ACKNOWLEDGEMENTS

The Chairman and members of the QRT take this opportunity to express their grateful thanks to Dr. Mangala Rai, Secretary, DARE and Director General, ICAR for the opportunity given to conduct this review. The team expresses sincere thanks to Dr. G. Kalloo, Former Deputy Director General (CS), ICAR for his co-operation and suggestions while undertaking this review.

The team very much enjoyed the work entrusted to it and received whole hearted co-operation, courtesy and hospitality from the scientists and other officers working at the various project centres in different states. QRT would like to thank each one of them.

The team would like to express its deep sense of appreciation to Dr. K.T.Krishne Gowda, Project Co-ordinator, Dr. V. R. Sashidhar and their colleagues at the Project Co-ordination Cell, AICSMIP, Bangalore for their extraordinary help in various ways in completing this assignment.

Dr. S. L. Mehta
Chairman, QRT

Dr. Basant Ram
Member, QRT

Dr. M. Rangaswamy
Member, QRT

Dr. N. Sankaran,
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1. INTRODUCTION

The Quinquennial review is an effective in built mechanism for monitoring and evaluation of research activities of Indian Council of Agriculture Research (ICAR) institutions through a specially constituted team of experts. Such a review is essential for assessing the progress of research, its relevance in order to ensure the efficiency of the research programmes. The ICAR, New Delhi constituted a Quinquennial Review Team (QRT) vide letter No. F. 26-1/2005-FFC dated 23.09.2005 to undertake review of the progress made by All India Co-ordinated Small Millets Improvement Project (AICSMIP) for the period 1-4-2000 to 31-3-2005.

1.1 Composition of the team was as follows

1. Dr. S. L. Mehta - Chairman
   Vice - Chancellor
   Maharana Pratap University of Agriculture
   & Technology, Udaipur-313 001.

2. Dr. Basant Ram - Member
   Director of Research
   G.B. Pant University of Agriculture &
   Technology, Pantnagar – 263145.
   Dist. Udham Singh Nagar, Uttaranchal.

3. Dr. M. Rangaswamy - Member
   Former Director
   School of Genetics & Plant Breeding
   Tamil Nadu Agricultural University,
   Coimbatore - 641 003.

4. Dr. N. Sankaran - Member
   Former Director
   Centre of Advanced Studies on
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   Tamil Nadu Agricultural University
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5. Dr. H. V. Narasimha - Member
   Former Head, Grain Science & Tech.
   CFTRI, Mysore – 570 013.

6. Dr. V.R. Sashidhar - Secretary
   Professor and Head
   Dept. of Crop Physiology
   University of Agricultural Sciences
   GKVK, Bangalore – 560 065.

1.1.1. The terms of reference

The terms of reference of QRT were as follows;

1. Assess the achievements of the project with reference to (i) Focus on national programmes, (ii) Multi location testing for yield, other agronomic attributes besides, evaluation to biotic and abiotic stresses, (iii) Exchange of scientific information and creating platform for scientific discussions, (iv) Inter institutional and inter disciplinary linkages, (v) Development of strategic and perspective plans, (vi) Linkages with international programmes (vii) Provision of off-season activities, (viii) Information on technology base, (ix) Kind of applied and strategic research undertaken, (x) Encouragement for the individual initiative and freedom provided to scientists, (xi) Optimum utilization of man power, resources, besides training opportunities provided for up gradation of skills of scientists working in the project and (xii) Duplication of work if any and

To examine/assess:

2. The budgetary requirements of the project in relation to its programmes and anticipated performance.
3. The kind of basic and strategic research backup available to the work carried out under the co-ordinated research project.
4. Whether there is a sense of ownership and wider acceptance of the co-ordinated project in the SAU where the centre is functioning.
5. The optimum utilization of manpower provided in the project for the work of the co-ordinated project.
6. The monitoring mechanisms of the co-ordinated project in the co-operating centres in order to avoid distortions / duplications / overlapping in programmes of AICRP and State Agricultural Universities including regional stations.
7. The number of co-operating centres included in the project and the need to continue them with mutual consent for true partnership to become active members of the co-ordinated system.
8. The extent of operating funds provided to the scientists working in the co-ordinated project and its sufficiency to meet the minimum requirements of the research programmes undertaken.
9. The research achievements of the project
10. The objectives, scope and relevance of the research programmes in overall national needs.
11. The likely impact of the research results on production of these crops in different production zones.
12. The kinds of research-extension linkages established with the end users of research results i.e. with the development agencies on one hand and farmers on the other.
13. Problems and constraints, if any, hindering the project in achieving its set goals and mandates.
14. To suggest changes/modifications in the organizational set up of the project to enhance the pace of research progress to meet the crop needs in both short and long term
15. To look into any other points considered relevant to the project.

1.1.2. Approach and modus operandi

The chairman of the QRT held detailed discussion with the Project Co-ordinator in order to chalk out the mode of operation including travel plans. To obtain a fair idea about the work going on in the project, the Project Co-ordinator was asked to prepare a consolidated report for the period under review. This was besides a detailed status report in a suggested format obtained from each of the project centres. The consolidated annual reports of the project and also the other important publications of the Project (both research and extension) were also seen. All these helped in assessing the contributions as well as shortcomings of each centre for making appropriate suggestions and recommendations for improvement.

The team, prior to taking up review met DDG (CS) on 19-12-2005 at the ICAR head quarters for initial briefing. The visits were undertaken to various centres. A full team or a sub group visited the centres of the project and other organizations directly or indirectly promoting small millets production in the country. A detailed itinerary of the centres visited and the list of persons met and discussed by the QRT are given in Annexure I and II, respectively.

The team during its visit to centres invariably went around the experimental fields, visited the laboratories, field demonstrations if any laid out at the research station. The team held discussions with the scientists working in the project, head of the schemes/ stations, Director of Research, Vice-Chancellor of the respective Agriculture Universities, senior officers of the State Departments of Agriculture and others associated in millets development. The team prepared a checklist (see annexure III), which was used during discussion at the centre. The visits to the centres were followed with a discussion among the team members. An effort has been made in this report not only to assess the overall contribution of the project but also contributions of individual centres in providing the required scientific backup to bring improvements in production and productivity of the small millets in the state/country. The paradigm shifts that are taking place in the farm sector has been kept in mind while assessing the role of these crops in the coming years and in making recommendations. The adjustments needed, the thrust and priorities to be assigned in the research programmes in order to realize the full potential of small millets in meeting the food needs of the region has been suggested. As the X^{th} plan is coming to a close, the report could be used as a strategy paper in formulating the research activities for the XI^{th} plan and beyond.

1.2. Small Millets in Indian Agriculture- Present scenario

Among rainfed crops, millets as a group figure prominently. India is the largest producer of many kinds of millets, which are often referred to as coarse cereals. However, realizing the nutritional superiority of these grains they are now considered as ***nutri*** - ***cereals*** (Nutritious grains). Millets grown in India are sorghum (Jowar), pearl millet (Bajra) and small millets which include finger millet (Ragi), kodo millet, foxtail millet, little millet, proso millet and barnyard millet. Of the total area of 23- 24 million ha under millets, small millets account for about 2.7 million ha and their cultivation extending from sea level in coastal Andhra Pradesh to 8000 feet above sea level in hills of Uttaranchal and North -Eastern states. These crops are grown in diverse soils, varying rainfall regimes and in areas widely differing in thermo and photoperiods. The resilience exhibited by these crops is helpful in their adjustment to different kinds of ecological niches and have made them quite indispensable to rainfed, tribal and hill agriculture where crop substitution is difficult. That is why it is important to enhance production and productivity of these crops to ensure food and nutritional security.

The major ragi growing states are Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Maharashtra and Uttaranchal. Karnataka State has the largest area of around 1 million hectares (60% of the total area) followed by Maharashtra, Orissa, Tamil Nadu, Andhra Pradesh and Uttaranchal each having 10-12 % of the area. The cultivation of kodo millet, little millet and foxtail millet is more in Madhya Pradesh, Chattisgarh, Orissa, Tamil Nadu, Jharkhand, Karnataka, Andhra Pradesh and Maharashtra. Madhya Pradesh with around 1 million hectares is important, with most area under kodo millet and little millet. Barnyard millet and proso millet are grown in Uttaranchal, north-east region, north Bihar, western Uttar Pradesh and Maharashtra.

Utilization of these grains is mainly as food for human consumption. The straw is a precious fodder for bovines. The grain is processed and consumed in traditional way and almost the entire produce is utilized at the farm/village level. Inspite of superior nutritive value of grains, their use is confined more to rural areas and very little finds its way to urban markets.

The problem of pests and diseases in small millets is negligible. Being eco-friendly crops they are suitable for fragile and vulnerable ecosystems and regarded as preferred crops for sustainable and green agriculture. The promotion of these crops can lead to Efficient Natural Resource Management and holistic approach in sustaining precious agro-biodiversity.

Production and productivity trends

The mean annual planting area under small millets is around 2.7 m ha. Of this nearly 1.6 million hectares is planted under finger millet (*ragi*), (Table 1). During the last three decades the area under finger millet has declined marginally but with significant improvement in productivity (Fig.1), the annual production is maintained around 2.1 m tonnes with productivity around 1300 kg/ha. Among grain crops, finger millet ranks fourth in productivity after wheat, rice and maize in India.

Table 1: Five year averages of area, production and productivity of finger millet and other small millets (1951-2005)

Year	Finger millet			Other small millets		
	Area ('000 ha)	Production ('000 t)	Productivity (kg/ha)	Area ('000 ha)	Production ('000 t)	Productivity (kg/ha)
1951-55	2246	1520	678	5189	2143	411
1956-60	2414	1874	778	5096	1976	389
1961-65	2519	1991	791	4755	1960	413
1966-70	2465	1721	703	4697	1697	361
1971-75	2409	1975	820	4609	1747	379
1976-80	2609	2726	1042	4465	1813	385
1981-85	2499	2593	1036	3623	1462	403
1986-90	2346	2544	1084	2890	1219	423
1991-95	2015	2542	1267	2077	954	457
1996-00	1826	2586	1420	1490	658	441
2001-05	1630	2098	1276	1078	490	459

Area in 000' hectares; Production in 000' tonnes; Productivity in Kg/ha .

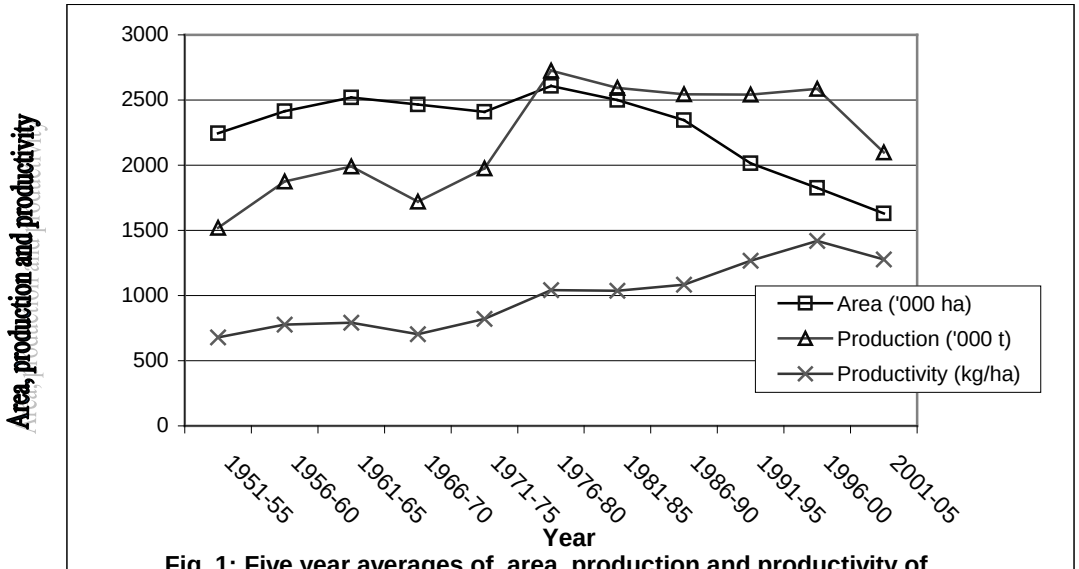
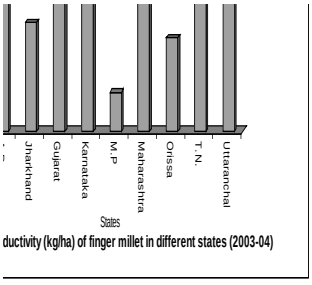


Fig. 1: Five year averages of area, production and productivity of Finger millet in India (1951 – 2005)

The comparison of productivity in different states brings out interesting facts. Barring Uttaranchal, Karnataka and Tamil Nadu, productivity of finger millet in other states is lower than the national average (Fig 2). The situation is more dismal for small millets particularly in state like Madhya Pradesh with largest area showing productivity lower than the national average (Fig. 3,4, 5 & 6).



ductivity (kg/ha) of finger millet in different states (2003-04)

In contrast, the area under other small millets has steeply declined (from 5.2 m ha in 1951 to 1.1 m ha in 2003) affecting production (2.2 m tonnes in 1951 to 0.51 m tonnes in 2003) and the productivity more or less stagnating around 494 kg/ha. Small millets are widely grown and the choice of a particular small millet crop, area grown and stability of its production as well as productivity are determined by vagaries of monsoon, scantiness of rainfall and its ill distribution in southern states, while it is stable in assured *kharif* situation, in tribal belts, hill tracks of Eastern, Central, Western and Northern states where low input agriculture is in vogue.

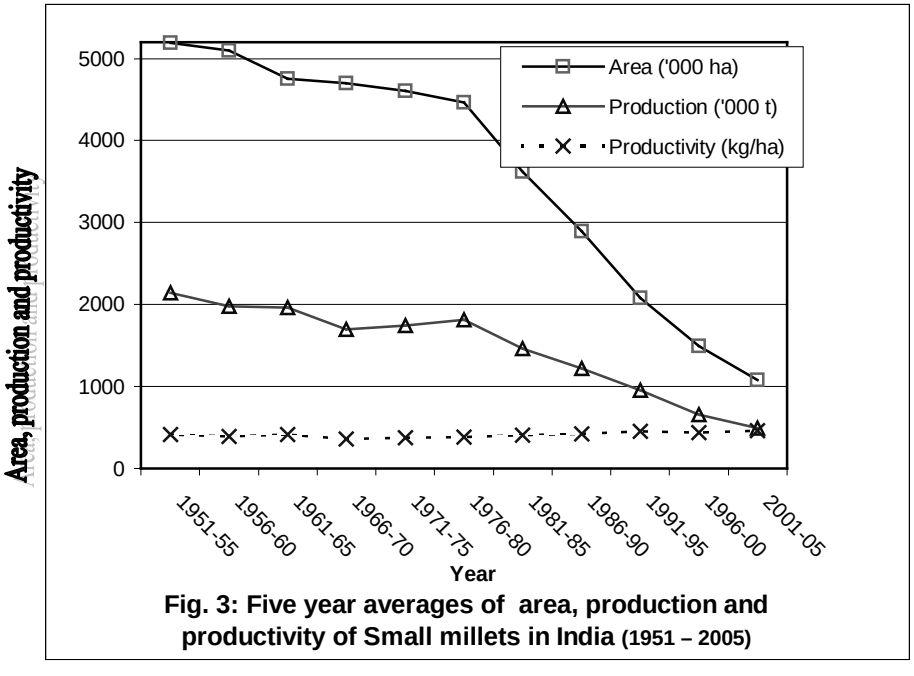


Fig. 3: Five year averages of area, production and productivity of Small millets in India (1951 – 2005)

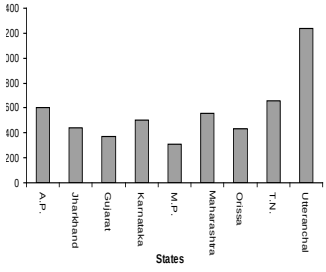
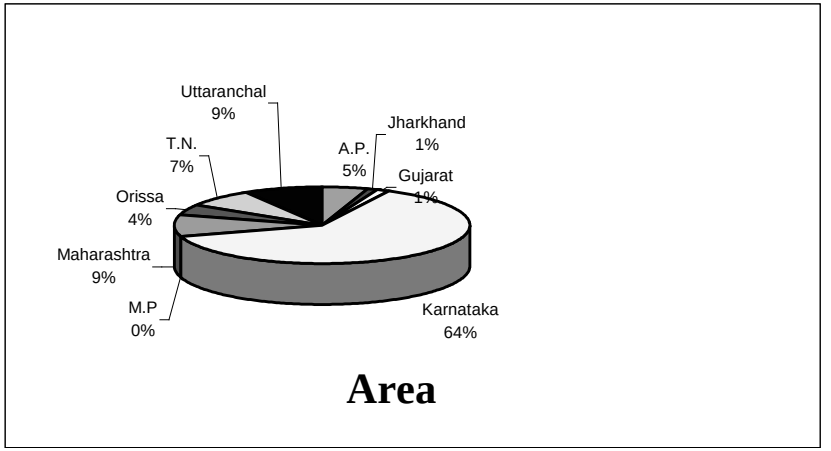


Fig. 4: Productivity (kg/ha) of Other Small Millets in Different States (2003-04)



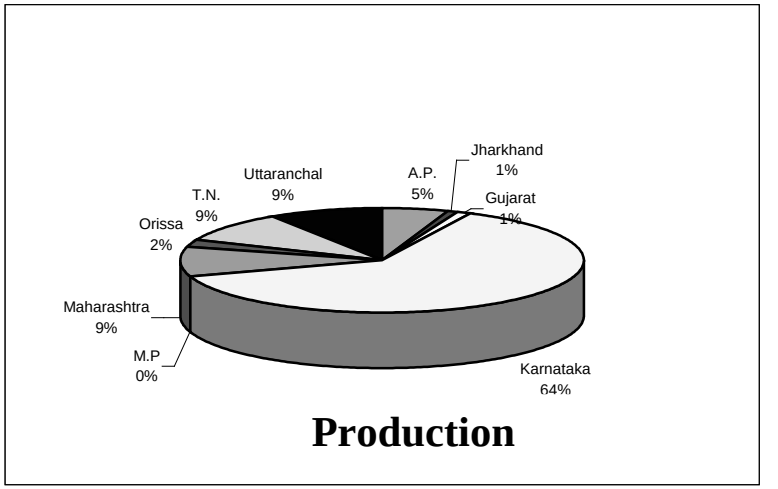
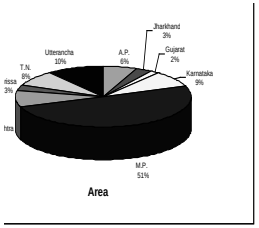


Fig. 5 : Per cent area and production of finger millet in different states (2003-04)



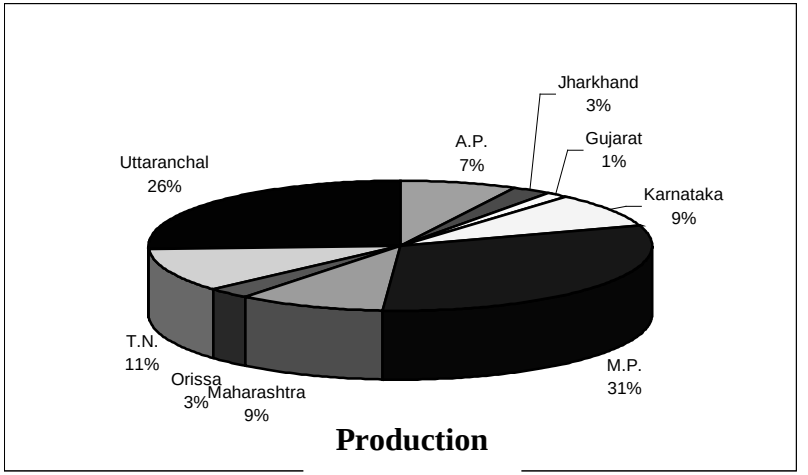


Fig. 6: Per cent Area and Production of other small millets in different states (2003-04)

The decade wise compound growth rate (CGR) for area, production and yield is given in table 2. It is seen that the growth rate of ragi was positive in the decades of 1951-60, 1971-80 and again during 2001-05. As far as production is concerned it was highest during 2001-05 and then in 1951-60. The growth rate for yield of finger millet has been positive except for the decade of 1961-70. During last decade CGR for yield is fairly high and this has been responsible for positive value in production.

The CGR for other small millets with respect of area and production has shown high negative values with higher growth rate for yield during 2001-05.

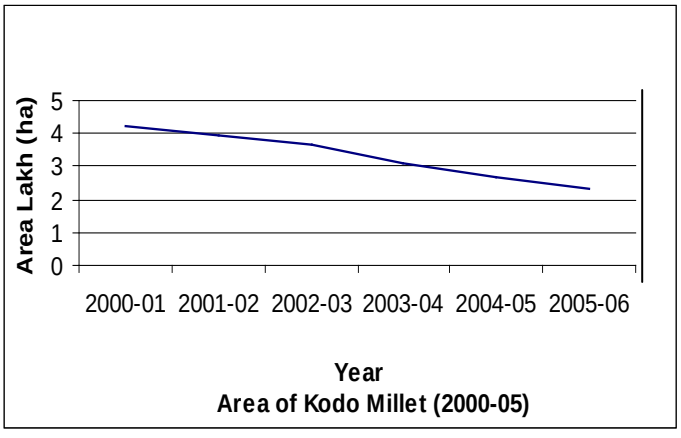
Table 2 : Decade wise compound growth rates (cgr) for area, production and yield of ragi and small millets during 1951 to 2005

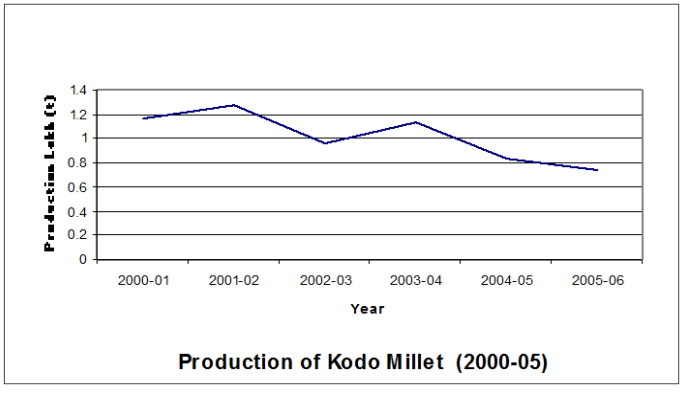
Year	Compound growth rate (CGR)					
	Ragi			Small millets		
	Area	Production	Yield	Area	Production	Yield
1951-1960	1.57	4.48	2.85	0.57	0.32	-0.12
1961-1970	-0.28	-1.00	-0.72	-0.32	-1.68	-1.35
1971-1980	1.25	4.28	2.99	-0.76	-0.51	0.25
1981-1990	-1.21	-0.10	1.13	-4.35	-3.26	1.36
1991-2000	-1.8	0.93	2.78	- 5.36	- 5.38	- 0.09
2001-2005	3.3	6.73	3.31	- 10.22	- 6.21	4.44

Area, production and yield during 2000-05 of kodo millet (Table 3 & Fig 7), little millet (Table 4 & Fig 8), foxtail millet (Table 5 & Fig 9), proso millet (Table 6 & Fig 10), and barnyard millet (Table 7 & Fig 11) are presented below, though the area has come down but the productivity increased.

Table 3: Area, production and productivity of Kodo Millet (2000-05)

Year	Area Lakh (ha)	Production Lakh (t)	Productivity (Kg/ ha)
2000-01	4.201	1.159	276
2001-02	3.947	1.272	322
2002-03	3.658	0.957	262
2003-04	3.109	1.132	364
2004-05	2.708	0.83	306
2005-06	2.348	0.732	312





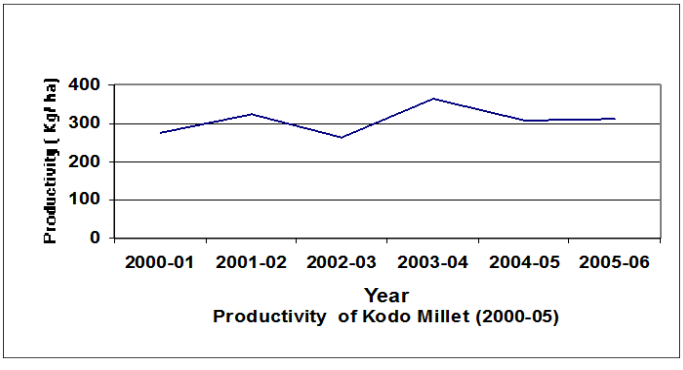
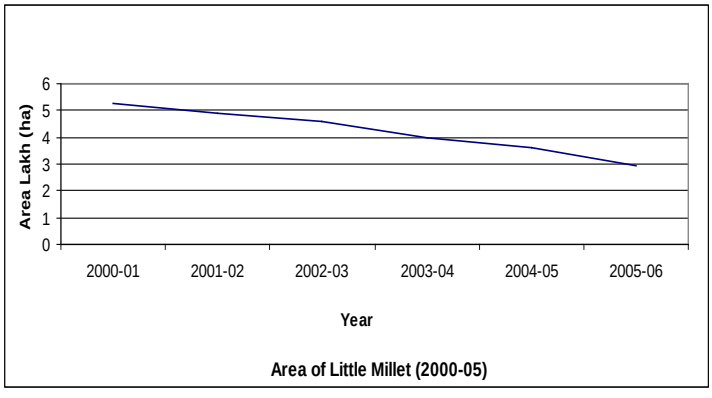
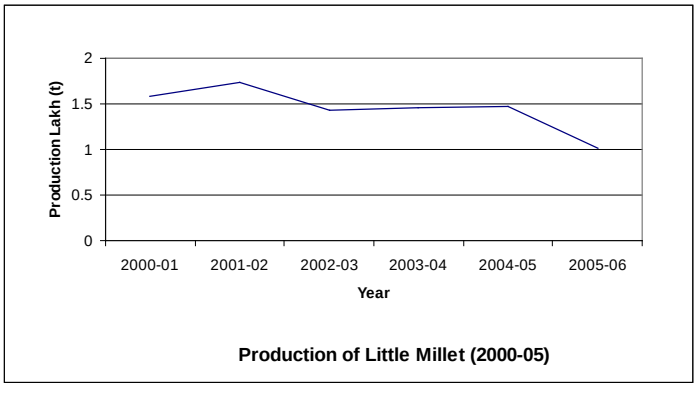


Fig. 7 : Area, production and Productivity of Kodo millet (2000-2005)

Table 4: Area, production and productivity of Little Millet (2000-05)

Year	Area Lakh (ha)	Production Lakh (t)	Productivity (Kg/ ha)
2000-01	5.278	1.59	301
2001-02	4.889	1.73	354
2002-03	4.579	1.426	311
2003-04	3.994	1.463	366
2004-05	3.626	1.477	407
2005-06	2.91	1.016	349





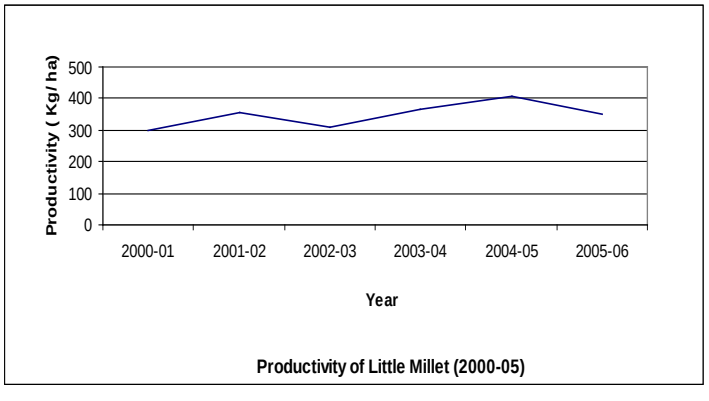
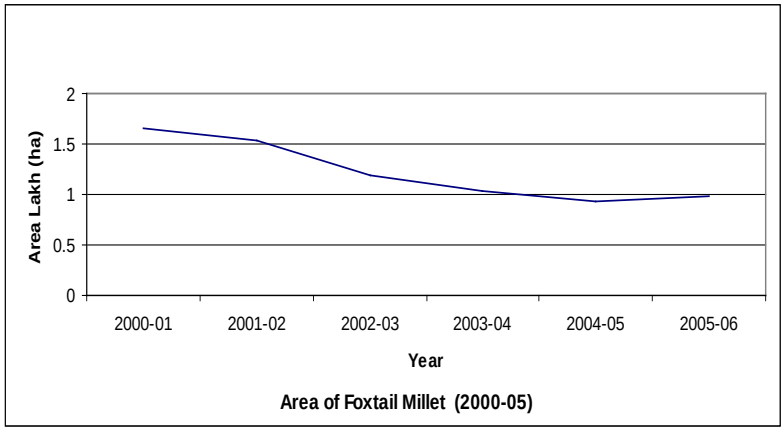
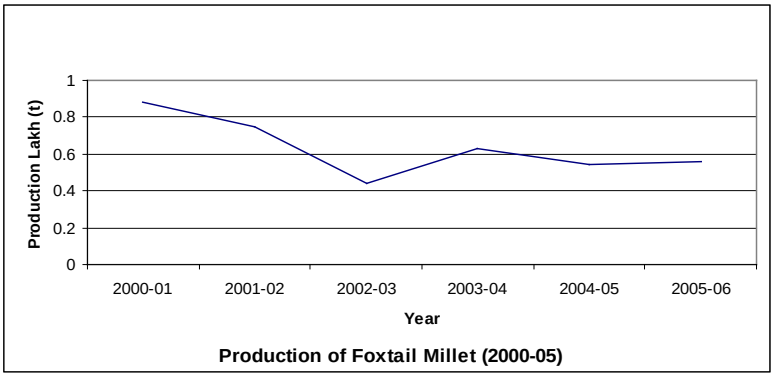


Fig. 8 : Area, production and Productivity of Little millet (2000-2005)

Table 5: Area, production and productivity of Foxtail Millet (2000-05)

Year	Area Lakh (ha)	Production Lakh (t)	Productivity (Kg/ ha)
2000-01	1.661	0.879	529
2001-02	1.535	0.748	487
2002-03	1.195	0.442	370
2003-04	1.037	0.629	607
2004-05	0.929	0.544	586
2005-06	0.984	0.556	565





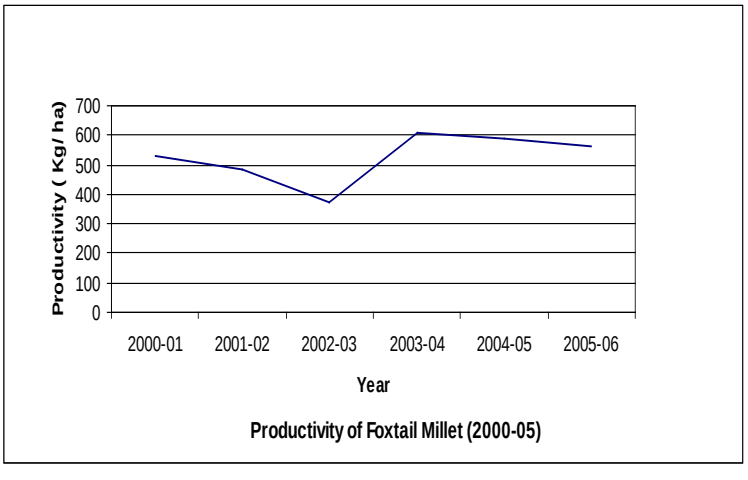
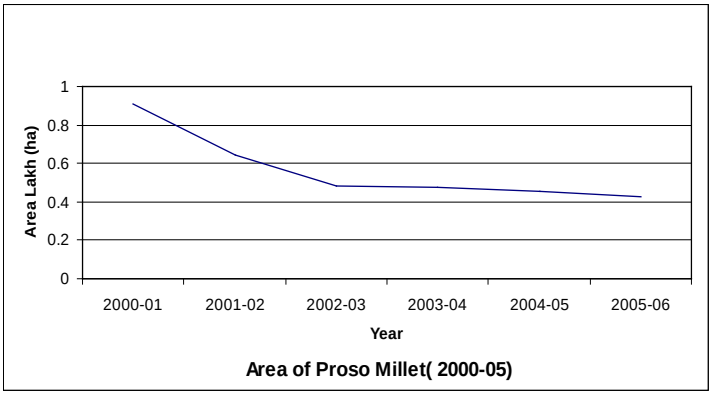
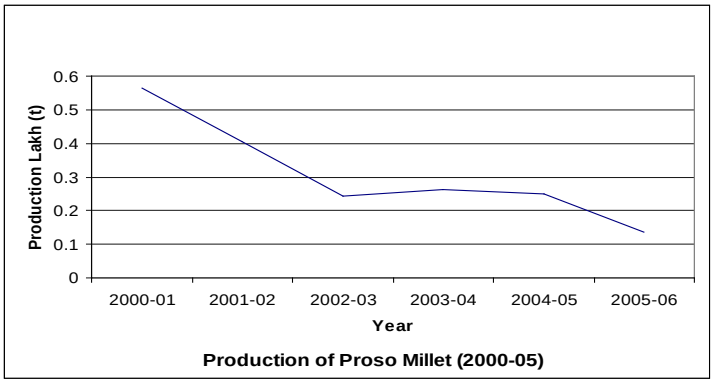


Fig. 9 : Area, production and Productivity of Foxtail millet (2000-2005)

Table 6: Area, production and productivity of Proso Millet (2000-05)

Year	Area Lakh (ha)	Production Lakh (t)	Productivity (Kg/ ha)
2000-01	0.911	0.563	618
2001-02	0.646	0.404	625
2002-03	0.484	0.244	504
2003-04	0.475	0.264	556
2004-05	0.458	0.251	548
2005-06	0.424	0.137	323





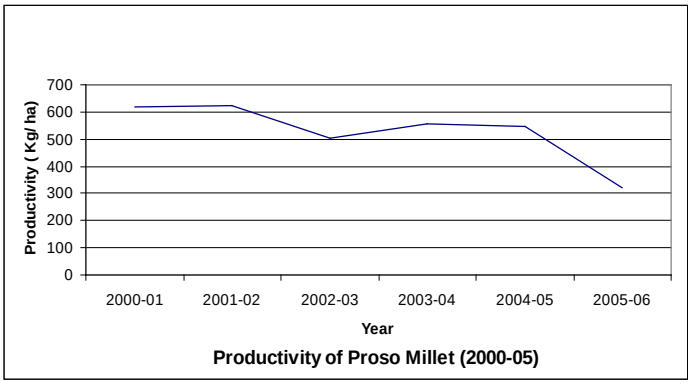
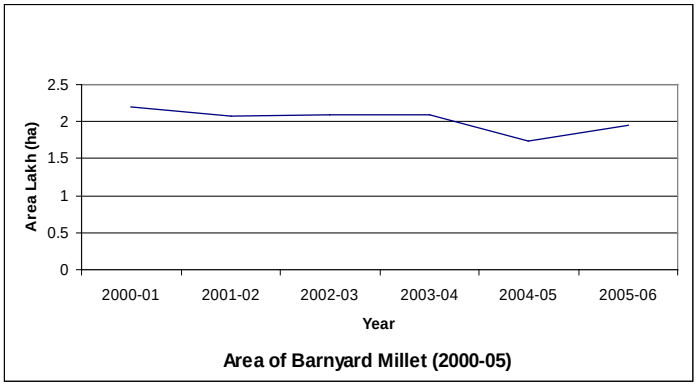
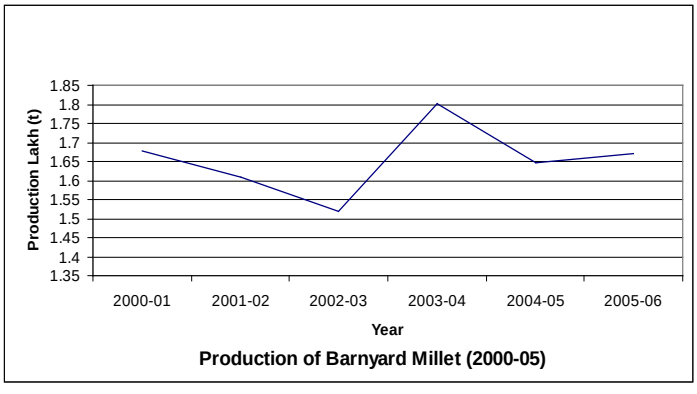


Fig. 10 : Area, production and Productivity of Proso millet (2000-2005)

Table 7: Area, production and productivity of Barnyard Millet (2000-05)

Year	Area Lakh (ha)	Production Lakh (t)	Productivity (Kg/ ha)
2000-01	2.191	1.678	766
2001-02	2.083	1.608	772
2002-03	2.09	1.52	727
2003-04	2.086	1.801	863
2004-05	1.734	1.648	950
2005-06	1.948	1.669	857





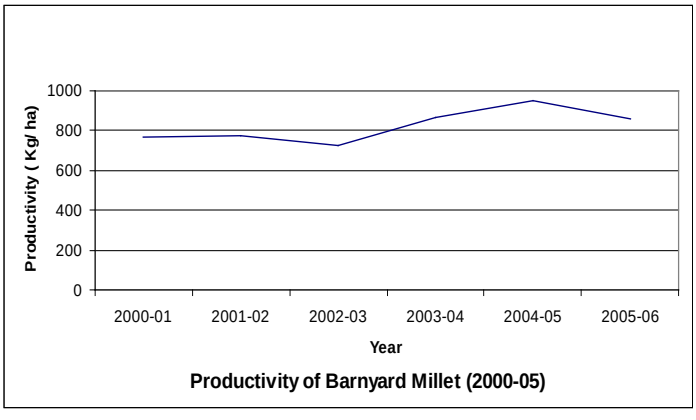


Fig. 11 : Area, production and Productivity of Barnyard millet (2000-2005)

Nutritional Quality of Small Millets

Small millets are very nutritious and even superior to rice and wheat in certain constituents (Table 8). Finger millet is the richest source of calcium (300-350 mg/100 gm grain). These millets are a good source of phosphorous and iron too. The protein ranges from 7-12% and fat from 1.12 to 5.0 %. The millet protein has balanced amino acid profile and good source of methionine, cystine and lysine (Table 9). The millet grain contains about 65% carbohydrate, a high proportion of which is in the form of non-starchy polysaccharides and dietary fibre which help in prevention of constipation, lowering of blood cholesterol and slow release of glucose to the blood stream during digestion. Millet grains are also rich in important vitamins viz., Thiamine, riboflavin, folic acid and niacin. It is of interest to note that lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycemia (diabetes) are reported among regular millet consumers.

Table 8 : Nutrient composition of millets and cereals (Per 100 G)

Food gain	Protein (g)	Carbohy-drates (g)	Fat (g)	Crude fibre (g)	Mineral matter (g)	Calcium (mg)	Phospho-rous (mg)	Fe (mg)
MILLETS								
Finger millet	7.3	72.0	1.3	3.6	2.7	344	283	3.9
Kodo millet	8.3	65.0	1.4	9.0	2.6	27	188	12.0
Proso millet	12.5	70.4	3.1	7.2	1.9	14	206	10.0
Foxtail millet	12.3	60.9	4.3	8.0	3.3	31	290	5.0
Little milet	7.7	67.0	4.7	7.6	1.5	17	220	6.0
Barnyard millet	6.2	65.5	2.2	9.8	4.4	11	280	15.0
CEREALS								
Wheat	11.8	71.2	1.5	1.2	1.5	41	306	5.3
Rice	6.8	78.2	0.5	0.2	0.6	45	160	

Millet grains are known for good shelf life. The grains dried to 10-12% moisture level can be stored for many years in farm homes. There are reports of finger millet kept for more than two decades without adverse affect on grain quality. The millet flour and their products also show good shelf life. Besides India, in many countries of Eurasia including China and Japan, foxtail millet, proso millet and barnyard millet have been popular food grains for many centuries.

Table 9 : Essential amino acids contents of millets and cereals (g/100g of proteins)

Amino acids	Finger Millet	Kodo Millet	Proso Millet	Foxtail Millet	Barnyard Millet	Wheat	Rice
Isoleucine	4.4	3.0	8.1	7.6	8.8	3.3	3.8
Leucine	9.5	6.7	12.2	16.7	16.6	6.7	8.2
Lysine	2.9	3.0	3.0	2.2	2.9	2.8	3.8
Methionine	3.1	1.5	2.6	2.8	1.9	1.5	2.3
Phenyl alanine	5.2	6.0	4.9	6.7	2.2	4.5	5.2
Threonine	3.8	3.2	3.0	2.7	2.2	2.8	4.1
Tryptophan	1.6	0.8	0.8	1.0	1.0	1.5	1.4
Valine	6.6	3.8	6.5	6.9	6.4	4.4	5.5

In rural India many kinds of traditional foods are made and form staple diet for many households. Ragi is eaten in the form of mudde (dumpling or stiff porridge) and / or roti. Many other traditional foods are made from popped ragi flour mixed with sugar / jaggery / ghee / milk / butter milk and salt. In several rural households a vast variety of traditional snacks are made from ragi and other small millets.

The millet grains offer many opportunities for diversified utilization and in adding value. With proper processing it is possible to make different kinds of food products by adopting appropriate milling, popping and other technologies.

Except finger millet other millets resemble rice in grain morphology containing husk, bran and endosperm. Traditionally the husk and bran are separated by hand pounding. However, in recent years milling technology has been improved to enhance the grain quality, save time, as well as energy. Millet mill both for cottage level and large scale processing is available. Milled millet can be further processed towards various food uses such as flakes, quick food cereals, ready to eat snacks, supplementary foods, extrusion cooking, malt based products, weaning foods, and more importantly health foods.

Finger millet flour is easy to make, since the endosperm and bran are pulverized freely and as such flour fibre content is normally higher. However, it is possible to reduce fibre content by adopting simple sieving methods.

Malting of ragi for food uses is in practice from time immemorial in southern India. Ragi has superior malting properties compared to other cereal grains like rice, maize, jowar and bajra. Ragi contains high level of calcium and its protein is rich in methionine and sulphur containing amino acids. Finger millet malt has acceptable taste, very good aroma and shelf life.

1.3. All India Co-ordinated Small Millets Improvement Project (AICSMIP) - the present organizational setup

Looking into the long felt research needs of these crops an independent All India Coordinated Small Millets Improvement Project (AICSMIP) was launched in 1986.

The Project Head Quarter is located at the University of Agricultural Sciences, GKVK Campus, Bangalore. Prior to launching of independent project the research needs of these crops (to a limited extent) were looked after by the All India Coordinated Millets Improvement Project. Pearl millet was the crop that was receiving maximum attention in erstwhile millet project. This obviously resulted in inadequate allocation of resources, time and efforts for small millets. Based on the recommendations of an expert committee, the small millets were separated from pearl millet and independent AICSMIP came into existence in 1986. This project has six crops in its mandate. They are finger millet or ragi (*Eleusine coracana*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*), proso millet (*Panicum miliaceum*) and barnyard millet (*Echinochloa frumentacea*). The present review is the third one and the first review was completed for the period 1986-93 under the chairmanship of Dr. S.R. Sreerangaswamy, Former Director, School of Genetics, TNAU, Coimbatore. The second review for the period 1-4-1994 to 2000 was under the chairmanship of Dr. P.N. Bahl, former Deputy Director General (Crop Science) ICAR, New Delhi

1.3.1. Mandates and objectives

1. To coordinate and monitor research in different centres and to organize research relevant to regional needs.
2. To evolve improved varieties and refine production and protection technologies and at the same time minimizing the cost of production.
3. To exploit the available genetic potential and thereby enhance the productivity
4. To conserve, evaluate and document the genetic resources and to promote their utilization in the research programme in different states.
5. To strengthen research in value addition and grain processing for expanding utility by finding alternative uses.

1.3.2. Organization and structure

The mandated research is carried out in the project through a network of centres located in SAUs, ICAR Institutes and other cooperating agencies (Table 10 and 11). The project centres at SAU's excluding Project Coordination Cell (PCC) at Bangalore and CFTRI Mysore are financed by ICAR and host institution on a 75 : 25 basis. The Cooperating Centres are partially supported through need based funds by the ICAR.

1.3.2.1. The setup in VIIIth Plan (1992-1997)

During VIIIth plan a total of 11 centres were functioning including the Coordination Cell of Bangalore. A centre was established during later part of VIII plan at CFTRI, Mysore in 1996 to work exclusively on grain processing, and value addition. The other SAU based centres were Coimbatore (TNAU), Nandyal and Vizianagaram (AP), Berhampur (Orissa), Dindori and Rewa (MP), Dholi and Ranchi (Bihar) and Ranichauri (UP). The Project Coordination Cell, Bangalore, is recognized as Active Collection Site and looks after collection, maintenance, evaluation, characterization, documentation and supply of germplasm. Under USAID-PGR programme, a medium term storage facility was provided for storage of collections.

1.3.2.2. The setup in IXth plan (1997-2002)

During the IXth plan, it was decided to broad base the research activities by providing support to the existing centres. In addition, two new centres one each at Mandya (Karnataka) and Jagadalpur (Chattisgarh) were created utilizing the available man power through redeployment.

1.3.2.3 The setup in Xth Plan (2002-2007)

During the Xth Plan a centre at Kolhapur was created utilizing the available manpower through redeployment.

Thus the project at present has 13 Centres. The location of these centres, the crops and disciplines handled are given in the following table.

TABLE- 10 : Location of project centres, their mandate crops and disciplines

Sl. no.	Centre	Location	Mandated crops	Disciplines handled
(A)	Project Coordination Cell, Bangalore	UAS, Bangalore, Karnataka	Finger millet and small millets Germplasm management of small millets, production physiology and basic breeding research	Genetic Resources, Breeding / Genetics, Physiology, Agronomy, Pathology, Entomology, Statistics and Data Management.
(B)	**Project Centres**			
1.	Coimbatore	Millets Research Station, TNAU, Coimbatore , TN	Finger millet and small millets	Breeding, Agronomy, Pathology, Physiology
2.	Nandyal	Regional Agricultural Research Station, APAU, Nandyal, AP	Foxtail millet	Breeding, Agronomy, Pathology
3.	Viziangaram	Millets Research Station, APAU, Vizianagaram, AP	Finger millet	Breeding, Agronomy, Pathology
4.	Rewa	College of Agriculture, JNKVV, Rewa, M.P.	Kodo millet Little millet	Breeding, Agronomy, Pathology
5.	Dindori	Tribal Area Research Station, JNKVV, Dindori, M.P	Kodo millet Little millet	Breeding, Agronomy, Entomology
6.	Ranchi	Birsa Agricultural University, Kanke / Ranchi, Jharkhand	Finger millet Little millet	Breeding, Agronomy, Pathology, Entomology
7.	Dholi	Tirhut College of Agriculture, Dholi (Muzaffarpur) RAU, Dholi, Bihar	Proso millet Finger millet Barnyard millet	Breeding
8.	Berhampur	Regional Agricultural Research Station, OUAT, Berhampur, Orissa	Finger millet Little millet	Breeding, Agronomy , Entomology, Pathology
9.	Ranichauri	Hill Campus, GBPUAT, Ranichauri, Uttaranchal	Finger millet Barnyard millet	Breeding, Agronomy, Pathology,
10.	Mysore (started in VIII plan in 1996)	CFTRI, Mysore Karnataka	Finger millet (major) and other small millets (limited)	Processing, Utilization and value addition
11.	Mandya **	V.C. Farm, RRS, Mandya, Karnataka	Finger millet	Breeding, Agronomy, Pathology
12.	Jagdalpur **	Zonal Agriculture Research Station, JGKVV, Jagdalpur, Chattisgarh	All small millets	Breeding, Agronomy, Pathology
13.	Kolhapur ***	AICRP on Small Millets, ARS, Kollapur	Finger Millet	Breeding, Agronomy

***** :*** *New centres approved in IX plan are functioning from April 2001*

******:*** *New centre approved in X plan is functioning from December 2004*

There are other co-operating (voluntary) centres participating in the research activities as detailed below.

Table 11 : Location of Co-operating centres

(A)	**ICAR Institute Based Centre**			
1	Almora	VPKAS, Almora, Uttar Pradesh	Finger millet Barnyard millet	Breeding, Agronomy Pathology, Physiology
(B)	**Co-operating (Voluntary) centres**			
1	Lam, Guntur	APAU, AP	Proso millet	Breeding and Varietal evaluation
2	Palem	APAU., AP	Finger millet Foxtail millet	Varietal evaluation
3	Peddapuram	APAU, AP	Finger millet	Varietal evaluation
4	Perumalpalli	APAU, UP	Finger millet	Varietal evaluation
5	Dahod	GAU, Gujarat	Finger millet Foxtail millet	Varietal evaluation
6	Waghai	GAU, Gujarat	Finger millet Little millet	Varietal evaluation
7	Aurangabad	MPKV, Rahuri	Finger millet Foxtail millet	Varietal evaluation
8	Palampur	HPKV, Palampur (HP)	Finger millet	Varietal evaluation
9	Amravathi	PKV, Akola, Maharashtra	Finger millet Foxtail millet Proso millet Barnyard millet	Varietal evaluation
10	Karad	KKV, Maharashtra	Finger millet	Varietal evaluation
11	Kolhapur	KKV, Maharashtra	Finger millet Little millet	Varietal evaluation
12	Majhera	GBPUAT, Pantnagar, UP	Finger millet	Varietal evaluation
13	Kanpur	CSAUAT, Kanpur, UP	Finger millet other Small millets	Breeding and Varietal evaluation
14	Bijapur	UAS,Dharwad , Karnataka	Foxtail millet	Varietal evaluation
15	Gulbarga	UAS, Dharwad	Foxtail millet Little millet	Varietal evaluation
16	Paiyur	TNAU, Coimbatore, TN	Finger millet, Little millet Kodo millet	Breeding and Varietal evaluation
17	Vamban	TNAU, Coimbatore, TN	Kodo millet	Varietal evaluation
18	Hanumanamatti	Agriculture Research Station, UAS, Dharwad, Karnataka	Foxtail millet Little millet Finger millet	Breeding Varietal evaluation Agronomy
19	Hagari	Agriculture Research Station, UAS, Dharwad, Karnataka	Foxtail millet	Varietal evaluation
20.	Pondichery	PJNCA & RI Karaikal, Pandichery	Finger millet	Agronomy

2. PROJECT MANAGEMENT

2.1. Administrative Aspect

All India Coordinated Small Millets Improvement Project (AICSMIP) is a National Project under the ageis of Crop Science Division of Indian Council of Agricultural Research, New Delhi located at UAS, Bangalore. It has the responsibility to plan, coordinate and execute the research programmes to augment the production and productivity of finger millet, kodo millet, little millet, foxtail millet, proso millet and barnyard millet. The mandated research in the project is carried out through net work of centres located in SAUs in the states and other cooperating agencies.

The salient feature of the project with regard to management functions are listed below.

- The Project Coordination Cell which is the head quarters of the project is located at the University of Agricultural Sciences, GKVK Campus, Bangalore
- At the Project Co-ordination Cell, except the Project Co-ordinator who is an ICAR employee, the other scientists are borne from UAS, Bangalore but working under the administrative control and technical guidance of the Project Co-ordinator.
- The staff strength of the project during the X^{th} plan is 101 out of which 43 are scientific positions, 20 are technical, 1 administrative and 37 are others (supporting and auxiliary). Of the 13 centres, 12 are located in the State Agricultural Universities and one is located at CFTRI, Mysore. The staff working in project centres are under the direct administrative control of respective state Agricultural Universities. As for as the technical matters are concerned, the centres work under the guidance of the Project Coordinator.
- During the Annual Workshop, the research activities are planned keeping in view the specific problems of the state or region. The programmes are carried out in a coordinated network with the idea of exchanging and sharing of the materials among the scientists of the centres.
- Logistic support is provided by the Project Coordination Cell with regard to 3 areas.
  a) Opportunity for interaction among scientists.
  b) Supplying germplasm & segregating materials as and when required by the scientists.
- The technical project leader (PI's) are responsible for execution, monitoring and reporting the activities of the project in the disciplines of (a) Crop Improvement (b) Agronomy (c) Pathology (d) Entomology (e) Physiology (f) Grain quality processing. .
- Monitoring teams for different geographical zones have been constituted with 3 to 4 members in each team drawn from different centres. These teams visit the project centres during the main crop season and oversee the implementation of the activities planned during the year. The monitoring team observations are sent to the concerned scientists as well as Director of Research of respective universities for information and follow up action taken wherever necessary. The monitoring team's observations are discussed in the annual workshop / group meeting.

2.2. Financial aspects

Financial outlay of the project for the VIIIth, IXth & Xth plan periods is given in Table 12. The funds provided during the IXth plan by and large was adequate in meeting budgetary needs of the centres. Higher allocation of funds for recurring contingency has to be made available for strengthening the activities of the centres to over come the difficulties of the centres and also keeping in view the overall increase in the price of inputs and other items cost for sustaining the progress.

Table 12: Financial outlay under various sub heads during VIIIth , IXth plan and Xth plan

Plan	Financial Outlay (Rs. in lakhs)							
	Pay & allowance	TA	Contin-gencies	Non-recurring	Others	Total	ICAR Share	State Share
VIIIth plan	292.033	13.30	57.4	32.57	HRD - 5.0 Need Based - 10.0 Publications - 2.0	395.303	329.732	65.571
IXth Plan	657.225	26.6	97.0	51.4		849.225	703.370	145.855
Xth Plan	917.84	37.90	166.30	53.30		1175.34	969.36	205.98

As the project head quarter is located in the State Agricultural University the actual financial releases are done at the ICAR head quarters and closely monitored both by the Crop Science Division and the Project Co-ordinator.

3. POLICIES, PRIORITIES, STRATEGIES AND PROGRAMMES

Current concerns

Even though productivity has been increased at most of the centres, total area and production are in decreasing trend because of non availability of profitable market to the farmers. Market for grain and value-added products has to be explored through mid day meals, poultry feed, hospitals, hotels and export. If necessary this task may be entrust to a consultancy groups.

3.1 Issues and Strategies

3.1.1 : Enhancing productivity of small millets through Judicious blending of conventional Genetic and Breeding Programmes, modern techniques, and Biotechnology tools.

- Modifications in breeding methods to break stagnant yield barriers.
- Integration of new tools like bio-technology with conventional methods.
- Surmounting and over coming restrictions in recombination breeding.
- Developing a location /region specific, disease free, high response to input management varieties.
- Developing varieties suitable to low input circumstances.
- Genetic enhancement of different species of small millets through recombination breeding involving wild species and exotic germplasm.
- Identifying varieties suitable to different times of sowing.
- Developing suitable varieties particularly in finger millet for irrigation and high inputs for the states of Tamil Nadu, A.P. and Karnataka.

3.1.2 : Increasing the returns to the small millet farmers through better crop management

- Evolving management practices for maximizing productivity in dryland.
- Developing practices to enhance the *in-situ* moisture conservation and its utilization
- Maximising the yields with a minimum use of inorganic fertilizers by suitable blending with various organic fertilizers.
- Enhancing fertilizer and moisture use efficiency through integrated nutrient management
- Integrating the bio-fertilizers in the nutrient management practices in order to minimise the cost of inputs.

- Exploring the possibilities of growing small millets as catch crops with an intention of increasing the cropping intensity under rainfed situations.

- Reduce the cost of cultivation through precision farming

- Enhancing the profitability of growing small millets by suitable inter-cropping systems specific to locations/regions.

- Assured grain procurement system with minimum support price

- Developing linkages with Industries for production of value added products

- Develop and popularise ways and means of production of health and medical foods which widens the marked base for these grains (Urban as well as export markets).

3.1.3 Crop protection programmes

- Developing integrated plant protection practices to minimise the loss in yield of crops due to the diseases (blast, Helminthosporium, downy mildew and smut)

- Biochemical basis of host and pathogen relationship

- Developing IPM modules for insect pest control

- Evolving a special package for organic millets by use of bio-pesticides.

3.1.4 : Promoting these crops for organic agriculture / and as health food crops.

- Developing technology for organic production of millets.
- Promoting these as health food in view of being their nutritional superiority high in fibre, low fat and low energy crops.
- Bringing awareness of their health benefits through print and electronic media

3.1.5 : Biotechnological research

Molecular and Marker Assisted selection programmes has to be developed on a priority basis in respect of

- Abiotic stress/ (Drought/ salinity)
- Micronutrients uptake particularly, calcium, Zinc, Iron.
- Mining of water through deeper root systems.
- Molecular basis of high Ca & Zn content.
- Exploiting the high endogenous levels of anti-oxidants already reported in the millets.
- Bio-technological avenues to improve fodder quality by targeting antinutritional factors (ANA) which reduce micro-nutrient availability in straw.
- MAS for resistance against blast disease and shootfly.

3.1.6 : Improving the fodder value

- Study of nutritional quality of fodder and breeding for improvement
- Exploring the possibilities of using grains as live stock feed.

3.1.7 : Promoting export

- Increasing both internal and external demand keeping in view the nutritional quality of these crops.

3.1.8 : Transfer of Technology from Lab to Land

- Verification tests of technology generated in the research stations in the real farming situations.
- Creating awareness at the urban and village level regarding the nutritional importance of small millets through public-private partnership programmes.

4. ACHIEVEMENTS

4.1. Research accomplishments

All India Co-ordinated Small Millets Improvement Project which was launched as an independent project in 1986 during VII plan has completed 19 years of its research and development service, till the end 2005. The first review of the project was done for the period 1986-1993 and second review for the period from 1994 to 2000. The QRT in its first report made many useful recommendations, both general and specific for improving the operational efficiency of the project. Some of those recommendations which did not require much additional investment in terms of manpower and costly infrastructure have been implemented partly in VIII plan and partly during IX plan. The work on nutritional quality, processing and utilization and value addition has been initiated by establishing a centre at CFTRI, Mysore.

The present review by QRT is the third one and is being undertaken at a critical juncture when coarse cereals in general and small millets in particular are fast losing their role and importance as a source of food. The area in many traditional states has gone down drastically affecting the food and feed security at the household / village level. It is obvious that the present review for the period 2001-2005 should be considered as important in order to not only re-orient the research activities in the changing scenario but also to re-recognize their role and importance to create greater awareness on the need for appreciating the excellent nutritional qualities of the grains among the general public and more importantly the urban population.

The research on small millets in the country is carried out in 14 centres, including the one new centre Kolhapur which started functioning from April 2004. So, the research accomplishments cover the achievements of 14 centres as well as the other co-operating institutes/ centres. The small millets research under the ageis of All India Co-ordinated Improvement Project is focused to state/regional needs from the point of developing appropriate agro production technology for maximizing production / productivity. The work is mostly multi-disciplinary and applied in nature. A brief account of the salient accomplishments for the period under review is presented.

SALIENT ACHIEVEMENTS DURING APRIL, 2000 – MARCH, 2005

4.1.1. Crop Improvement

The crop improvement was mainly aimed at developing varieties having both general and specific adaptation. Breeding for biotic stresses through the incorporation of resistant genes for major pests and diseases received attention. Among the diseases blast in finger millet, head smut in kodo millet, grain smut in barnyard millet and shootfly pest in *Panicums* have received more attention. A number of high yielding varieties were evolved and released in different states to meet the specific requirements.

1. The project Co-ordination Cell which is a recognized “active collection site” for conservation of small millets has augmented more than 12500 accessions. This includes 6257 in finger millet, 2512 in foxtail millet, 1111 in kodo millet, 868 in barnyard millet, 928 proso millet and 920 in little millet (Table 13). A total number of 1480 accessions have been supplied to other centres.

2. A number of germplasm accessions resistant to blast are identified (Table 14).

3. Identified sources of useful genes for high Ca, protein content and physiological traits and this would help in crop improvement as well as isolation of genes determining calcium uptake / deposition for use in transgenic development (Table 15).

4. A total of 1480 germplasm accessions were supplied to scientists in the project for crop improvement (Table16).

5. Seven varieties of finger millet, six varieties of foxtail millet, three varieties each of kodo and barnyard millet, four varieties of little millet and two varieties of proso millet, were evolved and released for cultivation of different agro-climatic regions (Table 17).

6. Grain yield, early maturity and blast resistance have been successfully combined with the release of variety GPU 45 at the National level and identification of GPU 48 at state level in Karnataka.

7. Pre-breeding using popular varieties with wild types for genetic enhancement and to gain desirable characters like drought tolerance, disease resistance and tillering ability.

Table 13: Status of germplasm collections at NAGS, P.C. Cell, Bangalore

Crop	No. of Accessions
Finger millet	6257
Foxtail millet	2512
Kodo millet	1111
Barnyard millet	868
Proso millet	928
Little millet	920
Total	12596

Table 14: Finger millet germplasm accessions resistant to blast

Sl No.	Accession No.	Sl No.	Accession No.	Sl No.	Accession No.	Sl No.	Accession No.	Sl No.	Accession No.
1.	GE 32	21.	GE 1409	41.	GE 3094	61.	GE 3509	81.	GE 4449
2.	GE 97	22.	GE 1546	42.	GE 3138	62.	GE 3513	82.	GE 4461
3.	GE 145	23.	GE 1676	43.	GE 3165	63.	GE 3526	83.	GE 4469
4.	GE 201	24.	GE 1995	44.	GE 3192	64.	GE 3541	84.	GE 4475
5.	GE 205	25.	GE 2092	45.	GE 3255	65.	GE 3542	85.	GE 4503
6.	GE 406	26.	GE 2263	46.	GE 3330	66.	GE 3548	86.	GE 4521
7.	GE 496	27.	GE 2679	47.	GE 3343	67.	GE 3738	87.	GE 4544
8.	GE 532	28.	GE 2700	48.	GE 3373	68.	GE 4163	88.	GE 4576
9.	GE 568	29.	GE 2706	49.	GE 3406	69.	GE 4211	89.	GE 4588
10.	GE 639	30.	GE 2718	50.	GE 3409	70.	GE 4218	90.	GE 4615
11.	GE 705	31.	GE 2791	51.	GE 3426	71.	GE 4247	91.	GE 4706
12.	GE 844	32.	GE 2792	52.	GE 3434	72.	GE 4287	92.	GE 4765
13.	GE 868	33.	GE 3035	53.	GE 3461	73.	GE 4318	93.	GE 4785
14.	GE 942	34.	GE 3045	54.	GE 3468	74.	GE 4321	94.	GE 4876
15.	GE 965	35.	GE 3063	55.	GE 3472	75.	GE 4328	95.	GE 4900
16.	GE 1126	36.	GE 3068	56.	GE 3480	76.	GE 4334	96.	GE 4913
17.	GE 1293	37.	GE 3070	57.	GE 3482	77.	GE 4355	97.	GE 4928
18.	GE 1310	38.	GE 3075	58.	GE 3484	78.	GE 4426	98.	GE 4984
19.	GE 1319	39.	GE 3090	59.	GE 3485	79.	GE 4435	99.	I8 IE
20.	GE 1348	40.	GE 3093	60.	GE 3502	80.	GE 4440	100.	IE 1012

Table 15 : Some of the identified sources of useful genes for high calcium, protein content and some physiological traits in finger millet

Sl. No.	Traits	Accession number
1	Low stomatal No., high PE, Low leaf area	GE 94, GE 325, GE 233, GE 187
2	High leaf area, High DM, Moderate to High PE	JNR 852, GE 2976, GE 1097, GE 476
3	High WUE under stress	GE 94, GE 2338, JNR 852
4	High biomass and high HI (> 35 %)	GE 187, GE 255, GE 325, GE 1179, GE 94, GE 717, GE 2338, GE 2327, GE 500, GE 2008, HR 2327, GE 2444
5	High test weight, long glume type with high ear photosynthesis	GE 2970, GE 3301, GE 2973
6	Good germination in crusted soils	PES 172, PR 202
7	Drought avoidance types	IE 2643, IE 3200, IE 2333
8	Grain Calcium content (>370 mg/100 gm)	GE 2073, GE 4140, GE 736, GE 3112, GE 5198
9	Grain Protein content (> 12 %)	GE 1680, GE 3885, GE 3764, GE 1538, GE 3149

Table 16: Supply of germplasm accessions during 2000 – 2004

Year	Finger millet	Foxtail millet	Kodo millet	Little millet	Proso millet	Barnyard millet	Total
2000	62	12	31	39	10	43	197
2001	57	27	20	15	16	17	152
2002	242	28	9	13	11	28	331
2003	258	17	2	3	65	9	354
2004	179	141	6	82	9	29	446
Total	**798**	**225**	**68**	**152**	**111**	**126**	**1480**

Table 17 : Varieties of finger millet released during 2000-2005

Sl. No.	Name of variety	Pedigree	Institute where developed	Year of release	Maturity (days)	Av. Yield (kg/ha)	Area of adaptation	Special features
1.	L-5	Malawi x Indaf 9	UAS, Nagenahally, Bangalore	2000	120-125	3500-4000	Karnataka	Late variety
2.	GPU 26	(I-5 x I-9) IE 1012	PC Unit, UAS, Bangalore	2000	100-105	3000-3500	Karnataka	Early, blast tolerant
3.	GPU 45	GPU 26 x L 5	PC Unit, UAS, Bangalore	2001	104-109	2700-2900	Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra	High yield, blast resistant
4.	Chilika (OEB 10)	GE 68 x GE 156	OUAT, Bhubaneshwar, Orissa	2001	120-125	2600-2700	Orissa, Madhya Pradesh, Gujarat, Andhra Pradesh and Tamil Nadu	Moderately resistant to blast, resistant to stem borer, late variety
5.	TNAU 946 CO (Ra) 14	Malawi 1305 x CO 13	TNAU, Coimbatore	2004	105-110	2700-2900	Tamil nadu	Resistant to neck and finger blast. Suitable for irrigated and rainfed conditions.
6.	VL 315		VPKAS, Almora	2004	110-115	2500-2700	Uttaranchal	Tolerant to finger and neck blast
7.	GPU 48	GPU 26 x L 5	PC Unit, UAS, Bangalore	2005	100-105	3000-3500	Karnataka	Early, high yield, blast resistant

Table 17 (Contd…….) : Varieties of small millets released during 2000-2005

Sl. No.	Name of variety	Pedigree	Institute where developed	Year of release	Maturity (days)	Av. Yield (kg/ha)	Area of adaptation	Special features
FOXTAIL MILLET								
1.	Meera (SR 16)	Pure line selection	MPUA & T, Udaipur	2001	75-80	1500-1700	Rajasthan	Stay green character, tolerant to Downey Mildew
2.	Sri Lakshmi	Pure line selection	ANGRAU, Hyderabad	2002	75-80	2000-2300	Andhra Pradesh	High seed yield
3.	Prathap kangni 1 (SR-1)	Selection from local germplasm	MPUA & T, Udaipur	2003	65-70	1800-2000	Rajasthan	Extra early maturity
4.	SR 51			2003			Rajasthan	Bold seeds
5.	PRK 1	Selection from **Tehri** collection	GBPUA & T, Ranihauri	2000	75-80	1900-2000	Uttar Pradesh	-
6.	TNAU 196		TNAU, Coimbatore	2005			Tamil nadu	-
KODO MILLET								
1.	Jawahar kodo 155 (RBK 155)	Selection from germplasm no. GPLM 251	JNKVV, Jabalpur	2000	105-110	2000-2200	Madhya Pradesh, Karnataka	Resistant to Head smut, shoot fly
2.	Jawahar kodo 48 (JK 48)	Pure line selection from local germplasm 48	JNKVV, Jabalpur	2001	110-115	2600-2700	Andhra Pradesh, Madhya Pradesh, Chattisgarh, Karnataka, Gujarat	
3.	KK 2	Selection from genetic collections of Ballia Dist.	CSAUA & T, Kanpur	2002	110-115	2000-2300	Uttar Pradesh	Resistant to Drought and lodging and suitable for saline condition

Table 17: (Contd….)

BARNYARD MILLET								
1.	Vl Madira 172	EF 2 x VHC 5205	VPKAS, Almora	2000	90-95	2100-2300	Uttar Pradesh, Gujarat and Karnataka	Tolerant to grain smut
2.	Sushrutha (RAU 11)	Introduction	RAU, Pusa and UAS, Dharwad	2000	90-95	2000-2200	Karnataka	
3.	VL Madira 181	ECC 27 x VL 60	VPKAS, Almora	2001	90-95	1600-1700	Bihar, Karnataka, Madhya Pradesh, Tamil Nadu	
LITTLE MILLET								
1.	Paiyur 2	Pure line selection from germplasm accession PM 295	TNAU, Coimbatore	2000	80-85	750-850	Tamil Nadu	
2.	Tarini (OLM 203)	Selection from local cultivar (KL 2) of Koraput Dist.	OUAT, Orissa	2001	75-80	1000-1100	Karnataka, Andhra Pradesh, Orissa, Bihar, Tamil Nadu	Resistant to blast and grain smut
3.	Kolab (OLM 36)	Mutant of SS-81-1	OUAT, Orissa	2001	75-80	1000-1100	Madhya Pradesh, Orissa, Chattisgarh, Bihar, Karnataka, Gujarat	Resistant to brown spot and sheath blight
4.	OLM 20	Mutant of SS-81-1	OUAT, Orissa	2003	75-80	1100-1200	Orissa, Madhya Pradesh, Chattisgarh	Drought tolerant
PROSO MILLET								
1.	GPUP 8	S 7 x L 111	UAS, Dharwad	2001	70-75	1500-1600	Karnataka	Resistant to brown spot
2.	GPUP 21	GPUP 14 x K 1	PC Unit, UAS, Bangalore	2003	67-75	1500-1800	Karnataka, Tamil Nadu	High yield, moderately tolerant to shoot fly

Crop Production

8. Double cropping of short duration finger millet in *kharif* followed by either horsegram/niger is a better option and remunerative for Jharkhand.

9. Sequence cropping of finger millet and soybean in *kharif* followed by oats/wheat in rabi are profitable options for Uttaranchal.

10. Pre emergence application of isoproturon @ 0.5kg a.i./ha for drilled ragi whereas oxyflurofen @ 0.1 kg a.i./ha for transplanted irrigated ragi is a better choice for controlling weeds effectively.

11. Transplanting finger millet is suitable and profitable even under very delayed sowing conditions.

12. Application of poultry manure to supply 100 % recommended nitrogen is a remunerative practice at Bangalore whereas pine needle compost (3.75 t/ha) along with rock phosphate and gypsum were a better choice for maximizing productivity.

13. Application of 7.5 t FYM/ha and rotating either with ground nut or maize with recommended inorganic fertilizers is remunerative practice for targeting higher production in ragi based cropping system at Bangalore.

14. Intercropping medium duration compact erect types of pigeon pea was an ideal choice and remunerative for growing ragi in Karnataka, Tamil Nadu and coastal Andhra Pradesh. Whereas, short duration pigeon pea with medium duration finger millet was a better option for Orissa.

15. Inter cropping field bean in finger millet (1:8) was a remunerative practice for Karnataka, adjoining areas of Tamil Nadu. Whereas, cluster bean as an inter crop in finger millet was a better choice for coastal Andhra Pradesh and Orissa.

16. Strip cropping of finger millet 2/3rd and pulses 1/3rd is a better option at Bangalore, whereas inter cropping of finger millet and pigeon pea (8:2) is an alternative choice at coastal Andhra Pradesh, northern Bihar and parts of Tamil Nadu.

17. Inter cropping foxtail millet and redgram/cotton/vegetable cowpea is a remunerative system for Rayalaseema regions of Andhra Pradesh and northern Karnataka.

18. Pre emergence application of isoproturon @ 0.5 kg a.i./ha found effective both in controlling weeds and enhancing productivity of foxtail millet.

19. Integrated nutrient supply of organics and inorganics (25 per cent each) along with bio fertilizer seed inoculation is a remunerative practice under low fertility conditions.

20. Niger – soybean – kodo or kodo – soybean – kodo are remunerative crop rotations for skeletal soils of Dindori.

21. Pre emergence application of Isoproturon @ 0.5 kg a.i./ha was found ideal and effective for maximizing productivity and weed control in kodo millet.

22. Inter cropping of little millet and cowpea either in 1:2 or 2:1 is profitable both at Kanke and Rewa centres.

23. Harvesting little millet at physiological maturity was found to minimise yield loss.

24. Sixty kilo gram nitrogen per hectare was found to be remunerative for maximizing productivity of proso millet under irrigated conditions.

25. Sowing during first fortnight of May was remunerative besides maintaining higher productivity in barnyard millet.

26. Pre emergence application of isoproturon @ 0.5 kg a.i./ha mixed with sand combined with two inter cultivations and one hand weeding was effective in providing good weed control and maintaining higher productivity.

27. Forty-kilo gram nitrogen per hectare was found to be optimum and economical for barnyard millet.

28. Integrated nutrient supply of organics and inorganics (25 per cent each) along with bio fertilizer seed inoculation was a remunerative practice under low fertility conditions for barnyard millet.

29. Application of 3.75 t FYM/ha along with rock phosphate and gypsum gave comparable yields on par with recommended nutrient supply through organics and inorganics in barnyard millet.

Crop protection

30. Finger millet Genotypes highly resistant to both neck and finger blast were identified.

31. In all the breeding and pathological studies through screening of germplasm accessions / lines, varieties were identified for further use in the crop improvement programmes.

32. Hot spots of different diseases- blast and cercospora leaf spot of finger millet, head smut of kodo millet, downy mildew of foxtail millet and grain smut were identified.

33. Spraying of SAAF @ 0.2 % at 50% flowering and one more need based spray after 10 days was effective in controlling neck and finger blast.

34. Choosing resistant variety and treating seeds with carbendazim @ 2 g/kg seed with recommended inputs effectively controlled the blast incidence and resulted in higher yield of finger millet; next best was selection of resistant variety for sowing.

35. In foxtail millet sowing early in July minimized the incidence of blast and rust.

36. Isolation, purification and characterization of phytotoxin and phytoalexin was helped in rapid diagnostic methods for resistance evaluation.

37. The roles of phenols, PAL, PPO, Chitinase, β-13-gluconase activities has been established in disease resistance.

38. Varieties resistant to insect pests were identified in all the small millets.

39. Intercropping/sprinkling of Niger/mustard helps in enhancing the population of parasites and predators in small millets.

40. A grain storage pest *Rhyzopertha dominica* was found for the first time feeding on stored ragi.

Crop Physiology

41. Screening of finger millet germplasm for higher water use efficiency, root traits has shown that AKP 2, A 404 are superior types.

42. Finger millet varieties Co 12, Paiyur 1 and GPU 28 were found tolerant to salinity.

43. Exogenously supplied calcium was able to partially nullify the adverse effect of sodium stress.

Processing and Value Addition

44. Decortication of finger millet has opened many ways of making new products from finger millet.

45. Par boiling of small millets also provided the opportunities for food and industrial utilization.

4.2 An assessment of Project centres

The AICSMIP has net work of 13 centres spread over 10 states where small millets are predominantly grown. Project Co-ordination Cell is located at GKVK campus, UAS, Bangalore. Out of these thirteen centres, Kolhapur centre is newly established one and started functioning from December, 2004. All centres are engaged in crop improvement, crop production based research except Mysore centre at CFTRI which is working on grain processing, diversified utilization and value addition.

The QRT team visited either in full or a partial team of at least three members to the following centres.

1. Berhampur
2. Pantnagar (Ranichauri)
3. Ranchi
4. Bangalore
5. Coimbatore
6. Mysore
7. Mandya
8. Vizianagaram

The Scientists of Jagadalpur centre were called at Berhampur. Principal Scientists of Dindori and Rewa presented the progress of the centres at Bangalore. Out of the 13 centres, the review of only Dholi centre could not be undertaken as the senior breeder working at this centre did not come for the presentation at Bangalore. The Nandyal centre report was presented at Vizianagaram. The team also visited the millet centre at VPKAS, Almora. Scientists of the Hanumanamatti and Kolhapur centres were called to present their work at Bangalore.

The review work of these 13 centres and the Project Co-ordination Cell was done according to the check list Annexure -III. This check list was framed during the first meeting of the QRT Team held on December 10th 2005 in ICAR, New Delhi. The same was sent to the officers in-charge to compile the progress report of the five year period. The team besides physically visiting most of the centres, critically examined these reports, and the assessment of team is as under.

4.2.1. Berhampur

a) Introduction

The AICRP (SM) centre at OUAT, Orissa was started in 1986-87 at Semiliguda in Koraput. Subsequently in the year 1989, the project was shifted to Berhampur. During July 1998 to 2002, the Entomologist was working at Semiliguda. Now all the scientists are working at Berhampur. Research on finger millet is also being continued at the Dept. of Plant Breeding and Genetics, Bhubaneshwar since establishment. Finger millet is one of the most important food crops of this area, particularly in tribal areas. The centre is provided with modest infrastructure facilities in terms of land and building and has four scientific positions, in the discipline of Breeding, Agronomy, Entomology and Pathology.

b) Achievements

In plant breeding, besides testing the finger millet and little millet entries of different centers, the Berhampur centre gave 12 finger millet and 7 little millet entries for all India testing. The centre released one finger millet variety 'Chilika'(OEB 10) and three little millet varieties 'Tarini' (OLM 203), 'Kolab'(OLM 36) and 'Sabara'(OLM 20).

In agronomy, 6-9 trials were conducted every year and improved production technologies such as optimum fertilizer dose and method of application, optimum plant population, bio-fertilizer application, intercropping, management of late sown crops and weed control measures have been developed. Under NATP, OFAR trials on intercropping of finger millet + Pigeon pea 8:2 was found profitable. The results of weed management trial is not reliable. The scientist concerned should be properly advised in this regard.

In entomology, all finger millet and little millet varieties under test in the coordinated trials were evaluated for grasshoppers, earworm, aphids and shoot-fly infestation. All the cultures of these crops developed by the centre were also evaluated for insect pest infestation. Control measures for finger millet earworms and little millet shoot-fly have been developed.

In pathology, all entries of finger millet in the coordinated trials were evaluated each year for leaf, finger and neck blast. Also, the cultures developed by this centre were evaluated for blast incidence. Control measures for neck and finger blast of finger millet and sheath blight of little millet have been developed. The sheath blight in finger millet is a serious problem therefore research activities should focus on this.

The scientists conducted FLD's in three different districts of Ganjam, Gajapati & Koraput. Improved variety with recommended package of practices gave 68-107% higher yield than local variety with farmers practice in finger millet and more than

double yield has been achieved in case of little millet. This has helped in popularizing varieties like Bhairabi(BM 9-1), Chilika (OEB 10), Suvra(OUAT 2), VL 149, PR 202 and Champavati of finger millet and Tarini(OLM 203), Kolab(OLM 36) and Sabara(OLM 20) of little millet. Front Line Demonstrations have also created awareness among the farmers regarding application of fertilizer, weed management, intercropping and disease/pest management, particularly blast in finger millet.

c) Overall Assessment

Crop Improvement

The centre has been instrumental in development of improved varieties and improved crop production and protection technologies, which have led to increase in productivity of millets.

Small millets are grown very commonly in Koraput region. Hence, taking the advantage of University Research Station located at Semiliguda, verification research particularly on aspects of breeding and agronomy may be carried out.

The vacant position of the breeder should be filled for effective use of breeding materials.

4.2.2. Jagdalpur

a) Introduction

The All India Coordinated Small Millets Improvement project was initiated at this centre in the year 2000 for improving the productivity of tribal crops such as Kodo, Sawan, Kutki and Ragi etc. The mandate of this project include varietal evaluation for developing suitable package of practices including disease and pest control measures for the zone and evaluation of cultivars with high yield and resistance to drought, pests and diseases. Prior to start of All India Coordinated project, this centre was functioning as a voluntary centre since 1986. Coordinated trials were conducted & evaluated at SGCARS, Jagdalpur.

b) Salient findings of research in different disciplines

In Little millet i.e. Kutki, which is the popular crop of this area, OLM-45 (Berhampur, Orissa) DLM-369, DLM-314 & DLM-80 from Dindori (M.P.) were found most suitable.

Chemical weed control : Isoproturon as pre emergence @ 0.5 kg a.i./ ha. along with two intercultivation gave maximum yield by controlling weeds.

Pathology

<u>Finger millet</u>

The following entries were found resistant to NB, FB & LB

Finger blast (FB)- L 32-5, ACPR-2, GPU-59, GPU-60

Resistant to Grain smut of Barnyard millet

ER-64, IS-144, VL-205, VL-198, VL-207, TNAU-72, TNAU-80, VL-190, VL-188

Brown spot resistance:- TNAU-72 & VL-199

Resistance to Head smut of little millet

DLM-314, TNAU-92, DLM-369, DLM-409 & RLM-36

Resistance to grains smut of foxtail millet

SIA-2881, VMFC-308, VMFC-322, TNAU-199, VMTC-311

c) Over all assessment

This centre started functioning from 2000 cropping season. Finger millet varieties HR 374, PES 400, VR 855, PR 202 and VL 315 are performing better. In kodo millet RK 5, RK 162, RBK 155, RK 65-18 and GPUK 3 are performing well. In little millet OLM 45, DLM 369, DLM 314 and DLM 80 were suitable for Chattisgarh. In case of foxtail millet SIA 2870, SIA 2871 and PS 4 are performing well. In barnyard millet VL 198, ER 64, VL 200 and VL 190 are doing well.

Breeding programme on little millet (Kutki) need to be concentrated since it is very popular crop in Chhattisgarh.

All small millets respond well to added nitrogen fertilizer however around 40 kg N/ha is an economical dose for these crops in poorer soil and it may be slightly reduced under fertile soils. Application of Isporturon @ 0.5 kg a.i/ha along with two inter cultivation is recommended to control weeds.

In pathology trials following entries were identified as resistant lines.

Finger millet: ACPR 2, GPU 59, GPU 60 are resistant to finger blast

OEB 52, JM 3, VL 328, ACPR 2, GPU 59 and GPU 60 are highly resistant to neck blast.

In kodo millet RK 80, RK 31, RK 5, DPS 676 are resistant to head smut.

Two sprays of Saaf @ 0.2% was most effective in controlling blast in finger millet.

Frontline demonstrations were conducted in above crops to popularise the technologies.

Bastar region has tremendous potential for growing small millets. Therefore the centre should focus on transfer of technology in the area.

4. 2. 3. Ranichauri

a) Introduction

The All India Coordinated Small Millets Improvement Project was started at Hill Campus in 1987 with the objective to boost up production of small millets in the area. Approach included improvement in the traditional practices and developing location specific suitable production technology for Ragi (*Eleusine coracana*), Sawan (*Echinochloa frumentacea*), Cheena (*Panicum miliaceum*) and Kauni (*Setaria italica*) which are some of the major small millets crops of the Uttaranchal state.

b) Salient findings of research in different disciplines

- Hill Campus bred seven finger millet entries viz. PRM 9801, PRM 9802, PRM 9803, PRM 9806, PRM 9810 PRM 9812 and PRM 401 were promoted to National Coordinated Varietal trials.
- Genetic Male Sterile (GMS) line INFM 95001, which was developed through mutation breeding in early ninetees in Africa by ICRISAT, was introduced at Hill Campus and intensive breeding programme was started.
- In barnyard millet, two entries (PRB 9402 & PRB 9403) were contributed to national trials in 2000 and another 2 entries (PRB 401 & PRB 402) contributed in 2005. One variety PRB 9403 (PRJ 1) with high yield potential was released in Uttaranchal.
- Under Front Line Demonstrations, PRJ 1 was superior to local check every year and yielded 62 to 186% more grain than local check. PRJ 1 also produced about 50% more stover as compared to local check.
- Finger millet + Soybean-Oat was the best cropping sequence for Uttaranchal hills. The second best cropping sequence was Finger millet –Oat and FM + S-Wheat.
- Ist week of May was the optimum sowing time for realizing higher yield of barnyard millet. Further delay reduced the yield drastically.
- Under integrated nutrient management for FM-based cropping system, application of 7.5t/ha FYM gave significantly higher yield as compared to no application of FYM.
- Band placement of fertilizer in finger millet was superior to broadcasting method. Band placement of 2 t of enriched compost with 100 % NPK was superior.
- Inter cropping of finger millet and soybean (1:1 row) and incorporation of soybean as green manure along with 7.5 t/ha of pine needle compost gave yield at par with the application of 3.7 t FYM /ha coupled with Mussoorie rock phosphate and gypsum.
- In barnyard millet band placement of enriched FYM was superior over broadcasting method and highest grain yield (2560 kg/ha) was obtained by band placement of 2.5 t of enriched compost with 150% NPK compared to other treatments.
- June sowing led to higher incidence of blast and Cercospora leaf spot diseases in finger millet than July sowing.
- The three blasts in finger millet could be successfully managed by the application of Propiconazole (0.1%), Hexaconazole (0.1%) and Hinosan(0.1%).

- Seed treatment with *Trichoderma harzianum* (TH) + one spray of *Ps. fluorescense* was effective in reducing all the three blasts. However no clear differences with respect to control of Cercospora leaf spot were observed.
- Cercospora leaf spot of finger millet was found to be a serious disease in mid and high hills, where rainfall is high and mean daily temperature does not exceed 20^{o}C. The intensity of the disease was low in lower hills. At the Hill Campus, where screening of finger millet germplasm is underway for many years, it was found that over a span of five years no entry/ germplasm was resistant in the advanced varietal trials. While 2 and 3 entries were resistant under Initial Varietal Trial and National Screening Nursery .
- Because of its characteristic slow growth, Cercospora was difficult to isolate from the diseased leaves. Out of eight media that were tested for growth and sporulation of the pathogen, Ragi Flour Lactose Yeast Agar (RFLYA) [Ragi flour 20g, Lactose 5g, Yeast, Agar, 20g] was the best with respect to growth and sporulation of the fungus *in vitro*.
- Blast pathogen characterization was done involving 1650 *Pyricularia grisea* isolates collected from 24 ragi growing locations in the country. A repository of such a collection, the only one in the country, is now being maintained for future research.
- Almost all locations shared common pathotypes. Bangalore and Ranichauri harboured maximum pathotypes that were common across most locations. This was interpreted as evidence of migration, probably through seed.
- The results showed that the pathotype composition of *Pyricularia grisea* population in different parts of the country to be very complex.
- Resistance genes in the host differentials have not yet been fully characterized. Larger incompatibilities suggest that it has gene (s) that have wider spectrum of resistance or are more adaptive than other genes. In the longer run there might be the need to have Near Isogenic Lines.
- RAPD analysis could generate polymorphism among *P. grisea* isolates by the primers used.
- **For the first time**, blast pathogen population from finger millet has been characterized from India on an area-wide basis.

c) Over all assessment
Crop Improvement

Crop improvement work in barnyard millet has led to release of high yielding variety of barnyard millet- PRJ 1. Cropping system research has helped to identify a profitable and sustainable cropping system. Nutrient management strategies have been developed. The state has been declared as an organic state, good programme is going on about organic production research.

Breeding work may be intensified with site-specific crosses. Transgenic plants may be developed through collaborative projects with University staff. TGMS lines may be developed for hybridization programme.

Crop Protection

The centre has been conducting basic and applied research on small millets, particularly on finger, barnyard and foxtail millet, and has the necessary infrastructure including facilities for molecular analysis. The strength has been utilized for generating very useful information on the blast pathogen population characterization from different locations of the country. A repository has been created where in several thousand blast isolates have been maintained. A set of differentials has been developed for race characterization of blast isolates from different regions. The centre can serve as the nodal centre for blast research and can contribute in development of durable resistance against blast in ragi at different centres. The approach of cultivar mixture for the management of blast in ragi has been found to be useful and should be advanced to farmer fields as well as other centres. The centre also has strength in developing biocontrol agents and has a collection of several hundred agriculturally important micro organisms. Some of these have been tested under AICRP and have been found to be effective against blast in ragi. Such strains should be widely tested and an IDM programme should be developed wherein use of cultivar mixtures as well as bioagents should be integrated. The centre has also done useful work in the understanding of Cercospora leaf spot disease of finger millet, a disease specific to Himalayan region only. Beside the core programme, the centre has handled two sponsored research schemes an ICAR adhoc project on “Understanding etiology and biology of Cercospora leaf spot disease of finger millet, and an NATP Project on “Strengthening research on integrated management of blast of ragi”.

4.2.4. Ranchi

The centre is located at Kanke, main campus of the Birsa Agricultural University. All the four disciplines of Breeding, Agronomy, Pathology and Entomology have been provided. The main activity has been on finger millet and little millet which are important dryland food crops of plateau region of Bihar.

Besides conduct of Co-ordinated varietal trials, the centre maintains active collection of germplasm of finger millet and little millet. Crop improvement work through hybridization and further selection is in progress. The University has produced nearly 5280 kg seeds of finger millet variety A 404 and distributed to farmers. Birsa Gundli was produced to an extent of 120 kg for popularising this variety. Finger millet variety JM 3 is found to be promising and is in pipeline for release. Two entries JM 1 and JM 2 are also found promising.

Finger millet responds well to applied fertilizers up to 60 kg N/ha whereas little millet responds only upto 40 kgs/ha. Transplanting of finger millet and sowing of pigeon pea simultaneously in 8:2 row was found profitable. Little millet + Pigeon pea in 2:1 row gave high yield and returns. Similarly, little millet + soybean in 4:2 row was ideal to obtain higher return than pure crop of little millet.

Finger millet variety GPU 28 resistant to blast disease in Karnataka and Tamil Nadu, is susceptible to blast in Ranchi area. Two sprays of Hinosan (0.2%) was most effective in controlling blast in ragi. Niger or mustard as intercrops in finger millet attract natural enemies and there by prevent the insect pests in finger millet.

Front Line Demonstrations on finger millet and little millet were taken up during this period. However, the coverage of area under FLD's was low.

4.2.5. Bangalore

a) Introduction

The Project Co-ordinating Unit at UAS, Bangalore in addition to Coordinating and monitoring the research activities in different centres also undertakes independent survey, research and extension activities. During the last five years under report, extensive survey in different parts of the country was conducted and a large collection of germplasm of various millets has been established. Research activities have been strengthened in all the disciplines, which have resulted in release of highly productive varieties like GPU26, GPU45 and GPU 48 in finger millet and GPUP 21 in proso millet. Improved management practices were identified for finger millet and other small millets. Besides, plant protection packages for small millets were also developed. Testing the technology through large scale demonstration and front line demonstrations also formed the core activities of the project.

b) Salient findings of research in different disciplines

Project Co-ordination Cell, Bangalore is being recognized as a National Active Germplasm Site for conservation of small millets germplasm, helped in augmenting more than 12596 accessions. This includes 6257 accessions in ragi, 2512 in foxtail millet, 1111 in Kodo millet, 868 in barnyard millet, 928 in proso millet and 920 in little millet.

Core set of germplasm in different small millets have been formed based on evaluation of both qualitative and quantitative data and also geographical origin. In finger millet 551 accessions, 291 accessions in foxtail millet and 160 accessions in proso millet were selected as core set.

Four varieties - three in finger millet and one in proso millet were evolved and released for cultivation in different agro climatic regions.

Blast resistance has been successfully combined with high grain yield, quality fodder and early maturity led towards the release of varieties GPU 45 at the National level, GPU 26 and GPU 48 for Karnataka State.

The role of tannin and phenols in determining resistance in the plant system of finger millet blast disease has been demonstrated.

A pre breeding activity was initiated in finger millet by utilizing close wild relative *E. africana* which is easily crossable with cultivated species *E. coracana*. *E africana* has many desirable characters viz., tillering ability, drought tolerance, high bio mass production and earliness. For combining these characters to cultivated species, three released varieties were successfully crossed with wild species. Some superior identified lines were utilized in recombination breeding programmes.

Development of white seeded ragi varieties was initiated by crossing a white seeded African accession with locally adapted brown seeded varieties having blast resistances and higher seed yield. In addition, efforts were also made to improve protein content and amylase activity. Presently identified elite white seeded lines are in preliminary yield trials.

Double cropping of short duration Cowpea / French bean in kharif followed by transplanted ragi gave higher returns.

Transplanting finger millet is suitable and profitable even under very delayed sowing conditions.

Application of poultry manure (2 tonnes/ha) to supply 100 % recommended nitrogen is a remunerative practice at Bangalore.

Application of 7.5 t FYM/ha and rotating either with ground nut or maize with recommended inorganic fertilizers is remunerative practice for targeting higher production in ragi based cropping system at Bangalore.

Inter cropping finger millet and field bean in 8:1 proportion was a remunerative practice for Southern Karnataka instead of akkadi system in villages which are well connected to big cities.

Strip cropping of finger millet 2/3rd and pulses 1/3rd is a better option at Bangalore.

Genotypes highly resistant to both neck and finger blast were identified.

Spraying of Saaf @ 0.2 % at 50% flowering and one more need based spray after 10 days are effective in controlling neck and finger blast.

Choosing resistant variety and treating seeds with carbendazim @ 2 g/kg seed with recommended inputs effectively controlled the blast incidence and resulted in higher yield of finger millet; next best was selection of resistant variety for sowing.

The purification and characterization of phytotoxin and phytoalexin helped in rapid diagnostic methods for resistance evaluation.

The roles of phenols, PAL, PPO, Chitinase, β-1, 3-gluconase activities are well established at Project Co-ordinating Unit, Bangalore.

Intercropping/sprinkling of Niger/mustard helps in enhancing the population of parasites and predators in small millets.

A stored grain pest *Rhyzopertha dominica* was found for the first time feeding on stored ragi was observed.

Screening of finger millet germplasm for root traits has shown that AKP 2, A 404 to be superior types.

Regeneration and transformation protocols were standardised.

Genetic engineering protocols for high osmolyte accumulation was developed, and transgenics to these osmolyte genes showed higher drought tolerance.

c) Over all assessment

i) **Crop Improvement**

The centre has done excellent in all the four major activities of research besides Co-ordinating and monitoring the project activities.

The centre need to initiate serious work on developing transgenics and also in identifying gene that lead to higher calcium level in ragi.

The frontline demonstrations conducted by the Co-ordinating unit has earned good name for effective implementation of the programme by the farmers.

Many excellent publications both in local language and in English have been brought out by the unit.

ii**) Crop protection**

Entries under different nurseries have been screened against the diseases and useful sources of resistance identified. An integrated management strategy involving the use of Pseudomonas fluorescens and a spray of Saaf (a fungicide) has been found useful against neck and finger blast. Useful work on the identification of slow blasting genotypes, characterization of components of resistance and biochemical characterization of blast toxin has been conducted. It would be necessary to standardize artificial inoculation techniques for the important diseases so as to challenge breeding material all round the year.

4.2.6. Rewa

a) Introduction

All India Coordinated Millets Improvement Project, Rewa (M.P.) came into existence during 1976, which was separated as All India Coordinated Small Millets Improvement project in 1986. The mandate of the project is to develop / identify high yielding varieties of Small millets possessing inbuilt resistance / tolerance against the biotic stresses, development of low cost cultivation practices, cheaper and feasible plant protection measures. The research achievements of the project are summarized as under :

b) Salient findings of research in different disciplines

One kodo millet variety JK 155 was released and notified (821 E / 13.9.2000) at national level in the year 2000. Variety is medium tall, semi-spreading, semi compact ears, resistant to shoot fly and moderately resistant to head smut. It matures in 99 days with grain yield potential of 29 Q/ha. Another variety JK 136 was released at state level in 2002.

Five little millet genotypes namely RLM 11, RLM 13, RLM 14, RLM 21 and RLM 36 developed at Rewa center were submitted for testing under Coordinated trials. Two

little millet genotypes viz. RLM 21 and RLM 11 performed well at all India level and surpassed grain yield by 48 and 26%, respectively over the national check CO 2.

Four genotypes of barnyard millet namely TNAU 63, VL 197, TNAU 25 & VL 199 performed well in coordinated trials and gave more than 10% higher grain yield over the best national check K1. Only one genotype of foxtail millet SIA 2644 surpassed the grain yield by 8.2% than the national check PS 4.

In cropping system studies, highest kodo millet equivalent grain yield was recorded in pigeon pea sole (53.9 Q/ha) followed by Kodo millet + pigeon pea inter cropping in 2 : 1 proportion (45.5 Q/ha). Highest monitory returns of Rs 21,715 ha $^{-1}$ and B : C ratio of 5.14 was obtained in pigeon pea sole cropping system.

Pre emergence application of Isoproturon @ 0.5 kg a.i ha $^{-1}$ gave highest grain yield of 18.2 Q/ha, which was 111% higher than unweeded check.

Front Line Demonstrations on kodo millet and little millet were conducted in 47.6 ha and 10.4 ha area, respectively in Rewa, Sidhi, Shahdol and Panna districts. Two cropping systems i.e. sole cropping system and inter cropping with pigeon pea were demonstrated. Average increase of 39.2% in grain yield was achieved in improved practices under sole cropping system, whereas it was 35.5% in intercropping of kodo millet with pigeon pea. In Little millet, an increase of 58.8% and 70.8% in grain yield was recorded under sole cropping and inter cropping with pigeon pea, respectively.

c) Over all assessment

i) Crop Improvement

High yielding varieties and few new entries have come from this centre for coordinated testing. In respect of Agronomy, not many good production practices have emerged mainly because of frequent transfer of agronomist from the unit.

Area of small millets (other than finger millet) is more (58%) in M.P. kodo millet and little millet are major small millets in the state. Area, production and productivity are coming down every year. Varietal improvement has to be intensified to improve the productivity by improving the breeding programmes. F1 materials should not be bulked.

ii) Crop Protection

The center has fairly good out put in Plant Pathology. Major diseases of small millets, viz., finger millet, foxtail millet, kodo millet, little millet and barnyard millet, in the region have been identified. Of these head smut in kodo millet, grain smut in barnyard millet and blast of foxtail and finger millet have been found to cause economic losses. Screening work has led to the identification of several useful sources of resistant material. Chemical control of smuts in kodo millet and little millet has been demonstrated. Some variability in the pathogen of head smut in kodo millet has been recorded but needs to be further carried out over a large pathogen population. Artificial inoculation technique for smuts should be standardized and sets

of representative isolates be used for disease screening especially for breeding material. The center should lead research with respect to the understanding of smut diseases of small millets.

Shootfly in kodo millet, little millet, and ear head worm in finger millet have been found to be the major pests. Entomology work has been largely restricted to screening of germplasm lines only and some useful material has been identified. Application of chlorpyriphos has been found to be effective in the control of shoot fly in kodo millet and little millet. There is need to ascertain cost: benefit ratio of the treatment. An IPM technology should be developed.

4.2.7. Kolhapur

a) Introduction

Sub-montane zone is one of the most concentrated small millets growing area in Maharashtra State. It is characterized by hilly area and undulating topography with entisol soil group. The climatic conditions of the region are most suitable for small millets. The scheme on All India Coordinated Small Millets Project on Small Millets was sanctioned in 2004 at Zonal Agricultural Research Station, Kolhapur. Improved varieties may be introduced to increase the productivity of the state.

b) Salient findings of research in different disciplines

The NARP Kolhapur was previously working as a voluntary centre and has conducted varietal and multilocation trials on finger millet and the technology generated therein has been transferred through extension agencies to the farmers. After inception of AICRP on Small Millets center at Kolhapur, the following research activities are carried during the year.

Technology Generated and Transferred

The important achievements are as

1) For medium deep soil, application of 60 kg N + 20 kg P_2O_5 (Godavari) and application of 30 kg N + 20 kg P_2O_5 per hectare for shallow soil is recommended.
2) The Ragi/ Nagli varieties PES–400, HR–374 and Godavari are recommended for general cultivation.
3) Intercropping of Nagli + Soybean 2:4 or 4:4 or Nagli + Cowpea 2:4 is recommended for higher monitory returns.
4) The application of Isoproturon @ 0.375 kg a.i. /ha or Oxyflurofen 0.1kg a.i/ha (pre-emergence) in 500 liters of water + one hand weeding after 30 days of sowing is recommended for economical weed management in Nagli Ragi Crop.
5) The medium maturing and high yielding variety RAU–8 of Nagli is recommended for general cultivation.

C) Over all assessment

Being a new centre, it is too early to have real assessment.

4.2.8. Mandya

a) Introduction

Zonal Agricultural Research Station (UAS, Bangalore), Mandya centre has contributed maximum by releasing 25 ragi varieties so far which led to self sufficiency in ragi production. In addition, Mandya centre scientists have contributed for popularising ragi products by giving training to nearly 5000 farm women.

b) Salient findings

Crop improvement

In Advanced varietal trial for medium maturity group. GPU-45 was the highest yielder with 43.95 Q/ha followed by PR-202 (40.24 Q/ha) while TNAU-914 was the poorest yielder (27.01 Q/ha).

In multilocation trial, MR-27 the highest yielder with 38.12 Q/ha followed by MR-29 (37.72 Q/ha) and L-9-S-8 (37.62 Q/ha).

In the advanced varietal trial comprising of early and medium duration varieties, the entry GPU-52 was the highest yielder (44.14 Q/ha) and maturing in 115 days, followed by Indaf-9 and TNAU-946 yielding 39.40 and 38.66 Q/ha respectively.

In the multilocation trial, the entry L-5 was found good yielder (46.66 Q/ha), followed by GE 4903 x Sel.14-7 (45.92 Q/ha), L-85 (40.23 Q/ha) and MR-31 (40.11 Q/ha).

33 crosses were made using Malavi Lines, F1 seeds were collected and it will be further advanced during summer 2002

Among the herbicide tested, oxyflurofen @ 0.1 kg a.i/ha as pre-emergent spray recorded significantly higher yield (3376 kg/ha and 1956 kg/ha) under transplanted and drilled condition respectively in irrigated system.

In white ragi trial, eleven entries were evaluated for grain yield. The entry GPUW was found numerically superior by yielding 43.9 Q/ha compared to check variety Indaf-11 (39.0 Q/ha). Further, the blast incidence was very low ranging from 2.0 to 10.0 per cent.

The economics of weed control in drilled finger millet under irrigated condition indicates that Oxyflurofen @ 0.1 kg a.i/ha recorded higher net returns (Rs.10628/ha), marginal returns (Rs.9599/ha) and C:B ratio (Rs.8.82), followed by recommended practice with a net return of (Rs.10381/ha), marginal return (Rs.9764/ha) and C:B ratio (Rs.6.5).

Plant protection

Among thirteen varieties tested, entries L-82, L10-58, VR-768, VR-862, VL-312, GPU-49, 51, 52, 58 and VAR-872 were free from neck blast and recorded less than two per cent incidence of finger blast and showed resistant reaction. Further, these varieties also showed resistant reaction against neck and finger blast during *Kharif*-2001.

Maximum incidence of neck and finger blast were observed in August second fortnight sowing in blast susceptible varieties, namely KM-252, PR-202 and Indaf-9 as compared to July or October sowing. Foot rot incidence was noticed in July – August sowing but not in October-November sowing, whereas, less incidence of brown spot was observed in July-August sowing and more incidence in September-October sowing. More than 50 per cent brown spot severity was observed in GPU-28, sown in October as compared to other varieties Further, it was also observed that GPU-28 sown in July has free from brown spot.

Among long duration varieties VR-768 gave significantly higher grain (4494 kg/ha) and straw yield (7190 kg/ha), followed by GPU-58 which recorded 4315 kg/ha and 6904 kg/ha of grain and straw yield respectively. Application of nitrogen at 120 kg/ha gave significantly higher yield (4551 kg/ha) compared to nitrogen at 100 kg/ha (4123 kg/ha).

Studies on optimizing fertilizer dose in finger millet under irrigated condition, application of twice the recommended NPK gave significantly higher yield (5759 kg/ha) on par with 50% more NPK (5634 kg/ha), 75% more NPK (5653 kg/ha) and recommended NPK + Azospirillum (5625 kg/ha). This was followed by on par yield with 25% more NPK (5291 kg/ha) and UAS recommendation (5162 kg/ha).

Studies on effect of blight disease on grain yield in finger millet showed that out of seven popular varieties, maximum (>70%) grain reduction due to blight disease was observed in GPU-28 followed by PR-202. While least grain reduction per finger per spikelet was observed on Indaf-7 followed by MR-6, Indaf-5, GPU-45 and Indaf-9.

Two sprays of Saaf a combination fungicide @ 0.1 per cent was found effective in reducing neck and finger blast and increasing the yield, followed by Hinoson @ 0.1 per cent. However integrated disease management of using resistant variety GPU-28 was profitable as compared to fungicidal application. None of the biopesticides were found effective against blast.

Among different treatments Captan drenching at 0.3 per cent was found effective in reducing the foot rot incidence followed by Captan root dipping at 0.2 per cent and Carbendazim at 0.1 per cent. Bioagents *Pseudomonas fluorescens* and *Trichoderma harzianum* were also found effective as compared to check.

c) Over all assessment

Excellent work on ragi varietal improvement is in progress. It should help in multiplication of newly released varieties and crops. Research on water management aspects needs more attention.

ii) Crop protection

The centre has been conducting various coordinated trials in finger millet, barnyard millet, foxtail millet and kodo millet. Several diseases such as blast, foot rot and rust in different millets are prominent at the centre. Some useful screening has been done against various diseases and sources of resistance identified. Utility of Saaf fungicide against blast in finger millet has been demonstrated. In view of the importance of the crops for the region as well as prevalence of several important diseases, it would be ideal to develop location specific trials that could generate basic information on the disease epidemiology and management.

4.2.9. Nandyal

a) Introduction

Among small millets, foxtail millet is the most important crop of this area and Nandyal is a lead centre. The centre has taken up crossing programme with clear objectives and generating large segregating material which has also been supplied to other centres.

b) Salient findings

Research on improvement of grain yield coupled with early duration was carried out. As a result SiA-2644, a local selection was identified. It was tested in All India Coordinated Trials. The grain yield is encouraging (26.9 q ha^{-1}) showing maximum returns during drought periods. This variety was released in the name of **"Srilakshmi"** at state level **in the year 2002**. The farmers have been convinced with the performance of these varieties and as a result it is spreading to a larger area.

c) Over all assessment

Andhra Pradesh is the largest foxtail millet growing state in the country. Sixteen species of Setaria are available at this centre. Interspecific crosses may be attempted to generate new breeding materials. The genes responsible for protein in foxtail may be identified.

Crop responds well to applied fertilizers and biofertilizer seed treatment. Inter cropping of pigeon pea after every five rows of setaria was found to bring higher return than sole crop of setaria. Setaria and green gram in 2:1 proportion also brings higher return as it prevents army worm incidence. Early duration varieties of setaria, intercropping with green gram and with less nitrogen fertilizer prevents army worm problem.

For Downy mildew control seed treatment with metalaxyl (0.1%) is effective. For control of rust, Chlorothalonil seed treatment (2 g/kg of seed) and spraying of the same chemical 0.1% at flowering is effective. Hinosan (0.1%) was found to be effective against blast of setaria.

4.2.10. Vizianagaram

a) Introduction

Finger millet locally termed, as ragi, Chodi or Taidalu is an important small millet crop in all the three regions of the state of Andhra Pradesh. The grain is utilized as human food and straw for cattle feed. The research work on this crop is being carried out in Acharya N.G. Ranga Agricultural University at research centers viz; Vizianagaram, Anakapalle and Peddapuram in north coastal zone, Perumallapalli in southern zone and Palem in north Telangana zone. Crop verification functions are carried out at other locations namely Seethampeta and Chintapalli in High Altitude Zone and Darsi in Krishna -Godavari zone. The research work carried out in the state has resulted in the release of good number of short, medium and long duration varieties suitable for various zones.

Salient Research Work

Crop Improvement

In the plant breeding discipline in addition to the evaluation of breeding varietal trials, collection of small millets germplasm, evaluation and maintenance was carried out. For the development of blast resistant lines conventional breeding was followed. The culture VR 762 based on the yield performance has been proposed for the release in the state of Andhra Pradesh. The other important cultures in the pipe line are VR 847, VR 849, VR 870, VR 914 & VR 915. The culture VR 847 is in the third year of advanced yield trial and the performance is far superior to other cultures in many of the centers tested. This culture will be proposed for Mini kits on all India basis during 2006 *kharif*. Promising single plant selections have been made from segregating material for blast resistance. In one of the crosses (IE2695 X Godavari) white grain ragi is isolated and advanced to F7 for stability coupled with resistant to blast, sheath blight and bacterial leaf blight. This station is also involved in evaluation and maintenance of small millet germplasm. During 2003, five hundred and fifty one ragi core collections were evaluated. In 2005 *kharif*, 508 ragi core collections supplied by ICRISAT, have been evaluated. Conduct of minikits, frontline demonstrations, extension programmes to spread the improved varieties and technologies are in progress. This centre has contributed very good improved cultures to the All India pool for evaluation in the co-ordinated trials.

Front Line Demonstrations

Under the NATP *"Refining small millets based cropping system for augmenting supply of legumes (grain/vegetables),* on-farm trials were conducted in farmers fields in 2001, 2002 and 2003 kharif under rainfed condition to validate the suitability of recommended ragi + red gram intercropping system in farming situations.

c) Over all assessment

Excellent work on crop improvement is going on and many high yielding varieties are likely to emerge from this centre. Improved varieties may be popularised by producing more seeds and distributing to the farmers.

Pathology research suffered a great deal as the position was vacant for most part of the time. To organise on farm demonstrations, there is a need to have one Agronomist at the centre.

4.2.11. Dindori

a) Introduction

Dindori comes under agro climatic zone III of Madhya Pradesh known as North-Eastern Hill zone of Chhatistgarh. Newly formed Dindori District ranks first among the small millets growing district of M.P. It contributes about 13.78 and 7.5 % to the total small millets area and production of the state. The area and consequently production of the small millets has declined but the productivity showed marginal increasing trend, due to the impact of location specific research and transfer of technology to farmers.

The focus of research is on evolving suitable varieties of Kodo and Little millet for poor & marginal farmers of hill region of Madhya Pradesh. In the initial phase, the local germplasms were collected from various districts of M.P. and evaluated for grain yield and other economic attributes.

b) Salient findings

Crop production

- Application of 40 kg N/ha in kodo millet increased (94.9 %) grain yield followed by 20 kg./ha. (52%) in comparison to control. In little millet crop, highest grain yield recorded with the application of 40 kg N/ha. was 723 kg/ha. which was 135% higher than no application of nitrogen (307 kg/ha).

- On the basis of 5 years experimentation, application of 40 kg N/ha gave highest kodo grain yield of 1206 kg/ha followed by 20 kg N/ha (941 kg/ha) as compared to no nitrogen (619 kg/ha).

- Two inter cultivation and one hand weeding produced maximum grain yield of 1372 kg/ha followed by pre-emergence spraying of isoproturon @ 0.25 kg a.i./ha (962 kg/ha).

- Enrichment with 100% RDF to 5 t FYM/ha and broadcasting gave higher grain yield of kodo millet.

- Kodo-Soybean-kodo crop rotation was found best for Dindori district.

- Under low fertility conditions, application of 50% RDF and inoculation with bio-fertilizer gave higher grain yield of kodo millet (1055 kg/ha) under rainfed conditions.

- Application of 7.5 t FYM/ha along with recommended NPK (40:20:10 kg/ha) gave significantly higher grain yield (1384 kg/ha).

c) Over all assessment

Kodo millet lines viz. DPS 365, DPS 141, DPS 34, DPS 735 and DPS 700 were found promising. In little millet DLM 322, DLM 80, DLM 82 and DLM 11 were promising.

Germplasm of kodo millet (692) and little millet (425) are maintained in this centre.

Breeding work on kodo and little millet need to be intensified since, these crops predominate.

Crop protection

No plant protection work has been undertaken at the center during the review period though several disease and pest problems exist. The post of an entomologist exists but has been vacant ever since the year 2000.

Crop improvement work is not going on smoothly at Dindori centre because of frequent transfer of breeders/ breeder posted to Dindori centre. The committee recommends that University should give undertaking that staff compliments would be provided and shall not be transferred for 5 years.

4.2.12. Coimbatore

Crop Improvement

The finger millet culture TNAU 946 has been released during 2004 as CO (Rari) 14. It is a cross derivative between Malawi 1305 x CO 13. This is a medium duration culture falling into the maturity group of 105-110 days. This has recorded an overall increase of 9.0% in grain yield (2774 kg/ha) over the check CO 13 (2546 kg/ha) in a total number of 134 trials for the last five years which is 13.3% increase over GPU 28 (2448 kg/ha) and 26.5% increase over the national check HR 374 (2192 kg/ha).

In Little millet the two cultures TNAU 81 and TNAU 91 were evaluated in a total of 244 trials. The average grain yield of TNAU 81 is 2351 kg/ha and TNAU 91 is 2659 kg/ha which is 18.86% and 34.43% increase over the check CO 3 (1978kg/ha) respectively. The cultures will be proposed for release during 2006.

In proso millet, two promising cultures TNAU 137 and TNAU 143 recorded 1211 kg/ha and 31.6% and 1337 kg/ha and 45.3% increased in yield over the check CO 4 920 kg/ha over a total of 155 trials.

In Barnyard millet, TNAU 87 (2503 kg/ha) which gave 90.5% increased in grain yield over the check CO 1 (1314 kg/ha) is under on farm trials during kharif, 2005 to evaluate its interaction with the environment.

In kodo millet high yielding culture TNAU 43 has been identified from evaluation under station trials. The selection recording 2259 kg/ha against 1407 kg/ha of CO 1 is being tested in on farm trials to find out its suitability to various environments.

Finger millet + field bean (8:1) and finger millet + Pigeon pea (8:2) inter cropping systems were profitable than sole crop of finger millet. Indeterminate field bean variety was more suitable than short duration type. Blending of organic, inorganic and biofertilizers enhance the efficiency of the applied fertilizers. Growing cowpea for vegetable purpose and incorporating the remaining crop residue into soil followed by transplanting of finger millet brings higher returns.

GPU series of finger millet varieties are found to be resistant to blast disease even in Tamil nadu also. Saaf (0.2%) at 50% flowering and second spray at 10 days after first spray recorded lowest blast incidence. Use of GPU 28 variety along with carbendazim at 2 g/kg of seed minimises the blast incidence.

Crop Production

The grain and straw yield of finger millet was the highest with intercropping of finger millet (CO 13) with vegetable cowpea (CO 4) in 8:2 ratio. Intercropping of finger millet with pigeon pea (CO 5) recorded the highest net return and B:C ratio.

c) Over all assessment

Crop improvement

Research work on apomictic plant may be intensified to fix the heterosis. Apomictic plants may be isolated from twin seedlings. More seedlings may be identified by raising seedlings in germination trays or paper towels. Interspecifric crosses may be taken up to develop new breeding materials.

Crop protection

Mottle streak disease of finger millet was characterized and presence of bacilliform Rhabdovirus was demonstrated. Control measures for the disease were also worked out. Some basic studies have been conducted with respect to *Pyricularia grisea* toxins and induced disease resistance in finger millet. The center has strength in bioagents production, therefore efficient strains of bioagents effective against important diseases of different small millets in the region should be evolved. Focus should be given on integrated disease management.

The centre has all the six small millets in its mandate as they are grown in different seasons in different parts of the state. The major area under small millet is in the districts of Salem, Dharmapuri and Erode.

4.2.13. Mysore

a) Introduction

The AICRP Centre on Small Millets with 100% financial support from ICAR, New Delhi was started at CFTRI, Mysore, during the VIII Plan period with a mandate of "Processing and value addition to small millets". During this report period April 2000 to March 2005, the Centre has accomplished the following R&D and related works.

b) Salient findings

Developed a process for decortication of finger millet (Ragi rice) which enables the millet to cook similar to rice or wheat. This is altogether a new product from finger millet.

In continuation of the work on diversification of finger millet malt, a health (beverage) food was successfully developed. The process enables to use about 35% finger millet malt in the health beverage formulation, which is several fold higher than the malt contents (about 5%) in ragi malt beverage formulations marketed.

Studies on the millet carbohydrates with respect to the non-starchy polysaccharides and nature of starch have been conducted which are helpful in understanding the low glycemic nature of millet foods. This has lead to initiate R&D work on development of millet based diabetic foods.

Investigations on the health benefits of phytochemicals of the millets has been initiated and utilization of the millet seed-coat as a source of antioxidant seems to be highly promising.

R&D work on parboiling of small millets has been initiated to diversify their food and industrial utilization.

The centre has been actively involved in transfer of technologies on diversified uses and value addition to small millets, to Self-Help Groups, women entrepreneurs and also to food processing industries.

Adequate infrastructure in terms of laboratory and grain processing facilities are available at the centre for undertaking R & D work on basic as well as applied aspects of small millets.

c) Over all assessment

Centre has done excellent work in relation to processing and value addition. But, the technology has not yet gone to industry.

Good number of publications and patents on value added products have been made. Efforts have to be made to popularize the products within India and abroad.

5. TECHNOLOGY TRANSFER

Recommendations on package of practices formulated based on three to four years of research and having impact on the production have been taken to farmers field for demonstration. With these technologies small millets production could be enhanced to meet the projected requirements at the National level. During the last five years viz., 2000-04, 2285 farmers were involved in the conduct of Frontline demonstrations representing different socio-economic strata on an area of 865 ha in the country.

The impact of these demonstrations indicated vast potential for increase in yield due to new recommended technology. The yield level and income of farmers could be substantially increased by the adoption of recommended technology. Enhancement in yield was around 82 % in finger millet, 95% in little millet, 83% in kodo millet, 43% in foxtail millet, 76% in proso millet & 82 % in barnyard millet.

Small millets despite low genetic potential, are grown because of socio-economic conditions of the farmers and assured income under low input conditions. Inclusion of legumes as component crops helped in additional legume yield leading to nutritional security of the family and improved soil productivity and health. Similarly the adoption of other key components like use of new high yielding variety, application of fertilizers etc. showed significant influence on the yield of the crop.

All centres have met the indented requirements of the Department of Agriculture and Cooperation, Government of India, to produce breeder seed particularly in finger millet, kodo millet and little millet. During the period under review as much as 110 q of breeder seed have been produced and supplied against the target of 90 q.

6. LINKAGES

Scientists of the Project Coordination Cell as well as of centres located in different parts of the country, the line departments especially with the respective state Departments of Agriculture, Directorate of Millets Development, Government of India, NGO's, SHG, State Seed Producing Agencies and others have been directly or indirectly involved in the promotion of these crops. The scientists are participating as resource persons in state / national level training programmes organized in different states.

The Project Co-ordination Cell, has established good rapport with the National Institutions like NBPGR, VPKAS, Almora and International Institution like IPGRI for effective conservation & utilization of genetic resources and this has helped in crop improvement work.

7. FUTURE PROJECTIONS AND PROGRAMMES

As a result of research work conducted by different centres of the All India Coordinated Small Millets Improvement Project located across the country and the Co-operative centres, it has now become possible, to give high yielding varieties suitable to different locations and specific conditions. Suitable production and protection technology have been evolved. Transfer of these technologies to the real farming situations was done by the project scientists, through conduct of frontline demonstrations. The results of these frontline demonstrations have proved beyond doubt, the benefits of the research and technologies developed.

The impact of the high yielding varieties and technology packages has been proven for enhancement of the productivity in finger millet. However, for other crops major improvement have not yet been registered. Hence, the future research should aim at enhancing the productivity, creating the demand, through processing value addition and awareness of the nutritional properties of the millets.

- Maintenance of germplasm may be restricted to one centre in each state.
- Wild accessions may be collected and included in the stream for utilization in interspecific crosses.
- From the available descriptors of germplasm, correlated characters for yield, quality, disease and pest resistance may be aimed at.
- Multiline concept as in wheat may be adopted for increasing the yield, pest and disease resistance.
- Apomictic plant for fixing heterosis for yield may be identified in selected centres through twin seedling method.
- Developing a package of practices for organic production of small millets.
- Nutritional management based on the cropping system.
- Contingent crop planning, management practices for aberrant weather situations should receive more attention.
- Finger millet is extremely rich in calcium and thus a boon for calcium supplementation. Biotechnology work need to be initiated to identify genes responsible for high calcium and these could then be used for enhancing calcium levels in other crops.
- The possibilities of taking small millets in dry land horticultural systems, should be explored.
- Efforts to enhance the productivity and profitability of the already identified intercropping systems, double cropping systems and relay cropping should be made.

- Exploiting the fodder value of these small millets through harvest and post harvest technology.

- A repository of pathogen collection, similar to Ranichauri be developed at more centres, including coastal and plain area ecosystem, besides Ranichauri.

- Resistance genes for blast in the host differentials has not been fully characterized. Larger incompatibilities suggest that it has gene (s) that have wider spectrum of resistance or are more adaptive than other genes. For testing Near Isogenic Lines (NILs) be developed.

- Basic studies on shootfly resistance in small millets need to be initiated

- Milling is an essential step of primary processing to obtain refined flour and pearled grains, which are more acceptable for human consumption. In the process the grains may first be dehusked in centrifugal shellers followed by debranning in hullers. The yield of pearled millets ranges from 63 to 79 percent. Dehusking and debranning in a centrifugal sheller followed by polishing in hullers yields 16 to 29 % husk and 5 to 9% bran. Parboiling of other millet grains is now being studied at the CFTRI centre. This would enhance their utility for cooking like rice and also their use in other value added products like expanded grains, flakes and noodles. There is a need to develop appropriate processing systems to produce quality products.

- Food and Nutrition Scientists from Home Science Colleges of the region be given responsibility on contractual basis to develop recepies for popularization of millet use.

- All centres to distribute at least 500 minikit (seeds) to farmers in their area for popularisation of new varieties.

- There is urgent need to involve colleges of Food Sciences and Technology in developing ready made food items containing Finger millet and Barnyard millet. For this purpose it is recommended that a provision for establishing pilot scale facilitates in Home Science Colleges for producing and marketing products made from small millets.

- Encourage private initiative in manufacture of bread and other food items made out of millets.

8. RESOURCES AND ORGANIZATION

Two decades of research carried out across the country on small millet under AICSMIP has helped in building the scientific information base for developing high yielding varieties production technology for enhancing the productivity of the millets. Although the area of these crops is coming down, the production and productivity has increased because of R & D efforts and dissemination of technologies to farmers.

QRT recommends establishment of Directorate for Small Millets Research (DMR) during the XIth plan.

The project does not have its own off-season nursery facility. The QRT recommends that the existing centre at Mandya under the jurisdiction of UAS, Bangalore be developed as off-season nursery for the AICSMIP. By providing little additional personnel and infrastructure support, Mandya centre can be developed as an ideal off-season nursery, because of the possibility of raising three crops.

9. RECOMMENDATIONS

9.1. General

- The small millets are known for their suitability to dryland areas, hill and tribal agriculture. They require less water for their growth and are ideally suited for cultivation under rain fed agriculture. Therefore ICAR should strengthen research on these crops keeping in view their indispensability to harsh agricultural situation.

- The small millets are nutritious and have high fibre content and abundance of good quality minerals. Therefore, It is important to encourage their food use to provide nutritional cover and promote general well being of people at large. The ICAR and Ministry of Agriculture may use various publicity media to educate people on the health benefits of these food grains and encourage their consumption.

- Small millets are not only valued as food crops but also as feed crops. The crop residue is fed to bovines in lean months. Therefore, attention also need to be focused on improving the feed value of crop residues.

- Small millets are eco-friendly crops and by and large free from pests and diseases. Their production in many regions is largely organically based. Small millets be promoted as health promoting organic food in international market.

- Nutritious value added products from small millet be made available through public outlets like ATICS of Universities and food chain stores etc.

9.2 Scientific

- The Project Coordination Cell, Small Millets, Bangalore is maintaining large diverse germplasm of about 13,000 accessions. Evaluation and utilization of these material is very important. Several diverse and useful materials are available and their exploitation in R & D activities will have to be promoted. Except finger millet germplasm evaluation in other small millets is less than adequate. In order to breed varieties of higher genetic sealing, scaling up of germplasm evaluation related activities is required. Therefore these approaches will have to be further expanded.

- Core collection of germplasm in finger millet has been constituted, fairly well evaluated and documented. The core set be supplied to all centres where finger millet is important for exploitation in breeding programmes. Similar efforts to form core germplasm in other small millets be made for use in breeding.

- The collection and conservation of primary genepool at NAGS Bangalore is quite commendable. Small millets as a group have number of wild and weedy relatives and their conservation is also equally important. Henceforth this activity be given due attention.

- In the area of evolving blast resistant varieties of finger millet good progress has been made especially in Karnataka. The GPU series varieties have high level of resistance and by large have helped in avoiding crop losses. In view of the fact that blast disease is endemic to many states in the country. It is recommended that similar efforts be made by other centres utilizing the resistant germplasm available.

- In general hybridization attempted in small millets with exception of ragi is rather limited. As a result generation of materials at many centres is not adequate. Therefore it is important to attempt high volume hybridization by centres involving carefully choosen germplasm as parents.

- ICAR should include biotechnology work in respect of small millets in the next work project or support to the extent of Rs. 50 lakh to four SAU's who are prepared to undertake focused time bound work on small millets.

- In recent years climate change and rainfall has been unpredictable affecting crop harvest drastically. The project should take note of these recurring weather disturbances and devise appropriate R & D strategies for mitigating their influence on crop production.

- Finger millet is also affected by *Heliminthosporium* leaf blast and leaf sheath diseases in many parts of the country. *Cercospora* leaf spot is a serious disease especially in mid and high hills. Resistant breeding is the best option to eliminate damage due to these diseases. Therefore, identifying resistant sources and utilizing them in breeding programmes to evolve resistant varieties needs immediate attention.

- In other small millets smut continued to pose threat to the crop. This area should receive adequate attention by way of identifying smut tolerant varieties for cultivation in different agro eco system.

- Shootfly continues to be a threat especially in little millet, proso millet and kodo millet. The crop losses are very high especially in crops planted late in the season. The project has made some efforts to understand the shootfly pest complex and identified some indicators of resistance. However, this area of research needs strengthening.

- The processed small millets are affected by several stored pests. Therefore, in the project, research on management of stored grain pest need to be strengthened.

- Harvesting and post harvest technology including threshing, cleaning, destoning and pearling should also receive due attention and for this AICSMIP may develop necessary linkage with other Institutions in the country.

- In view of the suitability of small millets for speciality foods it is recommend that AICSMIP should support colleges of Home Science for developing nutraceuticals and other functional foods in a time bound manner.

9.3 Project re-organization

- The QRT is convinced that small millets are important for livelihood security of people in many disadvantaged region. There is need to strengthen various on going programmes. However, looking into the importance and the role, these crops could play nationally and also for exports, QRT recommends that Directorate of Millet Research to be established in XIth plan.

- The Co-operative centre at Hanumanamatti coming under UAS, Dharwad has done good work on varietal front and transfer of technology. Therefore, QRT recommends making this as a regular centre of AICSMIP during XI plan.

9.4 Structural adjustments

- The research in the area of grain processing and value addition is crucial. At present, work is carried out only at CFTRI, Mysore. The QRT recommends that this area of research should be expanded involving colleges of Home Sciences in SAUs of the region.

9.5 Infrastructure

- A one time grant be provided for lab facilities, field storage, threshing yard facilities at centres which do not have such facilities.

- The QRT strongly recommends that ICAR should provide needed financial support for proper maintenance of cold storage unit as well as other essential items.

- In order to hasten the seasonal advancement of segregating materials, to take up hybridization programme of small millets AICSMIP Mandya centre be identified as National Hybridization nursery and strengthened with additional infrastructure and technical staff.

9.6 Human Resource Development and Employment Generation

- The All India Co-ordinated Small Millets Improvement Project should be supported to play the catalytic role in conjunction with the SAUs to popularize diversified uses of small millets.

- CFTRI and some SAU namely UAS, Bangalore have already developed many new products for diversified utilization at the home level. The AICSMIP should take necessary initiative to popularize these new products that could be made from ragi and other small millets by organizing large number of Training Programme at the National level.

9.7 Administrative Issues

- The QRT during its review observed that at few centres especially at Dindori research activities have got hampered due to lack of continuity of scientists

especially in the disciplines of Breeding and Entomology. The scientists posted to centres have lacked sense of commitment in spite of small millet being the most important crop to the region. DDG (Crops) should write to the Vice-Chancellor of the University for providing staff on regular basis otherwise centre be closed.

- At Dindori, Rewa and Ranchi centres it has been observed that scientists are not paying attention to main work in view of other activities of the University, such over burdening of project staff with other un related activities will seriously affect the research programmes of the centre. The QRT suggests that the necessary advise / guideline by provided by the council to the concerned University in this regard.

9.8 Financial

- The present allocation of Rs. 60,000/- recurring contingency grants to each scientists is inadequate in view of the increased labour charges and input cost. The QRT recommends that the recurring contingency be increased at least Rs.1,50,000 per scientist per year.

9.9 Transfer of Technology

- The emphasis on promotion of millets cultivation and utilization as food is gradually going down. However, it is by and large, recognized that these crops have unique adaptation to harsh agricultural niches and act as life support crops, providing adequate cushion in ensuring food security at the farm/village level. It is therefore important to take appropriate measures to improve productivity through strengthening transfer of technology efforts and bringing awareness.

- Spread of new technologies is rather slow in small millets. Despite availability of high yielding varieties, these have not reached to the farmers. QRT, therefore recommends that each centre should have more frontline demonstrations. Each centre should produce more certified seeds and distribute free mini kits to the farmers in the area for major adoption and impact.

- Adequate institutional arrangement for the production and supply of quality seeds should be put in place. At present the entire extension machinery is engaged in the development of other major crops grossly neglecting small millets.

9.10 Policies

- Highly subsidized wheat and rice are distributed at very low prices in public distribution system in the country. Under such circumstances even regular millet consumers are tempted to buy these fine cereals in the PDS than buying millets at higher price in the open market. To overcome this situation the QRT recommends that minimum support price be declared for small millets and these be included in the PDS with similar subsidy as in the case of rice and wheat.

- The global trade on small millets is worth Rs.100 crore. At present India's share in global trade is negligible. Promotional efforts are required for exporting millets to countries especially Europe, Australia, Japan and America.

ANNEXURE – I

ITINERARY OF THE QUINQUENNIAL REVIEW TEAM

Month / Date	Place	Name of the members
December 19, 2005	ICAR, New Delhi	Dr. S.L. Mehta Dr. Basant Ram Dr. Dr. M. Rangaswamy Dr. N. Sankaran Dr. H.V. Narasimha Dr.V.R. Sashidhar Dr. K.T. Krishne Gowda
January 25-26th, 2006	RRS, Berhampur OUAT, Bhubaneswar	Dr. M. Rangaswamy Dr. N. Sankaran Dr. V.R. Sashidhar
February 6th, 2006	GBPUAT, Pantnagar	Dr. S.L. Mehta Dr. Basant Ram Dr. Dr. M. Rangaswamy Dr. N. Sankaran Dr. H.V. Narasimha Dr.V.R. Sashidhar Dr. K.T. Krishne Gowda
February 7th, 2006	VPKAS, Almora	Dr. Basant Ram Dr. Dr. M. Rangaswamy Dr. N. Sankaran Dr. H.V. Narasimha Dr.V.R. Sashidhar Dr. K.T. Krishne Gowda
February 8 - 9th, 2006	BAU, Ranchi	Dr. M. Rangaswamy Dr. N. Sankaran Dr. V.R. Sashidhar
March 1 –2nd , 2006	UAS, Bangalore	Dr. S.L. Mehta Dr. Basant Ram Dr. Dr. M. Rangaswamy Dr. N. Sankaran Dr. H.V. Narasimha Dr.V.R. Sashidhar Dr. K.T. Krishne Gowda

March 3rd, 2006	CFTRI, Mysore ZARS, V.C. Farm, Mandya	Dr. S.L. Mehta Dr. Basant Ram Dr. Dr. M. Rangaswamy Dr. N. Sankaran Dr. H.V. Narasimha Dr.V.R. Sashidhar Dr. K.T. Krishne Gowda
March 4th, 2006	TNAU, Coimbatore	Dr. Basant Ram Dr. Dr. M. Rangaswamy Dr. N. Sankaran Dr. H.V. Narasimha Dr.V.R. Sashidhar Dr. K.T. Krishne Gowda
March 5-6th , 2006	ANGRAU, Vizianagaram	Dr. M. Rangaswamy Dr. N. Sankaran Dr. V.R. Sashidhar

ANNEXURE – II

LIST OF OFFICERS AND SCIENTISTS MET BY THE QRT FOR DISCUSSION

(Other than project persons)

1. ICAR, Head Quarters and Institutes

a Dr. Kalloo. G., Deputy Director General (CS & Hort), New Delhi
b Dr. Shukla,S.N., Asst. Director General (FFC), New Delhi
c Dr. Gupta, H.S, Director, VPKAS, Almora
d Dr. Arun Gupta, Senior Breeder, VPKAS, Almora
e Dr. Bhatt, J.C. Principal Scientist, Crop Protection Division, VPKAS, Almora

2. State Agricultural Universities

a Dr. Senapati, Vice-Chancellor, OUAT, Bhubaneswar, Orissa
b Dr. Gautam, P.L. Vice-Chancellor, GBPUA & T, Pantnagar
c Dr. Subba Rao, I.V, Vice-Chancellor, ANGRAU, Hyderabad
d Dr. Singh, N.N., Vice-Chancellor, BAU, Ranchi
e Dr. Sheelavantar, M.N, Vice-Chancellor, UAS, Bangalore
f Dr. Patil, S.A., Vice Chancellor, UAS, Dharwad
g Dr. Ramaswamy, C., Vice-Chancellor, TNAU, Coimbatore
h Dr. Sharma. S.D., Dean of Research, OUAT, Bhubaneswar
I Dr. Singh B.N., Director of Research, BAU, Ranchi .
j Dr. T.K. Prabhakara Setty, Director of Research, UAS, Bangalore

3. List of participants in the brain storming session on "Ways & Means To Promote Small Millets & To Make Them Economical To Farmers" held on March 2, 2006 at UAS Hebbal Campus, Bangalore

Sl. No.	Name and Address	Sl. No.	Name and Address
1.	N. Venkataram Director (Marketing) Nilgiris Mechanised Banery 28, Magrath Road, Bangalore	9.	Dr. M. Rangaswamy Former Director School of Genetics and Plant Breeding Coimbatore-641003
2.	H.K. Mahapatra Sr. Entomologist and Officer-in-charge SMIP, ARS (OUAT), Berhampur, Orissa	10.	Dr. B.R. Hegde Former Director of Research UAS, GKVK, Bangalore
3.	Dr. N.S. Tomar Sr. Scientist & Officer-in-charge SMIP, &SGCARC, Kumarwand Jagdalpur	11.	Dr. T.K. Prabhakara Setty Director of Research UAS, GKVK, Bangalore
4.	Dr. O.P. Dubey Principal Scientist JNKVV, RARS, Dindori (MP)	12.	Dr. G.K. Veeresh Former Vice-Chancellor & President (APOF) UAS, GKVK, Bangalore
5.	Dr. N.G. Malleshi Head, Dept. of Grain Science and Technology CFTRI, Mysore	13.	Dr. S.L. Mehta Vice-Chancellor MPUAT, Udaipur.
6.	Dr. Z.A. Haider Breeder (Small Millets) Birsa Agril. University Ranchi-834006 (Jharkhand)	14.	Dr. N.D.R.K. Sarma Senior Scientist and Head Agricultural Research Station Vizianagaram – AP
7.	Prof. B.T. Shankare Gowda Project Officer SGSY special project JSS Technical Institution complex SJCE Campus, Mysore-570006	15.	Dr. A.K. Jain Sr. Scientist (Plant Pathology) AICRP on Small Millets JNKVV, College of Agriculture Rewa (MP)
8.	Dr. N. Sankaran Former Director (CAS) & Head Agro TNAU, Coimbatore-3	16.	Dr. M. Devkumar Agronomist (ORP), UAS, Hebbal, Bangalore - 560 024

Sl. No.	Name and Address	Sl. No.	Name and Address
17.	Dr. H.V. Narasimha Former Head, Dept. of Grain Science & Tech. CFTRI, Mysore-570020. No.20, 1st Main, IV stage, TK Lay-out Mysore-570009.	26.	Prof. R.D. Nigade Agronomist, ZARS, Kolhapur Maharashtra
18.	Mr. T. Veerakempaiah Channadevi Agrahara Kodenur Post Doddaballapura Taluk Bangalore dist.	27.	Dr. Y. Narsimhudu Sr. Scientist and Head, AICSMIP Regional Agril. Research Station Nandyal – AP.
19.	Mr.T. Ramaiah Channadeviagrahara Kodenur Post Doddaballapura taluk Bangalore dist.	28.	Dr. C.R. Ravishankar Ragi Breeder, ZARS, V.C. Farm Mandya
20.	Dr. M. Mahadevappa Ex. Vice-Chancellor UAS(D), Ex. Chairman (ASRB) Advisor JSSRDF, Mysore. No.1576, Ist cross, Chandra Layout Bangalaore-560040.	29.	Dr. S.B. Battakurki Agril Engineering Specialist, EEU, UAS, Hebbal, Bangalore-24
21.	Dr. Basant Ram Director of Research GBPU &T, Pantnagar	30.	Mr. K. Sangappa Owner of Ragi processing Plant, APMC Yard, Yashawathapur, Bangalore.
22.	Mr. C.N. Swamy Joint Director of Agriculture (Dev.) Commissioner of Agriculture Seshadri Road, Bangalore	31.	Dr. A. Nirmala Kumari, TNAU, Coimbatore
23.	Dr. H. Subbaiah Joint Director of Agriculture Kolar	32.	Dr. B. V. Chinnappa Reddy, UAS, Bangalore
24.	Mr. S.S. Anwar Regional Manager National Seeds Corporation Bangalore-24.	33.	Dr. Rajendra Prasad, Special Officer (Seeds) NSP, UAS, Bangalore
25.	Mr. Ananda Krishna. K General Manager (Marketing) Karnataka State Seeds Corporation Bangalore	34.	Dr. G. Shanthakumar Asst. Professor ARS, Hanumanamatti

Sl. No.	Name and Address
35.	Dr. Arun Gupta Scientist (SS), VPKAS, Almora
36.	Prof. D.D. Kadam Jr. Breeder AICRP on Small Millets NARP, Kolhapur (Maharashtra)
37.	Dr. K.T. Krishne gowda Project Coordinator (Small Millets) ICAR, UAS, GKVK, Bangalore-560 065.
38.	Dr.Jayarame gowda Geneticist (Small millets) UAS, GKVK, Bangalore-560 065.
39.	Mr. M. Krishnappa, Associate Professor Small Millets, GKVK, Bangalore – 560 065
40.	Mr. K.R. Vasanth, Asst. Professor, AICRP on Small Millets, UAS, GKVK, Bangalore – 560 065
41.	Dr. A. Nagaraja, Pathologist, AICRP on Small Millets, UAS, GKVK,Bangalore – 560 065
41.	Mr. E.G. Ashok, Agronomist, AICRP on Small Millets, UAS, GKVK, Bangalore – 560 065
42.	Dr. P.S. Jagadish, Entomologist, AICRP on Small Millets, UAS, GKVK, Bangalore – 560 065
43.	Dr. J. Vijayakumari, Professor and Head, Dept. of Food Sciences & Nutrition UAS, Bangalore- 560 065
44.	Dr. Sashidhar. V.R., Physiologist, AICRP on Small Millets, UAS, GKVK, Bangalore – 560 065

Annexure III

CHECK LIST FOR CENTRE WISE REVIEW

(i) Technical

a). Implementation of allotted technical Programme
b). Workload to individual Scientist.
c). Does the academic qualification match the essential requirements of the position.
d). Question of entomology out-flow to recommended package
e). Adoption level of the technology package.
f). Projects obtained by the scientists initiative (other than AICRP)
g). Any basic research initiated.
h). Sharing/using of facilities for self and others.
i). Opportunities for interaction.
j). ITK identified and verified.

(ii) Technology transfer and linkages.

a) Details of FLD's conducted and response of farmers to new technology.
b) Seed produced and distributed to the agencies
c) Trainings conducted by the unit and details of personal involved
d) Project details
e) Inter divisional project details
f) Inter institutional project details.
g) Linkages with the departments and NGO's
h) Technology verification efforts (on farm testing).
i) Efforts made in diversified utilization of grains.

(iii) Administrative

a) Staff Position
b) Continuity of staff
c) Frequency of scheme scientists deployed for other than the scheme work.
d) Involvement of present scientists in research activities.
e) Scheme headed by whom.
f) Freedom for attending to projects legitimate work.
g) Extent of co-operation/Interaction among scheme staff.
h) Is the incumbent is at the same cadre as that of the sanctioned post.
i) Opportunities of in service training and acquiring higher qualification.

(iv) Financial

a) Budget and Utilization
b) Who operates the budget
c) Freedom for full utilization
d) Does the institution charge for the facilities given to AICRP

1. Land
2. Building
3. Electricity
4. Telephone
5. Postal
6. Security
7. Any other

e) Adequacy of the budget

1. Recurring
2. Non-recurring
3. Pay & Allowances
4. Travelling Allowances