1 Dr. K. P. Patel, Dean, Faculty of Agriculture, AAU, Anand										
	2	Dr. J. B. Prajapati, Dean, Faculty of Dairy Science, AAU, Anand	Member								
	3	Dr. A. M. Thaker, Dean, Faculty of Vety. Science, AAU, Anand	Member								
	4 Dr. D. C. Joshi, Dean, Faculty of Food Processing Tech. & Bio-Energy, AAU,										
		Anand and Dean, Faculty of Agril. Engineering and Technology AAU, Godhra									

			कृष्णवाली राष्ट्र कृषिसंपल्लम्						
Sr.No.	Name, Designation & Address								
	5	Dr. D. C. Joshi, Dean, Faculty of Agril. Engineering and Technology AAU, Godhra (Up to 30-09-2016) Dr. R. Subbaiah, Dean, Faculty of Agril. Engineering and Technology AAU, Godhra (From 01-10-2016)	Member						
	6	Dr. D. R. Kathiriya, Dean, Faculty of Agril. Information Technology, AAU, Anand	Member						
	7	Dr. Y. C. Zala, Principal, IABMI, AAU, Anand	Member						
3	Dr. H (Up Dr. A	P.P. Patel, Director of Extension Education, AAU, Anand to 30-06-2016) Arun Patel, Director of Extension Education, AAU, Anand m 01-07-2016, onwards)	Member						
4	The C	Conveners of the AGRESCO Sub-committees							
	1	Dr. R. S. Fougat, Convener of Crop Improvement Research Sub Committee and Professor and Head, Department of Plant Biotechnology, AAU, Anand	Member						
	2	2 Dr. M. V. Patel, Convener of Crop Production Research Sub Committee and Professor & Head, Dept. of Agronomy, BACA, AAU, Anand							
	3	3 Dr. P. K. Borad, Convener of Plant Protection Research Sub Committee and Professor & Head, Dept. of Entomology, BACA, AAU, Anand							
	4	Dr. Y. C. Zala, Convener of Social Science Research Sub Committee and Principal, IABMI, AAU, Anand	Member						
	5	Dr. A. H. Jana, Convener of Dairy Science and Food Processing Technology & Bio-energy Research Sub Committee and Professor, Dept. of Dairy Technology, DSC, AAU, Anand	Member						
	6	Dr. M. T. Panchal, Convener of Animal Health Research Sub Committee and Professor, Dept. of Gynaecology, College of Veterinary Science & A.H., AAU, Anand	Member						
	7	Dr. K. N. Wadhwani, Convener of Animal Production Research Sub Committee and Professor & Head, Dept. of LPM, College of Veterinary Science & A.H, AAU, Anand	Member						
	8 Dr. M. L. Gaur, Convener of Agricultural Information Technology an Agricultural Engineering & Technology Research Sub Committee and Principa Agricultural Engineering & Technology, AAU, Godhra								
5	Two Eminent Scientists outside the university nominated by the Vice Chancellor in o with Director of Research								
	1	Dr. Anil R. Chinchmalatpure, Principal Scientist & Head, Central Soil Salinity Research Institute, Regional Research Station, P.O.Maktampur, Bharuch – 392012	Member						
	2 Dr. K. S. Patel, Retd. Associate Director of Research, GAU, Ahmedabad								

कृण्डल्से राष्ट्रं कृषिसंचलम्						
Sr.No.		Name, Designation & Address				
6	Five cons	Professors or their equivalent from the university nominated by the Vice (ultation with Director of Research	Chancellor in			
	1	Dr. N. I. Shah, Professor& Head, Department of Horticulture, BACA, AAU, Anand	Member			
	2 Dr. A. J. Dhami, Professor, Dept. of Gynaecology, Veterinary College, AAU, Anand					
	3 Dr. J. B. Prajapati, Professor & Head, Dept. of Dairy Microbiology, College of Dairy Science, AAU, Anand					
	4 Dr. R. F. Sutar, Professor, FPT & BE, AAU, Anand					
	5	Dr. M. L. Gaur, Professor & Head, Soil & Water Engineering, College of Agril. Engg., AAU, Godhra	Member			
7	One Rese	Progressive Farmer nominated by the Vice Chancellor in consultation wit arch	h Director of			
	1	Shri Devesh Rameshbhai Patel, Satva Organic, Subhash Chowk, Boriavi, Ta. & Dist. Anand	Member			
8	The I	Director of Agriculture/Horticulture/Animal Husbandry	Member			
9	The A	Associate Directors of Research (Agriculture and Animal Science)				
	1	Dr. D. M. Korat, Associate Director of Research, (Agriculture), AAU, Anand	Member			
	2	Dr. M. K. Jhala, Associate Director of Research (Animal Science), AAU, Anand	Member			
10	Dr. K	K. B. Kathiria, Director of Research & Dean, PG Studies, AAU, Anand	Member Secretary			

RESEARCH SUB-COMMITTEES

To evaluate the research work and to finalize the technical programmes for future research, the research areas of different subjects have been subgrouped in to 8 research sub-committees, as follows.

FACULTY OF AGRICULTURE

- 1 Crop Improvement Research Sub-committee: Genetics & Plant Breeding, Plant Biotechnology, Nanotechnology, Plant Physiology and Biochemistry
- 2 Crop Production Research Sub-committee: Agronomy, Soil Science, Horticulture, Meteorology and Bio-fertilizer
- 3 Plant Protection Research Sub-committee: Entomology, Plant Pathology and Nematology

4 Social Science Research Sub-committee: Agril. Statistics, Agril. Economics, Extension Education and International Agril. Business Management

FACULTY OF VETERINARY SCIENCE

- 5 Animal Production Research Sub-committee: Animal Biotechnology, Animal Breeding and Genetics, Animal Physiology & Bio-chemistry, Livestock Production and Management, Animal Nutrition, Reproductive Biology and Poultry Science
- 6 Animal Health Research Sub-committee: Vet. Medicine, Vet. Microbiology, Vet. Pharmacology, Vet. Parasitology, Vet. Surgery, Vet. Pathology, Gynaecology & Obstretrics, Veterinary Public Health, Vet. Clinics and Anatomy

FACULTY OF DAIRY SCIENCE AND FOOD PROCESSING TECHNOLGY & BIO-ENERGY

7 Dairy Science and Food Processing Technolgy & Bio-energy Research Sub-committeee: Dairy Microbiology, Dairy Engineering, Dairy Technology, Dairy Economics, Food Biotechnology, Dairy Chemistry, Post Harvest Technology, Food Processing Technology and Bio-Energy.

FACULTY OF AGRIL ENGINEERING AND AGRIL. INFORMATION TECHNOLOGY

8 Agril. Engineering and Agril. Information Technology Research Sub- committee: Soil and Water Conservation, Farm Power Machinery, Agril. Product Processing and Renewable Energy, Agril. Information Technology.

4.1 NEW CROP VARIETIES, FARM IMPLEMENTS AND VARIOUS AGRICULTURAL AND ALLIED SCIENCE TECHNOLOGIES DEVELOPED

Research Sub-Committees met and finalized different research programmes considering the feedback received from farmers through extension machinery and educational needs as per today's global requirement in agricultural sciences. As a result of sincere efforts of the scientists, the research accomplishments made are as follows.

		No. of recommendations			
		finalized			
Name of the sub-committee	Date of Meeting	For farmers	For scientific community and entrepreneurs		
Crop Improvement	21-22 March, 2016				
Varieties Released		03	-		
Basic Science		02	-		
Crop Production	10-11 March, 2016				
Cultural Practices		05	-		
Nutrient Management		03	-		
Water Management		01	-		
Weed Management		01	-		
Plant Protection	4 -5 March, 2016				
Insect Pest Management		03	38		
Disease Management		05	01		
Dairy Science, Food Processing	1-2March, 2016	19	08		
Agril. Engineering & Agril. IT	22 Feb, 2016	05	06		
Animal Health	26-27 Feb, 2016	01	03		
Animal Production		03	05		
Social Science	15-16 Feb, 2016	-	06		
Joint AGRESCO, AAU, Anand	4 April, 2016	51	67		
Combined AGRESCO of SAU's at AAU, Anand	11-13 April, 2016	51	67		

The details of recommendations of AAU, Anand approved in the combined AGRESCO meeting of SAUs of Gujarat held at NAU, Navsari are given below.

RECOMMENDATIONS FOR FARMING COMMUNITY

CROP IMPROVEMENT

Varieties Released

1 Crop : Guineagrass

Variety :CO (GG) 3



This variety of guinea grass was developed through clonal selection and has already been released by TNAU, Coimbatore. It has light green foliage and robust tillering. This variety produced green forage yield of 2517 q/ha/year, which was 84.0, 92.4 and 83.1% higher than national check varieties BG-1, PGG-616 and Riversdale, respectively. The variety produced dry matter yield of 553.7q/ha/year, which was 54.4, 84.8 and 58.1% higher than BG-1, PGG-616 and Riversdale, respectively. Looking to the above features, it is recommended for the whole of Gujarat.

2 Crop : Forage Sorghum

Variety : Gujarat Anand Forage Sorghum 12 (GAFS12)



This variety of sorghum GAFS-12 has produced green forage yield of 300q/ha, which was 19.1, 65.2, 31.5 and 37.1 % higher with dry matter yield of 101q/ha, which was 14.4, 66.3, 57.4 and 66.0 % higher than check varieties viz. GAFS-11, S-1049, GFS-5 and C-10-2, respectively in middle Gujarat. It has thin stem and higher leaf stem ratio than checks. This variety of sorghum GAFS-12 is recommended for middle Gujarat.

3 Crop : Kodo millet

Variety: Gujarat Anand Kodra-3 (GAK-3)





This variety GAK-3 of kodo millet recorded 2457 kg/ ha grain yield, which was 27.5 and 37.9 % higher than the local check, GK-2 and national check, GPUK-3. This variety is recommended for middle Gujarat.

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CROP PRODUCTION

CULTURAL PRACTICES

1 Site specific nutrient management in soybean – wheat cropping system in middle Gujarat conditions

The farmers of Middle Gujarat Agro climatic Zone growing wheat after soybean are recommended to apply 120-60-120 kg NPK/ha along with 25 kg ZnSO₄/ha, 20 kg S/ha (through gypsum @ 150 kg/ha) and one foliar spray of 0.5 % FeSO₄ (5 g FeSO₄ + 1 g citric acid /l) to wheat at 30 days after sowing to get higher yield and net return.



2 Effect of method of sowing and seed rate on wheat in rice-wheat cropping system

The farmers of middle Gujarat agro climatic zone growing wheat after transplanted rice are recommended for line sowing (22.5 cm) of wheat in dry seedbed with seed @ 150 kg/ha followed by irrigation after sowing for higher yield and net return.

3 Performance of dual purpose forage crops under different cutting management system

The farmers of middle Gujarat agro climatic zone interested to grow oat (JHO 822) as dual purpose are recommended to harvest first cut at 60 days after sowing for green forage and leave it for grain production to get quality forage with higher grain yield and net return.

Response of *rabi* maize (GM 3 and HQPM 1) to tassel removal on maize productivity

The farmers of middle Gujarat agro climatic zone growing *rabi* maize (GM3 and 1HQPM) are recommended to remove tassel after 15 days of anthesis in alternate rows for getting higher yield and net return.



Production potential and economic feasibility of pigeon pea based intercropping system with different planting pattern

The farmers of middle Gujarat agro climatic zone growing pigeon pea are recommended to grow one row of black gram as intercrop in pigeon pea grown at 120 cm inter row spacing for getting higher yield and net return.



5

NUTRIENT MANAGEMENT

6 Response of different levels of nitrogen, phosphorus and bio-fertilizers on rice (*Oryza sativa* L.) under middle Gujarat conditions

The farmers of AES-V (Nawagam area) and AES-II (Thasra area) of middle Gujarat agro climatic zone growing paddy (GAR 13) are recommended to fertilize the crop with 120 kg N/ha only whereas, 100 kg N/ha for farmers of AES-III (Dabhoi area) to get higher yield and net return. Application of phosphorus is not beneficial to the crop.

7 Assessment of Natural Organic Liquid (NOL) and inorganic nutrient supply on yield of rabi fennel (GF 1)

The farmers of middle Gujarat agro climatic zone growing *rabi* fennel are recommended to apply recommended dose of fertilizer (90-45-00 kg NPK /ha) along with application of FYM @ 10 t/ha and seed treatment with AAU PGPR (Plant Growth Promoting Rhizobacteria) consortium @ 5 ml/kg of seed and apply NOL @ 500 l/ha drenching near plants as well as foliar spray of NOL @ 50 l/ha at 30 and 45 days after sowing for getting higher yield and net return.

	Quantity rec	of materials Juired					
Materials required	NOL for soil application (A)	NOL for foliar spray (B)					
Water (1)	500	10					
Desi cow dung (kg)	50	1 0.5					
Desi cow urine (1)	25						
Jaggery / Molasses (kg)	5	0.1					
Butter milk (l)	5	0.1					
Pulse flour (kg)	5	0.1					
Soil under banyan tree (kg)	2.5	0.05					
Mix the above materia keep it 2 to 7 days for s Mix the above materia	als (A) in barrel or tank and soil drenching.						
keep it 48 hours for foliar spray and use 1 lit mixtu							

keep it 48 hours for foliar spray and use 1 lit.mixture in 10 lit. of water.

These both mixtures should be stirred daily two times.

8. Long term effect of organic manures on soil, yield and quality of groundnut (*kharif*) – wheat crop sequence

The farmers of middle Gujarat agro climatic zone interested to grow groundnut (*Kharif*)-wheat crop sequence organically are recommended to apply 50 % N (12.5 kg N/ha) through FYM (2.5 t/ha) to groundnut and 50 % N (60 kg N/ha) through FYM (12.5 t/ha) to wheat. The remaining 50 % N to groundnut and wheat should be given through castor cake @ 0.3 and 1.3 t/ha respectively for getting higher yield, net return and maintaining soil health.





WATER MANAGEMENT

9 Improving use efficiency of inputs (water and nutrients) in *Bt*. cotton (G. Cot Hy 8 BG II)

The farmers of middle Gujarat agro climatic zone growing *Bt*cotton (G Cot. Hy 8, BG II) in paired

row (60 x 180 x 60 cm) are recommended to adopt drip irrigation at 0.8 PEF and fertilize the crop with 240 kg N/ha in four equal splits (60 kg N as a basal and remaining 180 kg N in three equal splits at one month interval through fertigation) to get higher yield and net return with 20 % water saving.

System details:

- 1 Lateral spacing: 2.40 m
- 2 Dripper spacing: 45 cm
- 3 Dripper discharge: 4 lph
- 4 Operating pressure: 1.2 kg/ cm^2
- 5 Operating frequency: Alternate day
- 6 Operating time: 84 minutes

WEED MANAGEMENT

10 Weed management in drilled paddy

The farmers of middle Gujarat agro climatic zone growing drilled paddy are recommended to go for two hand weedings at 20 and 40 days after sowing for higher yield and return. In case of paucity of labours, farmers can go for chemical weed control using oxadiargyl @ 90 g/ha as pre-emergence (3 DAS), followed by bispyribac sodium @ 25 g /ha at 20 DAS.



Hand Weedings at 20 and 40 DAS

PLANT PROTECTION

AGRICULTURAL ENTOMOLOGY

1 Documentation and evaluation of indigenous techniques for wild boar management

Install barbed wire fence on farm periphery with

AAU

posting cement poles at 10' (3.05 m) interval and tie 7 parallel rows of barbed wire one above the other and 2 rows diagonally crossing each other at the centre between two adjoining poles to restrict boar (*Sus scrofa*) entering into crop field. Tie parallel rows of barbed wires, starting from 6" (15.24 cm) above ground, lower 4 rows 8" (20.32 cm) apart and upper 3 rows 12" (30.48 cm) apart. Replacing lower 3 rows of barbed wire with chain linked net pushing 6" (15.24 cm) inside ground can increase the effectiveness.







2 Bio-efficacy of newer insecticides against brinjal shoot and fruit borer, *Leucinodes* orbonalis (Guenee)

For effective control of shoot and fruit borer (*Leucinodes orbonalis*) and getting higher fruit yield in brinjal, the farmers of middle Gujarat are recommended to spray emamectin benzoate 5 SG 0.0025 per cent (5 g/ 10 litre of water; 12.5 g a.i./ha) or chlorantraniliprole 18.5 SC 0.006 per cent (3 ml/ 10 litre of water; 30 g a.i./ha) when the pest crosses 5 per cent shoot damage and subsequent two sprays at 15 days after first spray application.

printed.	AU ang pilainon								
					Dosag	ge			
Year	Crop	Pest	Pesticides with formulation	g. a.i./ ha	Quantity of formulation/ ha	Conc. (%)	Dilution in 10 litre water	Appl. schedule	Waiting period /PHI (Days)
		L.	Emamectin benzoate 5 SG	12.5	250 g	0.0025	5 g		1
2016	Brinjal	Shoot & fruit bore	Chlorantraniliprole 18.5 SC	30	150 ml	0.006	3 ml	First foliar spray application at 5% damage of shoots and subsequent two at 15 days after first application	22

3 Evaluation of new molecules of insecticides against leaf folder of paddy

Farmers of middle Gujarat growing transplanted rice are recommended to spray flubendiamide 480 SC 0.015 per cent (3 ml/10 litre of water; 72 g a.i./ha) or indoxacarb 15.8 EC 0.015 per cent (10 ml/10 litre of water; 79 g a.i./ha) or acephate 75 SP 0.075 per cent (10 g/10 litre of water; 375 g a.i./ha) for the control of leaf folder at initiation of pest incidence.

					Dosage		-	e		
Vear	Crop	Pest	Insecticides with formulation	g.a.i. /ha	Quantity of formulation/ha	Conc. (%)	Dilution in 10 litre water	Appli. scheduld	Waiting period /PHI (Days)	
	2015 Rice		Flubendiamide 480 SC	72	150 ml	0.015	3 ml			
v		olde d ore	Indoxacarb 15.8 EC	79	500 ml	0.015	5 10 ml 10 ml 2100	at as St as		
201		Leaf fo and Stem b	Acephate 75 SP	375	500 g	0.075	10 g	Initial of po incide	Safe harve: per C	

PLANT PATHOLOGY AND NEMATOLOGY

4 Management of wilt and root rot of chickpea through seed biopriming and soil application of bio-agents

The farmers of middle Gujarat growing chickpea are recommended for application of *Trichoderma viride* or *T. harzianum* ($2x10^8$ cfu/g) enriched FYM (10 kg bioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed biopriming at the time of sowing i.e., soaking of seeds for 10 hrs in suspension of talc based formulation 1 % WP ($2x10^8$ cfu/g) of *T. viride* or *T. harzianum*, respectively @ 50 g product/250 ml of water/ kg of seed and shade dried, for the effective management of wilt-root rot complex.

			th 1		Dosag	ge	-			
Year	Crop	Pest	Pesticides wi formulation	a.i./ha	Quantity of formulation/ ha	Conc. (%)	Dilution in water	Application schedule	Waiting period/ PHI (days)	Remark
2016	Chickpea	Wilt and root rot	T. viride or T. harzianum 1 % WP			1.0		Application of <i>Trichoderma viride</i> or <i>T. harzianum</i> $(2x10^{8} \text{ cfu/g})$ enriched FYM (10 kg bioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed biopriming at the time of sowing <i>i.e.</i> soaking of seeds for 10 hrs in suspension of talc based formulation $(2x10^{8} \text{ cfu/g})$ of <i>T.viride</i> or <i>T. harzianum</i> , respectively @ 50 g product/ 250 ml of water/ kg of seed.		

5 Evaluation of bioagents for management of soil-borne diseases in mungbean through seed treatment and soil application

The farmers of middle Gujarat growing mungbean are recommended for application of *Trichoderma*

harzianum or*T. viride* $(2x10^8 \text{ cfu/g})\text{enriched}$ FYM (10kgbioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed treatment with *T. harzianum* or*T. viride* 1 % WP $(2x10^8 \text{ cfu/g})$ @ 10 g /kg seeds, respectively at the time of sowing for the effective management of root rot disease.

			ı		Dos	age				
Year	Crop	Pest	Pesticides with formulation	a.i./ha	Quantity of formulation/ ha	Conc. (%)	Dilution in water	Application schedule	Waiting period/PHI (days)	Remark
2016	Mungbean	Root rot	T. harzianum or T. viride 1 % WP			1.0		Application of <i>Trichoderma harzianum</i> or <i>T. viride</i> (2x10 ⁸ cfu/g) enriched FYM (10kgbioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed treatment with <i>T. harzianum</i> or <i>T. viride</i> (2x10 ⁸ cfu/g) @ 10 g /kg seeds, respectively.		

6 Evaluation of bioagents for management of soil-borne diseases in soybean through seed treatment and soil application

The farmers of middle Gujarat growing soybean are recommended for application of *Trichoderma*

viride or *T. harzianum* (2x10⁸ cfu/g- 1% WP) enriched FYM (10 kgbioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed treatment with *T. viride*or *T. harzianum* (2x10⁸ cfu/g) @ 10 g/kg seeds, respectively at the time of sowing for the effective management of root rot disease.

			-		Dosag	e			1	
Year	Crop	Pest	Pesticides with formulation	a.i./ha	Quantity of formulation/ ha	Conc. (%)	Dilution in water	Application schedule	Waiting period PHI (days)	Remark
2016	Soybean	Root rot	T. viride or T. harzianum 1 % WP			1.0		Application of <i>Trichoderma viride</i> or <i>T.</i> <i>harzianum</i> (2x10 ⁸ cfu/g) enriched FYM (10 kgbioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed treatment with <i>T. viride</i> or <i>T. harzianum</i> (2x10 ⁸ cfu/g)@ 10 g/kg seeds, respectively.		

7 Effects of different dates of sowing on 8 occurrence of root-knot disease in bidi tobacco nursery

Farmers of middle Gujarat growing bidi tobacco are recommended to raise the nursery by sowing the seeds up to third week of July to minimize root- knot nematode disease and thereby getting more number of healthy seedlings.

Evaluation of bio-fungicides for management of maydis leaf blight, turcicum leaf blight and curvularia leaf spot diseases in maize

Farmers of middle Gujarat growing *kharif* and *rabi* maize, are recommended to treat the seeds with talc based formulation of *Trichoderma viride* 1% WP ($2x10^8$ cfu/g) @ 7 g/ kg seeds at the time of sowing followed by four sprays of

cow urine 10 per cent (1 litre / 10 litre of water) or neem leaf extract 10 per cent (1 litre / 10 litre of water) at 30, 40, 50 and 60 days after sowing for the management of maydis and turcicum leaf blight and curvularia leaf spot diseases.

BASIC SCIENCES

PLANT PHYSIOLOGY

1 Influence of chemicals and PGRs on growth and dry biomass yield of Dodi (*Leptadenia reticulata* (Retz.) W. & A.)

The farmers of middle Gujarat agro-climatic zone-III growing dodi crop in *kharif* season are recommended to spray urea 2% with potassium chloride (KCl) 2% at 45 and 75 days after planting for getting higher dry biomass yield as well as net return.



Urea 2% + Potassium chloride (KCL) 2%



Control (only water spray)

2 Influence of source manipulation through decapitation and PGRs on growth, yield and quality of cluster bean (*Cyamopsistetragonaloba* L. Taub.) seed cv. 'PusaNavbahar'

Farmers of middle Gujarat agro-climatic zone-III growing cluster bean cv. PusaNavbahar in *kharif* season for seed production are recommended to spray GA3 20 mg/l at 45 DAS with decapitation of the plant at 70 DAS for getting higher seed yield as well as net profit.

DAIRY SCIENCE / FPT & BE

DAIRY SCIENCE

1 Use of Basil (Tulsi leaves) as flavouring ingredient in the manufacture of ice cream

A technology for making acceptable basil flavoured ice cream is developed by Anand Agricultural University, Anand using basil juice (6% TSS) @ 6.0% or freeze dried basil powder (5% moisture) @ 1.0% in ice cream mix. Basil powder is preferred over basil juice.



2 Evaluating the effect of partial homogenization of milk on the quality of Mozzarella cheese

The technology developed by Anand Agricultural University for Mozzarella cheese making from partially homogenized milk enables obtaining product with higher yield, superior appearance and baking qualities, and greater cost returns compared to the one prepared from unhomogenized milk.



3 Formulation of ready mix carrot halwa from dried carrot shreds

A technology to prepare Carrot Halwa ready-mix is developed by Anand Agricultural University using carrot shreds mixed with Khoa and Ghee, followed by drying under vacuum. The prepared Ready-mix for Carrot Halwa had a shelf-life of 45 and 30 days at $7\pm2^{\circ}$ C and $30\pm2^{\circ}$ C respectively when packed in Met-Polyester/Polyfilm pouches (85 µm) and packed under CO₂ environment. The ready-mix and water (85°C) in the proportion of 1:2 (w/v), along with sugar (28 - 36% by weight) can be mixed to get good quality carrot Halwa.



4 Screening of qualitative tests for detection of adulterants in milk

Large numbers of qualitative tests for detection of adulterants in milk are reported in literature with wide procedural variations. Among all the tests compared and evaluated at AAU, Anand, following tests were found to give the best results and hence, are suggested for practical application.

PART I Qualitative tests suggested for detection of adulterants in milk

Sr. No.	Adulterant	Test	Reported by
1	Detergent	Methylene blue	Paradkar <i>et al.</i> (2000), FSSAI (2015)
2	Urea	DMAB	Bector <i>et al.</i> (1998), Dixit (2012), Sharma <i>et</i> <i>al.</i> (2012), FSSAI (2015)

3	Ammonium salts	Phenol	Mittal & Roy (1976), Srivastava (2010), FSSAI (2015)
4	Glucose	Barfoed	Roy & Mittal (1977), Sharma <i>et</i> <i>al.</i> (2012), Dixit (2012), FSSAI (2015)
5	Sucrose	Seliwanoff (solid)	Sharma <i>et al.</i> (2012)
6	Maltodextrin	Iodine	Dairy Development Department of Maharashtra (2013)
7	Starch	Iodine	BIS (1960), Anon. (2006), Dixit (2012), Sharma <i>et</i> <i>al.</i> (2012)
8	Nitrate	Dipheny- lamine	FAO (1986)
9	Sulphate	Barium chloride	Sharma <i>et al.</i> (2012), FSSAI (2015)
10	Gelatine	Picric acid	Jacobs & Jaffe (1932), DGHS (2005), FSSAI (2015)
11	Formaldehyde	Leach	Williams & Sherman (1905), BIS (1961)
12	Hydrogen peroxide	<i>p</i> -Phenylen ediamine	Draaiyer <i>et al.</i> (2009)
13	Neutralizers	Rosolic acid	DGHS (2005)
14	Borax & Boric acid	Turmeric paper	Anon. (2006), Dairyforall (2006), Singh <i>et al.</i> (2012), Dixit (2012)
15	Salicylic acid	Ferric chloride	Dixit (2012)
16	Benzoic acid	Ferric chloride	Singh <i>et al.</i> (2012), Dixit (2012)

Note: For sodium chloride, potassium chromate test needs modification to increase the test accuracy for detection (Anon. 2006, Dairyforall 2006, Anon. 2009, Srivastava 2010, Singh *et al.* 2012, Dixit 2012, Sharma *et al.* 2012, Kamthania *et al.* 2014, FSSAI 2015).

PART II If qualitative test for detection of adulterant is performed in milk itself; it is suggested to perform at optimum temperature as given below.

Sr. No.	Adulterant	Test	Optimum temperature
1	Detergent	Methylene blue (FSSAI 2015)	20 to 30°C
2	Urea	Urease (Paradkar <i>et al.</i> 2000)	40°C
		Phenol (Paradkar <i>et al.</i> 2000)	20°C
3	Starch	Iodine(BIS 1960, Anon. 2006, Dixit 2012, Sharma <i>et al.</i> 2012)	20°C
4	Maltodextrin	Iodine (Sharma <i>et al.</i> 2012)	30°C
5	Hydrogen peroxide	<i>p</i> -phenylenediamine (Draaiyer <i>et al.</i> 2009)	20°C
		Iodometry (Sharma <i>et al.</i> 2012, FSSAI 2015)	10°C
6	Borax & Boric acid	Turmeric paper (Dairyforall 2006, Dixit 2012, Singh <i>et</i> <i>al.</i> 2012)	20 to 30°C

Note: No influence of temperature of milk (10-40°C) was found on performance of DMAB test for urea (Anon. 2009, Dixit 2012, Sharma *et al.* 2012, FSSAI 2015), Rosolic acid test for neutralizer (DGHS 2005), Ferric chloride test for benzoic acid (Dixit 2012, Singh *et al.* 2012) and Ferric chloride test for salicylic acid (Dixit 2012) detection.

PART III If qualitative test for detection of adulterant is performed in milk itself; it is suggested to perform at optimum temperature as given below.

Sr. No.	Adulterant	Test	Optimum heating period
1	Ammonium salts	Phenol (Mittal & Roy 1976, DGHS 2005, Srivastava 2010, FSSAI 2015)	20 sec

2	Glucose	Barfoed (in milk) (Roy & Mittal 1977, Vishweshwar & Krishnaiah 2005, Anon. 2006, Singh <i>et al.</i> 2012, Sharma <i>et al.</i> 2012, Dixit 2012, Kamthania <i>et al.</i> 2014, FSSAI 2015)	3 min
3	Sucrose	Seliwanoff (resorcinol solid) (Sharma <i>et al.</i> 2012)	4 min
		Seliwanoff (resorcinol solution) (Srivastava 2010)	5 min
4	Formal- dehyde	Leach (heating by direct flame) (Williams & Sherman 1905, BIS 1961, Vishweshwar & Krishnaiah 2005)	1 min
		Leach (heating in boiling water bath) (Sharma <i>et al.</i> 2012)	4 min

Studies on physico-chemical and sensory characteristics of iron rich biscuits

Anand Agricultural University has developed a technology for preparation of Iron-rich biscuits with improved protein content which can be prepared using a mixture comprising of rajkeera (rajgaro)flour, bengal gram flour, refined wheat flour and wheat flour along with whey powder, coconut powder, amaranth leaves powder, cocoa powder, sesame seeds, spices and condiments.



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6 Optimization of biomass production for probiotic *Lactobacillus helveticus* MTCC 5463

Cheddar cheese whey supplemented with 0.95% each of yeast extract and proteose peptone at pH 6.25 and inoculated with 6% (v/v) active culture of *Lactobacillus helveticus* MTCC 5463 and fermented at 40°C for 24 hours can yield 3.25 g/l dry cell biomass and 14.82 log cfu/g total viable count.

7 ACE Inhibitory activity of *Lactobacillus helveticus* MTCC 5463 in fermented milk added with honey

A technology developed by Anand Agricultural University is recommended for the preparation of fermented milk rich in ACE inhibitory activity (antihypertensive property), which can be prepared using toned milk and fermented by *L. helveticus* MTCC5463 at the rate of 2% for 24 hours at 42°C.

8 Utilization of Whey Protein Concentrate (WPC) in the selected cultured dairy product i.e. fermented milk drink

A technology for making acceptable 'Mango based fermented milk drink' is recommended by Anand Agricultural University using Double Toned Milk, 1.23% Whey Protein Concentrate (WPC-70), 0.1% Pectin and 18.24% Mango pulp. The shelf life of fermented milk drink at $7\pm2^{\circ}$ C was 9 days.

9 Development of commercial process for manufacture of 'carrot halwa'

Commercial process for the manufacture of carrot halwa using scraped surface heat exchanger developed by Anand Agricultural University is recommended. The process saves about 66% of processing time with 67% saving in the thermal energy and in-canned sterilized carrot halwa has better sensory and nutritive attributes with extended shelf-life up to 6 months as compared to carrot halwa prepared by traditional method.

10 Development of commercial process for manufacture of 'bottle gourd halwa'

Commercial process for the manufacture of bottle gourd halwa using scraped surface heat exchanger developed by Anand Agricultural University is recommended. The process saves about 63% of processing time with 66% saving in the thermal energy and in-canned sterilized bottlegourd halwa has better sensory and nutritive attributes with extended shelf-life up to 6 months as compared to bottlegourd halwa prepared by traditional method.

11 Evaluation of energy conservation potential of soft starter in dairy industry

Application of soft starters in operating machinery up to 5 kW is recommended, which results in saving of average instantaneous energy and average overall energy in the range of 4.00 to 17.16 and 0.10 to 4.57%, respectively, depending on the loading conditions.

FOOD PROCESSING TECHNOLOGY

12 Edible coating material for extending the shelf life of tomato fruits

Farmers, Entrepreneurs and Agro-processing units involved in post-harvest handling of



tomato fruits are advised to use the technology of edible coating developed by AAU, for extension of shelf life. For storage of prebreaker stage tomatoes at ambient conditions $(27\pm3^{\circ}C)$ the coating formulation of Bee wax 20%, oleic acid 2%, sodium hydroxide 4%, glycerol monostearate 1%, remaining 73% hot distilled water is recommended, which will extend shelf life by 24 days. For low temperature storage $(15\pm2^{\circ}C)$, the coating formulation comprising of Bee wax 20%, mineral oil 15%, oleic acid 2%, sodium hydroxide 4%, glycerol monostearate 1 %, remaining 58% hot distilled water is recommended, which will extend the shelf life of tomatoes by 15 days compared to non-coated tomatoes stored at the same temperature.



0 to 6 days



0 to 24 days



0 to 36 days

13 Biodiesel conversion technology

Entrepreneurs interested in producing biodiesel from sunflower oil and cottonseed oil are advised to use the biodiesel conversion technology developed by AAU, Anand. The process involves transesterification with methanol in presence of specific catalyst (Sodium hydroxide) under controlled reaction followed by separation of glycerol and other downstream processes.

14 Design and development of multi-chamber equipment for online measurement of rate of respiration of fruits and vegetables

Entrepreneurs and instrument manufacturers interested in online measurement of rate of respiration of fruits and vegetables or equipment for above purpose are advised to use the design of multi-chamber equipment for online continuous measurement of respiration rate developed by AAU, Anand. The system is quick, accurate, versatile and user friendly for continuous determination of the rate of respiration under varying storage environments for different fruits and vegetables.

15 Development of osmotically dehydrated whole aonla fruits

The entrepreneurs and fruit processors interested in production of osmotically dehydrated whole Aonla are advised to use processing technology developed for the purpose by AAU, Anand. The technology involves ultrasonication, osmotic dehydration in sugar syrup (580 Brix) followed by hot air drying and results in good quality whole sweetened dehydrated Aonla. Final product packed in HDPE (200 gauge) bags can be stored at ambient storage condition $(27\pm2^{\circ}C, 65\% \text{ RH})$ for six months.

16 Production technology for superior quality malt flour from moth bean

The entrepreneurs and food processors



interested in manufacture of malt based products are advised to adopt the production technology of mothbean malt developed at AAU, Anand. The technology involves soaking and germination of mothbean for 12 and 36 hours, respectively, followed by drying at 60°C and milling. This process reduces the antinutrients, thereby improving the assimilable nutrients (proteins, carbohydrates and minerals) in malted mothbean.



17 Supercritical fluid extraction of carotenoids from vacuum dried pumpkin powder

The entrepreneurs and food processors interested in production of carotenoids from pumpkin powder are advised to use supercritical extraction technology developed by AAU, Anand. This technology involves extraction of carotenoid from vacuum dried pumpkin powder using blanching, sulphitation, drying, sieving and super critical fluid extraction using CO₂ at controlled pressure and temperature. The process enables to achieve the maximum yield of solvent-free carotenoid (0.6 g/100 g) having higher β -carotene content (151.47 mg/100 g). This extract is stable up to 45 days at -18°C temperature.



Vacuum dried pumpkin powdercarotenoids

18 Development of High Protein Pumpkin Bar

The food processors interested in development of nutritious protein fortified pumpkin bar are advised to follow the protocol developed for this purpose by AAU, Anand. The technology involves addition of whey protein concentrate (5%), maltodextrin (0.1%), pectin (0.2%) and citric acid (0.86%) to pumpkin pulp, cooking, drying and packaging of final product in metallized cast polypropylene (MPP).



19 Super critical fluid extraction of oleoresins from red chilli

The entrepreneurs and food processors interested in production of oleoresins, capsaicin and pigment compounds from red chillies are advised to use supercritical extraction technology developed for this purpose by AAU, Anand. This technology involves better recovery of oleoresins (6.5%), capsaicin (2.2%) and pigment compounds having 16024 NesslerimeterColourValue(NCV)usingdrying, sieving and CO₂ supercritical fluid extraction at controlled pressure and temperature. The process results in s uperior quality oleoresins, capsaicin and pigment compounds as compared to conventional extraction methods.

AGRICULTURAL ENGINEERING AND AIT

AGRICULTURAL ENGINEERING

Development and evaluation of a multipurpose tool bar for mini tractor suitable for the cropping pattern of middle Gujarat region

A mini tractor (15-20HP) drawn multipurpose tillage tool developed by Anand Agricultural University is suitable for seed bed preparation at wapsa conditions under sandy loam soil of middle Gujarat Agro-climatic zone in a single operation. The implement consisting of iron ploughs for tillage and clod crusher for breaking clods is useful for preparation of seed bed in a single pass with a saving of upto 50% in the

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cost of operation as compared to the cultivator. Therefore, it is recommended for farmers of the region to prepare the seedbed by using the developed implement.



2 Modification of three point linkage system of medium tractor drawn sowing machine to operate by mini tractor

By modifing the three point hitching system of the sowing machines designed for medium size tractor (35-40 HP), it can be easily operated by the mini tractor (15-20 HP) and saving upto 20 % in sowing operation can be achieved as compared to the medium sized tractor. A 100 kg front ballasting in the mini tractor will be required. The manufacturers of the seed drill are advised to follow the hitching specifications given below for fabrication of the new seed drill so that the machine can be operated by the mini tractor also : (1) Maximum distance between lower hitching points has to be set in the range of 60-70 cm and (2) Vertical distance between top hitching point and lower hitching point has to be set in the range of 50-60 cm.



Development and evaluation of mini tractor drawn semi automatic potato planter

A mini tractor(15-20 hp) drawn two row semiautomatic potato planter developed by AAU is recommended for the farmers for planting the potato crop. The planter places the potato tubers and fertilizer at appropriate depths in a single operation. In the planter the distance between two rows (45-70 cm) can be adjusted as per requirement. Use of this planter with mini tractor will save about 40% cost of the potato planting as compared to the medium size tractor (35-40 hp) operated planter. The cost of the planter is estimated as Rs. 26000/-.

Design and Development of a Throat Type Up Draft Biomass Gasifier for Thermal Application

The throat type updraft biomass gasifier developed by AAU is recommended for thermal applications at community kitchen, restaurants, dhabas and similar establishments' owners who are interested in shifting to biomass gasifier system. The developed gasifier can be successfully operated using maize cobs, sized wood and saw dust briquettes. Maize cob is found more suitable for throat type updraft gasifier as compared to other two fuels. The newly developed gasifier remains about 50% cheaper in operation as compared to that with the LPG system.

AIT

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5 Development of Mobile based application for farmers

Anand Agricultural University has started "i-khedut" mobile application. This application provides package of practices and animal husbandry related information in Gujarati language and hence recommended for use by farmers of Gujarat.

Annual Report 2016 -17

ANIMAL PRODUCTION

1 Study on Nutritional Status of dairy animals of Botad district

The farmers of Botad district are advised to feed daily additional 1.0 and 1.5 kg compound concentrate mixture to cows and buffaloes yielding 5.0 to 9.0 and 9.0 to 13.0 kg milk daily respectively throughout the year in order to fulfill their nutrient requirement.

2 To study the effects of feeding different quality maize on production performance and egg quality parameters of White Leghorn birds

Significantly higher content of β -Carotene (8.559 ppm), protein (13.22%) and deep yellow colour of egg yolk are observed in the eggs of White Leghorn birds fed on layer ration prepared by using yellow maize (Gujarat Anand Yellow Maize Hybrid-1) as compared to white maize (Gujarat Maize-3), High Quality Protein Maize-1 (HQPM-1) and purple maize; thus resulting in value addition and satisfying consumer's preference for deep yellow yolk. Hence, it is recommended to use yellow maize (Gujarat Anand Yellow Maize Hybrid-1) in preparation of layer ration.

3 Performance of Indigenous Sheep under Water Restriction and Rehydration in middle Gujarat Agro climatic zone

Marwari and Patanwadi hoggets can be maintained on 2.0 litres of water, daily.

ANIMAL HEALTH

1 Studies on Clinico-biochemical aspects of Ancylostomosis in dogs

The prevalence of Ancylostomosis (14-37%) has been observed round the year in pet dogs of Anand district. Hence, the pet owners are advised to follow the deworming schedule prescribed by veterinarians.

Recommendations for scientific community and entrepreneurs

PLANT PROTECTION

AGRICULTURAL ENTOMOLOGY

1 Bio-efficacy of different insecticides against anar butterfly, *Virachola Isocrates* (Fabricius) infesting pomegranate

Two sprays of flubendiamide 39.35 SC 0.015 per cent (3 ml/10 litre of water) or chlorantraniliprole 18.5 SC 0.006 per cent (3 ml/10 litre of water) or emamectin benzoate 5 SG 0.0025 per cent (5 g/10 litre of water) first at initiation of the pest and second at 30 days after first spray proved effective for the control of anar butterfly, *Virachola isocrates*(Fabricius) infesting pomegranate in mrug bahar.

2 Residue and persistence of ethion 50 EC in/on cabbage

Two foliar sprays of ethion 50 EC in cabbage at 10day interval @ 500 g a.i./ ha starting from 50 per cent head formation resulted in its residue below the limit of quantitation of 0.05 μ g/g in cabbage heads if harvested from 7th day after the last spray. Therefore, PHI of 7 days could be suggested if ethion 50 EC is recommended in cabbage with MRL of 0.05 μ g/g.

3 Residue and persistence of acephate 75 SP in/ on cabbage

Two foliar sprays of acephate 75 SP in cabbage at 10 days interval @ 560 g a.i./ha starting from 50 per cent head formation resulted in cabbage head residue below the MRL 2.0 μ g/g (CODEX) immediately after the last application. Therefore, PHI of 1 day could be suggested if acephate 75 SP is recommended in cabbage.

4 Residue and persistence of triazophos 40 EC in/on cabbage

Two foliar sprays of triazophos 40 EC in cabbage

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at 10 days interval @ 500 g a.i./ha starting from 50 per cent head formation resulted in its residue below the limit of quantitation of 0.05 μ g/g in cabbage heads if harvested from 10th day after the last spray. Therefore, PHI of 10 days could be suggested if triazophos 40 EC is recommended in cabbage with MRL of 0.05 μ g/g.

5 Residue and persistence of carbendazim 50 WP in/on cabbage

Two foliar sprays of carbendazim 50 WP in cabbage at 10 days interval @ 250 g a.i./ha starting from 50 per cent head formation resulted $0.70 \,\mu$ g/g residues even on the 15th day of the last application which, being higher than limit of quantitation of 0.05 μ g/g, label claim of carbendazim 50 WP, can be considered for cabbage based on the risk assessment.

6 Residue and persistence of quinalphos 25 EC in/on cabbage

Two foliar sprays of quinalphos 25 EC in cabbage at 10 days interval @ 250 g a.i./ha starting from 50 per cent head formation resulted in its residue below the limit of quantitation of 0.05 μ g/g in cabbage head if harvested from 5th day after the last spray. Therefore, PHI of 5 days could be suggested if quinalphos 25 EC is recommended on cabbage with MRL of 0.05 μ g/g.

7 Residue and persistence of ethion 50 EC in/ on cauliflower

Two foliar sprays of ethion 50 EC in cauliflower at 10 days interval @ 500 g a.i./ha starting from 50 per cent curd formation resulted in its residue below the limit of quantitation of 0.05 μ g/g in cauliflower curd if harvested from 15th day after the last spray. Therefore, PHI of 15 days could be suggested if ethion 50 EC is recommended on cauliflower with MRL of 0.05 μ g/g.

8 Residue and persistence of acephate 75 SP in/ on cauliflower

Two foliar sprays of acephate 75 SP in cauliflower at 10 days interval @ 560 g a.i./ha starting from 50 per cent curd formation resulted in 0.12 μ g/g residues even on the 15th day after the last application, which, being higher than the limit of quantitation of 0.05 μ g/g, label claim of acephate 75 SP, can be considered for cauliflower based on the risk assessment.

Residue and persistence of carbendazim 50 WP in/on cauliflower

Two foliar sprays of carbendazim 50 WP in cauliflower at 10 days interval @ 250 g a.i./ha starting from 50 per cent curd formation resulted in 0.16 μ g/g residues even on the 15th day of the last application, which being higher than limit of quantitation of 0.05 μ g/g, label claim of carbendazim 50 WP, can be considered for cauliflower based on the risk assessment.

10 Residue and persistence of triazophos 40 EC in/on cauliflower

Two foliar sprays of triazophos 40 EC in cauliflower at 10 days interval @ 500 g a.i./ha starting from 50 per cent curd formation resulted in its residue below the limit of quantitation of 0.05 μ g/g in cauliflower curd if harvested from 10th day after the last spray. Therefore, PHI of 10 days could be suggested if triazophos 40 EC is recommended in cauliflower with MRL of 0.05 μ g/g.

11 Residue and persistence of quinalphos 25 EC in/on cauliflower

Two foliar sprays of quinalphos 25 EC in cauliflower at 10 days interval @ 250 g a.i./ha starting from 50 per cent curd formation resulted in its residue below its MRL of 0.1 μ g/g in cauliflower curd if harvested from 7th day after the last spray. Therefore, PHI of 7 days could be suggested.



12 Residue and persistence of quinalphos 25 EC in/on chilli

Two foliar sprays of quinalphos 25 EC in chilli at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted in its residue below its MRL of 0.2 μ g/g in green chilli fruits if harvested from 5th day after the last spray. Therefore, PHI of 5 days could be suggested.

13 Residue and persistence of triazophos 40 EC in/on chilli

Two foliar sprays of triazophos 40 EC in chilli at 10 days interval @ 500 g a.i./hastarting from fruiting stage resulted in its residue below its limit of quantitation of 0.05 μ g/g in green chilli fruits if harvested from 15th day after the last spray. Therefore, PHI of 15 days could be suggested if triazophos 40 EC is recommended in chilli with MRL of 0.05 μ g/g.

14 Residue and persistence of chlorpyriphos 20 EC in/on chilli

Two foliar sprays of chlorpyriphos 20 EC in chilli at 10 days interval @ 300 g a.i./ha starting from fruiting stage resulted in its residue below its limit of quantitation of 0.01 μ g/g in green chilli fruits if harvested from 10th day after the last spray. Therefore, PHI of 10 days could be suggested if chlorpyriphos 20 EC is recommended on chilli with MRL of 0.01 μ g/g.

15 Residue and persistence of carbendazim 50 WP in/on green chilli

Two foliar sprays of carbendazim 50 WP in chilli at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted in its residue below the MRL 2.0 μ g/g (CODEX) in green chilli fruits on the 3rd day after the last application. Therefore, PHI of 3 days could be suggested if carbendazim 50 WP is recommended in chilli.

16 Residue and persistence of fluopyram 200 + tebuconazole 200 - 400 SC in/on chilli

Three foliar sprays of fluopyram 200 + tebuconazole 200 - 400 SC in chilli at 10 days interval @ 100 + 100 g a.i./ha starting from fruiting stage resulted in its residue below its limit of quantitation of 0.05 μ g/g in green chilli fruits on the 20th day after the last application. Therefore, PHI of 20 days could be suggested if the fluopyram 200 + tebuconazole 200 - 400 SC combination is recommended in chilli with MRL of 0.05 μ g/g.

17 Residue and persistence of carbendazim 50 WP in/on capsicum grown in open field

Two foliar sprays of carbendazim 50 WP in capsicum grown in open field at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted in its residue 0.41 μ g/g in the fruits even on the 20th day after the last application, which, being higher than the limit of quantitation of 0.05 μ g/g, label claim of carbendazim 50 WP, can be considered for capsicum based on risk assessment.

18 Residue and persistence of chlorpyriphos 20 EC in/on capsicum grown in open field

Two foliar sprays of chlorpyriphos 20 EC in capsicum grown in open field at 10 days interval @ 300 g a.i./ha starting from fruiting stage resulted in its residue below its MRL 2.0 μ g/g (CODEX) in the fruits immediately after the last application. Therefore, PHI of 1 day could be suggested if chlorpyriphos 20 EC is recommended in capsicum grown in open field.

19 Residue and persistence of quinalphos 25 EC in/on capsicum grown in polyhouse

Two foliar sprays of quinalphos 25 EC in capsicum grown in polyhouse at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted in its residue below its limit of quantitation of 0.05 μ g/g in the fruits if harvested from 10th day after the last spray. Therefore, PHI of 10 days could be

suggested if quinalphos 25 EC is recommended in capsicum grown in polyhouse with MRL of 0.05 μ g/g.

20 Residue and persistence of triazophos 40 EC in/on capsicum grown in polyhouse

Two foliar sprays of triazophos 40 EC in capsicum grown in polyhouse at 10 days interval @ 500 g a.i./ha starting from fruiting stage resulted in its residue below its limit of quantitation of 0.05 μ g/g in the fruits if harvested from 15th day after the last spray. Therefore, PHI of 15 days could be suggested if triazophos 40 EC is recommended in capsicum grown in polyhouse with MRL of 0.05 μ g/g.

21 Residue and persistence of chlorpyriphos 20 EC in/on capsicum grown in polyhouse

Two foliar sprays of chlorpyriphos 20 EC in capsicum grown in polyhouse at 10 days interval @ 300 g a.i./ha starting from fruiting stage resulted in its residue below its MRL of 2.0 μ g/g (CODEX) in the fruits immediately after the last application. Therefore, PHI of 1 day could be suggested if chlorpyriphos 20 EC is recommended in capsicum grown in polyhouse.

22 Residue and persistence of acephate 75 SP in/ on capsicum grown in polyhouse

Two foliar sprays of acephate 75 SP in capsicum grown in polyhouse at 10 days interval @ 560 g a.i./ha starting from fruiting stage resulted in its residue 0.42 μ g/g in the fruits even on the 15th day after the last application which, being higher than limit of quantitation of 0.05 μ g/g, label claim of acephate 75 SP, can be considered for capsicum based on the risk assessment.

23 Residue and persistence of carbendazim 50 WP in/on capsicum grown in polyhouse

Two foliar sprays of carbendazim 50 WP in capsicum grown in polyhouse at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted

in its residue $0.25 \,\mu g/g$ in the fruits even on the 20^{th} day after the last application which, being higher than limit of quantitation of $0.05 \,\mu g/g$, label claim of carbendazim 50 WP, can be considered for capsicum based on the risk assessment.

24 Residue and persistence of quinalphos 25 EC in/on tomato

Two foliar sprays of quinalphos 25 EC in tomato at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted in its residue below its limit of quantitation of 0.05 μ g/g in tomato fruits if harvested from 7th day after the last spray. Therefore, PHI of 7 days could be suggested if quinalphos 25 EC is recommended in tomato with MRL of 0.05 μ g/g.

25 Residue and persistence of carbendazim 50 WP in/on tomato

Two foliar sprays of carbendazim 50 WP in tomato at 10 days interval @ 250 g a.i./ha starting from fruiting stage resulted in its residue below the MRL 0.5 μ g/g (CODEX) in the tomato fruits on the 15th day after the last application. Therefore, PHI of 15 days could be suggested if carbendazim 50 WP is recommended in tomato.

26 Residue and persistence of chlorpyriphos 20 EC in/on tomato

Two foliar sprays of chlorpyriphos 20 EC in tomato at 10 days interval @ 300 g a.i./hastarting from fruiting stage resulted in its residue below its limit of quantitation of 0.01 μ g/g in tomato fruits if harvested from 7th day after the last spray. Therefore, PHI of 7 days could be suggested if chlorpyriphos 20 EC is recommended in tomato with MRL of 0.01 μ g/g.

27 Residue and persistence of imidacloprid 70 WG in/on tomato

Three foliar sprays of imidacloprid 70 WG in tomato at 7 days interval @ 35 g a.i./ha starting from fruiting stage resulted in its residue below



its MRL of 1.0 μ g/g in tomato fruits one hour after the last application. Therefore, PHI of 1 day could be suggested if imidacloprid 70 WG is recommended in tomato.

28 Residue and persistence of fluopyram 400 SC in/on tomato

Soil drench of fluopyram 400 SC @ 250 g a.i./ ha in tomato, twice at 15 days interval starting from fruiting stage revealed its residue below determination level in tomato fruits even up to 15 days after the last application. Therefore PHI of 1 day could be suggested if fluopyram 400 SC is recommended in tomato.

29 Residue and persistence of imidacloprid 17.8 SL in/on okra

Two foliar sprays of imidacloprid 17.8 SL in okra at 10 days interval @ 20 g a.i./ha starting from fruiting stage resulted in its residue below its MRL of 2.0 μ g/g in okra fruits one hour after the last application. Therefore, PHI of 1 day could be suggested.

30 Residue and persistence of imidacloprid 17.8 SL in/on brinjal

Two foliar sprays of imidacloprid 17.8 SL in brinjal at 10 days interval @ 20 g a.i./ha starting from fruiting stage resulted in its residue below its MRL 0.01 μ g/g 1-day after the last application. Therefore, PHI of 1 day could be suggested if imidacloprid 17.8 SL is recommended in brinjal.

31 Residue and persistence of spiromesifen 22.9 SC in/on brinjal

Two foliar sprays of spiromesifen 22.9 SC in brinjal at 10 days interval @ 96 g a.i./ha starting from fruiting stage resulted in its residue below limit of quantitation of 0.05 μ g/g in brinjal fruits one day after the last application. Therefore, PHI of 1 day could be suggested.

32 Residue and persistence of fluopyram 200 + tebuconazole 200 - 400 SC in/on onion

Three foliar sprays of fluopyram 200 + tebuconazole 200 – 400 SC in onion at 10-day interval @ 75 +75 g a.i./ha starting from bulb formation stage resulted in the residue below their limit of quantitation of 0.05 μ g/g in onion bulbs on the 50th day (at harvest) after the last application. Therefore, the PHI of 50 days could be suggested for bulb onion if the fluopyram 200 + tebuconazole 200 – 400 SC combination is recommended in onion with 0.05 μ g/g MRL. However, in spring onion, as the residue levels are higher than the limit of quantitation even on the 20th day, risk assessment can be carried out to fix the MRLs.

33 Residue and persistence of flubendiamide 240 + thiacloprid 240 - 480 SC in/on redgram

Three foliar sprays of flubendiamide 240 + thiacloprid 240 - 480 SC in red gram at 10 days interval @ 48 + 48 g a.i./ha starting from pod formation stage resulted in the residues below their limit of quantitation of 0.05 μ g/g in matured pods on the 41st day (harvest) after the last application. Therefore, PHI of 41 days could be suggested for matured pods/seeds if flubendiamide 240 + thiacloprid 240 - 480 SC combination is recommended in red gram with 0.05 μ g/g MRL. However, in green pods, as the residue levels are higher than the limit of quantitation even on the 20th day, risk assessment can be carried out to fix the MRLs in green pods.

34 Residue and persistence of trifloxystrobin 25 + tebuconazole 50 - 75 WG in / on cowpea

Two foliar sprays of trifloxystrobin 25 + tebuconazole 50 - 75 WG in cowpea at 10 days interval @ 87.5+175 g a.i./ha at pod formation stage resulted in the residues below their limit of quantitation of 0.05 µg/g in matured pod / seed on the 42^{nd} day (harvest) after the last application. Therefore, PHI of 42 days could be



suggested for matured pods if the trifloxystrobin 25 + tebuconazole 50 - 75 WG combination is recommended in cowpea with 0.05 µg/g MRL. However, in green cowpea pods as the residue levels reached below determination limit of 0.05 µg/g on the 20th day, PHI of 20-day could be suggested for green pods.

35 Residue and persistence of deltamethrin 2.5 EC in/on chickpea

Three foliar sprays of deltamethrin 2.5 EC in chickpea at 7 days interval @ 12.5 g a.i./ha starting from pod setting stage resulted in its residue below its limit of quantitation of 0.05 μ g/g in matured pods/seeds on the 37th day (harvest) after the last application. Therefore, PHI of 37 days could be suggested if deltamethrin 2.5 EC is recommended in chickpea with 0.05 μ g/g MRL in seed. However, for green pods, PHI of 7 days could be suggested.

36 Bio-efficacy of newer insecticides against tomato leaf miner, *Liriomyza trifolii* (Burgess)

For effective and economical management of leaf miner in tomato, spray spinosad 45 SC, 0.0135 per cent (3 ml/ 10 litre water; 67.5 g a.i./ha) or abamectin 1.9 EC, 0.0006 per cent (3 ml/ 10 litre water; 2.85 g a.i./ha) alongwith 400 g jaggery, first at the appearance of the pest, and subsequent two sprays, at 15 days interval.

37 Evaluation of different miticides against paddy mites

One spray of spiromesifen 240 SC, 0.024 per cent (10 ml/10 litre of water, 120 g. a.i./ha) or propargite 57 EC, 0.057 per cent (10 ml/10 litre of water, 285 g. a.i./ha) or fenpyroximate 5 SC, 0.005 per cent (10 ml/10 litre of water, 25 g. a.i./ ha) at the time of initiation of yellow leaf mite of paddy was found effective.

38 Evaluation of synthetic insecticides for the control of *Spodoptera litura* Fabricious infesting bidi tobacco under nursery conditions

Application of emamectin benzoate 5 SG, 0.0025 per cent (5 g / 10 liter water; 7.5 g a.i./ha) in tobacco nursery was found effective against leaf eating caterpillar (*Spodoptera litura* Fabricious) infesting bidi tobacco seedlings at the initiation of infestation.

PLANT PATHOLOGY AND NEMATOLOGY

39 Bio-efficacy of newer fungicides against maydis leaf blight, turcicum leaf blight and curvularia leaf spot diseases in maize

For the management of leaf blight(maydis and turcicum) and curvularia leaf spot diseases of maize during *kharif* and *rabi* seasons, the seed treatment with captan 75 WS @ 3 g/ kg seeds followed by two sprays of azoxystrobin 18.2% + difenconazole 11.4% (29.6 SC), 0.03% (9.2 ml/10 litre of water) at 30 and 45 days after germination was found effective.

DAIRY SCIENCE

1 Comparative appraisal of physical, chemical, instrumental and sensory evaluation methods for monitoring oxidative deterioration of ghee

- (1) Among BIS, AOAC, AOCS, FOX and IDF methods for determination of peroxide value of ghee, the use of FOX method is recommended since it is best correlated with the flavour score of ghee.
- (2) Among Weight gain, Conjugated dienes content, Iodine value, FFA content, Kreis number and Peroxide value (by FOX method) for monitoring primary stage of oxidation in ghee, determination of peroxide value of ghee by FOX method is recommended since it is best correlated with the flavour score of ghee.
- (3) Among Thiobarbituric acid, ρ-Anisidine value, Totox value and Carbonyl value for monitoring



secondary stage of oxidation in ghee, the method of Carbonyl value is recommended since it is best correlated with the flavour score of ghee.

2 Preparation of ghee from camel milk and evaluation of its shelf life

The ghee prepared from camel milk has Reichert Meissl(RM) value of 9.91 and Butyrorefractometer Reading (BR) at 40°C of 44.52. These parameters do not fulfill the present requirements specified by FSSAI and AGMARK for ghee. Therefore, while formulating FSSAI and/or AGMARK specifications for ghee prepared from camel milk, the RM value and BR reading at 40°C reported in the present study will be useful.

3 Evaluation of selected spices/herbs for their suitability to enhance the shelf life of paneer

Among the common culinary spices/herbs (ajwain, asafoetida, black pepper, cardamom, cinnamon, clove, coriander, cumin, fenugreek, garlic, ginger, mint, onion and turmeric), cardamom was found to be most effective to improve the shelf life of paneer. The addition of crushed cardamom seeds in milk @ 0.6% of the expected yield of paneer improves the shelf life of paneer up to 21 days at $7 \pm 1^{\circ}$ C.

4 Characterization of Khoa prepared from camel milk and evaluation of its suitability for preparation of selected sweets

The flavor of gulabjamun prepared from camel milk khoa blended with refined wheat flour (10%), suji (12%), baking powder (0.25%) and water can be improved using cardamom, when added both in dough (20 ml extract of 7.5% crushed cardamom seed in water) and in sugar syrup (63°Brix) (3 g crushed cardamom seeds in 1 lit of sugar syrup).

5 Study on distribution pattern of nitrogenous components in milk

In pooled cow milk samples collected from Anand district, the average values of total nitrogen (TN),

casein nitrogen (CN), whey protein nitrogen (WPN) and non-protein nitrogen (NPN) were 0.5102, 0.3903, 0.0793 and 0.0411%; in buffalo milk 0.6230, 0.4922, 0.0879 and 0.0429% while in mixed milk 0.5588, 0.4360, 0.0810 and 0.0418% respectively. Distribution of total nitrogen amongst CN, WPN and NPN was 76.50, 15.53 and 8.06% in cow milk; 79.00, 14.11 and 6.89% in buffalo milk; while it was 78.02, 14.50 and 7.48% in mixed milk respectively.

6 Metagenomic and Clinical investigation of synbiotic fermented dairy product containing probiotic *Lactobacillus helveticus* MTCC 5463 in geriatric volunteers

A honey supplemented probiotic fermented milk containing *Lactobacillus helveticus* MTCC 5463 is recommended for consumption by geriatrics as it is found to have immune boosting functional property in geriatrics and positively modulates the gut microflora.

The metagenomic study revealed that the faecal samples were dominated by Firmicutes (50%), Actinobacteria (20%) and Proteobacteria (10%) and feeding honey supplemented probiotic fermented milk resulted in 7% increase in Firmicutes, 1.5 % rise in Actinobacteria and 1.9% increase in Proteobacteria.

FOOD PROCESSING TECHNOLOGY

7 Screening of novel thermotolerant yeast with improved process economics for bioethanol production

Ethanogenic and thermotolerant AAU cultures ETGS1 and ETDLT1 are identified as strains of *Saccharomyces cerevisiae* and *Kluyveromyces marxianus*, respectively. These strains have shown potential for bioconversion of starch and lactose containing substrates into ethanol. Scientists interested in the process development for bioconversion of starch or lactose into ethanol can use these strains. AAU

8 Screening, Identification and Characterization of Lactic Acid Bacteria with probiotic potential and phytic activity

Lactic acid bacterial strains *Pediococcus acidilactici* ID-01 and *Pediococcus lolii* ID-02 were isolated and identified having probiotic potential and phytate degrading ability. Scientists interested in phytate processing are advised to use these AAU strains.

AIT

9 e-Student Corner with Attendance and Result module for UG courses

e-Student corner web system developed by Anand Agricultural University is recommended for attendance, results and fees collection. The system is useful to Course Teachers, Academic incharges, Principals, Registrar and Administrative Officers to carry out various academic activities of AAU and recommended for use in Anand Agricultural University.

10 Web User Interface Assisted Document Management System

Web user interface assisted document management system developed by Anand Agricultural University automates the workflow process. It is applied for digitization of documents and recommended for use in Anand Agricultural University.

11 Development of web based Procurement Management System

Web based procurement management system developed by Anand Agricultural University is useful to purchase goods. The system generates comparative statement, kharid patrak etc. and is recommended for use in Anand Agricultural University.

12 Development of web based Online Tour Program

Web based online tour program developed by

Anand Agricultural University is useful to place online tour proposals for university staff members with provision for approval from authorities. It also generates print out of tour diary, TA-DA reports, and previous tour reports and is recommended for use in Anand Agricultural University.

13 Development of web based Online Bill Processing System

Web based online bill processing system developed by Anand Agricultural University automates many financial functions like budget entry, grant allocation, checking bill, passing bill and necessary reports for management. It is recommended for use in Anand Agricultural University.

14 Development Web Based PG Module of Student Corner for Anand Agricultural University

Web based PG Module of Student Corner developed by Anand Agricultural University is useful to store and manipulate PG students' information like basic details, course, degree, major and minor subjects major guide, seminar and synopsis approval date, thesis title, thesis date and notification. It is also useful for managing student progress in his/her studies and recommended for use in Anand Agricultural University.

ANIMAL PRODUCTION

1 Effect of climatic factors on daily milk production of dairy cows

Minimum temperature, morning relative humidity and wind speed are responsible for 66 % of total climatic variations in milk yield of dairy cows. Minimum temperature and morning relative humidity are negatively correlated, while wind speed has positive impact on milk yield.

2 In vitro evaluation of Fenugreek (Trigonella foenumgraecum) for its influence on substrate degradation and methanogenesis.

Supplementation of Fenugreek seeds at 2% level in

the total mixed ration for adult goats significantly (P<0.01) improved *in vitro* digestibility of dry matter and organic matter with reduction in methane emission.

3 Effect of incorporation of dried date palm (*Phoenix dactylifera* L. [Arecaceae]) leaves in total mixed ration for adult sheep and goats

Total mixed ration without or with air dried or green date palm leaves replacing jowar hay at 40% DM equivalent basis, has no adverse effect on voluntary feed intake, body weights and cost of feeding in adult Surti goats and Marwari sheep.

4 Effect of incorporation of dried date palm (*Phoenix dactylifera* L. [Arecaceae] leaves in total mixed ration for adult sheep and goats

Total mixed ration without or with air dried or green date palm leaves replacing jowar hay at 40% DM equivalent basis on feeding adult Surti goats or Marwari sheep do not influence rumen fermentation patterns and digestibility coefficient for dry matter, organic matter, proximate constituents, neutral detergent fibres and acid detergent fibres.

5 To study the effects of feeding different quality maize on production performance and egg quality parameters of White Leghorn birds

Significantly higher content of lysine (0.427%), tryptophan(0.216%), anthocyanin (0.874 mcg%) and total anti-oxidant activity (13.876 mg/100 g) are observed in eggs of White Leghorn layer birds fed layer mash containing purple colour maize in comparison with white maize (Gujarat Maize-3), yellow maize (Gujarat Anand Yellow Maize Hybrid-1) and High Quality Protein Maize-1 (HQPM-1).

ANIMAL HEALTH

6 Study on effect of biherbal drug of *Bryophyllum* calycinumand *Tribulus terrestris* on urolithiasis.

The biherbalmethanolic extract of *Bryophyllum calycinum* (Panfuti) and *Tribulus terrestris* (Gokharu) (1:1) at the dose rate of 400 mg/kg body weight, orally, once in a day, for four weeks has antiurolithiatic effect on ethylene glycol induced urolithiasis in Wistar rat.

 7 Effect of Inclusion of Antioxidants - Cysteine and Taurine - in TFYG Extender on Refrigeration (5°C) and Cryopreservation (-196°C) of Buffalo Semen

Taurine @ 4 mg/ml or cysteine @ 1 mg/ml in standard Tris Fructose Yolk Glycerol (TFYG) extender is recommended to the semen banks as a routine antioxidant additive for improved cryopreservation and/or refrigeration preservation of buffalo semen as it significantly (p<0.01) enhanced sperm progressive motility, viability, and membrane integrity with reduced sperm/ acrosome abnormalities.

Seasonal Influence on Efficacy of Estrus Induction and Synchronization Protocols in Anoestrus cows and Buffaloes

Three estrus/ovulation synchronization protocols, viz., Ovysynch, Heatsynch and Triu-B used in true anoestrus crossbred cows during winter and summer seasons resulted in per cent estrus induction (corresponding values during winter and summer seasons - 100.00, 100.00, 100.00; 88.88, 92.30 and 90.90, respectively) and conception rates (58.33, 41.66, 50.00; 44.44, 46.15, 45.45, respectively). In anoestrus buffaloes, during winter and summer seasons, the corresponding per cent estrus induction and conception rates were 83.33, 91.66, 83.33; 73.33, 84.21, 83.33; and 58.33, 50.55, 50.00; 26.66, 21.05, 33.33, respectively. Hence, the three protocols can be used round the year in cows, whereas in buffaloes, Ovysynch protocol has to be used only during winter season.

8

SOCIAL SCIENCE

1 Yard stick of CV% for accepting the results of 3 Safedmusali (*Chlorophytum borivilianum*) crop experiments

The yard stick of CV% for accepting the results of Safedmusali (*Chlorophytum borivilianum*) crop experiments is 21 per cent for yield character.

2 Yard stick of CV% for accepting the results of Ashwagandha (*Withania somnifera*) crop experiments

The yard stick of CV% for accepting the results of Ashwagandha (*Withania somnifera*) crop

experiments is 22 per cent for yield character.

3 Yard stick of CV% for accepting the results of Isabgul (*Psyllium*) crop experiments

The yard stick of CV% for accepting the results of Isabgul (*Psyllium*) crop experiments is 23 per cent for yield character.

4 National level scale to measure attitude of extension functionaries towards Agricultural Technology Management Agency (ATMA)

The following national level scale to measure attitude of extension functionaries towards ATMA is recommended.

NI.	Statum	Re	oring			
INO.	Statements			UN	DA	SDA
1	I think that ATMA is the perfect platform to coordinate agricultural research and extension activities at district level.	5	4	3	2	1
2	I think that ATMA is impractical way to develop rural India.	1	2	3	4	5
3	I believe ATMA is in real sense bottom-up approach to develop rural India.	5	4	3	2	1
4	I believe that ATMA means too many cooks spoil the broth.	1	2	3	4	5
5	I feel that ATMA is an ideal instrument for the development of district.	5	4	3	2	1
6	I feel that ATMA creates conflicts among neighboring farmers.	1	2	3	4	5
7	ATMA in real sense is a decentralized model of development.	5	4	3	2	1
8	I feel that ATMA is more theoretical and less practical.	1	2	3	4	5
9	I believe that ATMA is the best agency to encourage Farmer's Interest Groups.	5	4	3	2	1
10	I feel that ATMA is an effective attempt joining all the stakeholders to develop district.	5	4	3	2	1
SA:	Strongly Agree, A: Agree, UD: Undecided, DA: Disagree, SDA: Strongly Disagree					

5 Scale to measure attitude of farmers toward use of mineral mixture in cattle

The following scale to measure attitude of farmers towards use of mineral mixture for cattle is recommended.

No	Statements	Responses & Scoring						
110.	Statements	SA	Α	UD	DA	SDA		
1	I trust adopting mineral mixture for milch animals.	5	4	3	2	1		
2	I believe that there is more propaganda about the use of mineral mixture as animal feed than truth.	1	2	3	4	5		
3	I think that mineral mixture helps to feed crucial minerals to milch animals.	5	4	3	2	1		
4	I believe that use of mineral mixture helps boosting milk yield in animals.	5	4	3	2	1		
5	I think use of mineral mixture helps in making animal bones stronger.	5	4	3	2	1		
6	I would like to advise my children to use mineral mixture for milch animals.	5	4	3	2	1		
7	Use of mineral mixture ensures higher fertility rate in milch animals.	5	4	3	2	1		

						कृष्णवाली राष्ट्रं कृषिसंपल्ला		
8	Use of mineral mixture reduces animal stress.	5	4	3	2	1		
9	I think that progressive livestock owner is one who uses mineral mixture for animal feed.	5	4	3	2	1		
10	I believe that health of milch animals can be improved faster using mineral mixture.	5	4	3	2	1		
11	I believe that vigour of milch animal can be increased using mineral mixture.	5	4	3	2	1		
12	I think using mineral mixture for milch animals is feasible only to rich farmers.	5	4	3	2	1		
SA=	SA - Strongly Agree A-Agree IID-Undecided DA-Disagree SDA-Strongly Disagree							

6 Scale to measure attitude of farmers towards dehorning in cattle

The following Scale to measure attitude of farmers towards dehorning in cattle is recommended.

No	Statements	Responses and Scoring							
INO.	Statements	SA	Α	UD	DA	SDA			
1	The dehorning in cattle is advantageous method.	5	4	3	2	1			
2	I dislike purchasing dehorned milch animals for my farm.	1	2	3	4	5			
3	The dehorning is the healthier approach to improve animal health.	5	4	3	2	1			
4	I think that dehorning in animals is unreliable practice.	1	2	3	4	5			
5	I feel that adoption of recommended dehorning practices in animals involves risk but worth taking.	5	4	3	2	1			
6	I think that dehorning reduces productivity of milch animals.	1	2	3	4	5			
7	Dehorning helps in reducing risk of injury to other animals.	5	4	3	2	1			
8	I think adoption of dehorning in animals is adoptable only by rich farmers.	1	2	3	4	5			
9	Dehorning helps in decreasing danger of injury to cattle keepers.	5	4	3	2	1			
10	I believe dehorning helps animals in behaving advantageously.	5	4	3	2	1			
11	I think that progressive animal keeper is one who believes in dehorning practices in their milch animals.	5	4	3	2	1			
12	I would dislike advising my children to adopt dehorning in milch animals.	1	2	3	4	5			
SA= S	Strongly Agree, A=Agree, UD=Undecided, DA=Disagree, SDA=Strongly Disagree			•					

4.2 AGRICULTURAL CROPS

4.2.1 Cereals

Rice

Crop Improvement

- Rice is the predominant cereal crop of central Gujarat. A large number of varieties have been developed by the Main Rice Research Station, Nawagam, Gujarat. Presently, the centre is working for the development of new varieties/ hybrids in rice. In addition, various breeding activities like development of fresh crosses, handling of segregating generations, screening of germplasm and different categories of varietal trials are regularly conducted at the station.
- During the year 2016-17 a total of 42 trials were successfully conducted in Crop Improvement department *viz*; transplanted trials, AICRIP trials, IRRI Nursery, AICRIP hybrid rice trials and other agency trials.
- Total 1639 genotypes were evaluated during *Kharif*-2016.
- In *Kharif*-2016 total 1727 plant grogenies of different generations were evaluated from which 1596 IPS and 174 bulks were made.71 new crosses were made for different traits.

State Transplanted Trials

• During *Kharif*-2016,11 transplanted trials were conducted at Nawagam, Dabhoi, Arnej, Dahod

and Thasra centers of Middle Gujarat.

AICRIP Trials

• During *Kharif*-2016 season, 17 AICRIP trials at Nawagam and Dabhoi centres were conducted. Likewise, under AICRIP, hybrid rice 5trials were conducted at Nawagam and Dabhoi locations.

State Drilled Rice Trials

• A total of 10 trials at Derol and 2 trials at Dabhoi were successfully undertaken during *Kharif*-2015.

Hybrid Rice Research

CMS Lines Multiplication Programme

At M.R.R.S., A.A.U., Nawagam, a total of 9 CMS lines were maintained and multiplied under strict isolation and with intensive roughing/purification. The flower duration and distinguishing morphological traits were studied in case of all the CMS lines and their corresponding maintainer lines. Further, a complete genetically pure nucleus block was maintained in case of IR-58025 A& B line. Apart from this GR-104 and GR-7 were planted with IR-58025 A line for development of hybrids. Total 16 crosses were conducted to check fertility restoration ability of high yielding rice genotypes.

Rice Trials: (ARS, Derol)

- In LSVT-EE, out of the 18 genotypes, baska-1 gave significantly higher yield as compared to best check Ashoka-200F.
- In LSVT-E, out of the 16 genotypes DDR-101 gave significantly higher yield as compared to best check GR-9.
- In SSVT-E, none of the genotypes gave higher yield as compared to best check GR-9.
- Among 12 genotypes evaluated in SSVT-drilled paddy, only one genotype *i.e.* IET-23337 recorded significantly higher yield than best check GR- 9.

- In PET-I of paddy, out of 14 genotypes evaluated, none gave higher yield as compared to best check GR-5.
- In PET-Aerobic of paddy, out of 12 genotypes evaluated, none gave higher yield as compared to best check GR-9.
- In AVT 1 EDS of paddy, out of 11genotypes evaluated genotype 107 gave higher yield as compared to check AAUDR-1.
- In IVT-E DS of paddy, out of42 genotypes evaluated, genotype 234 gave higher yield as compared to check GR-9.
- In AVT 1 Aerobic of paddy, out of 25 genotypes evaluated, genotype 3310 gave higher yield as compared to check AAUDR-1.
- In IVT– Aerobic of paddy, out of 57 genotypes evaluated, genotype 3439 gave higher yield as compared to check GR-9.

Rice Trials: (HMRS, Dahod)

At Hill Millet Research Centre, Dahod, six experiments of drilled and transplanted rice were conducted under state trials. Total 48 genotypes of drilled rice were evaluated. Out of these, 16 genotypes *viz.*, IET-24040, IET-22820, IET-24677, IET-24053, IET-24054, IET-23345, IET-24679, IET-24043, IET-24051, IR-82098-BB-23-B, IET-23355, IET-23337, IET-24058, IET-24674, IET-24692 and IET-24690 were found promising.

Crop Production

- Apart from Main Rice Research Station, Nawagam, two other centres Dabhoi and Thasra also conducted research experiments on transplanted and drilled paddy.
- During the reporting period, total 7 experiments (AICRP 4 + State 3) were conducted on different agronomical aspects. In AICRP trials, different varieties were tested with various nitrogen doses, sowing dates in transplanted and aerobic rice as



well as on cropping system and weed management. In state trials, research was carried out on response of rice to nitrogen, phosphorus and biofertilizers.

Plant protection

For plant protection in rice, 28 experiments (AICRP 19 + State 9) were conducted.

A total of 268 genotypes as well as advanced cultures including local checks viz., Gurjari, GR-7, GR-12, GAR-1, GAR-2, GAR-3, GAR-13, GR-11 and Masuri were screened for their reaction against major insect pests at Nawagam and Navsari locations. Out of 268 at Nawagam 198 entries and at Navsari, 96 entries showed 1 damage score (DS) against Leaf Folder, while 167 entries at Nawagam and 60 entries at Navsari were found promising against Stem Borer (1 DS).

Under entomological research, screening of paddy genotypes were carried out for their resistance to major pests, monitoring of pests and their natural enemies, studies on monitoring the activity of insect pests through light trap and evaluation of newer insecticides for the management of paddy pests. Moreover, studies were also conducted on pathological screening of genotypes for their resistance to leaf blight, blast and sheath rot diseases,field monitoring of virulence of major causal organisms and evaluation of newer fungicides against major diseases of paddy.

Maize

Crop Improvement

Kharif 2016

Testing of hybrids/varieties

Testing of hybrids/varieties developed by AICRP on maize centers and private sectors across the country as decided in 59thAnnual Maize Workshop meeting held from 10-12th April,2016 at Bangalore. Total 12 trials were conducted successfully comprising of normal maize and speciality corn. Total 3 zonal trials were conducted successfully.

Station (Location specific) programme

Research trials were conducted on heterotic and composite breeding for testing hybrids/varieties developed by this centre. Trials were taken at Godhra, Dahod, Khedbrahma, Bhiloda, Devagadhbaria, Vadodara, Derol and Jabugam centre for their multilocation evaluation. Total 33 trials were conducted successfully at different locations of Anand Agricultural University including MMRS, Godhra. Nucleus seed of GM-2, GM-3, GM-4, GM-6, Narmada Moti, IGI-1101, IGI-1102, IGI-1103, IGI-1104, HKI-193-1 and HKI-163 produced to raise breeder seed in subsequent winter/rabi season. Breeder seed of GM-2, GM-3, GM-4, GM-6 and Narmada Moti were produced at different centers of Anand Agricultural University to meet demand of indenters.

Rabi 2015-16

Testing of hybrids/varieties

Testing of hybrid/varieties were developed by different centers of AICRP on Maize and Private sectors across the country as decided by Director (Maize), Indian Institute of Maize Research, (ICAR), New Delhi. Total 7 trials of different maturity group and speciality corn were conducted successfully.

Station (Location specific) programme

Research programme was conducted for testing hybrids/varieties developed by this centre. Trials were taken at Godhra and Dahod centres for evaluation of single cross hybrids and varieties of normal maize and speciality corn *viz.*, Quality Protein Maize, sweet corn, pop corn, high oil corn and baby corn. Total 19 trials were conducted successfully at these two locations.

Evaluation of 54 inbred lines, populations and hybrids under heat stress conditions (summer) with collaboration of IIMR (Indian Institute of Maize Research) and CIMMYT, India was carried out.

Following crop improvement related work also was carried out.

AAU

- 1 Breeder/truthful seed of all released cultivars and hybrids and nucleus seed of inbreds were produced.
- 2 Generation advancement of elite single cross hybrids to be used as new experimental composites in future.
- 3 Development of old elite single cross hybrids (White & Yellow).
- 4 Development of new elite single cross hybrids (White & Yellow).
- 5 Generation advancement of existing early generation inbred lines (S5 onwards).
- 6 Maintenance and multiplication of existing experimental composites/inbred lines for further experimental use.
- 7 Local/indigenous/exotic germplasm collection, procurement through official visit/request from CIMMYT, NBPGR, WNC, IIMR, Private sectors, market and farmers fields as well.
- 8 Testing of inbred lines for their performance and hybrid development.

Crop Production

In *kharif*-2016, 4 trials and in *rabi*-2015-16, 2 trials were conducted.Outcome of these experiments are as under:

• In rainfed maize hybrids GAYMH-1 and GAWMH-2, farmers of Panchmahal district are advised to fertilizer crop with 160 kg N_2 and 20 kg P_2O_2 per hactar ewhile of Dahod district are advised to fertilizer crop with 160 kg N_2 and P_2O_5 per hactare for securing higher grain yield with high net return. The Nitrogen application can be given in 4 equal splits at basal, 4 leaves, 8 leaves and tasseling stage of the crop growth.

Plant Protection

• The screening of maize genotypes for resistant to major insect pests and diseases under field

conditions in *kharif* and *rabi* seasons was crried out.

- *In-vivo* evaluation of new ways to control plant diseases and insect pests was carried out.Seed treatment + soil application + spray application with *Trichoderma viride* was found to control banded leaf and sheath blight (BLSB) disease severity whereas, salicylic acid (4mM) spray along with seed treatment @ 0.75 mM was found significantly controll Maydis leaf blight, Turcicum leaf blight and Curvularia leaf spot diseases, 100 ppm salicylic acid (SA)was found best in checking banded leaf and sheath blight (BLSB) disease and stripped plant with variety GM-6 was found best in checking banded leaf and sheath blight (BLSB) disease severity under field conditions.
- Screened different genotypes against *Maydis* leaf blight, *Turcicum* leaf blight, *Curvularia* leaf spot etc. and all resistant genotypes are promoted by IIMR, Ludhiana at national level.

Wheat

Crop Improvement

Triticum aestivum

RRS, Anand

Total six trials were conducted at the centre, including one AICRP, four state and one station trial

- Under Advanced Varietal Trial (AVT (HF) T.S.), out of 8 genotypes was significantly out yielded or were numerically higher than best check variety GW 496.
- Total 36 entries were evaluated under Small Scale Trial (SST (HF) T.S.)
- (*T. aestivum*). Genotype J-2014-29 was found promising.
- In Large Scale Trial (LST (HF) T.S.)(*T. aestivum*) out of 10 entries GW 480 significantly out yielded than the best check variety Lok-1.


- Total 7 entries were evaluated under Large Scale Trial (LST (HF) L.S.) (*T. aestivum*). Genotype GW-487 was found promising.
- In Zonal Varietal Trial (ZVT (HF) T.S.)(*T. aestivum*) out of 18 entries none of the entries was found promising.
- 10 new crosses were made at this centre, during the year to develop varieties. 226 different segregating generations were sown and selection was made from this generations.

Triticum durum

- At ARS Dhandhuka, 75 new crosses were attempted for development of high yielding varieties suitable under rainfed conditions. Out of 961 progenies, 849 IPS were selected.
- At ARS Dhandhuka, total 9 different trials viz. AVT (RI), NIVT-5B (RI), LST(RF), SST-I(RF), SST-II(RF), PYT(RF), PET(RF), SST-I (RI) & Agronomy Trail were allotted and conducted successfully.
- At RRS, Anand, under Large Scale Trial (LST (HF) T.S.)(*T. duram*) out of 8 none of the entries was found significantly superior or numerically higher than the best local check Lok-1.
- At ARS, Arnej, 5 experiments viz., SST(RF) T durum set –I, SST(RI) T durum set –I, SST(RF) T durum set-II, PYT(RF) T durum, PET(RF) T durum set-1 were conducted successfully.
- At ARS, Arnej, in wheat, out of 151 entries 22 entries of Arnej centre were found promising and were promoted in respective trials.

Crop Production

At ARS, Arnej, following research experiments for production technology in wheat were conducted during the reporting period.

1. Nutrient management through organic source in wheat (GW-496) in Bhal region

2. Effect of different levels of nutrient, phosphorus and bio-fertilizer on yield of irrigated (Triticum aestivum L.) in Bhal region

At Dept. of Agronomy, BACA, Anand, following research experiments for production technology in wheat were conducted during the reporting period.

• Response of wheat (*Triticum aestivum* L.) to N, P and K under middle Gujarat conditions:

The grain yield of wheat was significantly affected by various levels of nitrogen and phosphorus; however, the potash application failed to manifest significant effect on grain and straw yields of wheat.

Crop Protection

• At ARS, Arnej, the infestation of pink stem borer, *Sesamia inferens* at maturity stage was higher in un-irrigated wheat (16.07 %) as compared to wheat grown by restricted irrigation (9.97 %), while it was 11.05% in the irrigated wheat *i.e.*, GW 496.

Bajra

Crop Improvement

Kharif-2016 (RRS, Anand)

- Under Large Scale Hybrid Trial, total 21 hybrids were evaluated. GHB-1129 was found promising.
- In Small Scale Hybrid Trial, total 32 hybrids were evaluated. GHB-1225 was found promising.
- Total 12 hybrids were evaluated in Advanced Hybrid Trial (AHT – M). Two hybrids AHT-401 A and AHT-409 A were found promising.
- Under Advanced Hybrid Trial (AHT L), total 10 hybrids were evaluated. None of the hybrids was found promising.
- In Initial Hybrid Trial (IHT-M), total 36 hybrids were evaluated. Four hybrids IHT–214,IHT-215, IHT-220 and IHT-227 were found promising.

AAU

• Under Initial Hybrid Trial (IHT-L), total 35 hybrids were evaluated. Total six hybrids IHT-305, IHT-327, IHT-318, IHT-321, IHT-324 and IHT-310 were found promising.

Summer - 2016

- In Large Scale Hybrid Trial, total 15 hybrids were evaluated. Three hybrids GHB-1192, GHB-1197 and GHB-1195 were found promising.
- In the coordinated hybrid trial, (SHT) total 23 hybrids were evaluated. Eight hybrids SHT–103, SHT-120, SHT-110, SHT-112, SHT-115, SHT-107, SHT-109 and SHT-101 were found promising.
- In an Ad-Hoc research project financed by M/s PHI Seed Pvt. Ltd (Evaluation of performance of Pearl millet hybrids) two hybrids *viz*; 86 M 38 and 86 M 84 were evaluated with two local checks. Both the hybrids were found promising.
- 63 new crosses were made during summer to develop hybrids. 125 inbreds and 19 male sterile lines (A/B) were selected from ICRISAT.

Crop Production

Following experiments were carried out at Dept. of Agronomy, BACA, Anand.

Results on response of N, P and bio-fertilizers on summer pearlmillet (*Pennisetum glaucum* L.) showed that different levels of nitrogen significantly influenced the grain and fodder yields of pearlmillet. The grain yield of pearlmillet linearly increased with increase in level of nitrogen from 100 to 140 kg N ha⁻¹, while fodder yield of pearlmillet significantly increased with 120 kg ha⁻¹, but remained at par with 140 kg ha⁻¹.

• Results on varietal performance of pearlmillet under varying transplanting dates in semi *rabi* season showed that the effect of date of transplanting and varieties were found nonsignificant for the grain and dry fodder yields of pearlmillet.

Finger Millet and Kodo Millet

Crop Improvement

Kharif-2016

- At Hill Millet Research Centre, Dahod, six experiments of finger millet were conducted under AICRP and state trials. Total 81 genotypes of finger millet were evaluated. Out of these, 20 genotypes *viz.*, AVT (E&M)-3, IVT-9, IVT-5, IVT-10, IVT-16, WN-494, WN-544, WN-550, WN-585, WN-569, WN-591, WWN-35, WWN-26, WWN-28, WWN-32, WN-593, WN-630, WN-550, WN-467 and WN-544 were found promising for grain yield.
- Four varietal trials were conducted under AICRP, state and station trials in Kodo Millet and 36 genotypes were tested. Of these, 8 genotypes *viz.*, KAVT-1, KAVT-9, KAVT-2, KAVT-4, DK-159, DK-151, DK-150 and DK-143 were found promising for grain yield.

4.2.2 Pulses

Mungbean

Crop Improvement

Kharif-2016

RRS, Aannd

- In Large Scale Varietal Trial, out of six genotypes SKNM-12-06and NKM-15-08 recorded significantly higher yield than the best check variety GM 4 to the tune of 29.35 and 29.07 percent, respectively.
- 51germplsam lines were maintained. 56 plants were selected from segregating generations.

Pulse Research Station, Vadodara

- In PET trial, the genotype VMK-14-10 exhibited 9.4 per cent superiority.
- In SSVT trial, genotypes VMS-13-12 and NMK-15-12 were found to be numerically superior.



- In LSVT trial, on overall basis, the SKNM-12-06 and NKM-15-08 appeared promising, whereas, at Derol location, the genotypes SKNM-12-06, SKNM-14-01 and NKM-15-08 were shown 17.9, 3.4 and 2.2 per cent numerically higher yield.
- In *kharif* 2016, 12 new crosses were attempted for development of high yielding varieties. Total 54 plant progenies of various generations were raised. Out of these progenies, 27 IPS were selected.

ARS, Derol

- In LSVT, 14 genotypes including two checks were evaluated. Genotype SKNM-12-06 recorded significantly higher yield as compared to others.
- In SSVT, 14 genotypes including two checks were evaluated. Genotype SKNM-1514 recorded significantly higher yield as compared to others.

HMS, Dahod

 At Hill Millet Research Centre, Dahod, two experiments of mungbean were conducted under state trials. Total 16 genotypes of mungbean were evaluated. Out of these, 6 genotypes *viz.*, NMK-15-08, GJM- 1104, NMK-15-12, SKNM- 13-01, SKNM- 15-02 and VMS-15-1 were found promising.

Summer – 2016

RRS, Anand

• In Small Scale Varietal Trial total 18 genotypes of mungbean were evaluated including three check varieties. The yield differences due to the genotypes were found significant. None of the genotypes recorded significant difference in yield than the best check variety Meha.

Pulse Research Station, Vadodara

- In PET trial, the entries VMS-15-1 were found significantly superior. VMK-14-2 was found numerically superior over best check Meha.
- In SSVT trial, only ANDGG-13-01 gave 3.7 per

cent higher yield over check.

- In LSVT trial, among all genotypes, GM-11-02 was found 5.7 per cent numerically superior over best check Meha.
- In SSVT Mungbean trial, the entry NMK-15-08 was found significantly superior across the locations over Meha.
- In summer 2016, 9 new crosses were attempted for development of high yielding varieties. Total 50 plant progenies of various generations were raised. Out of these progenies, 50 IPS were selected.

Crop Production

Pulse Research Station, Vadodara

• Effects of sowing dates and spacing on semirabi greengram (*Vigna radiata* L.), wherein the treatment 3rd in the week of September sowing with the spacing 30 cm between rows recorded higher grain and straw yield.

Crop Protection

Pulse Research Station, Vadodara

Kharif-2016

- In LSVT trial, the pod damage due to *Maruka* vitrata was found in the range of 8.0% (Meha) to 11.0% (GM-4) atharvest. Aphid incidence was in the range of 8.33/5 plant (GAM-5) to 11.66/5 plant (GM-4). Whitefly population/5 plant was 19.00 (GAM-5) to 33.66 (GM-4). Thrips population/5 flower was 20.00 (SKNM-14-01) to 30.00 (GM-4). Under screening programme of 64 genotypes of mungbean, the pod damage due to *Maruca* vitrata was found lowest in VMG-67, whereas, it remained highest in VMG-5 at harvest.
- In SSVT trial, the pod damage due to *Maruka* vitrata was found in the range of 5.0% (SKNM-1508) to 10.0% (GM-4) at harvest. Aphid incidence was 2.0/plant (SKNM-1508) to 7.0/plant (GM-4). Jassid population was 3.0/plant (SKNM-1502, 1508, 1513, 1516, VMS-15-1, and 13-12) to 5.0/

AAU

plant(GM-4). Whitefly population/plant was 2.0 (SKNM-1508, 1516, and 13-01) to 6.0 (GM-4). Thrips population/flower was 4.0 (SKNM-1508, 1514, 13-01, VMS-15-1 and NMK-15-12) to 7.0 (GM-4).

- In PET trial, the pod damage due to *Maruka vitrata* was found in the range of 3.0% (VMK-14-9 and VMS-15-7) to 8.0% (GM-4) at harvest. Aphid incidence was 2.0/plant (VMK-14-1 and VMS-16-1) to 8.0/plant (VMS-16-3). Jassid population was 3.0/plant (VMK-14-1, VMS-15-7, 16-1, 16-3 and 16-7) to 6.0/plant (Meha). Whitefly population/ plant was 2.0 (VMS-15-2, 16-1, 16-5 and 16-6) to 7.0 (VMS-16-3). Thrips population/flower was 3.0 (VMK-14-1, VMS-15-3, 15-4, 16-3, 16-5 and GM-4) to 7.0 (VMS-16-1 and 16-4).
- Yellow Mosaic Disease was found lowest (3.04%) in GAM-5, whereas it was highest in GM-4 (16.82%).
- Over and all, among the tested 15 genotypes against insect pests and disease, VMG-67 was found superior over rest of the genotypes.

Dept. of Plant Pathology, BACA, Anand

- Fifty varieties /germplasm of mungbean screened against BCMV, among which, 25 genotypes (at Anand) and 11 genotypes (at Derol) showed 1.0 to 10.0% disease incidence The per cent disease incidence ranged from 0.20 to 20.83% and 4.17 to 36.67% at Anand and Derol locations, respectively.
- Lowest mungbean root rot incidence (14.37%), highest shoot length (9.21cm), highest vigour index (1143) and highest grain yield (827 kg/ha) was found in seed treatment with *T. viride* (10⁸ cfu/g) @ 10 g/kg seeds and *P. fluorescens* (10⁸ cfu/ml) @ 10 ml/kg seeds.
- DAS-ELISA technique was employed for the detection of the virus present in different parts of mungbean. The presence of BCMV was detected in complete seed as well as in seed coat, cotyledons and embryo of the seed in variety:

Meha with BCMV antisera. The infected tissues gave positive reaction as compared to Negative control (0.126) wherein O.D. value of 3.362, 3.045, 2.593 and 2.391 were obtained in seeds, seed coat, cotyledons and embryo, respectively.

Pigeon Pea

Crop Improvement

Pulse Research Station, Vadodara

- In LSVT-ME trial, none of the genotypes showed superiority over check varieties individual as well as overall basis.
- In PET trial, the genotype, AAUVT-15-6 gave 20.6 per cent significantly superior yield.
- In SSVT (Pigeon pea–Mid-late), among test entries, AAUVT-15-08 and AAUVT-13-20 gave 18.2 and 17.7 per cent numerically higher yield over check.
- In IVT (Pigeon pea–Mid-late), none of the genotypes was shown superiority over best check ICPL-87119.
- In *pre rabi* season in 2016, 68 new crosses were attempted of different generations for development of high yielding varieties. Total 308 plant progenies of various generations were raised. Out of these progenies, 204 IPS were selected.
- Total 647 germplasm of pigeon pea were maintained and 39 new germplasm were also collected during the year.

ARS, Derol

• In SSVT (ML) out of 14 genotypes tested. GJP 1502, AAUVT 15-07 and AAUVT 13-20 yielded higher than best check and rest of entries.

In LSVT (ML), BP 10-11 yielded higher than best check.

HMS, Dahod

• At Hill Millet Research Centre, Dahod, one experiment of pegionpea was conducted under



state trial. Total 7 genotypes of pegionpea were evaluated. None of these was found promising.

Crop Protection

Pulse Research Station, Vadodara

- In LSVT (ML), the pod damage due to *Helicoverpa* was found in the range of 8.0% (SKNP-1315 and AAUVT-1335) to 14.0% (Vaishali) at harvest. The pod damage due to *M. Obtusa* was found in the range of 9.0% (SKNP-1233, GJP-1303 and AAUVT-1335) to 12.0% (GJP-1406, BP-1104, BDN-2 and Vaishali) before harvest.
- In SSVT (ML), the pod damage due to *Helicoverpa* was found in the range of 6.0% (SKNP-1525 and AAUVT-1507) to 9.0% (SKNP-1416, GJP-1508, BP-1208, BDN-2 and Vaishali) at harvest. The pod damage due to *M. Obtusa* was found in the range of 5.0% (AAUVT-1504) to 9.0% (BDN-2) before harvest.
- In LSVT (ME), the pod damage due to *Helicoverpa* was found in the range of 8.0 (SKNP-1303) to 12.0% (GT-103 and UPAS-120) at harvest. The pod damage due to *M. Obtusa* was found in the range of 4.0% (SKNP-1303, SKNP-1004 and SKNP-1109) to 7.00% (GT-103 and UPAS-120) before harvest.
- In PET, the pod damage due to *Helicoverpa* was found in the range of 8.0% (AAUVT -14-22, AAUVT-15-6, AAUVT-15-9 and AGT-2) to 12.0% (BDN-2) at harvest. The pod damage due to *M. Obtusa* was found in the range of 7.0% (AAUVT-14-22) to 11.0% (BDN-2) before harvest.
- In IVT (ME), the pod damage due to *Helicoverpa* was found in the range of 8.0% (420 and 421) to 17.0% (425) at harvest. The pod damage due to *M*. *Obtusa* was found in the range of 8.0% (401, 410, and 422) to 13.0% (428) before harvest.
- In experiment of impact of sowing periods on incidence of pest complex in Pigeon pea,among

the varieties tested, AGT-2 remained superior to Vaishali and BDN- 2 in respect of lower *H. armigera* population and pod damage, but remained at par with Vaishali in having grain yield.

- In LSVT (ML), wilt incidence was found in the range of 0.50% (AAUVT-1335) to 3.40% (GJP-1303) per cent. The lowest and highest SMD was found in the entry SKNP-14-13 (0.08%) and GJP-1406 (3.19%), respectively.
- In SSVT (ML), wilt incidence was found in the range of 0.46% (SKNP-1416) to 2.51% (BDN-2). The observation on sterility mosaic disease indicates that none of the entries was found resistant to the disease except AAUVT-13-20. The lowest and highest SMD was found in the entry AAUVT-13-20 (0.0%) and BDN-2 (2.01%) respectively.
- In PET, wilt incidence was found in the range of 0.71% (AAUVT-14-2) to 3.81% (BDN-2). The observation on sterility mosaic disease indicates that noneof the entries was found resistant to the disease except AAUVT-14-2. The lowest and highest SMD was found in the entry AAUVT-14-2 (0.0%) to BDN-2 (5.71%) respectively.
- In LSVT (ME), wilt incidence was found in the range of 0.32% (GT-101) to 2.63% (SKNP-1408) per cent.The lowest and highest SMD was found in the entry GT-101 (0.32%) and GT-103 (1.50%) respectively.

Dept. of Nematology

• Out of fifty seven lines/cultivars of pigeon pea evaluated, three were resistant to *Meloidogyne javanica* pt-1.

Chickpea

Crop Improvement

• At ARS, Derol, In LSVT, none of the genotypes recorded significantly higher yield than the best

check GG-5.

- Out of the 14 genotypes including three checks evaluated in SSVT, none of the genotypes was found significantly superior to best check GG 5.
- At ARS, Arnej, in chickpea, total 104 entries were tested in different ten trials including co-ordinated, state and station trial. Among them, 18 genotypes /entries of Arnej centre were found promising and will be promoted in respective trials.
- At Hill Millet Research Centre, Dahod, 3 experiments of chickpea were conducted under state trial. Total 45 genotypes were evaluated. Out of these, 7genotypes *viz.*, GJG-1316, GJG-1013, GJG-1421, GJG-1506, GJG-1509, GJG-1505 and GJG-1504 were found promising.

Crop production

At ARS, Derol, an experiment on effect of sowing time and spacing on growth and yield of chickpea for green pod yield was conducted. Among the different main plot treatments, treatment D₃:1-Oct (40th Sd. Week) recorded highest yield as compared to rest of treatments. The same treatment also showed lowest days to maturity of green pods and significantly highest number of branches.

Crop Protection

- At ARS, Arnej, in a study on monitoring of gram pod borer, *Helicoverpa armigera* population through pheromone traps in chickpea, the maximum moths (11.13 moths/trap/week) were caught during 2nd week of December, 2016. After 3rd week of December, 2016, moths entrapped/trap continuously decreased.
- At, Dept. of Plant Pathology, management of seed associated *Fusarium oxysporum* f.sp. *ciceri* and *Macrophomina phaseolina* in chickpea was achieved through seed biopriming for 10 hrs. with suspension of talc based formulation (2x10⁸ cfu/g) of *Trichoderma harzianum* AAU isolates @ 50 g in 250 ml of water/kg of seed + soil application of

T. harzianum enriched FYM (10 g *T. harzianum* / kg FYM) @ 100 g /m² of soil/furrow, resulting in maximum vigour index (7624) with minimum disease incidence (13.67%) having highest yield 1354 kg/ha, which was followed by seed biopriming for 10 hrs. with suspension of talc based formulation ($2x10^8$ cfu/g) of *Trichoderma harzianum* PAU isolates @ 50 g in 250 ml of water/kg of seed as compared to treated check and untreated check.

Soybean

Crop Improvement

TRTC, Devgadh Baria

- 94 germplasm lines were maintained. Out of these,two new promising GP lines viz., LGP-22 and KB-68 included in diff. trial for testing.
- Under multilocation varietal trial of soybean, significantly maximum pooled for number of branches per plant, number of pods per plant and seed yield were recorded in the variety NRC-37, during *Kharif*-2016.
- In Initial Varietal Trial of Soybean, significantly maximum pooled seed yield was recorded under coded variety T-15, T-1 and T-5 during the *Kharif*-2016.
- At Dahod centre, one experiment of chickpea was conducted under state trial, wherein, total 6 genotypes were tested, of which, genotype NRC-37 was found promising.

Dept. of Genetics and Plant breeding

• Forty diverse genotypes of soybean were evaluated for yield, morphological characters and quality attributes. The maximum seed yield was observed in the genotype NRC-37,followed by PK-746, DS-89-18 and JS-335. The genotype J-301 (43.64 %) had highest protein content, which was followed by genotypes GS-2 (42.38 %), DS-83-12-2 (42.10 %) and AGS-13 (41.29 %). Similarly, the maximum oil content was represented by genotype NRC-37 (20.03 %), followed by HIMSO-5506 (19.88 %), EC-93601 (19.77 %) and MACS-58 (19.29 %).

• The genetic diversity of twenty genotypes of soybean was studied using 34 SSR primers, out of which, 20 primers generated polymorphic results. These twenty genotypes were grouped in two different clusters *i.e.* A and B. Cluster A comprised of genotypes MACS-58, CAT-148, AGS-156, CAT-746, IC (SH)-8744, PI-283327, VLS-20, EC-93601 and MO-32 and rest of the genotypes were clustered in group B.

Crop Production

TRTC, Devgadh Baria

- The experiment on the effect of intercropping pattern on soybean and maize, indicated that the highest equivalent yield of soybean (1068.4) was recorded under treatment $T_6 \{Soybean + Maize (3:2)\}$, which was at par with Treatment $T_4 \{Soybean + Maize (2:1)\}$.
- The results of the experiment on effect of organic manures, Bio- Fertilizers, Levels of Nitrogen and Phosphorus on seed and straw yield of soybean were found significant. The highest soybean yield was recorded under O₁ –vermi compost @ 2.5 t ha⁻¹N₂ 45 kg N ha⁻¹, P₂ -60 kg P₂O₅ ha⁻¹and B₂ Rhizobium + PSB, respectively.
- A trial was conducted on the effect of fertigation on soybean productivity. The results of the present investigation clearly highlighted the fact that among all the fertigation treatments, Fertigation at flowering (50% RDF as basal + 50 % RDF through fertigation) showed best in growth parameters (branches per plant, pods per plant, plant dry weight at 30, 45 and 60 DAS) and also yield and yield parameters (seed index, seed yield and straw index).
- The results of experiment on response of seed rates on different soybean varieties were found non-significant with respect to seed and straw

yield of soybean. The highest soybean yield was recorded under variety V_1 –NRC-37 and seed rate R_2 - 80 kg ha⁻¹, respectively. Also, straw yield was found in similar order.

• The results of the experiment on the effect of row spacing on different soybean varieties were found non-significant with respect to seed and straw yield of soybean. The highest soybean yield was recorded under variety V₁ –NRC-37 and spacing S₂- 45 x 10 cm, respectively. Also, straw yield were found in similar order.

Crop Protection

At Dept. of Plant Pathology, BACA, Anand, application of *Trichoderma virideorT. harzianum* (2x10⁸ cfu/g)enriched FYM (10 kgbioagent/ ton FYM) in furrow @ 1 ton/ha, followed by seed treatment with *T. virideorT. harzianum*(2x10⁸ cfu/g)@ 10 g/kg seeds, at the time of sowing was found effective for the management of root rot disease in soybean.

Clusterbean

Crop Improvement

ARS, Derol

- In SSVT/LSVT of guar, out of 11 genotypes GAUG 1305 recorded significantly higher yield as compared to other entries.
- In feeler trial of guar, out of 41 genotypes SPS-8 recorded significantly higher yield as compared to other entries.

Blackgram

Crop Improvement

• At Dahod centre, two experiments on blackgram were conducted under state trial,wherein, total 29 genotypes were tested, of which,13 genotypeviz.,GJU-1509, VUG-32, VUG-18, VUG-19, NUK-15-09, NUK-15-10, SKNU-13-

03, SKNU-12-07, SKNU-13-02, SKNU-12-08, DERUG-16-1, DBUGP-6-2 and DERUG-16-2 were found promising.

• At Devgadh Baria centre, total 66 germplasm lines were maintained. Out of these, 4 promising germplasm *viz.*, DBUGP-2-2, DBUGP-2-5, DBUGP-6-1 and DBUGP-6-2 were selected.

PRS, Vadodara

Summer 2016

- In PET-I trial, the entries VUG-40 (1125 kg/ha), VUG-51 (1014 kg/ha) VUG-82 (951 kg/ha) and VUG-84 (944 kg/ha) were found numerically superior.
- In PET-II trial, the varieties PANT U 31 (819 kg/ha) and VUG-63 (708 kg/ha) were found significantly superior in performance over best check GU-1 (521 kg/ha) respectively.
- In ZVT trial, on overall basis, T-9 (762 kg/ha) was considered as best check varieties, while genotypes, DERGU-17-5 (784 kg/ha), DBUGP-2-2 (832 kg/ha) and DBUGP-2-5 (773 kg/ha) were found numerically superior. Among these three genotypes, DERUG-17-5 showed resistance (0.0-2.6 %) reaction against YMD.

Kharif 2016

- In PET-I trial, out of tested genotypes, VUG-19 (990 kg/ha), VUG-51 (903 kg/ha), VUG-63 (897 kg/ha) and VUG-23 (887 kg/ha) were found numerically superior.
- In PET-II trial, none of the genotypes showed superiority over check variety GU-1 (691 kg/ha). On overall basis, genotypes DBUGP-6-2 (1081 kg/ha) and VUG-19 (1040 kg/ha) showed 14.4 and 10.0 per cent yield superiority. Both the promising cultures also showed resistance reaction against YMD except Jabugam location.
- In SSVT + LSVT trial, on the basis of average performance, genotypes viz., VUG-32 (1071

kg/ha) and VUG-18 (985 kg/ha) exhibited 35.7 and 24.8 per cent yield advantage. At Vadodara location, VUG-32 (989 kg/ha) showed 4.8 per cent numerically superior, whereas, at Dahod location, the genotype GJU-1509 (1188 kg/ha), VUG-32 (1153 kg/ha), VUG-18 (1127 kg/ha), NUK-15-09 (1113 kg/ha) and NUK-15-10 (1030 kg/ha) were found significantly superior.

Crop Protection

PRS, Vadodara

- Out of 15 genotypes tested against insect pests and disease, VUG-07 was found superior over rest of the genotypes.
- In SSVT + LSVT, the pod damage due to Maruka vitrata was found in the range of 5.0% (VUG-32) to 8.0% (SKNU-13-02, 13-03, NUK-15-10 and T-9) at harvest. Aphid incidence was 4.0/plant (VUG-32) to 8.0/plant (GJ-1). Jassid population was 4.0/plant (SKNU-12-07) to 7.0/plant (GJU-15-06, VUG-32 and GJ-1). Whitefly population/ plant was 5.0 (SKNU-12-08, NUK-15-09 and VUG-32) to 8.0 (SKNU-13-03, VUG-18 and GJ-1). Thrips population/flower was 5.0 (SKNU-12-08, GJU-15-09 and VUG-32) to 7.0 (SKNU-12-08, GJU-15-09 and VUG-32) to 7.0 (SKNU-13-03, 13-05 VUG-18 and GJ-1).
- In ZVT, the pod damage due to Maruka vitrata was found in the range of 5.0% (VUG-63, 32 and DERUG-17-1) to 8.0% (T-9) at harvest. Aphid incidence was 3.0/plant (VUG-18, 63, 32, DERUG-16-2, 27-2, DBUGP-2-2 and DBUGP-2-5) to 6.0/plant (T-9). Jassid population was 4.0/plant (VUG-63, 32 and DBUGP-6-2) to 7.0/plant (DERUG-20-4 and DBUGP-6-2) to 7.0/plant (DERUG-20-4 and DBUGP-2-5). Whitefly population/plant was 3.0 (VUG-32) to 7.0 (DERUG-17-05, 20-4 and DBUGP-2-2). Thrips population/flower was 3.0 (VUG-18 and 63) to 7.0 (DERUG-16-1).
- In PET-I, the pod damage due to *Maruka vitrata* was found in the range of 6.0% (VUG-23) to



10.0% (T-9) at harvest. Aphid incidence was 3.0/ plant (VUG-23) to 7.0/plant (VUG-50 and T-9). Jassid population was 4.0/plant (VUG-23 and 51) to 8.0/plant (T-9). Whitefly population/ plant was 5.0 (VUG-23, 63 and GU-1) to 8.0 (VUG-35, 82 and T-9). Thrips population/flower was 4.0 (VUG-23) to 8.0 (T-9).

- In PET-II, the pod damage due to *Maruka vitrata* was foundin the range of 6.0% (PANTU-40) to 9.0% (T-9) at harvest. Aphid incidence was 4.0/ plant (PANTU-40) to 8.0/plant (T-9). Jassid population was 3.0/plant (PANTU-40) to 6.0/ plant (PANTU -31 and T-9). Whitefly population/ plant was 4.0 (PANTU-40 and GU-1) to 6.0 (T-9). Thrips population/flower was 4.0 (PANTU-40) to 7.0 (T-9).
- During the season the incidence of YMD was found very very low. Hence only four genotypes showed YMD in the range of 0.44% (SKNU-1305) to 1.89% (GJU-15-06).

4.2.3 Oilseeds

Castor

Crop Improvement

RRS Anand

- Three new hybrids were tested against wilt disease in national wilt screening nursery.
- Two new pistillateline ANDCP-15-01 and ANDCP-15-02 were developed.
- 58 new germplsam lines were collected and total 195 lines were maintained for future breeding work.
- For new inbred development programme, 10 new crosses were made and from different generations 201 plants with desired characters were selected.
- Total 71 new crosses were made for hybrid and

25 crosses made last year were tested in different trials.

- Eight experiments including coordinated, state and station trials on castor were conducted.
- The Initial Varietal Hybrid Trial (IVHT) out of 18 hybrids/varieties only JHB 1018 hybrid was recorded significantly higher seed yield than the best check GCH-7 and yield increase was 22.37 per cent over the best check hybrid GCH 7.
- Under Advanced Hybrid Trial (AHT), none of the hybrids exhibited superiority than best check GCH-7 (3447 kg/ha) under both the conditions.
- In Large Scale Hybrid Trial (LSHT), out of nine hybrids tested, four hybrids JHB 1018, JHB 1022, JHB 1013 and SHB 966 were recorded numerically higher yield than check GCH-7.
- In replacement of existing wilt susceptible pistillate line VP-1 trial, out of 12 entries VP-1 based hybrids in comparison to wilt susceptible VP-1 based hybrids. The entry SKN-15-07 noted higher seed yield.
- In Preliminary Hybrid Trial (PHT), out of 37 hybrids,two hybrids viz., ANDCH-13-91and ICH 68 were found significantly superior than the check GCH-7.
- Under Zonal Trial -2 (ZT-2), out of 13, two hybrids viz., SCH 53 and ANDCH-13-17 recorded significantly higher yield than the check GCH-7 with tune of 36.27 and 25.00 per cent than best check hybrid GCH 7.
- In Preliminary Varietal Hybrid Trial (PVHT), out of 14 entries, two hybrids, SHB 1011 and JHB 1050 were found numerically higher yield than the check GCH-7.
- In Preliminary Hybrid Trial (PHT) out of 12 hybrids and two checks, ANDCH-13-25 and ANDCH 14-03 exhibited their superiority than the check GCH-7 with the tune of 17.42 and 4.02 per cent, respectively.

ARS, Sansoli

- In castor, total 71 entries were tested in five different trials including state, zonal and station trials.
- Four hybrids were contributed for wilt resistance at S.K. Nagar, Anand and Indian Institute of Oilseeds Research, Hyderabad for all India level. Among these, SCH 53 hybrid was found wilt resistant and hence, contributed for IVHT trial.
- Sixty eight germplasm lines of castor were evaluated and maintained.
- New germplasm of castor were collected and 68 crosses were evaluated.
- Four hybrids were contributed for yield performance at State Level in PHT Trial. Total seven entries comprising one variety and six hybrids were contributed for evaluation under Zonal Trials.

Crop Production

- At RRS, Anand, In *rabi* castor based intercropping system trial, significantly higher castor equivalent yield was recorded under the treatment castor + chickpea (1:3), which was at par with the treatments of castor + chickpea (1:2) and castor + guar (1:2).
- In experiment on relay cropping of castor with legumes, significantly higher castor equivalent yield was recorded under the treatment of soybean (sowing in first fortnight of July) + Castor (sowing in last week of August).
- At Dept. of Agronomy, BACA, in the experiment on response of castor (*Ricinus communis* L.) to N, P and K under middle Gujarat conditions, result indicated that the seed yield of castor recorded significantly higher under treatment N₂ (100 kg ha⁻¹), which remained at par with nitrogen level N₃ (125 kg ha⁻¹). However, castor stalk yield was significantly increasing with the increasing level of nitrogen from N₁ to N₃, whereas, significantly higher seed yield of castor was obtained with P₂

(50 kg P_2O_5 ha⁻¹) over control, which was at par with $P_1(25$ kg P_2O_5 ha⁻¹).

Mustard

Crop Improvement

RRS, Anand

- Two experiments including co-ordinated and state trials on mustard were conducted.
- One PET trial was conducted.
- In Initial varietal trial (Irrigated) (IVT), out of 30 mustard genotypes, KMR 15-4, PR-2012-9, Divya-88, KM 126, SitaraSringar and RMM 09-10 were found promising.
- Under Large Scale Varietal Trial (LSVT), out of twelve mustard genotypes, SKM -1118 had noted numerically higher seed yield than the best check variety GDM-4.
- In Small Scale Varietal Trial (SSVT), total 14 mustard genotypes were evaluated. The genotypes, SKM 1428 and SKM 1424 had achieved higher yield than the best check variety GDM-4.
- In Preliminary Yield Trial (PET), none of the genotypes were found significantly superior.

Groundnut

Crop Improvement

RRS, Anand

Summer-2016

- Total three crosses were raised in summer 2016 for advancement of generation and in *Kharif* 2016 twelve new crosses were made.
- In summer, 14 entries were bulked and put in PET trial for their evaluation.
- From different generations, total 173 Individual plants were selected and maintained.
- The entry AG-2012-6 was tested in LSVT trial.

- Six experiments including coordinated, state and station trials were conducted.
- Under Initial Varietal Trial-I (IVT-I), outof 15 entries none was found significantly superior.
- In Initial Varietal Trial-II (IVT-II), out of 17 genotypes INS-I -2014-22 was found promising.
- In Large Scale Varietal Trial-SB (LSVT-SB), ten genotypes were evaluated. The entries ICGV-03042, AG-2012-06 and ICGV-07222 were found promising.
- Under Small Scale Varietal Trial-SB (SSVT-SB), out of 18, two genotypes, JB 1381 and JB 1375 recorded higher yield.
- In Zonal Varietal Trial (ZVT) at Anand, Thasra, Jabugam, Thasra and Sansoli out of 21 accessions, AG-2013-14 recorded higher pod yield and were found promising than the best check TG-26 at Anand.

Kharif 2016

- Two experiments of state were conducted.
- In Large Scale Varietal Trial (LSVT), twelve genotypes were tested for pod yield. Genotype ICGV 03043 and ICGV 07222 were found promising.
- Under Small Scale Varietal Trial (SSVT), out of 19 genotypes none was found promising.

4.2.4 Fibre crops

Cotton

Crop Improvement

RRS, Anand

Kharif 2016

- Five experiments including co-ordinated, state and station trials on cotton were conducted.
- In PHT-National Trial (H xB), 8 hybrids including checks were tested. The seed cotton

yield differences were significant among eight interspecific hybrids. Among the eight coded test hybrids, hybrid 815 had recorded the highest seed cotton yield followed by entry no. 818 and 816.

- In the coordinated H x B hybrids trial, CHT (Zonal Trial), total seven coded H x B inter-specific cotton hybrids were evaluated. The comparison of data revealed that the hybrid 6195 had yielded the highest seed cotton yield.
- In the co-ordinated Varietal Trial of *Gssypium barbadense*, total six coded cotton genotypes were evaluated and the genotype 6186 yielded the highest seed cotton yield and lint yield.
- In PVT of *G. barbadense* cotton under irrigated condition, total five *G. barbadense* genotypes were evaluated and the seed cotton yield differences due to genotypes were significant. The genotype 6171 yielded the highest seed cotton yield and lint yield.
- Under Small Scale Varietal Trial (SSVT) total eight *G. barbadense* genotypes including a check variety Suvin were evaluated for their seed cotton yield performance. None of the genotypes yielded higher than check variety Suvin.
- Total 47 germplasm were maintained and utilization in breeding programme.
- 55 new crosses between H x B were evaluated for improving fibre quality along with yield. In Segregating generations, 100 IPS were selected and shelfed for next generations.

In Varietal trials

• In *Kharif* 2016-17, different trials of desi cotton (*G. herbaceum*) including national, state and station trials were conducted for seed cotton yield and fibre quality performance at Viramgam and seven other rainfed locations of Gujarat. The result of MLT, LSVT and SSVT trials revealed that entries *viz.* GVhv 767,GVhv 772,GVhv 817, GVhv 834,GVhv 855, GVhv 864, GVhv 865, GVhv 875, GVhv 881, GVhv 885, GVhv 917 and

AAI

GVhv 938 were found promising for seed cotton yield as well as fibre quality parameters.

- First time in the world, identified male sterile line in *Gossypium herbaceum var. wightianum* and maintained for further use in crop improvement programme.
- During *Kharif* 2016-17, total fifteen trials of *G. herbaceum* were conducted across eight locations including national, state and station trials for yield, yield contributing characters and fibre quality evaluation under rainfed situation of Gujarat. Total 172 entries were evaluated among different trials. Total 1802 progenies were sown of various generations (F_1 - F_6) and promising individual plants were selected from segregating materials. Centre has maintained, characterizing 309 germplasm lines of *G. herbaceum*. This centre has also produced 5235 (ungraded) kg breeder seed of four cultivated desi cotton varieties.
 - At Dept. of Seed Science and Technology, seed and seedling quality performance of 33 cotton genotypes were evaluated in the seed testing laboratory, DSST, AAU, Anand. The seed quality parameters viz., germination (%), seedling length (cm), seedling fresh weight (g), seedling dry weight (g), vigour indices and electrical conductivity were tested. Significant variation was observed in the seed quality of cotton genotypes. The cotton genotypes V-797 recorded 100% seed germination and significantly highest vigour index I (2002). Significantly highest seedling length was recorded by the genotype ADC-1 (21.85 cm), which was at par with the genotype GVhv-918 (20.83 cm), whereas the genotypes GVhv-916 recorded the lowest germination (5.33%).

Plant Protection

Studies on population dynamics of key pests of cotton, surveillance of lepidopterous pests through sex pheromone, survey of insect pests in Bt as well as non-Bt cotton and screening of deshi cotton varieties for their resistance to key pests under rainfed conditions were carried out at Viramgam.

Similarly, survey of diseases of deshi as well as *Bt*.cotton and screening of deshi cotton varieties for resistance to various diseases under rainfed conditions were also carried out at Viramgam.

4.2.5 Cash Crops

Bidi Tobacco

Kharif-2016

Crop Improvement

- In AVT-I, the entry ABD 152 showed significant superiority for cured leaf yield over better checks GT 7 and MRGTH1.
- In AVT-II, ABD 131 showed numerical maximum yield.
- In breeding trial for normal planting, Line ABD 145 showed significant superiority for cured leaf yield over better checks GT 7 and MRGTH 1.
- In breeding bidi tobacco genotypes for early maturity, the cured leaf yield differences among the lines were significant. All the lines showed significant superiority over check A 119.
- In variety assessment trial, GABT 11 gave significant superiority for yield than rest of the varieties and hybrid.
- Breeding for resistance to drought trial, the cured leaf yield differences due to soil moisture regime were non-significant, whereas due to genotypes were significant. Five entries showed significant superiority for cured leaf yield over the checks.
- In evaluation of bidi tobacco hybrids, four hybrids viz; BTH 315, BTH 330,BTH 338 and BTH 340 showed significant superiority for yield over MR GTH 1.

Rustica Tobacco

• In initial varietal trial, the line AR 121 showed significant superiority for yield than checks.

- In AVT I, line AR 126 gave numerical maximum yield.
- IN AVT II, the cured leaf yield differences were non-significant among the genotypes tested.
- In breeding trial for normal planting I, AR 122 showed numerical higher yield over checks.
- The yield differences were significant among the genotypes tested in NP II. The Line AR 137 registered numerical maximum cured leaf yield.

Crop Production

- The results on "Effect of long term manuring on yield and quality of bidi tobacco and soil productivity" revealed that except leaf length, yield and different morphological parameters of tobacco variety GABT 11 were not significantly changed due to different treatments of bulky manures. Similarly, in case of manurial combination, yield and different morphological parameters of tobacco were not significantly affected due to different manurial combination treatments.
- An experiment carried out on "Effect of secondary and micro nutrients on growth, yield and quality of tobacco" revealed that yield and different morphological parameters of tobacco variety GT 7 were not significantly altered due to different treatments of secondary and micro nutrients.
- Experimental results on "Assessment of cropping sequences for bidi tobacco growing area of middle Gujarat agro climatic zone" showed that significantly the highest tobacco equivalent yield and maximum net profit were recorded under Tobacco- Pearlmillet (Summer) cropping sequence than remaining cropping sequences.
- Statistical results on "Assessment of alternate crop sequences for bidi tobacco growing area of middle Gujarat Agro-Climatic Zone" indicated that significantly the highest tobacco equivalent yield and maximum net profit were obtained from

Tobacco-Pearlmillet (Summer) cropping sequence than remaining cropping sequences.

- Statistical results on "Assessment of alternate crop sequences for bidi tobacco growing area of middle Gujarat agro-climatic zone" indicated that significantly higher tobacco equivalent yield, total income and maximum net profit were obtained from Tobacco-Pearlmillet (Summer) cropping sequence as compared to tobacco alone, groundnut with potato and sesamum with potato crop sequences.
- An experiment carried out to revalidate the fertilizer recommendation of widely cultivated bidi tobacco varieties revealed that varieties MRGTH 1 and GT 7 being at par with each other, gave significantly higher tobacco yield and the maximum leaf size as compared to variety A 119. However, bidi tobacco varieties GT 7, MRGTH 1 and A 119 recorded significantly taller plants in descending order, respectively, while, yield and different morphological characters were not significantly influenced by varying levels of nitrogen.

Crop Protection

Entomological Research

- Screening of bidi tobacco genotypes against leaf eating caterpillar (*Spodoptera litura* Fab.) in nursery, out of 779 bidi tobacco cultures / genotypes, none of the cultures / genotypes was found free from infestation due to *S. litura* under natural infestation.
- Evaluation of insecticidal toxicity against tobacco mealy bug *Phenacoccus solenopsis* Tinsley and its parasites & predators under laboratory conditions revealed that the insecticides *viz.*, triazophos 40% EC, azadirachtin 1%, EC imidacloprid 17.8% SL, thiamethoxam 25% WG and buprofezine 25% SC tested against mealy bug and its parasitoids under net house and laboratory conditions were found highly toxic to both.

AAU

• Screening of different *rustica* tobacco lines, against leaf eating caterpillar showed that the population of leaf eating caterpillar was not sufficiently built up and for this reason the nursery remained free from infestation of *Spodoptera litura* (F).

Plant Pathology and Nematology

- In a trial on monitoring resistance development in *Pythium aphanidermatum* to metalaxyl MZ, results revealed that in nursery conditions 26 per cent damping-off disease incidence in metalaxyl MZ applied @ 2.16 kg/ha was recorded in comparison with control. The pathogen, which survived in fungicide treated beds, was further screened in laboratory against the fungicides with three different concentrations and 100 per cent inhibition of the pathogen was observed after 72 hrs. This showed that resistance has not been developed in the pathogen.
- In a trial on screening for resistance to dampingoff and root-knot in tobacco, results revealed that out of 14 genotypes/lines, a line ABD 138 showed moderately resistant reaction to dampingoff disease in the nursery conditions, while all the lines were either susceptible or highly susceptible to root-knot disease in pots.
- Out of 109 genotypes screened, 24 genotypes were found free from root-knot index in root-knot sick field and selected for further screening in the next year.
- In a trial on breeding for resistance to tobacco mosaic in bidi tobacco, results revealed that eighty three (including twenty three mosaic resistant cultures) entries grown in different generations were artificially inoculated with tobacco mosaic virus and evaluated for resistance to mosaic. Out of these, 69 entries including segregating materials showed resistance to the disease and these materials are maintained by plant breeding section for further breeding work.

4.2.6 Forage Crops

Crop Improvement

Rabi-2015-16

Oat (AICRP Trials)

- Under IVT (single cut), the entry HFO-427 gave significantly higher GF yield, DM yield and CP yield barring the entries VOS-15-24 and JHO-15-1 for GF and JHO-15-2 for CP yield. The entry NDO-911 had the highest Crude protein content.
- Under First Advance Varietal Trial (Single cut), the entry SKO-225 gave significantly higher GF yield than other entries and also remained first for per day GF production, while entry OL-1769-1 gave significantly higher DM yield and CP yield. Moreover, it also remained at the top for per day DM yield. The highest Crude protein content was recorded by the entry OS-432.
- Under Second Advance Varietal Trial (Single cut), out of twelve entries, the entry OS-406 gave significantly higher GF, DM and CP than other entries under study. It also stood first for per day productivity.
- In Initial Varietal Trial (Multicut), among 12 entries, the entry OL-1842 produced significantly higher GF and per day GF yields, while entry OL-1867 gave significantly higher DM yield, CP yield and per day DM yield. The entry PLP-19 ranked first for Crude protein content.
- In the second Advance Varietal Trial (Multicut), the entry JO-4-317 gave significantly higher DM and CP yield as well as synthesized the highest Crude protein and per day production.
- In the Second Advance Varietal Trial for seed purpose, the check variety UPO-212 remained at the top for seed yield, per day seed yield, while other check variety RO-19 gave significantly higher straw yield.
- In Initial Varietal Trial for dual purpose, the

entry JHO-15-5 gave significantly higher GF, CP yields and the highest per day GF yield as well as crude protein content, while the entry JO-09-509 gave significantly higher DM yield as well as the highest per day DM yield. The check variety UPO-212 gave significantly higher seed yield, while, the entry OL-1802 gave significantly higher straw yield.

• In Second Advance Varietal for Multicut (Repeat), only one entry was evaluated and it is not found superior than check variety UPO-212, which yielded significantly higher GF, DM and CP and also remained at the top for per day GF and DM yield.

Lucerne

AICRP Trials

• Under Varietal Trial in Lucerne, out of eight entries none of the entries was able to survive for the third year.

State Trials

- In LSVT trial, the entry AL-62 gave significantly higher GF and DM yield and numerically higher CP yield.
- In SSVT trial, the entry AL-80 gave highest GFand DM yield and significantly higher CP yield.

Barley

AICRP Trials

• In Initial Varietal Trial, the yield differences among eighteen entries were found significant. However, for seed yield CV% were found higher due to poor regeneration capacity of particular varieties and aphid susceptibility and hence precise inference can't be drawn. The entry IVTIRTSDP-2 was found significantly superior for GF yield.

Makhhan Grass

• In an evaluation of performance of Makhhan Grass Hybrid, it can be concluded that yieldwise Makkhan grass remained at the bottom. However, it was at par with Lucerne for GF yield. Makkhan grass gave higher GFY in first, second and third cut than Lucerne. Makkhan grass proved promising in producing more number of tillers per plant (16.32) and leaf stem ratio (3.67), which showed its superiority for regeneration power and palatability over other grasses in the present study. Moreover, its maximum plant height was recorded during 2nd and 1st cut and then gradually reduced in subsequent cuts, which showed that the growth of Makkhan grass was maximum in cold environment.

KHARIF-2016

AICRP Trials

Forage Maize

- In Initial Varietal Trial, among thirteen entries, the entry IVTM-11 produced significantly higher GF yield than all other entries except the national check variety African Tall, whereas, the entry IVTM-12 gave higher DM yield than all other entries being at par with entries IVTM-11 and African Tall (NC).
- In combined first and second Advanced Varietal Trial, the entry CAVTM-3 produced higher GF yield than all other entries being at par with CAVTM-4. The said entry also produced higher DM yield than all other entries except CAVTM-4, CAVTM-6 and African Tall (NC).

Forage Pearl millet

• In Initial Varietal Trial, the entry IVTPM-13 gave significantly higher GF yield than all other entries except the entries IVTPM-2 and IVTPM-10. The entry IVTPM-2 produced the highest DM yield among all the entries.

Forage Cowpea

• In Initial Varietal Trial, the entry IVTC-9 produced significantly the highest GF, DM and CP yields

among all the entries.

• In First Advanced Varietal Trial in Forage Cowpea, out of eleven entries AVTC-6 yielded the highest GF and DM and was found significantly superior over other entries barring the check variety GFC-1 for GFY.

Bajra Napier Hybrid

• In Varietal Trial (Perennial), out of twelve hybrids, the entry VTBN-3 gave significantly the highest GF and DM yields among all the entries.

Dichanthium

• Under Varietal Trial, out of ten entries, entry VTD-8 produced significantly higher GF and DM yields than all other entries barring the entry VTD-6 for both yields.

Cenchrus cilliaris

- In Varietal Trial, among nine entries the entry VTCC-6 gave higher GF and DM yields than all other entries except the entry VTCC-9.
- In Varietal Trial(Perennial), with the check variety GAAG-1, and was conducted at Anand, the entry VTCC-15-4 had produced the highest GF and was found significantly superior to all other entries except the entries VTCC-15-3 and VTCC-15-6 whereas the entry VTCC-15-3 gave significantly higher DM yield than all other entries except VTCC-15-4 and VTCC-15-9.

Cenchrus setigerus

• In Varietal Trial (Perennial), this experiment comprising of ten entries, was conducted at Anand. Five cuts were taken in a period of 390 days. The yield differences were found significant. The entry VTCS-15-8 had produced higher GF than all other entries barring the entries VTCS-15-1, VTCS-15-3, VTCS-15-4, VTCS-15-5 and check variety GAAG-1. The said entry VTCS-15-8 also gave higher DM yield than all other entries except VTCS-15-1, VTCS-15-4 and GAAG-1.

Sehima

• In Varietal Trial in Sehima, three cut swere harvested, but out of seven entries, only one entry VTS-6 survived till date.

Pennisetum hybrid

• Ten entries were tested with three cuts, the entry IGPISH-2 produced significantly the highest GF and DM yields among all the entries.

Bajra x Napier hybrid (Perennial)

• Among Nine hybrids, the hybrid VTBN-1 produced higher GF yield than all other entries except VTBN-6 and VTBN-8,whereas, the entry VTBN-2 gave significantly the highest DM yield among all the entries in pooled.

Desmenthus

• Among six entries, the entry VTD-3 had produced significantly higher GF yield than all other entries except VTD-6. The said entry gave the highest DM yield among all the entries.

Clitoria ternatea (Perennial)

• This is the fourth year of the trial. Three cuts were harvested within a period of 453 days. The yield differences were found significant. The entry VTCT-1 produced significantly the highest GF and DM yields among all the entries.

STATE TRIALS

Forage Maize

• In SSVT Trial, the entry AFM-5 produced significantly higher GF and DM yield than all other entries except the entries AFM-4 and AFM-8.

Forage sorghum

• In SSVT Trial, the entry AFS-67 produced significantly higher GF yield than all other entries being at par with AFS-64 and AFS-68.



- In LSVT Trial, the entry DSF-117 had produced significantly higher GF yield than all other entries, whereas, the entry DSF-123 gave significantly higher DM yield than all other entries barring the DSF-117.
- In SSVT (multilocation) at four locations, the check variety CoFS-29 remained at the top for GF yield and other check variety SSG-59-3 was ranked first for DM yield.
- In LSVT (SC) out of four locations, the entries AFS-53 and E-194 remained at the top for GF and DM yields, respectively.

Forage pearl millet

• The LSVT trial was the highest GF produced by the entry AFB-37 and was found significantly superior to other entries. The said entry also gave significantly the highest DM yield among all the entries.

Crop Production

AICRP trials

In trial on effect of N levels on forage yield of promising entries of oat (AVT-2 SC) results indicated that, treatment V₃ recorded significantly higher green forage yield and remained at par with V₉. Significantly the highest dry matter and crude protein yields were recorded under V₁. Plant height recorded at harvest was found higher under V₉ and it did not significantly differ with V₁, V₃, V₄, V₁₁, whereas number of tillers was recorded significantly higher under V₆ and remained at par with V₁, V₂, V₃ and V₅. Leaf stem ratio was found significantly higher under treatment V₃ and did not differ significantly from V₉

Application of 120 kg N ha⁻¹ recorded significantly the highest green forage, dry matter and crude protein yields. Same trend was recorded with respect to plant height, number of tillers and leaf stem ratio.

• An experiment on studies on carbon sequestration

in perennial grass based cropping systems was conducted. Significant differences were observed in GFY, DMY, CP, Plant height, No. of tillers/ meter row, length and breadth of leaf were found significant due to different cropping systems. Treatment T_1 (BN hybrid at recommended spacing) recorded significantly the highest green forage, dry matter and crude protein yields. Same trend was observed in Plant height, No. of tillers/ meter row, leaf length and leaf breadth.

A trial on effect of different techniques of seed priming on productivity of forage Maize. Treatment T_6 required maximum days for 50% germination compared to all other treatments. Significantly higher germination percentage at 10 DAS was recorded under treatment T_4 followed by T_1 , T_2 , T_3 and T_6 . Same trend was observed in plant height. Treatment T_4 recorded significantly higher green forage yield of maize, which did not differ significantly with T_2 , T_3 and T_5 . With respect to dry matter and crude protein yields treatment, T_4 recorded significantly the highest dry matter and crude protein yields.

State trials

A trial on influence of weed management practices on growth and seed yield of Oat (Avena sativa L.) was conducted. Treatment T_{11} (HW at 20 DAS fb IC at 40 DAS) recorded significantly lower monocot weed, total weed count and weed dry weight was at 30 DAS, but it was at par with treatment T₁₀ [Pendimethalin @ 0.9 kg/ha (PrE) fb HW at 40 DAS]. The same trend was observed at 60 DAS. Application of pendimethalin @ 0.9 kg/ha (PrE) fb HW at 40 DAS (T₁₀) recorded significantly minimum dicot at 30 DAS and it was at par with T₁₁ for recording minimum number of dicot weed at 60 DAS. Yield and yield attributes was significantly influanced by the weed management practices Treatment T_{11} and T_7 being at par and recorded significantly higher seed yield. Straw yield, tillers, plant height and penical length was recorded higher in T₁₁(HW at 20 DAS fb IC at 40 DAS) and it remained at par with T_6 and T_7 .

 An experiment on effect of cutting management and fertility levels on growth and seed yields of multicut fodder sorghum [Sorghum bicolor (L.) Moench] var. CoFS-29 was conducted. Results showed that green forage yield of the forage sorghum var. CoFS-29 recorded significantly the highest in C₃ treatment (two cut for GFY at 50 days interval) in both cuts. The same treatment recorded significantly the highest seed yield and test weight. Plant population per meter row, plant height and number of tiller per plant did not affect by cutting management.

Application of 160 kg N/ha recorded significantly the highest green forage, seed and straw yield as well as test weight, plant height and number of tillers. Application of phosphorus did not exert significant variation in yield and yield attributing characters except seed yield. Significantly the highest seed yield was found with application of 60 kg P/ha.

Interaction effect between cutting management and nitrogen was found significant with respect to green forage yield of 1st and 2nd cut, seed yield and straw yield, whereas CxP was found significant only in GFY of 2nd cut. Combined effect of nitrogen and phosphorus were found non significant in all parameters. Combination of CxNxP was found significant with respect to seed yield only.

A trial on influence of nitrogen levels on yield and quality of guinea grass was made. Variety V₁ (GG-9-1) was found significantly superior than V₂. It produced significantly higher total GFY, DMY and CPY. Plant height and number of tillers/plants was also found highest with the same variety.

Application of 25 kg N/ha was found significantly superior than higher dose of nitrogen i.e., 50 and 75 kg N/ha in yield and yield attributing characters in all parameters except plant height.

Interaction between VxN was found significant with respect to DM and CP yields only. Significantly highest DMY and CPY was observed in treatment combination V_1N_1

An experiment on effect of boron and cutting management in seed production of Lucerne influence was conducted. Application of boron did not induce any significant difference on Green forage yield, dry matter yield, crude protein yield, plant height as well as number of tillers per meter row length. Significantly the highest seed and straw yield was registered under treat B_2 (0.04 %) compared to other treatments. Test weight of Lucerne was also recorded higher with same treatment, but it did not differ significantly from $B_1(0.02\%)$

Green forage, dry matter and crude protein yields of the Lucerne were found significantly the highest under treatment C_4 (Last cut at 2nd week of March & leave for seed production) compared to other treatments. Significantly the tallest plant was recorded under treatment C_1 , whereas number of tillers was recorded significantly higher under C_4 treatment and it remained at par with treatment C_3 . Seed and straw yield of Lucerne as well as test weight was also recorded significantly the highest under treatment C_1

Interaction effect between boron levels and cutting management was found significant with respect to straw yield. Treatment combination B_2C_1 recorded significantly the highest straw yield compared to all other treatment combinations.

4.3 HORTICULTURAL CROPS

4.3.1 Vegetables *Kharif – Rabi:* 2016-17

Brinjal

Crop Improvement

• In brinjal crop, 11 experiments were conducted (five trials of state and six trials of AICRP) during



kharif and *rabi* seasons. So far as evaluation of germplasm is concerned, 200 germplasms were maintained and 10 new germplasms were collected.

• For heterosis breeding, 10 fresh crosses were made as well as 20 crosses were made for ongoing programme. Total 210 germplasms were evaluated and maintained. Moreover, 299 segregating progenies were evaluated and individual plant selections were made for the next year.

Chilli

Crop Improvement

- Seven trials (Four trials of state and three trials of AICRP) were conducted.
- For heterosis breeding, 05 fresh crosses were made as well as 18 crosses were made for ongoing programme. Total 122 germplasm lines were maintained. Five crossed were made for hybrid evaluation. Total 278 segregating progenies were evaluated and individual plant selection was made for the next year, out of which 1 CMS line and 6 GMS lines were maintained.

Tomato

Crop Improvement

- In tomato, 12 experiments were conducted, which include six state trials and six AICRP trials.
- Total 58 germplasm lines were maintained and evaluated. Seven fresh crosses were made for hybrid evaluation. In all, 161 progenies of segregating materials were evaluated and individual plant selection was made for the next year.

Pulses

- Four state trials of clusterbean were conducted during *kharif* season.
- Total 99 germplasm lines of cowpea, Indian bean and valor were maintained and evaluated.

Potato

• Total 68 germplasm lines were maintained and evaluated.

Summer and Kharif-2016

Bottle gourd

- Four trials were conducted including two state trials and two AICRP trials during *kharif* and summer season.
- Total 168 germplasm lines were maintained and evaluated. Ten fresh crosses were made for hybrid evaluation.

Muskmelon

- Three trials were conducted including two state trials and one AICRP trial during *kharif* and summer season.
- Total 125 germplasm lines were maintained and evaluated.

Ridge gourd

- One trial was conducted during *kharif* season.
- Total 149 germplasm lines were maintained and evaluated.

Sponge gourd

- Two trials were conducted including one state trial and one AICRP trial during *kharif* and summer season.
- Total 63 germplasm lines were maintained and evaluated.

Cucumber

- Two state trials were conducted during *kharif* and summer season.
- Total 174 germplasm lines were maintained and evaluated. Five fresh crosses were made for hybrid evaluation.



- Eight trials were conducted including six state trials and two AICRP trials during *kharif* season.
- Total 367 germplasm lines were maintained. Thirty five cross were made for hybrid evaluation. Total 191 segregating progenies were evaluated and individual plant selection was made for the next year.

4.3.2 Medicinal and Aromatic Plants

Crop Improvement

Isabgul

Crossing programme in Isabgol

- Todevelopmalesterilelineanditsmaintainerin2016-17 in Isabgol sib mating programme was carried out in 108 male sterile plants in 12 different lines, 50 to 80 percent male sterility was recorded.
- 2 Ball type, Tetraploid and wheat mutant were used as male parent to cross with normal female sterile plant. .

Following experiments in isabgol were conducted during the year 2016-17.

AICRP trials

- AVT I: Advanced Varietal Evaluation trial of MLT for Isabgol (Medium maturinggroup-120 days)
- AVTII: Advanced Varietal Evaluation Trial of MLT for Isabgol (Early maturing Group 90-100 days)
- Advanced Varietal Evaluation Trial (AVT-II) of MLT for Isabgol (Early maturing group90-100 days)
- Initial Varietal Evaluation trial (IVT) of MLT for Isabgol (Medium maturing group-120 days)

State trials

• PET: Evaluation of early Genotype of Isabgul

In this experiment, early genotypes of Isabgol

showed significant variation for seed yield and it came to scrutiny that genotype AOP 6 performed significantly (850.52 kg/ha) posing the highest per day productivity (8.77 kg/ha/day) among the early genotypes, while DPO 186 provided significantly higher yield (1073.92 kg/ha) along with superior per day productivity (8.75 kg/ha/day) among the late genotypes. It was also observed that none of the genotypes under testing could out perform the standard check variety GI 2, which recorded 1253.65 kg/ha seed yield with highest 10.26 kg/ ha/day productivity.

Ashwagandha

• During the experimental period AWS 1(2B) was found promising.

Following experiments in Ashwagandh were conducted during the year 2015-16.

AICRP trials

AVT II: Evaluation of promising lines of Ashwagandha (Early maturing group i.e. annual type)

Crossing programme in Ashwagandha

In Ashwagandha, 60 different accessions were maintained.

- Total 80 fresh crosses were made for hybrid evaluation and out of these 75 crosses are retained.
- 44 F₁ lines were grown and shelfed for further breeding programme
- 60 F₂ progenies were grown and selected plants were shelfed for further breeding programme.

Aloevera

• One state trial on evaluation of Aloevera accessions was conducted during the year 2016-17 in which, the proposed variety, GAKP 1 yielded 106.40 t/ ha fresh leaf, which is 44.11% and 25.75% higher than checks Anand local and Kutch Selection,



respectively. Similarly, this variety yielded 62.79 t/ha mucilage, which was 57.72 and 38.36% higher than checks Anand local and Kutch Selection, respectively. Further, the proposed variety GAKP 1 produced 23.29 kg/ha Aloin-A, which was 105.92 and 109.26 per cent higher over both the checks Anand local and Kutch Selection, respectively.

Senna

- One AICRP trial on Evolution of promising genotypes of Senna (MLT) was conducted during the year 2016-17.
- Maintenance of Gujarat Anand Senna 1 is continued as per selected breeding method and maintained for genetic purity.

Safed musali

• One AICRP trial on Evolution of promising genotypes of *Safed Musli* (MLT)was conducted during the year 2016-17.

Turmeric

 Under AICRP Trial, among the genotypes evaluated in IET trial, the genotype evaluated ACL 15 recorded maximum fresh rhizome yield and it was followed by GNT-1 and *Suvarana* (52.04 t/ ha).

Asalio

• IET trial on evaluation of promising lines of *asalio* in MLT (AVT II)

Basil

• MLT–IET evaluation of promising lines of basil for high yield and quality

Kalmegh

• MLT-IET evaluation of promising lines of *kalmegh* for yield and quality

Crop production

Following experiments were conducted on different crops during the year 2016-17.

- A trial was conducted on effect of irrigation schedule (IW/CPE ratio) on dry biomass yield of Dodi. Significantly higher dry biomass yield was recorded under treatment 1.0 IW/CPE ratio. It was at par with treatment 0.8 IW/CPE ratio.
- An experiment was conducted on effect of different levels of nitrogen and phosphorus on drybiomass yield of Dodi. Significantly higher dry biomass yield was found under application of nitrogen 200 kg/ha which was statistically at par with application of 150 and 100 kg N/ha. Significantly highest value of dry biomass yield was recorded in the application of phosphorus 25 kg /ha.
- An experiment was conducted on effect of different organic manures and nitrogen levels on yield of vernonia (Kalijiri). Significantly highest seed yield was recorded with application of FYM @10 t/ha in both the years as well as in pooled results, whereas, where nitrogen level is concerned, significantly highest seed yield was obtained with application of nitrogen @ 50 kg/ha during both the years as well as in pooled.
- A trial on effect of organic manures on yield and qulity of Tulsi (*Ocimum sanctum*) was conducted. Significantly higher dry biomass yield of tulsi crop was observed under application of FYM @ 15 t/ha.
- A trial on effect of different spacing and date of planting on dry biomass yield of Artemisia (Artemisia annua Linn.) was conducted. Significantly higher dry biomass yield of artimisia crop was observed under treatment of D4: 3rd week of December with S1 :60 cm x 60 cm spacing.

4.3.3 Fruit crops

Department of Horticulture, BACA

Following eight field trials were conducted during the year 2016-17 on different horticultural crops. Out of these, two trials were on flower crops.

Sr.

No.

2

Pomegranate

Name of

Cross

17.

Citrus

•	Following crosses	were
	2016-17.	

in mango cv. Kesar

Allahabad Safeda

Crop Improvement

G-137 x	06
Mridula	

Cross

Seedless lemon X Acid lime

Acid lime X Seedless lemon

College of Horticulture

Following experiments were conducted during the year 2016-17.

Horticulture

- i. Effect of spacing on production of Capsicum in open ventilated poly house
- ii. Effect of nitrogen and phosphorus on growth, flowering and yield of gladiolus (Gladiolus grandiflorus L.) cv. American Beauty under middle Gujarat Agro climatic conditions
- iii. Nutrient management through organics in onion (Allium cepa L.) as intercrop in sapota orchard Growth Dimension and Change in Cropping Pattern in Gujarat

Plant Pathology

- i. Management of citrus gummosis (Phytophthora citrophthora).
- ii. Bioefficacy and phytotoxicity evaluation of XLC 750 against powdery mildew of mango.

Entomology

i. Bio-efficacy of different insecticides against leaf webber infesting mango.

Post Harvest Technology

- i. Development of whey based RTS fruit beverage from musk melon and lime.
- ii. Development of technology for production and preservation of Moringa oleifera (Drumstick) fruit pulp.

Agril. Engineering

i. Integrated land and water resources management in the Panam canal command for maximization of net annual return

4.3.4 Floriculture

Following two field trials were conducted during the year 2016-17 on flower crops.

(Rosa damascena L.)

under net house conditions

Gujarat agroclimatic conditions

(Manilkara achras L.) cv. Kallipatti

1

5

Effect of plant growth regulators on growth,

2 Effect of integrated nutrient management on

chrysanthemum (C. coronarium L.) cv. Local

3 Comparative performance of leafy vegetables

4 Effect of rejuvenation on growth, yield and quality

in old orchard of mango cv. Rajapuri under Central

Effect of different organic manures and PGPR

consortium on growth, yield and quality of sapota

6 High density plantation and canopy management

7 High density plantation and pruning in guava cv.

8 Effect of different spacing on growth & yield of capsicum under open ventilated poly house

Following cross were made during the year 2016-

Number of

plants in beg

00

made during the year

Number of

plants in

nursery

10

01

Number of plants

in field

01

flowering and flower yield of Deshi Red Rose

growth, flowering and flower yield of annual white



- Effect of plant growth regulators on growth, flowering and flower yield of Deshi Red Rose (*Rosa damascena* L.)
- Effect of integrated nutrient management on growth, flowering and flower yield of annual white chrysanthemum (*C. coronarium* L.) cv. Local

4.4 PESTICIDE RESIDUES, AGRIL. ORNITHOLOGY, PLANT PROTECTION AND MICRONUTRIENTS

Pesticide Residues

Research work carried out at Pesticide Residue Laboratory during the year 2016-17.

SPONSORED SUPERVISED FIELD TRIALS

• Residue and persistence study of dimethoate 30 EC on cotton

Three foliar applications of dimethoate in cotton (@ 300 and 600 g a.i. ha⁻¹ were given to study the residues in lint, oil, cake and soil and it was found below determination limit of 0.05 μ g g⁻¹ in cotton lint, oil, cake and soil at either dose of application.

• Residue and persistence study of tebufenpyrad 20 WP in/on tomato

Two foliar applications of tebufenpyrad at 20 days interval starting from fruiting stage in tomato @ 100 and 200 g a.i. ha^{-1} resulted in residues of 0.169 and 0.176 µg g⁻¹ in standard and double dose, respectively.

• Residues and persistence study of flonicamid 15% + fipronil 15% -WG (UPI 1810) in/on cotton

Two foliar applications of a combination product of flonicamid + fipronil in cotton @ 60 + 60 and 120 + 120 g a.i. ha⁻¹ was carried out as per GAP to study the dissipation in leaves and harvest time residues in lint, seed, cake, oil and soil. Flonicamid being systemic insecticide dissipated at relatively slower rate in/on cotton leaves. At harvest the residues were below determination limit of 0.02 $\mu g g^{-1}$ in seed, cake, lint and soil and 0.05 $\mu g g^{-1}$ for oil. Fipronil, being contact insecticide, dissipated at relatively faster rate with biphasic mode in/on cotton leaves. At harvest, the residues were below determination limit of 0.005 $\mu g g^{-1}$ in lint, seed, cake and oil. However, in soil 0.005 and 0.028 $\mu g g^{-1}$ residues were detected at standard and double dose, respectively.

• Residue and persistence study of imidacloprid 350 SC in/on chilli

Two foliar applications of imidacloprid at 6 days interval were made starting from fruiting stage in chilli fruits and soil at 80 and 160 g a. i. ha-1. One hour after the last foliar application, the residues were 0.62 and 1.14 μ g g-1 in standard and double dose, respectively. The levels thereafter declined gradually and reached below determination level on 15th day and 20th day at standard and double dose, respectively. Residues of the metabolite 6-CNA were detected below determination level in all sample collections. The red chilli fruit and soil samples collected at harvest, revealed no residues at either dose of application. The dissipation pattern of imidacloprid was slightly erratic and of biphasic mode. The half-life of standard dose for phase-I (0-3 day) was 2.09, while by omitting 7th day residue level, the half-life for phase-II (3-10 day) was 8.85 days. However, in double dose the half-life for phase-I (0-3 day) and phase-II (3-15 day) were 2.49 and 5.03 days, respectively.

Residues and persistence study of afidopyropen 50 DC in/on brinjal

Two foliar applications of afidopyropen 50 g/L DC @ 50 g a.i. ha^{-1} and 100 g a.i. ha^{-1} on brinjal was carried out as per GAP to study the dissipation in fruits. The initial levels of afidopyropen after last application were below determination limit (BDL) of 0.05 µg g⁻¹ and 0.05 µg g⁻¹ in standard and double dose respectively.

Residues and persistence study of afidopyropen 50 DC in/on cotton

To study the dissipation pattern of afidopyropen

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in cotton leaves, the trial was carried out at AAU, Anand as per GAP, while for harvest time residues in lint, oil, cake and soil the multi-location trials were carried out at AAU, Anand, UAS, Dharwad, MPKV, Rahuri, RVSKW, Gwaliar and UAS, Raichur. At harvest, the residues of afidopyropen were below determination limit of 0.05 μ g g⁻¹ in lint, oil, cake and soil of AAU, Anand samples as well as in all the samples received from other locations.

Residue and persistence study of fluopyram 200 + tebuconazole 200 – 400 SC in mango and soil

In all four sprays of a combination product, fluopyram + tebuconazole were made as foliar application. First two sprays at 10-day interval during flowering stage and after three months, two more sprays at 10-day interval during raw mango fruiting stage were carried out. Residue analysis was performed for mango fruits sampled after third and the fourth spray. Immediately after the third application, 0.123 and 0.213 μ g g⁻¹ fluopyram residues were detected in mango fruits at standard and double dose, respectively.

After the 4th spray the dissipation of the residues for lower dose was biphasic while for higher dose it was monophasic.

In case of raw mango fruits used for pickles, matured fruits and mango pulp, fluopyram and tebuconazole residues were BDL for either dose. Soil samples collected 22^{nd} day after the last spray revealed residues 0.210 and 0.166 µg g⁻¹ of fluopyram and tebuconazole residues, respectively, only at higher dose, but in lower dose it was BDL.

Residues and dissipation of fosetyl Al 80 WP in/ on tomato

Soil drenching of fosetyl aluminium twice @ 2.4 and 4.8 g a. i./L/m² at 7 day interval in tomato revealed residues below determination level in standard dose. For double dose, the residues were below determination level up to the 10th day, which suddenly increased to 0.13 μ g g⁻¹ on the 15th day and declined to 0.07 μ g g⁻¹ on the 20th day. The soil samples collected on 20th day after last application revealed residues below determination level for either dose.

• Residues and persistence study of fluopyram 400 SC in tomato (Second season)

Two soil drench applications of fluopyram in tomato at 15-day interval @ 250 and 500 g a.i. ha⁻¹did not reveal detectable residues in any of the samples analyzed. The soil collected after 15 days of last application revealed residues of 1.19 and 2.85 μ g g⁻¹ in standard and double dose, respectively.

Residues and persistence study of imidacloprid 17.1 SL in chilli

Two foliar applications of imidacloprid @ 80 and 160 g a.i. ha⁻¹at 6 days interval starting from fruiting stage in chilli revealed the initial residues in chilli fruits were 0.62 and 1.14 μ g g⁻¹ in standard and double dose, respectively. The red chilli fruit and soil samples collected at harvest, revealed no residues at either dose of application. The dissipation pattern of imidacloprid was slightly erratic and of biphasic mode. The halflife of standard dose for phase-I (0-3 day) was 2.09, while by omitting 7th day residue level, the half-life for phase-II (3-10 day) was 8.85 days. However, in double dose the half-life for phase-I (0-3 day) and phase-II (3-15 day) were 2.49 and 5.03 days, respectively.

Residue and persistence study of flubendiamide 240 + thiacloprid 240 – 480 SC in/on brinjal

To study the residues and persistence study of combination product flubendiamide 240 +thiacloprid 240 - 480 SC in brinjal and soil, the trial was carried out as per GAP. Two foliar applications of flubendiamide + thiacloprid were given @ 84 + 84 and 168 + 168 g a.i. ha⁻¹at 10 days interval starting from fruiting stage. Flubendiamide residues were calculated as the sum of flubendiamide and its metabolite desiodo. Flubendiamide being non-systemic in nature dissipated at a very fast rate with initial deposits of 0.05 and 0.17 μ g g⁻¹ at standard and double dose, respectively and reached below determination limit on the 3rd day. The dissipation of flubendiamide and its metabolite was very fast, so half-life could not be worked out for both the doses. The dissipation study of thiacloprid in brinjal did not reveal detectable residues in any of the samples analyzed. The soil samples collected after 20 days of the last application revealed residues of flubendiamide, its metabolite des-iodo and thiacloprid below the determination limit of 0.05 μ g g⁻¹ in standard and double dose, respectively.

• Residues and persistence study of flonicamid 50 WG in/on cotton

To study the dissipation pattern of flonicamid in cotton leaves, the trial was carried out at AAU, Anand as per GAP, while for the harvest time residues in lint, oil, cake and soil the multilocation trials were carried out at AAU, Anand, Sriganganagar, PAU, Ludhiana and MPKV, Rahuri. The substance dissipated at the mean rate of 15.15 % per day with a half life of 3.27 days at 150 g a.i. ha⁻¹ dose. The samples of cottonlint, cake, oil and seeds collected at 1st picking and soil samples collected at harvest were below the determination limit in AAU, Anand samples as well as all the samples received from other locations.

State Plan Projects

• Monitoring of pesticide residues from various agricultural commodities:

From January, 2016 to December 2016, total 470 samples comprising vegetables (216), pulses (72), spices (158) and water (24) were collected from market places. The samples were subjected to multi-residue analysis for 144 pesticides. The result revealed presence of pesticides in 88 samples (18.72%). Packaged drinking water did not reveal presence of any of the pesticides tested. In pulses, 2 samples of chickpea and 1 samples of green gram were found positive from each of the

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36 samples, respectively. Among the six different vegetables analyzed, bottle gourd, little gourd, onion and potato samples were quite safe,in which out of 36 samples 2 samples of bottle gourd, 5 samples of little gourd and 2 samples of onion were found positive, while out of 36 samples each of Indian bean and pigeon pea analyzed, 16 and 7 samples were found positive, respectively. In spices, total 158 samples were analyzed, out of that which 53 (33.53%) samples were found positive. Of the 15 samples of cardamom and 32 of cumin, 10 and 29 were found positive, respectively. Out of 32 samples of each of coriander and funnel, four samples of both the commodities were found positive.

• Monitoring of Organic Products

During January to December 2016, total 129 organic products comprising vegetables (92), fruits (7), cereals (9), pulses (9) and spices (7) were collected from market places. The samples were subjected to multiresidue analysis for 144 pesticides. The results revealed presence of pesticides in 3 samples (2.3 %). Among all the vegetables collected, one sample each of capsicum, green chilli and coriander leaves were found positive. All fruits, cereals, pulses, milk and spices samples were free from pesticide residues.

• Status of pesticide residues in vegetable ecosystem

In all, 54 farm-gate samples comprising vegetables (52), fruits (1) and spices (1) were analysed in which both fruits and spice samples were found positive. Out of 52 vegetables samples, 2 samples of little gourd and 1 sample of bottle gourd were found positive.

In order to know the status of pesticide residues in vegetable ecosystem, samples were collected from farmers' field and subjected to multiresidue analysis for 144 pesticides. The results revealed that among the 8 different vegetables comprising little gourd (11), Indian beans (9), bottle gourd AAU

(21), pointed gourd (2), potato (6), smooth gourd (1), sponge gourd (1) and pigeon pea (1), only one sample of bottle gourd and two samples of little gourd were found positive with pesticide residue. One sample each of fruit and spice were found positive with pesticide residues.

• Monitoring of surface and ground water for pesticide residues in the SSP command Phase-I area.

In order to know the status of pesticide contamination in surface and ground water in Vadodara and Bharuch districts of SSP command Phase-I area, 25 samples each as pre- and postmonsoon were collected and analyzed for pesticide residues. None of the samples was found positive with pesticide residue.

Total 50 surface and ground water samples collected from different water bodies did not show presence of any pesticide residue above limit (tested for 144). Thus the surface and ground water in Vadodara and Bharuch districts of SSP command Phase-I is free from pesticide residues tested for.

Monitoring of surface and ground water for pesticide residues in the SSP command Phase-II area

In order to know the status of pesticide contamination in surface and ground water in different regions of Gujarat, 64 samples each pre and post-monsoon were collected from Kheda, Ahmedabad, Gandhinagar, Mehsana, Surendranagar, Banaskantha, Patan and Saurashtra regions and analyzed for pesticide residues. None of the samples was found positive with pesticide residue.

Total 123 surface and ground water samples collected from different water bodies from Kheda, Ahmedabad, Gandhinagar, Mehsana, Surendranagar, Banaskantha, Patan and Saurashtra regions of SSP command Phase-II did not show presence of any pesticide residue above detection limit (tested for 144). Thus the surface and ground water in Vadodara and Bharuch districts of SSP command Phase-II is free from pesticide residues tested for.

Monitoring of pesticide residues at National level (Sponsored by GOI)

National level monitoring project is sponsored by Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. There is a network of 23 laboratories all over the country. Pesticide Residue Laboratory, A.A.U., Anand is one of the laboratories involved in market sample analysis of fruits, vegetables, pulses, cereals, spices, spice powder, milk and water.

In all, 1011 samples comprising vegetables (396), fruits (128), seed spices (211), cereals (144), pulses (72), milk (36), and surface water (24) were collected from market places of different towns/ cities of Gujarat. Out of 396 vegetable samples analyzed, 83 (21%) were found positive for as many as 30 pesticides; however, only 20 samples (5%) violated MRLs. In case of fruit samples (128), only 18 (14%) were found positive for 15 pesticides and 4 (3%) sample exceeded the MRLs. In spice samples (seeds, fruits & berries, powder) (211), comprising cumin, fennel coriander, cardamom, fenugreek, black pepper, ginger powder and dry red chilli, 103 (49%) were found positive and 32(15%) violated the MRL. Cereals (wheat & rice- 144 samples) were relatively safe from residue point of view as only 8 samples (6 %) were found positive and two exceeded the MRL. As no MRLs are available for most of the spices (coriander, fennel, cardamom, fenugreek, black pepper, ginger powder and dry red chilli) in FSSAI, MRL violation could not be worked out. Pulses (72), Milk (36) and surface water (24) samples were absolutely free from pesticides (below LOQ).

In all 189 samples comprising vegetables (180), fruits (8) and Spices (1) samples were collected directly from different farms of different villages/ towns/cities of Gujarat. The samples were subjected to multiresidue analysis for 144 pesticides. Out of 180 vegetable samples analyzed, 86 (48%) were found positive for as many as 28 pesticides. Out of these samples 48 samples (27%) violated MRLs. In case of fruit samples (8), 1 sample was found positive. One sample of spices was analysed and was found positive for pesticides. As FSSAI MRLs are not available, MRL violation could not be worked out.

In all, 114 samples comprising vegetables (88), Cereals (5), Fruits (7), Pulses (9) and Spices (5) were collected directly from markets of different villages/towns/cities of Gujarat. The samples were subjected to multiresidue analysis for 144 pesticides. Out of 88 vegetable samples analyzed, 2 (2%) samples were found positive for as many as 3 pesticides. Out of these samples, 1 sample (3%) violated MRLs. In spices, out of 5 samples 2 (40%) were detected positive for 8 pesticides. MRLs are not established for spices power in FSSAI, hence violation could not be worked out. Cereals (5), Fruits (7) and Pulses (9) were free from pesticides.

Agril Ornithology

Following research work was carried out in the project of Agril Ornithology.

• Monitoring of bird population in wetlands of Gujarat

Waterfowl census was carried out on 125 important wetlands of Gujarat state in January-February 2017. Total 6,04,575 birds were recorded on 82 sites belonged to 105 bird species. Amongst 16 diverse groups recorded, the biggest group was Geese & Ducks (1,98,406 birds) followed by Rails, Gallinules & Coots (1,91,278 birds) and Shorebirds-Waders (1,01,978 birds).

• Evaluation of bird predation on honey bees/ pollinators

On an average 7.6 and 4.67 number of

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honey bee (*A. melifera*) were consumed by green bee-eater and black drongo, respectively. Mean number of prey per pellet (97 pellets) ranged from 2 to 24 with an average of 12.28 ± 6.86 . The proportion of identified prey items was: hymenoptera (85.81 %) > odonata (7.56 %) > coleoptera (6.63 %).

• Effect of roosting of Rose-ringed Parakeet on agricultural crops

Mean percent earhead damage of five fields at 5-6 & 6-8 km distance from the roosting site were 27.9 ± 12.22 and 9.1 ± 2.70 %. Surface area damaged (%) were calculated as 1.05 and 0.79 by using polynomial equation of damage assessment method.

• Community structure of birds in Groundnut crop fields of Saurashtra region

Total 34 species and 774 birds were recorded from five districts by visiting 40 transect sites during 21-09-2016 to 24-09-2016. Maximum species diversity index was observed in Junagadh district. (2.69) and minimum index was recorded in Botad (1.95).

• Identification of breeding sites (Heronry) of Cattle Egret in Gujarat

Total 81 heronries in 13 districts, recorded in previous years were geocoded and mapped. Total number of Cattle egret nests was 9359, which formed 42.69 % of total nest record. Most of the colonies were close to the human habitation (84%) and in proximity of water body (72.84%).

• Identification of breeding colonies of Painted stork in Gujarat

About 64 nesting sites of Gujarat state were surveyed. Active breeding colonies were recorded in only 10.93 % of previously recorded sites. Colony distribution map is prepared. Many of the colonies started with onset of monsoon but were deserted later due to in-sufficient rain.



Identification of breeding colonies of Openbilled Stork in Gujarat

Total 35 nesting sites from 12 districts of Gujarat are reported & presented in GIS map. Total number of nests of Open-billed Stork recorded was 890 nests. Highest number of nests were recorded at Bharuch (350 nest) followed by Atul (150) and Navasari (140) colony.

• Ecological significance of wild fleshy fruit trees for conservation and management of depredatory and predatory birds: Indian sandalwood, Santalum album

Total 3 species of birds were recorded foraging on *Santalum album* berry fruit. Average 0.667 birds foraged on Sandalwood tree. The most abundant species was Indian Koel (0.511 birds), followed by Red-vented bulbul (0.122 birds/tree).

- Adaptive research on bird management techniques
 - Demonstration of bird management techniques in Bajra crop at Gopalpura village, Anand
 - Demonstrated Pigeon control techniques in houses and offices
 - Distribution of sparrow nest boxes throughout year

• Monitoring of breeding performance and population status of Sarus Crane

Population: During May-June 2016, total 1189 Sarus Cranes were counted from the state. Highest number of Cranes was recorded at Gobarapura talav (290 cranes) followed by Saroda (101) and Vank (86). Out of total 1189 cranes sighted, there were 370 adults and 19 pairs with 14 juveniles, whereas 771 cranes could not be categorized. The geo-coded data map is prepared.

Breeding performance: A survey was conducted to determine distribution of the territorial breeding pairs of the Sarus Crane in Anand-Kheda district.

Total 258 cranes were recorded in which only 12 birds were juveniles. The Adult: juvenile ratio was 1.0: 0.048. Out of 24 pairs seen, 14 pairs were without any juvenile suggesting breeding failure; 8 pairs were with one juvenile, whereas 1 pair had two juveniles with them.

• Documentation of Wetland Biodiversity in selected agro-ecological regions of Gujarat

Avian Diversity: (A) shift in wintering ground of cranes: A shift in wintering ground of cranes was noticed. Once abundant in Saurashtra region, the wintering cranes have shifted to central Gujarat. This shift is probably due to a shift in cropping pattern and availability of canal waters. B) Breeding record of Slender-billed Gull and Caspian Tern: Nesting of Slender-billed Gull and Caspian Tern was confirmed in the third consequent year in Bhavnagar district.

Diversity of Freshwater Fishes of Central Gujarat: Two more freshwater fishes were identified, making our record to fifty one species.

Odonate diversity of Gujarat: Odonates diversity was studied in Kachchh, Saurashtra and north Gujarat during 2016. Total of 27 species were recorded from Kachchh and 38 each in Saurashtra and north Gujarat. Now, total Odonate species recorded from Gujarat is eighty two (82).

• Monitoring of Flamingos breeding ground in Rann of Kachchh

During monsoon, certain area of Little Rann got inundated for a longer time and considerable quantum of rain during August and September led to partially successful breeding of Lesser Flamingos. Field survey and satellite imagery indicated that flamingos bred only in the Little Rann, west to Vachchhraj Solanki *bet*, south to Nanda *bet* in LRK. This was physically confirmed.

Biocontrol

Total fifteen experiments were conducted at Biocontrol Research Laboratory, including eleven AICRP trials and four state trials Research carried out during the year is as under:

• Biodiversity of biocontrol agents from various agro ecological zones

The activity of biocontrol agents were monitored during *kharif* and *rabi* season in different crops. With a view to know the activity of egg-parasitoid *i.e., Trichogramma* species, sentinel cards with eggs of *Corcyra cephalonica* were placed in various crops *i.e.*, tomato, groundnut, maize, cotton, castor, okra and observed for egg parasitism. The diversity of *Chrysoperla*, coccinellids, spiders, antagonistic bacteria-*Bt*, entomopathogenic nematodes (EPN) was studied.

• Survey and monitoring of papaya mealy bug *Paracoccus marginatus*

Survey for ascertaining the outbreak of mealybug was carried out at farmers' fields in Anand, Kheda, Vadodara, Chhotaudepur and Sabarkantha districts during the entire year. Only trace incidence has been reported in the surveyed fields. The parasitoid *Acerophagus papayae* was noticed parasitizing mealy bug.

• Bio-efficacy of microbial insecticides against *Spodoptera litura* in cabbage

Experiment of cabbage was laid out during Rabi 2016. Sufficient pest infestation was not found in experimental area. Hence, the experiment will be concluded next year by conducting the experiment under laboratory conditions.

• Biological control of chilli anthracnose disease

Seed treatment, seedling dip and foliar spray of *Pichia guilliermondii* (Y12) resulted in low anthracnose disease intensity (6.23 %) and higher yield (83.27 q/ha) and this treatment was found at par with the treatment of *Pseudomonas fluorescens* with disease intensity (6.58 %) and yield (79.99 q/ha).



Treated



Untreated

Survey and surveillance of American pinworm, *Tuta absoluta* on tomato

In the year 2016-17 regular survey was conducted in Anand, Vadodara Chottaudepur and Sabarkantha districts to assess the incidence and damage by *Tuta absoluta* in tomato crop. During the survey the *Tuta absoluta* moth catches were recorded and no damage symptoms were found on the crop.

Biological suppression of American pinworm, *Tuta absoluta* on tomato

During the year 2015-16, lower leaf and fruit damage was observed in the treatment Azadirachtin 1500ppm @ 2ml/liter, followed by the treatment *Beauveria bassiana* @ 4g/ liter (2x10⁸cfu g⁻¹) and (*Trichogrammaachaeae* @ 50000/ha release - 6 releases). However, the lowest leaf and fruit damage was recorded in chemical treatment Indoxacarb @ 2ml/liter. During the year 2016-17 the pest incidence was not recorded in the experimental field. Micronutrients

Brief results of the work carried out during the period under report are given below.

- In Nutrient indexing of micro- and secondary nutrients deficiency in rice-wheat growing area of middle Gujarat. The soil and leaf samples were collected at critical stage as well as grain and straw of rice and wheat were collected at harvest.
- Significant improvement in grain, straw and total yields of *bajri*, mustard and cowpea crops were noticed due to application FYM under intensive cropping.
- The significant effect of Zn and B application at different rate and frequencies were observed on maize-wheat and groundnut-cabbage crops respectively under phasing trial.
- In the study of bio-toxic effects of heavy metals on animal-human health, the soil and plant samples were collected further, animal and human blood samples will be collected with the help of respective collaborative partners.
- The soil categorized under low, medium and high group to find out the critical limit of Ni and will be started in *rabis*eason.
- After screening four multi heavy metal tolerance isolates *viz. Pseudomonas azotoformans, Bacillus infantis, Bacillus megaterium, Micrococcus terreus,* new technical programme has been conducted to assess the efficacy of heavy metals tolerant native bacterial culture for bioremediation of heavy metals using multi-cut forage sorghum.
- Under the assessment and characterization of micronutrient contents and heavy metals accumulation in different vegetables grown in industrial and peri urban areas in Gujarat, vegetable samples were collected from different locations of markets and were analyzed for micro and heavy metal contents.
- Under the assessment of organic and inorganic

nutrient supply system on yield and quality of crops under different crops/ cropping system, experiments were conducted on wheat, gram and sapota at different locations.

- The Soyabean crop was grown to evaluate the comparative efficiency of S containing fertilizers as source of plant available sulphur.
- To assess the efficacy of sulphur and zinc containing complex fertilizer for maximizing yield and quality through balanced nutrition of mustard crop. The result revealed that all the treatments, containing S and Zn were found to improve mustard grain yield significantly over no S and Zn *i.e.*, respective controls.
- Under the evaluation of Efficacy of Sulphur and Zinc containing Complex Fertilizer for Maximizing Yield and quality through Balanced Nutrition of Groundnut Crop, the significantly highest pod yield of groundnut was recorded due to application of T4 (NPSZN) in which N, P, S and Zn were applied through the conventional source.
- The beneficial effects of S, Fe, Mn and Zn were demonstrated under FLD to the tribal farmers and organized farmers day and several farmer shibirs to advocate the technology developed by the department.
- Total 6684 (23843 total readings) soil /plant /feed /fodder /blood /effluent /fertilizers samples have been analysed and recommended/suggested to the farmers/ PG students/entrepreneurs /private agencies etc. accordingly.

Agril. Entomology, BACA, AAU, Anand and Vaso

Following research work has been carried out during the year.

• For Bio-efficacy and damage caused by *Spilosoma obliqua* in cowpea the treatments of thiodicarb 75 WP 0.15%, indoxacarb 15.8 EC 0.0145% and emamectin benzoate 5 WG 0.0025% were found effective in checking the incidence of *S. obliqua* in cowpea, which reflected on yield.

- Significantly lower population of aphid was found in the treatment of flonicamid 50 WG 0.075% which was at par with clothianidine 50 WDG 0.02%, carbosulfan 25 EC 0.04% and thiacloprid 24 SC 0.02% having 8.14, 8.38 and 8.68 aphids per twig, respectively. These treatments produced seed yield of 7.65 to 7.54 q/ha.
- Among the different treatments, chlorantraniliprole 20 SC 0.006%, flubendamide 48 SC 0.015%, indoxacarb 15.8 EC 0.015% and emamectin benzoate 5 WG 0.0025% were found effective in checking the capsule damage caused by *D.punctiferalis*. These treatments produced 22.22 to 23.89 q/ha yield of castor seeds.
- The flower and boll damage was found lower in treatment of 60 pheromone traps/ha followed by 50, 40 and 30 traps/ha. These three treatments of pheromone registered higher moth catches and yield of seed cotton.
- The foraging activity of different honeybee species viz., Apis dorsata, A. florea, A. mellifera, A. cerenaindicaand Trigonaa sp. was observed on different crops viz., sunflower, damro. castor, lucern, waterlily, green gram, coriander, sesamum, cotton, shankhpushpi, maize, golden rod, gaillardia and mustard throughout the year. It was found that there was no activity of honeybees in any of the crops at 6 hr in the morning. The foraging activity was found between 8 to 16 hr on different crops during crop season. The maximum activity of different species was observed between 10 to 12 hr on most of the crops, while in case of shankhpushpi, the activity was found only between 8 to 12 hr. Among different crops, the maximum foraging activity was found on shankhpushpi by A. florea.

Plant Pathology, BACA, AAU, Anand

Studies on identification of source of resistance in vegetable crops for certain diseases, monitoring of seed-borne diseases, determination of host-range of bean common mosaic, standardization of bio-priming for seed borne diseases and management of early

blight of potato were carried out.

In addition to the above, facilities for mushroom cultivation and studies on epidemiology and management of yellow mosaic virus of pulses and vegetable crops have been strengthened.

Achievements

• Rapid and reliable techniques for detection of pathogens has been developed. Detection of conidia of *Alternaria burnsii* from cumin seeds by seed washing method:

Cumin seed samples (ten) were collected from blight infected field, and mixed together to have one uniform seed lot. Flasks (50 ml) containing one gram seed and 10 ml distilled water was shaken for 10 minutes to separate fungal conidia from the seed. Then, aliquot from each of the flasks was centrifuged for 10 minutes at 2000 rpm. Supernatant was decanted leaving the sediment at the bottom of the centrifuge tube. Sediment was suspended into one ml water. Suspension was examined in microscope to count the conidia. Conidia were transfered to PDA plates to test conidial viability. However, this method is relatively quick, but only surface (externally seed borne) borne conidia can be detected.

- Effective management of cumin blight (*Alternaria burnsii*) has been achieved through three sprays of azoxystrobin, 0.025% after initiation of the disease at 10 days interval resulting in minimum disease intensitywith highest seed yield 592 kg/ ha.Moreover, the azoxystrobin, 0.025% has also controlled the post-association of *Alternaria burnsii*, which affects the cumin seed quality.
- Investigation on analysis of farmers saved seed samples indicated alarming association of *Aspergillus flavus* and *A. niger* with groundnut in Gujarat.
- Management of seed associated *Fusarium* oxysporum f.sp. ciceri and Macrophomina phaseolina in chickpea was achieved through

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seed biopriming for 10 hrs. with suspension of talc based formulation $(2x10^8 \text{ cfu/g})$ of *Trichoderma harzianum* AAU isolates @ 50 g in 250 ml of water/kg of seed + soil application of *T. harzianum* enriched FYM (10 g *T. harzianum* / kg FYM) @ 100 g /m² of soil/furrow resulting in maximum vigour index (7624) with minimum disease incidence (13.67%) having highest yield 1354 kg/ ha,which was followed by seed biopriming for 10 hrs. with suspension of talc based formulation (2x10⁸ cfu/g) of *Trichoderma harzianum* PAU isolates @ 50 g in 250 ml of water/kg of seed as compared to treated check and untreated check.

- Fifty varieties /germplasm of mungbean screened against BCMV, 25 genotypes (at Anand) and 11 genotypes (at Derol) showed 1.0 to 10.0% disease incidence. The per cent disease incidence ranged from 0.20 to 20.83% and 4.17 to 36.67% at Anand and Derol location, respectively.
- To know the status of cumin diseases on farmers' fields, field survey was undertaken in the cumingrowing districts of Gujarat during Rabi 2015-16. The major cumin disease observed was blight. Of the 109 fields surveyed, 67 fields showed percent blight index in the range of 1.0 to 4.5%.
- Significantly lowest early blight disease index 0.98, 1.25, and 1.82 was observed at 1st, 2nd& 3rd sprays. Seed (tuber) treatment with mancozeb, 1kg/100 kg potato + 5.0 kg talc powder as dry seed treatment to cut tubers before 12 hrs of planting) + first spray of propiconazole 25 EC, 0.025% (25 g a.i/ha), second spray of azoxystrobin 23 SC, 0.025% (69 g.a.i/ha) and third spray of propiconazole 25 EC, 0.025% (25 g a.i/ha) with significantly highest tuber yield of 31.83 t/ha.
- Lowest mungbean root rot incidence (14.37%), highest shoot length (9.21cm), highest vigour index (1143) and highest grain yield (827 kg/ha) was found in seed treatment with *T. viride* (10⁸ cfu/g) @ 10 g/kg seeds and *P. fluorescens* (10⁸ cfu/ml) @ 10 ml/kg seeds.
- DAS-ELISA technique was employed for the

detection of the virus present in different parts of mungbean. The presence of BCMV was detected in complete seed as well as in seed coat, cotyledons and embryo of the seed in variety: Meha with BCMV antisera. The infected tissues gave positive reaction as compared to Negative control (0.126) wherein, O.D. values of 3.362, 3.045, 2.593 and 2.391 were obtained in seeds, seed coat, cotyledons and embryo, respectively.

4.5 CENTRE FOR PLANT BIOTECHNOLOGY

Work carried out at Department of Agricultural Biotechnology during the year 2016-17 is summarized below:

The crops in which research was carried out are Okra, Guar, Desi Cotton, Custard apple, Ocimum, Tomato, Cumin, Rice, and Saffron. The planning was done to carry out crop based research for improvement of yield and quality. Breeding varieties/hybrids for resistance to various biotic (disease and insect resistance) and abiotic stresses (drought and salinity resistance), identification and molecular characterization, cloning of genes for economic traits and development of transgenic plants. Crop-wise research activities carried out at this department under various schemes are given below:

Desi Cotton

- Interspecific hybridization in Cotton.
- Development of colchiploid in desi cotton.
- For SNP development through genotyping-bysequencing technique in desi cotton, 12 genotypes were chemically sheared with two restriction enzymes (rare and frequent cutter).
- DNA library was prepared and library has been sequenced on Miseq platform.

Maize (Zea mays L.)

• 75 Maize genotypes were characterized for 8 morphological and for 8 biochemical parameters



associated with for fodder quality.

- Plant height, stem girth, leaf-length and -width demonstrated positive correlation with green fodder yield per plant.
- All genotypes were also analyzed through SSR markers for diversity study.
- During SSR analysis, a total of 133 alleles from 21 primers were generated with mean PIC value, 0.58.

Okra

- Screening of wild germplasm of okra for YVMV resistance
- Interspecific hybridization in okra

Kalmegh and Stevia

- LC/MSMS based identification and quantification of major bioactive compound form *Andrographispaniculata* and stevia plants were successfully carried out.
- The developed methods were highly sensitive enough to detect and 8ng/ml andrographolide and 6ng/ml stevioside.

Tomato

- Transcriptome analysis of SL-120 genotype of tomato using Illumina*Mi-Seq* NGS platform for identification root knot nematode resistance gene.
- Gene specific primers were synthesized from Transcriptome data.
- Identification and isolation of 3.7 kb *Mi*gene has been successfully carried out.
- Construct was developed for *Mi gene* under CaMV35 promoter in binary vector.
- Interspecific hybridization in Tomato (Solanumlycopersicum L).
- QTL mapping for nematode resistance in tomato.

Guar

• Development of genomic SSR marker using

Illumina*Mi-Seq* NGS Platform through genome survey sequencing.

• A total of 12 GB of paired-end raw sequencing data, comprising 543745 reads from a 600-700bp insert DNA library, was generated by IlluminaMiseq system.

Cumin

- A total of 16 cumin genotypes including five released varieties were analysed using 10 sequence-related amplified polymorphism (SRAP) markers.
- Mean similarity coefficient was 0.454 while average polymorphism for SSR was found to be 95%.

Rice

- A total of 96 rice genotypes were screened on LCMS-MS for grain secondary metabolites.
- Data on 50% flowering time, plant height, maturity time, seed length-breadth were also collected.
- Same genotype set was also genotyped with 5261 SNP using iScan platform.
- Population structuring on STRUCTURE software identified 5 groups in studied genotypes for further association study.
- Metabolite profiling of 26 phenolic compounds have been carried out in 96 genotypes of rice.

Saffron

- The residues of the previous T1 lines of transgenic maize were properly disposed in presence of members of IBSC committee.
- Rising of T2 lines in contained greenhouse.
- PCR based detection of ZCO gene in T2 transformed maize lines
- Screening of T3 lines has been carried out for detection of *ZCO* and *GLT-2* saffron genes.
- Propagation of transformed seed material for two more generations for stability of gene is under

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progress.

- Development of multi-construct genes cassette of saffron genes both for colour and fragrance is under progress.
- Attempts have been made for development of tissue culture regeneration protocol from immature maize embryo for stable transformation of genes.

Custard Apple (Annona species)

• Interspecific hybridization among various *Annona* species.

Validation/confirmation of hybrid purity of different interspecific hybrids among Annona species.

Liquid chromatography–mass spectrometry technology

• LC-MS/MS method has been developed and validated for quantification of 26 phenolic and 4 carotenoids compounds (Figure 1).

- The method is capable of detecting limit of linearity (Regression coefficient of ~0.99) which showed the linearity and precision of developed method.
- The developed methods are highly sensitive and reproducible to detect compounds at very low concentration.
- Peptides identification from fermented camel, goat and skimmed milk were successfully carried out. The identified peptides were showed anti-hypersensitivity activity which were also confirmed through ACE inhibitory enzyme assay. The reported lactic acid culture and identified peptides can be good candidate culture for fermentation of milk, which, in turn is ultimately useful to treat heart and blood sugar related problems (Figure 2).



Figure 1. Quantification and identification of 14 phenolics compounds through LC/MSMS.



Figure 2. Snapshot of peptide identified from fermented camel milk through LC/MSMS analysis

Transcriptome Analysis

• Transcriptome analysis of resistance SL120 and Susceptible AT-3 tomato varieties were successfully carried out using Illumia platform from both roots and leaves when challenged with nematode inoculation in sick plot. Transcriptome analysis from samples tested from root and leaves of resistant and susceptible plant (Table 1).

- Differential gene expression analysis showed up regulated expression of *Mi* gene in resistance root while it was down regulated in susceptible root and leaf.
- A total of 20.46 million reads were obtained after

Table 1. Details of sequencing reads obtained from resistant and susceptible line

Sample	Total pair-end Reads	Total filtered pair- end reads	Total mapped reads (%)
RL	4944968	4781564	4266029 (89.2)
RR	5078524	4972570	4308812 (86.4)
SL	4594105	4403136	3645569 (82.6)
SR	5846752	5692525	4945561 (86.7)

*RL : Resistant Leaf, RR : Resistant Root, SL : Susceptible Leaf, SR : Susceptible Root

- From all genes identified only disease resistance genes were extracted and heat map was generated. Heat map showed a significant fold change expression in resistance leaf and root sample of SL-120 cultivar.
- Expression of *Mi* gene was not only observed in root but also in leaf, which showed its systemic expression throughout the resistance plant (Figure 3 and Figure 4).

	Experiment	nt Suceptible			Resistance		
Feature ID	Fald the	srl_good (paired)	. sl1_good (paire		rr1_good Expressi	rll_good	Means
	Fold Cha	Expression values	Expression values	Means		Expressi	
late_blight_resistance_protein_R1-A-like-1	21.50	2.00	0.00	1.00	33.00	10.00	21.50
late_blight_resistance_protein_R1-A-like-2	21.50	2.00	0.00	1.00	32.00	11.00	21.50
TMV resistance protein N-like isoform X3-1		0.00	2.00	1.00	6.00	12.00	9.00
protein_DOWNY_MILDEW_RESISTANCE_6-like_isoform_X1-2	5.50	0.00	2.00	1.00	11.00	0.00	5.50
putative_multidrug_resistance_protein-2	4,85	13.00	0.00	6.50	58.00	5.00	31.50
protein_PLANT_CADMIUM_RESISTANCE_12-like-1	4.00	2.00	0.00	1.00	4.00	4.00	4.00
protein_PLANT_CADMIUM_RESISTANCE_12-like-2	4.00	2.00	0.00	1.00	4.00	4.00	4.00
putative_late_blight_resistance_protein_homolog_R1A-4-3	4.00	2.00	0.00	1.00	8.00	0.00	4.00
pleiotropic_drug_resistance_protein_3_isoform_X1-2	3.80	35.00	9.00	22.00	136.00	31.00	83.50
putative_late_blight_resistance_protein_homolog_R1A-3_isoform_X1	8 3.75	2.00	2.00	2.00	11.00	4.00	7.50
pleiotropic_drug_resistance_protein_3_isoform_X3-2	3.68	18.00	20.00	19.00	128.00	12.00	70.00
pleiotropic_drug_resistance_protein_3_isoform_X3-1	3.66	34.00	4.00	19.00	116.00	23.00	69.50
putative late blight resistance protein homolog R1A-3 isoform X2	2 3.39	19.00	12.00	15.50	84.00	21.00	52.50
Lycopersicon esculentum plant resistance protein (Mi-1.1) mRNa	3.36	39.00	41.00	40.00	194.00	75.00	134.50
Lycopersicon esculentum plant resistance protein (Mi-1.1) mRNA	3.18	46.00	41.00	43.50	193.00	84.00	138.50
protein_PLANT_CADMIUM_RESISTANCE_8-like-2	3.00	4.00	0.00	2.00	12.00	0.00	6.00
pleiotropic_drug_resistance_protein_3_isoform_X2-1	2.96	40.00	10.00	25.00	126.00	22.00	74.00
putative_late_blight_resistance_protein_homolog_R1A-4-4	2.89	15.00	4.00	9.50	45.00	10.00	27.50

Figure 3. Differential gene expression analysis of Migene in both samples



Figure 4. Snapshot of heat map of resistance and susceptible genes

- Gene specific primers were designed for full length amplification of *Mi* gene. High fidelity Phusion Tag DNA polymerase was employed to perform PCR.
- Identified fragmentof 3.7 Kb was then cloned in plant Binary vector pRI-101-AN-DNA (Figure 5).


Figure 5. *Mi* gene amplification and confirmation by restriction digestion of *Mi*-101-AN-DNA

Molecular marker development

- In **cumin**, first time SRAP markers were applied to examine the variability in a set of 16 genotypes. The number of amplicon varied from 3 to 13, while amplicon size ranged from 120 to 500 bp.
- Total 60 alleles were generated with an average of 6.0 alleles per primer. The polymorphism information content (PIC) value ranged from 0.143 to 0.5.



Dendogram of 16 cumin genotypes showing the genetic similarity detected by 10 SRAP primers using UPGMA cluster analysis

• These SRAP primers will be important genomic resources for purity testing and identification of cumin genotypes.

were present in 1864 sequences. The developed markers will be helpful in development of linkage map and characterization of guar germplasm.

• In guar, analysis of high quality reads showed s total of 25679 SSRs. A set of 1883 sequences contained more than 1 SSR while compound SSR

Genetic engineering

• Screening of T3 transformed maize lines for detection of ZCO and GLT-2 genes (Figure 1)



PCR screening forZeaxanthin Cleavage Oxygenase (Zco) gene

PCR screening forGlucosyltrasferase (GLT-2) gene



Maize cobs of T3 generation for both ZCO and GLT-2 genes

DNA fingerprinting

- A total of 321 DNA fingerprints have been generated using different marker system (Table 1).
- Robust and polymorphic markers were selected for generating successful DNA fingerprints.
- A total of 199 SSR, 97 ISSR, 466 RAPD and 12 AFLP markers were used for generating crop specific DNA fingerprints.
- DNA fingerprinting profile of these crops was sent to their respective Research Stations for further use.

Crops	Number of	Fingerprints			
	varieties	SSR	ISSR	RAPD	AFLP
	Year 2012-15	5			
Green gram	2	-	8	32	-
Dill Seed	1	-	8	60	-
Brinjal	6	10	8	60	-
Lucerne	2	-	-	21	-
Rice	22	12	14	10	-
Chilli	8	10	-	10	-
Tobacco	8	10	-	-	-
Maize	4	10	-	10	4
Cotton	5	-	12	10	-
Date palm	4	2	-	12	-
Cowpea	1	-	-	15	-
Papaya	12	-	-	20	-
Tomato	7	-	-	-	4
Wheat	28	-	-	-	4
Bryophyllumcalcinum	1	-	-	12	-
Tribulusterrestis	1	-	-	12	-
	Year 2016-17	,			
Kalmegh	1	-	-	-	1
Asalio	1	-	-	-	1
Senna	1	-	-	-	1
Wheat	1	-	-	-	1
Chickpea	1	-	-	-	1
Rice	13	-	-	-	1
Maize	14	_	_	-	1
Lucerne	1	-	_	-	1
Cotton	5	-	-	-	1
Dill Seed	1	-	-	-	1
Total	321	199	97	466	22

Table 1. DNA fingerprints profile of various crop varieties/lines

Distant hybridization

Okra

In summer, a total of 3 F₂, 29 F₃, 41 F₅, 7 F₆ and 16 F₈ were sown. Only one F₂ cross combination (GO-2 x GP-47), 26 out of 29 F₃, 26 out of 41 F₅ germinated. The plant stand was very poor in most of the segregating populations. In F₃, F₅, F₆ and F₈, the number of promising lines showing 0% YVMV

incidence were 7, 3, 2 and 14, respectively. The 28, 37, 16 and 7 IPS were made from F_4 , F_6 , F_7 and F_9 , respectively. 15 new crosses were attempted in summer-2016.

In *Kharif*, a total of 88 segregating lines including 28 F₄, 37 F₆, 7 F₇ and 16 F₉ were sown. 28 F₄, 34 F₆, 7 F₇ and 16 F₉ germinated. In Kharif 31, 114, 7 and 16 IPS were made from F₄, F₆, F₇ and F₉.

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respectively. Total 62 new crosses were attempted involving the different. Four cross combinations were made using embryo rescued plant as one of the parent viz., Embryo rescued hybrid x GAO5, Embryo rescued hybrid x Pusasavani, GAO5 x Embryo rescued hybrid and Pusasavani x embryo rescued hybrid.

Tomato

- Out of the 17 tomato lines imported from TGRC, California, 13 have been established in the field and one accession LA-1022 did not germinate at all.
- The 10 lines of tomato including the accessions of *S. habrochaites*, *S. arcanum*, *S. pimpinellifolium* and *S. lycopersicum* were screened for root-knot nematode resistance in sick plot at Department of Agri-Nematology. A line *S. arcanum* (LA-2157) was found highly resistant for both *M. incognita* and *M. javanica*. A total of 8 new crosses have been made including the parents viz., GT-2, AT-3, LA-2157 (*S. arcanum*), SL-120, LA-2819, LA-0490, LA-2127, LA-4440 and LA-1970 (*S. peruvianum*)

Cotton

- Out of the total 128 F_2 lines of 23 cross combinations raised in cotton, 7 lines were having fibre length of 28 mm or above. 30 F_3 lines which have 27mm and above fiber length with high seed cotton yield have been selected from above segregating materials. Out of 145 F_3 lines of 8 cross combinations raised, 24 lines were found to have fibre length of 28mm or above.
- 23 new crosses were attempted using different genotypes viz.,G. Cot-16, GSB-41, GSB-44, G.Cot-20 and one of colchicine treated parent.
- The seed material of genotype ALF 1027 was subjected to colchicine treatment with different concentrations (0.2%, 0.4%, 0.6%, 0.9%, 1.0% and 1.5%) and three different methods -treatment after Germination, Seed soaking Treatment and

Cotton swabbing method. Only two plants could survive under the treatment of cotton swabbing method at a conc. of 0.2 and 0.6 % and are in the laboratory for pre-hardening.

Custard Apple

 50 crossed plants of different combinations have been successfully established in the farm. Three new crosses were attempted in custard apple taking three combinations viz., *A.reticulata* (forage) X Balanagari, *A.reticulata* (Botany) X Balanagari, *A.reticulata* (Botany) XA.atimoya.

Confirmation of purity of hybrids developed among different Annona species

• A total of 30 lines of custard apple including 5 different parents comprising 2 *A.squamosa*, 1 *A.atimoya*, 1 *A.cherimoya* and 1 *A.reticulata* and their 25 hybrids were subjected to PCR amplification for confirmation of hybrids purity. Total 20 SSR (Simple sequence repeats) primers were screened for checking the purity of 25 hybrids of custard apple. However, only 14 primers gave the amplification of genomic DNA. The two primers producing the polymorphic amplicons and discriminating the two parents as well as their hybrids were taken for further analysis. The DNA banding pattern supported the hybrid purity of 17 hybrids out of the 25 hybrids developed.

Plant Tissue Culture

Tissue culture work carried out during the year 2016-17 is summarized below:

Development of regeneration protocol for large scale production of Coconut (*Cocos nucifera L.*)

- Experiments were carried out to standardize various surface sterilization procedures for green coconut leaf.
- Surface sterilization procedures for various explants of coconut viz. shoot tip, primordial leaf, root, green leaf obtained from 5-6 months old coconut seedlings were attempted (Table 1).

• Surface sterilization procedure for the various explants obtained from a whole coconut tree was standardized.

Development of molecular markers for clonal fidelity testing of tissue culture raised plants of date palm (*Phoenix dactylifera L.*) variety Barhee

- Screening of RAPD primers from 14 different
 series was conducted and from them R-6 marker was selected. All the 15 tissue culture raised plants evaluated for clonal fidelity with R-6 marker were found true-to-type (Fig. 1).
- Screening of ISSR primers from 26 reported markers was conducted and from them ISSR-39 was selected for clonal fidelity. All the 24 tissue culture raised plants evaluated for clonal fidelity with ISSR-39 marker were found true-to-type.
- Screening of SSR-6, SSR-13, SSR-15 and SSR-16 reported markers was conducted and from them no markers were selected for clonal fidelity.
- Local specific SSR marker was screened and SSR-1 showed different band size as compared to *Barhee*. Thus, it was selected to check clonal fidelity as well aselimination of mixing of plantlets of other genotypes, if any. All the 24 tissue culture raised plants evaluated for clonal fidelity with SSR-1 marker were found true-to-type.

Micropropagation technology development in pomegranate var. *Bhagwa*

- Study on effect of casein hydrolysate (CH) on control of defoliation of leaves of pomegranate variety '*Bhagwa*' was carried out (Fig. 2).
- Successful primary hardening of plantlets of pomegranate variety '*Bhagwa*' was performed using various hardening mixtures.
- Secondary hardening of the successfully primary hardened plantlets of pomegranate variety *'Bhagwa'* has been achieved with an overall survival rate of 85%.

Refinement of date palm micropropagation protocol for early callus induction and for other stages

- Somatic embryo induction and maturation was carried out in the axenic cultures of Khallas variety developed during November, 2013 (Fig. 3).
- Effect of various plant growth regulators (2,4-Dichloro phenoxy acetic acid, Abscisic Acid and Indole-3-butyric Acid) and culture vessels on synchronous growth of embryogenic cultures was studied.
- Effect of casein hydrolysate and various plant growth regulators (Benzyl Adenine and Abscisic Acid) on embryo induction and maturation was studied.

Technology development for mass multiplication of bamboo using tissue culture

- Study on effect of different PGR and their combination on initiation of sprout in yellow bamboo has been attempted (Table 2).
- Aseptic cultures of local variety (Solid type) and green genotype bamboo have been maintained.

Technology development for micropropagation of Indian sandalwood (*Santalum album* L.)

- Explants collected and initiated from locally available elite candidate (plus) trees (CPT) to study *in vitro* responses (Fig. 4).
- Two different experiments were carried out for defoliation control and root induction in cultures of local elite tree (12 years old) initiated during previous year (Table 3).
- Effect of Phloroglucinol and IBA on defoliation control and root induction in sandalwood.
- Effect of ABA on root induction in sandalwood.
- Experiments were carried out for *ex vitro* root induction.

Effect of different biotic factors like PGPR,

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Mycorhiza, with IBA on root induction in sandalwood during primary hardening was studied.

Technology development for mass multiplication using tissue culture and sex determination using molecular markers in papaya

- Locally available genotypes of papaya were collected and initiated to study *in vitro* responses.
- Experiments were carried out for root induction in *in vitro* culture of Papaya

Development of cell lines resistant to Altenaria blight (Alterneria burnsii var. cumini) of cumin (Cuminum cyminum L.) using in vitro techniques

- Effect of activated charcoal, phloroglucinol and agar for reduction of vitrification of the shoots during regeneration was studied
- An attempt was carried out to induce roots on regenerated shoots of cumin using Indole-3-butyric Acid and Benzyl Adenine.



Fig 1: Screening of 280 RAPD primers with the pooled DNA samples of micropropagated Date palm (var. *Barhee*). Lanes highlighted with arrow sign indicates screened primer number in its respective series. L represents 1 kb DNA ladder and 1-20 represent primer numbers of respective series



Fig 2: Effect of various casein hydrolysate treatments on control of defoliation of the leaves in pomegranate



Fig 3: Somatic embryo induction in Khallas variety of Date palm

Nanotechnology

Nanotechnology is a quickly rising invigorating multidisciplinary field of science, endowed with several potentialities and multiple applications. Nanotechnology has emerged as a technological advancement that could develop and transform the entire agri-food sector, with the potential to increase agricultural productivity, food security and economic growth for industries. The development of nanobiotechnology provides a novel method and protocol for life science. Nanoparticles as gene carriers become popular in the mammalian cultured cells, whereas its application in plant cells is still very limited. Minimizing the evaporation of soil water by using special matrix based material which will retain the water inside the soil, and also does not interfere with the other physiological activity forming a permeable membrane. The water loss due to transpiration can also be minimized using such biological activity permeable membrane. Formulating novel nanoparticle hybrid materials to control spoilage-related microflora can significantly decrease the loss due to spoilage, that generally takes place during long distance transportations of nutritive goods.

Nanotechnology work carried out during the year 2016-17 summarized below:

Application of silver nanoparticles for contamination control in plant tissue culture

- Different concentrations of silver nanoparticles coupled with incubation time (mins) was carried out using explants collected from disease free sandalwood, banana and parwar.
- All the treatment combinations were found to be effective in reducing contamination compared to control treatments. The best treatment among the different concentration and incubation for various plants were as follows:
- *For sandalwood experiment*: 150 mgl⁻¹ concentration for 80 mins.
- *For banana experiment*: 100 mgl⁻¹concentration for 100 mins.
- *For parwar experiment*: 100 mgl⁻¹ concentration for 80 mins..

Effect of nano-zinc application on morphological parameters of rice variety Jaya

• A field experiment was conducted at Nawagam

for evaluation of commercially available zinc nanoparticles for its possible growth stimulatory effects on rice variety Jaya.

• Rice plants were exposed to zinc nanoparticles exhibited *at par* compared to ZnSO₄ and recommended dose for all the morphophysiological parameters like shoot length (cm), number of tillers, penicle length (cm) and dry matter (gm).

Green synthesis of metallic nanoparticles and their antimicrobial activity against plant pathogens.

Green synthesis using different substrate concentration:

- (i) Zinc nanoparticles (ZnNP) have been synthesized using neem leaf extracts and zinc sulphate as a substrate and synthesized at room temperature and water bath (100°C). The synthesized particles were characterized visually by colour change and using different instruments.
- (1) Water bath (100°C) mediated ZnNP synthesis:
- (A) UV-visible spectroscopy
- With increasing period of incubation, the colour change occurs from transparent to yellowish brown in all treatments, indicating the bioreduction of zinc oxide particles.
- (ii) Characteristic broad peak in the UV-visible spectrum for zinc oxide nanoparticles for all the treatments was found to be 334 nm.

(B) Size (nm)

(i) Effect of different substrate concentration (0.1 and 0.2 M) and substrate volume (80.0 ml) was studied using 5% 20ml neem leaves extracts. Among which, intensity based Z-average size range of ZnNP was found to be between 335.6 nm to 474.0 nm with minimum particle size of 335.6 nm for 0.2 M ZnSO₄ exposed for 20 mins in waterbath at 100°C. The number based size distribution ranges from 114.7 to 362.1 nm with

minimum size of 114.7 nm for 0.1 M $ZnSO_4$ exposed for 20 mins in waterbath at 100°C.

(C) Polydispersity index (pdi)

i) The pdi value of ZnNP synthesized using $ZnSO_4$ as a substrate ranges from 0.333 to 0.630 with minimum pdi of 0.333 for 0.2 M ZnSO₄ exposed for 80 mins in waterbath at 100°C.

(D) Count rate (kcps)

(i) The count rate (kcps) of ZnNP synthesized using $ZnSO_4$ as a substrate ranges from 149.3 to 202.2 with maximum count rate of 202.2 for 0.1 M $ZnSO_4$ exposed for 60 mins in waterbath at $100^{\circ}C$.

(E) Antibacterial activity

- (i) The antibacterial activity of commercially available ZnNP was compared with streptocycline at different concentrations in mgl⁻¹ and μ gl⁻¹. The maximum zone of inhibition was observed for ZnNP synthesized using ZnSO₄ as a substrate.
- (ii) Each synthesized ZnNP particles were evaluated for its antibacterial activity against *Xanthomonas* sp. isolated from infected rice leaves under *in vitro* conditions.
- (iii) Different concentrations (50 and 100 μ l) of ZnNP were assessed for their maximum zone of inhibition (mm) wherein particle synthesized using 0.1 M ZnSO₄ solution exposed to 40 mins under water bath gave highest inhibition zone of 40.5mm compared to 200 ppm each of streptocycline (20.0 mm) and commercial ZnO NP (21.5 mm).
- (2) Room temperature mediated ZnNP synthesis:

(A) UV-visible spectroscopy

 (i) With increasing period of incubation, the colour change occurs from transparent to yellowish brown in all treatments, indicating the bioreduction of zinc oxide particles. AAU

(ii) Characteristic broad peak in the UV-visible spectrum for zinc oxide nanoparticles for all the treatments was found to be 334 nm.

(B) Size (nm)

(i) Effect of different substrate concentration (0.1 and 0.2 M) and substrate volume (80.0 ml) was studied using 5% 20ml neem leaves extracts. Among which, intensity based Z-average size range of ZnNP was found to be between 350.1 nm to 413.3 nm with minimum particle size of 350.1 nm for 0.2 M ZnSO₄ exposed for 12 hours at room temperature at 37° C. The number based size distribution ranges from 178.5 to 287.8 nm with minimum size of 178.5 nm for 0.1 M ZnSO₄ exposed for 12 hours at 7°C.

(C) Polydispersity index (pdi)

(i) The pdi value of ZnNP synthesized using $ZnSO_4$ as a substrate ranges from 0.402 to 0.509 with minimum pdi of 0.402 for 0.2 M ZnSO₄ exposed for 0.2 M ZnSO₄ exposed for 24 hours at room temperature at 37°C.

(D) Count rate (kcps)

(i) The count rate (kcps) of ZnNP synthesized using $ZnSO_4$ as a substrate ranges from 145.5 to 449.7 with maximum count rate of 449.7 for 0.1 M $ZnSO_4$ exposed for 12 hours at room temperature at $37^{0}C$.

(E) Antibacterial activity

- (i) The antibacterial activity of commercially available ZnNP was compared with streptocycline at different concentrations in mgl⁻¹ and μ gl⁻¹. The maximum zone of inhibition was observed for ZnNP synthesized using ZnSO₄ as a substrate.
- (ii) Each synthesized ZnNP particle was evaluated for its antibacterial activity against *Xanthomonas* sp. isolated from infected rice leaves under *in vitro* conditions.

(iii) Different concentrations (50 and 100 μ l) of ZnNP were assessed for their maximum zone of inhibition (mm) wherein, particle synthesized using 0.2 M ZnSO₄ solution exposed to 12 hour at room temperature gave highest inhibition zone of 37.5 mm compared to 200 ppm each of streptocycline (20.5 mm) and commercial ZnO NP (21.5 mm).

pH mediated green synthesis

(A) Size (nm)

(i) Chemical mediated synthesis of zinc nanoparticles has been carried out and effects of different pH (7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0) has been assessed using 0.1 M zinc sulphate with dispersing agent, among which, size range of ZnNP was found to be between 3.46 nm to 125.5 nm with minimum particle size of 3.46 nm at pH 11.5. The number based size distribution ranges from 1.21 nm to 41.21 nm with minimum size of 1.21 nm at pH 11.5.

(B) Polydispersity index (pdi)

The pdi value of ZnNP synthesized using $ZnSO_4$ at different pH intervals ranges from 0.22 to 0.442 having dispersing agent with minimum pdi of 0.22 for solution containing 0.1 M ZnSO₄ at pH 11.5.

(C) Count rate (kcps)

The count rate (kcps) of ZnNP synthesized using $ZnSO_4$ as a substrate ranges from 186.5 to 475.1 with maximum count rate of 475.1 at pH 11.5.

(D) Antifungal activity

The antifungal activity of synthesized ZnNP at different pH was compared with control. The maximum inhibition of mycelia growth was observed for ZnO NPs synthesized using ZnSO4 at pH 11.5 solution with dispersing agent compared to control.



Morphological and physiological effects of (A) At 25°C hydrophobic soil on growth of maize

Total microbial count using maizer hizospheric soil was found to be at par for control and all the hydrophobic soil layering soil samples.

- **Synthesis** and characterization of hydroxyapaptite nanoparticles its and applications potential phosphorous as fertilizers
- (1) Effect of CMC concentration
- (A) Size (nm):
- Effect of different CMC concentration (100, 250, (i) 500, 1000 and 2000 ppm) as a stabilizing agent for HAp (4mg/ml) was studied. Among which, intensity based Z-average size range of HAp NP was found to be between 227.7 nm to 795.6 nm with minimum particle size of 227.7 nm for 100 ppm CMC-HAp at 0 day. The number based size distribution ranges from 50.55 to 777.4 nm with minimum size of 50.55 nm for 100 ppm CMC-HAp on 0 day.

(B) Polydispersity index (pdi)

The pdi value of CMC-HAp NP synthesized at (i) different concentrations of CMC ranges from 0.137 to 0.377 with minimum pdi of 0.137 for 1000 ppm CMC-HAp on 0 day.

(C) Count rate (kcps)

The count rate (kcps) of CMC-HAp NPs at (i) different concentrations of CMC ranges from 249.3 to 404.1 with maximum count rate of 404.1 for 500 ppm CMC-HAp on 0 day.

(2) Effect of incubation study (25 and 37°C)

Effect of temperature (25 and 37°C) on CMC-HAp stability was studied on 15th, 30th and 45th days after synthesis.

- (a) Size (nm)
- After 15 days of incubation, intensity based (i) Z-average size ranges from 161.6 nm to 825.8 nm with minimum particle size of 161.6 nm for 100 ppm CMC-HAp stored in amber bottle. The number based size distribution ranges from 115.2 to 878.9 nm with minimum size of 115.2 nm for 100 ppm CMC-HAp.
- (ii) After 30 days of incubation, intensity based Z-average size ranges from 163 nm to 758 nm with minimum particle size of 163 nm for 100 ppm CMC-HAp stored in glass bottle. The number based size distribution ranges from 109.8 to 767.7 nm with minimum size of 109.8 nm for 100 ppm CMC-HAp stored in glass bottle.
- (iii) After 45 days of incubation, intensity based Z-average size ranges from 193.4 nm to 1083 nm with minimum particle size of 193.4 nm for 100 ppm CMC-HAp stored in amber bottle.
- (b) Polydispersity index (pdi)
- (i) After 15 days of incubation, pdi ranges from 0.09 to 0.262 with minimum pdi of 0.09 for 100 ppm CMC-HAp stored in amber bottle.
- (ii) After 30 days of incubation, pdi ranges from 0.088 to 0.252 with minimum pdi of 0.088 for 100 ppm CMC-HAp stored in amber bottle.
- (iii) After 45 days of incubation, pdi ranges from 0.143 to 0.241 with minimum pdi of 0.09 for 250 ppm CMC-HAp stored in glass bottle.

(c) Count rate (kcps):

- After 15 days of incubation, the count rate (kcps) (i) ranges from 187.5 to 331.3 with maximum count rate of 331.3 for 500 ppm CMC-HAp stored in glass bottle.
- (ii) After 30 days of incubation, the count rate (kcps) ranges from 230.1 to 389.7 with maximum count rate of 389.7 for 250 ppm CMC-HAp stored in glass bottle.



- (iii) After 45 days of incubation, the count rate (kcps) ranges from 249.6 to 463.9 with maximum count rate of 463.9 for 100 ppm CMC-HAp stored in glass bottle.
- (B) At 37°C
- (a) Size (nm)
- (i) After 15 days of incubation, intensity based Z-average size ranges from 174.9 nm to 871.6 nm with minimum particle size of 174.9 nm for 100 ppm CMC-HAp stored in amber bottle. The number based size distribution ranges from 97.23 to 802.8 nm with minimum size of 97.23 nm for 1000 ppm CMC-HAp stored in glass bottle.
- (ii) After 30 days of incubation, intensity based Z-average size ranges from 217.9 nm to 855.4 nm with minimum particle size of 217.9 nm for 100 ppm CMC-HAp stored in glass bottle. The number based size distribution ranges from 116.5 to 933.4 nm with minimum size of 116.5 nm for 100 ppm CMC-HAp stored in amber bottle.
- (iii) After 45 days of incubation, intensity based Z-average size ranges from 182.5 nm to 649.1 nm with minimum particle size of 182.5 nm for 100 ppm CMC-HAp stored in amber bottle.

(b) Polydispersity index (pdi)

- (i) After 15 days of incubation, pdi ranges from 0.122 to 0.343 with minimum pdi of 0.122 for 100 ppm CMC-HAp stored in glass bottle.
- (ii) After 30 days of incubation, pdi ranges from 0.209 to 0.301 with minimum pdi of 0.209 for 100 ppm CMC-HAp stored in glass bottle.
- (iii) After 45 days of incubation, pdi ranges from 0.118 to 0.279 with minimum pdi of 0.118 for 100 ppm CMC-HAp stored in amber bottle.

(c) Count rate (kcps)

(i) After 15 days of incubation, the count rate (kcps) ranges from 206.9 to 320.6 with maximum count rate of 320.6 for 500 ppm CMC-HAp stored in glass bottle.

- (ii) After 30 days of incubation, the count rate (kcps) ranges from 192 to 297 with maximum count rate of 297 for 500 ppm CMC-HAp stored in glass bottle.
- (iii) After 45 days of incubation, the count rate (kcps) ranges from 251 to 322 with maximum count rate of 322 for 2000 ppm CMC-HAp stored in glass bottle.
- Characterization of zinc and iron oxide nanoparticles and its effect on artificially aged soybean seeds
- (i) The hydrodynamic diameters of ZnNPs determined by DLS were 20.65 ± 0.07 with polydispersity index (Pdi) of 0.32.
- (ii) The zeta potential of these particles was found to be 41 mV which is a strong zeta value for zinc nanoparticles.
- (iii) The particles concentration per mL was found to be 32.02×10^8 for zinc nanoparticles.

Experiment for seed treatment

- (i) An experiment was carried out for determination of incubation time (1, 2, 3, 4 and 5 hrs.) and different morpho-physiological parameters were recorded.
- (ii) Seed germination percentage was found to be highest with 5hrs treated seeds.
- (iii) Loss due to fungal infection was also found to be least for seeds treated with Zn NPs for five hours.
- (iv) Maximum shoot and root length was recorded in seeds immersed in ZnNPs solution for five hours.
- (v) Number of lateral roots was found to be higher in 5 hrs treated seeds compared to all other incubation durations.

Biochemical studies for artificially aged seeds

- (i) Antioxidant enzyme activity was found significantly lower compared to control
- (ii) Protein content was also found to be significantly different compared to control.



Fig. 4: Effect of incubation time (20, 40, 60 and 80 mins) on Zinc oxide nanoparticles size and polydispersity index



Fig 5:Effect of green synthesized zinc oxide nanoparticles on Xanthomonas oryzae (a) 200 ppm Streptocycline (b) 200 ppm Commercial ZnO NP (c) 50 μl Green synthesized ZnO (d) 100μl Green synthesized ZnO



(A)



(B)

Fig 6: Effect of zinc oxide nanoparticles synthesized at different pH against Alternaria burnsii

(A) at 5ml and (B) 10ml of zinc oxide nanoparticle solution.

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4.6 PLANNING AND MONITORING, AGRI-CULTURAL RESEARCH AND EDUCA-TION

Planning and development committee was constituted as per common statutes for Agricultural University of Gujarat, 2011 under section-III of statutes No. 48 to 51.

- The financial provisions made by project-incharge was scrutinized, compiled and prepared plan budget and put up in Planning and Development Committee, Finance committee and Board of Management. Thereafter, it was submitted to Government of Gujarat for provision in budget for the year 2016-17.
- An Annual plan of ₹ 8564.85 Lakhs was approved by Government of Gujarat for Agricultural Research and Education. But, revised budget of ₹ 7486.85 Lakhs was approved and released the grant accordingly by the State Government. The detailed provisions of plan are as follow.

Head	On going	New Item	Total
Education	4770.54	300.00	5070.54
Extension	379.36	0.00	379.36
Education			
Research	2641.34	448.61	3089.95
IT	25.00	0.00	25.00
Total	7816.24	748.61	8564.85

- Following new projects were approved by state government in Budget for the year 2016-17.
- 1 Establishment of instructional processing facilities for students, Anand
- 2 Student & faculty exchange programme under national and international collaboration, Anand
- 3 Merit scholarship scheme for economically poor under graduate students at Anand Agricultural University, Anand
- 4 Centre for Advanced Research on plant viruses, Anand
- 5 Research on organic farming, Anand

- 6 Advanced Research on pest management through birds, Anand
- 7 Development of food decontamination technology for safety and quality of fresh and minimally processed fruits and vegetables, Anand
- 8 Research on supply chain and market integration for key agro commodities for farmer's awareness and income enhancement in middle Gujarat, Anand
- Two review meetings were conducted in October, 2016 and January 2017 to review the expenditure made and requirement of grant by circular from concern scheme-in-charge. Grants were realloted as per the demand and utility in the project.
- Quarterly and Annual progress reports of plan schemes were prepared and submitted to Government of Gujarat.
- Legislative Assembly Question (LAQ), Rajysabha Starred Question (RSQ) and Legislative Starred Question (LSQ) raised during the year were compiled and submitted to the Government.

Indian council of Agricultural Research (ICAR) Development Grant.

"Strengthening and Development of Agricultural Education in SAU's"

- ➤ The demand of ₹ 1340.85 Lakhs for "Strengthening and Development of Agricultural Education in SAU's was submitted to Indian Council of Agricultural Research (ICAR) as per the demand received from the Principals/Deans of colleges.
- ➤ The grant of ₹ 586.69 lakhs was released by ICAR for "Strengthening and Development of Higher Agricultural Education in India".

'Student READY'

The demand of Rs. 45.65 Lakhs for 'Student READY' was submitted to Indian Council Agricultural Research (ICAR) as per the demand received from Deans of various faculties. The grant AAL

of Rs. 82.26 lakhs was released by ICAR for 'Student READY'. Annual Utilization Certificate (AUC) of said grant was submitted to ICAR, New Delhi for the financial year 2016-17.

'National Talent Scholarship'

- The demand of Rs. 20.72 Lakhs for 'National Talent Scholarship' was submitted to Indian Council of Agricultural Research (ICAR) as per the demand received from Director of Student Welfare. The grant of Rs. 20.02 lakhs was released by ICAR for 'National Talent Scholarship'. Annual Utilization Certificate (AUC) of said grant was submitted to ICAR New Delhi for the financial year 2016-17.
- Half yearly and Annual Progress Report were submitted to ICAR as per the activities carried out during the year.

4.7 WATER TECHNOLOGY

Considering the importance of irrigation in Agriculture, Agricultural Research Station for irrigated crops, Thasra, conducted some experiments as listed below:

• Nitrogen management in Summer Sesamum (Sesamum indicum L.) under drip irrigation system in goradu soil of middle Gujarat conditions

The results revealed significant differences for Sesamum yield due to different irrigation treatments. Treatment I₃ (0.8 ADFPE) recorded significantly the highest Sesamum yield (947 kg/ha). Similarly fertigation treatments revealed significant differences for Sesamum treatment N₁ (100 % RDN through fertigation) being at par with treatment N₂ (80 % RDN through fertigation) recorded significantly higher Sesamum yield 883 kg/ha.

• Nutrient management through fertigation in Guava

The results are non-significant for tree canopy,

stem girth and tree height but were found significant for no. of fruits per plant and fruit yield per plant and per hectare due to fertigation treatments. Treatment N_4 (100% RDF) being at par with treatments N_2 and N_3 recorded significantly higher number of fruits per plant (179.75) over treatment N_1 . Similarly treatment I_4 (100% RDF) being at par with treatments I_3 (75% RDF) recorded significantly higher fruit yield per tree (59.32 kg) as well as per hectare (16431 kg/ha).

Extension and demonstration schemes for irrigation funded by Sardar Sarovar Narmada Nigam Limited at sub center of Anand Agricultural University viz. Thasra, Dhandhuka, Dabhoi and Khandha, organized 107 training programmes on campus and off campus on the subject of irrigation scheduling, method of irrigation and related aspects. In all 4110 farmers attended the training programme.

4.8 AGRICULTURAL RURAL DEVELOPMENT STUDIES

Rural development programme revolves around raising economic and social level of the rural people as the main objective.

Research in context with the above said objectives can throw some light in the direction of bringing rural development. Keeping this in view, research in extension education is conducted in the broad areas of Adoption and diffusion of innovations, transfer of technology, role of mass media in dissemination of technology, impact of different programmes and centres on rural development, communication behavior of rural people/ farmers, bench mark surveys etc.

Other Indicators

Anand Agricultural University (AAU), Anand signed MoU with different institutes durning the year 2016-17 as follow.

Sr. No.	Name of Institute	Area
1	NRCM, Hyderabad	Undertaking activities related to Teaching, Extension and Research in the areas of Animal Husbandry and Veterinary Science
2	GLS, Vadodara	Promotion of biotechnology in agriculture, jointly modifying or developing package of practices beneficial to agriculture and farmers
3	Faculty of Science, Uni. of Copenhagen, Denmark	For cooperation in the field of Education & Research
4	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur	For Collaboration in Research and Extension Education, Students and Faculty Exchange
5	Assam Agril. Uni., Jorhat	For Collaboration in Research and Extension Education, Students and Faculty Exchange
6	AMC, Ahmedabad	Commercializing of Bio NPK Liquid Biofertilizer technology
7	Indian Veterinary Res. Institute, Izatnagar	Collaborating in various areas of Academic activities

4.9 VETERINARY SCIENCE & ANIMAL HUSBANDRY

Research endeavour of various research projects under Veterinary Science & Animal Husbandry faculty has focused on two broad areas viz. Animal Production and Animal Health.

Animal Production Group

The department of Animal Genetics & Breeding is known at national level for its contribution in molecular characterization of indigenous livestock breeds. The department is actively engaged in molecular analysis of various lesser known livestock breeds like Duma sheep, Kharai camel, Kachchi horse, Kachchi donkey, Halari donkey, Kahmi goat, Nari cattle, Gujarat Malvi cattle, etc by microsatellite markers, SNP genotyping

and its association with reproduction traits related to infertility in cattle & buffalo, screening of Dumba sheep for presence of fecundity gene mutation in BMP15, BMPR 1B and GDF9 genes responsible for high prolificacy. The department is also performing whole genome sequencing of Gir cattle and Jaffarabadi buffalo to identify the SNPs (single Nucleotide Polymorphism) related to production and reproduction traits. In addition, 126 animals including breeding bulls were screened for karyotyping and chromosomal aberration. A total of 184 blood samples of indigenous as well as crossbred bulls were screened for genetic defects (BLAD, Citrulinaemia, Factor - XI, DUMP and CVM) and performed Genome Sequencing for the breeds of Gir cattle and Jaffarabadi buffaloes and generated around 9 GB data.

Department of Animal Biotechnology, College of Veterinary Science and Animal Husbandry, AAU, Anand carried our research work under following areas;

- Mining lignocellulolytic enzymes from rumen metagenome
- Metagenomic Analysis of Ruminal Microbes
- Semen sexing in cattle
- Whole Genome Sequencing and development of Allied Genomic Resources in two commercially important Fish *Labeo rohita* and *Clarias batrachus*
- Development of Recombinant poultry vaccine with HVT (Herpes Virus Turkey) as backbone
- Identification of 'Molecular Portraits' in Squamous Cell Carcinoma of Horn in Kankrej (*Bos indicus*) Bullocks
- Controlling Enteric Pathogens of Poultry: Host/ Microbiota
- Interactions, Risk Assessment and Effective Management
- Interventions
- Host Transcriptomics and Gut Microbiome

Analysis in Broilers with Contrasting Feed Conversion Ratio

 Cloning, Characterization and Functional Screening of Industrially Important Novel Cellulose Encoding Genes from the Bovine Rumen Microbial Community using Metagenomic Approach

Central Poultry Research Station was established during the year 1964 under the Institute of Agriculture. Since then the centre is actively engaged in Poultry Research, Extension and Education activities. Apart from this, the centre is having poultry feed manufacturing unit which caters the need of experimental feed required for Anand centre. The centre is also imparting Poultry Training to unemployed youth for self employment.

Research work in endocrinology of reproduction and embryo transfer (IVF) in buffaloes is carried out at Reproductive Biology Research Unit. Extension activities viz., '*Mahila Pashupalan Talim Yojna*' is continuing with the financial support of GCMMF and '*Surti* Buffalo Breeders Association' with the financial help of Department of A.H., Government of Gujarat. During the year, in the embryo transfer project research work on IVM of buffalo oocytes was carried out by TCM-199 and also with TCM-199 plus BES or BFF as supplements. It was observed that use of BFF gives 73.52% maturation rate, which is higher than that of BES.

In the Strengthening of RBR unit scheme, work regarding ITK of feeding moth bean (*Phaseolus aconitifolius*) was carried out. In experimental group, after feeding moth beans buffalo heifers exhibited estrus within 30 days and body wt. was 274.50 kg. (wt. gain 8.00 kg.) at the age of 27.58 months. Study on impact of proactive measures in pregnant buffalo and cow under field conditions revealed that incidences of post-partum complications and Agalectia were lower compared to control animals. Package of practices for the same was given for animal owners. Work was carried out on Surti and Marwari goats kept at Ramna

Muvada find out optimum weight of puberatal Surti and *Marwari* goats for the first time breeding and research work on restricted mating in adult breedable Surti goats were concluded.

Under *Mahila Pashupalan Talim Yojna* a total of 29 one week training programmes were conducted and 651 women were trained during the year.

Under *Surti* Buffalo Breeders Association, 2 awareness camps, 5 on campus training programmes, 3 calf rallies and 6 educational tours were arranged in which, 63,188,166 and 261 owners of Surti buffaloes participated, respectively.

The major research areas of Animal Nutrition Research Centre are Animal Nutrition Survey in different districts of Gujarat state, fodder production and utilization, nutrient requirements of animals, utilization of agro-industrial byproducts and waste materials, studies on evolving area specific mineral mixtures and strategies for feeding of livestock during scarcity period. Currently, the department is engaged in research work on formulation and evaluation of crop residue based total mixed rations for various categories of livestock; development of area specific mineral mixtures to correct deficiencies; Bypass Nutrient Technology; studies on effect of Phyto-chemicals on Nutrient Utilization, Health Attributes and Production of Ruminants and developing feeding strategies to minimize the effect of heat stress in animals. Work carried out during this year includes the study on nutritional status of animals carried out in randomly selected 24 villages from six talukas of Chhota Udepur district in summer, and monsoon, Methane mitigation in buffalo on legume straw based Total Mixed Ration in which in Phase-I, in vitro studies were conducted to arrive at optimum level of incorporating groundnut straw, replacing wheat straw in TMR whereas, in Phase II: In vivo study, the feeding trial was conducted for 120 days on 6 buffaloes, using switch over design, effect of supplementing Fenugreek (Trigonella foenum graecum) seeds in total mixed ration (TMR) of Surti goats and crossbred cows on nutrient utilization and milk production, development of area-specific



mineral mixture formulations for Mahisagar district, formulation and evaluation of total mixed ration comprising of pigeon pea (Cajanus cajan) straw in adult sheep, formulation and evaluation of total mixed ration comprising of Gram (Cicer arietinum L) straw in adult goats, Studies on aflatoxin M1 level in milk of dairy animals in Anand District, studies on the effect of different levels of SSF Biomass based on Wheat straw. Jowar straw and Paddy straw in Total Mixed Rations (TMR) on in vitro digestibility and methane emission, studies on effect of different SSF Biomass in TMR on digestibility of nutrients and rumen fermentation in small ruminants, effect of supplementing Jivanti (Leptadenia reticulata) and bypass fat in total mixed rations on nutrient utilization and milk production of Surti goats, studies on the effect of feeding bypass fat and yeast (Saccharomyces cerevisiae) supplemented total mixed ration to adult sheep during hot summer and Methane mitigation in cattle using legume straw based Total Mixed Ration with SSF Biomass.

At Livestock Research Station, research is being carried on crossbreeding of *Kankrej* with Holstein Friesian with 50 % genetic inheritance of each, and management of genetic data for planning to provide bull-calves to agencies & farmers involved in cross breeding. Following work was carried out during the year.

- Installation and operation of pipeline milking machine
- Screening of Kankrej & crossbred animals for A1, A2 genotype
- Body condition Score and milk production recorded
- Prevalence of mastitis, and antibiotic sensitivity
- Effect of high plan of nutrition on growth of heifers.

Animal Health Group

During the year under carcass Collection Scheme, 69 carcasses of animals and 2744 carcasses

of layer type birds were received for postmortem examination. Histopathological diagnosis was given in 775 tissue specimens received from various parts of Gujarat State. The scheme was useful to the farmers and field veterinarians as they were provided diagnostic services and advice for prevention and treatment of animal and poultry diseases. The scheme also provided useful material for undergraduate and postgraduate teaching for better understanding of the subject of Veterinary Pathology. A total of 8865 carcasses of broilers were received for postmortem diagnosis under the Etiopathological Studies on mortality in broilers and major disease conditions were recorded. The poultry farmers were provided guidelines for prevention, treatment and control of disease in broilers.

The Department of Veterinary Microbiology undertakes time-bound research projects in addition to the diagnostic services provided for various bacterial, viral and fungal diseases of animals and birds. The Department has 3 AAU funded Research Schemes (Non-plan) viz., Central Disease Research Station (Bacterial), Diagnostic Centre for Mastitis and Research Centre for Viral Diseases. In addition, the Department has ICAR funded scheme (Plan) All India Network Programme on Haemorrhagic Septicaemia. Under the scheme, *Pasteurella multocida* organisms were isolated and confirmed from the suspected cases of H.S. and were characterized by biochemical and molecular tools as well as antibiogram profile.

Department of Veterinary Parasitology focused on Haematological and Biochemical examination of blood samples collected from the infected as well as non-infected group of cattle and buffaloes. A total of 502 blood samples of Cattle and 495 samples of Buffaloes were examined during the study and among them 42 samples of cattle and 66 samples of buffaloes were found positive for the *Trypanosomaevansi* infection. For the comparative analysis between conventional Blood smear examination and PCR based examination, a total of 110 samples were diagnosed by both the techniques. Research in the areas of Indigenous medicinal plants, Toxicology of xenobiotics and Pharmacokinetics of drugs was the focus of the Department of Veterinary Pharmacology & Toxicology. During this period plants *Solanum xanthocarpum* and *Achyranthes aspera* were selected for scientific validation of their antilithiatic properties. After procurement of fruits of plants *Solanum xanthocarpum* and roots of *Achyranthes aspera* from their natural habitate, identification and authentication were carried out.

Department of Veterinary Medicine provided diagnostic and therapeutic management measures of various diseases of livestock. A total of 152 clinical cases of dogs with skin/earlesions were diagnosed and their therapeutic management was undertaken. Twelve types of skin conditions were encountered during the study, which affected 25 different breeds of dogs. Bacterial infection of skin was the most common condition which was closely followed by arthropod parasite infestation. Out of 390 goats examined, 53 exhibited involvement of parasitic infection. The highest number of fecal samples showed presence of *Trichuris spp., Strongyloides spp., Trichostrongylus spp., Amphistome spp., Coccidia spp. and Fasciola spp.*

A total of 3457 major/minor surgical interventions/ radiographic examinations/ Wild life/ emergency/ ambulatory treatment were done in the Department of Surgery & Radiology. 2003 Emergency cases were also referred and treated at the department. Camps and expertise services were provided to farmers of different districts, A. H. Department, Gujarat State and Co-operative dairies and forest department as and when required. Under planned scheme, this Dept. has acquired multipara monitor and anesthetic apparatus for birds. In Birds, combination of different anesthetic medicines along with Inj. Butorphenol Tartrate as pre anesthetic was studied.

Department of Animal Reproduction, Gynaecology and Obstetrics under 'Cattle Infertility Scheme' studied the causes of infertility in bovine by attending 324 cases at College Clinic. The portable USG Unit was used for diagnosis of early pregnancy in cattle and buffaloes as well as for diagnosis of pregnancy/pseudo-pregnancy/pyometra in canine/goat/mares with the total of 235cases examined. Under the scheme 'Imparting Education on Semenology & Frozen Semen Technology to the Students and Field Veterinarians, a total of 570 semen ejaculates were obtained from 10 bulls and were evaluated macro- and micro-scopically. Under the project 'Augmenting Reproductive Efficiency in Dairy Animals of Tribal Areas using Controlled Breeding Technologies and Ultrasonography', more than 250 animals were screened gynaeco-clinically in 8 villages by organizing special RHC camps. Findings of the research project entitled 'AICRP on Nutritional and Physiological Interventions for Enhancing Reproductive Performance in Animals' revealed that a very high incidence of infertility exists in dairy animals; both the synchronization protocols were equally efficacious in terms of estrus induction and conception; optimum feeding right from calf hood improves growth rate, body weight and thereby enhances early onset of puberty in both crossbred cattle and Surti buffalo heifers. Further, a peripartum supplementation of multi-minerals (50 g) and bypass fat (100-250 g) for 90 days overall and above routine farm feeding also enhanced uterine involution and improved postpartum fertility as well as milk production in Jaffrabadi buffaloes.

4.10 DAIRY SCIENCE

Dairy Technology department conducted research work on various aspects such as (a) Study on use of Mulberry in development of natural ice cream. The rate of addition of *Mulberry* fruit in the form of mulberry pulp was studied. Three different levels of natural *Mulberry* pulp i.e. @ 8%, 10% and 12% were added to prepare the natural ice cream using sago (@ 1.0%) as stabilizer and WPC-70 (@ 0.5%) as emulsifier. The cost of mulberry ice cream made using standardized formulation as against control ice cream was also computed.

The Dairy Chemistry Department carried out



research activities in three plan research projects, two other agency projects and one departmental project. In a plan project on development of methods for detection of adulterants, the interference of one adulterant on detection of the other adulterant was checked. Further, the effect of processing of milk on detection of adulteration was also evaluated. Moreover, suitability of different IR technology in analysis of ghee was evaluated. In a project on natural food additives, the efficacy of common culinary spices for enhancing shelf life of ghee was evaluated. In the project of whey utilization, butter milk was prepared using combination of dahi and fermented whey. Further the use of whey as a medium for biomass production of lactic acid bacteria was studied.

The Dairy Microbiology Department isolated, characterized and got the NCBI gene accession numbers for 13 Lactic acid bacterial isolates and submitted them in the NCVTC for accession numbers. The Department is a partner in a DBT collaborative project on Development of Technology for the preparation of Fermented Rice Beverage in Meghalaya and evaluation of its functional properties, It is also a partner in a collaborative project on 'Bio-prospecting of lactic culture from North Eastern region to develop functional fermented soya foods with potential health benefits' with North Eastern Hill University (NEHU), Tura, Meghalaya which is financed by DBT, New Delhi.

Following research work was carried out by Dairy Microbiology Department.

- 15 cultures were submitted to NCBI and Gene Bank accession numbers are assigned from VTC project (ICAR funded).
- 21 *Lactobacillus* cultures were submitted to NCBI and Gene Bank accession numbers are assigned from DBT funded project on Bio-prospecting of lactic culture from North Eastern region to develop functional fermented soya foods with potential health benefits.

The Department of Dairy Engineering was

actively involved in research on (i) Mechanization of Traditional Indian Dairy Products (ii) Development and Performance Evaluation of Scraped Surface Heat Exchanger for Continuous Thermization of Shrikhand (iii) Design, Development and Performance Evaluation of Renewable energy based equipments for it application in various unit operations in dairy processing.

4.11 AGRICULTURAL ENGINEERING AND TECHNOLOGY

The four departments in the college, i.e., Soil and Water Engineering (SWE), Farm Machinery and Power Engineering (FMPE), Renewable Energy (RE), and Agricultural Process Engineering (APE) are working to develop site specific or area specific technologies for progressive farming with enhanced returns through efficient management & utilization of natural resources (land, water, vegetation and energy), agricultural mechanization, agricultural processing and post-harvest technology. Study on farm machines like maize sheller, planters, weeders and potato harvesters as well as vibration on tractors, canal scheduling, rainfall forecasting, post-harvest techniques for custard apple, seed properties & repose angle of grain measurement, biomass combustion drying systems for ginger and turmeric and multipurpose solar food processor were carried out by different departments.

4.12 FOOD PROCESSING TECHNOLOGY AND BIO ENERGY

The following research works were carried out during the year.

• Production of high quality powder with maximum retention of essential oil using cryogenic grinding cumin & oriander

Technology of cryogenic grinding developed for superior quality cumin and coriander powder with higher retention of volatile oil (84 & 93 % respectively) compared to conventional grinding.

Sterilization of Red Chilli using irradiation

Gamma irradiation protocol developed for fungal decontamination of chilli powder. The technology results in safe storage of packed and irradiated (7.5 kGy) ground chilli powder in ambient condition for six months and more.

• Development of vacuum dried khaman

Production technology for preparation of dried khaman, involves vacuum drying (600 mmHg, 80°C, 180 min) of *khaman* pieces. Final product packed in aluminium laminated pouches can be stored under ambient storage condition $(27\pm2^{\circ}C)$ for 60 days. This can be easily rehydrated for consumption in 5 min using warm water (~50°C) with addition of 68 gm water to prepare 100g product.

• Ohmic heating of mango pulp

In preservation of mango pulp by using ohmic heating processing technology, processing parameters are voltage (160 V), temperature (80°C), with holding time of 4 min. The pulp retains better nutrients (7.1 Overall Acceptability) is stable and acceptable upto 67 days of storage in glass bottles, under refrigerated condition at 7 ± 2 °C. Energy requirement for ohmic heating of mango pulp was almost 3.5 times lesser than the conventional heating.

• Effect of gamma irradiation on milling and cooking characteristics of pigeon pea

Irradiation (10 kGy) resulted in good milling characteristics, reduction in cooking time ($\sim 50\%$) and phytic acid content ($\sim 66\%$), and improving protein digestibility (80%).

• Popping of sorghum grains using microwave energy

Technology for production of ready to puff sorghum grain using microwave energy involves use of Gujarat local (White) variety (17% moisture content, 1.33% salt, 10% oil).The technology enables production of puffed sorghum in domestic convective cum microwave oven (18 W/g, 160s). The pre-treated grains can be stored safely for 3 months and more in microwavable pouches.

• Design and development of grader for aonla fruits

For production of extruded food product from tomato pomace, the technology developed the extruder to be operated at 140°C barrel temperature, 400 RPM screw speed, raw material moisture content of 16.44%. This technology involved use of dehydrated pomace @5% and its extrusion with the corn @80% and Bengal gram @15% resulting in extruded product rich in protein, fiber and lycopene.

• Production technology for superior quality Malt Flour from Finger millet (*Ragi*)

The technology involves soaking and germination of finger millet for 12 h and 24 h respectively, followed by drying at standard temperature followed by milling. This process reduces the anti-nutritional factors like Phytic Acid and Trypsin Inhibitor Activity to 60.02% and 49.96% respectively.

Canning of mango slices

For production of canned mango slices processing technology in which, canned mango slices put in 20°Brix sugar syrup and thermally processed (retorted) at 100°C for 10 minutes result in good quality product. Processed mango slices can be stored at ambient storage condition $(30\pm2^{\circ}C)$ for one year.

Development of carotenoid fortified cookies

For production of fortified cookies, using carotenoid involves use of carotenoid extract obtained by super critical fluid extraction from vacuum dried pumpkin powder. Addition at the rate of 350 mg of extract per 100g of refined wheat flour is recommended. The cookies thus obtained contained 42.17 mg of β -carotene per 100g of product with a shelf life of 60 days.



• Development of production technology for sesame spread.

For production of sesame spread by treatments includes roasting (180 °C for 20 min) of de-hulled sesame, cooling, mixing of sesame seeds with sugar (7.3%), lecithin (1.2%), hydrogenated vegetable oil (5%) and salt (1.2%) and grinding the mix for 3 min at low speed to produce good quality sesame spread. Sesame spread can be stored at refrigerated condition ($7\pm2^{\circ}C$) for three months.

• Super critical extraction of essential oil from curry leaves

For production of essential oil from curry leaves, the technology involves recovery of essential oil (1.3%) using drying, sieving and CO_2 supercritical fluid extraction at controlled pressure (125 bar) and temperature (45°C). The process results in superior quality essential oil compared to conventional extraction methods.

• Development of poultry dropping based biogas system for energy utilization in poultry farm.

For development of poultry dropping based biogas system, the biogas yield from poultry dropping was about 12.87% more than cattle dung for 2m³/day capacity biogas plant. The cost of biogas production from poultry dropping was calculated as Rs.31/m³/ day. The produced biogas can be used to operate poultry brooders. By using the gas, 403.2 kWh electricity can be saved in three weeks duration for raising 1000 chicks as against electrically operated brooders.

4.13 AGRICULTURAL INFORMATION TECHNOLOGY

This institute prepares human resources in the field of Agriculture Information Technology (AIT) as a tool to sharpen the edges of the agriculture structure in the country. AIT has emphasized and encouraged research right from its inception. At present, active research is being carried out within the institute on various aspects of Agricultural Information Technology and also in many ways in which ICT impacts society and culture. During the year, work was undertaken on web based application to analyze the data of the experiments using designs like Completely Randomized Design, Randomized Block Design, Latin Square Design, Split plot design and Strip Plot design and also for illustration purposes in the classroom teaching as well as for the researchers with interest in experimental designs. (http://agresco.aau.in)

4.14 INFORMATION TECHNOLOGY CENTER

The Information Technology Center at Anand Agricultural University caters to the demand for the use of Information Technology in the field of agriculture for the State Agricultural Universities of Gujarat. On inclusion in various committees of the university, the Director, IT took several measures to carry forward the IT activities at various levels. During the year, substantive work was done not only in the technical or administrative matters of ITC, but also pertaining Network problems at all the four universities.

AAU Web Application

- Anand Agricultural University, Anand has developed new dynamic website. Website has 2-tier authentication. The website has dynamic uploading for all the colleges, extension centers, research centers, etc.
- The dynamic updation of the site from the concerned end user is under admin approval process. Furthermore, this website has some pages in regional language (i.e Gujarati) so that farmers of Gujarat can get benefit from that.

AAU Web Mail

- A web mail service has been incorporated in the website, enabling the users to read and reply their e-mails from any computer of LAN or using wireless network.
- There are more than 5500 e-mail users. The web site has been maintained and updated regularly by the DIT.

- AAI
- Web based Annual Budget Management System
- The Budget Management System enables state agricultural universities to manage the annual budgeting and funding process.
- The system will adapt to a variety of budgeting procedures and will be powerful enough to replace traditional methods of manual record keeping system. The system will notify the percentage of expenditure, used/remaining for the university, scheme and budget wise.
- This online application is designed to be flexible with many user-based options.
- Web based application for Dead Stock and IT Asset information Management
- Web-based System is designed and developed to manage Dead Stock and IT Assets information (to store information and retrieve it in various report formats).
- It is used to store dead stock items under multiple budget heads and keep their related entry in the dead stock register.
- If we store these register information in database, we can easily and quickly retrieve information in the desired format when required.
- Online Information Management for Extension Education Centers of AAU
- Web based online Information Management for Extension Education Centers system enables to manage various extension education activities by the different extension education centers of AAU.
- The system is used to store and manipulate the training data, FLD information, budget information, extension activities, results of OFT and success stories of the extension center of AAU and can generate necessary reports for management.

4.15 FISHERIES SCIENCE

In order to create awareness among the farmers for adopting fish farming and to utilize available resources in a fruitful manner for generating employment opportunities in rural youths, trainings have been imparted at grass root level by imparted identified fisheries thrust areas on the basis of Inland Fisheries Resources and fish production of middle Gujarat. It has been found out that there are certain needs of the training and encourage farmers for fish farming through Fish seed rearing at village tank, Carp breeding and hatchery management, Composite fish culture through village pond and Fresh water prawn culture management. Two training programmes were conducted in different subjects viz., Composite fish culture and Freshwater Aquaculture techniques in which total 76 farmers and 9 women were trained. Total four demonstrations on composite fish culture management have been conducted. Under extension activities, celebration of National Fish farmers' Day, participation in Gosthies, two Exhibitions, two field days, 15 field & diagnostic visits, 35 farmers visits to center, 5 Lectures delivered, two Press notes and 30 Advisory Services have been carried out during this year.

4.16 HOME SCIENCE

Polytechnic in Food Science and Home Economics is actively involved in research work apart from teaching and extension. During the year, two research projects were carried out by the polytechnic as follows.

• Development of high fiber bakery products using anola and carrot pomace after juice extraction.

Formula standardization and sensory, physical and physicochemical characteristics for biscuits and bread developed using anola powder were carried out.

• The Study on In *vitro* Antioxidant and Antidiabetic activity of Garden cress seed (*Lepidium sativum*).

The antioxidant activity (DPPH and ABTS)



and total phenolic compounds of Garden cress seed (*Lepidium sativum*) were analysed in the laboratory.

4.17 AGRICULTURAL METEOROLOGY

The following research work was carried out during the reporting period.

- Development of weather based models for predicting outbreak of mustard aphids.
- Flowering to seed development phase is the most crucial time for aphid infestation.
- Aphid occurrence observed during flowering to seed development phase found least affected by variation in weather parameters.
- Peak aphid intensity was recorded under seed development phase.
- Sowing on 10th October and 20th October was found most appropriate for more production and escaping high aphid intensity in mustard.
- Crop weather relationship of *kharif* groundnut (*Arachis hypogeae L.*)
- Yield attributing characters viz., number of mature pods per plant, weight of mature pods per plant and weight of total pods per plant and plant height were found responsible for enhancing pod yield under sowing at the onset of monsoon.
- Soil moisture >10% was found optimum during crop life cycle for higher pod yield of groundnut.
- CROPWAT 8.0 model was found suitable for soil moisture simulation of kharif groundnut field.
- All the weather parameters of seed setting and pod maturity phases were found significantly associated with pod yield except mean temperature.
- Rainfall distribution during peg initiation to pod maturity is found most crucial for recording higher pod yield of groundnut.

- Crop growth simulation modeling and crop weather relationship of wheat
- Higher straw yield, harvest index, test weight, number of tillers per plant, grain weight per ear, number of spikeletes per spike and plant height played significant role in obtaining highest grain yield of wheat under 15th to 30th November sowing.
- Wheat yield is associated with the weather experienced by the crop during CRI to flowering growth period.
- Simulations made by DSSAT v4.6 were average to poor for wheat phenology, growth and yield of all cultivars. The models' performance may improve with rigorous calibration with more seasonal data.

AICRP- NICRA

The Weather based Agro-Advisory Bulletins were prepared considering the stage of standing crops and IMD weather forecast with technical input received from Subject Matter Specialist of KVK Mangalbharti, Golagamdi, Sankheda. The bulletins were disseminated through personal contact, panchayat notice board, Newspaper etc. During the year, total 88 Weather based Agro-Advisory Bulletins have been prepared and issued to the farmers. During the year total 92 weather based Agro-Advisory Bulletins have been prepared and issued to the farmers. The feedback for the advisories reflected that majority of the farmers are very cautious regarding pest and diseases outbreak in their crops. For majority of the farmers, rainfall and temperature forecasts are most crucial to them and they were interested in a detailed advisory on plant protection measures for cotton and paddy crops.

IMD-FASAL

Development of yield forecasting models based on weather parameters

The crop yield forecasting models were developed for *kharif* cotton 2016 using the weather



data from 15th June to 21st October (F2 forecast) and 15th June to 25th November, 2016 (F3 forecast) for two districts viz. Sabarkantha and Vadodara.

Table A: Distric	t wise crop	yield fo	orecasting	model o	f cotton
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Stage	District	Regression equation	R ²	Forecast yield (kg/ ha) for 2016
F2	Vadodara	$\mathbf{Y} = 569.45 + 22.15^{*} \text{Time} + 9.25^{*} \text{Z}21 + 0.02^{*} \text{Z}381 + 0.07^{*} \text{Z}241$	0.97	681
(21 st October)	Sabarkantha	Y= 167.08+ 1.11*Z561 + (-0.81*Z571)	0.74	525
F3	Vadodara	Y = 744.28 + 22.48*Time + 5.32*Z11 + 0.02*Z381 + 0.12*Z461	0.95	649
(25 th November)	Sabarkantha	$Y = -2678.80 + 43.82 \times Z21 + 0.01 \times Z351$	0.78	550

Rabi season

For *rabi* season mustard, wheat and potato for different districts were assigned, models were developed and yield were predicted for different crops.

Mustard

Table B: District wise crop yield forecasting model of mustard

Stage	Districts	Regression equation		Forecasted yield (kg/ha) for 2016-17
F1	Banaskantha	Y= 922.48 + Z141*3.146 + Z171* 2.103 + Time*8.859	0.68	1401
(23 rd December) Sabarkantha		Y = 1405.45 + Z41*3.353 + Z231* 2.018 + Time*13.37		1467
F2	Banaskantha	Y= 2303.11+ Z21*68.06 + Time* 14.21+ Z361*4.31 + Z141*1.598 + Z360*0.86+ Z151*0.43	0.96	1432
(21 st January)	Sabarkantha	Y=1462.95+Time*23.81 + Z231* 1.59 + Z130*0.62	0.86	1687
F3	Banaskantha	Y= 2623.23 + Z21*97.74 + Z161* 6.26 + Z240*0.07 + Z461*0.50	0.86	1524
(18th February)	Sabarkantha	Y=1304.61+Time*24.67 + Z231* 1.62 + Z130*0.66	0.78	1688

Z361-Tmin*VP1; Z241-Tmax*RH1; Z231-Tmax*Tmin; Z130-BSS*Tmin; Z240-Tmax*RH1; Z141-BSS*RH1; Z230-Tmax*Tmin; Z671-VP1*VP2.

Wheat

Table C: Development of district wise yield forecasting of wheat

Stage	Districts	Regression equation	R ²	Forecasted yield (kg/ha) for 2016-17
	Anand	Y= 1235.55+ Time*54.18 + Z351*0.89 + Z160* (-1.05) + Z30*7.94	0.95	3034
F1 (21st	Banaskantha	Y= 4144.83 + Z231*1.47 + Z161* 15.34	0.77	2696
January)	Bhavnagar	Y= 4331.59 + Z31*72.69 + Time* 26.52 + Z41*40.28	0.83	2765
January)	Dahod	Y= 1168.06 + Z71*57.21 + Z141*0.97 + Z341* 0.86 + Z370*0.20	0.84	1980

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F1 (21st	Kheda	$ \begin{array}{c} Y = 473.17 + \text{ Time} * 53.16 + Z61 * 153.00 + Z151 * 1.15 + \\ Z471 * 0.73 + Z141 * 1.21 \end{array} $	0.93	2646
	Panchmahal	Y= 868.20+ Z141*1.44+ Z21*36.40	0.74	1850
January)	Sabarkantha	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	0.74	2451
	Vadodara	Y= 5036.32+ Z141*2.164+ Z251*0.24	0.67	2356
	Anand	Y= 2036.49 + Time*55.14 + Z351*1.06 + Z160*-0.61	0.90	3240
	Banaskantha	Y= 2154.49 + Time*94.14 + Z351*3.06 + Z160*-0.81	0.88	2868
	Bhavnagar	Y= 2956.19 + Z31*63.92*Time + Z171*11.57 + Z41*24.56+Z71*-64.163	0.89	2892
F2	Dahod	Y= 554.96 + Z371*3.57 + Z41*8.1 + Time*12.31	0.77	2162
(18 th February)	Kheda	Y=735.89 + Time*54.93 + Z61*72.35 + Z131*4.87 + Z171*3.18	0.91	2992
	Panchmahal	Y= 2274.40 + Z371*1.31 + Z121*4.33 + Z141*0.66	0.78	1881
	Sabarkantha	Y= 6271.87 + Z261*1.65 + Z21*43.31 + Z271*1.42	0.65	2752
	Vadodara	Y=4975.33 + Z121*2.85 + Z241*0.21 + Time*14.34 + Z131*3.13	0.88	2587

Z231-Tmax*Tmin; Z160-BSS*VP1; Z151-BSS*RH2; Z161-BSS*VP1; Z31-Tmin; Z41-RH1; Z121-BSS*Tmax; Z141-BSS*RH1; Z10-BSS; Z40-RH1; Z71-VP2; Z451-RH1*RH2; Z21-Tmax; Z271-Tmax*VP2; Z241-Tmax*RH1.

Wheat yield prediction using crop growth simulation model (DSSAT v 4.6)

The DSSAT (4.6) crop growth simulation CERES- Wheat model was used to simulate and predict pre-sowing (F1) and mid stage of wheat crop. For the year 2016-17, the period of weather data to be used at different stages during crop growing period is actual data, while for the remaining period of the year, normal weather data of the different districts were used in crop growth simulation model. The yield forecasted using crop growth simulation model and statistical model are compared with average yield. In some districts, there is not much difference in results for forecasted crop yield by both the methods (Fig 1 and 2).









Winter Potato

Stage	Districts	Regression equation	R ²	Forecasted yield (Kg/ha)
F1	Banaskantha	Y=17581.163+1100.821*Z31+819.167*Z21	0.37	27875
(9 th January)	Sabarkantha	Y = 49821.765 + 8.379*Z341 + 465.88*Z21	0.49	22200
F2	Kheda	Y=13360.05+0.68*Z470	0.51	24250
(13 th Febru- ary)	Banaskantha	Y=23186.6 +-4.12*Z170 + 918.06*Z21 + 1266.19*Z61	0.62	20201
	Sabarkantha	Y=26820.31+66.90*Z131+3.5*Z241	0.59	20506

Table D: Development of district wise yield forecasting for potato

Z571-RH2*VP2; Z231-Tmax*Tmin; Z31-Tmin; Z21-Tmax; Z341-Tmin*RH1; Z30-Tmin; Z361-Tmin*VP1; Z121-BSS*Tmax; Z130-BSS*Tmin.

IMD- GKMS

• Gramin Krishi Mausam Sewa (GKMS) at Dept. of Agril. Meteorology, Anand Agricultural University, Anand

• Total 104 weather based agro-advisory bulletins were issued in local newspapers *viz.*,Sardar Gurjari, Naya Padakar, Divya Bhashkar (Anand and Kheda editions) and Gujarat Samachar-Kheda Edition. Daily weather data are being sent regularly to press media of local newspapers. Bulletins are uploaded on the IMD website and University's webpage www.aau.in. In addition to this, bulletins are regularly sent by Email to State Department of Agriculture through Gujarat Agricultural Universities Council, Director of Agriculture, Joint Director of Agriculture (State), Associate Director of Agriculture (State) Gandhinagar,



different Agencies involved in agriculture viz., N-Logue communication, Project Co-ordinator, AICRP on Agro-Meteorology CRIDA, Hyderabad and AIR Vadodara, DD Ahmedabad, SMS service provider Routers, Handigo, Nokia and IFCO. TV talk on importance of weather based agroadvisory services has also been delivered by Bisag studio. All possible measures were taken to improve awareness among the farming community regarding the activity of the project and utility of weather forecast in crop production to minimize input cost and maximizing crop production by organizing Farmers' Awareness Programme (FAP) and personal contact with individual farmers and farmers' club of some villages nearby Anand district.

4.18 SEED PRODUCTION

Ensuring quality of seeds to farmers, Anand Agricultural University has registered its trademark and logo of **'ANUBHAV SEED'** with the Trademark Registration Authority of India. All the seed producing centres/units of Anand Agricultural University, Anand is well equipped with seed production machinaries required for all operations starting from land preparation to harvesting. The total seed production of the year 2016-17 is **5561.88** quintals showing nearly two and half times increase over the year 2004-05 (2247.83 quintal). The seed processes and seed testing facilities have been made available, which has boosted the efforts of seed quality assurance.

Seed and Seedling production, 2016-17

(In quintals)

Sr. No.	Сгор	Nucleus/ Parent	Breeder	Foundation	Certified	T/L	Total
1	Paddy	3.62	169.67	641.70	1594.10	680.76	3089.85
2	Maize*	1.07	84.67	31.50		88.50	205.74
3	Wheat*		260.00	36.00	468.50	422.07	1186.57
	Pulses						
4	Green gram	0.30	10.51	03.85		12.15	26.81
5	Gram*		26.52	10.00		96.57	133.09
6	Pigeonpea	0.40	06.68	13.20		19.00	39.28
	Oilseeds						
7	Castor (Hy.)					205.35	205.35
8	Groundnut		21.60				21.60
9	Soybean	0.08	6.50	10.50	144.75	12.00	173.83
	Cash/ Other crops						
10	Cotton		63.86			38.00	101.86
11	Tobacco					87.25	87.25
12	Cluster bean (Seed)					87.35	87.35
13	Sunhemp					12.68	12.68
	Forage crops						
14	Lucerne*	0.70	15.50			09.00	25.20
15	Oat*	4.00	85.00			06.00	95.00
16	Rajka-Bajra					03.15	03.15
17	Sorghum					09.30	09.30
	Total (Field crops)	10.17	750.51	746.75	2207.35	1789.13	5503.91

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Sr. No.	Сгор	Nucleus/ Parent	Breeder	Foundation	Certified	T/L	Total
	Vegetables						
18	Cluster bean (Veg.)					4.30	4.430
19	Pigeonpea(Veg.)	0.130**				2.50	2.500
20	Cowpea (Veg.)		3.950			1.00	4.950
21	Chilli (Veg.)	0.006				1.59	1.596
22	Brinjal	0.005				0.40	0.405
23	Okra	0.070	0.600			2.45	3.120
24	Tomato	0.005				0.09	0.095
25	Bottle gourd					0.20	0.225
26	Cucumber	0.025***				0.04	0.040
27	Pumpkin					0.02	0.020
28	Ridge gourd					0.02	0.020
29	Drumstick					0.20	0.200
30	Onion	0.010					0.010
	Spices (Seed)						
31	Cumin					16.00	16.00
32	M & A plants seed					24.36	24.36
	Total (Horti. Crops)	0.251	4.550			53.17	57.971
	Grand Total	10.421	755.060	746.75	2207.35	1842.30	5561.881

* Provisional, ** all pulse vegetables, *** cucurbits

Planting material production

Seedli	ngs and Planting materials	Nos.
1	Tobacco	23,50,000
2	Napier/ Gajraj rooted slips	2,60,000
	Total	26,10,000
Tissue	cultured plants	
1	Date palm	1,000
2	Parval	16,000
3	Stevia	2,000
4	Kankoda	3,000
5	Pomegranate	500
	Total	22,500
Veg. S	eedlings/ planting material	
1	Brinjal	1,23,200
2	Chilli	2,69,300
3	Tomato	20,600
	Total	4,13,100
Horti.	Seedlings/ planting material	
Fruit	Planting materials	
1	Sapota grafted	502

2	Mango grafted	1136
3	Custard apple grafted	784
4	Jambu / Bijora grafted	52
5	Guava grafted	353
6	Pomegranate/ Mulberry grafted	20
7	Fig/ Litchi/ Cherry grafted	11
8	Aonla grafted	158
9	Chandan/ Rayan plant	1587
10	Kagzi Lime/ Sarbati lime plant	7628
11	Cashewnut plants	462
12	Rangooni badam plants	73
13	Custard apple plants	520
14	Guava plants	840
15	Phalsa plants	1989
16	Jambu plants	697
17	Drumstick plants	20949
18	Jackfruit plants	388
19	Karamada/ Gunda plants	3143
20	Fruit plants bud sticks	765
21	Other plants of fruits	645
	Total	42,702

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FLOWERS AND ORNAMENTAL PLANTS (Nos.)							
1	Rose (Deshi)	6609		12	Trees of different types	5702	
2	Mogra	2018		13	Potted plant (big)	746	
3	Ixora	1080		14	Potted plant (medium)	686	
4	Bogain vellia	1291		15	Hanging Basket	130	
5	Chrysanthemum	3539		16	Plastic pot (big size)	12	
6	Jasud	1329		17	Plastic pot (medium size)	31	
7	Chandan	55		18	Chrysanthemum seedling	17200	
8	Climbers different types	1089		19	Marigold seedling	30525	
9	Seasonal flower seedling	2066		20	Gaillardia seedling	1100	
10	Seasonal seed packet	495		21	Seasonal seedling others	27325	
11	Plants of different types	31970			Total	1,34,998	



MEDICINAL & AROMATIC PLANTS (Nos.)				
1	Madhunasini	313		
2	Jammu lemon grass	323		
3	Tulsi	1167		
4	Parnfuti	170		
5	Cuttings	795		
6	Dodi	6000		
7	Satavari	617		
8	Rajani gandha	169		
9	Senna	145		
10	Galo	136		
11	Kuvarpathu	543		
12	Hadsakad	804		
13	Lsanvel	162		
14	Putranjiva	126		
15	Sindur	157		
16	Parijat	158		
17	Chives	122		
18	Karmada	207		
19	Fudino	161		
20	Rice plant	163		
21	Safed chitrak	403		
22	Sitafad	137		
23	Safed musali	122		
24	Ajamapan	111		
25	Indrajav	1047		
26	Ashwgandha	146		
27	Brahmi	289		
28	Tulsi seedlings	32000		
29	Kariyatu seedlings	10000		
30	Others	1537		



Ashwgandha



Senna



Safed musali



Dodi