NATIONAL AGRICULTURAL TECHNOLOGY PROJECT

Rainfed Agro-Ecosystem

Production System Research

COMPLETION REPORT
1999-2004

Agro-Ecosystem Directorate (Rainfed)
Central Research Institute for Dryland Agriculture
Hyderabad

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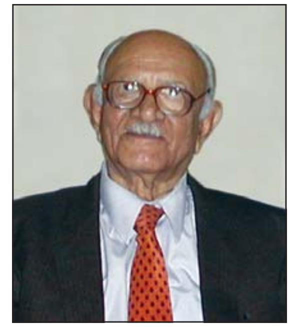
Foreword



Sustainable management of natural resources is key for improved agricultural productivity and better livelihoods for farmers in rainfed regions of the country. Over the years, large number of improved technologies like superior varieties, nutrient management, pest control, cropping system etc. were evolved for major rainfed crops like pulses, oilseeds, cotton and nutritious cereals in different agro ecological situations in the country. Application of these technologies resulted in significantly higher yields at research stations across the country. But the actual yields realized by the farmers still remain low and this yield gap is a major concern for the Government of India.

There are many reasons for the continued yield gap. However, the most important has been the field level constraints in adopting the best technologies and management practices by the farmers for realizing optimum productivity from a given crop or cropping system, as done at the research stations. It is more so in rainfed regions where the growing environment is quite heterogeneous and the risks are enormous in adopting any new technology which requires higher investments. It is therefore important to critically understand the performance of the improved technologies under farmer's conditions and analyze how best to leverage to farmers strengths and overcome the weaknesses in order to bridge the yield gap as much as possible. The production systems research (PSR) under rainfed agro ecosystems of the NATP attempted to address this issue through a farmer participatory on-farm research mode. Network projects were formulated in all the five production systems on major thrust areas like rainwater management, INM, IPM, on-farm varietal testing, post harvest technology and value addition.

As a chairman of the Scientific Advisory Panel (SAP), I have been associated with the NATP project with reviewing, approval and monitoring of the sub projects under rainfed agro ecosystem between 1999 to 2004. This was a major effort of on-farm research in more than 200 districts involving nearly 8000 farmers. As a departure from the normal crop demonstrations, these experiments were located in specially identified target districts which have fairly large area under a given production system but lag behind in productivity. This participatory research model was fairly successful in generating useful data on farmers micro farming situations which truly reflects the strength of the technology and its application domain. In addition to identifying and validating nearly 48 technologies in different production systems, the sub projects have also resulted in transferable technologies in the area of post harvest technology and value addition which can be taken up by private entrepreneurs. The project tested successfully a new model of inter institutional research with in built monitoring mechanism which should be main streamed into the research system of the NARS. This completion report eloquently captures all the major events in the implementation of the project covering the project development processes, salient achievements, technology transfer, linkages and impact. I am sure this report will be quite useful to all the stakeholders of rainfed agro ecosystem research in the NARS.

I wish to acknowledge the excellent co-operation and efforts of the all my colleagues in the scientific advisory panel (SAP) who played a key role in identification and formulation of relevant research projects in the priority domains. Some of them who were associated for most part of the project implementation and made substantial contribution include Drs.N.G.P.Rao,I.C.Mahapatra, B.K.Soni, N.N.Goswami, S.Bislaiah, R.K.Gupta and S.N.Puri. The agro ecosystem Directors, Dr.Y.S.Ramakrishna, the present Director and Dr.H.P.Singh, the former Director of CRIDA, efficiently implemented the projects at the AED level. Dr.B.Venkateswarlu, Principal Production System Scientist (PPSS) did an excellent job in coordinating the work, organizing the SAP meetings and documentation, which was responsible for good recognition and appreciation of the AED Rainfed by PIU, NATP. Dr.K.P.R.Vittal, former PPSS, played immense role in the project development process by preparing the base documents and putting in place the functional network for different sub projects. I wish to specially acknowledge the cooperation of all the participating farmers and project scientists who contributed to the success of this major project in evaluating, validating and refining various technologies to improve the productivity and sustainability of this stressed ecosystem.

I wish to acknowledge and congratulate all those involved in the successful implementation of this unique project.

J.S. Kanwar
Chairman, SAP (Rainfed)

October, 2005

Preface

The rainfed agro ecosystem covered the largest programme under production systems research of NATP. It involved 103 sub projects at a final outlay of Rs.90 crores for a period of 5 years (1999 to 2004). The sub projects were identified after detailed exercise on target area identification and problem prioritization. The unique feature of the programme was that 66 of the 103 projects were based on on-farm participatory research in a network mode. This approach helped in generating extensive data from the farmers micro farming situations and a better understanding of the farm level constraints. It resulted in greater visibility and a significant horizontal diffusion of technologies among farmers. I am grateful to Dr. Mangala Rai, Director General, Dr. R.S. Paroda, former Director General and Dr. J.S. Samra, Deputy Director General (NRM), ICAR, for their guidance, support and encouragement without which it would have not been possible to implement such a major project successfully.

The Rainfed Agro Ecosystem Directorate (AED) was fortunate to have the guidance of eminent experts both from within and outside the country in drawing up comprehensive research programme. In particular the role of the scientific advisory panel (SAP) led by Dr.J.S.Kanwar, an eminent scientist of international repute was most helpful in developing, reviewing and monitoring of the sub-projects. I am thankful to all the SAP members *viz.* Drs. N.G.P.Rao, I.C.Mahapatra, B.K.Soni, N.N.Goswami, J.C.Katyal, S.Bislaiah, R.K.Gupta, S.N.Puri, D.N.Jha, P.S.Reddy, P.Das, Joseph Thomas, S.Chellaiah, P.K.Khosla, O.P.Pareek and P.K.Singh for their active participation and guidance in successful implementation of the programme. I also thank all the Vice-Chancellors, Directors of research of SAU's, Directors of ICAR research institutes and nodal officers of all participating institutes for their active participation, organizing site committee meetings and undertaking internal monitoring which helped in timely completion of the projects.

We present in this report, a summary of all activities carried out in the PSR component of AED(Rainfed) including project development process, salient achievements and impact. I hope this will be informative and useful to all the research institutes, agricultural universities, development departments, NGOs and policy makers in the country. I wish to place on record, the excellent support and cooperation received from the National Directors of NATP, Drs.G.L.Kaul, P.L.Gautam, S.L.Mehta and Mruthyunjya in effective implementation of the project. Drs.D.P.Singh, A.K.Raheja and R.K.Gupta National Coordinators (PSR) from PIU, NATP also extended timely help and cooperation during the entire project period.

I wish to acknowledge the efforts of Dr.H.P.Singh, former AED for launching the programme and implementing it for most part of the five year period. Dr.B.Venkateswarlu, PPSS has put in excellent efforts in coordinating the programme and running it successfully at the AED level. Due to his meticulous follow up action on the decisions taken by the SAP, organizing peer reviews and documentation, the AED(Rainfed) got high appreciation from PIU, NATP. Dr.K.P.R.Vittal, former PPSS, played an important role through his painstaking efforts in the initial stages of the project development process and its implementation upto 2001. Some of the other scientists who assisted in successful implementation of the programme in the directorate include Drs.G.Subba Reddy, Ch.Srinivasa Rao, U.S.Victor, K.V.Rao, U.K.Mandal, K.L.Sharma, Srinath Dixit who served in different committees and helped in developing, reviewing and finalizing the projects.

The facilitators of different production systems viz., Drs. S.K.Mohanty/B.N.Singh/Devaraj Panda for rainfed rice, Dr.D.M.Hegde for oilseeds; Dr. Masood Ali for pulses; Dr.S.K.Banarjee for cotton; Drs. B.S.Rana/M.H.Rao/S.Indira/S.V.Rao for nutritious cereals provided immense support to the programme through review of projects in their respective domains, participation in the SAP meetings and bringing out progress reports on time.

The Agro Ecosystem Directorate was ably supported by Finanance Offficers P.V.Epachan, S.K.C.Bose and P.Bala Brahmaiah. Mrs.P.Lakshmi Narasamma,(T-6) worked with utmost devotion and commitment in budget release and maintenance of accounts. The other technical staff who contributed significantly for the success of project include I.Rama Mohan, (T-6) K.Samabasiva Rao, (T-4) and Hemlata Kapil (T-II-3). The AED cell was well supported by assistant administrator officer, G.Laxminarayana, assistant, K.R.Srinivas Rao and stenographers M.A.Rekha, G.Varalakshmi, and Late Sh.Nagabhushana Sharma. Large number of other regular staff of CRIDA and contractual staff like research associates, senior research fellows and data entry operators provided valuable support to the programme whose help is gratefully acknowledged.

Y.S.Ramakrishna
AED (Rainfed)

October, 2005

Contents

CHAPTER 1

Executive Summary

Covering 66% of the cultivated area, Rainfed Agro-Eco System (AES) occupies an important place in Indian agriculture. Besides supporting 40% human population, the rainfed AES also supports two thirds of the livestock. Low and erratic rainfall, degraded soils and poor resource base of farmers are some principal constraints affecting productivity and sustainability. Following a new paradigm of eco-region based research initiated under NATP, the rainfed AES was sub divided into five homogenous production systems i.e. rainfed rice, oilseeds, pulses, cotton and nutritious cereals. 103 sub projects were taken up in a network mode to address critical gaps identified in each of these production systems.

To begin with, a detailed assessment of target area was made by a critical analysis of production and productivity trends of important crop/cropping systems/live stock and status of natural resources in more than 300 districts in semi arid and sub humid zones in the country. Specific target districts (225) representing large area under important commodities with low or stagnant productivity were selected for taking up production system research in a network mode. Relevant sub projects in the areas of natural resources management (NRM), Integrated Pest Management (IPM), rainwater management, cropping systems, horticulture, post harvest technology and livestock production were taken up to address the identified constraints. Of the 600 initial proposals received, the scientific advisory panel (SAP) approved 103 projects considering the relevance of the project for a given production system, institutional participation, technical programme of the proposal and activity milestones. Sixty five projects were implemented through on-farm adaptive research (OFAR) mode involving farmers from target villages as partners. This was the most significant aspect of programme in rainfed agro-ecosystem which paid high dividends, as extensive data could be generated from farmers' micro farming situations in different agro-ecological sub regions.

In the rainfed rice based production system, 35 projects were taken up covering rainwater management, crop diversification, Integrated Nutrient Management (INM), IPM, horticulture and fisheries. The main objective were to improve the productivity and sustainability of rainfed rice based production system as a whole through increased yields, cropping intensity and better management of natural resources. In a network project in Chhattisgarh, Jharkhand and Orisssa, surplus rainwater during *kharif* season could be successfully harvested and recycled through construction of on-farm reservoirs (OFR) on a field scale. This OFR technology helped in managing drought in standing rice crop and also increased the cropping intensity through *rabi* cropping. The entire cost of water harvesting could be recovered by additional income generated from the project in a period of 3 years. Based on the success of the project, the

Government of Chhattisgarh took a major initiative to construct two lakh such structures in a five year period under drought relief programme. Similarly in semi-arid areas of the country, large number of *in situ* moisture conservation practices like ridge and furrow method of planting, conservation furrows, compartmental bunding and wide row planting were field tested on more than 2000 farmer's fields on cotton, oilseeds, *rabi* sorghum and pearlmillet. These technologies gave additional returns of 20-25% over farmers practice translating in to monetary benefit of Rs.800-2000/ha. depending on the crop/cropping system.

In Chhattisgarh and Jharkhand, participatory on-farm research demonstrated opportunities for additional income generation of Rs.1000-2000/ha/year through introduction of pulse and oilseeds based intercropping systems in place of rainfed rice on uplands. In medium and low lands, it was possible to increase cropping intensity through a second crop of gram or vegetables by adoption of moisture conservation practices during *rabi*. This technology, if adopted on community basis, can bring large areas of *rabi* fallows in eastern India under productive use.

Bio and chemo intensive IPM modules were evaluated on farmer's fields on rainfed rice, oilseeds and pulse based cropping systems. In general, both bio and chemo intensive modules performed on par in terms of yield and benefit-cost ratios, but proved significantly superior over farmers practice. Adoption of bio intensive modules, however contributed to 45-60% reduction in use of pesticides, benefiting the environment and also resulted in a significant build up of beneficial insects and natural enemies after three years. Similarly, INM experiments demonstrated that sustainable yield on long term basis can be realized with balanced fertilization or when chemical fertilizers are combined with organic sources of nutrients at least up to 25% of the recommended level. In view of the shortage of FYM across the country, the adoption of green leaf manuring or incorporation of intercropped legumes emerged as a viable alternative in all the production systems.

In the area of varietal development, the sub projects supported the on-going programmes with focus on participatory varietal evaluation which resulted in identification and release of two varieties of rainfed rice, one variety of jute and one variety of dual purpose sorghum. As a significant development, four high quality arboreum cotton varieties were identified through extensive on-farm trials in Maharashtra, A.P. and Karnataka. These varieties exhibited on par performance with hirsutum hybrids with 40% lower cost of cultivation, particularly on use of pesticides. Mill tests have confirmed their quality superiority and suitability for textile industries on par with well known hybrid cottons. This opens up immense opportunities for popularizing desi cottons in rainfed areas both to save on cost of production and reduce the chemical load on the environment.

Significant successes were achieved in the area of post harvest technology and value addition from more than a dozen projects taken up on sweet sorghum, safflower, sunflower and minor millets. Cultivars of sweet sorghum with high biomass yield (upto 40 t/ha) were identified. Contract farming trials on pilot basis in Karnataka and A.P. revealed that 40-50 liters of fuel grade ethanol can be produced from one ton of sweet sorghum stalks. Rainfed farmers can earn a net income of Rs.15,000 to 20,000/ha by growing this new crop. Following this promising outcome, a stakeholders meeting was organized on promotion of this technology during August, 2004 in Hyderabad inviting representative from sugar and distillery industries. The meeting concluded that considering the biomass yield, short duration and low water requirement as compared to sugarcane, sweet sorghum has good potential as alcohol raw material in view of the Government of India's decision to mix 5% ethanol in auto fuels.

Technologies for production of natural colors, herbal tea and card boards were standardized from safflower crop which attracted the attention of entrepreneurs in Maharashtra. Farmers growing this low input crop have opportunity to upgrade their income, once these products are commercialized. A contract farming project is planned in Maharashtra for production of sufficient raw material to dye 5000 m cloth. Protocols for production of complete feed using sunflower heads (which otherwise go waste) were developed. Buffaloes, cattle and sheep supplied with such feed recorded 1 – 1.5 kg/day of increased milk yield over farmers practice. Similarly, a detoxification technology for utilization of castor cake as animal feed was standardized and transferred to M/s.Jayanth Oil Mills, In Vadodora. The animal trials are in progress in Gujarat.

An integrated paddy-cum-fish-cum-duck farming system was tested in Jharkhand and West Bengal for tribal farmers. This system proved quite beneficial not only in utilizing the small ponds in the rice landscape for fish and duck culture but also utilizing the duck manure for improving paddy productivity. This farming system module was adopted by ATMA project in Dumka district of Jharkhand and has potential to improve the income and livelihoods of small farmers in 10-15% of the rice area in Jharkhand.

Overall, the 103 sub projects resulted in development of 49 usable technologies in different production systems, out of which, 20 technologies were transferred to TAR-IVLP programme for assessment and refinement. Twelve technologies have potential for upscaling/commercialization out of which two have been already commercialized. The production system research covered 8000 farmers in 2000 villages in a four years period providing extensive opportunities for horizontal learning among farmers in the target districts through formal training programmes, krishi melas and exposure visits. It resulted in improved institutional mechanism to carry out network research. The involvement of multi disciplinary inter institutional scientist teams and electronic connectivity introduced effective partnerships which reduced the transaction time and contributed to timely completion of project milestones. Thirty five of the 103 projects were targeted towards generating technologies for small and marginal farmers in rainfed areas and five projects specifically developed technologies for improving income and nutritional security of tribals by crop diversification and integration of livestock in the cropping systems. Through successful validation of IPM modules on more than 1000 farms across the country, the research clearly demonstrated that pesticide use can be brought down to 40% of the current level, if concerted efforts are made to augment the availability of bio agents and encourage farmers for whole village adoption of IPM.

A structured monitoring and evaluation mechanism through site committees, peer review teams and annual workshops helped in effective review and monitoring of the projects and achieving the milestones under NATP, which can be main streamed into regular programmes of the NARS, particularly in implementing eco region based production system research. Considerable progress was made on human resource development with 94 and 54 scientists trained in India and abroad respectively on project related skills. Effective linkages between PSR, TAR-IVLP and ATMA projects resulted in improved uptake and adoption of technologies in the target districts and areas covered by the zonal research stations. This activity need to be continued on regular basis and state line departments have to be sensitized on technologies emerged from NATP projects.

The formulation of the well designed technical programme to address location specific problems and its regular monitoring through the peer review mechanism resulted in improved quality of research both in terms of better methodology and outputs. More than 196 national and 17 international publications were made in referred journals, 300 papers presented in national symposia/seminars/conferences and 114 bulletins/ brochures/books published which provide valuable information and can be made use by extension service providers. Eighteen projects were identified to document the success stories through multi media/CDs out of which seventeen have been completed.

Overall, the production system research provided valuable experience in multi institutional problem oriented eco-region based research and generated many usable technologies which can be adopted by the user agencies for improving productivity and reducing risk in the rainfed farming system. On the flip side, linkages between scientists working in NATP and others involved in the core programmes at the Institutes/SAUs, remained weak. The eco-region approach followed in the project for PSR emerged as a powerful model for addressing complex problems but it needs to be institutionalized in the regular ICAR programmes funded through network projects and CESS fund schemes etc. Otherwise there is a risk of continuing with the existing commodity/discipline-wise approach where as the livelihoods of most farmers in rainfed areas are never linked to a single crop or animal but the entire farming system.

CHAPTER 2

Rainfed Agro-Ecosystem: An Introduction

2.1 The Rainfed AES

Rainfed Agro Eco System (AES) occupies an important place in Indian agriculture. It covers about 66% of the net cultivated area supporting 40% of the India's 1000 million population and contributes 44% to the food basket. Ninety one percent coarse cereals, 90% pulses, 85% oilseeds, 65% cotton and 55% rice are grown under rainfed conditions. The rainfed agro ecosystem also supports two thirds of India's livestock population. The farming systems are quite complex with a wide variety of crops and cropping systems, agroforestry and livestock production. The ecosystem as a whole is characterized by instability in biological productivity caused by aberrant wheather. Farmers are resource poor with inadequate infrastructure and credit support. Rainfed AES was one of the five agro-ecosystems supported for production system research with an out lay of Rs.103.5 crores.

2.2 Problems and Constraints

The Rainfed AES suffers from low and erratic rainfall, degraded soils and poor crop and livestock productivity. Coupled with poor socio economic base and infrastructure, the small and marginal farmers living in these vast tracts are unable to improve their livelihoods due to low and unstable income and lack of alternative options of income generation. Acute shortage of fodder limits the livestock productivity. Adoption rate of new technologies is low due to lack of location specific technologies, poor investment capacity, inadequate extension services and lack of market information. Rainwater is the critical input in determining the productivity in all these areas, but the inability of managing either deficit or excess rainwater through proper harvesting methods has always been a constraint in upgrading productivity. Soils are highly deficient in major and minor nutrients and top soil erosion is a wide spread problem. Thus, management of rainwater, soil and nutrient management emerge as key strategies for improvement of agriculture in this eco system. The sub-projects under Rainfed AES, therefore, mainly addressed problems of natural resource management like soil and rain water in all the five major production systems, in addition to enhancing input use efficiency and environmental conservation through INM (Integrated Nutrient Management) and IPM (Integrated Pest Management) and post harvest technology and value addition. Diversification of agriculture was given special attention in the programmes of this agro eco system.

2.3 The Production Systems Approach

Following a new paradigm of agro-ecosystem (eco region) based research initiated under National Agricultural Technology Project (NATP), the rainfed AES was sub divided in to 5 homogenous production systems; viz. i) Rainfed rice based system, ii) nutritious (coarse) cereals based system, iii) oilseeds based system, iv) pulses based system and v) cotton based system. Individual projects were developed to address problems of the farming system as a whole with in each of these five production systems including horticulture, agro -forestry and livestock production. Nearly 66% of the sub projects were taken up in 5 produciton systems were based on participatory on farm research so as to develop technologies relevant for different locations and compatible with farmers resources. The average cost of the projects was Rs.100 lakhs.

2.4 Project Development Process

A detailed exercise of identifying the target domain for Production System Research (PSR) was carried out by the Agro Ecosystem Directorate (AED). The crop, livestock and socio economic data for all districts with less than 30 percent irrigated area (considered as rainfed) were analyzed to identify districts with highest area under a given crop/cropping system but with stagnant, declining or low productivity. The underlying implication of this approach was that any improvement in the productivity of crops and livestock in such districts will have a greater impact at the state and national level due to the involvement of large area /number of farmers.

Following the agro-ecosystem analysis, two base documents entitled "**Research Prioritization in rainfed rice based production system**" and "**Prioritization in four rainfed crop based production systems**" were prepared by the AED in 1999, which listed all the resources, constraints and critical research gaps in each of the production system in detail. Full use was made of the critical analysis of the rainfed typologies made by ICRISAT, material from IRRI and NCAP, New Delhi and other relevant literature available on the subject. The report of World Bank Consultant, Dr.Rattan Lal was of great value in identifying the specific thrust areas of research. An "**Atlas of Rainfed Production Systems**" was prepared by super imposing target domain on the Agro Eco Sub Regions (AESRs). SWOT (Strengths, Weaknesses, Opportunities and Thrusts) analysis of each production system (PS) was made and opportunities and strategies for improving productivity were identified. These documents served as the basis for formulation and approval of the PSR projects under Rainfed AES. The key points of the research prioritization documents and its relationship with the thrust areas identified under NATP were presented to scientists from Indian Council of Agricultural Research (ICAR) iinstitutes/State Agricultural Universities (SAUs)/ Zonal Agricultural Research Stations (ZARS)/Non Governmental Organisations (NGOs) who submitted the initial proposals. It was emphasized that the Production System Research has to be carried out in OFAR mode in the identified target districts. The document identified 225 such target districts from 13 states. Individual proposals in identified thrust areas were invited from across the country from SAUs, ZARS, NGOs, and ICAR Institutes. In pursuance of the philosophy of the NATP, scientists from most ZARS of SAUs created in the earlier World Bank funded NARP project were encouraged to participate in the PSR. Scientists from 48 such ZARS directly or indirectly participated in the 103 sub-projects approved in the rainfed AES.

A total of 650 individual proposals were received initially by the AED (Rainfed) from ICAR Institutes/ SAUs/NGOs etc. Considering the thrust areas identified under NATP, thematic and orientation workshops were organized at the AED level and proposals were grouped into different themes within each production system. During 1997 to 1999, four thematic workshops, two orientation workshops and 5 crop based workshops were organized to fine tune the proposals and reorganize them both theme and production system wise. The lead institutes and potential scientists as Principal Investigators (PIs) were identified from ICAR institutes/ SAUs considering the expertise available and the relevance of the project to institution/state (see **Annexure-XI** for complete list of meetings and workshops held for formulating the projects).

At this stage, the Scientific Advisory Panel (SAP) of Rainfed AES was constituted with experts from different subjects related to the AES and Dr. J.S. Kanwar, a well known agricultural scientist as the chairman and other members representating expertise in different subjects and experience of different regions and institutions. (see **Annexure-XV**). The SAP also included a social scientist (Dr.Dayanath Jha from NCAP) to ensure that each project adequately addresses the concerns of the stakeholders and issues related regional and gender equity. The initial meetings of the SAP were primarily focused on identifying the researchable areas in Rrainfed AES within the overall priorities of the NATP. The SAP also interacted during the thematic workshops and helped in aligning the submitted proposals with the macro level thrust areas identified. Once the draft sub-projects were prepared, the same were peer reviewed by two experts in the concerned subject. The project drafts were then placed before the SAP for review. The sub-projects were considered production system wise. Considering the relevance of the proposal, its technical quality, deliverables and milestones, the SAP made critical observations for revision, improvement or rejection of the proposals. The projects were then revised by the PIs/CCPIs by modifying the technical programmes and in some cases including new centers, changing the location of the experiments etc. and resubmitted. Such projects were finally considered by the SAP and again critically examined to make them scientifically acceptable and achievable within the budgetary limits. The consultation of peer review members, SAP, Directors, Nodal officers and Project Coordinators led to the finalisation of projects. By peer review, the SAP ensured the technical quality and through consultations with the Directors of Research and Nodal Officers of the identified institutes, it was ensured that all the relevant institutions for a given project were made partners in the project.

During the two year period between 1999 to 2000, more than 14 meetings of the SAP were organized for production system wise consideration and approval of the projects (see **Annexure IX** for complete list of SAP meetings and the agenda covered). The key criteria of the decision making of the SAP was identifying appropriate and relevant problem, well structured technical programme to address the same and pluralism i.e multi institutional participation in project formulation. Since most of the scientists are oriented towards mono disciplinary commodity focused research, the SAP had to spend considerable time and effort in formulating network projects that addressed the production system/cropping system approach incorporating all elements of the farming system that had the potential of making an impact on the livelihood of the farmers. From a total of 650 proposals submitted, after various stages of review, only 103 were finally approved (Table 1). The projects covered all major themes identified under NATP and involved several institutions across the country (see **Annexure XIV**).

2.5 On-farm Participatory Research (OFR)

Most projects were designed in such a way that the available/developed technologies are tested as a package on the farmers' field and compared with his own practice in order to understand the constraints in adoption of improved technologies. This simple design facilitated easy understanding of the merit of the introduced technology by the participating

Table 1: Number of projects submitted and approved in PSR mode under rainfed AES

Name of the Production System	No. of initial proposals received	No. of sub-projects approved
Rainfed rice based	210	35
Oil seed based	90	18
Pulses based	70	12
Cotton based	80	11
Nutritious Cereals based	200	27
Total	650	103

farmers. Each trial was implemented in 5 villages of the target district with two to three farmers in each village. This not only generated valuable data from the farmer's micro farming situation for scientific analysis but also served as a demonstration for farmers in neighboring villages.

The project scientists brought large number of farmers from relevant villages to see these on farm trials at appropriate time. This could serve the purpose of dissemination of technologies. For each of the approved projects, a detailed technical programme yearwise, treatments, names of the target districts, villages, no. of farmers, minimum data sets etc. was brought out in the form of two volumes entitled **"Technical programme of PSR projects under Rainfed AES"** (**Volume I - Rainfed Rice; Volume II - Oilseeds, Pulses, Cotton, Nutritious Cereals**) which was circulated to all the PIs/CCPIs. These documents proved quite valuable not only for the PIs but also for the Nodal Officers and Directors of Research of SAUs for internal monitoring and for members of the peer review teams for external monitoring. To guide the PIs in carrying out on-farm adaptive research, which is statistically sound and to ensure that all relevant data are collected and analyzed properly, a manual entitled **"Guidelines for on farm adaptive research"** was brought out by the AED (RF) and distributed to all the PIs/CCPIs.

In order to develop technologies relevant to the target domain, on farm research was carried out in districts with highest area under a particular crop or cropping system but with low or stagnant productivity and income. The OFR under 66 projects covered 225 such target districts (Fig. 1).

2.6 Sensitization of the Project Teams

Once the project approvals were completed, all the PIs and CCPIs were given an orientation to the agro eco system research including guidelines on administrative and financial responsibilities of the PIs/CCPIs reporting requirements, annual reviews and monitoring and evaluation mechanism at different levels. A separate workshop was also organized for all the Nodal Officers from SAUs and ICAR Institutes during 2000 and the importance of internal review mechanism and site committees was emphasized. The launch workshop was organized for all the PIs/CCPIs of the production system research at CRIDA, Hyderabad during June 2000, chaired by Dr.R.S.Paroda, Director General, ICAR.

2.7 Institutional Mechanism

While the agro ecosystem director (AED) and principal production system scientist (PPSS) coordinated the implementation of the projects at AES level, at each of the participating institution, a site committee (SC) was constituted which was chaired by the Vice Chancellor or Director to over see the implementation of projects under different modes at the institute/university and remove bottlenecks if any. The site committees were also charged with the responsibilities of internal monitoring and evaluation. The nodal officer of the concerned university/institute was the contact point for all matters regarding implementation of the PSR project, and as a member secretary convenes the site committee meetings.

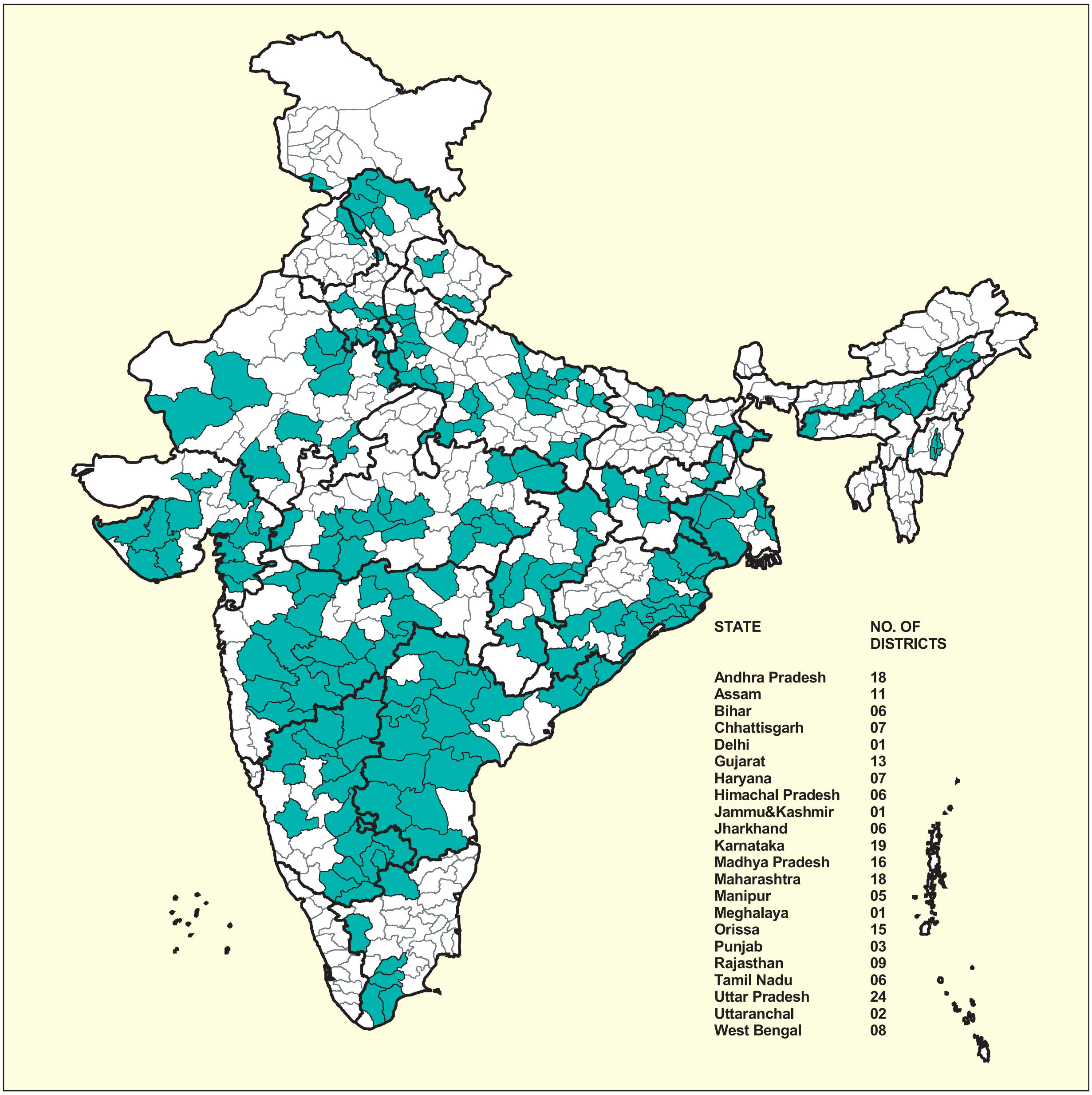


Fig.1 : Target districts of production system research under rainfed AES

The PSR projects were truly multi institutional with each sub project involving an average of five cooperating centers. Of the 476 total nodes in 103 sub projects, majority were located at SAUs (327) and ICAR institutes (136). There was also participation from other Universities outside NARS (4), departments of the central and state governments (5) and NGOs (4). The institutional participation production system wise is given in Table 2 and complete list of scientists along with project titles is given in **Annexure-VIII**.

The implementing institutions contributed about 50% of the time of the participating scientists, physical infrastructure like laboratories, research farms and communication facilities.

Table 2: Institution wise break up of nodes (scientist teams as lead or cooperating centers for a given sub project) under rainfed (AES)

Production System	ICAR Instt.	SAUs	Other Universities and research Institutes	GOI / State depts.	NGOs	Total
Rainfed rice based production system	36	126	1	3	1	**167**
Oilseeds based production system	36	62	1	—	1	**100**
Pulses based production system	22	27	2	—	—	**51**
Cotton based production system	16	29	—	—	—	**45**
Nutritious cereals based production system	26	83	—	2	2	**113**
Total	**136**	**327**	**4**	**5**	**4**	**476**

However, project specific critical inputs like equipments, speciality chemicals, need based civil works/ renovation of laboratories, contingencies for transport and contractual services for hiring Research Associates/Research Fellows were provided by the project. These inputs enabled efficient utilization of the existing scientific manpower and infrastructure. *Contractual research help* and *efficient mobility* were the two important factors that helped in successful implementation of the projects.

CHAPTER 3

Salient Achievements

More than 400 scientists participated from ICAR institutes, SAUs and NGOs during 1999-2000 to 2004-05 in the PSR projects. The research programmes which were primarily on-farm-participatory, resulted in development of large number of new technologies and refinement/ validation of existing technologies aimed at improving the productivity and profitability. This was a massive on-farm participatory research effort ever attempted in the country in the recent past. The scale of the projects in terms of villages, districts and number of farmers covered etc. are given in **Annexure II.** Some projects provided valuable insights on the constraints of given production systems and opportunities for improvement which can form the basis for new policy initiatives. In few other cases, production system research helped in speeding up of the technology development like release of new varieties. Under PSR a total of 49 usable technologies were developed which have potential to improve productivity of crops, animals and agro-forestry systems (see **Annexure I**). Detailed results from each of the project from five production systems are given in this chapter:

3.1 Rainfed Rice Based Production System

Rainfed rice is grown on 22.5 million ha. constituting 50% of the gross area under rice. The average productivity has remained around ≥ 1.0 t/ha for many years. Rainfed is grown on different land situations and management conditions. After a detailed constraint analysis, 35 sub projects were formulated under this production system. These projects have addressed key issues such as rainwater conservation, crop diversification, cropping systems, integrated nutrient management, participatory varietal development, IPM, model farming systems and post harvest technology. Significant achievements from these projects are summarized below:

Increasing cropping intensity

Rainfed rice in eastern states is grown under 3 types of land situation i.e. uplands, midlands and lowlands. Chattisgarh, MP, Orissa and Jharkhand have 20, 20, 46 and 40 percent area under upland, 45, 65, 30 and 35 percent area under midland and 35, 25, 24 and 25 percent area under lowlands respectively. On station research in the past clearly indicated the scope for crop diversification in uplands and increasing the cropping intensity in lowlands utilizing the residual moisture. However, in the absence of clear-cut data on economics under farmer's conditions, these recommendations were not widely adopted in these states. Therefore, a comprehensive network project was taken up in a participatory mode. Under this project, suitable cropping systems for diversification in uplands (intercropping), efficient sequence cropping systems in midlands and low lands were evaluated for 3 years in 40 villages in 6 target districts from 3 states involving 300 farmers. Based on three years pooled data across target districts, the following conclusions were drawn.

Upland ecology

Intercropping of rice+ redgram/sesamum in Raipur, rice + redgram in Rewa and Sidhi and redgram + groundnut in Dhenkanel, Ranchi and Darisai (East Singhbhum) districts were found to be most profitable choices for uplands. Sole maize for (cobs) was also equally profitable in Dhenkanal and Ranchi. In Orissa, horsegram and sesamum could be successfully grown after the harvest of *kharif* maize indicating the potential of double cropping even in uplands. At all locations, integrated weed management(IWM) was the most cost effective option to realise higher productivity. Weeds are a major yield limiting factor in uplands.

Mid land ecology

Under midland situation, recommended practices to achieve the targeted yield (TY) which include best variety + line sowing + RDF gave 25-42% additional yield of rice over farmers practice in different target districts. The yields of the *rabi* crop (after rice) with recommended practices were higher than farmers practice at all locations. Among *rabi* crops, gram was found to be the most promising in Raipur (7.24q/ha), Rewa (8.8 q/ha), Sidhi (7.53q/ha), Ranchi (7.89q/ha) and Darisai (8.18 q/ha). At Bhubaneswar however, green gram (5.58 q/ha) and blackgram (5.83 q/ha)were most profitable.

Lowland ecology

Under lowland situation, the recommended practice to achieve TY recorded 30-75% higher rice yield over farmers practice indicating greater response to inputs and management practices in low lands as compared to uplands and medium lands. Highest net returns were realized with *rabi* crops like gram and safflower in Raipur, lentil in Rewa and Sidhi, pea in Bhubaneswar, gram at Ranchi and Darisai grown with improved practice.

Optimum utilization of rice fallows in eastern states through profitable cropping systems during winter can also bring higher returns to the farmers. Among the sole and intercropping systems tried, gram + linseed (2:2) at Raipur, gram + mustard (4:2) at Sidhi were found to be most promising. However, linseed as a sole crop gave highest economic returns at most locations. Cropping intensity in target villages under this project ranged between 105-128% before the start of the project i.e. in 1999-2000 which increased to 115-177% in the final year i.e. 2003-04 (Fig.1). Gram, lentil, safflower, groundnut, maize and redgram were accepted by the farmers as profitable in rice-based cropping system in the target districts. In Chhatisgarh, the area under double cropping increased significantly during the last five years with the realization among farmers that higher profitability is possible with

Rice + pigeonpea (5:2) intercropping system on farmers fields in Rewa district (MP)

Redgram+groundnut intercropping (2:6) on uplands of Dhekanal district of Orissa

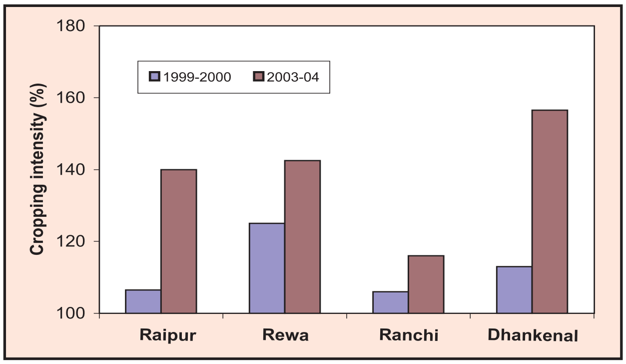


Fig.1: Change in cropping intensity in OFAR villages in four target districts before and after the project

pulses and oilseeds as a second crop after *kharif* rice. Increased cropping intensity also provided additional employment to agricultural labourers and helped in checking migration.

In a related project, implemented by CRRI, Cuttack with collaborating centers from BCKV, Kalyani, NDUAT, Faizabad, CAU, Imphal and AAU, Jorhat, a number of rice based cropping systems were introduced in rainfed upland, medium and low land situations to increase the cropping intensity by efficient rainwater management and improved water use efficiency. The target districts covered were Bhadrak, Balasore, Myurbhanj in Orissa, Bankura and Purulia in West Bengal, Thoubal and Imphal in Manipur, Golaghat and Jorhat in Assam and Faizabad and Sultanpur in UP.

The existing practice of single crop of *kharif* rice was changed to two crop and three crop system by harvesting rain water and utilization for second and third crop. The key strategy followed was to renovate the existing village tanks for harvesting water from the village catchments. Based on three years on farm trials, the best cropping system identified were rice-mustard-pulses, rice-mustard-vegetables, rice-groundnut, and rice-blackgram-sesasum. Of these, rice-mustard-sesasum was widely accepted by the farmers in Bhadrak and Balasore district of Orissa. This system increased the farmers earning from Rs.1.25 to Rs.6.15/- per rupee invested with a net profit of Rs 32,600 per ha. This higher cropping intensity also provided round the year employment to the farm labor by generating 218 labor days/ ha as against 108 for sole crop of rice.

The three crop sequence of rice-mustard-sesamum adopted by entire village community of Narsingpur gram panchayat of Bhadrak district became a success story which attracted the attention of the district administration. Solely depending on rainwater, the villagers could double their income in a three year period by increasing cropping intensity and water management.

On-farm rain water management

Managing rainwater is crucial for enhancing rainfed rice production in Chhattisgarh, Madhya Pradesh, Orissa, and Jharkhand. These areas receive relatively high rainfall (>1200 mm) and yet *kharif* rice suffers from dry spells mainly due to poor water management. High rainfall also results in runoff and soil loss. Conservation and utilization

Rice-mustard-sesame cropping system on farmers fields in Bhadrak district of Orissa of harvested rainwater for *kharif* crop during dry spells or for a second crop was considered an important strategy in this regard. Through a network project in these states, rain water was harvested through construction of small scale water harvesting structures (WHS) called on-farm reservoirs (OFRs) on farmers fields along the slope of the given rice landscape for storage of excess rainfall and ground water structures like dug wells and ditches in recharge areas. Each operational site covered an area of 22-40 ha. The crop productivity and cropping intensity in the area served by WHS was compared with the crop grown outside the area. In both the locations, rainfed rice was grown with farmers and improved packages of practices.

Based on 4 years experience of this operational scale project covering a total of 100 ha. in 3 states, the economic benefits and viability of the OFR technology became evident (Table 1). Significantly higher productivity of *kharif* rice and cropping intensity was recorded in the project area as compared to outside. The stored water could be used both for saving the *kharif* rice during drought period and also to plant a *rabi* crop. During 2002 drought year, the performance of the technology convinced the farmers and state line department. The per hectare cost of this technology is Rs 13,000-15,000 based on data generated in 4 blocks. The cost of water harvesting structures (Rs.5.02, 4.73, 8.63 and 3.32 lakhs respectively in Bhagbhara, Dindori, Keonjhar and Darisai blocks respectively) could be recovered by additional income generated from the project in a period of 3 years with adoption of improved package of practices for *kharif* rice

Table 1: Impact of OFR technology on yield of *kharif* rice and cropping intensity (due to *rabi* cropping) in the project area of 3 states

Year	Rainfall+	Rice area** served by WHS (ha)	Yield of unmilled rice (t/ha)			Cropping Intensity (%) **	
			Without WHS	With WHS		Without WHS	With WHS
			Control	FP	IP		
Bagbahara, Chhattisgarh (Replications =3)							
2000-01	573	37.1	0.53	3.05	NT	100	111
2001-02	1144	39.6	3.20	4.20	5.62	105	139
2002-03	452	45.4	0.24	3.93	5.12	100	126
2003-04	1359	39.6	3.05	4.14	4.96	105	138
Dindori, M.P. (Replications =3)							
2000-01	876	11.9	0.73	1.60	NT		
2001-02	1200	29.6	1.05	1.69	3.38	115	149
2002-03	980	26.9	1.21	1.76	3.04	115	154
2003-04	1289	24.9	1.40	1.96	3.34	120	152
Keonjhar, Orissa (Replications =2)							
2001-02	1028	18.0	2.13	2.68	3.52	100	112
2002-03	850	23.0	1.52	2.64	3.62	100	127
2003-04	921	23.0	2.10	2.67	3.80	100	132
Darisai*, Jharkhand (Replications =2)							
2001-02	1090	16.8	1.84	2.62	3.96	-	-
2002-03	900	18.4	0.82	1.91	3.71	-	-
2003-04	800	20.5	0.66	1.44	2.28	-	-

NT = the treatment was not tried . FP=farmers practice, IP=Improved practice * No *rabi* crop was taken in Darisai; ** Based on total area for all replications + June to September

OFR in Upland **OFR in Midland** **OFR in Lowland**

Water harvesting structures on the rice fields along the slope on farmers fields in Bagbhara block in Chhattisgarh

and growing of *rabi* crops. *Rabi* crops like gram, wheat and vegetables could be grown successfully by using the harvested water. As a result of recharge from OFRs, the groundwater level in the project area improved which reached less than 1 m. depth during rainy season and 2-3 m. depth in winter. The increased returns from higher yields as well as increased cropping intensity justify the investment on water storage and groundwater recharge structures. Along with using harvested water, adoption of improved package of practices both for *kharif* and *rabi* crops is key to recovering the investment on WHS as early as possible. The project had a visible impact by way of saving rice crop from drought, increasing groundwater recharge and water availability for the second crop. Based on the success of this approach, the Government of Chhattisgarh decided to go for wider adoption of this technology in the state by constructing 2.00 lakhs OFRs in a 3 year period. Other states like Jharkhand and Orissa also evinced interest in adopting this approach in the National Watershed Development Project for Rainfed Areas (NWDPRA).

Utilization of excess rain water for fish culture

Excess rainwater during *kharif* in medium and lowlands can be stored in refugees outside the rice fields to enable fish culture. Maintaining optimum weir height is the key to successful implementation of this strategy. A four year study in the target districts of Dhenkanal, Mayurbhunj (Orissa), Ranchi (Jharkhand) and Jabalpur (M.P) indicated that the stored water in refugees can be used for fish culture and also for raising a *rabi* crop. Excess water was stored in small refugees outside the rice fields in medium and low lands. About 5% of the area was allotted for this purpose. Three weir heights were tried ie. 15, 20 and 25 cm on 6-8 farmers fields in each target district. Four fish species i.e. *C.catla, L.rohita, C.mrigala, C.carpio* in 30:30:20:20 ratio were grown in the refugees @ 20,000 fingerlings/ha. *Rabi* crops like winter rice, pumpkin, greengram and blackgram were grown by utilizing the harvested water, while fruit plants like papaya and banana were raised on the enbankment of the refugees.

In medium lands, based on the three years data, 20 cm weir height was found optimum for realizing higher grain yield of rice while highest fish yield was realized with 15cm height. However, during drought year with shortage of water, 25 cm weir height showed higher rice yield. The benefit of this technology can be maximized by using high yielding rice varieties. Among the four fish species tried, the growth of C. *carpio* was maximum followed by C. *mrigala* and C. *catla* in all the treatments. Bottom feeders (C. *carpio* and C. *mrigala)* registered better growth rate than that of *L. rohita* (column feeder). Among bottom feeders,

Table 2: Rice, fish and rice equivalent yield under different treatments on farmers field in Dhenkanal district of Orissa (Based on three years pooled data i.e. 2001-04 of 8 farmers)						
Weir height	Rice area (m^2)	Refuge area (m^2)	Total area (m^2)	Rice yield (t/ha)	Fish yield (kg/ha)	Rice equivalent yield(t/ha)
Medium land 15cm weir height	3202	171	3373	4.6	1694	5.23
Medium land 20cm weir height	4595	294	4889	5.3	1265	5.74
Medium land 25cm weir height	2217	184	2401	4.8	1279	5.44
Lowland	1167	1200	2367	4.34	685.4	5.61

growth of C. *carpio* was to better than C. *mrigala* due to superior feed utilization. The treatment wise rice, fish, and rice equivalent yields based on three years pooled data are given in table 2. This integrated rice-fish farming raised the equivalent yield of rice @ nearly 3-4% per unit percent of area devoted for the refuges and tanks in spite of poaching of fish. The cropping intensity increased to 200% in the farmers field. The B:C ratio increased to 2.78 with 20 cm weir height. The net water productivity for *kharif* rice, rice + fish + on-dyke horticulture and rice + fish + on-dyke horticulture + *rabi* crops were 2.06, 2.17, 3.07 and 3.76 respectively.

The gross and net returns were highest with 20 cm weir height considering the over all returns from rice and fish produciton. With the use of HYV, these returns could be further enhanced (Table 3). The project results clearly brought out that, *in-situ* and *ex-situ* conservation of rainwater, short-duration pisciculture in the water stored in the refuges, on-dyke horticulture and *rabi* cropping with conserved water is a viable option for increasing the income of small and marginal farmers in rainfed medium lands. The stored water can also be utilized for providing supplemental irrigation to *kharif* rice during dry spells. In the lowlands, construction of drainage channel, soil maneuvering and integration of fish culture increases the land and water productivity. This dual production system (rice and fish) in *kharif,* perennial horticulture on dykes and short duration *rabi* crops could generate substantial additional income, employment and nutritional security to the farmes. In addition, this system minimizes the risks, eco-friendly and exploits synergy between different components.

Table 3: Benefit cost ratio of the integrated farming system in Dhenkanal district of Orissa (Based on three years pooled data ie.2001-04)				
Weir Height	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C ratio
15 cm	43,992	16,621	27,371	2.65
20 cm	46,238	16,621	29,617	2.78
25 cm	44,829	16,621	28,208	2.70
Rice C.V. Jagannath with best treatment (20 cm)	48,567	16,621	31,946	2.92

Watershed based resource management

Since soils in rainfed rice growing states of eastern India show diverse topography and slopes, conservation of top soil, controlling runoff and optimum tillage are key to improving productivity. Three projects addressed this problem in different target districts and promising technologies were evaluated on farmers fields.

Soil and runoff control on a toposequence

A network project on soil and runoff control on a toposequence in eastern high lands of Orissa, A.P. and Chhattisgarh was taken up with the primary objective of rehabilitation of degraded hillocks, identification of vegetative barriers and suitable tree species for bund plantation. The project also aimed at identifying suitable medicinal plants for each of the target districts. Under each of the objectives, different treatments and species were evaluated for three years in the target districts of Koraput and Bhawanipatna(Orissa), Jagdalpur (Chattisgarh), Chintapalle (AP), and Jorhat(Assam). The main focus was to conserve the natural resources of tribal dominated hilly regions and identify the opportunities for generating supplementary income.

Among the various location specific horti-pasture systems tried for rehabilitation of degraded hillocks, guava + stylo in Koraput, cashew + deennath grass in Bastar and ber + natural grass in Kalahandi districts were found to be the most profitable. All these horti-pastural systems considerably improved the soil health. For example, the organic carbon content increased from 0.5 to 1.0% at Koraput and 0.422 to 0.55% at Jagdalpur after four years. Out of different hedge rows evaluated to arrest the soil loss on sloppy lands, *Glyricidia* and Assam shade at Koraput, mulberry and *Leucaena* at Jagdalpur, perennial pigeonpea at Bhawanipatna and jatropha at Chintapalle were found to be most promising. Supplementation of the hedge rows with grass filter strips improved their efficacy in controlling soil loss. For example at Koraput, Assam shade + sambuta grass was quite effective and allowed the least run off (8.9%) and soil loss (5 t/ha). The year wise runoff and soil loss under different treatments at Koraput are presented in table 4.

Among the multipurpose trees tried for bund plantation *Gmelina arborea* was most acceptable to the farmers which showed highest survival rate in three of the five target districts ie. Koraput, Bhawanipatna and Jagdalpur. The project was also successful in identifying anumber of medicinal plants which can survive successfully in tribal areas (Table 5).

Safe disposal of excess water from rice landscape

The hilly areas of Orissa receive an annual rainfall of 1400 mm, which sometimes occurs as heavy down pour. Due to this high intensity, fertile

Table 4: Effect of hedgerow treatments on run off and soil loss at Koraput

Treatment	Run off (%)				Soil loss (t/ha)			
	2002	2003	2004	Mean	2002	2003	2004	Mean
Assam shade + no grass	12.35	13.01	12.9	12.75	7.4	8.36	7.5	7.75
Assam shade + Sambuta grass	8.1	9.45	9.1	8.88	4.95	5.19	4.99	5.04
Gliricidia + no grass	11.53	12.29	11.8	11.87	5.26	6.57	7.4	6.41
Gliricidia + Sambuta grass	10.35	11.27	10.5	10.71	5.9	7.1	6	6.33
Pigeonpea + no grass	14.75	16.25	17.2	16.07	8.8	10.24	10.1	9.71
Pigeonpea + Sambuta	12.75	14.16	14.5	13.80	6.5	7.85	8.1	7.48

Table 5 : Potential medicinal plant species identified for different target districts		
Location	**No. of species survived**	**Few prominent and accepted species**
Koraput	31 (42)	Bhrungraj (*Eclipta prostrata*) Khadi siju (*Euphorbia tirucalli*) Kanchan (*Bauhinia variegata*) Sarpagandha (*Riwolfia tetrafila*) Chini champa (*Artabotrys hexapetalus*)
Jagdalpur	12 (21)	Akarkara (*Spilanthus acumella*), Ashvagandha(*Withania somnifera*) Bach (*Acorus calamnus*) Tikhur (*Curcuma angustifolia*) Sarpgandha (*Rauwolfia serpentina*)
Chintapalle	8 (18)	Long pepper (*Piper longum*) Bryophyllum(*Bryophyllum pinnatum*) Lepidium (*Lepidium sativum*) Indian Penny wort (*Centella asiatica*) Indian senna (*Cassia senna*)
Jorhat	8 (10)	Mint (*Mentha sp.*) Musandri (*Houttunia cordata*) *Swertia chirayta* Sarpagandha (*Rauwolfia serpentiana*)

soil from the upper reaches of the rice landscape is eroded and deposited (sand casting) in the lower regions. In order to check this soil loss and dispose the excess run off safely, three treatments were tried on farmers fields for the three years with paddy as the test crop. These include brush wood structure (T1), loose boulder structure (T2) and control (T3). Each treatment was laid out on seven farmers fields. Waste weir of 0.5 to 0.8 m width was provided in each treatment depending on the expected runoff.

Based on three years data, loose boulder structures performed better than the brush wood structure. Both the structures trapped the silt creating a cementing layer which acted as a barrier for the flow of excess water which facilitated silt deposition and moisture conservation. The mean yields (of seven farmers) of local and

Guava + stylo based horti pastural system for rehabilitation of degraded hillocks (left) and hedge rows of *Glyricidia* and assam shade with grass filter strip (right) in Koraput district of Orissa

Loose boulders (left) and brush wood (right) structures across the field bund for control of soil loss and safe disposal of excess water in Sudreju watershed of Phulbani district of Orissa

HYVs of rice are presented in table 6 along with silt load and soil moisture in the profile. Higher soil moisture stored in the loose boulder treatment resulted in more grain yield of rice. The mean soil moisture recorded under T2 was 14.36% as against 12.38% under T1 and 8.35% under T3. Similarly, the mean silt load deposited was 0.65 t under T2 as against 0.34 t in T1. Based on overall performance, loose boulder structures were found more effective, durable and hence can be recommended for field bund protection as a waste weir.

Remote sensing for identification of critical areas in watershed

Remote sensing has proved to be an effective tool for mapping natural resources in the country. Of late, it is increasingly used for planning and monitoring of many area based development projects. In view of the importance of watershed approach in rainfed rice based production system and the need for covering large area, a pilot project was taken up to study the possibility of using remote sensing technology for identification of critical areas for prioritized land treatments in micro watersheds. The project was implemented in 6 micro watersheds in the districts of Koraput and Nayagarh (Orissa), Mahasamund (Chhattisgarh), Ranchi (Jharkhad), Purulia (West Bengal) and Jorhat (Assam).

During the first two years, soil maps of the watersheds were prepared at 1:50,000 scale using satellite data from IRS-IC/ID images. Digital database for soil maps were made using ARC / INFO package and attribute data were incorporated for each mapping unit. The parameters considered for identification of critical areas in the watershed are soil depth, texture, internal drainage, slope,

Table 6 : Volume of silt deposited, area affected due to siltation, soil moisture content and rice yield under different runoff control treatments in Sudreju watershed of Phulbani district in Orissa

Treatment	Silt load in tones	Affected area due to siltation in downstream (m^2)	Average soil moisture content at harvest (%)	Rice yield (t/ha)		
				HYV*	Local	Mean
T_1	0.034	0.38	12.83	2.05	1.97	2.01
T_2	0.065	0.13	14.36	2.13	1.98	2.06
T_3	–	1.37	08.35	1.81	1.78	1.80
Mean	0.050	0.63	11.70	1.99	1.91	1.95

T_1- Brush wood structure; T_2- Loose Boulder structure; T_3- Control; * Vandana erosion and soil reaction. The soil polygons were reclassified based on the above parameters and individual thematic layers were generated. Area statistics were generated for the watershed parameter-wise to identify the critical parameter in the watershed from crop productivity point of view. A composite layer was generated from the individual thematic layers and critical areas were mapped based on the limitations of the above mentioned soil parameters. Polygons with severe limitations under each parameter were grouped as high priority zone and polygons with no limitations as low priority zone. Polygons with moderate limitations were grouped under medium priority zone. This knowledge base was applied on to the composite layer and composite polygons were reclassified and a map showing priority zones was developed.

A representative micro watershed of 500 – 1000 ha was selected from the high priority zone for preparing natural resource inventory at 1:12,500 scale using high resolution satellite data (LISS III + PAN). Critical areas were identified in the micro watershed using the above-mentioned methodology, and action plan map was generated for the micro watershed. Based on the this methodology, action plans prepared for all the six micro watersheds were implemented during the third and fourth year. Extensive data were generated on the impact of the watershed programme planned by using the remote sensing technology. Based on the 5 years study, it was clear that remote sensing and GIS techniques can be successfully applied to prepare action plans, for monitoring of the progress and final impact in terms of additional water resources generated and increase in vegetation index etc.

Similar procedures were adopted for identification of critical areas in watersheds under different agro-ecological regions and action plans were developed both at regional level ie at 1: 50000 scale and specific action plans at micro watershed level i.e. at 1:12500 scale. This study revealed that by using advanced technologies like remote sensing and GIS, critical areas could be located in the watersheds in a short time and cost effective manner, thus helping the researcher / planner to focus more on these areas while planning for watershed development following the production system approach.

Contingency planning through weather monitoring

Based on daily and weekly weather data for all the mandals in Andhra Pradesh, weekly water balance were computed using visual basic programme. These data were used to prepare thematic maps on rainfall variability and the probability of mild, moderate and severe droughts. This value added information was used to implement contingent strategy on not only the choice of crop but also its management after planting in collaboration with the Department of Agriculture, Govt. of Andhra Pradesh. This collaborative effort paid rich dividends during the drought year of 2002 and the state has been making use of this approach during 2003, 2004 and 2005 *kharif* seasons for drawing contingency plans. The agro climatic zone wise cropping strategies were suggested for A.P for NSP commnd areas, rainfed red and black soil areas during 2003 based on this approach which was quite successful.

Risk management

In another network project, impact assessment of the watershed approach through technology interventions and its potential for risk management was studied by judicious mix of biophysical experimentation and socio economic surveys. The weaknesses in the existing approach and constraints in adoption of new technology were examined in detail in three states viz. Orissa, Chattisgarh and Jharkhand covering five target districts ie. Keonjhar, Manasamund, E.Singhbhum, Ranchi and Dhenkanal. After a detailed study of the farmers perception and the level of technology adoption in the selected watersheds for 3 years, the following recommendation emerged from the project.

- An effective institutional mechanism for management of common property resources in watersheds is needed
- Measuring intangible benefits in the watershed programmes are of critical importance
- Livelihood issues should receive greater emphasis than introduction of new technology alone

Appropriate benchmarking and concurrent and post facto evaluation are critical in learning proper lessons which are useful for upscaling.

Soil quality in rice based cropping systems

One of the principal factors for stagnant crop productivity is the declining soil health across the country. This is more so in the rice based production system where cropping intensity is high and there is large gap between nutrient removal and addition across different regions. There are also non nutritional soil related factors which limit the crop productivity in intensive cropping systems. To assess the long term impact of same cropping system on soil quality, soil samples from five rice based cropping systems, one jute based cropping system, one groundnut based cropping system and one *kharif* sorghum based cropping system were studied for physical, chemical and biological properties. The changes in designated soil quality parameter were quantified under different management practices. Based on data so generated, an effort was made to identify the most sensitive parameters which indicate changes in soil quality and also develop an index viz. soil quality index (SQI) which quantifies the aggradative or degradative changes in soil as a result of a particular cropping system.

The soil quality index was calculated by two methods i.e. conventional (by comparing with fallow as base line) and statistical (giving appropriate weightage for different parameters for their importance in maintaining soil quality). Based on analyzed data, master variables/ indicators were identified for each cropping system and soil type. Of the 32 parameters analyzed, 5-6 parameters [mean weight diameter, organic C, available N, K & Zn and microbial biomass carbon] were identified as key indicators for their overriding influence in assessment of soil quality. The indicators which accounted for more than 24% contribution to SQI were organic C in rice-wheat, dehydrogenase activity in rice-rice, MBC in rice-field pea, hydraulic conductivity in sorghum-castor, MBC and available P in jute-rice-wheat and bulk density in groundnut-red gram cropping system. These indicators could largely explain the goal variables ie. yield and SYI (sustainable yield index).

The master variables were used to derive the SQI (soil quality index). SQI values for selected rice based cropping systems and changes in SQI over time under different management practices are presented in table 7. It is obvious that continuous cultivation without any fertilization or only N-application resulted in net degradation of the soil. Cultivation without balanced NPK was also unable to maintain the soil quality. Only integrated application of NPK and FYM could sustain and for a few cases aggrade (improve) soil quality over fallow land. Application of only N, NP and even NPK in few instances caused a net degradation in soil quality. Relationship between SQI and yield were strong when data of a single location /cropping system were considered but became weak when the data from all cropping system was pooled together indicating the complex inter play of many environmental variables influencing the soil quality and need for further work.

Organic carbon pools

In a related project, changes in different pools of soil organic carbon(SOC) were studied

Table 7 : Soil quality index (SQI) and changes in the index due to different management practices in five cropping systems/ locations.

Treatment	Rice-Rice (Titabar)	Rice-Lentil (Varanasi)	Jute-Rice-Wheat (Barrackpore)	Rice-Rice (Cuttack)	Rice-Field pea (Keonjhar)
Control	2.27 (-28.6)	1.63 (-8.0)	1.04 (-49.0)	2.77 (-16.8)	0.31 (-19.7)
N alone	2.60 (-14.0)	1.48 (-11.7)	1.38 (-35.0)	2.91 (-14.8)	0.35 (-7.1)
NP	2.59	—	1.66	3.21	0.78
NPK	2.79 (0.9)	1.52 (-9.7)	1.87 (19.0)	3.10 (-9.7)	0.81 (31.7)
NPK + FYM (5 t/ha)	2.84 (35.0)	1.87 (8.6)	2.10 (45.1)	4.00 (8.6)	1.13 (51.2)
Treatment Period (years)	15	19	33	35	16

Values in the parenthesis indicate % changes in soil quality as compared to fallow.

as influenced by cropping system, tillage and agronomic practices followed under long term fertilizer experiments (LTFE) mostly in semi arid region. Variations in different pools of organic carbon and its dynamics has important implications on nutrient availability to plants. Soil samples at different depths from LTFE plots were analysed for total SOC; active and passive pools ; total nutrients and physical, chemical and biological properties. The treatments mainly consisted of control, N, NP, NPK and NPK+FYM applied plots. The cropping systems followed were rice-wheat at Raipur(5 years), rice-wheat-jute at Barrackpore(29 years), soybean-wheat at Ranchi (29 years), groundnut-wheat at Junagadh (6 years), fingermillet-maize at Bangalore (14 years), sorghum-wheat at Akola(14 years), *rabi* sorghum at Solapur (12 years). Based on the analysis, the following conclusions were drawn.

The results indicated that imbalanced use of inorganic fertilizer N or NP alone could not sustain higher productivity of the cropping system in Alfisol of Bangalore and Ranchi, Inceptisol of Barrackpore and Raipur, Vertisol of Akola and Solapur. Balanced use of NPK sustained crop productivity which was higher than that of control, N and NP treatments. However, use of NPK + FYM helped in maintaining maximum productivity over time.

Continuous application of inorganic fertilizer N or NP alone could not improve active pools of carbon (SMBC, water soluble C and water soluble carbohydrate). Balanced use of NPK along with FYM registered the highest active pool of SOC as illustrated by the data at Barrackpore (Fig.2). Application of fertilizer NPK, either alone or in combination with FYM maintained higher quantity of organic carbon and it's pools at the surface soil (0-15 cm depth). This indicated that the organic pools of C, N, P and S might be maintained in rhizosphere zone thereby sustaining soil quality and productivity. Particulate organic carbon (organic C in different aggregates) is a slow pool of C that increased with decreasing particle size of the aggregates and helped in sequestering higher amount of C under 100% NPK and NPK + FYM treatments. Passive pool of HA-C was comparatively lower than FA-C in treatments receiving NPK and NPK + FYM possibly due to higher root biomass and regular application of newly humified manure into the soil.

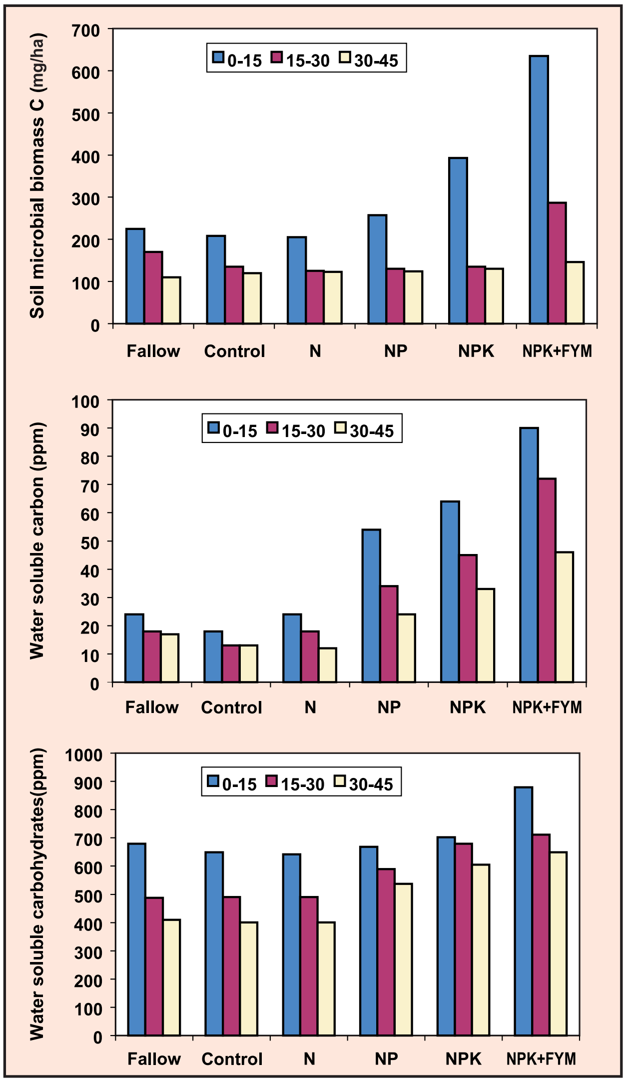


Fig 2. Active pools of carbon under different treatments in a long term (29 years) fertilizer experiment at Barrackpore

Balanced fertilization enhanced SOC restoration due to higher root biomass and rhizodeposition even under intensive cultivation, whereas no fertilization or unbalanced fertilization led to negative impact on SOC restoration in long term land use/crop management practices. The net SOC input was found in the order of NPK +FYM > NPK > NP > N > control. It was interesting to note that wherever optimum NPK is applied, even intensive cropping did not deplete the SOC in a long term. Thus, the notion that continuous cropping and fertilization causes decline in SOC and deterioration of soil quality was not found to be true in this study.

Integrated nutrient management

The role of integrated nutrient management in sustaining the productivity of rice based cropping system was studied in two projects in the states of Orissa, West Bengal, Assam and Bihar. In the first project, five nutrient management treatments were tested on farmers fields for three years at five locations in the jute-rice cropping system which is quite exhaustive in nutrient removal. Based on the 3 years result, it emerged that targeted yields (TY) of jute (2.5 to 3.0 t fibre/ha) and rice (3.5 to 4.0 t/ha) can be achieved at all locations with 100% N of TY through urea or 75% through urea + 25% of N through Glyricidia/FYM (INM treatment). However, maximum yields for both the crops were realized with INM treatment at Barrackpore, Kendrapara, Naogaon and Katihar while at Cuttack the yields were at par under both the treatments (Table 8). Available N status of the soil after crop harvest and crop nutrient removal etc. were also favourable with INM treatment. However, net returns were more with 100% urea at most locations mainly because of the high procurement cost of FYM and labour intensive nature of the green manuring technology. Nevertheless, farmers were convinced on the usefulness of raising *Glyricidia* on field bunds as a source of organic manure for sustaining jute-rice production system.

In the second project, different INM modules were evaluated on farmers fields for rainfed rice in uplands and medium lands in Phulbani district of Orissa. Based on 3 years data (2001 to 2004), it was concluded that 75% RDF (60-30-30) + 5 t/ha of FYM and intercropped blackgram produced highest yield of rice in uplands. In medium lands, intercropped green manure of either sunhemp or *Sesbania* was found more promising than greengram or blackgram. Following the promise of this

Table 8 : Effect of different nutrient management treatments on fibre yield of jute and grain yield of rice at different locations (Mean over 3 years for Jute and 2 years for rice)

Treat-ment	Fibre yield of jute (t/ha)					Grain yield of rice (t/ha)				
	Barrack-pore	Cuttack	Kendra-para	Nagaon	Katihar	Barrack-pore	Cuttack	Kendra-para	Nagaon	Katihar
T_1	2.79	2.79	2.31	2.55	2.32	3.76	3.43	3.7	3.32	2.97
T_2	2.92	2.72	2.45	2.66	2.50	3.88	3.42	3.9	3.41	3.04
T_3	2.51	2.26	2.10	2.29	1.85	3.48	2.57	3.42	3.03	2.64
T_4	2.62	2.23	2.29	2.47	2.02	3.57	3.08	3.57	3.28	2.67
T_5	2.35	1.75	1.90	1.79	1.34	3.11	2.26	3.33	2.34	1.40

T_1 : 100% N through urea for targeting 2.5-3.0 t/ha jute fibre and 3.5-4.0 t/ha rice grain on soil test based Targeted Yield equation (TY)

T_2 : 75 % N of TY through urea + 25% N of TY through *Gliricidia*/FYM

T_3 : 75% N of TY through urea

T_4 : 50% N of TY through urea + 25% N of TY through *Gliricidia*/FYM

T_5 : Farmers practice (Half the recommended dose of nitrogen)

technology, large number of training programmes were organized in the target district.

Integrated pest management

Insect pest and weeds are major yield limiting factor in rainfed rice based production system. Following a paradigm shift in the concept of pest management with increased emphasis on non chemical and eco friendly approaches, two network projects addressed the technical feasibility and economic viability of integrated pest management (IPM) and integrated weed management (IWM) modules on farmers fields. In case of IPM, on farm adaptive trials were carried out in 5 target districts viz. Cuttack(Orissa), Titabar (Assam), Imphal (Manipur), Bankura(West Bengal) and Warangal (AP). Five villages were selected in each district and two farmers from each village. Three treatments *viz.,* Farmers practice (FP) involving conventional practices of the farmers, Scheduled Treatment (ST) involving application of insecticides based on a regular schedule irrespective of pest incidence and Integrated Pest Management (IPM) treatment - consisting of an optimum combination of location specific pest control components such as resistant variety, balanced fertilizer application, release of *Trichogramma* egg parasitoids, use of pheromone traps against yellow stem borer(YSB) and need based application of pesticide specific to each location. During the first three years (2001-2003), these three modules were evaluated on the farmers field while during final year (2004) extensive demonstrations were conducted in the target districts following the whole village approach and the economic benefits of the technology were estimated. During the entire period, a total of 1052 ha area was covered under IPM involving 950 farmers in 216 villages.

At each of the OFT locations, the population of the major pests of the region were significantly brought down by the IPM module as compared to the ST and FP. For example, at Cuttack, the brown plant hopper (BPH) population were significantly less in ST (26.5 hoppers/10 hills) and IPM (27.1 hoppers/10 hills) compared to FP (64.7 hoppers/10 hills). In Titabar, stem borer damage was significantly less in IPM treatment (4.4 to 4.7%) and ST (5.2 to 5.8 %) compared to FP (8.6 to 10.8%) both at vegetative and reproductive stages. At Imphal, Incidence of gall midge at 2.3% in IPM was significantly lower than that of ST (5.5%) and FP (5.7%). At Warangal, incidence of gall midge and YSB, key pests in this region, was low. The white ear incidence due to YSB was upto 6.1% in FP and comparatively lower in IPM (3.6%) and ST (4.2%). At Bankura, BPH population were significantly lower in IPM (2.8 hoppers/hill) and ST (3.4 hoppers/hill) compared to FP (14.7 hoppers /hill). The yields and cost benefit ratios based on three years data are presented in table 9. The IPM treatment was beneficial over ST and FP but it was significant only at Cuttack and Titabar.

Further analysis on the economic impact indicated that the IPM treatment yielded a net returns of Rs, 11,276 per ha over farmers practice (FP) at Cuttack while at Imphal, the benefit due to IPM package was Rs. 50, 610 per ha. At Warangal, IPM treatment yielded a net profit of Rs.19, 253 per ha. At Titabar and Bankura also, IPM treatment was economically more profitable than ST and FP. There was also a favorable impact on the environment with considerable build up of natural enemies recorded at all the locations. At Cuttack, the population of spiders and mired bugs; at Titabar, the numbers of spiders, ground beetles, coccinellids and dragon flies and at Imphal, the population of spiders and coccinellids were significantly higher in IPM plots than the ST plots. At Bankura, a significant increase in the level of parasitic and predatory population was noted in the IPM plots, in particular the stem borer egg parasitism due to *Tetrastichus schoenobii.*

Over all, the IPM project generated good awareness among farmers and their knowledge level increased by 40-50% during the three years. The farmers are now fully aware of the advantages of pest monitoring, identification of natural enemies, use of hormone traps and need base use of insecticides. Further spread of the technology can lead to significant reduction in use of insecticide in rice based production system in the target districts covered.

In another project, proven technologies for integrated weed management(IWM) in upland rice were evaluated on farmers fields at 3 locations ie .Dhenkanal, Hazaribagh and Faizabad. In each target district, the major weed flora was also characterized. The major weed flora in Dhenkanal belong to the broad leaved species like *Cassia tora, Croton bonplandianum, Borreria hispida, Phyllanthus niruri, Phyllanthus simplex, Cleome viscose, Oldelandia corymbosa, Desmodium triflorum, Eclipta alba, Ludwigia parviflora, Aeschynomene indica, Lindernia ciliata, Lindernia crustacean, Corchorus olitorius* and *Scoparia dulcis* which comprise 45-60% of the total weed population. At Hazaribagh, the predominant weed flora were *Echinochloa colona*, *Cyperus rotundus, Cyperus cuspidatus*, *Cyperus iria* and *Fimbristylis miliaceae, Commelina benghalensis, Panicum repens* and *Setaria gluca* etc., while at

Table 9: Performance of different pest management modules on grain yield (t/ha) and economic returns from rainfed rice in different target districts (mean of three years)

Treatment	Target districts									
	Imphal		Warangal		Bankura		Cuttack		Titabar	
	Grain yield	C:B ratio	Grain yield	C:B ratio	Grain yield	C:B ratio	Grain yield	C:B ratio	Grain yield	C:B ratio
IPM	4.6	1:2	4.0	1:3.1	4.5	1:1.3	6.1	1:9.5	5.3	1:2.8
ST	4.2	1:1.6	4.0	1:2.2	4.7	1:0.8	5.8	1:5.1	4.7	1:2.4
FP	4.0	1:1.4	3.5	1:1.4	3.8	-	4.1	-	3.9	1:2.2

IPM : Integrated Pest Management; ST : Scheduled Treatment; FP : Farmer's Practice

Farmer fixing the pheromone lure in Cuttack district (left) and scientists explaining the concept of ETL to the participating farmer in Birbhum, West Bengal (right)

Faizabad sedges like *Cyperus rotundus* and *Fimbristylis dichotoma,* grasses like *Echinochloa colona, Echinochloa crusgulli,* and *Cynodon dactylon* and the broad leaved weeds like *Phyllanthus niruri* and *Eclipta alba* were the major weed species found.

Three weed management packages were tried in five villages in each target district, involving two farmers from each village. These include chemical weed control (CW) by pre-emergence application of butachlor @ 1.25-1.5 kg a.i./ha at 3-5 days after sowing (DAS) combined with one hand weeding (HW) at 40-45 DAS (T1); mechanical weed control (MW) by finger weeder at 20 -25 DAS supplemented with one hand weeding (T2) and two hand weedings at 20-25 and 40-45 DAS as a weed free check(T3) were compared with farmers' traditional practice of weeding at 50 – 60 DAS (T4).

In Dhenkanal district, yield improvement due to adoption of IWM practices like mechanical weeding with finger weeder combined with one hand weeding (MW+HW) was 68% and with chemical weed control combined with one hand weeding (CW + HW) was 49% over farmers practice. The grain yield in both these treatments was at par with weed free check but significantly higher than farmers practice. MW + HW was the most cost effective weed control option for rainfed upland rice (B:C ratio 1:2.21). Data on grain and straw yields, weed control efficiency and B:C ratios are presented in table 10. In Hazaribagh, the highest grain yield of 2.20 t/ha

Table 10: Performance of rice crop (var. Vandana) under different weed management techniques in Dhenkanal district (Based on 3 years pooled data)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Weed density (No./m^2)	Labour requirement for weeding (mandays/ha)	Cost of weed control (Rs/ha)	Benefit: Cost ratio
T_1	2.56	4.87	78.4	37	2290	1.55
T_2	2.89	5.45	58.3	35	1988	2.21
T_3	2.92	5.36	65.5	80	4000	1.38
T_4	1.72	3.36	148.7	-	-	-
CD(p=0.05)	0.46	0.35	9.0			

*See text for treatments

(var. *Vandana)* was recorded with chemical weed control by butachlor (@ 1.5 kg a.i./ha + one hand weeding at 40-45 DAS). It was 218% higher than unweeded check. The yield increase due to MW+HW 137% and 217% respectively over unweeded check. However, CW + HW was the most cost effective weed control option (B:C ratio 1.61) for rainfed upland rice in this district. In Faizabad, the highest grain yield of 2.73 t/ha (var. NDR 97) was recorded with two hand weedings which was 55% more than the unweeded check. The yield improvement due to IWM practice (CW+HW) was 46% over unweeded check. Here, bushening at 20 DAS + HW at 30-40 DAS was the most preferred treatment by the farmers.

Participatory varietal selection

Although large number of varieties of rainfed rice have been recommended for different land situations viz uplands, mid lands, low lands and deep water, their adoption by farmers is quite low. The performance of these varieties is not consistent under farmers situations. In view of this, the promising cultures and released varieties of rainfed rice have been evaluated extensively and varieties identified based on performance in OFTs and choice of farmers. For the first two years ie. 1990, 2000, the cultures were evaluated on research stations and promising ones were then tried on farmers fields during subsequent years ie. 2001-2004. OFTs were carried out in 9 target districts with 5 villages in each district and 5 farmers in each village. The cultures were tested under two management practices viz. improved practice which includes (i) line sowing behind the plough, (ii) use of weedicides and other intercultural operations (iii) use of recommended dose of fertilizer and timely application of pesticides and farmers' practice viz., (i) broadcasting or *biasi* method of sowing, (ii) use of no weedicides and no intercultural operations (iii) sub optimum and imbalanced use of fertilizers and no pesticides application.

In Chattisgarh, OFTs were conducted in 45 villages involving 115 farmers. *Danteswari* (3.7 t/ha) and IET 15969 (R 1037-649-1-1) (3.1 t/ha) out yielded the check *Poornima* (2.9 t/ha) in rainfed uplands, while IET 16697 (R 1057-1631-1) recorded higher yield (4.0 t/ha) over the check IR 36 in rainfed mid lands. In lowlands, IET 14070 (R 650-1817) with 5.8 t/ha out yielded the check *Pooja* (3.5 t/ha) at Raipur and Jagadalpur while *Bamleshwari* (6.7 t/ha) recorded maximum yield over *Swarna* (6.4 t/ha) at Raigarh. However, IET 13310 (R 304-34) has been proposed for release in Chhattisgarh state with the name '*Kaushalya*' owing to its resistance to gall midge and tolerance to BPH with an average yield of 5.0 t/ha across all the locations tested in Chhattisgarh.

In Orissa, OFTs were conducted in 35 villages involving 65 farmers. IET 14100 (ORS 1206-25-1) was released as "*Jagabandhu*" during 2002 in Orissa by State Varietal Release Committee for rain fed low lands due to its wide adaptability for shallow low lands and semi deepwater situations, tolerance to leaf folder, BLB and high yield (5.1 t/ha). This variety is likely to supplement *Savitri* and *Kanchan* for shallow low lands and can stand water depth upto 40 cm. It was well accepted by the farmers in both coastal and plateau regions of the state by virtue of its greater adaptability under both shallow and semi deep water situations. It can also withstand flash floods.

IET 15169 (ORS 1519-2) with 25 q/ha yield potential was proposed as ***Jogesh*** for release in the state. It matures within 100 days with short bold grains and translucent white kernel with greater head rice recovery, resistant to Gall midge 1 and moderately resistant to stem borer. By virtue of its high yield, tolerance to moisture stress and higher adaptability under upland situation it is well accepted by the farmers. IET 15296 (ORS 102-4, proposed for release as **Siddanth**) with 23 q/ha, of grain yield is a derivative from the cross

Performance of 'Jagabandhu' on rainfed lowlands in Orissa

Jajati / Annapurna. It matures in 103 days with short bold golden grains and translucent white kernel and greater head rice recovery. It is tolerant to brown plant hopper. By virtue of its high yield, intermediate stature, better grain quality, field tolerance to major insect pest and diseases under upland situation it is popular among the rain fed rice farmers of Orissa and release proposals have been submitted to SVRC, during 2003.

OFTs in Jharkhand were conducted in 17 villages on 50 farmers' fields and results revealed that *Ravi* (2.8 t/ha) and *Krishana Hasma* (2.5 t/ha) in uplands, *Triguna* and IR 64 (4.0 t/ha) in medium lands and *Swarna* (4.1 t/ha) and *Vibhava* (4.05 t/ha) in lowlands out yielded the check varieties. The rainfed upland trials conducted in 7 villages involving 18 farmers' in Medak, Adilabad and Ranga Reddy districts of AP revealed that *Tulasi* (2.2 t/ha) and OR 1519-2 (1.9 t/ha) were promising. Across locations improved management resulted in 17.2 % yield increase over farmers' practices in rainfed uplands and 12.8% in rainfed lowlands with a net benefit of Rs.1000/- to 1500/-.

Deep-water rice varieties

Deep water rice is grown on 3 m ha in the eastern states of Orissa, Bihar, Assam, West Bengal and Eastern U.P. Compared to other land situations, deep water ecosystem did not recievie adequate attention in past, in terms of varietal availability and management practices. In order to critically evaluate the performance of the available deep water rice varieties on farmer's situation and to promote the inter state flow of promising varieties, a network project was taken up in the states of Orissa, Assam, Bihar, UP and West Bengal, covering 40 districts and 498 farmers. During the first year, a survey was conducted in the target districts on the extent of deep water and semi deep water rice, most commonly grown varieties and the management practices adopted by the farmers. It was found that the farmers largely grow traditional varieties which are not recommended for deep-water conditions and only a very small percentage of farmers follow the recommended practices.

Based on the survey results, 21 deep water rice verities were taken up for evaluation in 40 target districts. These varieties include *Durga, Sarala, Bahadur, Padmanath, Phanindra, Ranjit, Kishori, KDML 105, Rajshree, Vaidehi, Bhudeb, Barh Avarodhi, Jal Lahari, Jalpriya, Jalshree, Golak, Hanseshwari, Jitendra, Sabita, Mahananda* and *Ambika*. These were pooled from different states for testing across the target districts for agronomic performance. During second year of the OFTs, varieties for rainfed semi deep water lands and rainfed shallow land were also included.

Based on the 3 years yield data and farmers' preference, the best varieties identified for different states are: **Orissa** - *Durga* and *Ambika* for deepwater ecology, *Sarala* for semi deepwater ecology and *Rajshree* and *Ranjit* for Rainfed shallow water ecology; **Assam** -KDML 105, Phanindra for deepwater ecology, *Bhudeb*, *Mahananda* for semi deepwater ecology and Rajshree, Bahadur and Ranjit for rainfed shallow water ecology; **Bihar** - *Ambika*, *Bhudeb*, *Rajshree* and *Mahananda* for deepwater ecology, *Vaidehi* and *Jalpriya* for semi deepwater ecology and *Rajshree* for Rainfed shallow

An excellent crop of Ambika on farmers field in Bihar

water ecology; **U.P.** - *Barh Avarodhi, Mahananda* for deepwater ecology, *Sarala* for semi deepwater ecology and *Rajshree* and *Jallahri* for rainfed shallow water ecology; **West Bengal** - *Ambika* and *Hanseshwari* for deepwater ecology, *Golak* for semi deepwater ecology and *Rajshree* for rainfed shallow water ecology. A list of best varieties for deep water, semi deep water and shallow low lands are given in table 11.

In the agonomic trial, local and improved varieties were evaluated under farmer's and improved management practices. Results across locations revealed that cultivation of local varieties with improved practice is the most beneficial while improved variety with improved practice gave highest biological productivity. Balanced fertilizer application viz. N40, P20 and K20 increased the yield and profitability at all centers over other combinations.

Varietal selection based on ORYZA-IN model

With an aim to optimize the crop performance under different micro farming situations of rainfed favourable low lands by matching the N application to a given variety considering its characteristics, ORYZA I N, a simulation model was used to identify varieties suitable for a given agroclimatic conditions and rates of N application. The model was calliberated with weather, crop and soil data for simulation of grain yield of rice at different locations during the first two years. Later, on-farm trials were carried out in 11 districts in West Bengal, Orissa, Assam, Bihar and Chhattisgarh to validate the model. There was a good match between the variety selected by the model and the results observed in the OFTS. The new approach consisting of the variety recommended by the model, N dose and timing of application contributed significantly to an yield gain of 33% over farmers practice across locations. Outputs from this model can be used for a new decision support system aimed at improved crop management for a given micro farming situation. This also requires a re-visit of some of the varieties released based on All India Coordinated trials.

Jute variety with quality textile fibre

Jute is an important fibre crop part of the rainfed rice based production system in eastern India. In a network project, the on going jute improvement work was strengthened by carrying out basic studies on the biochemical aspects of

Table 11 : Best deep water rice varieties preferred by farmers for different situations in five states

State	Deepwater	Semi deepwater	Rainfed Shallow
Orissa	Durga, Ambika	Sarala	Rajshree and Ranjit
Assam	KDML 105, Panindra	Bhudeb, Mahananda	Ranjit, Bahadur, Jalshree
Bihar	Ambika. Bhudeb, Rajshree and Mahananda	Vaidehi and Jalpriya	Rajshree
Uttar Pradesh	Barh Avarodhi, Mahananda	Sarala	Rajshree, Jal Lahari
West Bengal	Ambika, Hansheswari	Golak	Rajshree

fibre quality and on farm trials on performance of promising crosses in 6 target district of Assam, Bihar, Orissa and West Bengal with a view to identify high yielding varieties with quality fibre acceptable to farmers and trade. The overall aim is to improve the profitability and sustainability of the jute-rice cropping system.

During the 4 years, extensive crosses were made at CRIJAF and promising progeny in both *C.olitorious* and *C.capsularis* were advanced. The best five-germplasm lines in each of the species were identified (Table 12). In order to aid the genetic improvement programme, a tissue culture protocol for jute was standardized based on shoot tip culture. In view of the relationship between peroxidase enzyme and fibre quality, a rapid screening antibody mediated kit was developed to assay jute peroxidase at seedling stage. This technique enables quick screening of the germplasm for fibre quality early in the life cycle so that the promising ones can be considered for crossing.

Based of extensive on farm trials at Barrackpore, Nagaon and Kendrapara, S-19 of

S-19, an improved strain of *C.olitorius*, released as *Subala*

C.olitorius was found to be the best performer both for fibre yield and quality. This was released during 2004 at national level under the name

Table 12 : Best five germplasm accessions from *C.capsularis* and *C.olitorius* based on fibre yield and quality parameters.

Sample ID	Fibre Yield (g/pl)	Fibre Strength (g / tex)	Fibre Fineness (tex)	Cellulose (%)	Lignin (%)
		C. capsularis			
BZ-1-3	8.0	17.32	1.77	60.2	10.55
NPL/KUC/094C	8.8	13.33	1.60	77.20	15.40
Solimos	9.13	18.66	1.60	46.0	14.95
BZ-2-2	8.0	18.28	1.50	51.5	15.85
JRC-321	7.13	22.70	1.40	77.15	16.00
		C. olitorius			
JRO-524	10.59	23.24	2.2	56.90	17.95
KEN/DS/060C	11.00	11.40	1.8	80.03	16.15
KEN/DS/053C	10.20	22.44	2.5	60.65	20.16
NPL/YPY/026C	10.00	25.48	2.9	62.68	14.67
JRO-3670	9.00	19.88	2.1	60.22	15.81

Subala. S-19 recorded 10% higher fibre yield over the check(JRO525) with higher fibre tenacity (g/Tex) of 30.5 as against the check (29.1) and fibre fineness (Tex) of 2.9 as against 3.3 of the check. It has a zero root content with 0.03% defect.

The cropping system involving Subala and Naveen of rainfed rice was found to give the maximum returns to farmers (fig 3).

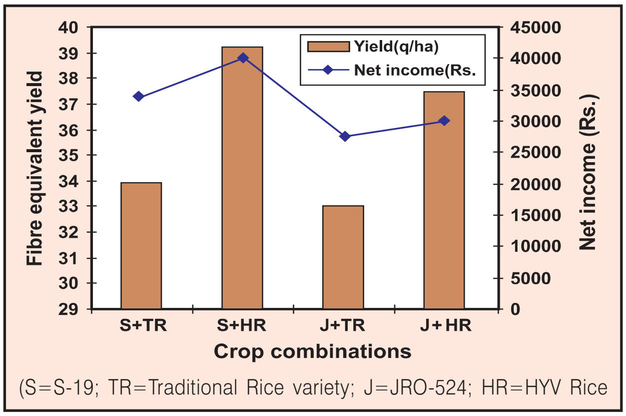


Fig.3: Production economics in jute-rice cropping system under rainfed conditions

Growth promotion of jute through RNMV

Rice Necrosis mosaic virus (RNMV) is known to promote growth of jute plants and fibre yield, though the mechanism is not known. Seed treatment with virus resulted in growth promotion including height and leaf area in on station trials at CRIJAF, Barrackpore. To understand the mechanism of this growth promotion and the related bio safety issues of using virus for seed treatment, a network project was taken up at CRIJAF with collaborating centres at CRRI, Cuttack, Jute research station, OUAT and RARS, Assam.

The virus particle was fully characterized and multilocational on farm trials were carried out on the impact of energizing jute seed with RNMV. Mass culturing of RNMV under controlled condition was successfully standardized. The virus was purified in active state and two protein bands *viz.* 68 kD and 20 kD were obtained in 15% SDS-PAGE suggesting the bipartite nature of the virus. Electron microscope study of purified virus confirmed that the virus is composed of two distinct flexuous particles of the size 275 x 13 x 14 nm and 550 x 13 x 14 nm. RNMV treated jute (*C. olitorius*, cv. JRO-524) plants grew faster without any necrotic symptoms. The RNMV energized jute (JRO 524E) plants were grown in replicated plots along with control at CRIJAF experimental farm. The energized plants grew faster and recorded significant increase in fiber yield. The growth promotion properties were inherited to the next generation via seeds.

On-farm trials were conducted with energized jute seed (JRO 524E) on farmers' fields in Nowgaon, Kendrapara and Salehpur. Two years pooled data showed higher growth and yield with energized seed with reduction in incidence of pests and diseases. The fibre yield increase was 15% at Nawgaon, Assam, 11% at Kendrapara and 29% at Salepur with half of the recommended dose of fertilizer ($N_{20}P_{10}K_{10}$) over the non energized seeds. The RNMV-technology was acceptable to farmers due to its higher C:B ratio over farmers practice. The C:B ratio were 1.92 and 1.6 with treated seeds as against 1.6 and 1.44 with untreated at Nowgaon and Kendrapara respectively. Overall, this technology has potential to increase the fiber yield from the existing level of 20 q/ha to 29q/ha. As there was no evidence of transfer of RNMV from jute to rice crop in jute-rice cropping system and no other detrimental effect on succeeding rice crop, this technology can be adopted in the jute-rice production system.

Diversification in upland rice areas: Agri-horticulture

Large areas under rainfed upland rice in the eastern highlands of Orissa are unable to support the livelihood of the farmers in view of the low and unstable productivity. Based on on station research, several options of crop diversification have been suggested in these areas. However, their adoption has been quite low. To assess the feasibility and profitability of alternative options of land use in the rainfed uplands, a number of agri horticulture systems were introduced and evaluated in Orissa, MP, Chhattisgarh and Jharkand covering five target districts (Koraput, Jabalpur, Ambikapur, Ranchi, and Daltonganj). Intercrops like cowpea, french bean, tomato, ragi, ginger, blackgram, turmeric etc. were introduced in mango and litchi orchards of different ages and compared with sole upland rice and paddy intercropped with in the orchards.

Based on four years data on yield and economics, the best agri horticultural systems were identified for each of the target districts. In Koraput, mango+guava+turmeric gave the highest rice equivalent yield but the B:C ratio was higher with mango+guava+cowpea due to the high cost of cultivation for turmeric (Table 13). Similarly, in Palamau district in Jharkhand mango+guava+arhar recorded the highest net returns (Rs.28,445/-) and B:C ratio (3.07). Mango+pomegranate+ginger in Jabalpur, Mango+papaya+cowpea in Sarguja and mango+guava+frenchbean in Ranchi district were the most profitable systems, recording B:C ratios of 3.33, 1.7 and 2.05 respectively.

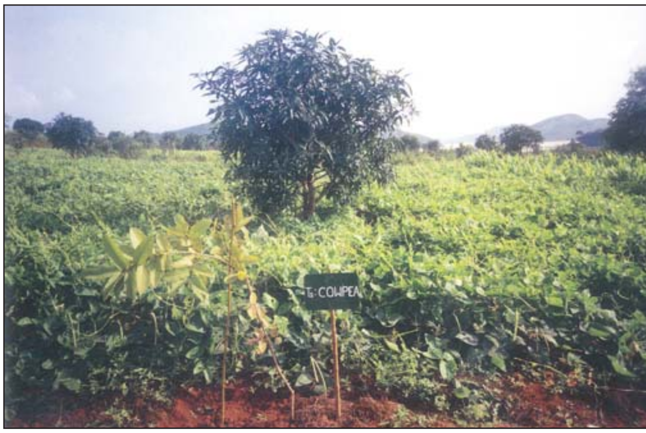
Gopalput village in Koraput district of Orissa presents a good example for the success of this project. All the participating farmers are now earning enough to support a decent livelihood and stopped migration to towns for work. This village became a radiant centre for other developmental agencies. DRDA, Koraput and district watershed mission have upscaled their activities in the district. The district administration, Koraput is replicating this model in other watersheds for land use diversification.

In a related project, nursery management and improved cultivation practices for rainfed vegetable crops were evaluated on farmers fields in 5 districts i.e. Bhubaneswar, Ranchi, Dumka, Jabalpur and Raipur. Low cost locally available materials were tried for creating shade, mulching and weed management. Most acceptable technology however was mulching with paddy straw in turmeric both for weed control and moisture conservation.

Table 13 : Yields and net returns of different vegetable and fruit based agri-horticultural systems in target districts as compared to paddy based Agri-horti system. (Based on mean of three years)

Center	Target district	No.of farmers	Best Agri-Horti system identified	Farmers practice	Rice yield equivalent		Net returns		BC ratio	
					IP	FP	IP	FP	IP	FP
OUAT	Koraput	25	Mango+guava+Cowpea	Mango +	41.43	20.12	36290	8270	1.66	1.48
			Mango+guava+Frenchbean	upland	40.24		34420		1.64	
			Mango+guava+Turmeric	rice	88.00		36290		1.40	
BAU	Palmau	15	Mango+guava+Blackgram	Mango +	115.0	5.86	37773	14358	2.49	2.32
			Mango+guava+Arhar	paddy	36.2		28444		8.07	
JNKVV	Katni, Jabalpur	26	Mango+pomegranate+ginger	Mango +	139.19	30.0	34603	4854	3.33	1.35
			Mango+guava+Ginger	Paddy	39.84		40510		1.83	
IGKVV	Sarguja	8	Mango+papaya+cowpea	Mango +	17.56	8.19	34605	-775	1.70	0.64
			Mango+papaya+ginger	Paddy	146.69		40510		1.55	
HARP	Ranchi	15	Mango+Guava+French bean	Mango +	13.84	1.13	32257	1356	2.05	0.47
			Mango+guava+turmeric	Paddy	60.99		42933		2.03	

IP-Improved practice; FP-Farmer's practice



Mango+guava cowpea (left) and mango+ginger (right) as profitable options of crop diversification in upland areas of Koraput district in Orissa

Use of neem cake and intercropping African marigold with tomato (16:1) were also found promising IPM practices which resulted in higher marketable yields in tomato.

Rice based agroforestry system

Annual crops or multi purpose trees can be grown on rice field bunds to produce additional income with marginal investment on seed. Such rice based agroforestry systems are quite common in eastern India. A network project was taken up in 6 target districts of Dhenkanal, Nayagarh, Raipur, Mahasamund, Basti and Barabanki to further improve this indigenous system by optimizing planting geometry and spacing. Based on 2 years data, it was found that blackgram and pigeonpea grown on field bunds in double rows produced 8.75 and 12.12 kg of seed respectively per 100 m bund length in Nayagarh district translating to Rs.590/- and Rs.655/ha of additional income. *Acacia mangium,* a fast growing tree legume @ 80-100 trees/ha was found most promising in Nayagarh and Dhenkanal districts. The tree produced a biomass of 2 – 3 kg/tree after one year from pruning. Similarly, *Gmelina arborea* and *Delbergia sissoo* were promising tree species found for field bund plantation in Raipur and Faizabad districts, respectively.

Medicinal plant biodiversity

Tribal areas are rich in medicinal plant diversity. A comprehensive survey of 40 districts inhabited by tribals in M.P and Chhattisgarh were carried out for 2 years for documenting medicinal plant biodiversity. Nearly 400 plant species were collected from Bastar, Balaghat, Shahdol, Bilaspur, Durg, Mahasamund, Kanker, Korba, Rajnandgaon, Sarguja, Ambikapur, Raigarh, Sidhi and Seoni, Khandwa, Tikamgarh, Dindori, Morena, Ratlam, Hoshangabad, Mandala, Jhabua, Dhar, Khargaon, Betul, Chindwara districts of Chattisgarh and M.P. and herbaria were prepared and preserved at JNKV, Indore. The traditional use of these plants and their useful parts were described based on extensive discussions with the local tribes. After careful taxonomic assessment, a publication containing the description of each of the collected species, useful part and the location of collection was brought out. Five training programmes were conducted for the tribals on *in situ* conservation of the rare and endangered species. The live collections are being maintained at JNKVV, Indore.

Improved productivity form *utera* cropping

Utera cropping is a relay intercropping of hardy pulses crops like lathyrus with *kharif* rice followed by most small and marginal farmers in eastern India. In Chhattisgarh alone, *utera* cultivation is practiced on 20% of the 36 lakh ha. rice area. The main constraints in improving the productivity of this system are the poor plant stand of the *utera* crop and sub optimal nutrient use. Through a network project in 13 districts (Dindori, Seoni, Balaghat in M.P.; Rajnandgaon and Mahasamund in Chhattisgarh; Burdwan and Midnapore in West Bengal; Khurda in Orissa; Kamrup, Naogaon, Morigaon in Assam and Dumka and Godda in Jharkhand) the yields and net returns from the best *utera* crop along with *kharif* rice were studied both under farmers and improved practice.

Based on 4 years on station and on farm trials, the best *utera* cropping system for each of the target district and suitable agro technologies were identified. In Burdwan and Midnapore (West Bengal); Seoni, (MP); Naogaon and Morigaon (Assam); Dumka and Godda (Jharkhand) districts, linseed was found to be the best utera crop in terms of productivity and economic returns. Fieldpea and blackgram were most promising in Dindori (MP) and Khurda(Orissa) districts, respectively, while Lathyrus was most profitable in Mahasamund and Rajnandgaon (Chhattisgarh) and Kamrup district in Assam. The mean yield of the entire cropping sytem and net returns both under farmers and improved practice are given in table 14.

Table 14 : Grain yield and net profit of rice based *utera*-cropping systems under farmer's and improved practice (Mean of 2 years based on 10 farmers in each district)

Treatment	Rice yield (q/ha)	Utera yield (q/ha)	Net profit (Rs.)	B:C ratio	Rice yield (q/ha)	Utera yield (q/ha)	Net profit (Rs.)	B:C ratio
	Dindori (Field pea)				Seoni (Linseed)			
FP	17.52	5.71	2700	1.23	16.50	4.75	3375	1.28
IP	43.65	10.13	17150	2.01	45.84	6.86	18210	2.21
	Mahasamund (Lathyrus)				Rajnandgaon (Lathyrus)			
FP	37.59	3.71	5253	1.37	35.52	3.91	7951	1.54
IP	34.85	5.54	9575	1.57	44.71	5.55	13700	1.83
	Burdwan (Lathyrus)				Midnapore (Lathyrus)			
FP	38.63	4.76	9987	1.68	30.29	6.78	9281	1.66
IP	48.08	9.38	20485	2.26	47.99	11.98	23347	2.55
	Khurda (Black gram)				Kamrup (Lathyrus)			
FP	29.33	3.15	5967	1.39	34.87	4.10	6350	1.42
IP	41.15	6.42	16927	2.06	47.01	5.10	13085	1.82
	Naogaon (Lathyrus)				Dumka (Lathyrus)			
FP	28.63	4.01	4236	1.28	15.96	3.52	5239	1.25
IP	45.60	6.13	14470	1.88	34.29	5.21	11354	1.56
	Godda (Linseed)							
FP	14.89	1.02	2926	1.07				
IP	33.46	2.98	9390	1.49				

FP-Farmers practice (local rice variety with farmers method of planting and management of utera crop); IP-Improved practice (HYV of rice with recommended NPK + recommended P of utera crop, optimum planting time of utera with 10kg N/ha and harvesting of rice at 20cm stubble height)


Performance of lathyrus as an *utera* crop under farmers practice (left) and improved practice (right) in Mahasamund district, Chhattisgarh

Seeding *utera* crop at two weeks after flowering of preceding rice was found to be the optimum time in all the districts. Application of recommended dose of fertilizers to rice in addition to recommended P (20kg P_2O_5/ha) of *utera* crop and 10 kg N/ha to *utera* crop at the time of sowing was most efficient nutrient management practice in different rice based *utera* cropping systems across locations. Harvesting of rice at 20cm stubble height resulted in best establishment of the *utera* crop and higher yields of the system as a whole.

Among the rice varieties evaluated, early maturing varieties like IR-36 and IR-64 (120 days) were most suitable in Dindori and Dumka districts while medium duration varieties like Mahamaya (125-130 days) was ideal in Mahasamund, Rajanandgaon, Seoni and Balaghat. Late maturing varieties (above 130 days) like *Swarna* in Burdwan and Midnapur districts, Puja in Khurda district and Ranjit in Naogaon, Morigaon and Kamrup districts were found to be best suited for getting highest returns from *utera* system.

The OFTs during first two years and large scale demonstrations during 2003-04 revealed that the improved *utera* cropping system resulted in two times higher grain yield of rice and the *utera* crop over farmer's practice. Though improved practices required more investment, the profitability was 7 to 45 per cent higher which justifies higher investments. Impact analysis in the target villages in the final year indicated 50% increased awareness among the farmers surveyed on the availability of better *utera* crops than currently grown. Majority farmers showed their preference for substituting the low value *utera* crops with high value one like linseed in Seoni, Burdwan and Midnapore districts and blackgram or linseed in Khurda. However farmers did not accept the recommendation of sowing *utera* crops two weeks after flowering of rice and leaving 20 cm stubble height. They rather preferred to sow the *utera* crop on the basis of cessation of rainfall.

Improved *biasi* system

Biasi is a traditional method of rice cultivation common in eastern and central India where farmers broadcast paddy seed and incorporate excess plant population through a process of thinning carried out by a country plough. It is followed mostly in medium and low lands covering more than 5 m ha in Chhattisgarh, Orissa, Jharkhand and Eastern MP. In order to enhance the productivity in such areas, a series of improvements were made in the traditional system through reduced seed rate, balanced nutrition and use of improved implements like *trifal* for *biasi* operation and spiral ploughing.

However, this improved technology has not been adopted by the farmers widely. In order to critically assess advantages and limitations of the system, participatory on farm trials were carried out for three years (2000 to 2003) involving 130 farmers in 34 villages of 10 target districts in five states.

Based on three years results across the target districts, the improved *biasi* system in rainfed low lands increased the rice yield from 3 t/ha to 5 t/ha. In low lands, the improved system consisted of summer ploughing + recommended variety (different for each state). + INM with early dry seeding with basal fertilizer + biasi ploughing with *trifal*. The center wise promising varieties identified for biasi cultivation for low lands are *Mahamaya* for Mahasamund and Ambikapur; *Mahanadi* and *Ramchandi* at Bhawanipatna; *Mahamaya* and *Swarna* at Jagdalpur; *Kanchan* and *Mahanadi* at Keonjhar; CR1017 and CR 1018 at Jhargram; *Mahamaya* at Darisai. For medium lands IR 36 and MTU 1010 at Mahasamund; IR 36 at Ambikapur; *Kharbela* and *Moti* at Bhawanipatna; IR 6436 at Jagdalpur; *Tapaswi* and *Konark* at Keonjhar; MTU 7029 at Jhargram; and *Bamleswari* at Darisai. Varietal replacement as a component of the improved biasi produced higher yields but farmers faced marketing problem. For example in Chhattisgarh, *Mahamaya* and *Bamleswari* produced higher yield in improved system than *Swarna* but farmers are unwilling to shift to bold grain type. They prefer dwarf high yielding fine varieties to replace *Swarna*. Therefore, the availability of such varieties are key to popularization of the improved *biasi* system.

Biasi operation using *Trifal* on farmers fields in Mahasamund district

Among different bullock drawn implements evaluated for carrying out *biasi* operation under broadcast seeding conditions, *tifal* developed by IGKV, Raipur, gave the best performance followed by wedge plough developed by CIAE, Bhopal and BAU, Ranchi at all the centers. *Tifal* recorded 29% more yield over the farmers indigenous plough. The energy requirement was also significantly lower with *tifal.* The overall economics of traditional and improved biasi method of rice cultivation is give in table 15. Both on the cost of cultivation and productivity, the improved practice showed clear superiority.

Improved tillage and farm implements

Mechanization plays an important role in rice based production system facilitating optimum tillage and timely seedbed preparation/ transplanting. Tillage in particular is of critical importance in realizing maximum productivity in rainfed rice under different land situations. The available water capacity (AWC) is low in red and lateratic soils of eastern India. Rainfed rice in such soils is subjected to frequent dry spells. Though it is reported that the AWC could be increased by deep tillage, addition of organic matter or soil compaction, the benefits and the feasibility of wider option of such technologies under farmers conditions are not known. In a network project taken up in 8 target districts (Bhubaneswar, G.Udaigiri, Faizabad, Anakapalle, Darisai, Titabar, Gayeshpur and Jagdalpur) tillage related soil constraints were identified and different tillage and INM practices were tried to over come soil constraints and weed control. The project also tested different puddlers for low land rice were also tested.

Table 15 : Economics of rice cultivation under traditional and improved *Biasi* systems (Based on 2 years data with 50 farmers)

Input	Human h/ha	Animal pair h/ha	Material kg	Total cost Rs/ha	Human h/ha	Animal pair h/ha	Material kg	Total cost Rs/ha
	Traditional Practice (FP)				Improved Practice (IP)			
Seedbed preparation	51	51	0.1 kg wood	1327	45	45	0.05 wood/steel	1172.0
Seed	—	—	130 kg	780	—	—	100 kg	900.0
Basal fertilizer (I)	—	—	—	—	—	—	18 N 46 P 30 K	180.0 920.0 450.0
Seed/ fertilizer application	24	20	0.1kg wood	553	10	10	0.2 kg steel	267.0
Biasi operation	25	25	0.1kg wood	651	10	10	0.05kg steel	262.0
Chalai	360	-	—	2880	80	—	—	640.0
Fertilizer (II)	—	—	18 kg N 46 kg P (DAP)	180.0 920.0	—	—	25 kg N	250.0
Fertilizer (III)	—	—	46 kg N (Urea)	460.0	—	—	22 kg N	220.0
Weedicide	—	—	3kg	1200.0	—	—	3 kg	1200.0
Harvesting & threshing	100	40	0.2	1520.0	100	40	0,2	1520.0
Total	560	136	—	10,471	245	105	—	7,981
Resource Cost (Rs/ha)	4480.0	2448.0			1960.0	1890.0		
Output Analysis								
Productivity, t/ha				3.0				5.0
Production cost(Rs/kg)				3.5				1.60

Note: Rates considered: Human labour= @ 8 Rs/h, Animal pair= @ 18 Rs/h, Implement, wooden=@ 10 Rs/kg Iron = @ 35 Rs/kg, Weedicide =@ 400 Rs/kg, Seed (Farmer)= @ 6 Rs/kg, Seed (market) =@ 9 Rs/kg, fertilizer, N = @10 Rs/kg, P = @20 Rs/kg, K = @15 Rs/kg. Farmer's land and supervision charges not included.

From the diagnostics surveys, low AWC, low organic matter in uplands and poor drainage in low lands were found as the major soil related constraints in the target districts. Data from OFTs on assessing optimum tillage for rainfed upland rice indicated that improved tillage using disc harrow as secondary tillage practice significantly increased the grain and straw yields as compared to conventional tillage with wooden country plough. Addition of FYM prior to conventional or improved tillage practice not only increased the rice yields but also reduced the energy requirement during ploughing. One summer ploughing followed by two pre-sowing ploughings by disc or mould board plough along with application of weedcide @ 1 kg a.i. ha^{-1} significantly decreased the weed growth and increased the grain and straw yields as compared to conventional tillage (Table 16).

In case of rainfed transplanted rice, two improved tillage practices were compared with the conventional tillage in all districts. Twice puddling either by power operated rotavator/cage wheel or by locally developed bullock drawn puddler significantly increased puddling index as well as grain and straw yields as compared to puddling by bullock drawn wooden plough (conventional method). The grain and straw yields of rice were more with power operated rotavator/cage wheel

Table 16 : Influence of tillage methods on grain yield (q ha^{-1}) of upland rice at different locations (mean of three years ie. 2001-03)					
Tillage treatments	Bhubaneswar	Anakapalle	Gayeshpur	Darisai	Jagdalpur
T_1	35.32	24.20	14.99	27.20	30.74
T_2	37.13	30.60	15.97	32.90	34.32
T_3	38.98	25.60	16.38	32.90	35.86
T_4	40.91	31.80	17.68	36.50	37.77
CD(0.05)	1.94	1.10	2.93	3.98	4.86

T_1–One summer ploughing (SP)+twice presowing ploughings (PSP) by country plough(Farmer's Practice) T_2–One SP + twice PSP by MB plough; T_3 –T_1 + FYM @ 5 t ha^{-1}; T_4 –T_2 + FYM @ 5 t ha^{-1}

than with bullock drawn puddler. The energy requirement during puddling was the minimum in case of power operated rotavator/cage wheel, intermediate in case of bullock-drawn locally developed puddler and maximum in case of bullock drawn country plough.

Among different bullock drawn puddlers evaluated, puddler-99 was found to be most suitable for increasing the puddling index, low energy requirement during puddling and for significantly increasing the grain and straw yields of rainfed transplanted low land rice. The benefit cost ratio for rice cultivation was maximum with puddling by puddler 99.

The cost benefit analysis of improved tillage vs. farmers practice was worked out at all the locations during 2004-05. In case of low land rice, puddling by cage wheel, rotavator or locally developed improved puddlers was considered as improved method and compared with farmers practice of puddling with country plough (Table 17). The improved method resulted in low energy and water requirement for the crop and higher yields and B:C ratio.

Another network project evaluated and refined a large number of prototype farm implements for dry and wet tillage, seeding, transplanting, fertilizer application and inter culture in rainfed rice based production system. Based on 3 years OFTs and development activities, the following conclusions could be drawn.

- Tractor drawn rotavator was found to be more efficient and economical as compared to bullock drawn desi plough and MB plough.

Table 17 : Economic analysis of improved vs. farmers method of tillage on yield and economic benefit from low land rice on farmers fields at 6 locations (mean of 2 years)					
Location	Farmers method		Improved method		% increase
	Grain yield (q ha^{-1})	B:C ratio	Grain yield (q ha^{-1})	B:C ratio	in yield
Bhubaneshwar	35.0	1.46	40.8	1.71	16.57
G. Udayagiri	34.2	1.65	40.1	2.01	17.25
Anakapalle	32.6	1.54	36.5	1.77	11.96
Gayeshpur	32.2	1.68	36.8	2.05	14.29
Darisai	41.4	2.27	49.3	2.57	19.08
Jagdalpur	33.0	1.50	39.1	1.83	18.49
Titaber	44.4	1.86	51.3	2.19	15.54
Faizabad	36.1	2.50	39.5	2.75	9.42

The field capacity of rotavator were 0.3 to 0.4 ha/h as compared to bullock drawn plough of 0.05 ha/h.

- The yield of crop by tractor rotavator tilling was about 10 to 14 % higher than other tillage practices.
- Highest yield was obtained with tractor drawn seed drill as compared to bullock drawn seed drill and broadcasting. The Indira seed drill became popular among farmer's of Chhatisgarh due to low cost of operation
- The tractor drawn zero till drill was found to be economical for direct sowing in low lands under rainfed conditions. The field capacity was about 0.65 ha/h.
- The cost of transplanting by self-propelled rice transplanter was less (40 to 50 %) compared to random and line transplanting of rice by rope and guide. The field capacity was 0.15 ha/hr.
- The cono weeder and peg type weeder were found more economical and effective over manual hand weeding.
- One hundred sixteen manufacturers were trained at CIAE, Bhopal on commercial production and 8 tailor made programmes were organized for artisans during the three years period.

Post harvest technology

Extensive losses occur during storage, drying and milling of rice in eastern India due to climatic factors like high rainfall/humidity and traditional methods of drying and storage. Losses upto 15-20 percent are common during storage and milling. In order to minimize these post harvest losses, simple low cost and location specific improved practices were tried in farmers households through participatory research in 9 target districts in Orissa, Assam, Manipur, Jharkhand and Chhattisgarh covering 200 farmers in 13 villages. The improved practices were drying on black polythene mat, wire mesh rack; storage in RCC ring bin; improved bamboo bin and rat proof wooden bin and milling by using rubber sheller with emery cone/ jet polisher. At all locations drying on black polythene mat was found to be superior followed by wire mesh and farmers practice. However, considering the durability, wire mesh rack was cost effective to the farmers.

RCC ring bin of 5-6 quintals capacity was found quite safe for storage of paddy at 12-14% moisture content for six months period with less than 5% infestation at Cuttack and Keonjhar. The performance RCC ring bin at Jorhat was superior over the traditional practice for storage of paddy up to 6 months with 5% lower infestation. Tribal farmers of Orissa and Assam considered this type of bin as elephant proof for its firm construction like a mini silo. Similarly metal bin at all locations, improved bamboo bin (polythene lined and mud plastered) at Raipur and rat proof wooden-bin at Imphal were found safe to store paddy for six months both for consumption and seed purpose. Insect infestation in the stored grain was in the safe range of 3-6% and germination in the range 77-90% at most locations as compared to high infestation (up to 15%) and low germination (32%) with traditional storage. The improved bins are completely rat proof. Therefore, 6-8% of the stored grain could be saved which otherwise is lost due to rat damage in traditional storage devices like gunny bags, bamboo bins etc. Thus by adopting improved technology, farmers could prevent losses to the tune of 10-15%. For rice milling, the advantage of rubber sheller and emery cone/jet polisher over the traditional huller milling was evident in all districts. It was possible to produce about 10% extra milled rice and 12% extra head rice while milling raw paddy in improved mills as compared to huller mill. In case of parboiled paddy, 4-5% extra head rice was produced compared to huller milling.

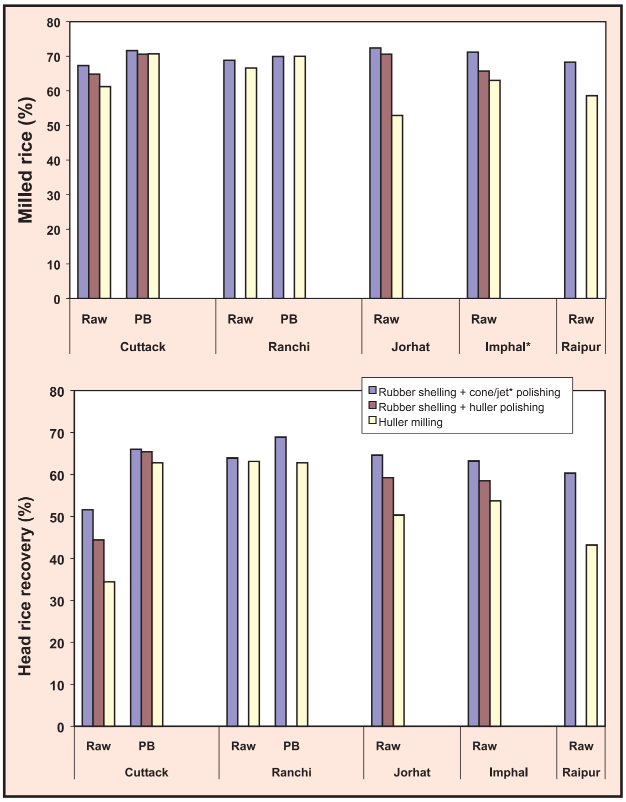


Fig 4: Effect of milling methods on average milled and head rice recovery for raw and parboiled (PB) rice

Thus, by adopting improved practices of drying, storage and milling, 15-20% extra rice was available to the farmer indirectly due to prevention of losses at different stages.

Rice-fish-duck farming system

In the tribal areas of Jharkhand, West Bengal and Chhattisgarh the yields of rainfed rice are low due to low input use. Since the holdings are small, tribals are unable to eke out livelihood from cropping alone. Therefore, two paddy based farming system models, rice-fish-duck and rice-fish-pig were evaluated in Chhattisgarh, Jharkhand and West Bengal. The main approach followed was to integrate all three components in such a way that the outputs from one component are used as inputs to another. Pig manure is added to the rice crop and paddy husk is fed to the pigs. Pond soil and water are enriched with droppings of ducks and addition of pig manure. This approach can be followed in naturally occurring small ponds and also water storage structures created as a part of watershed development.

Participatory on farm research was conducted involving 155 farmers @ 69 farmers in Jharkhand (Ranchi, Dumka, Chaibasa and Jamtara), 69 farmers in West Bengal(Purulia, Midnapur and Bankura) and 17 farmers from Chattisgarh(Raipur, Durg, Mahasamand). The rice-fish-duck system was tested with 85 farmers and rice-fish-pig was tested with 68. In representative villages and blocks, individual

Integrated rice-fish-duck/pig farming system in Jharkhand and West Bengal farmers with small ponds ranging from 0.03 to 0.6 ha. and paddy area of 0.04 to 0.16 ha were selected and the integrated package was introduced. In case of ducks, two varieties ie.*Desi* and *Khaki Campbell* and in case of pigs T&D and upgraded black pig varieties were tried. The parameters studied were survival, overall productivity, manure production and returns to the farmers. Four fish species ie. Catla, Rohu, Grass carp, Mrigal and Common carp were seeded into the ponds @ of 10,000-25000 per ha. The rice crop was irrigated with pond water rich in duck manure besides fertilizing with pig manure. The dropping from the ducks in the pond enriched the pond water with nutrients. The rice bran was used as a feed for the pigs/ducks. With this integration, the economics of the system was worked out involving 155 farmers in 3 states.

Based on 4 years evaluation of the two systems ie. rice-fish-duck and rice-fish-pig, it was evident that the farmers income can be increased by more than 200 % particularly in the states of Jharkhand and West Bengal. The production of fish, reached upto 1245-2400 kg/ha/yr, with this integrated system from an average productivity of 350-500 kg/ha/yr in Jharkhand. The productivity of paddy fish, ducks/pigs and the net returns based on the data over three years period are presented in table 18. The egg production from the ducks ranged between 80-120 eggs/yr. The local ducks were found to survive better than the K*haki Campbell* under farmers conditions. Stall feeding of pigs was not profitable and hence farmers were advised the feed pigs on agricultural waste which was well accepted. The integrated system gave an additional income of Rs.10,000 per year to the participating farmer. Overall the returns on rupee invested were Rs.4 in fish cum pig system and Rs.5 fish cum duck system.

There was a significant change in the proportion of the farmers income realized from

Table 18: Yields and income from different components of the rice-fish-duck and rice-fish-pig farming system for the participating farmers in Jharkhand and West Bengal (Mean of three years ie. 2001-02 to 2003-04)

State	No.of farmers	Avg. area under paddy per farmer (ha)	Avg. Paddy yield (t/ha)	Avg. Pond area per farmer (ha)	Avg. Fish yield per farmer (t/ha)	Avg. no.of ducks/ pig per farmer	Income from paddy per farmer (Rs.)	Income from fish per farmer (Rs.)	Income from ducks per farmer (Rs.)	Total income per farmer (Rs.)	Expendi-ture per farmer (Rs.)	Net income (Rs./ farmer)	C:B ratio
A. Rice-fish-duck farming system													
Jharkhand	10	0.36	4.2	0.105	0.761	25	5711	2831	2841	11317	3123	8193	1.38
West Bengal	9	0.85	4.7	0.038	1.15	15	15914	1685	2686	19642	6932	12710	1.54
Chattisgarh	7	0.60	5.0	0.611	1.9	165	11570	35587	1839	44329	18509	25821	1.71
B. Rice-fish-pig farming system													
Jharkhand	12	0.36	4.5	0.147	0.88	7	5141	2949	10798	20992	5684	15309	1.37
West Bengal	9	0.32	4.7	0.037	1.4	3	5747	2240	6065	20208	7241	12967	1.55
Chattisgarh							No trial						

different occupations following the introduction of this system. More income was derived from ducks and pigs after the project. A break up the additional income from different sources indicated that income from pigs was maximum followed by fish and duck eggs. In these areas, farmers usually integrate only rice and fish. With the integration of animal component, the contribution of agriculture, animal husbandry and fisheries, to the farmers' income changed from 58%, 28% and 14% before the project to 39%, 55% and 6% after the project.

However, several constraints were observed in upscaling the system. For example, the availability of *Khaki Campbell* ducklings is a major constraint. The number of hatcheries have to be increased by several folds. Mass mortality of ducks was found due to the pesticides used for paddy. The pigs during the crop season damage the paddy crop. Wash out of insecticide from agricultural fields also causes mortality of fish. In Chattisgarh, most of the ponds are very big and used by the community for irrigation and other domestic uses. Individual ponds are very few. Hence, farmers here did not accept the rice-fish-pig system whereas rice-fish-duck system can be popularized in the selected areas. Rice-fish-pig sytem has maximum potential in West Bengal, where as in Jharkahnd both the systems can be upscaled. Already, the ATMA project in Dumka and Jamtara have adopted the rice-fish-pig system successfully. So far, more than 500 farmers have been trained.

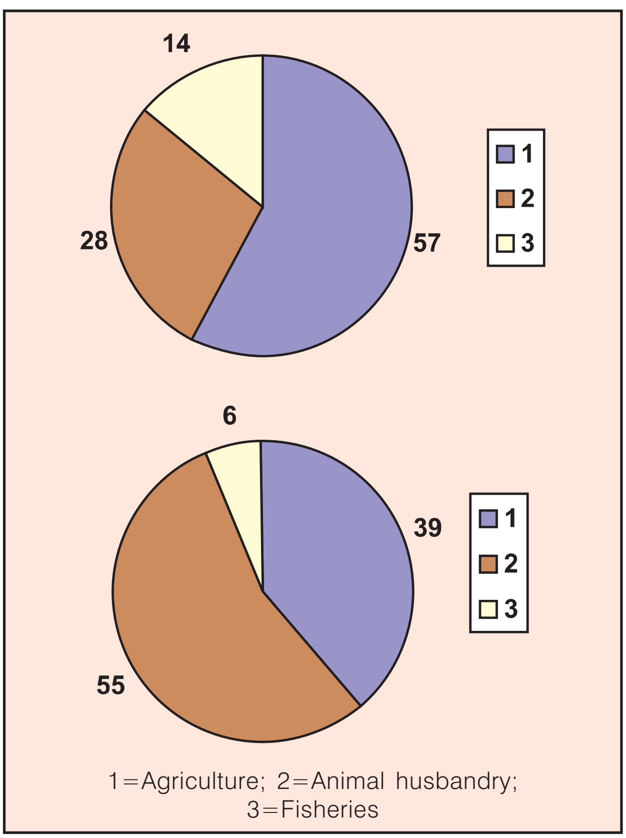


Fig 5: Percentage contribution of different components in annual income before (top) and after (bottom) the project

Livestock production and health

Cattle, buffaloes, small ruminants and poultry provide significant part of the income for small and marginal farmers in the rainfed rice based production system. A project on feed and fodder resources for livestock in Chhattisgarh and Jharkhand explored non conventional crop residues and tree leaves. A total of 116 feed and fodder samples collected from all the districts of Chhattisgarh were analysed for the chemical composition. Based on the efficiency, suitable combinations of feeds were formulated for stall fed cattle, pigs and poultry. At BAU, Ranchi, anti-nutritional factors like tannins and oxalates in fallen tree leaves like *sal* were neutralised by treating with urea. Four per cent urea treatment and incubating the leaves for 3 weeks enabled removal of tannins to non toxic levels. Goats fed with urea treated leaves showed significantly higher drymatter intake and body weight gain than the untreated leaves.

In a related project, extensive survey on prevalence of gastro-intestinal parasites like nematodes and trematodes and blood protozoans was carried out in Ranchi, Dumka, West Singhbhum and Palamau districts of Jharkhand; Durg, Raipur, Bastar, Rajnandgaon districts of Chhattisgarh and Kalahandi, Phulbani, Dhenkanal districts of Orissa. The survey covered 2377 stall fed and 6738 grazing cattle and buffaloes and 2659 sheep and goats of 3968 farmers in 66 selected villages of three states. The overall prevalence rates of helminths were 43.45% in stall-fed and 54.99% in grazing cattle and buffaloes and 52.31% in goats. A lower prevalence rate of blood protozoan infections was observed in stall fed (0.58 to 1.07%) than the grazing animals (2.09 to 3.48%).

From field level animal trials, oxyclozanide and triclabendazole against trematodes, fenbendazole and albendazole against nematodes were found to be effective anthelmintics. Quinopyramine, buparvaquone and diminazine were found efficacious against blood protozoans. Ivermectin, deltamethrin and flumethrin could control ectoparasitic infestation. Package of practices advised for control of helminthic diseases include (i) mass administration of effective anthelmintics at 3-6 months interval (ii) prompt disposal of dung from sheds/fields to compost pits and (iii) prohibition/restricted grazing of livestock in water logged areas infested by snails. 47,422 heads of livestock own by 7643 farmers from 44 villages in 3 districts of Orissa, 28 villages each from 4 districts of Chattisgarh and Jharkhand were covered under the programme. Adoption of package of practices significantly brought down the prevalence rate of helminthic infection both in stall-fed and grazing animals of sample villages. An increase of 10.20 to 15.95% and 5.58 to 11.66% in milk production was recorded in stall-fed and grazing cattle respectively. The average benefit towards cost of increased mild yield was about Rs.7.00 per day per cow (cross-bred) in stall-fed and Rs.3.00 per day per cow (Indigenous) in case of the grazing milch cows. The projected profit to farmers was Rs.2,100 per 300 days lactaion in case of stall-fed cows and Rs.630 in case of grazing cows in 210 days lactation.

Improving rainfed rice productivity : Policy options

Two projects have looked at the resource related and socio-economic constraints limiting rainfed rice productivity in eastern India. The bio-physical and socio-economic parameters of selected districts with high area and low or stagnant productivity were analysed and related with the production and productivity trends during the last 20 years. The key suggestions emerged are:

- To develop technologies for diverse ecosystems with focus on stabilizing the yields in aberrant weather seasons rather than increasing the yields.
- Greater public investment in infrastructure and transport will help the small and marginal farmers in marketing of the produce which is a major constraint at present.
- Of the 15 agro climatic zones in eastern India, 5 zones have low yield gap, 5 exhibit moderate gap and high gap exists in another 5 zones. The high zones fall in Jharkhand (3), Orissa (1) and Madhya Pradesh (1). Enhancing the accessibility to new technologies will be the key to bridge the yield gaps in these zones.
- When yield gaps were super imposed on bio-physical parameters using GIS; low input use, particularly of chemical fertilizers was found to be the major contributor in most districts. There is a need for promoting balanced fertilizer use in these districts by integrating with rainwater conservation.

Rainwater conservation technologies have conclusively demonstrated their potential to mitigate the drought effects, particularly in uplands and medium lands. However, the required social and institutional mechanisms for community-based water harvesting and sharing have to be developed.

3.2 Rainfed Oilseeds Based Production System

Oilseed crops are grown both during *kharif* and *rabi* seasons under sole, inter and sequence cropping systems. Due to biotic and abiotic stresses and absence of major break through in varietal development, the productivity continues to remain low. Though price fluctuations have an impact on input use and productivity, the non-adoption of improved practices is also a major cause for lower yields. Therefore under NATP, problems related to varietal performance, moisture conservation, IPM, INM and post harvest processing have been addressed. The main focus has been to evaluate the available technologies on farmer's fields and work out the cost benefit analysis under real farm situations. . In total, 82 target districts spanning over 18 states have been covered under these projects. In this chapter, the summary findings from the 18 PSR projects are presented.

Moisture conservation and nutrient management

Optimum nutrient supply and *in situ* moisture conservation(SMC) are critical for maximizing oilseed production under rainfed conditions. In order to standardize location specific modules containing suitable variety for a given micro farming situation, moisture conservation and nutrient management practices, a network project was taken up in 5 oilseeds growing districts viz. Raichur, Mahabubnagar, Solapur, Indore and Junagarh. The project covered sunflower, castor, safflower, soybean and groundnut in respective districts and two soil types viz. Alfisols and Vertisols. In each crop, the existing and improved varieties were compared for yield on farmer's fields with recommended moisture conservation and fertilizer application practices vs. farmer's practice. The main aim was to identity suitable varieties which can perform under moisture and nutrient constraints experienced under farmer's conditions.

In case of castor, based on 2 years pooled data from Mahboobnagar and Rangareddy districts involving 15 farmers, recommended moisture conservation (Key line cultivation and opening furrows between two rows 40-45 DAS) and fertilizer application (60:40:30 kg of N, P_2O_5 and K_2O/ha) enhanced the seed yield by 25.2 %. (914 kg/ha) and oil yield by 16.9 % with additional net returns of Rs. 1057/ha over farmers' practice. The cultivar DCH-32 recorded 18 % higher seed yield (877 kg/ha) with mean net returns of Rs. 6286/ha and B:C ratio of 2.65. It performed well both under stressed and unstressed conditions.

In case of sunflower, the trials were carried out for 2 years in vertisols of Raichur district both in *kharif* and *rabi*. Based on pooled data, it was found that recommended moisture conservation practice (opening furrow after 2 rows at 30-35 DAS) and fertilizer application of 35:50:35 kg of N, P_2O_5 and K_2O/ha could realize an yield advantage of 26 % and 14.4 %, respectively during *kharif* and *rabi* and additional net returns of Rs. 4165/ha and Rs. 1662/ha over farmer's practice. The hybrid KBSH-44 was distinctly superior in yield (998 kg/ha during *kharif* and 888 kg/ha during *rabi)* compared to MSFH-17. The hybrid KBSH–44 produced 31.1 % and 21% higher seed yield and additional net returns of Rs. 3685/ha and Rs. 2473 /ha over MSFH-17 during *Kharif* and *rabi,* respectively. On farm trials on sunflower were also carried out in Alfisols in Mahboobnagar district of AP in shallow and deep soils. On the basis of three years data (2001 to 2003), deep soils recorded significantly higher yield (818 Kg ha^{-1}) over shallow soils (666 Kg ha^{-1}). The increase in yield with recommended SMC (deep tillage with conservation furrows at 1.2 m) over farmer's practice was 18 %. The increase was 35 % with fertilizer application (854 Kg ha^{-1}) over farmers practice (630 Kg ha^{-1}). Among the cultivars,. KBSH-1 (841 Kg ha^{-1}) recorded 18 % higher yield over Morden.

In case of groundnut, pooled data for two years in vertisols of Junagadh district revealed that improved method of SMC(opening dead furrows after every 3 rows) RDF (12.5:25 N, P_2O_5 ha) recorded 9.3% higher pod yield and 21.1% more oil compared to farmer's practice. The NMR were also higher (Rs.27,589/ha) with improved technology compared to farmer's practice (Rs.22,177/ha). Spanish cultivar, GG-5 produced higher pod yield and net returns compared to local cultivar J-11. In Virginia cultivars, GG-13 was superior recording 19.4% higher pod yield over GAUG-10. In case of soybean, OFTs were carried out to compare SMC + fertilizer application treatment with farmer's practice (FP). Broad bed and furrow (BBF) increased seed yield by 14.4 and 27% over flatbed with RDF (1959 kg/ha) and farmer's practice (1765 kg/ha), respectively. The highest net returns of Rs. 15366/ha and B: C ratio of 2.76 was realised from BBF + RDF (20:27:17 N, P_2O_5 and K_2O kg/ha) as compared to FP (net returns Rs. 11352/ha, B: C ratio 2.48).

In case of safflower, recommended method of moisture conservation (keyline cultivation and soil mulch up to flowering) along with recommended fertilizer application (50:25 N, P_2O_5) kg/ha recorded the highest yield (1360 kg/ha) in Solapur as compared to 1168 kg/ha in farmer's practice in low phosphorus soils. In medium P soils, improved moisture and nutrient management practices resulted in maximum yield of 1440 kg/ha as compared to farmer's practice (1283 kg/ha). Additional net returns of Rs. 1302/ha and Rs. 2967/ha were obtained in low and medium P soil respectively. DSH-129 recorded highest yield and net returns.

The overall results in all the oilseed crops indicated that 25-50% additional yield and income can be realized by a combination of improved variety, moisture conservation practice and recommended nutrient application (Table1).

Documentation of indigenous water conservation practices

Farmers in rainfed areas adopt numerous indigenous moisture conservation practices in all the cropping systems, more so in oilseeds, which are grown in drought prone areas. With a view to document and improve such practices, a survey was conducted at 19 locations representing the target domains of the all India coordinated reserach project on dryland agriculture. After a two year intensive survey, 140 ITKs practiced by farmers in different AESRs were listed. Each ITK was documented in terms of its adoption, utility and scope for further improvement. The awareness level of farmers on moisture conservation practices

Performance of sunflower (KBSH-1) under farmers practice (left) and recommended practice of moisture conservation and fertilizer application (right) in Mahaboobnagar district of A.P.

Table 1 : Impact of improved moisture and nutrient management practices with best cultivars in 5 oilseed crops based on OFTs in 5 target districts (mean of 2 years i.e. 2001-02 and 2002-03)

Target district and crop	Soil type	No.of farmers		Seed yield (kg/ha)		Net returns (Rs./ha)		B:C Ratio	
				Best treatment	Farmers Practice	Best treatment	Farmers Practice	Best treatment	Farmers Practice
Mahboobnagar									
Castor	Alfisols	29	RMNM	914	730	6374	5314	2.54	2.70
			CV	877	743	6286	6078	2.65	2.45
Raichur									
Sunflower	Vertisols	29	RMNM	974(K)	773	10503	6398	2.65	2.42
				888(R)	776	8135	6473	2.71	2.02
			CV	998(K)	761	9615	5930	2.67	2.00
				942(R)	778	8284	5810	2.44	1.98
Mahboobnagar									
Sunflower	Alfisols	36	RMNM	1056	660	8377	3770	2.60	1.44
			CV	841	713	7450	3946	2.20	1.65
Junagadh									
Groundnut	Vertisols	40	RMNM	2194(S)	2035	23750	22050	2.51	1.45
				2263(V)	2044	25237	22604	3.26	3.30
			CV	2195(S)	1944	24306	20261	2.60	2.71
				2082(V)	2046	24324	21598	1.78	3.04
Indore									
Soybean	Vertisols	37	RMNM	2242	1765	15366	11352	2.76	2.48
			CV	2149	2048	15072	13704	2.85	2.67
Solapur									
Safflower	Vertisols	28	RMNM	1378	1225	18445	17354	3.02	3.25
			CV	1410	1308	19184	18421	3.02	3.32

RMNM-Recommended Moisture & Nutrient Management practice; CV-Cultivar; K-*Kharif*; R-*Rabi*; S-Spanish; V-Virginia

in villages covered under the watershed projects and those not covered was also quantified. In general, the awareness was low and farmers perceive that water conservation practices are not cost effective if they have to do on their own. Community approach in adoption of moisture conservation practices was also found to be lacking.

Impact of watershed projects

In a related project, the impact and sustainance of the bio-physical and socio-economic improvements due to watershed programmes have been assessed in 37 watersheds implemented by different agencies like NWDPRA (13), MORD (7), NARS(7), IFA(5), NGOs (5). Generally, the implementation of the watershed project resulted in better adoption of improved technologies related to seed (31%), fertilizer use (68%), plant protection (27%) and weeding (87%) as compared to the non watershed areas where the adoption rates are 23, 59, 14 & 81%, respectively. Important parameters like rise in ground water table, surface water storage, control of soil erosion and increasing the cropping intensity were sustained in the watershed areas even after considerable lapse of time but there were significant differences among watersheds in post project maintenance and sustained peoples participation. The socio-economic indicators are better with watersheds managed by NGOs as compared to other agencies.

INM in oilseed based cropping system

Though a number of INM packages have been recommended for various oilseed crops and cropping systems, the farm level adoption has been quite low. In order to understand the constraints and the potential benefits at farmer's level, extensive on-farm trials were conducted in 8 major oilseed growing districts in M.P(Bhopal), Maharashtra (Parbhani, Latur), Karnataka (Raichur), Jharkhand (Ranchi), Punjab (Nawanshahr), Rajasthan (Bharatpur) and A.P (Mahboobnagar). The cropping systems studied were soybean-chickpea(Bhopal), greengram-safflower (Parbhani), fallow-sunflower (Latur and Raichur), castor (Mahabubnagar), groundnut + pigeonpea (Ranchi), fallow-mustard (Bharatpur), maize-raya (Nawanshahr). For three years continuously, different INM treatments were compared with farmers practice in each of the cropping systems involving 15 farmers in every target districts.

Based on 3 years data with 15 OFTs, application of 100% RDF+ 2 t FYM/ha enhanced the net income of farmers by about Rs.2119 and Rs.3172/ha over farmers practice in case of soybean-chickpea cropping system. In Bharatpur district, growing mustard following green manuring with *Sesbania* during *kharif* saved 25% recommended dose of N besides improving soil properties significantly. Similarly, replacing 25% or 50% of the RDF with FYM improved the yield of sunflower in Raichur and castor in Mahabubnagar districts. In Ranchi, yields of groundnut and pigeon pea were highest with 100% RDF + FYM @ 2t/ha + lime @2 t /ha along with soil moisture conservation which were 80% higher than farmer practice. Based on results across locations and cropping systems in the target districts, application of FYM in soybean-chickpea system and in fallow-sunflower system; lime along with FYM in groundnut + pigeonpea intercropping system; green manuring in safflower, castor and mustard were found beneficial in increasing yield and income over farmers practice/ RDF. Introducing soil moisture conservation measures resulted in significant increase in yield and net returns, particularly in sunflower in Latur, safflower in Parbhani and castor in Palem.

Mustard crop on farmers fields in Bharatpur district with best INM practice (green manuring with sesbania + 2 t/ha FYM + 75% RDF)

Oilseeds production in salt affected soils

Oilseed crops occupy 14% of the gross cropped area. Considerable oilseed area in the major growing states of Gujarat, AP, Tamil nadu, Karnataka, Maharashtra and UP. is affected by salinity/alkalinity. Drought and salinity have a compounding effect in these areas severely limiting yields. Previous research established varieties and management practices for realization of better yields in salt affected soils but the performance of such technologies and the cost effectiveness have not been tested under farmer's conditions. In a network project, both cultivars and improved management practices for oilseed production in saline and sodic soils were compared with farmer's practice in 5 oilseed crops(castor, safflower, linseed, sunflower and mustard) in 5 target districts (Mahboobnagar, Parbhani, Gangavati, Kanpur and Dantiwada).The improved practice consisted of seed soaking in 1% NaCl for 3 hours (seed priming) application of FYM @ 2 t/ha and sowing on the sides of the ridges in ridge and furrow method of planting, while the farmer's practice was flat planting. During the first year, pot experiments were conducted on genotypes and their salinity tolerance. Based on the results, OFTs were carried out from year two onwards. Ten farmers were selected from 5 villages in each district @ 2 from each village. The salinity levels on the selected farmers fields ranged between 4.5 to 9 dS/m and the sodicity between 20 to 70 ESP. Based on trials carried out for 3 years, the best variety and ideal management practice for each crop and target district were identified.

In case of safflower, the genotype S-13-5 was found to be most tolerant (10.3 q/ha) followed by A-1(10.07 q /ha) and *Sharada* (8.21 q/ha). The improved practice enhanced the productivity by 25%(10.5 q/ha) as compared to farmers practice (8.5 q/ha). The net returns were also higher by Rs.1815 /ha (Table 2).

In case of castor, 962 kg/ha bean yield was realized with improved practice as against 766 kg/ ha under farmers method. There was also an increase of 27% in oil yield. Castor variety 48-1 showed the highest yield under sodic condition over *Jyoti* and *Kranti* (Table 3). In case of Linseed, *Padmini* and *Sweta* were the best performing varieties under saline soil while the improved crop management strategies of drill seeding, application 2t FYM/ha and straw mulching enhanced the seed yield by 34% over farmer's practice in sodic soil.

The genotypes KBSH-1 (6.7 q/ha) and P-64A43(6.8 q/ha) were the best performers under saline soils in case of sunflower out of the 12 genotypes evaluated. Improved practice with tolerant genotypes resulted in significant increase in yield and oil content over popular variety of Morden. The improved practice gave additional net returns

Table 2 : Economics of improved production technology for safflower under saline conditions on farmer's fields (based on 2 years data with 11 farmers in Parbhani district of Maharashtra)

Treatments	Cost of cultivation (Rs. / ha)	Yield (q/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
Recommended Practice	5791	10.58	14664	8873	2.53
Farmers Practice	4751	8.52	11809	7058	2.48
Sale price of safflower seed Rs = 1386/- per quintal					

Table3 : Benefit cost ratio of castor cultivation in sodic soils in OFTs of Mahboobnagar district with farmer vs.improved practices(Mean of 2 years based on 7 farmers)

Treatment	Seed yield (kg/ha)	Gross Returns (Rs/ha)	Cost of Production (Rs/ha)	Net Returns (Rs/ha)	Benefit Cost Ratio	Additional Returns (Rs/ha) over FP	
Management							
Improved practice	929	13006	6288	6718	2.07	1622	
Farmers practice	756	10584	5488	5096	1.93	-	
						Additional returns (Rs/ha) over	
Genotype							
48-1	937	13118	6288	6830	2.08	Kranthi	Jyothi
Kranthi	785	10990	6288	4702	1.75	2128	1834
Jyothi	806	11284	6288	4996	1.79		

of Rs.1420 /ha and 1300/ha with KBSH-1 and P-64A43 genotypes respectively. In case of mustard also, the improved management practice of seeding on the ridges and application of castor cake @ 1 t/ha improved the productivity by 14% and the variety *Bio 902* was the best performer even upto 8 ds/m salinity. Overall in all the crops tested, it was possible to realize additional profits due to the adoption of salinity/ sodicity tolerant variety and improved crop management specific to the location.

Integrated pest management

Since pests and diseases are major yield reducers in oilseeds based cropping systems, integrated pest management (IPM) has emerged as key strategy to optimize yields. Though large number of IPM modules were recommended for sole crops and cropping systems, their economic viability and performance at field level under farmers situation are not evident. Hence, a comprehensive network project covering 7 oilseed based cropping systems was taken up to validate the IPM modules and work out the cost benefit ratios on farmer's fields. The trials covered 134 farmers in 39 villages of 7 target districts (Gurgaon, Ananthpur, Raichur, Parbhani, Sholapur, Rangareddy and Mahboobnagar). The IPM modules varied in each target district depending on the cropping systems and the major pests prevalent in the area.

In case of mustard, the IPM module was compared with farmer's practice in the villages Bhora Khurd and Wazirpur in Gurgaon district of Haryana for 3 years. The main IPM component was seed treatment with *Trichoderma viride* @ 4gm/kg seed for root rot, white rust and other soil borne diseases. The disease incidence and the efficacy of the IPM treatment varied between years due to the climatic factors. From 3 years data, the most important components of IPM module effective in mustard were timely sowing and seed treatment with *T.viride*. The year wise data on yield and NMR from mustard are presented in Table 4.

In case of groundnut + pigeonpea inter-cropping system tried in 5 villages of Ananthpur district covering 16 farmers, IPM modules and farmers practice did not reveal significant yield differences. However, a significant increase in the natural enemy population was noted in the IPM plots. In Raichur district, the IPM module in sunflower + groundnut intercropping system gave a B:C ratio of 1.68 as against 1.35 in farmer's practice based on 2 years data. With safflower+ chickpea intercropping systems in Solapur district, the best module showed additional returns of 25-30% based on yields recorded on 10 farmers fields. Seed treatment with *Trichoderma*, mixing sorghum seed, bird perches and spray of NSKE were accepted

Table 4 : Yield and CB ratio of mustard during 2000-03, in IPM and Non-IPM plots in Bhora Kurd and Wazirpur village of Gurgaon district (Data based on 6 farmers from each village)

Treatment	Year	Yield kg/ha	Total cost of production (Rs./ha)	Total returns (Rs./ha)	C:B ratio
IPM module	2000-01	2101	12751	37818	1:2.97
	2001-02	1890	10704	24570	1:2.30
	2002-03	1375	12326	24750	1:2.00
Farmers practice	2000-01	1742	12269	31356	1:2.56
	2001-02	1490	10881	19370	1:1.78
	2002-03	1313	12269	23634	1:1.93

*Sale price of mustard Rs.1800/quintal

as the most important IPM components by the farmers here. In case of sole safflower tried in Parphani district, 46% increase in seed yield was recorded due to the adoption of IPM. The IPM module on castor consisted of the use of resistant variety (*jyothi)*, spray of 5% NSKE and destruction of egg masses of *Spodoptera.* Seed treatment with carbendazim was found most acceptable by the farmers in Maboobnagar, district of AP. Across farmer's fields in five target villages, an average 28% increase in seed yield was recorded over farmer's practice due to IPM. Similar positive impact of the IPM module was noted near Palem in the same district on castor. Under the project, technology was standardized for production and release of aphidophagous natural enemies *C. sexmaculata* and *I.scutellaris* at PDBC, Bangalore.

Controlling stem necrosis in groundnut

Peanut stem necrosis disease (PSNB) appeared for the first time in Ananthpur district of Andhra Pradesh in 2000. The disease caused havoc during that year, affecting more than 2,25,000 ha. resulting in economic losses of Rs.3 billion. The disease was later identified as stem necrosis caused by tobacco streak virus (TSV). A network project was implemented during 2001 to 2003 to study the etiology of the disease in different states and develop cost effective and environmental friendly control package. The partners were ICRISAT, NBPGAR, ANGAU and UAS(D).

Under the project, the causative agent was confirmed as TSV which was the first report in the world on the occurrence of this virus in groundnut. TSV infects many widely distributed weeds, of which *Parthenium hysterophorus* plays a major role in its spread by thrips. Of the crop species, *Helianthus annus* (sunflower) and *Tagetes patula* (marigold) also act as a sources of inoculum. Natural incidence of TSV was also detected in urd bean, mung bean safflower sun hemp.

The virus spreads through pollen from infected *Parthenium* through thrips. Studies conducted on seeds collected from mechanically inoculated TSV infected plants of groundnut, sunflower, marigold, french bean, mung bean, urd bean, soybean, *Chenopodium* and *Parthenium* and field infected plants of groundnut, sunflower and *Parthenium* failed to show seed transmission of the virus in these species. However, more studies are needed to come to a firm conclusion.

Extensive surveys conducted during the past three years revealed that PSND in groundnut is confined to Andhra Pradesh only. After the 2000 epidemic, in general, the PSND incidence, was low in following years. However, during 2004 rainy season, due to favorable conditions, its incidence was high in some pockets in Andhra Pradesh as farmers failed to take up precautionary measures in spite of warnings of potential high incidence.

Due to low natural PSND incidence and prevailing drought conditions, field screening of germplasm and breeding materials at Kadiri, Rajendranagar and Raichur did not produce conclusive results. However, in the glasshouse screening at NPBGR and ICRISAT, no genotype showed resistance to TSV. But with diluted concentration of virus at ICRISAT, three genotypes (ICGV 99029, ICGV 01276 and ICGV 92267) showed consistent tolerant reaction to TSV. In

Groundnut plants affected with PSND showing characteristic necrotic symptoms addition to their tolerance to TSV, these genotypes also possess tolerance to PBND, rust and late leaf spot. These would make good parents in a multiple disease resistance breeding program in groundnut. Thirteen wild *Arachis* accessions also showed useful levels of resistance to TSV under glasshouse conditions. Further tests are in progress at ICRISAT to confirm the results. Seed treatment with Imidacloprid 200 SL @ 2ml kg^{-1} of seed was effective in controlling thrips up to 30 DAS and it was also cost effective (1:1.96). Indirectly, it also reduced the PSND incidence.

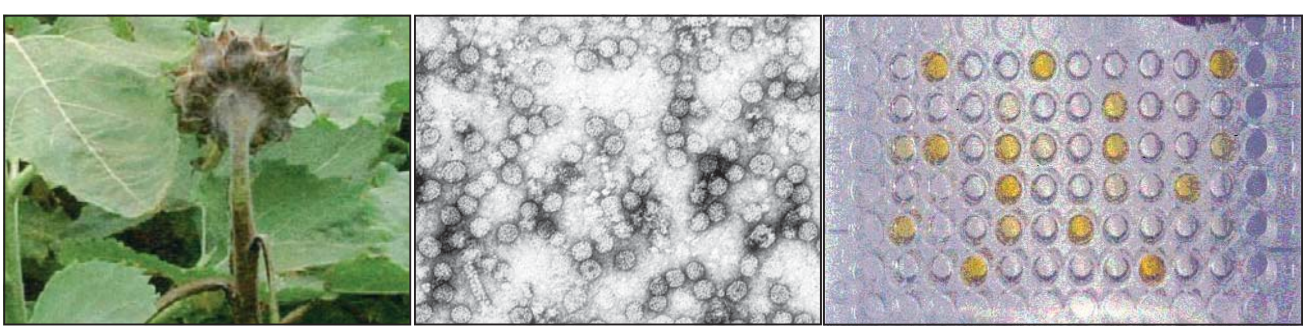
Preliminary results indicated that border cropping and intercropping with pearl millet and sorghum could check the PSND incidence on farmers fields .The most important recommendation however is the eradication of the *Parthenium* weed which was taken up in a campaign mode by Dept. of Agriculture, Govt. of A.P in the affected areas. So far, no incidence of PSND was recorded in Gujarat, Maharashtra and Karnataka.

Sunflower necrosis disease

Sunflower necrosis, a serious disease of sunflower and several other economically important crops, was first noticed on sunflower in Karnataka in 1997. Since then the disease became increasingly important on several crops in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu and Uttar Pradesh. Its occurrence in other sunflower growing areas could not be ruled out. The disease on sunflower is characterized by sudden necrosis of part of the leaf lamina followed by twisting of leaves and systemic mosaic/necrosis of the lamina, petiole, stem, and floral calyx and corolla.

Recognizing its economic value, a comprehensive project was taken at Indian Agricultural Research Institute(IARI), New Delhi to survey the severity of the disease in different states, characterize the virus and develop a diagnostic kit. During 2001, etiology studies revealed that the causative agent is tobacco streak virus (TSV), which is ascribed to the genus *Ilarvirus.* The virus reproduced the original symptoms when inoculated on healthy sunflower plants. Based on the coat protein gene sequence, the identity of the virus as a strain of TSV was confirmed. CP gene was 717 nucleotides long, which could code for a coat protein of 238 amino acids. The CP gene could be deployed as transgene in the breeding programme to confer resistance and develop virus resistant transgenic sunflower or groundnut plants.

Rapid and reliable diagnosis methods for detection of the virus based on enzyme-linked immunosorbent assay (ELISA), dot immunobinding assay (DIBA), Western blot(WB), polymerase chain reaction (PCR) and Nucleic acid spot hybridisation (NASH) were developed (Figure 3). Immuno- as well as nucleo- probes (polyclonal antiserum and primers) against TSV were produced, which led to the identification of chilli, cotton, groundnut, mungbean, okra, soybean, sunn-hemp, and urdbean as the natural hosts of TSV. Information on the



Sunflower necrosis disease symptoms (left); electron micrograph of purified virus (center); and a diagnostic test for virus detection based on ELISA (right) variability of TSV will have important bearing on its control through resistant varieties. TSV population originating from different hosts and locations was serologically indistinguishable. Coat protein (CP) genes of TSV isolates originating from sunflower (Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu), chilli (Uttar Pradesh), cotton (Maharashtra), mungbean (Tamil Nadu) and sunhemp (Karnataka) were found to be highly conserved (up to 100%), suggesting their common origin.

TSV does not appear to be seed-borne in sunflower as the virus was not detected in seeds from seven sunflower genotypes tested, PAC 1091 (0/360), KBSH-1(0/531), JKSF-51(0/82), POC-1(0/1076), PS-21(0/90), ZSH1(0/524) and ZSH 9760(0/434). Since, TSV has been reported to be seed-transmissible in soybean (up to 90%) and common bean (up to 26%), there is a possibility of its introduction through seeds of a susceptible crop.

Aflatoxin control in groundnut production

Groundnut is an important oilseed crop frequently infected with aflatoxin. The post harvest infection of groundnut pods and seed by *Aspergillus flavus* is the major cause of this problem. Since, aflatoxin has now become a major technical barrier for export of groundnut kernels, a network project was taken up to assess the extent of the problem and apply various management practices for its control through farmers participation in Gujarat and A.P. It was implemented at NRCG, Junagadh; ICRISAT, Hyderabad and ANGRAU, Ananthpur. The project attempted to undertake survey for the incidence in the major growing districts of AP and Gujarat and evaluate an integrated package on management of the toxin on farmer's fields. Pod and soil samples collected from Gujarat (1570), Andhra Pradesh (1592) and Karnataka (329) were analyzed for soil *Aspergillus* population, seed infection & colonization and aflatoxin content.

A detailed survey was undertaken to map nil, low and high-risk areas for aflatoxin contamination based on analysis of pod and soil samples. Wide variation was noticed across twelve districts for the distribution pattern of *Aspergillus*. The seed infection and soil population was low in Gujarat as compared to A.P. While about 25% of the samples were free from infection, in the rest of the samples, the infection ranged from 1-60%. Soil samples showed fungal population in the range of 0-390x10^3 propagules per gram of soil. However, in A.P. and Karnataka, the seed infection ranged from 1-97%. The fungal population in the soil samples ranged from 0-740x10^3 propagules per gram of soil. One hundred elite groundnut accessions were screened in concrete blocks artificially enriched with the inoculum of highly toxigenic strain of *A. flavus* (Af11-4) during *kharif* 2001 and 2002. Among them, 11 genotypes did not show infection during both the years. Aflatoxin content in these genotypes ranged from 0.06 (ICGV 01149) to 75.96 ppb (ICGV 01119).

An integrated aflatoxin control package was developed based on the HACCP analysis. The package included summer ploughing, use of healthy seed @ 120 kg/ha, seed treatments with carbendazim @ 2g/kg, furrow application of *Trichoderma* (biocontrol agent tested at NRCG) based in the castor cake or farm yard manure @ 2.5 kg for 500 kg/ha, spray of 5% neem seed kernel extract, spray of a mixture of mancozeb (0.2%) and carbendazim (0.05%), harvest at right maturity, drying pods to reduce moisture quickly to <9%, and sorting of diseased pods. The package was effective in reducing soil *A. flavus* population, seed infection, colonization and aflatoxin content. The yield increase ranged from 11.6 to 28.7% in Gujarat and 10 to 30% in AP (Table 5).

Livestock feed from oilseed by-products

Although oil meals are routinely used as feed ingredients for livestock, many by-products of

Table 5 : Reduction of Aflatoxin incidence and yield benefits in groundnut due to improved package in on-farm trials in Gujrat and A.P.			
Reduction in	*Kharif* 2001	*Kharif* 2002	*Kharif* 2003
		Gujarat	
	(36)	(50)	(30)
Aspergillus population (x10^3.g $soil^{-1}$)	24	27	37
Seed infection %	20	28	36
Seed colonization %	17	20	34
Aflatoxin content	28	38	41
Yield benefit %	11.64	12.38	28.36
		Andhra Pradesh	
	(36)	(40)	(40)
Aspergillus population (x10^3.g $soil^{-1}$)	31	33	15
Seed infection %	22	06	19
Aflatoxin content	19	35	28
Yield benefit %	29.29	Marginal	10.51

*Figures in parenthesis indicate number of on farm trials

oilseed crops still go unutilized. In order to utilize the sunflower heads and castor cake as livestock feed, a comprehensive project was taken to study the current use pattern of these materials, preparation of complete feed formulations and assess the impact on milk productivity. The estimated availability of sunflower heads (SFH) and castor cake in the country are 11 and 5.9 lakhs tons, respectively. Field surveys indicated that sunflower heads are largely wasted after harvest of the crop, while castor cake is used as an organic fertilizer/soil amendment. Sunflower heads with a proximate composition of protein (7.2 – 11.6%), crude fiber (17.69 – 33.12%), fat (2.4 – 7.4%) and neutral detergent fiber (26.7 – 52.07) is superior to many of the commonly used roughages like ragi straw, paddy straw, sorghum stover, maize stover etc. Similarly castor cake is also rich in nutrients but the constraint has been anti-nutritional factor, the ricin.

Sunflower heads

Detailed survey in the target districts indicated that hardly 3-5 percent of farmers are utilizing SFH for feeding their animals. SFH after removal of seeds were either being burnt in the field or was being dumped on wayside. A complete feed technology was developed for making effective use

Sunflower heads after harvest of the crop (left); pellets of complete feed with 40% sunflower heads (center); dairy cattle feeding on SFH based diet (right) of sunflower heads. SFH was incorporated effectively as the sole roughage component upto 40% level in the complete feed. For increasing the nutrient utilization, the Expander–Extruder technology was followed in manufacturing of SFH based complete feed. Animal trials conducted at farm level with cattle indicated that 40% SFH based complete feed resulted in better digestibility of all the nutrients as compared to conventional feeding.

Multi location field trials with SFH based complete feed were undertaken in the states of Karnataka, Andhra Pradesh and Maharashtra covering 202 farmers in 18 villages of 5 target districts. On an average, there was an increase of 1.5 to 2.0Kg milk/ day/ animal in the group fed SFH based complete feed. The average expenditure on feed on each of the animal in the complete feed group (Rs 61.45) was higher than control (Rs 47.46). However higher returns were also realized in the group, as there was a significant increase in the milk yield/animal/ day. The total returns per animal per day was Rs 84.70 in the treatment group with a net profit of Rs 23.25 per day while a mere Rs 2.46 was received as profit in control with a total return of Rs 50.22.

To take the technology of complete feed directly to the farmer's doorsteps, mobile disintegrator and grinder cum mixer has been designed and installed at three places of the target districts. These are being maintained and operated by local Self Help Groups (SHGs) on community basis. The approach has been quite successful.

Castor cake

The major limiting factor in utilization of castor cake (CCK) is the presence of the anti-nutritional factor i.e. ricin. Various physical and chemical detoxification technologies were tried to detoxify the ricin and make CCK suitable for feeding of livestock. Lime treatment of CCK proved to be the most effective detoxification method. The efficacy of detoxification technology was tested in a comprehensive manner by quantification of ricin in untreated and treated samples, animal trials and histo-pathological studies.

Field trials conducted at Banaskanta district of Gujarat indicated that inclusion of 10 % CCK in the concentrate mixture of lactating buffaloes has economic advantage without adversely affecting feed intake, nutrient utilization, milk yield and general health. The daily feed cost (Rs/head/day) was Rs. 74.88 in control group, which was significantly higher than the CCK based ration fed group that recorded Rs. 68.89 feed cost. The group of buffaloes fed CCK based rations recorded 24.25 % higher return over the control group. The technology was transferred to M/s Jayant Oil Mills, Vadodara for upscaling (see chapter on technology transfer for details).

The project has succeeded in developing effective technologies for making use of sunflower heads and castor cake as animal feed. However, there is a need for large-scale dissemination of these technologies among farmers.

Detoxifying aflatoxins in poultry and livestock feeds

Aflatoxin production in stored poultry and livestock feeds has become a major health hazard for poultry and animal production in the country. This problem is severe in parts of the country where high humidity exits during storage. With an aim to control aflatoxin development in the stored feeds, a number of cost effective control measures were tried in a network project in A.P. (PDP, Hyderabad), Haryana (CIRB, Hissar), Karnataka (NIANP, Bangalore) and Assam (AAU, Guwahati).

A total of 253 feed ingredients (maize, sorghum, pearl millet, ragi, sunflower cake, ground nut cake, deoiled rice bran, soyabean meal etc.), fodder and finished feeds were analysed for aflatoxin contamination. Incidence was very high in ground nut cake (86%) and mixed feed (60%) followed by maize (45.5%), while milling by products, millets and other protein meals contained less amount of aflatoxin. Fodder samples of maize, sorghum and gram husk contained no detectable aflatoxin. In the positive samples, average aflatoxin content was 118 ppb. Feeds stored in air- tight containers below 7.5% moisture had low fungal growth and aflatoxin production, while those containing above 12.5% showed higher growth and toxin production. Storage of feed ingredients in open containers in godowns at moisture levels of 12-14% showed increase in aflatoxin production in 7-14 days of storage. Higher aflatoxin production was observed in gunny bags as compared to HDPE bags.

Propionic acid (0.1 - 0.5%), copper sulphate (0.05 - 0.1%), ammonia (0.5%) and sodium hypochlorite (0.5%) were most effective in their anti-fungal property (85 - 100%). Propionic acid, sodium propionate, benzoic acid and ammonia completely inhibited aflatoxin production in feed. Highest fungal inhibition and aflatoxin production (upto 70%) were seen in feed with citric acid (0.02 %) even after 6 months of storage. Seeds, leaves and barks or their extracts of various herbs viz. Neem, Custard apple, *Rai* Eucalyptus, *Ocimum*, *Andrographis* etc. were evaluated for their efficacy in preventing fungal infestation of feeds. Clove oil (0.5%) completely inhibited fungal growth and aflatoxin production. Turmeric, onion, garlic, neem oil, neem leaves and neem seed cake showed moderate effect. Neem bark water extract inhibited the development of *Aspergillus parasiticus* by 63.3% while powder prevented aflatoxin production upto 86%. Mixture of leaves and bark of *Andrographis paniculata* (at 0.4%) decreased fungal colonies (57%) and level of aflatoxin (59%).

Dietary supplementation with vegetable oils like sunflower oil (3-6%) and soybean oil (3%) could counter the ill effects of aflatoxin in broiler chicken. Methionine (0.8%) in feed also ameliorated adverse effects of aflatoxin on body weight. Herbal agents like *Emblica officinalis* or *Ocimum sanctum* or *Piper nigrum* (0.2%) or *Curcuma longa* (0.15%) have also improved the feed conversion efficiency, feed intake and body weight in aflatoxin fed chickpea.

Six week old broilers fed on control (L), aflatoxin (M) and methionine supplemented diet (R)

The project threw up several options of counteracting the aflatoxins in livestock and poultry feed. These results are to be popularized and suitable policy guidelines are to be issued on feed formulations and storage conditions.

Technology for improving seed viability in soybean

Low viability of soybean seeds is a constraint for farmers to retain the harvested seed for next year planting. In order to enhance the viability upto 9 months (till next sowing season), low cost technologies are needed which can be adopted by the farmers at the village level. This problem was addressed by JNKVV Jabalpur and GBPUAT, Pantnagar by analyzing the causes for low viability, designing and field testing of various low cost devices for storing soybean seeds for longer periods. The salient results are:

- Higher retention of viability was achieved when soybean seeds were stored at partial vacuum (200 mm Hg) and lower moisture content (<10%). Soybean seed stored at low RH (20%) and low temperature (5°C) showed high retention of viability.

- Higher germination percent (12% higher than control) was achieved after six months when seeds were stored in vaccumised GI containers
- Metalized polyester (300 gauge) and laminated LDPE (300 guage) bags retained vacuum for longer periods. A low cost foot operated vacuum packaging machine was developed, which costs about Rs.5000/-. With this machine 80-120 bags can be vaccumized per hour. Seeds could be stored upto 9 months in nitrogen filled metallized polyester bags without loss of germination.
- Double walled GI bins with thermocol lining were found to be ideal among various structures tested along with PUSA bin for retention of germination upto 6-9 months.
- A low cost technology of storing seeds in sand (upto 40%) filled in mud plastered bamboo basket was also found highly successful and acceptable to the farmers. The storage conditions were further improved by replacing sand with ash (40%). After 9 months of storage, 65% germination was recorded with ash mixing. These are simple practices, the farmers can adopt in their households.

A low cost mud plastered bamboo baskets for storage of soybean seeds to retain viability

Safflower harvester

In view of the spiny nature of safflower crop, manual harvesting has been difficult which is one of the reasons for the decline in area under safflower. In order to over come the drudgery and improve the efficiency of harvesting, a project was taken up at UAS, Raichur and CIAE, Coimbatore to develop a safflower harvester, which can also be used as multi crop harvester. During 2000 and 2001, two prototype harvesters were designed one each at UAS, Raichur and CIAE, Coimbatore. Both the models, (Model I and II) were extensively field tested in the target districts of Raichur and Gulbarga during 2001 and 2002. During 2003, a collection tray attachment was added to the improved model and the machine was made more versatile for harvesting other crops also.

The cost of operation per hectare for harvesting safflower intercrop with the machine was Rs.638 and Rs.666/ha with and without tray attachment, respectively, which was lower by 25.81 and 23.14% over manual harvesting. The cost of harvesting by prototype II was lower compared to manual harvesting besides reduced drudgery. The saving in labour was also significantly higher (fig.1). The break even point for the harvester is 21.38 ha and

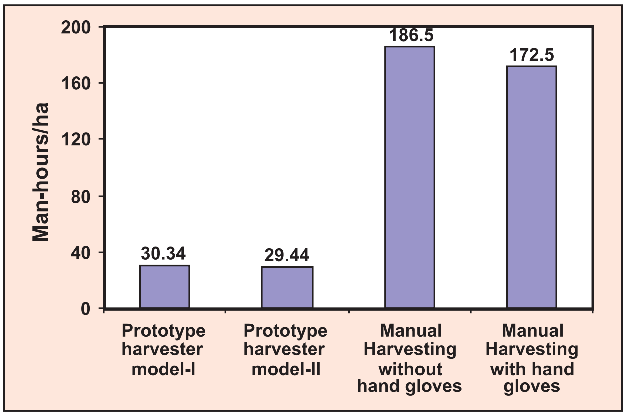


Fig.1 : Average labour requirement with different methods of harvesting for safflower as sole crop

23.8 ha per annum with and without tray attachments, respectively and the pay back period is 3.14 years at an annual usage of 400 ha.

During 2003-04, the benefit-cost ratio of manual harvesting and machine harvesting were computed and analysed. A minimum BC ratio of 1.33 was observed for harvesting wheat with prototype harvester model-I, while the maximum (3.16) was recorded for harvesting safflower as sole crop. In case of model-II, the minimum BC ratio of 1.3 was observed for wheat and maximum of 2.9 for safflower as sole crop. Trials at Dharwad and Raichur indicated the suitability of mechanical harvesting technology coupled with manual collection for harvesting safflower and wheat and farmers were satisfied with the machine performance. Safflower farmers were willing to increase the area under the crop, if small capacity mechanical harvesters are made available on custom hiring basis.

Oilseeds based apiary and eri culture

In addition to the main products, oilseeds based cropping systems also offer opportunities for generating additional income through apiary and use of foliage as silkworm feed (Eri silk). Accordingly, in a network project taken up in the target districts of Hassan, Bangalore rural, Gadag, Dharwad in Karnataka; Parbhani and Hingoli in Maharashtra and Bawal in Haryana, honey bee colonies were introduced in oilseed crops like sunflower, safflower, niger and taramira and the honey production and profitability to the farmers was determined.

On station results during 2001-04 showed that two bee colonies per acre can produce significant impact on crop yield. Accordingly OFTs, on large plots were conducted in all the target districts maintaining two colonies/acre. The yield advantage and total additional returns in different districts are given in Table 6. The higher yields obtained in sunflower and safflower were mostly due to higher seed set and better grain filling.

During 2003-04, the economics of the system as a whole was worked out besides studying the impact of pest management practices on mortality of bees.

Keeping one and two colonies/acre resulted in net returns of Rs.396 and Rs.676 from plots of niger. In sunflower, keeping one and two colonies/acre increased the mean bee activity/min from zero in control to 1.64 and 1.93/head/5flower heads respectively. As a result, increase in yield by 81 and 102% over control were registered. Net gain was Rs.7477 and Rs.9749/acre from plots pollinated with one and two bee colonies. Safflower pollinated @ one and two colonies/acre exhibited yield increase

Multi-crop safflower harvester with collection tray harvesting the crop

Discharging the safflower crop by lifting the tray

Table 6 : Additional income due to increased yield and honey from apiary on farmers fields								
Name of the Village	District	No.of farmers	Crop	Additional seed yield due to bee colonies (kg/acre)	Value of additional yield/acre (Rs.)	Qty.of honey produced/ acre (kg)	Value of honey/ acre (Rs.)	Total additional gain due to bee colonies
Kandali	Hassan	8	Niger	29.6	534.0	3.5	352.7	886
Kanavi Harti Mundargi Asundi	Gadag	20	Sunflower	147.0	2205.0	3.0	300.0	2505
Tadborgaon Dharmapuri Zari Shirdshahapur Devalgaon Avcha	Parbhani Hingoli	8	Safflower	92.0	1656.0	2.5	248.0	1904

of 22.3 and 38% respectively. This was attributed to increased activity of hive bees at 1.75 and 2.71/ m^2/min respectively as compared to 0.58 bees in the control. Net monetary benefit accrued was Rs.973 and Rs.2169/acre. In *taramira*, yield was 6.25 and 8.2q/ha in plots of one and two bee colonies against 5q/ha in the control.

The recommended package of practices (RPP) of pest management which are largely based on chemical pesticides were found to be detrimental to honeybees. The pesticide based recommended practice resulted in mortality of bees @ 15.44, 50.8, 15.3 and 20.9 per day in sunflower, safflower, niger and taramira compared to 2.56, 3.2, 0.56 and 18.2 per day in IPM plots. Increase in yield in IPM plots @ 20.6, 21.0 and 3.4 per cent over RPP was realized in sunflower, safflower and taramira. Results from the 3 years study on 4 crops clearly revealed that integration of oilseeds production with apiary can substantially increase the production and income to small farmers in drought prone areas of Karnataka, AP., Maharashatra and Haryana.

Eri culture

In order to improve the profitability of eri silk production in north eastern states, a network project was taken up in Assam, Manipur and Karnataka which tested various options to maximize production of castor leaves and improve cocoon yield. Experiments were conducted on varietal performance in castor for leaf production, nutritive value of leaves, feed efficiency of eri races and agronomic practices for optimizing leaf yield. On station research indicated that adoption of improved agronomic practices for castor resulted in significantly higher leaf production and cocoon yield in all the states. Variety 48-1 in Assam and Red petiole in Manipur were found to support the highest cocoon yield with white Manipuri race, while DCH-177 supported the highest coccon parameters for Bangalore eco race.

On farm adaptive research during 2001-2003 in the target districts revealed that crop management practices like planting geometry, fertilizer application, nipping and flower bud removal have significant impact on the leaf production and coccon yield.

Improved practices increased the leaf yield over Farmer's practice ranging from 42.50% to 173.00% in Assam, 87.34 to 333.33% in Manipur and 10.26% to 18.41% in Karnataka.

Red petiole variety of castor, worms feeding on castor leaves,
a manipuri woman weaving and a shawl produced with eri silk

48-1, local Red non-powdery and DCH-177 emerged to be the most promising varieties with highest leaf yield under the rainfed agro-ecosystem of Assam, Manipur and Bangalore respectivley. To illustrate, the coccon yield, shell yield and rearing capacity of Manipur race on two castor varieties are presented in Table 7.

Out of three eco-races studied in farmers' rearing condition, Assam local eco-race exhibited higher consistency on both the castor varieties as compared to Bangalore & Manipur eco-races in relation to rearing, cocoon and grainage parameters. 48-1 and local Red non-powdery were at par in relation to larval parameters of local race in Manipur.

Table 7 : Performance of local Manipur race of eri silkworm on two castor varieties under farmer's rearing conditions (Data are based on mean of 5 farmers for two years ie. 2002-03 and 2003-04)

Treatment	Cocoon yield (kg/ha)	Shell yield (kg/ha)	Rearing capacity (DFLs/ha)
RNP (FP)	128.68	14.06	180.51
RNP (IP)	516.67	65.65	757.92
48-1 (FP)	117.06	13.32	183.59
48-1 (IP)	418.29	49.93	520.64
CD at 5%	70.09	8.90	86.62

* RNP: Red non powdery; FP : Farmers' practice; IP : Improved practice
* Data are based on mean leaf yield considering mean consumption; mean ERR, mean silk percent etc.

However, local Red non-powdery had significantly better performance than 48-1 for cocoon yield, shell yield and rearing capacity. Rearing in spring season was found to be better than autumn. Cost benefit (C:B) ratio was better under improved practice than farmers' practice for both local & hybrid castor varieties in all states. Local Red non-powdery variety with C:B of 1:2.31, 48-1 with 1:2.36 and DCH-177 with 1:1.60 were the profitable varieties for ericulture in the rainfed agro-ecosystem of Manipur, Assam and Karnataka, respectively.

No major pest and disease incidence was noticed during the rearing of eri silkworm. However, Seedling blight, Castor semilooper, Castor shoot & capsule borer, Red hairy caterpillar could cause moderate to severe damage to castor. *Eleusine indica, Cynodon dactylon* and *Axonopus cimeinus* were major weeds in the castor field. 3-10 weeks after sowing of castor seed had been the critical period of weed competition.

Value added products from safflower

Safflower is an important oilseed crop grown largely in Maharashtra and few districts in Andhra Pradesh and Karnataka. The returns from this crop have remained low over the years due to stagnant productivity and lack of product diversification. Natural dyes and medicinal properties of safflower petals are well known. In order to generate systematic data and develop commercially viable technologies for isolation and extraction of these natural products and formulating them into commercially usable products, a network project involving CIRCOT and UDCT, Mumbai and MAU, Parbhani was taken up. The project focused on optimization of petal yields from farmers fields, stadardising extraction technology for dyes and developing protocols for formulation of herbal tea and production of cardboard from stalks.

Yellow dye from petals

An efficient extraction method for recovery of yellow dye was standardized and scaled up to pilot level at CIRCOT. The water soluble yellow dye represents 25-30% of the total dye. The results showed that 2.5 kg of cotton cloth could be dyed with good color reproducibility and uniformity by using 1 kg of petals. Different shades of colour were created by employing eco friendly mordants. A readymade recipe was developed for cottage industries. The quantity of yellow colouring matter in petals of different varieties is shown in fig.2.

Petal yield from different varieties

Non-spiny varieties were found more suitable for dye production enabling the collection of 800-900g of petals per worker/day as compared to spiny varieties, where only 210-260/g/worker/day could be collected (Table 8). Harvesting of petals

Table 8 : Average petal collection, petal and seed yield of spiny and non spiny varieties of safflower in Parbhani district, Maharashtra, 2001-02

Variety Name	Colour	Average petal collection (gm/day/worker)	Average petal yield (kg/ha)	Average seed yield (kg/ha)
NARI- 6	Dark red	800	201.65	1530.3
JSI-7	Reddish Yellow	820	169.24	1602.4
JSI-97	Light red	830	256.17	1959.9
JSI-103	Red	840	218.62	1785.0
Sharda	Light red	240	84.36	2070.5
Bhima	Yellow	230	74.59	2093.6
C.D. at 5%			32.82	551.9

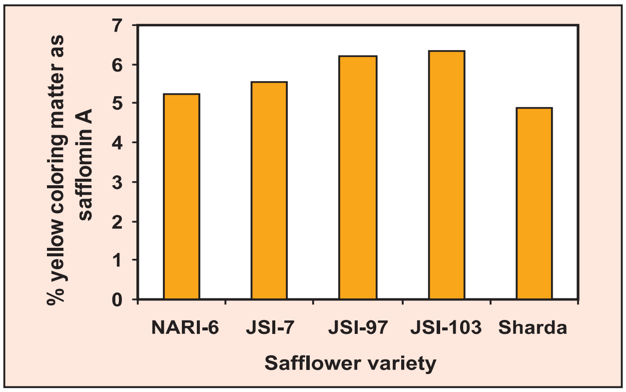


Fig.2 : Quantity of yellow colouring matter in petals of different safflower varieties

15-20 days before final harvest was the optimum time for highest dye recovery. Dyeing trials with 5 commercial varieties of safflower revealed that the intensity was maximum with JSI7 (K/S value of 7.3) in case of yellow dye. As with yield of petals, the non-spiny varieties fared better for color intensity also. *Bhima,* though a high yielding variety was found to be poor with a K/S value of just 1.3.

Petal powder as food additive

Technology was developed to incorporate safflower petal powder and also yellow dye in powder form in various popular food, bakery and dairy products. Such products showed wide acceptance in organoleptic tests. Production of yellow dye through spray drying was demonstrated in 50 kg industrial trail. Cost of production per kg is estimated as Rs. 1500/-. Detailed tests with 20 commercial varieties showed that heavy metals like As and Hg were completely absent in all varieties while others like Cu and Zn though detected were within the permissible limits.

Herbal tea from petals

In order to utilize the nutritive and medicinal properties of safflower petals, a recipe was successfully formulated for the preparation of herbal tea known as *"Safo tea"*. The main ingredient of the formulation is petal powder along with other herbal ingredients. Storage techniques for petals and packaging for tea pouches were also developed at MAU, Parbhani. Safflower tea could be produced economically at Rs.800/- per Kg and has a good export market.

Yellow dye in pharmaceutical products

The crude yellow dye was purified and incorporated in several pharmacological formulations. Animal studies demonstrated the anti-Inflammatory and anti-hyperlipidemic properties of the purified dye. The yellow dye was also used as a colourant for tablets. The stability and colour intensity were comparable to that of synthetic colourants presently used by the industry. Preliminary cost estimates indicated that cost of coating 1000 tablets with safflower yellow is Rs.10/- as against cost of Rs.6/- for synthetic dye.

Particle board from stalks

Safflower crop generates one ton of stalk per hectare. The projected overall availability of ligno-cellulosic bio-mass is about 7 lakh tons per annum in the country. This bio-mass if properly exploited could be of considerable help in meeting the acute shortage of ligno-cellulosic raw material by the paper and board industries. Besides, the bio-mass could fetch additional income to farmers in the range of Rs.500– 1000/- per ton. Technology was developed for the production of Particle and hard board employing safflower stalk. The stalk yielded a good quality board conforming to IS specifications. Presently the cost of safflower is cheaper than the conventional raw materials.

Bio-enrichment of petal residue

Residue petal after dye extraction can be enriched employing a microbial consortium developed at CIRCOT through anaerobic fermentation. The bio-enriched product showed a 35% increase in protein content as compared to control. The enriched material can be used in poultry feed ration.

Safflower crop

Catton apparel dyed with Safflower yellow

Herbal tea from safflower petals

Safflower petals

Cardboards made from safflower stalks conforming to BIS standards

Analysis of production constraints in major oilseed growing districts

The production constraints in the oilseeds based cropping systems have been studied in major oilseed growing target districts in the states of Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka for groundnut, Rajasthan, M.P and Assam for rapeseed and mustard and M.P for soybean and sesamum. Climatic, edaphic and socio-economic factors affecting productivity were identified using GIS and strategies for increasing the productivity have been suggested. These include

- Major thrusts on seed village concept to produce seed where it is needed.
- Increased adoption of *in situ* moisture conservation
- Promote soil test based fertilizer use
- Introduction of low cost hand operated weeding devices
- Decentralized market yards, price support and insurance
- Mechanization of harvesting operations to over come problems of seasonal labour shortages

Specific constraints in adoption of inter cropping systems

Major oilseed crops in the country are grown in inter, sequence and mixed cropping. Such inter and mixed cropping systems provide the much needed yield stability besides diversifying the risk. However, several constraints affect the wider adoption of recommended intercropping systems.

In a comprehensive project covering 30 locations, the major constraints in adoption of inter/mixed cropping systems by farmers were studied. The most important gaps and suggested areas of research are:

- Lack of suitable seeding machinery for timely planting of intercrops in the recommended row ratios and geometry.
- Non-inclusion of staple crop of the region in some of the recommended systems leading to lack of adoption by the farmers.
- Lack of awareness on the best intercropping system for that area and the non-availability of seeds of the intercrop.

- Open grazing of the long duration crop after the harvest of first crop.
- Lack of proper INM and IPM recommendations leading to realization of sub optimum yield potential.

Lack of marketing facilities and remunerative prices to one or both of the intercrops particularly if it is not a staple crop.

3.3 Pulses Based Production System

Ninety percent pulses are grown under rainfed conditions. These crops are grown mostly in inter and sequence cropping systems all over the country under varied rainfall and soil conditions. Production of pulses has remained more or less stagnant for the last 4 decades and the impact of improved technologies has not been quite evident as in case of cereals and commercial crops. Poor adoption of HYVs, abiotic stresses and severe losses due to pests and diseases are some major constraints. In the pulse based production system, network projects were taken up in the areas of rainwater management, integrated nutrient management, IPM, and post harvest storage to develop cost effective technologies addressing the above constraints and validate them under farmers conditions.

Integrated pest and disease management

Pigeonpea and chickpea are the most important pulse crops in the country. Over the years many IPM modules were developed for both these crops to minimize the use of chemicals and tackle the problem of pest resistance/ resurgence. Two comprehensive projects were taken up on both these crops to develop ecologically sound and economically viable IPM modules, on-farm validation of such modules and monitoring the effect on pathogen and natural enemies.

In case of pigeonpea, results from the on-station research for 3 years (2000-2003) revealed that pigeonpea + sorghum was the most efficient and best intercropping system at all locations i.e. Kanpur (2:1 row ratio), Sehore (2:2) and Gulbarga (1:2). Chemo-intensive IPM gave the highest C:B ratio at high pest load while bio-intensive IPM was superior or on-par at low to moderate pest loads. ETL based sprays could reduce number of sprays from 6 to 4 at Gulbarga with higher pigeonpea equivalent yield. At Sehore, one spray each of NSKE (5%) and recommended pesticide could control all major insect pests. Sorghum + pigeonpea intercropping was a new introduction to this area and proved more remunerative than soybean as sorghum did not require major pest control efforts. At Kanpur, where long duration pigeonpea was the main crop, podding duration is quite long ranging from December to March and pod fly infestation starts immediately and continues up to crop harvest besides pod borer infestation in March. With this scenario, even chemo-intensive IPM with two sprays could give only 2.05 C:B ratio. Bio-intensive IPM yielded 1.65 C:B ratio against 1.59 in control. For this location, two sprays of monocrotophos and endosulfan were not enough to control the pests. Spray schedules need to be imposed based on podding behaviour of pigeonpea variety and ETL of pod fly and pod borer.

Ridge sowing provided higher initial plant stand, reduced phytophthora blight and improved grain yield in pigeonpea. Seed treatment with

Sorghum intercropped with pigeonpea - a key component in IPM on farmers fields in Kanpur district

Trichoderma harzianum @ 10 g/kg seed was most effective in reducing the *Fusarium udum* population in the soil and wilt incidence. Sorghum intercropping also reduced parasitic nematodes.

Bio and chemo-based IPM modules were compared for their effectiveness on 90 farmer's fields in 3 target districts for 2 years. In Kanpur, based on two years data, CIPM was most effective for pest management and also higher grain yield and CBR over BIPM and control (Table 1). Similar trend was found in Gulbarga district which also recorded high pest load. In Sehore district, however, there was moderate pest load and both BIPM and CIPM performed on-par but superior over farmers practice. While there is certainly good scope to popularize bio intensive IPM modules, non-availability of *Trichoderma* formulations, pigeonpea ridge planter and suitable spraying device at 2 m height for uniform coverage were major bottlenecks for effective adoption of IPM modules in pigeonpea.

In case of chickpea, the network project aimed at developing IPM modules against *Helicoverpa armigera* and wilt/dry root rot disease. An effort was made to validate location specific biointensive modules for Kanpur (North East Plain Zone), Sehore (Central Zone) and Gulbarga (South Zone). Based on 4 years (2000-2003) data, chickpea intercropped with mustard (4:2) was the best at Kanpur (8.75% pod damage) followed by chickpea + linseed (10.35%) pod damage. BIPM module was better (7.9% pod damage) than CIPM (9.42% pod damage) and control (15.34%). At Sehore, chickpea intercropped with either mustard or linseed recorded 5% pod damage, but CIPM was superior over BIPM (3.16% and 5.18% pod damage

Table 1: Effectiveness and cost benefit ratios of different IPM modules in pigeonpea + sorghum inter cropping system on farmers fields (mean of two years with 10 farmers in each district)

Module name	Pod borer (%)	Disease incidence wilt (%)	% pod damage by pod borer	Grain damage: Podfly (%)	Grain damage: Pod borer (%)	Pigeonpea equivalent yield (kg ha^{-1})	C:B ratio
			Kanpur				
Bio intensive IPM (BIPM)	3.7	5.1	37.8	18.0	16.7	1318	1:1.96
Chemo intensive IPM (CIPM)	3.1	5.9	31.9	14.6	13.0	1596	1:2.66
Farmers practice	5.9	7.6	44.8	21.7	17.9	997	1:1.68
CD at 5%	NS	NS	3.4	3.8	0.97	215	-
			Gulbarga				
Biointensive IPM	-	0.92	30.9	-	-	1023	1:4.02
Chemointensive IPM	-	0.65	23.3	-	-	1173	1:5.33
Farmers practice	-	4.03	41.5	-	-	689	1:2.28
CD at 5%	-	1.20	2.9	-	-	56	-
			Sehore				
Biointensive IPM	0.3	0.8	-	4.9	5.1	1184	1:2.09
Chemointensive IPM	0.2	0.8	-	5.2	5.4	1137	1:2.02
Farmers practice	1.2	1.9	-	9.6	9.6	921	1:1.65
CD at 5%	0.3	1.0	-	2.2	2.2	49	-

respectively) at this location. At Gulbarga, intercrop of safflower in 6:2 row was better (12.54% pod damage) than 3:1. Due to high pest pressure, CIPM performed better (10.0% pod damage) than BIPM (12.68% pod damage).

Ten promising chickpea genotypes having confirmed resistance against wilt were screened against *H. armigera*. These genotypes showed only low to moderate resistance against this pest at all the 3 locations namely Kanpur, Sehore and Gulbarga in on-station trials. Promising accessions from these localities were RSG 888, JG 130, ICCV 10, PDG 84-10 and JG 74. Among the antagonistic fungi (AF) tried against chickpea wilt, PDBC Tv 23 and Th 10 strains of *Trichoderma* were superior in reducing disease incidence (22-24%) which was on par with chemical treatment of Thiram + Carboxin (22.8%) as against 44.7% incidence in control. Seed inoculation with *Bradyrhizobium* and treatment with *Trichoderma* were compatible for good nodulation in chickpea. Encouraging results were obtained with the egg parasitoid *Telenemus remus* which showed 95% parasitisation of *H.armigera* eggs. A new egg parasitoid, *Trichogramma mwanzai* was imported from Kenya which is under quarantine evaluation.

On-farm adaptive research was carried out in 8 districts covering 27 villages in the states of U.P., M.P. and Karnataka wherein BIPM and CIPM modules were compared with farmers practice. Over all data for three years (2000-2003) indicated that BIPM recorded lower pod damage (6.25%) than CIPM (7.07%) and farmers practice (12.75%) at Kanpur. At Sehore, both BIPM and CIPM showed on-par performance, while at Gulbarga, CIPM was superior mainly due to high pest load. At all the locations, BIPM recorded much lower pod damage than farmers practice. Pooled data of 3 years in each of the target districts revealed that both yield and cost benefit ratios were higher with BIPM at Kanpur whereas at Sehore and Gulbarga, CIPM was superior (Table 2).

Nematode control in pulses

Root knot and cyst nematodes cause considerable damage to pulse crops sometimes causing up to 30% yield losses. An integrated project was taken up to assess the nematode population in major pulse growing areas, identify low cost management techniques based on biological methods, resistant cultivars and cropping systems both in pigeonpea and chickpea. A large number of on-farm trials were conducted besides extensive survey of farmers fields in target districts for the nematode infestation.

Heterodera cajani was the major nematode in pigeonpea, while root-knot nematode, *Meloidogyne incognita* was recorded as a major problem both in pigeonpea and chickpea. The major findings are:

Table 2 : Yield and cost benefit ratios in chickpea on farmers fields in 3 target districts with different IPM modules (Mean of 3 years, with 10 farmers at each location)

Module	Kanpur			Sehore			Gulbarga		
	Yield kg/ha	Increase over FP (%)	C:B ratio	Yield kg/ha (%)	Increase over FP	C:B ratio (%)	Yield kg/ha	Increase over FP	C:B ratio
BIPM	1717	32.3	1:3.42	1555	5.0	1:2.47	1417	43.0	1:4.15
CIPM	1668	30.0	1:3.77	1650	10.0	1:3.39	1522	47.0	1:6.79
FP	1161	–	–	1475	–	–	798	–	–


Promising chickpea based intercropping systems for IPM on farmers fields in Hamirpur district, U.P

Pigeonpea

- Population of root-knot nematode on pigeonpea was highest in the month of September, whereas it was lowest in December/January.
- Pigeonpea + pearlmillet- fallow cropping system or intercropping with sorghum + sesamum at 1:1 ratio was found effective in reducing pigeonpea cyst and root-knot nematodes significantly. Short duration pigeonpea followed by cereals or fallow was a cost effective method to control nematode population. Nematode infestation was low in intercropping of maize + pigeonpea and sorghum + pigeonpea than sole pigeonpea.
- Among different management practices tried, highest economic returns were achieved by the integrated approach of seed treatment with neem seed powder (@ 5% w/w) + latex of *Calotropis procera* (@1% v/w) which was followed by seed treatment with neem seed powder, latex of *C.procera*, intercropping with bajra, and soil application of neem seed powder @ 50 kg/ha and summer ploughing 2-3 times at fortnight interval (Table 3). Being low input technologies, these management options can be easily adopted by farmers.
- Pigeonpea CV-ICP-8863, KPL-44, ICP-14722, ICPL-89048, PI-397430, ICPL-89045 and ICP-8859 were showed nematode resistant reaction under field condition.
- Wilt resistant cultivars of pigeonpea ICP 9114, ICPL 8863, DPPA 85-13, ICP-14722, PI 397430 and ICP 12 were found susceptible in the presence of pigeonpea cyst nematode, *Heterodera cajani* and wilt fungus. The wilting percentage of the resistant cultivars increased in the presence of both nematodes and fungus.
- Seed treatment with neem seed powder @ 5% w/w + *Paecilomyces lilacinus* @ 10^8 spore/kg seed enhanced the grain yield and reduced the root-knot nematode population significantly.
- Seed treatment with neem seed powder @ 5% w/w alone and in combination with latex of *Calotropis procera* @ 1% v/w reduced the wilting of plants considerably and increased the yield by two fold with cv UPAS-120 and 35% with cv.Bahar.

Chickpea

- Monitoring of nematode population in chickpea growing farmer's fields indicated that *Meloidogyne incognita, Heterodera cajani, Pratylenchus thornei, Tylenchorhynchus brassicae* and *T.indicus* were present in all chickpea fields and reproduced at high frequency.
- Intercropping of mustard with chickpea was the most effective method of reducing nematode

Table 3: Comparative efficacy of chemical and biological methods of controlling root-knot nematodes in pigeonpea and chickpea in the OFTs carried out in Kanpur and Itawa districts (Mean of 6 farmers in each village for 3 years)

Treatments	Baikunthpur (Kanpur)						Bakewar (Itawa)					
	Chickpea			Pigeonpea			Chickpea			Pigeonpea		
	Yield (kg/ ha)	*Meloidogyne* population/ 100cc		Yield (kg/ ha)	*Meloidogyne* population/ 100cc		Yield (kg/ ha)	*Meloidogyne* population/ 100cc		Yield (kg/ ha)	*Meloidogyne* population/ 100cc	
		45 DAS	70 DAS		45 DAS	70 DAS		Initial	Final		Initial	Final
Seed Treatment - Chemicals												
Dimethoate	1730.3	28.7	53.2	1624	119.5	43.2	1567.2	137.0	46.7	1522.0	134.7	49.7
Monocrotophos	1715.1	47.0	80.2	1640	127.7	33.0	-	-	-	1470.0	118.5	35.7
Chlorpyriphos	1353.9	46.7	74.0	1466	134.5	24.7	1283.0	134.0	36.0	1992.0	128.7	30.0
Triazophos	1570.3	44.2	75.7	1734	131.0	34.7	997.5	129.0	49.0	1762.0	130.2	38.5
Seed Treatment - Botanicals												
Neemark	1590.0	41.5	81.0	1632	132.7	27.7	967.0	135.2	51.0	1578.0	134.0	34.7
Neem seed powder	1918.1	29.0	48.7	1980	133.5	20.5	1608.5	133.5	32.7	2608.0	129.7	22.2
Latex	1874.7	29.5	54.7	1994	130.5	22.0	1636.7	131.7	38.0	2642.0	132.5	23.0
Seed Treatment - Bioagents												
Aspergillus niger	1631.7	38.5	71.0	1586	128.0	32.0	1018.5	127.2		1088.0	131.7	34.0
Paecilomyces lilacinus	1867.8	27.0	54.7	1676	129.5	36.0	1115.5	134.5	53.5	1186.0	132.7	40.5
Soil Application - Chemicals and Botanicals												
Carbofuran	1569.3	42.0	80.5	1950	132.7	25.2	-	-	-	2620.0	134.0	20.7
Neem seed powder	1709.6	45.0	75.5	1638	136.7	32.5	-	-	-	1452.0	138.5	37.5
Check	1473.4	68.7	122.2	586	136.2	130.0	715.7	132.5	119.0	1016.0	134.7	130.2
CD at 5%	682.81	7.2	7.8	343.1	10.50	9.86	82.81	9.58	17.34	530.9	12.91	9.31

population. In mustard + chickpea inter-cropping system, infestation of root-knot nematode was significantly lower than sole chickpea.

- Wilt resistance in resistant chickpea cultivars (Avrodhi, Phule G5, KPG-59 and H-86-72) was broken down in the presence of root-knot nematode and wilt fungus (*Fusarium oxysporium, F. sp. ciceri*) which was observed in varying degrees depending upon the level of infestation. Cultivars showing less than 10% incidence can be grown in nematode infested areas.
- Field trials in nematode infested farmer's fields showed highest C:B ratio when seed treated with neem seed powder @ 5% w/w followed by latex of *Calotropis procera* (@ 1% v/w), dimethoate (@ 0.8% w/w), *Paecilomyces lilacinus* (@ 10^8 spores/Kg seed) and soil application of neem seed powder (@ 50 kg/ha).
- Demonstration trials on integrated nematode management on several farmer's fields showed successful performance of the technology of seed treatment with neem seed powder @ 5% w/w + Latex of *C.procera* @ 1% v/w against nematode and wilt complex. Soil application

of neem seed powder @ 50kg/ha and seed treatment @ 5% w/w increased the grain yield by more than 30% over check and reduced the nematode population upto 40%.

- Seed treatment with neem seed powder @ 5% w/w and spore suspension of *Trichoderma harzianum* @ 2% v/w reduced the spread of the wilting of plants 75 days after sowing and increased the grain yield by two fold.

Yellow mosaic virus control in pulses

Yellow mosaic virus (YMV) causes severe yield losses in short duration pulses like mungbean and urdbean. Besides assessing the disease incidence and severity in different states, an integrated package was tried for three years at Hyderabad, Coimbatore, Berhampur and Kanpur for effective management of the disease through participatory on-farm trials. Additionally detailed studies on epidemiology of the virus were also carried out at all locations. Based on the survey at different locations in the country, PBNV in Andhra Pradesh, MYMV in U.P., MYMV and ULCV in Tamil Nadu and MYMV and PBNV in Orissa were found to be most important viral diseases causing economic yield losses. It was further noted that in Tamil Nadu, urdbean grown in late *kharif* season was free from disease. Similarly MYMV incidence in *kharif* mungbean was negligible in Orissa. A positive relationship was observed between *Thrips* population i.e. *Thrips palmi* and PBNV incidence in A.P.

Appropriate spacing (30 x 5cm) of mungbean and urdbean in A.P. could reduce the disease incidence and vector population to minimum in A.P. Sorghum or pearlmillet as intercrops in mungbean and urdbean could effectively check the virus incidence both during *kharif* and *rabi*. MYMV resistant cultivars in mungbean and urdbean were identified at Kanpur (mungbean cv. Narendra Mung-1; urdbean cv. IPU-94-1), Coimbatore (Mungbean cvs. VGG77 and CO-6; Urdbean cvs. ADT-5, Vamban 3 and VBG 55) and Berhampur (mungbean cvs. TM 96-2 and PDM 84-143; urdbean cvs. PU-30 and KU-300) where MYMV is economically important. Several other entries with multiple disease resistance were also identified.

On-farm testing of the integrated virus management package in different target districts gave encouraging results. The package tried in A.P. to control PBNV in mungbean and urdbean consisted of seed treatment with Gaucho, intercropping with sorghum at 1:3 ratio and spray with Imidaclorprid after 30 days of sowing. Many farmers have not accepted sorghum intercrop in mungbean and urdbean, and hence a 7-row border crop of sorghum was suggested which farmers readily accepted. At Behampur, in both the crops, seed treatment with imidacloprid @ 5 g/kg and thiamethoxam @ 2 g/kg followed by spraying of

Crop stand of urdbean under farmers practice (left) and integrated management package (right) on farmers fields in Berhampur district of Orissa imidacloprid @ 0.25ml/liter irrespective of sole crop or inter crop resulted in low disease incidence, vector population and higher yield in all the test varieties. In Coimbatore, Vamban and Arupukottai districts of Tamil Nadu, growing resistant cultivars was found to be the most effective component of the virus management in mungbean and urdbean. In Kanpur district also, growing resistant varieties of mungbean and urdbean was the best and most economical practice for management of YMV.

Efficient management of pulse based intercropping systems

Major pulse crops like pigeonpea and chickpea are grown in different intercropping systems with crops like sorghum and pearlmillet. Over the years many package of practices on efficient variety, integrated nutrient management (INM), integrated weed management (IWM) and soil moisture conservation have been recommended for different soil types and cropping systems. However, they have not been tested in an integrated manner on farmers fields for their effectiveness and economic viability.

On-farm trials were conducted in Ahmednagar (pigeonpea + pearlmillet), Sehore (pigeonpea + soybean), Kanpur (chickpea + mustard), Gulbarga (pigeonpea + sesamum), Amaravati (pigeonpea + soybean), Guntur (pigeonpea + mungbean), Bharuch (pigeonpea + urdbean) and Ranchi (pigeonpea + rice) districts wherein different treatments of integrated nutrient and weed management practices along with superior variety were compared with farmers practice for two years (2001-02 and 2002-03). Each trial was laid out on 5 farmers fields or more. Following are the best practices identified at each center.

- In Ahmednagar, intercropping of pigeonpea (BSMR-736) + pearlmillet (*Shraddha*) with ridges and furrows for (moisture conservation) + 50% RDF + 5 t/ha of FYM + biofertilizers + weed control (through herbicides) was found to be the best package (9.07 and 8.34 q/ha of pigeonpea and pearlmillet respectively). The net monetary returns of the system were Rs.9585/ha.

Pigeonpea + soybean intercropping system on farmers field in Chandwad village of Sehore district under best treatment

- In Sehore, INM (50% RDF + FYM @ 5 t/ha + biofertilizer) along with weed control through pendimethalin @ 0.75 kg a.i./ha recorded the highest pigeonpea equivalent yield (15.92 q/ha) and net returns (Rs.13,321/ha) in pigeonpea + soybean (2:4) intercropping system.
- In Kanpur, highest grain yield of chickpea (18.19 q/ha), mustard (5.91 q/ha) and chickpea equivalent yield (25.28 q/ha) were obtained from intercropping of chickpea + mustard (6:2) with INM (50% RDF + 5 t/ha + FYM + biofertilisers) + IWM (Pendimethalin PE @ 0.75 a.i. kg/ha) + one hand weeding at 40 DAS).
- In Guntur, intercropping of pigeonpea + mungbean (1:3) with 100% RDF + moisture conservation (twice intercultivation) recorded the highest net returns (Rs.12466/ha) and benefit : cost ratio (1.86).
- In Gulbarga, intercropping system of pigeonpea + sesamum (1:2) with 50% RDF + FYM @ 5 t/ha and (application of

Pendimethalin @ 1.5 a.i. kg/ha + one hand weeding at 45 DAS) recorded highest grain yields of pigeonpea (14.88 q/ha), sesamum (3.31 q/ha) and pigeonpea equivalent yield (PEY) (19.24 q/ha).

- In Amaravati, highest pigeonpea equivalent yield (PEY) (14.84 q/ha) was obtained from intercropping of pigeonpea + soybean (1:2) with 100% RDF (25:50:00 NPK kg/ha - pigeonpea & 30:75:00 NPK kg/ha - soybean) + moisture conservation (opening of furrow in the row with a hoe at 30 DAS).
- In Bharuch, intercropping system of pigeonpea + urdbean (1:2) + 100% RDF (20:40:00 NPK kg/ha for both the crops) + moisture conservation (BBF) recorded highest PEY (15.21 q/ha) and B:C ratio (1:3:6).
- In Ranchi, maximum seed yield of pigeonpea (11.01 q/ha), rice (9.12 q/ha) and PEY (13.01 q/ha) were obtained with intercropping system (pigeonpea + rice 1:2) + moisture conservation (compartmental bunding) + INM (50% RDF + 5 t FYM/ha + biofertilisers) + IWM (Pendimethalin PE @ 1.5 kg/ha + one hand weeding (45 DAS).

In situ moisture conservation in pulse based cropping systems

Farmers adopt various indigenous moisture conservation practices (ITK) in pulse cultivation across the country. The performance of such ITKs and its improved versions were evaluated in comparison to recommended practices in 86 on-farm trials in 7 districts viz., Nalgonda, Agra, Bijapur, Jabalpur, Mirzapur, Solapur and Kota on major pulse based cropping systems.

In Nalgonda district, conservation furrow at 3m interval in castor + pigeonpea intercropping system (5:1) increased the interception of runoff which resulted in 11 % additional moisture storage in the profile over farmers practice and increased yield of both component crops. In deep alluvial soils of Agra district, growing of green gram (5.8 q/ha) for grain with moisture conservation practice of dyking during *kharif* followed by mustard (13.7 q/ha) during *rabi* proved better package than fallow-mustard (11.5 q/ha). In medium to deep Vertisols of Bijapur district, greengram – sunflower production system with compartmental bunding during *kharif* resulted in increased yield of green gram (15 q/ha) compared to farmers practice (11.5 q/ha). During *rabi,* wider row spacing (135 cm) for sunflower compared to farmers' practice (35 cm) gave 162 % higher yield over farmers practice (8.7 q/ha). In shallow soils, higher yields were recorded with intercropping of pigeonpea (5.7 q/ha) and groundnut (7.8 q/ha) in 2:4 ratio with deep ploughing, residue incorporation and conservation furrow compared to farmers' practice (1: 5 row ratio) and ploughing with country plough (4.5 + 6 q/ha).

In Jabalpur district, improved system of *Haveli* i.e., partial collection of *haveli* water within or in the vicinity of *haveli* fields and recycling the harvested water for supplemental irrigation to *rabi* chickpea resulted 21% increased yields over farmers practice (15.9 q/ha) of growing chickpea on conserved soil moisture after release of impounded water from *haveli* fields. For *in-situ* moisture

Performance of pigeonpea on ridge and furrow system on farmers fields in Varanasi district conservation on sloppy lands, improved method of line sowing across the slope and furrowing at 1.8 m interval yielded higher soybean (13.7 q/ha) compared to farmers' method of broadcast sowing without furrowing (9.3 kg/ha). Similarly moisture conservation practices during *kharif* resulted in higher yields of *rabi* crops like wheat.

At Kota, mechanized tillage (summer ploughing with tractor drawn MB plough followed by harrowing with cultivator) and conservation furrows at 3.6 m interval across the slope recorded an additional yield of 3.9 q/ha (30%) in maize and 107 kg/ha (16%) in blackgram compared to farmers' practice of summer ploughing with *kuly* (13 q/ha and 6.9 q/ha) in maize+blackgram (1:1) inter cropping system. At Varanasi, summer tillage with MB plough, line sowing of pigeonpea and sesame resulted in doubling of pigeonpea equivalent yields (17.1 q/ha) over farmers' practice of summer criss cross ploughing with country plough and broadcast sowing (8.3 q/ha). Ploughing with tractor drawn MB plough resulted in 12% additional moisture storage in the profile and 10% reduction in run off from treated fields. Improved practice of planting pigeonpea on ridges and rice in furrows in ridge and furrow land configuration doubled the yield of pigeonpea (16.4 q/ha) and recorded bonus rice yield of 8.7 q/ha as compared to only 11.8 q/ha of pigeonpea with farmers' practice (flat planting pigeonpea).

The 3 years on-farm trials in different target districts showed that improved ITK was significantly superior to farmers ITK in most cases, but the differences between IITK and recommended package of practices (scientific method) were not significant. To illustrate, the pooled data for 3 years on groundnut + pigeonpea intercropping system on farmers fields in Bijapur district is given in Table 4.

INM in pulse based cropping system

Integration of INM with moisture conservation in a given cropping system is key for improving productivity and stability. Although, the advantages of INM and moisture conservation were proved in on station trials, their adoption and economics under real farm conditions have not been studied. In a network project on 60 farmers fields in 5 target districts, the best INM+soil moisture conservation (SMC) practice for most profitable pulse based cropping systems were identified in OFTs conducted for 3 years. In Bhopal and Raisen districts, economic analysis of soybean-chickpea and soybean-lentil system with a range of nutrient management options indicated that 75% NPK + 2.5 t FYM/ha along with soil moisture conservation measure during *kharif* season

Table 4: Performance of farmers ITK, Improved ITK and scientific method of moisture conservation in groundnut + pigeonpea intercropping system on farmers fields in Bijapur district (mean of 10 farmers for 3 years i.e. 2001-2003)

Treatments	Row ratio	Yield (kg/ha) Pigeonpea	Yield (kg/ha) Groundnut	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)
Cross ploughing with wooden plough(ITK)	5:1	397	614	19426	6555	12871
	4:2	496	591	20748	7158	13593
Deep ploughing + residue incorporation (IITK)	5:1	467	712	22646	7305	15341
	4:2	546	663	23088	6305	16783
T2+Conservation furrow (scientific)	5:1	528	791	25325	7105	18220
	4:2	610	765	26280	7255	19025

was by far the most profitable treatment, which led to 14 to 23% more chickpea and 18 to 27% more lentil yield during *rabi*. Soybean-chickpea was the most productive/remunerative cropping system in Bhopal and Raisen districts. In Hamirpur district, 100% NPK + FYM + moisture conservation was the best practice among the nutrient management options tried and urdbean-chickpea was more remunerative than sorghum- chickpea system. In Rewa and Satna districts, paddy-chickpea system was more profitable with INM (recommended NPK + FYM) + drainage/moisture conservation treatments which resulted in 27-65% higher chickpea yield over farmers practice. In addition to supporting higher yields, this treatment improved soil quality parameters at all locations.

The improved INM technology was adopted by 70% of farmers during 2003-04 in target villages with an average yield gains of 7.87 qha^{-1} in soybean, 9.33 q ha^{-1} in paddy and 5.87 q ha^{-1} in chickpea. The total production in the villages of Banganala watershed of Rewa district increased by 1234 quintal of soybean, 2684 quintal of paddy and 1192 quintal of chickpea whereas in village Pal of Jhalmal nala watershed in Satna district, increased production of 358 quintals of soybean 1372 quintals paddy and 247 quintals of chickpea were recorded. Data on the benefit cost analysis of various cropping systems in the target districts are presented in Table 5.

Liquid biofertilisers

Biofertilisers in India are generally packaged in carrier materials like lignite, charcoal and soil + FYM etc. Contamination has been a major constraint with carrier-based inoculants which results in low shelf life and poor quality inoculants. A technology for production of liquid bio-fertilizers was standardized at university of Agricultural Sciences, Bangalore for *Bradyrhizobium* initially, which was latter extended to *Azotobacter, Azospirillum* and PSB (*Bacillus megatherium*). The technology is based on use of cell protectants like PVP and glycerol. By changing the proportion of the cell protectants, two formulations i.e. LF-1 and LF-2 were developed for each of the organism. LF-2 was found to be superior than LF-1 for all the organisms in terms of longer shelf life. In case of *Bradyrhizoium,* liquid inoculant maintained

Table 5: Benefit: cost analysis of various cropping systems in 4 target districts under different nutrient management options (mean of 15 farmers in each district, pooled over 3 years, 2000-03)

Treatments	Bhopal & Raisen		Hamirpur		Rewa & Satna	
	Soybean-Chickpea	Soybean-Lentil	Sorghum-Chickpea	Urdbean-Chickpea	Soybean-Chickpea	Paddy-Chickpea
T_1	1.82	1.33	1.28	1.56	2.00	1.86
T_2	1.93	1.39	1.43	1.75	2.07	1.92
T_3	2.05	1.46	1.33	1.68	2.17	2.08
T_4	2.29	1.59	1.27	1.67	2.10	2.18
T_5	2.09	1.60	1.44	1.77	1.98	2.33
C.D (P=0.05)	0.27	0.24	0.12	0.14	NS	0.21

Soybean-Chickpea / Soybean-Lentil / Paddy-chickpea
T_1 Farmers practice
T_2 Recommended NPKS Zn
T_3 75% recommended NPK + FYM (@2.5 t/ha)
T_4 75% recommended NPK + FYM (@2.5 t/ha) + SMC/drainage
T_5 100% recommended NPK + FYM (@2.5 t/ha) + SMC/drainage

Urdbean-Chickpea / Sorghum-Chickpea
T_1 Farmers practice
T_2 100% NPK
T_3 75% NPK + FYM
T_4 75% NPK + FYM + SMC
T_5 100% NPK + FYM + SMC

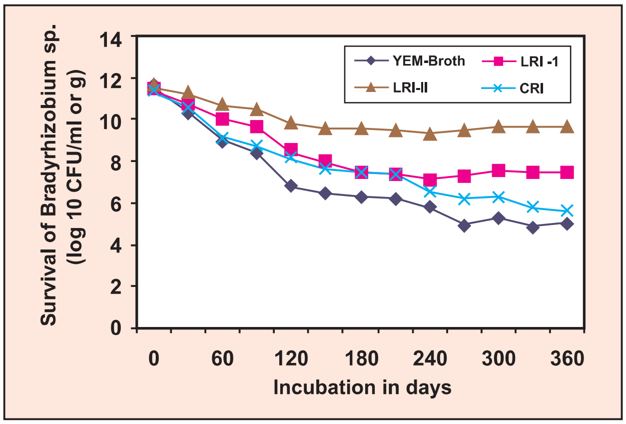
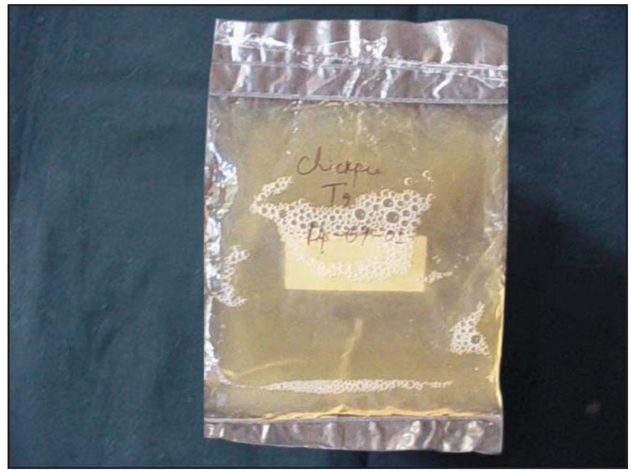


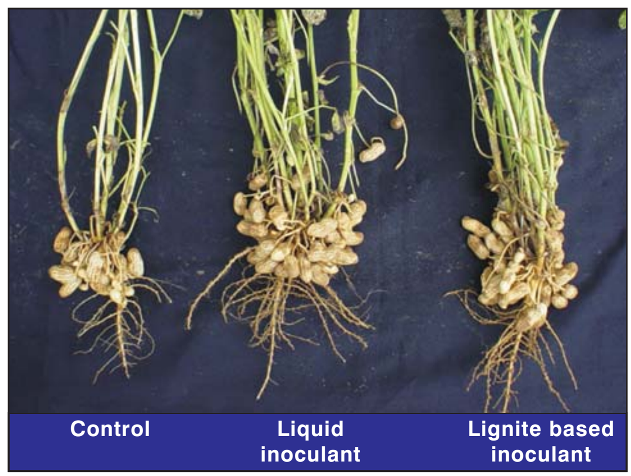
Fig.1: Effect of different inoculant formulations on the shelf life of *Bradyhizobium sp.*



Liquid Rhizobium inoculant

significantly superior counts of the organism upto one year (Fig.1). Storing the liquid inoculant in a pitcher filled with wet paddy straw was found to be the best low cost method for effective protection from high temperature and other adverse conditions.

The agronomic performance of the liquid *Rhizobium* inoculant (LRI) was evaluated through on farm trials for two years (2001-02 and 2002-03) in 13 districts covering 7 states through the KVKs. The over all results indicated the superiority of LRI over carrier based inoculant (CRI), in all the crops tested; but the highest was in soybean (Fig.2). The superior performance of the LRI was due to improved nodulation which led to higher seed yield.



Nodulation and pod yields of groundnut using different formulations of *Bradyrhizobium*

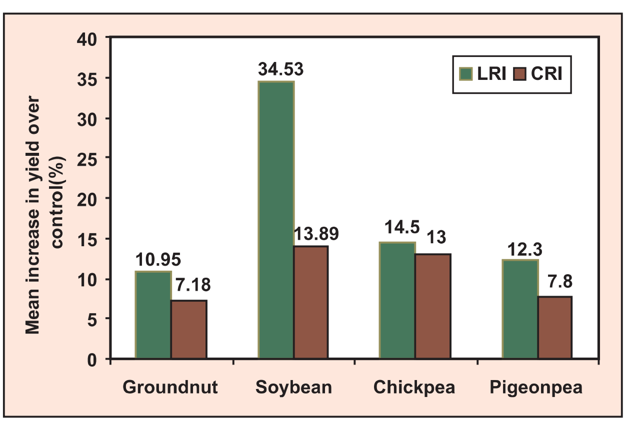


Fig.2: Performance of LRI and CRI in various pulse crops on farmers fields (based on mean of two years, from 3 locations for each crop and 10 farmers at each location

Low cost technologies for safe storage of pulses

Stored grain pests in pulses cause up to 30 per cent loss in farmers households mainly due to high moisture and improper storage conditions. In a net work project at Bhopal, Kanpur, Hissar and Coimbatore, a number of storage structures and chemical/herbal measures were tested in farmers households to minimize the losses due to pulse beetle.

At CIAE, Bhopal, pigeonpea could be stored safely upto 180 days in metalic bins after treating with 4% sodium bicarbonate solution. The technique of pre treatment with $NaHCO_3$ was widely popularized among farmers with 60% acceptability in the target districts. In Kanpur district, results from farmers household trials showed that inert materials such as *Parad Tikri* (half to one tablet/2 kg seed) and activated charcoal powder (12 g/kg seed) were most effective against bruchid, whereas lime, alum and fly ash recorded moderate level of protection. Oils of castor, mahua, neem and mustard (10 ml/kg seed) and plant products viz. annona seed powder, neem seed kernel powder and asaofetida were effective against bruchid wherein the seeds could remain infestation free and retain viability (85%) upto 9 months.

In Hissar district, groundnut oil @ 3.75ml/kg+turmeric powder @ 1.75g/kg, mustard oil @ 3.75ml+turmeric powder @ 1.75g/kg, neem oil @10ml/kg and 7 cm sand and dung cake ash covering were effective in controlling pulse beetle. The solar bed technique found effective from earlier studies was widely popularized during the year. The project thus helped in standardizing a number of low cost methods of pulse storage based on locally available herbal material and advanced techniques like use of traps and probes.

The probe-cum–pitfall trap developed, tested and demonstrated among farmers/households in Tamil Nadu reduced the grain damage by 3.5 times compared to traditional storage. The technology was transferred from TNAU to M/s. K.S.N.M. Marketing, Coimbatore for commercial manufacture. The trap is also being popularized by University of Agricultural Sciences (UAS), Dharwad in Karnataka under UAS-CIDA Project and under 'Grama Bhandari Yojana' scheme of Govt. of India in rural godowns of Tamil Nadu. During 2003-04, training programmes were conducted on $NaHCO_3$ pretreatment in 4 villages of Bhopal for 55 farm women on use of inert materials on herbal products /oils in 4 villages in Kanpur district for 53 farmers and for 27 women farmers on solar bed technology in 3 villages of Hisar district.

Improved dalmill for better recovery

Dal milling is an important way to add value to pulses and improve the profitability to farmers. To improve existing dal mill in terms of better recovery, quality and to reduce energy consumption three different models of dal mills were upgraded and tested at Kanpur, Bhopal and Hyderabad. Results from three years studies indicated that IIPR dal chakki was superior to CIAE and CFTRI models for key performance parameters. During 2002-03, the IIPR dal mill was modified to address some of the important defects detected in earlier study. Increasing the shaft diameter and the bearing width addressed the problem of uneven wearing of rubber discs. A pre-grader for raw grain, a grader for finished product, and speed reduction unit were added to improve the utility of the mill. The upgraded model is powered by 1.5 HP single-

Highly bruchid infected mungbean (left) pitfall trap demonstration to control pulse beetle (center) and drying on black polythene (right) phase motor performing all operations from grading of raw material, milling, husk separation to finished product grading. The first prototype of this mill costs about Rs.32,000/- along with prime mover but the commercial prototype would cost much less. With reel type grader, the grading requirement of IIPR Dal Mill was effectively met. At CRIDA, a pulse grain pre-treater cum dal polishing unit was designed and fabricated to improve the marketability of finished product. At CIAE, Bhopal, power operated cleaner/grader with a 400 kg/hr capacity has been fabricated. This cleaner contributes to low pollution inside the milling premises and maintains a healthy environment.

With upgradation of these dal mills, quality of finished products as well as working efficiency have improved significantly. Pre-milling treatment of pulse grain had also influenced the dal recovery and dehusking efficiency. Maximum finished product recovery for pigeonpea was obtained with oil and water treatment. The final product was found to be of acceptable quality to the trade. So far, 180 IIPR Dal Chakkis were sold to farmers indicating the high acceptability of the IIPR model.

As an entrepreneurship development effort, the existing dal mill with a farmer in Settur village of Anantapur district (A.P.) was modified to mill pigeonpea. With little modification of replacing the existing roller, providing an extra sieve set and a dal polisher, the farmer improved his income substantially. A comprehensive entrepreneurship development programme is under progress to popularize the modified versions of dal mills in different states.

Pulse by-products in goat production

Goat rearing is an important occupation of small and landless farmers in the country. Goats are reared mainly on grazing, but for intensive goat production, it is necessary to supplement with limiting nutrients through crop by products. Locally available by-products of pulses, oilseeds and cereal grains were evaluated for intensive goat production using local breeds of goat at Mathura (UP), Bidar (Karnataka), Akola (Maharashtra) and Hyderabad (AP).

At CIRG, Mathura, the kid starter ration made from 82 % by-product of pulses and oil seeds (arhar chuni - 30 parts, gram chuni-12 parts, til cake- 20 parts, linseed cake-10 parts, and mustard cake-10 parts) having 20% crude protein and 65 % total digestible nutrients (TDN) resulted in maximum average daily weight gain (58 g/h/d)with minimum cost of feed/kg body weight gain (Rs.29.76/-) when offered *ad libidum* along with arhar straw and available green fodder as compared to other feed combinations. Finisher ration containing 44 % by-product of oil seeds and pulses (linseed cake-12 parts, til cake-15 parts, arhar chuni-9 parts, gram chuni-8 parts) having 15 % crude protein and 75 % TDN offered @ 2% body weight to *Barbari* goats along with arhar straw *ad libdum* and available green fodder @ 300-400 g/ h/d produced 58 gm average daily body weight gain (BWG) with a feed cost of Rs. 36.43/kg BWG

Modified IIPR dalmill (left), rotary screen grader (center) and polishing machine (right)

Complete feed pellets prepared with different ratios of pigeonpea straw and concentrate for feeding goats at Akola (left); Feeding trails with milk replacer to kids at Mahboobnagar, A.P. (right)

and good quality meat and meat products. Good quality kofta could be prepared and stored upto 4 months from the meat of the animals fed on above finisher ration.

At Bidar, complete feed made from red gram straw 47 %, black gram straw 10 %, maize 13.18 %, groundnut cake 13.98%, black gram chuni 3.62%, red gram chuni 3.62%, rice polish 2.4%, wheat bran 2%, mineral mixture 1.7 % and molasses 3 % having roughage to concentrate of 57:43 with 15.9 % digestible CP and 65.98 % TDN had 4.95 % dry matter intake with an average daily gain of 75 gm /head in local *Bidri* goats. At ANGRAU, Hyderabad, better growth (80.25 g/h/d) with high feed conversion efficiency (9.56 %) and low cost per kg body weight gain (Rs.35.51/-) was recorded in local goats reared on complete diet consisting of arhar straw 35 %, subabul leaves 25 %, groundnut cake 12 %, maize 23 % molasses 2 %, mineral mixture 2 % and salt 1 % with slightly higher dressing percentage and higher fat and lower lean meat as compared to other feed combinations. At Akola, complete feed made from arhar straw 60 %, groundnut cake 10.8%, arhar chuni 12 % cotton seed cake 4 %, jowar 12 % mineral mixture 0.8 % and salt 0.4 % (14.87 % crude protein) proved better as compared to other feed combinations.

A complete feed consisting of arhar chuni straw 50 %, subabul leaves 10 %, groundnut cake 14 %, maize 8%, wheat bran 9%, arhar chuni 2%, rice polish 2 %, molasses 2%, mineral mixture 2% and salt 1% with 13.76% crude protein and 55.77% TDN were found better for lactating goats (does) in A.P. The milk replacer containing 9 % soybean meal with 24 % crude protein were found palatable at all the centers and can be used safely for rearing young kids (20 to 90 days of age).

The goat breeds fed with pulse by-products had the potential for meat production as they attained above 10kg carcass weight at the age of 9 or 10 months when proper combination of CP and TDN were maintained in their ration. Good quality Kofta could be prepared from Barbari goats and safely stored for 4 months without significant loss in eating quality. Practical demonstrations of products developed from pulse by-products were organized during training programmes on commercial goat farming at CIRG, Makhdoom covering 45-50 participants each time.

Agro economics constraints in pulse production

The agro-economic characterization and constraint analysis of rainfed chickpea and pigeonpea based cropping systems were carried out in 16 districts (48 blocks and 144 villages) in 5 states covering 864 farmers each for chickpea and pigeonpea. Data on soil, rainfall and input use etc. and important socio-economic variable were collected and related with productivity. The study indicated that the low yields attained by farmers are due to low and erratic rainfall in 75% of blocks having a co-efficient of variation of 20 to 50%. In most blocks, large and medium farmers attained better productivity compared to small farmers due to better resources and input use. Out of 48 blocks, farmers attained lower than average yields in 72% of the blocks and out of 144 villages, lower yields were realized in 80% of the villages. Pest and diseases were the next important biotic constraints causing production losses. The low yield realization was due to low and erratic rainfall, low to medium soil fertility, poor pest and disease management and lack of improved seed availability. Based on detailed analysis of constraints and opportunities, following strategies are suggested for improving chickpea and pigeonpea productivity in the target districts:

- Adoption of recommended soil and water conservation measures with focus on *in situ* moisture conservation
- Drought resistant/tolerant varieties that fit into the local cropping systems
- Adoption of integrated pest and disease management on whole village basis
- Integrated nutrient management in cropping system perspective
- More emphasis on intercropping in drought prone areas
- Crop insurance, support price and marketing

3.4 Cotton Based Production System

Sixty five percent of the cotton crop is grown in the rainfed production system. Productivity has been stagnating for quite some time due to a number of resource and crop related constraints. One major concern is the rising cost of cultivation and highly fluctuating productivity of hybrid cottons which is pushing many farmers into debt trap. Therefore under NATP, a major focus was given to identify *arboreum* cottons with superior quality so that the farmer's risk is minimized. Other resource management issues like rainwater conservation, INM and raising the crop on salt affected soils were addressed by conducting on-farm trials in major cotton growing target districts. Salient outcomes from these sub projects are outlined below:

Germplasm enhancement

Under this thrust area, four sub projects were implemented; ie.i) identification of superior quality arboreums; ii) development of transgenics in diploid varieties; iii) collection and evaluation of indigenous germplasm from NEH region and iv) evaluation of cotton germplasm for gossypol.

Arboreum varieties with superior fiber quality

In view of the increasing cost of cultivation of hybrid cottons, a project was taken up to identify quality *arboreum* varieties that are adapted to low input rainfed situations. Extensive OFTs were conducted in 6 target districts i.e. Parbhani, Dharwad, Nagpur, Khandwa, Adilabad (Mudhol) and Kovilpatti with 5 to 10 farmers in each district covering the major growing tracts. The best available quality *arboreum* in each district were compared with the leading *hirsutum* hybrids and Bt cotton hybrids. On-station studies was conducted at MAU, Parbhani on making further crosses and genetic improvement of fiber quality. Overall data for three years (2001, 2002 & 2003) indicated the clear superiority of *arboreum* varieties under farmers conditions. Quality *arboreums* like PA-255, PA-402, DLSA-17 and MDL-2463 either produced on par or superior seed cotton yield as that of leading *hirsutum* hybrids. Three years yield data

Table 1: Performance of quality *arboreum* varieties on farmers fields across locations in comparison to hirsutum checks and Bunny (based on 3 years mean)

Strains	Seed cotton yield (Kg/ha)				% increase over				C:B ratio
	2001-02 (35)*	2002-03 (26)	2003-04 (36)	Mean (97)	LAC	LHC	LHHC	Bunny	
Quality arboreums									
PA-255	835	1137	778	916	1.66	22.95	37.12	10.22	1:3.69
PA-402	803	1039	737	859	-	15.30	28.59	3.37	1:3.46
MDL-2463	853	1032	775	889	-	18.93	32.63	6.62	1:3.57
DLSA-17	850	1072	730	884	-	18.66	32.33	6.38	1:3.56
Checks									
LAC	800	1002	-	901	-	-	-	-	1:3.27
LHC	754	736	-	745	-	-	-	-	1:2.19
LHHC	662	750	592	668	-	-	-	-	1:1.57
Bunny	-	903	759	831	-	-	-	-	1:1.95

LAC = Local *arboreum* check, LHC = Local *hirsutum* check and Local *hirsutum* H x H hybrid check, (figures in parenthesis represent no. of locations)

from 97 OFTs on yield of quality *arboreums* as compared to local hirsutum checks and *Bunny* are presented in table 1. Higher C:B ratios are clearly evident with *arboreums.* Higher stability during drought years was another advantage observed with *arboreums*. The data from OFTs in different target districts clearly indicated that farmers can get comparable yields with *arboreums* while saving upto 40% on the cost of seeds and inputs associated with hybrid cottons.

Following is the introduction of Bt.cotton during 2002, it was necessary to compare the performance of quality arboreum *vis-à-vis* the Bt.hybrids. Sixty four OFTS were carried out for 2 years (2003-04 and 2004-05) comparing the best arboreums versus *Bunny* and MECH-184/162 in 6 target districts (Table 2). Despite the relatively low market price realized for arboreum cotton, the C:B ratio was significantly higher (1:2.68) than that of *Bunny* (1:1.49) and Bt. Cotton(1:1.92), mainly due to the lower cost of cultivation with arboreums.

Fibre quality assessment

One of the limitations in popularising *arboreum* cottons is the low market price for the lint obtained by the farmers due to the poor quality image associated with *desi* cottons. The fibre and yarn qualities of quality *arboreum* PA-

Promising quality arboreum genotypes, PA – 255 from Parbhani (left), DLSA 17 from Dharwad (center) and MDL-2463 from Mudhol (right)

Table 2 : Performance of quality *arboreums* in comparison with *Bunny* and Bt cotton in the OFTs in six target districts (mean of 2 years ie. 2003-04 and 2004-05)

Target districts	No. of farmers	Seed cotton yield (kg/ha)		
		Quality arboreum	Bunny	MECH-184 / 162 Bt
2003-2004				
Parbhani	5	847 (PA-255)	632	725
Dharwad	4	960 (DLSA-17)	781	1130
Nagpur	6	429 (PA-255)	484	525
Khandwa	6	1163 (PA-255)	1064	1246
Mudhol	10	1214 (MDL-2463)	1143	1267
Kovilpatti	5	495 (PA-255)	457	479
2004-2005				
Parbhani	5	915 (PA-255)	745	921
Dharwad	1	325 (DLSA-17)	695	750
Nagpur	5	760 (PA-255)	1099	1315 (RCH-2)
Khandwa	5	1147 (J. Tapti)	1040	1205
Mudhol	7	867 (MDL-2463)	863	1218
Kovilpatti	5	865 (PA-255)	950	880
Mean	64	796	829	971
Monetary returns		13,333	15,958	18,691
C : B Ratio		1:2.68	1:1.49	1:1.97

Cost of Cultivation (Rs./ha)

Quality *arboreums*	:	Rs.4960
Bunny	:	Rs.10,650
Bt hybrid	:	Rs.9450

Market Rate (Rs. / q)

Quality *arboreum*	:	Rs. 1675
Bunny / Bt hybrid	:	Rs. 1925

255 (*Parbhani Turab*) were therefore mill tested at M/s.Maral Overseas Limited, Indore an 100% EOU and compared with *hirsutum* variety LRA-5166. The quality parameters as assessed by Central Institute of Research on Cotton Technology (CIRCOT), Mumbai, using the advanced fibre information system are listed in Table-3. On most of the fibre and yarn parameters, PA-255 compared well with LRA-5166, a leading hirsutum type. These results confirm the quality superiority of improved *arboreum* cottons paving the way for an increased thrust on *desi* cottons for rainfed areas.

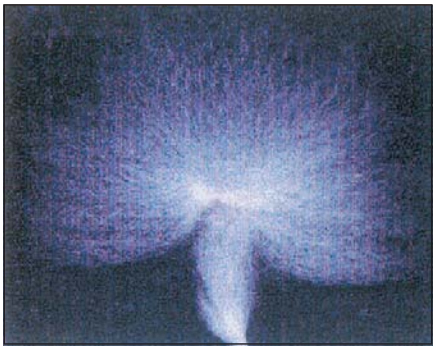
In case of yarn test also, PA-255 compared well LRA-5166 in count strength, transozet breaking

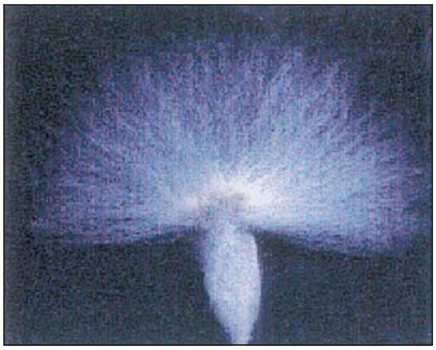
Table 3 : Comparison of fibre quality data of PA-255 (*arboreum)* and LRA-5166 (*hirsutum)*		
Trait	**PA-255**	**LRA-5166**
Length by weight (mm)	23.4	22.6
Upper quality length (mm)	27.7	28.3
Short fibre content (W) % < 12.7	8.9	13.9
Length by number (mm)	17.7	16.3
Short fibre content (n)	30.0	39.7
5 % length (mm)	32.1	31.8
2.5 % length (mm)	34.4	34.1
Fineness (m/tex)	16.6	16.4
Immature fibre content	5.4	6.7
Maturity ratio	0.92	0.87
Nep (um)	6.81	774
Nep (Cnt/g)	92.4	163
Seed coat Neps (um)	10.38	1439
Seed coat Neps (Cnt/g)	7.3	26
Uniformity ratio	48	46
Micronaire value	4.7	43
Fibre strength (g/tex)	22.9	22.7
Elongation (%)	4.9	5.6
Short fibre content	9.9	12.7

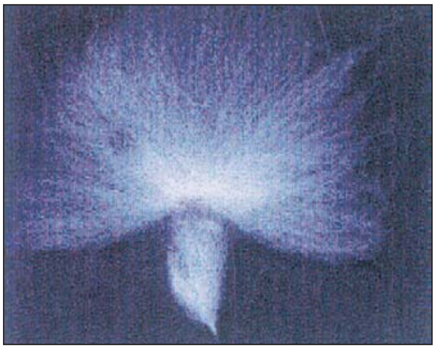
force, tenacity and elongation. Since *desi* cottons proved on par both in terms of yield and quality, they need to be popularised among farmers in rainfed areas. In view of the increasing demand for seed, each centre initiated steps to produce breeders seed. MAU, Parbhani produced 5 tons of seed during 2004. Each participating centre have also made sustained efforts to organise Kisan melas and interface with cotton corporation/ millers for popularising quality arboreums.

Indigenous cotton germplasms from NEH regions

A number of indigenous cotton cultivars of *G.arboreum* and *G.barbadense* were grown by local farmers on hill slopes in north eastern states since long. These cottons possess certain unique properties of stress tolerance, high ginning percentage and non-shedding of kapas after boll bursting. However in the recent past, cotton cultivation is going down here due to poor marketing facilities and much


PA-255 (26.3 mm)


PA-402 (26.1 mm)


NH-452 (23.5)

Comparison of fibre length of improved *arboreums* (PA-255 and PA-402) with *hirsutum* hybrids (NH-452) of the valuable germplasm is being lost. Therefore, an effort was made at AAU, Diphu to collect and characterize indigenous cotton germplasm of north eastern hill region.

Thirty five indigenous cotton germplasm were collected from various cotton growing areas of NE region. Out of these, twenty four were *arboreum* type and eleven were *barbadense*. Fifteen *arboreum* lines were also introduced from CICR, Nagpur and ARS, Amudalavalasa and Mudhol, in A.P both under ANGRAU. Of the eighteen *arboreum* germplasm evaluated during *Kharif* 2001, 2002 and 2003 for various quantitative traits (listed in Table 4) days to flowering ranged from 71.7 in *Pheloso-1* to in *Mizo white*-1. The maximum plant height was recorded in *Garo Kil*-1 (206.6cm) and *Phelo Chapong* -2 (197.3 cm). Number of bolls/ plant was maximum in *Phelosaw*-1 (17.9 bolls/ plant) followed by *Pheloso*-1(17.0 bolls/ plant).Maximum boll weight was recorded in *Garo Kil* 2 (3.9g), *Phelopisa* (3.8g), *Garo* 1 (3.7g), *Garo Kil* 3 (3.6), and *Karbi* (3.6g). Seed cotton yield was maximum in *Karbi* (641.3 Kg/ha). Out of the introduced germplasm LD 230 and RG 8 exhibited maximum seed cotton yield (893.3 Kg/ha and 797.7 Kg/ha respectively).

Significant differences were also recorded among the *barbadense* cultivars for various traits studied on the basis of pooled analysis over two years. The cultivar, '*Phelopi*-1' showed maximum plant height (229.5cm) followed by '*Fellopi*-2' and '*Phelo Cheng Cheng*-1' with a plant height of 224.7cm and 217.8cm respectively. Maximum number of branches per plant was recorded in

Table 4 : Key traits of promising indigenous *arboreum* and *babadense* germplasm lines from NEH region.

Trait	Range	Cultivar ranking in descending order
	G.*arboreum* (mean of 3 years)	
Days to flower (Maximum)	Up to 86 days	*Mizo white-1 and Garo-1and Mizo white-2*
Days to flower (Minimum)	Up to 71 days	*Pheloso-1, Phelopi-4 and Karbi Phelopi and Garo kil-1*
Plant height (cm)	Up to 207	*Garo Kil-1, & Phelo Chapong -2*
Boll no./plant	Up to 18	*Phelosaw-1and Pheloso-1*
Boll weight (g)	Up to 3.9	*Garo Kil-2, Phelopisa, Garo-1 Karbi and Garo Kil-3*
Seed cotton yield (q/ha)	6.41	*Karbi*
Over all insect pest resistance/tolerance	Leaf roller, jassids, white fly and spotted boll worm	*Karbi, Garo1, Garo Kil 3 and Pheloso 1*
	G.*barbadense* (mean of 2 years)	
Plant height (cm)	Up to 229.5	*Phelopi-1, Fellopi 2 and Phelo Chang Chang-1*
Branches/plant	Up to 12.33	*Phelopi-1and Fellopi 2*
Boll no./plant	Up to 58.7	*Phelopi-1and Phelo Chang Chang-1*
Boll weight (g)	Up to 2.56	*Fellopi 2 and Phelopi 3*
Seed cotton yield (maximum) (q/ha)	12.45	*Fellopi 2 and Phelopi-1*
Ginning (%)	Up to 32.22	*Phelosaw 4, Karbi Phelo-2 and Phelopi- 1*
Over all insect pest resistance/tolerance	Leaf roller, jassids, white fly and spotted boll worm	*Fellopi-2, Phelopi-1 and Phelo Chang Chang-1*

'*Phelopi*-1' (12.33/plant) followed by '*Fellopi*-2' (12.17/plant) . Maximum number of bolls per plant was recorded in '*Phelopi*-1' (58.66 bolls/ plant) followed by '*Phelo Cheng Cheng*-1' (53.67bolls/ plant). Among the cultivars, *Fellopi*-2 and *Phelopi* 3 showed maximum boll weight (2.56g). '*Fellopi*-2' exhibited the highest seed cotton yield of 12.45q/ ha. Ginning percentage was maximum in '*Phelosaw*-4'(32.22%) followed by *Karbi-Phelo*-2 (31.95%) and '*Phelopi*-1' with 31.85% respectively.

The indigenous germplasm exhibited poor yield but higher tolerance to biotic and abiotic stress. Based on pooled analysis of 2 year data, leaf roller infestation was lowest in *Karbi, Garo Kil1* and *Garo Kil*3. In case of jassid, minimum population was recorded in *Karbi, Garo*-1, *Karbi Phelo*-1, *Garo Kil* 3 and *Garo* 2. Minimum white fly population (No. /5split cages) was recorded in *Karbi, Garo-1, Garo Kil 3* and *Pheloso*-1. Minimum percentage of spotted boll worm infestation was recorded in *Karbi, Garo Kil 3, Pheloso*-1 and *Garo*-1. The overall insect pest incidence was less in *Karbi, Garo-1, Gao Kil 3* and *Pheloso*-1. Among the *barbadense* cultivars, maximum leaf rolled was noticed in '*Karbi Phelo*-1' (29.40 %). However, minimum infestation was recorded in '*Fellopi*-2' (6.60 %) followed by '*Phelopi*-1' (7.33%). Jassid population (per 5split cages) was found minimum in '*Fellopi-2*' (12.33) followed by '*Phelopi-1*' (15.33) and '*Phelo cheng cheng-1*' (20.00) . While, the highest population was recorded in '*Phelo cheng cheng-3*' (33.00). The highest whitefly populations was observed in cultivar '*Phelo cheng cheng-3*' (36.33) and the lowest was recorded in '*Fellopi-2*' (13.67) followed by '*Phelopi-1*' (15.33) '*Phelo cheng cheng-1*' (15.00). Overall '*Fellopi-2*', '*Phelopi-1*' and '*Phelo cheng cheng-1*' were comparatively less infested by the insect pests.

Among the introduced lines, RG 8, LD 230, *Eknath*, MDL 1875 and AKA 8401 were found to adapt well in the NEH region.

Pheloso-1- indigenous *arboreum* collection from north east

In case of arboreum germplasm, high genetic advance was observed for no. of bolls/ plant, seed cotton yield and plant height indicating predominance of additive genetic variance in inheritance of these four traits. Hence, these traits are likely to be useful for phenotypic selection. In case of *G. barbdense*, high genetic advance along with high heritability were observed in seed cotton yield, number of branches/plant, boll weight and number of bolls/plant. These four traits predominantly exhibited additive gene interaction and thus become important in phenotypic selection.

Gossypol content in cotton germplasm

Gossypol in cotton is known to confer resistance to biotic stresses. At the same time, high gossypol is a negative factor in cotton seed industry as it imparts color to the oil, causes toxicity to non-ruminant animals and discolor eggs in poultry thus preventing the free use of cotton seed meal. Therefore, a comprehensive study was taken up at CICR Nagpur, to evaluate the cotton germplasm for gossypol and assess its implication for varietal improvement. During three year period between 2001-03, more than 1000 lines were evaluated by analyzing the gossypol in leaves, squares, flowers and bolls. The lines represent cultivated and wild germplasm from three major species of cotton. The project also helped in standardizing a reproducible colorimetric method for gossypol estimation using phloroglucinol.

Wild cotton species exhibited more gossypol than cultivated ones. Among the cultivated species, *G.arboreum* showed higher gossypol content followed by *G.hirsutum* and *G.herbaceum.* A data bank of seed gossypol content of 500 working collection has been prepared. The seed gossypol of quality *arboreum* lines from MAU, Parbhani was also estimated. Gossypol content was correlated with disease resistance in selected varieties. The germplasm lines were classified as low, medium, high and very high (Table-5). Low gossypol lines can be utilized in breeding for improvement of oil content where as high gossypol lines could be chosen as source of resistance in breeding programmes.

Transgenic diploid cottons

Diploid cottons are known for their adaptation to adverse conditions. Particularly these varieties are more tolerant to sucking pests. Though the area under diploid cotton has declined steadily over the last four decades, recently there is a revival of interest following the identification of several high quality *arboreums* with yield potential on par with the best *hirsutums*. The emergence of Bt cotton hybrids in *hirsutums* posed a challenge for a similar effort in *arboreum* varieties. Therefore, an attempt was made to standardise a tissue culture regeneration protocol for diploid varieties and introduction of Cry1A(c) gene for conferring resistance to cotton boll worm.

After trying a variety of media and hormone combinations, successful regeneration and transformation protocol was standardised for cultivars like AKA-8401,RG-8, AKA-5 and AKHY. Cry 1 A(b) and Cry 1 A(c) genes were introduced in these cultivars through *Agrobacterium* mediated transformation. Expression of the introduced gene was confirmed through assay of Bt protein through ELISA. Transformed plants of AKA 8401 and RG 8 were fully characterised and established in the soil. These are straight varieties, which can be used directly after necessary field trails for agronomic performance and bio safety. Subsequently, regeneration and transformation protocol was standardized for long staple *arboreums* like DLSA-24, PA-255, PA-183 and PA-405. Multiple shoots were induced from shoot tip explants for all the varieties. PA-405 recorded highest regeneration percentage followed by PA-183 (Fig 1). The regenerated shoots were transformed with Cry1A(c) gene construct obtained from NRCPB, IARI, New Delhi through *Agrobacterium*. Among the genotypes, PA-405 recorded highest transformation frequency (Table-6). These plants need to be analysed further, seed multiplied and followed up with field trials.

In situ rainwater conservation

Efficient utilization of rainwater through conservation and recycling is key to successful cotton production in rainfed areas. In fact this is the single most important factor that affects the productivity levels in rainfed districts. Both land

Table 5: Classification of cotton germplasm lines on the basis of seed gossypol content

Category	Gossypol Range	No. of germplasm lines: Wild species	*G. herbaceum*	*G. arboreum*	*G. hirsutum*
Low	0. - 0.5 %	1	18	2	162
Medium	0.5 - 1.0 %	3	14	24	134
High	1.0 - 1.5%	5	Nil	31	71
Very high	> 1.5%	9	-	47	35
Total		**18**	**32**	**104**	**402**

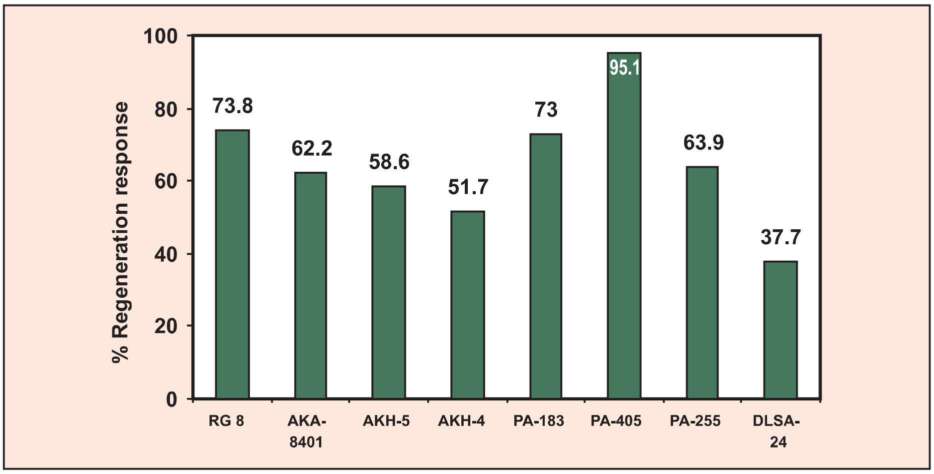


Fig.1: Regeneration response of different arboreum cotton varieties (left); transformed plant of AKA-8401 with CRY 1A (c) gene (right)

Table 6: Frequency of *Agrobacterium* mediated transformation with Cry I A (C) gene in different *abroreum* cultivars

Cultivar	No. of explants co-cultivated	Time of co-cultivation (hrs)	No.of explants regenerated	Transformation frequency (%)
RG 8	2301	24	33	1.4
	1230	48	30	2.4
AKA-8401	500	24	21	4.2
	642	48	—	—
PA 183	1608	24	25	1.55
	607	48	—	—
PA-405	937	12	42	4.48
PA-255	1530	0.5	26	1.69

configurations to conserve moisture *in situ* and cropping systems have been recommended to utilize soil moisture most effectively. In a network project covering major cotton growing districts, an integrated package consisting of suitable land configuration and crops/cropping systems were evaluated on different topo sequences (upper, middle and lower) on farmers fields in five target districts (Amravati, Yavatmal, Belgaum, Guntur and Vadodara).

In each target district 10 OFTs were carried out on farmers fields with slopes ranging from 2-5%. In the upper toposequences, *arboreum* cotton + sorghum intercropping with and without ridges and furrow system was compared with farmers method of sole hirsutum cotton and flat planting. In the middle toposequences, hirsutum cottons intercropped with greengram and hirsutums with supplemental irrigation were compared with farmers method of sole hirsutum on flat bed. In the lower toposequences, hirsutum cotton intercropped with soybean followed by chickpea as sequence crop was compared with sole hirsutum as farmers practice. For excess moisture management, both ridges and furrows, raised and sunken beds were compared with farmers method of flat bed planting.

On-farm trails for 3 years clearly showed that *arboreum* species were more productive on upper toposequences while for middle and lower toposequences, cotton based intercropping systems gave more net returns. Ridges and furrow system and contour sowing were beneficial irrespective of the toposequence. In the middle toposequences, cotton based intercropping systems were found superior over sole cotton. Due to additional moisture stored in the profile, the performance of long duration intercrops like pigeonpea was found to be better both in terms of yield and economic returns. In lower toposequence, cotton – chickpea sequence cropping, and irrigated chickpea were significantly superior to sole cotton. Next best was cotton + soybean – chickpea sequence in terms of CB ratio. For excess moisture situations, raised and sunken bed land configuration gave the highest seed cotton yield, GMR and CB ratio over all other treatments. Supplemental irrigation with harvested rainwater was the most effective component for improving productivity across all treatments. To illustrate, yields GMR and BC ratios of different cropping systems on 3 toposequences in Yavatmal districts are given in Table 7.

Impact study after 3 years OFT's in the target villages revealed that about 30-35% farmers adopted soybean – chickpea cropping system and use of harvested water for life saving irrigation whereas 50% farmers are now practicing ridge and furrow method of planting.

Impact of tillage and land configuration

Tillage and land configurations play an important role in conservation of rain water and optimum use of applied nutrients. In an effort to quantify the interactive effects of tillage, land

Table 7 : Seed cotton yield, GMR and B:C ratios from different cotton based cropping systems on upper, middle and lower topsequences in Yavatmal district (mean of 2 years ie. 2002-04)

	T_1	T_2			T_3		T_4	
Upper toposequence	**Cotton**	**Cotton**	**Sorghum**		**Cotton**	**Sorghum**	**Cotton**	**Sorghum**
Yield (q/ha)	4.83	4.16	10.95		5.36	14.05	7.46	18.40
GMR (Rs./ha)	11,865	18,554			23,712		32,106	
B:C ratio	1.36	2.38			3.07		3.69	
Middle toposequence	**Cotton**	**Cotton**	**Pigeonpea**		**Cotton**		**Cotton**	
Yield (q/ha)	6.63	6.30	2.22		8.64		10.98	
GMR (Rs./ha)	16,259	18,817			21,115		26,725	
B:C ratio	1.55	1.91			1.75		2.28	
Lower toposequence	**Cotton**	**Cotton**	**Soy bean**	**Chick pea**	**Cotton**	**Chickpea**	**Cotton**	**Chickpea**
Yield (q/ha)	5.74	6.07	13.32	7.40	18.71	9.01	7.77	10.77
GMR (Rs./ha)	13,999	39,787			35,585		37,914	
B:C ratio	1.60	3.18			3.02		3.44	

Upper toposequence

T_1 - Farmers practice-sole cotton+(hirsutum)+flat bed+100% RDF
T_2 - Arboreum cotton + sorghum + flat bed sowing + 100% RDF
T_3 - Arboreum cotton+sorghum on ridge and furrows+100% RDF
T_4 - T_3 + supplemental irrigation

Middle toposequence

T_1 - Hirsutun cotton sole on flat bed
T_2 - Hirsutum cotton + pigeonpea on flat bed
T_3 - Hirsutum cotton on contours
T_4 - T3 + supplemental irrigation with harvested water

Lower toposequence

T_1 - Hirsutun cotton as sole crop on flat bed
T_2 - Cotton on ridges and furrows+soybean as intercrop followed by chickpea
T_3 - Soybean followed by Chickpea
T_4 - Cotton followed by Chickpea with life saving irrigation through harvested water

configuration and organic residue management on cotton productivity and study the impact on soil health, a network project was taken up covering seven cotton growing districts. Seventy four on-farm trials were carried out for three years in 28 villages of the districts of Khargone (M.P.), Raichur (Karnataka), Junagadh (Gujarat), Khandwa (M.P.), Guntur (A.P.), Tuticorin (T.N.) and Nagpur (MH). Four treatments i.e. Conventional tillage (CT) + Flat bed method (Farmers' practice or T1), CT + Broad bed and furrow (100cm wide bed and 50 cm wide furrow on either side) + 100% RDF (T2), Reduced tillage (RT) + Broad bed and furrow (BBF) + 100% RDF + Green manure (T3) and RT + BBF + 100% RDF + Green manure + application of deficient nutrient (T4) were compared. Reduced tillage treatment involved one harrowing, need based interculture and pre emergence herbicide application. Growing sunhemp/greengram/cowpea between the rows of cotton as an intercrop and incorporating into the soil at 35 to 40 DAS was the green manure treatment followed.

At all the locations, T4, i.e. reduced tillage + BBF + 100% RDF + Green manure + application of deficient nutrient gave highest cotton yield except at Khargone where this was on par with T3. T4 recorded 35.9% higher seed cotton yield compared to farmers' practice (T1). Second best treatment was the one without application of

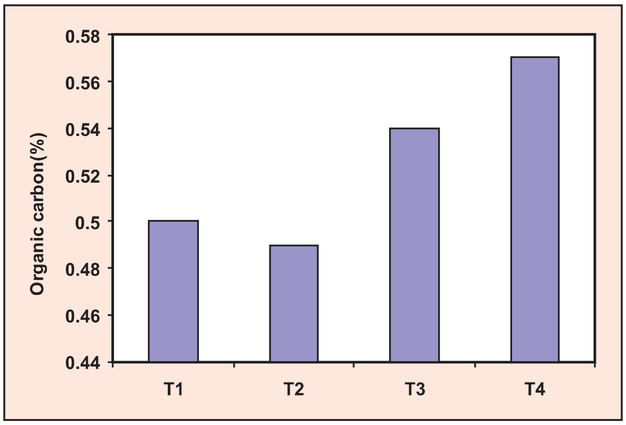


Fig.2 : Soil organic carbon (%) after two years of adopting tillage and INM treatments (see text for treatment details)

deficient nutrient (T3), which recorded 25.3 % higher yield over farmers' practice (T1). Thus, in most target districts, seed cotton yields from BBF system with reduced tillage and green manure application were significantly higher than Flat Bed (FB) system with conventional tillage (farmer's practice). This may be due to the synergistic effects of improved drainage, moisture conservation, reducing runoff and balanced nutrition.

At most locations, BBF along with green manure incorporation under reduced tillage increased SOC (Fig.2), moisture storage, porosity, mean weight diameter, infiltration rate and nutrient uptake. Bulk density, runoff and soil loss were reduced. At all the locations, the highest returns

Cotton planted on broad bed in Guntur district (left) and Sunhemp intercropped as green manure in cotton on farmers feld in Sulyakheri village in Indore district (right)

Table 8: Yield and economics of various tillage, SMC and organic residue management practices (see text for details of treatments) on farmers fields in the target districts (mean of 2 years with 10 farmers in each district)

Treatment	Raichur			Junagadh			Khandwa			Guntur		
	Yield (kg/ha)	Net returns	BC ratio	Yield (kg/ha)	Net returns	BC ratio	Yield (kg/ha)	Net returns	BC ratio	Yield (kg/ha)	Net returns	BC ratio
T_1	372	2641	0.67	718	6277	0.93	1228	10365	1.03	1642	—	—
T_2	452	3228	0.72	801	7571	1.09	1309	10426	0.92	1849	—	—
T_3	503	4030	0.88	846	8531	1.22	1535	12972	1.12	1982	—	—
T_4	543	4279	0.87	901	9619	1.50	1646	16056	1.36	2078	—	—
	Khargone			Kovilpatti			Nagpur					
T_1	960	15612	2.10	606	3102	1.32	585	-	-			
T_2	996	15872	1.42	685	4473	1.46	678	2756	3.25			
T_3	1150	18268	1.95	737	5172	1.50	743	3907	1.40			
T_4	1182	18536	1.88	754	4955	1.48	701	4788	1.46			

was recorded under T4 followed by T3. On an average, the best treatment (T4) gave an additional return of 4,400 per ha over farmers practice (Table 8).

Enhancing nutrient use efficiency

In an effort to enhance nutrient use efficiency by improved soil moisture availability, a network project was taken up in 7 target districts viz. Amravati, Yavatmal, Parbhani, Nanded (Maharashtra), Kurnool (A.P.), Dharwad and Belgaun (Karnataka). The interaction of moisture conservation method (ridge and furrow method and farmers practice) with nutrient management practices was tested for 3 years involving 10 farmers in each target district. Five treatments, namely, farmers practice (NP 90:25) with sowing on flat bed; RDF of NPK (80:40:40) with sowing on flat bed; recommended dose of NPK with ridge and furrows (RF), INM with flat bed and INM with RF. Components of INM included application of recommended NPK, $ZnSO_4$ (30kg /ha), FYM (2 tonne/ha), in *situ* green manure (intercrop), phosphate solubilizing bacteria (PSB) and 2% DAP (foliar spray) at boll formation.

All the treatments significantly improved the yield over farmer's practice (fig 3). However, the increase was more with RDF or INM and RF over farmers practice (NP 90:25). The seed yield was relatively higher at Yavatmal, Nandyal and Parbhani mainly due to better rainfall distribution during the season, while Amravati and Dharwad received poor rainfall which led to yield reduction. Based on data across locations, seed cotton yield increased by 52% through INM and 30% through recommended NPK over farmers practice under

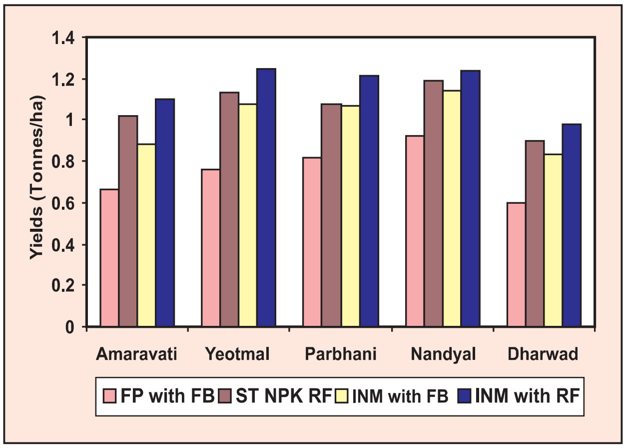


Fig.3 : Seed cotton yield under different moisture conservation and INM treatments on farmers field in 5 target districts (mean of 3 years based on 10 farmers in each district)

RF system. Higher yield in RF system over flat bed indicates the synergistic effect of moisture conservation and INM. Higher moisture availability (2-5%) was recorded in RF method over flat bed in all the target districts.

Economic returns

The additional returns with INM treatment over farmers' practice was Rs 6,720/ha at Nandyal, Rs 7,980 at Dharwad, Rs 8,190 at Parbhani, Rs 9,240 at Amravati and Rs 10,290 at Yeotmal (Table 9). Higher productivity in INM plots over farmers' practice led to higher gross returns. Application of RDF (NPK) combined with RF system gave the highest gross returns over to flat bed sowing.

Species/ varietal performance under different soil depth and rainfall situations

Of the total area of 80 lakh ha under cotton in India, 55 lakh is in central and south zones. Seventy five percent of the area in this zone is rainfed. Cotton is grown under a variety of situations including low, medium and high soil depths and low and high rainfall. Although tetraploid hybrid cottons are recommended for better environments, farmer have been indiscriminately growing these cottons under all situations of low and high rainfall and shallow to deep soils. Moreover, cotton genotypes recommended for a zone are generally developed based on, on station research under good environment, but when they are exposed to the farmer's conditions, the performance is quite poor leading to losses and indebtedness. In order to revisit the varietal/ species recommendations for different situations and identify the best package of practices under farmers conditions, a network project was taken up involving six institutes/ universities viz. UAS, Dharwad, CICR, Nagpur, GAU, Bharuch, MAU, Nanded, JNKVV, Khandwa and ANGRAU, Guntur (Lam). Both on station and on farm trials were conducted for 4 years. Leading varieties from *G.arboreum, G.herbaceum, G.hirsutum* and hybrids were evaluated under six environments i.e. deep soil+high rainfall (S1), deep soil+low rainfall (S2), medium soil + high rainfall (S3), medium soil + low rainfall (S4), shallow soil + high rainfall (S5) and shallow soil + low rainfall (S6).

Overall results from on station and on farm trials indicated the superiority of *G.arboreum* varieties in all soil depths irrespective of rainfall pattern. In particular, the performance was significantly higher in deep soil + high rainfall, medium soil+ high rainfall, medium soil+ low rainfall and shallow soil + low rainfall. This group of varieties responded strongly to soil depth with deep soils recording more than 100% additional yield over shallow soil. In high rainfall conditions, the soil depth showed profound influence on the yield of cotton in all the species and genotypes. Based on pooled data for 3 years, *Sahana* and DLSA 17 from

Table 9: Gross returns* (Rs/ha) under different moisture conservation and INM treatments in 5 target districts (based on 3 years data with 10 farmers from each district)

Treatment	Amravati	Yeotmal	Parbhani	Nandyal	Dharwad
Farmers practice+ with flat bed	13,860	15,960	17,220	19,320	12,600
RDF (NPK) with ridge and furrows	22,050	24,150	23,100	25,200	18,900
INM with flat bed	18,480	22,680	22,470	23,940	17,430
INM with ridge and furrows	23,730	26,250	25,410	26,040	20,580

*Rs. 21,000/tonne of Kapasl + Farmers practice represents N:P, 9:25 and sowing as flat bed

Dharwad, G cot 21 and G cot 23 from Bharuch, *Sarvottam* from Khandwa, AKA-801 and J.Tapti from Nagpur, *J.Tapti* and PA 183 from Nanded showed consistent superiority over others across different situations. At Lam, Guntur, MDL 2452 and MDL 2463 performed better during the first two years(2001-02 and 2002-03) while *Bunny* and NHH 44 and *Aravinda* performed better during 2003-04 across all situations. The performance of inter specific hybrids was comparatively poor except in medium soil + high rainfall situations. A list of best performing species and genotypes for different situations are given in Table 10.

Based on yield data and farmers preference, a distinct shift was noted towards *arboreums*. The demonstrations carried out in the final year(2004) further contributed to the shift. Many farmers in the target districts took up seed production on their own. The OFTs also convinced farmers that with relatively lower cost of cultivation they can get same returns with quality *arboreums*. One major output emerged from the project is the listing of recommended species, for different agro ecological zones as against the species and varieties currently used (Table 11).

Cotton production in salt affected soils

Salinity and sodicity affect nearly 12 million ha. in the country. Upto 10% area under cotton in different states suffers from the problems of salinity and sodicity. Reclaiming saline soils through engineering measures is not affordable by most small farmers. Therefore in a network project, an alternative option of identifying suitable species and varieties of cotton that can be grown on saline and sodic soils was tested. The problem soils are mostly located in Gujarat, Karnataka and Madhya Pradesh. A total of 36 entries from 4 different species were tried. On-station trials during first two years, indicated that varieties from *G.herbaceum* and *G.arboreum* were more tolerant to salinity/sodicity as compared to *G.hirsutum* and intra hirsutum hybrids. As a follow up, on-farm trials were carried during 2002 and 2003. Farmer's fields of different salinity (EC 4.00 – 6.00 dS/m) and sodicity (ESP 25-40) levels were selected in the target districts and the identified varieties were tested.

The overall results across centers and seasons indicated that varieties from *G.herbaceum* were superior to *G.arboreum* and *G.hirsutum* in

Table 10 : Genotypes with consistent performance across various growing situations in different agro ecological zones (Based on 3 year s pooled data)

Situation	UAS, Dharwad	MAU, Nanded	CICR, Nagpur	GAU, Bharuch	JNKVV, Khandwa	ANGRAU, Guntur
DH	Sahana DCH-32	BT- 184	AKA-8401	G.cot hy-8 G.cot-19	—	Aravinda Bunny
DL	—	J.Tapti	AKA-8401	G.cot hy-8 G.cot-16	—	MDL 2463 Narasimha
MH	Sahana DCH-32	J.Tapti	NHH-44	G.cot hy-8 G.cot-19	JK-4 Sarvottam	MDL 2463 NHH-44
ML	—	NH-545	J.Tapti	G.cot hy-8 G.cot-19	JK-4 Sarvottam	MDL 2450 NHH-44
SH	Sahana DCH-32	PA-255	NHH-44	—	—	Aravinda Narasimha
SL	—	J.Tapti	AKA-8401	G.cot hy-8 G.cot-19	—	MDL 2450 NHH-44

DH : Deep soil + High rainfall; DL : Deep soil + Low rainfall; MH : Medium soil + High rainfall
ML : Medium soil + Low rainfall; SH : Shallow soil + High rainfall; SL : Shallow soil + Low rainfall

Table 11: Current species choice of cotton in four states and suggested change based on performance under micro farming situations

Situation	Species currently grown	Area (lakh ha)	Suggested choice based on OFTs	Species currently grown	Area (lakh ha)	Suggested choice based on OFTs
	Karnataka			**Gujarat**		
DH	Hybrid(HB & HH)	0.5	*G.arboreum* Hybrid (HH & HB) *G.hirsutum*	*G.herbaceum*, Hybrids	1.5 0.75	*G.arboreum*, *G.herbaceum*
DL	*G.herbaceum*, Hybrids (HH)	0.75 0.10	*G.herbaceum* *G.arboreum*	*G.herbaceum*, Hybrids *G.arboreum*	2.75 0.75 0.25	*G.hirsutum*, Hybrids, *G.arboreum*
MH	Hybrid(HB & HH)	1.25	*G.hirsutum*, Hybrid (HB & HH) *G.arboreum*	*G.herbaceum*, Hybrids	0.5 1.5	*G.herbaceum*, Hybrids
ML	*G.herbaceum*, *G.arboreum*	0.75 0.15	*G.herbaceum*	*G.herbaceum*, Hybrids	1.5 0.65	*G.arboreum*, Hybrids
SH	Hybrid (HB)	0.75	*G.hirsutum* Hybrid (HB & HH)	—		—
SL	*G.herbaceum*	0.2	*G.herbaceum*, *G.arboreum*	*G.herbaceum*, Hybrids	3.4 1.4	*G.arboreum*, Hybrids
	Madhya Pradesh			**Maharashtra (Vidharba)**		
DH	*G.hirsutum* Hybrids	0.2 0.2	*G.arboreum* Hybrids	Hybrids	—	*G.arboreum*
DL	*G.arboreum*, *G.hirsutum* Hybrids	0.4 0.5 0.6	*G.arboreum*, *G.herbaceum*	Hybrids, *G.hirsutum*	—	*G.arboreum*, *G.herbaceum*
MH	*G.hirsutum* Hybrids	0.2 0.1	*G.arboreum* Hybrids	*Intrahirsutum*	—	Hybrids
ML	*G.arboreum*, *G.hirsutum* Hybrids	0.8 0.25 0.90	*G.arboreum*, *G.herbaceum* *G.herbaceum*	*G.arboreum* hybrids	—	*G.arboreum*
SH	*G.herbaceum*, *G.hirsutum*	0.20 0.10	*G.arboreum*, *G.hirsutum*	Hybrids, *G.hirsutum*	—	Hybrids, *Intrahirsutum*
SL	*G.arboreum*, *G.hirsutum* Hybrids	0.50 0.50 0.30	*G.arboreum*, *G.herbaceum*	*G.arboreum*, *G.hirsutum*, Hybrids	—	*G.arboreum*

all the zones tested. RAHS-14 and TDHC-11 were the most promising *herbaceums*. For sodic soils in Indore district also, RAHS-14 and *Jayadhar* were found to be best performing *herbaceums*, while G.cot 19 and J-Tapti were most promising among *arboreums*. However economic analysis based on 2003-04 OFT's indicated that except RAHS-14, other varieties did not give higher benefit cost ratio over check (*Jayadhar*). A list of most promising varieties for different locations is given in Table 12. Farmers feed back during 2004 indicated maximum preference for *Jayadhar* and RAHS-14 from *herbaceums* and *J. Tapti* from *arboreums* both in Karnataka and M.P. Based on the project results, RAHS-14 can be recommended for saline vertisols of Koppal district in Karnataka, *J-Tapti* for Khargaone district of M.P. and *G-cot 21* for sodic vertisols of Surendranagar district of Gujarat.

Table 12: Promising species/genotypes identified for saline/sodic soils in the target districts based on two years on-farm trials (10 farmers in each district)

Name of the university	Target district	Environment	Tolerant varieties identified *G.herbaceum*	*G.arboreum*	Local check
UAS(D)	Koppal	Saline	RAHS 14, DDHC 11	PA 183 AK 235	Jaydhar
JNKV	Khargaone	Sodic	Jaydhar RAHS-14	G.cot-19 J.Tapti	Vikram
GAU	Viramagam	Sodic	G.cot-21 G.cot-13	G.cot-19 AKA-9431	V797


A view of the saline soils in Koppal region of Karnataka (left) and performance of RAHS 14 on farmers fields (right)

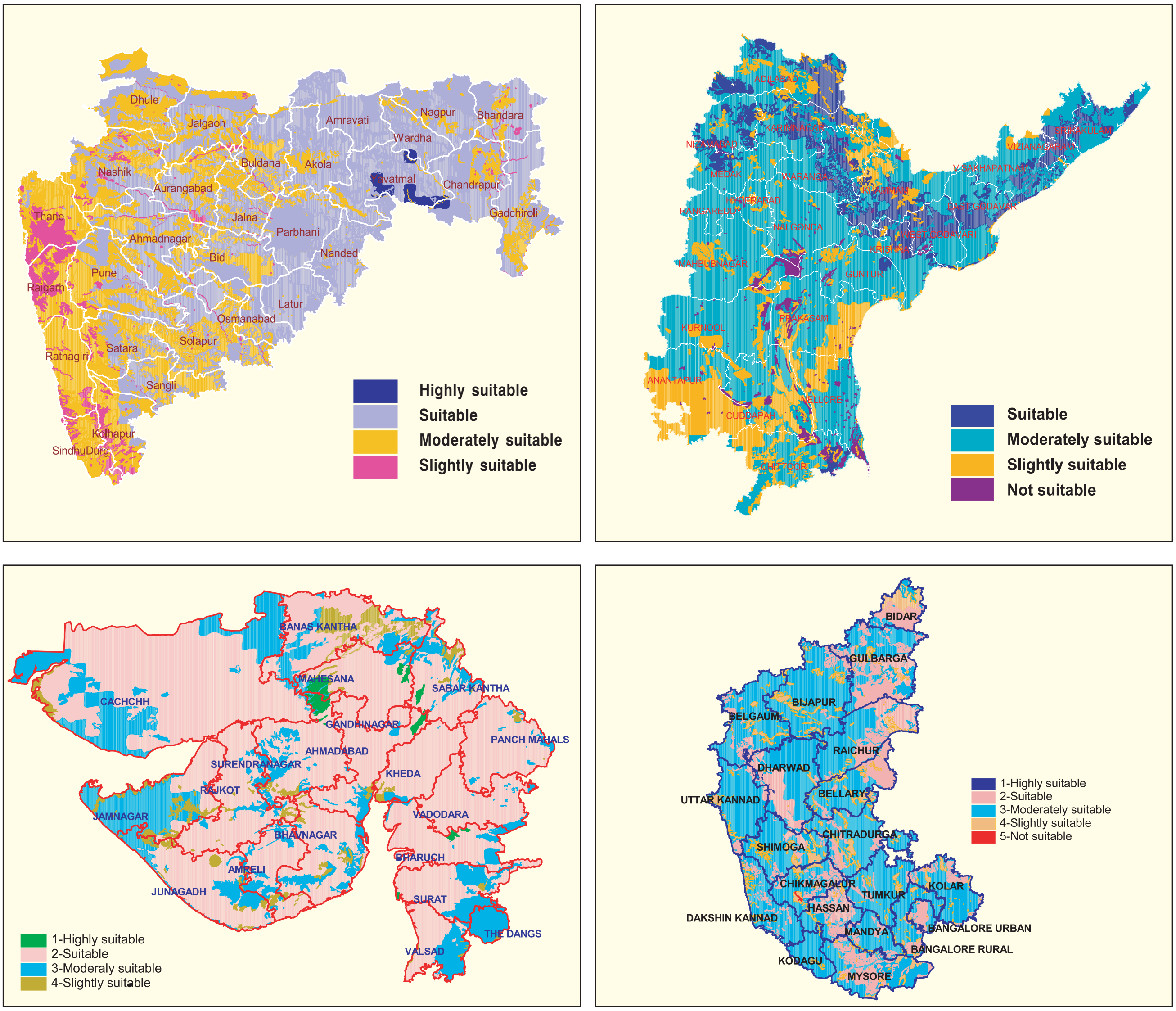
Digitization of database on GIS format

Cotton crop is grown in the country in different soil and climatic conditions. Extending this crop to unsuitable areas by farmers often leads to crop failures. Based on the available information on factors governing productivity of cotton in different soil and rainfall zones, the soil, climatic and crop production data was digitized for five states i.e. Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Karnataka in a GIS environment. Based on the analysis, all the districts were classified for suitability on a scale of 1-5 (1 = highly suitable, 2 = suitable, 3 = moderately suitable, 4 = slightly suitable, 5 = unsuitable).

The spatial maps delineating suitable areas for cotton cultivation in major states could be used for promoting the crop in the most potential areas. In particular, the spatial database linking production with soil and climatic parameters would be useful for policy interventions like crop insurance etc. Similarly, the limitation for soil resources like poor drainage, erosion etc. can be used to develop suitable research programs and the limitations can be over come there by bringing more areas under cultivation. The procedure developed for linking the crop coverage maps with crop models with details climate and soil resources can be used to estimate crop yields in a distributed way for basic simulation units for different soil and climate polygons in a GIS framework much before the harvesting of the crop thus enabling suitable interventions in the market or for export or for internal redistribution.

Agro-economic constraints in cotton production

The agro-economic characterization and constraints analysis of rainfed cotton based production system were carried out in 21 rainfed



Climate and soil suitability maps for cotton cultivation in A.P., Maharashtra, Gujarat and Karnataka

cotton growing district in 6 states covering 50 agro eco sub-regions. The gap between the potential yield and actual yield realized by different categories of farmers were determined based on survey of 1410 farmers in 125 villages. The potential yield of cotton cultivars ranged between 8 q ha^{-1} in Dharwad (cv *Jayadhar*) to 30 q ha^{-1} in Guntur (cv *Bunny*) (Table 13). The realized yields varied between 3.62 q ha^{-1} in Vadodara to 30 q ha^{-1}in Guntur.

Wide yields gaps were found in all major cultivars grown in different parts of the country. The relative yield gap as percentage of potential yield was highest in Vadodara (cv H-10) where, as much as 77 per cent of potential yield remains unrealized. The realized yields were closer to potential yield in Dharwad. No relationship between farm size and yield gap was found. The yield gap in the districts was related to soil and rainfall variation and socio economic variables. Farm size, potassium, pH, $CaCO_3$, Cu, Fe, pesticide use showed negative relationship with yield, while N, P, Zn, soil depth showed positive relationship. Cost of the seed has emerged as a major constraint in adoption of HYV among poor farmers. Poor price realization affects all categories of farmers. Based on productivity and profitability trends, cotton will continue to be major crop in all districts studied except Jalgaon and Guntur where it is likely to be partly replaced by more profitable crops like chillies.

Recommendations to improve productivity

- Development of varieties to shallow soil condition in rainfed areas.
- Micro farming situation focused extension strategy.
- Identification of compatible shallow rooted intercrops to utilize soil moisture effectively.
- Rain water conservation under different topo sequences.
- Promotion of IPM and INM.
- Promoting the utilization of cotton by-products.
- Improved market infrastructure, insurance and credit.

Table 8 : Yield gap in cotton, based on survey of 1410 farmers in 125 villages in 10 districts

Districts	Variety	Potential	Small			Medium			Large			Overall		
(AESR)		yield (q/ha)	Yield (q/ha)	Gap (q/ha)	% Gap	Yield (q/ha)	Gap (q/ha)	% Gap	Yield (q/ha)	Gap (q/ha)	% Gap	Yield (q/ha)	Gap (q/ha)	% Gap
Surendra-	0-13	14	5.92	8.08	57.71	4.87	9.13	65.21	5.68	8.32	59.43	5.49	8.51	60.79
nagar (2.4)	Devirnj	14	10.04	3.96	28.29	9.48	4.52	32.29	4.74	9.26	66.14	8.09	5.91	42.21
	H-6	15	5.92	9.08	60.53	9.14	5.86	39.06	8.05	9.92	66.13	6.71	8.29	55.26
Vadodara	Digvijay	14	3.67	10.33	73.79	4.79	9.21	65.79	3.88	10.12	72.29	4.11	9.89	70.64
(5.2)	H-8	15	3.74	11.26	75.07	7.68	7.32	48.80	4.04	10.96	73.07	6.60	8.40	56.00
	H-1O	16	4.08	11.92	74.50	3.68	12.32	77.00	3.44	12.56	78.50	3.62	12.38	77.38
Khandwa	H-8	18	10.20	7.80	43.33	9.25	8.75	48.61	10.20	7.80	43.33	9.88	8.12	45.11
(5.2)	JKH-I	20	14.00	6.00	30.00	10.25	9.75	48.75	10.80	9.20	46.00	11.68	8.32	41.60
	Khandwa-2	16	9.11	6.89	43.06	9.20	6.80	42.25	12.50	3.50	21.88	10.27	5.73	35.81
	D-9	18	9.11	8.89	49.39	10.00	8.00	44.44	10.30	7.70	42.78	9.80	8.20	45.56
	Vikram	14	9.00	5.00	35.71	8.74	6.26	44.71	9.80	7.74	55.29	9.18	4.82	34.43
Khargone	H-8	18	10.20	7.80	43.33	9.25	8.75	48.61	10.20	7.80	43.33	9.88	8.12	45.11
(5.2)	JKH-I	20	14.00	6.00	30.00	10.25	9.75	48.75	10.80	9.20	46.00	11.68	8.32	41.60
	Khandwa-2	16	9.40	6.89	43.06	8.75	7.25	45.31	9.60	6.40	40.00	9.25	6.75	42.18
	D-9	18	9.11	8.89	49.39	10.00	8.00	44.44	10.30	7.70	42.78	9.80	8.20	45.56
	Vikram	14	9.00	5.00	35.71	8.74	6.26	44.71	9.80	4.20	30.00	9.18	4.82	34.43
Nanded	NHH-44	18	3.81	14.19	78.83	4.88	13.78	76.56	5.91	9.09	67.17	4.86	13.14	73.00
(6.2)	JK-2	15	–	–	–	8.12	6.88	45.87	9.00	6.00	40.00	8.56	6.44	42.93
	Rasi	15	9.88	5.12	34.13	3.76	11.24	74.93	7.90	7.10	47.33	7.18	7.82	52.13
Amravati	Ankur-651	15	5.09	9.94	66.06	5.79	9.21	61.40	5.32	9.68	64.53	5.40	9.60	64.00
(6.3)	NHH-44	14	4.96	9.04	64.57	5.51	8.49	60.64	5.29	8.71	62.21	5.25	8.75	62.50
	AHH-468	16	4.68	11.32	70.75	4.69	11.31	70.69	3.42	12.58	78.62	4.26	9.74	73.38
Yavatmal	NHH-44	16	6.63	9.37	58.56	6.49	9.51	59.44	8.81	7.19	44.94	7.31	8.69	54.13
(6.3)	Ankur-651	15	7.20	7.80	52.00	7.25	7.75	51.67	6.55	8.45	56.33	7.00	8.00	53.33
	H-8	15	6.07	8.93	59.53	5.11	9.89	65.93	6.13	8.87	59.13	5.77	9.23	61.53
Jalgaon	Ankur-651	21	7.84	13.16	62.67	9.49	11.51	54.81	7.40	13.60	64.76	8.24	12.76	60.76
(6.3)	NHH-44	20	6.60	13.40	67.00	8.13	11.87	59.35	8.81	11.19	55.95	7.85	12.15	60.75
	Bunny	21	8.39	12.61	60.05	7.16	13.84	65.90	10.08	10.92	52.00	8.81	12.19	58.05
Dharwad (6.4)	Jayadhar	8	5.10	2.90	36.30	5.40	2.60	32.50	5.60	2.40	29.40	5.40	2.60	32.8
Guntur (7.3)	Bunny	30	16.4	13.6	45.30	14.50	15.50	51.80	15.80	14.20	47.50	15.50	14.50	48.20
	Desi	12	7.6	4.4	36.70	8.2	3.80	31.70	9.10	2.90	24.20	8.30	3.70	30.80

3.5 Nutritious Cereals Based Production System

Nutritious cereals like sorghum, pearl millet and finger millet are staple crops for poor people in arid and semi arid regions. Despite falling consumption of these crops, they continue to be important source of food for poor people in drought prone areas and as principal fodder source for livestock. These crops are highly adapted to drought conditions. Despite the low cost of cultivation, greater yield stability, high nutritional value and drought hardiness, the poor price realization is leading to declining profitability. The adoption of improved varieties and recommended package of practices is also quite low. Therefore, the major focus of this production system research was to improve the productivity of *rabi* sorghum whose area has remained unchanged and identify opportunities for diversification in *kharif* sorghum growing areas.

Changing scenario of kharif sorghum cultivation

Due to the fall in consumption of *kharif* sorghum, the area under the crop is steadily declining. However during drought years, the importance of sorghum as a fodder for livestock is realized by the farmers. In order to understand the factors for the decline in the *kharif* sorghum area and identify opportunities for its retention, a time series data analysis on production and productivity of the crop vis-vis other crop/cropping systems was carried out in seven districts of Maharashtra, A.P., Karnataka and M.P (Akola, Mahabubnagar, Adilabad, Dharwad, Belgaum, Indore and Khargaone). On-farm trials were also conducted in some of these districts to compare the productivity and profitability of sorghum with competing crops/cropping systems.

Results from the project clearly indicated that the area under *Kharif* sorghum invariably decreased in all the states. Except Akola, Nanded and Khargone, all other districts showed negative growth in production. The decline of sorghum area at macro level led to shortage of fodder for the livestock in these regions which forced the farmers to decrease their livestock. Acreage response analysis indicated that the area under sorghum in a particular year was determined by previous year area and yield of sorghum crop, the prices of the competing crops and the pre-sowing rainfall. According to the farmers opinion during the survey in Adilabad district of A.P., the prices of competing crops and the government policies towards the cash crops were the foremost reasons for the decrease in the area under *kharif* sorghum.

The output/input analysis of sorghum production revealed that 5 out of 8 target districts have an output /input ratio of more than one, where as the other three (Adilabad, Mahabubnagar and Akola) had less than one for *kharif* sorghum. Though the ratio was found more than one in some districts when compared to other competing crops, it was less profitable. In general sole *kharif* sorghum even with improved technology was unable to compete with other crops like cotton and soybean. However, when intercropped with crops like pigeonpea along with adoption of recommended package of practices, the returns are as good as other commercial crops or cropping systems. The competence level of different sorghum based cropping systems with competing crops in 8 target districts is given in Table 1. During drought years, even sole sorghum maintained its edge mostly as a source of fodder. Promoting sorghum as a source of raw material for alternate uses like alcohol and poultry feed can be one way of retaining the area under this highly adapted and resilient crop.

In a related project, a comprehensive data base on sorghum (*kharif* and *rabi*), pearl millet and finger millet was developed between 1970-1988 for major growing areas in the country. The output/input ratios of these crops with that of the competing crops have been worked out. The major

Table 1 : Competency level of different sorghum based cropping systems in target districts				
Target districts	Highly competitive	Near or at par with competing crops	Not competitive	Competing crops
Adilabad	Sorghum+ Soybean (IYR)	Sorghum+ Pigeonpea (IYR)	Sole Sorghum (EYR, IYR) Sorghum+ Pigeonpea (EYR)	Soybean and cotton
Mahabubnagar	—	—	Sole Sorghum (EYR, IYR), Sorghum+ Pigeonpea (EYR, IYR)	Castor
Dharwad	—	Sole Sorghum (IYR)	Sole sorghum (EYR), Sorghum+ Pigeonpea (EYR, IYR)	Groundnut
Belgaum	Sole sorghum (IYR), Groundnut followed by *rabi* Sorghum (EYR)	—	Soybean followed by *rabi* Sorghum (IYR)	Sole Cotton
Akola	Sorghum+ Pigeonpea (IYR)	Sorghum+ Pigeonpea Sorghum+ Soybean (EYR), Sole sorghum (IYR)	Sole Sorghum (EYR)	Soybean and Cotton
Nanded	Sorghum+ Pigeonpea (IYR)	Sorghum+ Pigeonpea (IYR, EYR) Sole Sorghum (IYR)	Sole Sorghum (EYR)	Soybean and cotton
Indore	Sorghum+ Pigeonpea (IYR), Sole Sorghum (IYR) and Sorghum+ Soybean (IYR)	—	Sole Sorghum (EYR)	Soybean
Khargaone	—	Sole sorghum (IYR), Sorghum+Pigeonpea (IYR) and Sorghum+ Soybean (IYR)	Sole Sorghum (EYR) and Sorghum+ Pigeonpea (EYR)	Soybean and cotton
(EYR-Existing Yield Regime; IYR-Improved Yield Regime)				

crops, which replaced sorghum, include pulses, maize, cotton, groundnut, castor and sunflower. A critical analysis of the dynamics of crop shift during the last three decades clearly brought out a need for diversification of the use of sorghum and other nutritious cereals into value added products (fodder, poultry feed and bio energy etc.).

Improving *rabi* sorghum productivity

Rabi sorghum is an important staple crop for millions of people in Maharashtra and Karnataka. Though there has been a steady decline in the area under *kharif* sorghum over the last three decades, the area under *rabi* remained more or less constant. The productivity also has not improved significantly. Unlike in *kharif*, HYVs did not make much impact on the productivity during *rabi*. Since *rabi* sorghum is grown with residual moisture, resource management becomes critical in enhancing productivity along with HYVs. Improved package of practice combining the best variety with resource management technology (compartmental bunding + INM) was evaluated on 421 farmers fields in 167 villages covering 7 districts for 3 years. The districts are Solapur, Sangli and Satara in

Maharashtra, Bellay, Bijapur and Raichur in Karnataka and Kurnool in A.P. which together cover two million ha. area under the crop.

Based on 3 years data (2000-03) across the target districts, the improved technology comprising *in situ* soil moisture conservation through compartmental bunding (10 X 10 m in the month of August –September), integrated nutrient management (60 kg N + 30 kg P_2O_5 + 3 t FYM per ha + *Azospirillum*) and high yielding cultivar of CSV 216R (*Phule Yashoda*), increased the productivity of *rabi* sorghum to 1029 – 1836 Kg/ha compared to farmers practice (633 to 1259 kg/ha) of normal planting an fertilization with M 35-1. The increase in stover yield was 2380 to 3924 kg/ha compared to 1488 - 2279 kg/ha with farmers practice. Mean yield data revealed that improved production technology boosted productivity of *rabi* sorghum by 52.4 and 62.3 per cent in terms of grain and stover yields respectively compared to farmers practice across the districts (Table 2).

Analysis of the contribution of the individual components the technology revealed that resource management technologies like moisture conservation and balanced fertilization caused improved yields (Table 3). On an average 100 kg additional yield was realized across centers due to compartmental bunding, while the benefits due to balanced fertilization (INM) were more than 200 kg. Improved variety (CSV-216-R or *Phule Yashoda)* enhanced the yield by about 100 kg/ha.

Assessment of *rabi* sorghum genotypes response to terminal drought tolerance revealed that relative water contents (RWC), chlorophyll stability index and stomatal conductance confer terminal drought tolerance in *rabi* sorghum. RSP-3, Q 104, DSV-5, CSV 13 and IS 2312 were identified as promising drought tolerent genotypes which were superior by 6-9 per cent compared to *Phule Maulee*, CSV 8R, RS 29 and M-35-1. Studies on charcoal rot incidence in relation to edaphic factors revealed that earliness as an escape mechanism for terminal drought confers yield advantage under dry land conditions. Resistance to charcoal rot and lodging is strongly correlated with stay green character of a genotype apart from plant stature. Early-medium genotypes that retain 1-2 green leaves up to physiological maturity are

Table 2 : Grain and stover yield with improved technology for *rabi* sorghum as against farmers practice in 7 target districts with 10 farmers in each district (pooled over 3 years).

Target district	Grain yield (kg/ha)			Stover yield (kg/ha)		
	Improved technology		Farmers practice	Improved technology		Farmers practice
	CSV 216R	CSH 15R		CSV 216R	CSH 15R	
Bijapur	1565	1546	994	3164	2279	1730
Raichur	1836	1702	1259	3924	2824	3279
Bellary	1510	1458	982	3369	3140	2086
Kurnool	1514	1427	966	3188	2822	1980
Sangli	1029	901	633	2430	2041	1515
Satara	1037	949	715	2388	1819	1488
Solapur	1217	1097	818	2678	2252	1917
Mean	1387	1297	909	3020	2454	1856

Farmers Practice: No CB + 10 kg N + 3 t FYM per ha + cv M 35-1
Improved technology: CB + INM + cv CSV 216R/CSH 15R
Integrated Nutrient Management (60 kg N + 30 kg P_2O_5 + 3 t FYM per ha + *Azospirillum*)

Table 3: Grain yield (kg/ha) of *rabi* sorghum as influenced by *in situ* moisture conservation, INM and cultivars in 7 target districts with 10 farmers in each district (pooled over 3 years)

Treatments	Bellary	Bijapur	Kurnool	Raichur	Sangli	Satara	Solapur	Mean
Moisture Conservation								
No Compartmental bunding (No-CB)	1148	1176	1148	1395	774	839	948	1061
Compartmental bunding (CB)	1299	1353	1302	1559	847	889	1041	1184
CD (0.05)	78.9	39.6	58.5	106.1	45.6	16.40	70.6	38.3
Nutrient Management								
Farmer's Practice (FP)	1092	1106	1081	1342	727	778	912	1005
INM	1355	1422	1369	1632	892	946	1076	1242
CD (0.05)	78.9	39.6	58.5	106.1	45.6	16.40	70.6	38.3
Cultivar								
CSV 216R	1276	1313	1278	1550	884	913	1076	1187
CSH 15R	1236	1272	1216	1471	791	857	965	1115
M 35-1	1158	1210	1180	1410	755	823	940	1068
CD (0.05)	29.9	53.5	39.5	55.7	50.0	39.00	32.6	16.4

likely to be more resistant to charcoal rot and lodging besides producing high grain and fodder yields. On station trials at Bellary on efficient resource management revealed that graded border strips and compartmental bunding with surface mulch were promising inter terrace rainwater conservation measures which minimized runoff by 57-77 per cent and soil loss by 37-50 per cent compared to up and down cultivation (65.6 mm runoff and 2639.5 kg/ha soil loss).

Dual purpose sorghum varieties

Fodder sorghum plays a pivotal role in the economy of dryland farmers, as it provides nutritional base to large livestock population. In U.P., Rajasthan, M.P. and Gujarat, farmers cultivate local cultivars to meet the fodder requirement as they are tall and produce more fodder. But the fodder value is poor as these cultivars are non-tan type and highly susceptible to foliar diseases. Similarly they are also susceptible

View of making compartmental bunding on farmers fields in Solapur district (left) and performance of CSV-216-R with improved package in Jath village of Sangli district (right) to grain mould. Bundelkhand (part of U.P. and M.P), Central U.P., Rajasthan and Gujarat serve as seed source for planting in Haryana, Punjab and western U.P. for single-cut fodder. In these states, farmers also plant multi-cut sorghum varieties for green fodder but the seed production of multi-cut types is very poor which does not meet farmer's needs. On the other hand, improved varieties and hybrids are dwarf, medium/early maturing and produce high grain but low fodder. Therefore dual purpose sorghums become important in these areas. In a network project taken up in Gujarat, U.P., M.P. and Rajasthan, efforts were made to identify cultivars with high quality grain and fodder and high level of resistance to leaf disease, grain mould and shoot fly.

Based on the on-farm trials conducted across different states and the pooled analysis of data over locations and years (2001-03), it was revealed that var. CSV-15 proved its superiority across locations with 54.25% higher grain yield than farmers local (Table 4). It also gave significantly higher grain and fodder yield over station checks at few locations. The fodder yield was also significantly higher. At all locations improved practice was superior over farmers practice both for grain and fodder. The variety exhibited a distinct superiority particularly for fodder yield in Surat and New Delhi, whereas in other districts, the grain yield was higher but the fodder yield was comparable with the farmers local or station checks.

In view of the susceptibility of dual purpose sorghums to stem borer, shootfly and pyrilla, field studies were carried out at IARI, New Delhi to evolve effective control measures. Use of resistant variety and seed treatment with imidacloprid effectively controlled the shootfly and protected against stem borer upto 50 days after germination. The promising germplasm and breeding material were evaluated at all locations during the year and the segregating materials characterized. SH-107 (4626 kg/ha) was identified as the best performer in an evaluation trial of 22 tall dual purpose hybrids at Surat. From feed back studies with farmers, it was evident that they prefer dual purpose sorghums with atleast 7 feet tall with good grain.

Improving pearl millet productivity through moisture and nutrient management

Pearl millet is a staple crop for millions of people in arid and semi arid regions. It is an ideal crop for of delayed monsoon. Despite the introduction of many HYVs and hybrids, the yield gap between research stations and farmers fields remains high.

Table 4: Grain yield (kg/ha) of different dual purpose sorghums under improved and farmers practice in various target districts (mean of 3 years ie. 2001-04)

Location/ Treatment	Surat	Udaipur	Indore	Mauranipur	New Delhi	Mean	% increase over local IP	% increase over local FP
CSV-15 (IP)	3310	2269	2306	2462	2433	2556	54.2	-
CSV-15 (FP)	2520	1759	2409	1856	1884	2014	-	56.6
Station Check (IP)	2301	2034	2324	2528	1811	2200	32.7	-
Station check (FP)	1712	1536	2168	1890	1422	1746	-	35.0
Farme'r local (IP)	2362	1209	1232	1882	1602	1657	-	-
Farme'r local (FP)	1806	820	1122	1456	1223	1286	-	
C.D@5%	381	568	604	382	318	340	-	-

Station check: Surat and New Delhi(GJ-39), Udaipur (SU 658), Indore (SPV 1022) and Mauranipur (SPV 1388); IP:Improved Practice, FP:Farmers Practice

Farmers local sorghum (left) and CSV15 (right) at Mauranipur in Jhansi district on farmers fields

The genetic potential of the improved varieties is not being realized on farmers fields due to poor crop management. In order to enhance its productivity both in arid and semi arid regions, two network projects were taken up wherein high yielding varieties were evaluated under moisture conservation and INM treatments as an integrated package.

On-farm trials were conducted in 6 target districts (Aurangabad, Beed, Ahmednagar, Dhule, Bijapur and Kovilpatti) in semi arid regions mostly covering the vertisol regions of the SAT and 7 target districts (Jodhpur, Barmer, Sikar, Jhunjhunu, Banaskantha, Jamnagar and Mahendragrah) in arid region in Gujarat, Haryana and Western Rajasthan. Ten to fifteen farmers were involved in each target district. In the SAT districts, two moisture conservation techniques i.e. opening of ridges and furrows with tied ridging (M_1) and paired row planting at 30/60 cm and opening of furrows in wider rows at 35 DAS (M_2) and two nutrient management treatments i.e. recommended dose of fertilizers (N_1) and 50% RDF + FYM @ 2.5 t/ha + biofertilizers (N_2) were tested against farmers practice.

On the basis of 3 years pooled data across districts, paired row planting at 30/60 cm and opening of furrows in wider rows at 35 DAS recorded significantly higher grain (2065 kg/ha) and fodder yield (3166 kg/ha) over ridges and furrows method with tied ridging (1886 and 2890 kg/ha grain and fodder yield respectively). Similarly the net monetary returns(NMR) recorded by paired row plating were significantly higher (Rs.5526/ ha) over ridges and furrows with tied ridging (Rs.4685/ha). The paired row planting treatment resulted in higher moisture conservation in the profile (Fig.1).

Among the nutrient management systems, application of 50% RDF + FYM @ 2.5 t/ha + bio fertilizer seed treatment recorded significantly higher grain (2051 kg/ha) and fodder yield (3117 kg/ha) and net monetary returns (Rs.5780/ha) over recommended dose of fertilizers (1883 and 2957 kg/ha grain and fodder yield as well as Rs.5350/ ha net monetary returns). However at Kovilpatti, ridges and furrows with tied ridging + 50% RDF + FYM @ 2.5 t/ha + biofertilizer seed treatment recorded significantly higher grain yield of 1709

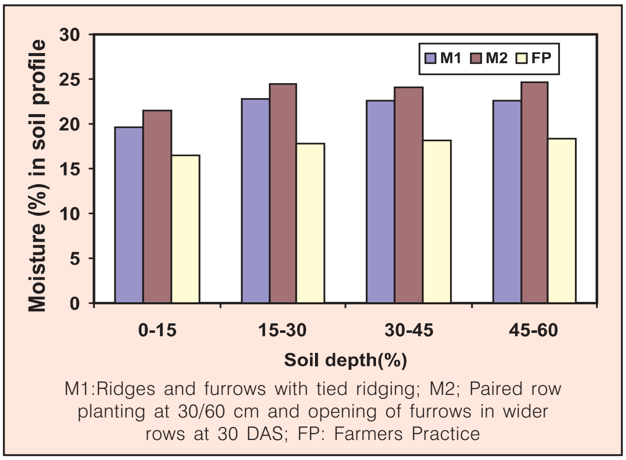


Fig.1 : Effect of conservation practices on soil moisture content at tillering stage on farmer's field in Aurangabad district

Pearlmillet with best moisture conservation (ridge & furrow after interculture at 30 DAS in wider row spacing) and INM on farmers fields in Barmer district

kg/ha and B:C ratio of 2.57 over farmers practice (1148 kg/ha and 1.39 respectively). Among the cultivars evaluated for moisture stress conditions, *Saburi* was found to be most superior in Aurangabad and Dhule districts, whereas ICTP-8203 out performed other genotypes in Bijapur district. AIMP-92901 recorded highest grain and NMR in Kovilpatti district.

Impact studies during 2004 indicated that 15% farmers in the target villages have adopted the technology, particularly of improved seed varieties. There is a need for taking up seed production of these varieties locally.

In the arid region, more than 100 on-farm trials were carried out for 3 years in 7 target districts in Gujarat (Banaskantha and Jamnagar), Rajasthan (Jodhpur, Barmer, Sikar and Jhunjhunu) and Haryana (Mahendragarh). Among different varieties and hybrids evaluated including the local check, ICMH-356 gave the highest yields of 1708, 1761 and 631 kg/ha respectively in Jodhpur, Barmer and Fathepur Shekawati districts on farmers fields. In OFTs of Gujarat, GHB-577 proved to be the best with grain yields of 3033 and 2440 kg/ha in Jamnagar and Banaskantha districts respectively. At Bawal, HSB-117 recorded the highest yield of 1916 kg/ha.

Based on 4 years pooled data across centers, maximum grain and fodder yield were recorded with ridge and furrow after interculture (30 DAS) in wider row spacing (60 cm) with 50% of recommended N through fertilizer + 50% N through FYM which was significantly superior to moisture conservation + 100% RDF and farmers practice (Table 5). The same treatment recorded highest yields on farmers fields in Gujarat and Haryana. However, in case of Haryana, 100% N through chemical fertilizers produced more fodder yield. The best varietal combination for mixed cropping of pearl millet + cluster bean were also identified for each of the target districts.

Legumes in minor millets based intercropping system

Fingermillet, kodomillet and little millet are generally grown in tribal areas in mixed cropping systems. The tribals in these areas suffer from malnutrition due to inadequate protein in their diet. Hence an attempt was made to introduce a variety of food legumes in tribal areas of Berhampur, Vizianagaram, Dharmapuri, Dindori and Bangalore rural districts through farmer participatory on-farm research. Both grain and vegetable legumes were tried in inter and sequence cropping systems.

Table 5: Effect of different moisture conservation techniques on grain and fodder yield (kg ha^{-1}) of pearl millet (Mean of 4 years data based on 15 farmers in each district)

Treatment	Jodhpur*		Barmer		Fatehpur Shekhawati		Jamnagar		Banaskanta		Bawal	
	Grain	Fodder	Grain	Fodder	Grain	Fodder	Grain	Fodder	Grain	Fodder	Grain	Fodder
T1	1028	1589	785.5	1376	888	2293	2544	5028.5	1575	2949	2043	5155
T2	1130	1704	810	1464	977	2630	3188	5847	1877	3361.5	2028	5076
T3	756	1214	528	1031	682.5	1997.5	1862.5	4242	1013	2465	1817	4657

*Mean of 3 years

T1 = Ridge and furrow after interculture (30 DAS) in wider row spacing (60 cm.) with recommended N through fertilizer (40 kg/ha)

T2 = Ridge and furrow after interculture (30 DAS) in wider row spacing (60 cm.) with 50% of recommended N through fertilizer + 50% through organic manure

T3 = Farmers practice

On-farm trials in Bangalore rural and Kolar districts showed significantly higher net monetary returns (NMR) and BC ratio with finger millet + pigeonpea (1:1.98) and finger millet + fieldbean(1:1.48) as compared to farmers practice of finger millet + akkadi(1:1.21) system based on 3 years pooled data (Table 6). The results were similar for all 3 years despite the variation in rainfall showing the advantage of pulse intercropping instead of mixed cropping. In Ganjam district too, finger millet + pigeonpea intercropping proved superior to sole finger millet both in terms of yield and monetary returns. Double cropping of vegetable cowpea (for utilization of biomass as fodder or incorporation into soil) followed by finger millet sequence cropping has enhanced finger millet grain equivalent yield by 150 per cent (4760 kg/ha) over sole finger millet (1902 kg/ha). The gross monetary returns were also proportionately higher with double cropping.

In 13 OFTs carried out in Dharmapuri district of Tamil Nadu, intercropping of fingermillet and field bean (8:1); finger millet and pigeon pea (8:2) were compared with monocropping of finger millet. Finger millet + field bean gave higher NMR (Rs.18634/ha) and a B:C ratio of 2.47 than finger millet + pigeon pea (Rs.17608/ha NMR and 2.34 B:C ratio respectively). Lowest NMR were realized with monocropping of finger millet (Rs.13875/ha and B:C ratio 1.98). Similarly in Vizaianagarm district, fingermillet + pigeonpea (8:2) and in Dindori district (M.P.), kodo millet + pigeonpea (8:2 and 2:1) and Kodo millet + blackgram (2:1) performed significantly superior to farmers practice of mixed intercropping with kodo millet and pulses (Table 7). These trials on farmers fields generated

Table 6 : Yield and NMR from finger millet and pulse intercrops on farmers fields in Bangalore rural and Kolar districts (Mean of 3 years based on 10 farmers from each district)

Cropping System	Finger millet grain yield (kg/ha)	Finger millet straw yield (kg/ha)	Pulse yield (kg/ha)	FM grain equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	Net monetary returns (Rs/ha)	B:C ratio
FM+PP	2811	5334	417	5177	11604	15332	1.31
FM + FB	2626	4784	163	4686	11712	11953	1.01
FM+AK	2011	4932	—	3644	10924	9219	0.85

FM : Finger millet; PP : Pigeonpea; FB : Field bean; Ak : Akkadi Practice

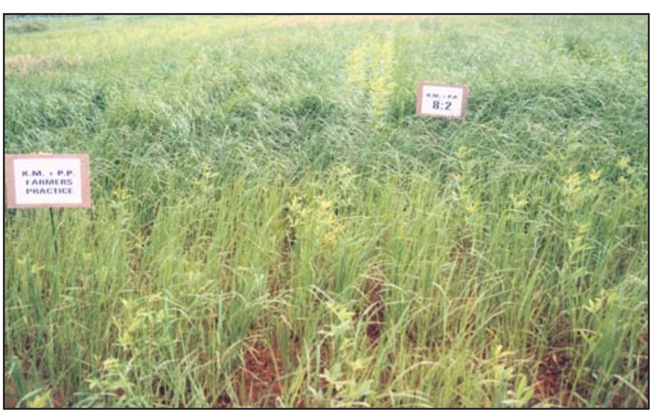
Table 7 : Grain yield and monetary returns from kodo millet based intercropping systems in farmers field in Dindori district, M.P. (Mean of 40 farmers for 3 years)

Treatment	Kodo yield (kg/ha)	Legume Intercrop yield (kg/ha)	Kodo GEY (kg/ha)	Gross monetary returns (Rs /ha)	Net monetary returns (Rs/ha)	B:C ratio
Farmers practice (broadcasting)	520	92	882	4410	1135	1.35
Kodo millet + Pigeonpea 2:1	890	306	1808	9040	4293	1.89
Kodo millet + Blackgram 2:1	1053	434	2572	12859	8030	2.67
Kodo millet + Pigeon pea 8:2	1201	208	1825	9124	4481	1.96

awareness on the importance of legumes both for income generation and nutritional security and if widely adopted can ensure better protein supply to the tribal communities.

Management of blast disease in finger millet

Finger millet is an important small millet which occupies over 2 million ha area. Blast is one of the serious disease that limits the productivity of this crop. Network research was taken up at Bangalore, Coimbatore and Ranichauri on management of this disease. The approach involved characterization of the pathogen, germplasm screening and on-farm trials for testing the efficacy of integrated disease management package. Studies indicated that the blast pathogen induces a phytoelexin, pyrichalasin-H in the infected leaves. The toxin was characterized through chromatography. Based on the R_f values, it was identified as Oryzalexin A and B, respectively which was the first report about the occurrence of such phytoelexin in finger millet. From extensive screening of 400 lines, only 9 lines were found to be resistant. These include GE-253, GE-325, GE-355, GE-371, GE-387, GE-393, GE-408, GE-409. These lines were completely resistant to neck blast as against 57.5% in check (C-273) while the incidence of finger blast varied between 7 to 30% as against 36% in check. Four lines were found to be resistant for both. Dis-coloured seed invariably carried the pathogen regardless of resistant or susceptible nature of the varieties. Extensive studies were done on pathotyping at Ranichauri. After thorough analysis of 1200 isolates from 9 locations in 16 host differentials, the highest diversity was found in Bangalore which were divided into 6 groups.



Left : Kodomillet + pigeonpea under farmer's practice (front), Improved practice (behind) in Dindori district of M.P.
Right : Fingermillet + pigeonpea (8:2) on farmers fields in Mudalapalaya village of Bangalore rural district

Finger millet on farmers field in Kolar district with improved vs. farmers practice of blast mangement

On-farm trials were carried out in Karnataka (83), Tamil Nadu (14) and Uttaranchal (23) wherein 4 treatments were compared i.e. farmers variety untreated (T_1), farmers variety with seed treatment with carbendazim @ 2g/kg seed (T_2), improved variety untreated (T_3) and improved variety with seed treatment as in T_2 (T_4). The improved variety was GPU-28 in Karnataka and Tamil Nadu and VL-149 in Uttaranchal. The pooled data between 2000-2003 of the OFTs in 7 districts of Karnataka are presented in Table 8. Improved variety with seed treatment gave highest yield and recorded least disease incidence followed by improved variety without seed treatment. The farmers variety recorded lower seed yield and higher blast incidence irrespective of seed treatment.

Forecasting grain mould in sorghum

In a related project, weather based prediction model for forecasting the outbreak and disease intensity of grain mould in sorghum was developed. The onset and intensity were influenced by rainfall during post-flowering stage irrespective of quantity (20 mm or more) both across locations (Akola, Coimbatore, Dharwad, Palem and Parbhani) and cultivars (CSV-15, SPV-461, CSH-13 and CSH-14). Minimum temperature (19-21° C) also favoured disease development. Forewarning advisory based on the prediction equation comprises of fungicide spray with captan @2g/l+aureofungin @0.2mg/l.

Rainwater management in maize based cropping system

Two network projects addressed rainwater management issues in rainfed maize based cropping system in central and western India and Shivaliks. In both the projects, the main objective was to conserve the rainwater either *in situ* or harvest in ponds and recycle it for crop life saving irrigation and increase the cropping intensity. In the first project, the best *in situ* moisture conservation + INM treatment for different topo sequences was compared with farmers practice in 5 major maize growing districts in Rajasthan (Udaipur, Bhilwara), Punjab (Nawanshahar), M.P. (Jhabua), Gujarat (Panchmahal) and A.P. (Karimnagar).

Based on the on-station trials, four promising treatments were evaluated on farmers fields during 2001-02 and 2002-03. These include farmers practice (T1), 50% recommended dose through inorganic fertilizers + 2.5 ton organic manure/ha + biofertilizer seed inoculation (*Azotobactor*+PSB

Table 8 : Performance of OFTs on blast management package on farmers fields in Karnataka (Mean of 46 trials for 3 years i.e. 2000-03)

Treatments	Neck Blast (%)	Finger Blast (%)	Seed Yield (kg/ha)
Farmers variety + Untreated	6.1	6.8	1676
Farmers variety + Seed treatment with carbendazim @ 2 g /kg seed	3.1	3.9	1827
GPU 28 V2 + Untreated	0.4	1.3	2524
GUP 28 V2 + Seed treatment with carbendazim @2g/kg seed	0.1	0.6	2708

@600g/ha seed each) along with other recommended cultural practices and cultivar(T2), 100% recommended dose through inorganic fertilizers + 5 ton organic manure/ha + bio-fertilizers as per treatment T2 along with other improved cultural practices and cultivar (T3), treatment T3 + intercropping of maize with legume (T4). The results indicated that the treatment comprising of intercropping maize with legume with 100% RDF + 5 t FYM/ha + biofertilizer recorded highest maize equivalent yields and net returns at all centers. The best treatment was further evaluated during 2003-04 in the same target districts for its profitability along with farmers practice through 15 OFTs in each district. Improved practice recorded 213, 70, 52 percent higher maize equivalent yields at Udaipur, Nawanshahr and Jhabua districts respectively. Best results were obtained on lower toposequence. The over all results clearly indicated the importance of toposequence based *in situ* moisture conservation and INM in realizing higher productivity and monetary returns in rainfed maize based production system (Table 9).

In another network project, the impact of rainwater recycling on yield of maize and on cropping intensity was evaluated in sub mountain regions, receiving more than 1000 mm rainfall. Two major production systems i.e. maize – wheat and rice –

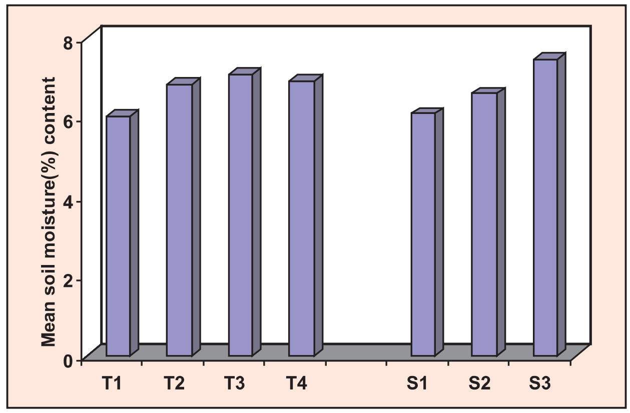


Fig.2 : Effect of different treatments and topo-sequences on mean soil moisture content at 15-30 cm soil depth at harvest (mean of locations for two years i.e. 2001 and 2002

wheat were covered in the states of Haryana, Punjab, H.P, J&K, U.P. and Bihar. Water storage capacity of 2.4, 0.9, 0.6 and 0.8 ha m was created in micro watersheds in Solan, Panchkula, Jammu and Hoshiarpur districts, respectively. The life saving irrigation provided with this additional water showed positive impact at all the locations, but the most notable was in Johranpur village of Himachal Pradesh. In this village, based on maize – wheat production system, the maize yields prior to the project ranged between 10-15 q/ha while in the past wheat crop used to fail completely two out of five years. The creation of water harvesting farm ponds and diverting the runoff into two

Table 9: Effect of different treatments and topo-sequences on maize equivalent grain yield and net returns in 6 target districts (Mean of 2 years with 10 farmers in each district)

Treat-ments	Udaipur		Bhilwara		Nawanshahr		Jhabua		Panchmahal		Karimnagar
	MGEY	NMR	MGEY	NMR	MGEY	NMR	MGEY	NMR	MGEY	NMR	MGEY
T_1	10.06	6408	9.82	3477	12.10	1260	11.26	2676	12.68	4032	22.18
T_2	21.66	12531	12.72	4273	14.10	1646	13.96	3637	14.95	5361	35.72
T_3	27.72	15869	14.85	5132	16.40	2183	17.76	4923	18.07	6307	46.17
T_4	33.65	19290	20.26	8280	27.40	5686	21.78	6351	19.22	8018	57.77
Topo-sequences											
S_1 (High)	20.76	11681	13.37	4410	18.80	3627	12.22	3204	14.44	4666	34.46
S_2(Middle)	23.15	13544	14.22	5174	17.70	2893	17.03	4402	16.15	5986	40.79
S_3 (Low)	25.91	15449	15.64	6286	15.90	1580	19.31	5584	18.10	7133	45.89

MGEY: Maize Equivalent Grain Yield; NMR: Net Monetary Returns

Comparison of the farmers practice of sole maize (left) with improved practice of legume intercropping, moisture conservation and INM (right)

ponds changed the face of the village. During 2001-02, the stored water could irrigate 8 ha. of land. During 2003-04, the seepage losses from the ponds were arrested by polythene linning. As a result, the water available in the pond during 2003 was 1.8, 1.75, 2.34 and 4.66 times more during September, October, November and December respectively as compared to 2001. The over all cost benefit ratio of the polythene lining was worked out to be 1:2.56. With the harvested rain water, a total of 8 ha. could be provided supplemental irrigation during the year. A notable spin-off of water harvesting was the crop diversification. Besides increasing the diversification index among small and marginal farmers, the annual net agricultural income increased from Rs.7,448/- before the start of the project to Rs.24,590/- by the end of 2003-04 season. The impact of the project on various crop parameters before and after the project is given in Table 10.

The data reveals a significant shift from maize – wheat cropping system to other high value crops like vegetables, mustard, urd, gram, taramira tomato and perennial fruit crops like mango mainly due to water availability after the *kharif* season. During last three years, the project generated cumulative additional income of Rs.5,65,686/- as against the total investment of Rs.6 lakhs. The income from different livelihood sources also significantly changed after the project with a significant rise from agriculture and horticulture (Table 11). This project clearly


A water harvesting pond of 1.7 ha m capacity completely filled with the runoff water from the village catchment (left), a view of the diversified cropping systems in Johranpur village after the project (right)

Table 10: Percent area under different crops and value of output in Johranpur village, H.P. before (2000) and after (2003) the project				
Crops	Before the Project		After the project	
	% of Area	% value of output	% of Area	% value of output
Seasonal crops				
Wheat	50.00	31.14	37.24	29.95
Maize	46.55	27.78	31.03	19.34
Chari	1.72	0.51	2.06	0.30
Mustard	—	—	5.52	1.36
Urd	—	—	9.61.	1.56
Taramira	—	—	1.38	0.16
Gram	—	—	2.06	0.53
Sub-Total	**98.28**	**59.43**	**88.95**	**58.20**
Perennial crops				
Mango, Anola +Papaya	1.72	1.50	7.25	4.92
Tomato	—	—	3.80	9.73
Sub-Total	**1.72**	**1.50**	**11.05**	**14.65**
Allied products				
Dairying	—	39.07	—	31.80
Fishing	—	—	—	0.35
Sub-Total	**—**	**39.07**	**—**	**32.05**
Total	**100.00**	**100.00**	**100.00**	**100.00**
Absolute area /value	**20.0 ha**	**Rs.4,15,321**	**29.0 ha**	**Rs.10,51,348**

highlighted the key role of water resource development for improving farm productivity and livlihoods in the sub mountain regions.

Constraint analysis in rainfed maize based production system

A comprehensive study covering bio physical and socio economic constraints in maize based production system was carried out for 70 target districts in the country falling in MP(21), Rajasthan(15), UP(11), Orrisa(6), AP(5), Gujarat(3), Karnataka(3), Jharkhand(3) and Punjab(3). A critical analysis of the climatic and soil parameters, inputs, credit and marketing aspects was done to identify major constraints and opportunities for increasing the returns.

Table 11 : Impact of watershed development project on the source of income of farmers in Johranpur (H.P)				
Source of income	Before		After	
	Income	%	Income	%
Agriculture +Horticulture	123416	14.52	426609	25.83
Animal Husbandry	162279	19.09	193018	11.69
External sources	530480	62.40	945620	57.25
Other sources with in the village	34000	3.99	86500	5.24
Total	**850175**	**100.00**	**1651747**	**100.00**

The compound growth rate analysis for Rajasthan revealed that the area under maize decreased in Ajmer, Baran, Bundi, Jhalawar, Kota and Pali districts. This was due to replacement of maize by other crops like pearlmillet, soybean and groundnut. On the other hand, maize area increased in Chittorgarh, Dungarpur and Udaipur districts significantly by replacing cotton, rice and sorghum. In case of Punjab, area under maize decreased over time in all the three-targeted districts. With increase in irrigation facility, the farmers have shifted towards paddy due to less risk and high returns. Area under maize in M.P. during 1990-91 to 2000-2001 declined significantly by 1.16% per annum, which rose only during the period 1979-1980 to 1989-90. This reflected in declining trend in growth rate of production from 6.41 to 0.25% per annum due to shrinking area. Bastar, Bilaspur, Surguja, Chhindwara, Guna, Indore, Ratlam, Dewas, Dhar, Jhabua and Shivpuri registered significant decline growth while rest of eleven targeted districts recorded increasing growth rate in area. Maize area decreased in all the three-targeted districts in Jharkhand without affecting the level of production. This increase in yield growth may be attributed to the genetic break through in maize technology coupled with better plant nutrient management. The study showed that maize was being substituted by pigeon pea in this state. In case of Karnataka, maize recorded a significant growth both in area and production. Similarly, maize area increased significantly in the target districts of Andhra Pradesh except Nizamabad where commercial crops like sugarcane and chillies, which are more remunerative, replaced maize area in this district. Maize area did not vary much in Gujarat but high variability was noticed in the production and productivity of maize in all the targeted districts. Bajra, groundnut and green gram were the competiting crops. In Orissa, decrease in maize area in Kalahandi district was due to substitution by pulse crops.

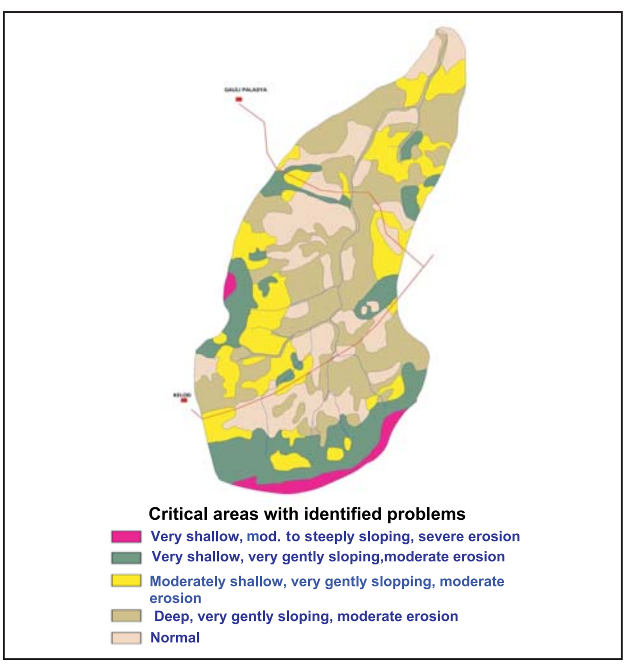
Socio-economic survey of two selected districts in each state was carried out. Based on detailed personal interview with farmers (400 at each centre) the principal constraints were identified. Erratic and inadequate rainfall (agro-climatic) was the main constraint in Rajasthan, Jharkhand, Gujarat and Andhra Pradesh. Farmers of these areas face serious problem of water shortage at critical stages of crop growth especially at flowering and milking stage. Availability of proper seed and fertilizer at right time and credit facility were the next important constraints in Rajasthan and Gujarat. In general marketing of surplus produce at reasonable rate was also an important constraint in all the states especially in U. P., Rajasthan, Gujarat, Jharkhand and Orissa. Next important constraint recorded by the respondents was availability of timely credit. Availability of irrigation, credit and plant protection chemicals timely was the problems for farmers in Punjab. High cost of seed and fertilizer were the main constraints in Madhya Pradesh followed by inadequate rainfall, non-availability of extension services and credit. Market yard and sub yards must be established at micro level so that farmers can get remunerative price. Jharkhand and Gujarat were also facing similar problems. High cost of seed and fertilizer were major constraints in Karnataka followed by extension services and knowledge on inputs. Poor extension services was the most important constraint in Orissa. The suggested strategies to over come these constraints are :

- Popularization of short duration composites and pulses as intercrops where growing season is less than 105 days. There is a need for short duration hybrids suitable to such areas.
- Adoption and popularization of soil fertility based fertilizer recommendation at micro level.
- Establishment of maize processing units for value added products, especially in tribal areas of Rajasthan and Gujarat.

- Small and marginal farmers invariably use lower inputs like fertilizers and pesticides. Better credit support will enhance input use by these farmers and result in higher productivity.
- Introduction of crop insurance programme in districts where the rainfall fluctuations are high.
- Maize should replace paddy in chronically water shortage districts.

Remote sensing in planning and monitoring of micro watersheds

As most of the nutritious cereals are grown under low rainfall areas, rainwater conservation and management on watershed basis is a key input for improving productivity. In order to improve the implementation of watershed development projects at all stages including planning, action plan preparation, implementation and monitoring, remote sensing technology was utilized in 5 pilot projects. During 2001 and 2002 using the IRS-IC/ID LISS-III and PAN data supported with ground information, thematic maps on soils, land use, land cover and hydrogeo morphology were prepared. These maps were utilized for preparation of action plans for each of the 5 micro watersheds in M.P. (Gaulipalasiya, Indore), Gujarat (Vagra, Bharuch), A.P. (Sakalaseripalli, Nalgonda), Maharashtra (Vadala, Solapur : Nipana, Akola). During 2003-05, the prioritized land treatments for critical areas were implemented which included construction of conservation structures and taking up crop demonstrations. The performance of conservation structures and the agronomic trials was assessed critically in all the micro watersheds in terms of additional water resources generated and improvement in crop yields. In Gaulipalasia, the ground water level improved by 5-6 m, runoff reduced by 10-12%, crop yields increased by 50-75% and net income of participating farmers doubled due to the implementation of the watershed programme. Mono cropping area came under sequence cropping. Quickbird multi-spectral pictures were obtained to map the structures at high resolution in each of the micro watersheds, as illustrated in the picture of Nipana watershed in Akola district, which clearly depicts the intermittent contour trenches (ICT) and farm ponds (FP). The experience from 5 pilot watersheds clearly indicated that remote sensing technology can be successfully used for planning and monitoring of watershed projects. The main advantage of this



Map showing the critical areas ideitified for prioritized treatment in Gaulipalasia watershed (left) and Quick bird multispectral data picture of the treated area in Nipana watershed (ICT=Intermittent Contour Trenches; FP=Farm Pond) technology lies in identifying critical areas in the wateshed which helps the planner to focus more on these areas so that maximum returns could be realized from the potential areas. The technology can be readily made use in effective implementation of the on going National Watershed Programme on Rainfed Areas (NWDPRA) and the Integrated Watershed Development Programme (IWDP) and other area development projects where natural resources conservation is an important component.

Land use practices and carbon sequestration

The importance of soil organic carbon in sustaining productivity is recognized globally. However, in India only recently this problem is receiving some attention. In order to identify cropping systems/land use practices that sequester more carbon, 28 benchmark sites covering 52 pedons across 5 bio climatic zones of the SAT region were studied in detail. The initial soil properties of these benchmark sites were used as reference points and improvement in soil organic and inorganic carbon stocks along with other properties were studied as influenced by different land use practices (forest, horticulture, agriculture, fallow) and management practices (high, low and farmers management).

Highest concentration of organic carbon (1.44%) was observed under forest system, followed by permanent fallow (1.42%), horticultural system (0.80%), agricultural system (0.70%) and wasteland (0.47%). The sequestration of inorganic carbon on the other hand was found to be highest in horticultural system and agricultural system (0.80%), followed by wasteland (0.70%) and forest system (0.16%). The improvement of organic carbon under different agronomic management followed in order : High Management > Low Management > Farmers' Management. Intercropping system (cotton/pigeonpea) restored more carbon compared to sorghum (cereal) based cropping system. Irrespective of bioclimatic systems, introduction of pigeonpea with or without other leguminous crops, improved SOC status in Indian soils. Legume-based intercropping system (soybean/pigeonpea and green gram/ pigeonpea) restored higher amount of SOC, soil microbial biomass (SMBC) compared to double crop in rotation (soybean-wheat/paddy-paddy cropping system). From the overall studies, some of the best cropping systems for carbon sequestration in different production systems of SAT regions are listed in Table 12.

Improving grain quality in *kharif* sorghum

One of the reasons for the steady decline in area under *kharif* sorghum is the low grain quality due to deterioration caused by unseasonal rains. A number of technologies like harvesting at physiological maturity and artificial drying, pearling, chemical treatment, solarisation and identification of grain mould tolerant genotypes were tried to over come this problem. The technology of harvesting at physiological maturity and artificial drying was tried in 6 districts of A.P., Maharashtra, Karnataka, M.P. and Tamil Nadu for three consecutive years. From farmers fields (10 farmers from each district) a portion of the crop was harvested at physiological maturity and artificially dried with the help of a suncue drier, while the rest was harvested at normal time and sun dried (farmers practice).

The technology of harvesting at physiological maturity and artificial drying was found to be most effective to improve grain quality and fetch higher market price. On an average, over three years, adoption of this technology resulted in 35% increase in market price of the produce as compared to farmers practice (Table 13). The difference was more during 2001-02 and 2003-04 when the grain mould incidence was more due to late rains. During 2002-03 the incidence was low resulting in low

Table 12 : Some promising cropping systems in SAT regions for higher carbon sequestration					
Sl.No.	Soil series	Rainfall (mm)	Cropping system and management	Carbon stock SOC %	Carbon stock SIC %
	Cotton/Sugarcane system				
1	Asra	975	• 2 year rotation of Cotton+Pigeonea-sorghun-chickpea • Green manuring (Sunhemp/Sesbania)	0.92	0.64
2	Paral	794	• Cotton+Pigeonpea • Sorghum as third intercrop	0.63	1.19
3	Nimone	520	• Cotton+Pigeonpea • Sorghum fodder and Sesbania green manure as regular rotation • FYM and ferlizer : normal dose • Water requirement – 1000-1200 mm/ha	0.76	1.71
			• Sugarcane-Wheat/sorghum • N:P – high dose • FYM – Nil • Irrigation : 30 per year • Water requirement – 2500-3000mm/ha	0.76	2.64
	Soybean				
4	Nabibagh	1209	• Soybean-Wheat • Seedrate – high • Fertilizer – balanced • FYM – (3-4 t/ha (annual)	0.75	0.65
5	Sarol	1053	• Soybean-Wheat/fallow • FYM – regular	0.76	0.78
6	Kasireddypalli	764	• Soybean+Pigeonpea (4:1) • Fertilizers – 40 kg P_2O_5/ha • Manure – Gliricidia as green manure • BBF (1.05/0.5m)	0.76	0.53
	Cereals				
7	Hayatnagar	764	• Sorghum-Castor (2 year rotation) • Fertilizers – Recommended dose • Manure – Sorghum/gliricidia stubbles	0.93	—
			• Sorghum-castor (2 year rotation) • Fertilizer – Recommended dose	0.96	—
8	Teligi	632	• Paddy Monocrop under canal irrigation • Monocropped paddy under high inputs	1.03 0.80	1.31 0.96

difference between market price of normal grain and that of artificially dried. In order to bring down the cost of artificial drying, a low cost community drier was fabricated to dry large quantity of grain in a short time (1.5 t panicles/h). Three such community driers were successfully tested in Parbhani, Dharwad and Mahabubnagar districts which are now running successfully. These driers will be operated on custom hiring basis by farmers groups/cooperatives.

Pearling also improved the market price of the deteriorated grain with an average additional price realization of 26% across locations. Among various anti heating chemicals tried, treatment with 4% acetic acid was found to be the most effective in preventing grain deterioration due to

Year	Target District	Harvesting at physiological maturity and artificial drying	Normal harvesting and sun drying (farmers practice)	Additional price realisation (Rs/tonne)	% increase in the price
2001	Akola	3997	2419	1578	65.2
	Parbhani	4053	2697	1356	50.3
	Mahabubnagar	5514	3014	2500	83.0
	Coimbatore	8072	5831	2241	38.4
	Mean	**5409**	**3490**	**1919**	**55.0**
2002	Akola	4710	4255	455	10.7
	Parbhani	5118	4819	298	6.19
	Mahabubnagar	4603	4206	397	9.44
	Indore	4117	3578	539	15.1
	Dhar	5469	5094	375	7.36
	Mean	**4803**	**4390**	**413**	**9.4**
2003	Akola	4500	3100	1400	45.2
	Parbhani	5250	4150	1100	26.5
	Mahabubnagar	5250	3650	1600	43.8
	Coimbatore	7000	4230	2770	65.5
	Indore	4670	3220	1450	45.0
	Mean	**5334**	**3670**	**1664**	**45.3**

Table 13 : Impact of harvesting at physiological maturity and artificial drying on the market price (Rs./ton) of *kharif* sorghum in the target districts during 2001-03.

*T1 = Harvesting at physiological maturity and artificial drying , **T2 = Harvesting at normal maturity and sun drying

moulds. Acetic acid treatment (4%) fetched a market price of Rs.4200/t as against Rs.3600/- with normal grain in Mahaboobnagar district. Among various released cultivars evaluated for grain mould tolerance, CSH-16 was found to be the most tolerant in field conditions. Under epiphytotic conditions, SVD 9601 was found to be promising with a grain mould score of 2.3. On-station trials resulted in identification of several promising high grain quality lines both from *kharif* and *rabi* germplasm. Any of these approaches can be adopted in the grain mould affected areas depending on the rainfall pattern and availability of local resources.

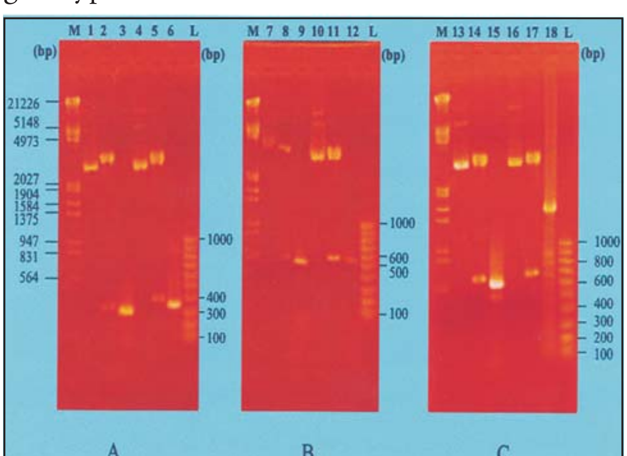
Improving roti making quality through gene transfer

Although sorghum contains similar levels of starch and protein as in other cereals, some factors like poor dough making quality, low digestibility, presence of tannin, and poor shelf life and inability to make soft, fluffy, palatable and easily digestible rotis limits its wide spread use by all consumers. Genetic engineering offers an opportunity to improve the physical and nutritional quality of grain sorghum by incorporating suitable seed storage protein genes from other species like wheat with good roti making quality.

For achieving this, appropriate sorghum genotypes were identified, gene constructs were made, an efficient regeneration system was standardized and biolistic transformation was done with glutenin gene. Cultivars of sorghum with better *roti* making quality were screened for the activity of amylase, protease and chitinase in germinated seedlings. Genotypes like SPV-1517, which showed higher chitinase activity, an indication of better shelf life were selected for further studies. Simultaneously, HMW glutenin proteins from wheat were purified and antibodies were raised against these to screen cDNA clones for an array of glutenins. Putative cDNA library for the HMW gene genes was prepared.

Helping the farmers to identify physiological maturity (left) artificial drying in sun cue drier (center) and sorghum grain before and after pealing (right)

The γ-Kafirin promoter was isolated and cloned (NCBI accession No.AY 294255) which was then fused to wheat HMW.gene (IAX-1, Idx5 and IDY10). The gene construct was cloned into suitable expression vector (Fig.4) before the HMW-gs under kafirin promoter could be introgressed in sorghum. An efficient transformation system was established using immature embryo explants (Fig.5) of the genotype M-35-1 and WB-4 through biolistic method. A total of 186 putative transgenic plants were obtained with plasmid PIAX-1 (containing wheat native promoter and HMW-gs, IAX-1), using the sorghum genotype M-35-1.



Lane M : Marker lambda hind III/EcoR I
Lane L : 100 bp DNA ladder
Lane 1&4 : Cloned undigested plasmid pGEM-T easy
Lane 2&5 : EcoR I digested cloned plasmid
Lane 3&6 : PCR amplified insert (cloned)

A : 1-3 clone MML 001; 4-6 clone MML 002
B : 1-3 clone MML 003; 4-6 clone MML 004
C : 1-3 clone MML 005; 4-6 clone MML 006

Fig.4 : Cloning of Kafirin promoter in pGEM T vector. Analysis of recombinants

Biofuel from sweet sorghum

Towards diversifying the use of grain sorghum, a comprehensive project was taken up to assess the potential of sweet sorghum stalk as a raw material for ethanol. Although sweet sorghum is used in many countries like Brazil for ethanol production, in India the progress in its utilization has been limited due to lack of data on feasibility and economic viability. A network project addressed this problem during 2001-05. The approach involved cultivar evaluation for juice extractability, estimating alcohol yield in the laboratory and pilot plant and making other value added products like jaggery, syrup, starch, bakery products and paper. Based on the response from the stakeholders, ethanol production was found to be most promising in view of the anticipated demand of ethanol as biofuel in the country.

Based on multi location (Hyderabad, Akola, Parbhani, Rahuri, Anakapalle, Phaltan and Virinjipuram) evaluation during 2001 and 2002, NSS-104, RSSV-47 and NSS-208 were found to be efficient for cane yield and juice extractability. June and February plantings were found ideal for maximum biomass and sugar content in the cane. The lean period for sugarcane was found to be ideal period for sweet sorghum harvest, so that the existing sugar mills can be operated for an additional three months. Harvesting at milky stage produced higher biomass in all the varieties but juice volume was found to be higher during harvest

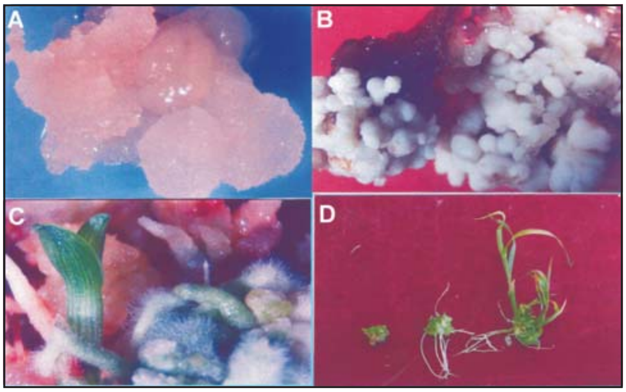


Fig.5 : Protocol for regeneration from sorghum immature embryo explants depicting (A) friable & embryogenic calli (B) white embryogenic calli (C) regeneration from friable calli (D) regeneration from white calli

at maturity. Among 4 yeast strain identified, two were found superior for ethanol production with all genotypes. These were identified as *Candida tropicalis* and *Cryptococcus albidus*. *C.tropicalis* showed alcohol tolerance upto 20%.

In general, upto 2000 l of alcohol can be produced from the crop grown in one ha. both from stalk and grain. However, some genotypes can yield upto 3000 l/ha. Data on alcohol yield from different sweet sorghum genotypes from breeding trials at Akola is presented in Table 14. Genotype RSSV-91 (1709.28 l) and NSSV-218 (1572.73 l) were found to be the best for recovery of alcohol from stalk juice, but maximum grain alcohol was obtained from NARISSH-43 (2014.65 l) followed by AKSSV-21 (2006.54 l) and NSSV-219 (1969.51 l). As regards of total alcohol yield from stalk juice and grain, AKSSV-22 recorded highest recovery (3354.67 l) followed by RSSV-91 (3161.35 l) and NARISSH-43 (3136.82 l).

A pilot contract farming and juice extraction study involving M/s.Renuka Sugars in Belgaum district of Karnataka on six hundred acres rainfed lands resulted in 9% ethanol yield from the juice and 46.4% bagasse. Two varieties (SSV-74 and SSV-84) and one hybrid *(Madhura)* were grown in this contract farming experiment. The cost of ethanol from sweet sorghum was worked out to

Table 14 : Average alcohol yield (l/ha) from advanced sweet sorghum genotypes at Akola, Maharashtra

Cultivars	From stalk juice (l/ha)	From grain (l/ha)	Total yield (l/ha)
RSSV-24	684.61	1021.63	1706.24
RSSV-44	670.77	1729.69	2400.46
RSSV-45	490.72	783.60	1274.32
RSSV-46	890.69	1720.87	2611.56
RSSV-57	1018.91	1009.72	2028.63
RSSV-58	987.37	1635.23	2622.60
RSSV-59	1439.82	877.59	2317.41
RSSV-216	568.54	1547.13	2115.67
RSSV-218	1572.73	1532.43	3105.16
RSSV-219	857.51	1969.51	2827.02
RSSV-91	1702.28	1452.07	3161.35
RSSV-106	1275.38	1286.08	2561.46
RSSV-120	877.60	1359.89	2237.49
RSSV-13	994.12	767.33	1761.45
RSSV-253	1091.47	950.81	2042.28
RSSV-254	1502.55	967.99	2470.54
NARISSH-43	1122.17	2014.65	3136.82
AKSSV-22	1492.66	1862.01	3354.67
AKSSV-21	868.61	2006.54	2875.15
SSV-84	1020.07	854.16	1874.86

be Rs.13.41/liter which was lower than Rs.1.87 from the ethanol produced from the molasses (Table 15). The quality of rectified spirit from sweet sorghum was of superior quality with good flavour, low in aldehydes and free from sulphates. By producing natural syrup from sweet sorghum stalk juice, Rs.12,000/ha net returns can be realized from one hectare. The other successful products developed from sweet sorghum include cakes and biscuits from sorghum flour, sorbitol and jaggery. Multilocational evaluation of promising genotypes in advanced varietal trials revealed that all the genotypes produced higher biomass than the check (SSV-84) indicating the possibility of identifying sweet sorghum genotypes with higher biomass production than SSV-84.

Considering the potential of sweet sorghum for ethanol production, large number of sugar industries have come forward to take up contract farming around the distilleries. During 2004, two large contract farming projects were initiated in A.P. (with M/s.Sagar Sugars) and Maharashtra (M/s.Godavari Sugars).

Table 15 : Comparative cost (Rs./litre) of ethanol production from sweet sorghum and molasses

Item	Sweet Sorghum	Molasses
Manpower	0.50	0.25
Steam	1.00	1.00
Electricity	1.00	1.00
Yeast	0.10	0.10
Management /Admin	0.10	0.25
Pollution Control	Nil	0.25
Raw material	10.41	12.13
Total (Rs.)	**13.11**	**14.98**

Health food from sorghum and millets

Sorghum, pearl millet and finger millets are known for their nutritional values. Due to the increased availability of fine cereals like rice and wheat, the consumption of these coarse grains is falling. Lack of product diversification and value addition is another reason for falling consumption of nutritious cereals. In a network project covering arid, semi arid and hilly regions of the country where pearl millet and minor millets are widely grown, the consumption, storage and utilization pattern of these crops was studied among the rural households. It was generally found that all over the country these grains are stored and consumed in a traditional manner without any value addition.

A number of value added products were prepared from all these crops at CCSHAU, Hisar (pearl millet), UAS, Bangalore (finger millet) and GBPUAT, Ranichauri (barnyard millet, foxtail millet). In addition to making large variety of supplementary foods, major focus was on

Field view of sweet sorghum crop and green canes after harvest formulating diabetic foods and evaluating the same among the target population for their effect on glycemic index. To improve the digestibility of coarse cereals based products, appropriate processing techniques such as acid treatment, heat treatment, blanching and malting for pearlmillet; germination, popping and roasting for finger millet; popping for barnyard and foxtail millet and popping and paraboiling for sorghum were standarised.

A variety of micronutrient enriched nutritious and health foods were prepared from sorghum, pearl millet and finger millet flour. These include diabetic biscuits, chapatti mix and cake from pearl millet, noodles and papads from finger millet, cookies and *bhakari* from sorghum. Fingermillet based vermicelli was formulated for different hypoglycaemic foods like *ashwagandha* root powder, *madhunasini* leaves powder, *jamum* seed powder, fenugreek seed powder and *amruthballi* leaves powder. All these vermicelli products reflected low glycaemic index when tested on diabetics. To meet the growing challenge of nutritional deficiencies among children, RTE finger millet sweet and spiced micronutrient enriched mixes were prepared. Dietary intervention with RTE extruded products with 50% fingermillet resulted in improvement in calcium and phosphorus status in children. Biscuits and sweets for diabetics were prepared from barnyard and foxtail millets and tested for sensory evaluation, shelf life and glycaemic index. Both the millet based biscuits reflected lower glycaemic index (Fig.6). Recipe for barnyard and barnyard-*methi pulao* was also standardized for diabetics.

Special sorghum flour was developed for diabetics and high fibre biscuits were produced from malted sorghum flour. These biscuits and cookies had excellent taste, flavour, colour, texture, appearance and nutritional profile. Use of multi-layered laminated pouches and vacuumisation or flushing enhanced shelf life of biscuits for six months and retained essential quality attributes. Pearl millet based supplementary foods developed earlier including *namkeen sev, matar, ladoo, popped ladoo,* cake, *nankhatai* etc. were evaluated nutritionally and for shelf life. The products stored well at 30^{o}C upto 3 months without much change in organoleptic acceptability.

Efforts were also made for dissemination of

Diabetic health food from millets (left) and training of women self help groups (right)

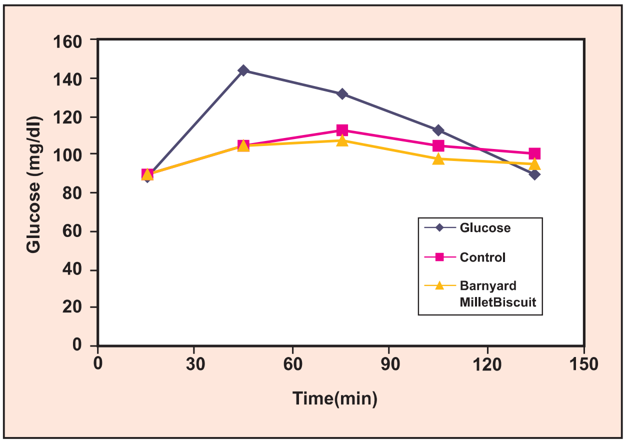


Fig.6 : The blood glucose response curve of control and barnyard millet biscuits in comparison to glucose load of 50 g

information on health benefits of millets to the stakeholders through trainings and demonstrations. More than 2000 women were trained at 3 centres during the project period and 15 sponsored training programmes were organized for the women self help groups (SHG) sponsored by the Panchayati Raj institutions. A national seminar on "Processing and utilization of pearlmillet for nutritional security" was organized at the lead centre (CCSHAU, Hisar) on October 7-8, 2003. Commercialization of products through small entrepreneurs and capacity building of self-help groups are continuing.

Crop diversification and alternate land use systems

In view of the low profitability and declining area under *kharif* sorghum, a number of alternate land use systems were evaluated in the traditionally *kharif* sorghum growing areas in different states. These options include agri-horticulture, agri-silviculture and silvi-pasture and industrial biomass plantation. The problems related to compatibility of the perennial and annual crop, initial establishment and profitability were addressed in these projects.

Horticulture, agri-horticulture and hortipasture systems

In order to assess the potential of agrihorticutlure systems as a substitute for *kharif* sorghum, production problems and economic returns from important mango and ber based agrihorti systems were studied in a network project in A.P. and Maharashtra. A diagnostic survey in the target districts (Mahabubnagar, Rangareddy, Beed, Sangli)revealed that there was a substantial shift towards perennial fruit trees viz., mango, ber, pomegranate, custard apple, fig, tamarind, sapota, guava, aonla, papaya, citrus etc. apart from growing vegetables, timber yielding and multipurpose tree species in place of *kharif* sorghum. Many of these orchards were maintained under virtually neglected conditions with meager fruit yields. Farmers preferred teak, neem, *Leucaena*, *Acacia*, *Dalbergia*, *Hardwickia* and *Gmelina arborea* mainly on farm bunds rather than regular plantations and in a few cases in non-arable drylands.

INM and *in situ* moisture conservation interventions based on soil analysis significantly improved the fruit yields in young (5-7) and old (> 10 years) orchards of mango in Mahaboobnagar district. With these interventions, mango yields were enhanced from 0.75 to 2 t/ha. in young orchards and 3 to 8 t/ha. in older orchards. Pasture species like *Cenchrus* and *Stylo* could be successfully grown in the interspaces of young orchards supporting profitable sheep farming. Similar improvements in yields were recorded in trials carried out on farmers orchards in Ranga Reddy, Beed and Sangli districts (Table 16). Soil test based nutrient use and *in situ* moisture conservation treatments significantly improved the yields and returns from ber, pomegranate and custard apple based agri-horti-pastural systems in the target districts. These results offer hope for profitable use of areas which were hitherto under *kharif* sorghum.

In another network project, a number of vegetable crops were intercropped in existing farmer's orchards of mango, sapota, custard apple and ber and the cost-benefit ratios worked out. The trials were carried out in Bangalore, Junagadh, Guntur, Jabalpur, Beed, Dharwad and Rahuri districts covering a total of 140 farmers in 61 villages.

At, Bangalore, intercropping of ragi and dolichos in young mango orchards resulted in an additional income varying from Rs.12,877/- to Rs.15,090/ha. In Guntur (A.P.) intercropping of black gram in mango orchard not only increased the mango yield (4.3) t/ha but also recorded highest net returns Rs.30,307/ha as against 3.54 t/ha and of Rs.19,688/- with sole mango. Mango intercropped with blackgram recorded an additional benefit of Rs.10,619/- per hectare to the farmer. Sapota intercropped with clusterbean recorded the highest yield of 14.29 t/ha, followed by intercrop ing with blackgram (14.24 t/ha) as against the sole yield of 13.17 t/ha. In mango based intercropping system in Bijapur, mango + groundnut recorded the highest net income (Rs.78,714/ha) with an additional income of Rs.10,624/ha from the intercrops. In sapota based intercropping system, sapota + groundnut recorded the higher net income of Rs.22,886/ha with an additional income of Rs.9,228/ha.

At Jabalpur, (M.P.) cultivation of cowpea (*kharif*) followed by bengal gram (*rabi*) as a sequence cropping in mango gave maximum productivity of 109 q/ha whereas, the highest gross returns of Rs.55,433/ha and net returns of Rs.45,433/ha were obtained when pigeon pea + tomato were grown in 2:2 paired rows as companion intercrops. Groundnut as intercrop gave highest net income (Rs.56,309/ha) followed by green gram (Rs.44,977/ha) in mango in Junagadh district (Gujarat). At Ambajogai (Maharashtra) intercrops like soybean + mustard resulted in higher yield and net returns of (Rs.12,743/ha) in mango orchard from intercrops. Cultivation of sesame (*kharif*) as an intercrop in aonla and ber at Dhule, (Maharastra) gave maximum returns of Rs.48,971/ha and Rs.32,114/ha, respectively and also additional income of Rs.14,791/ha and Rs.14,175/ha.

Among various *in situ* moisture conservation practices tried on farmers fields, circular basin

Table 16 : Yield of mango as influenced by different treatments on farmers fields in target districts (means of four years: 2001-2004)

Treatments	Yield (t/ha)									
	5-7 year group					> 10 year group				
	M*	R*	B*	S*	Mean	M*	R*	B*	S*	Mean
I. With SWC Measures										
RDF alone	2.87	0.63	1.07	2.02	1.65	10.60	9.76	8.88	7.81	9.26
FYM alone	2.30	0.69	0.85	1.94	1.45	8.83	9.81	6.06	7.84	8.13
RDF+Sorghum	2.50	0.64	0.91	1.72	1.44	8.89	10.17	6.97	7.15	8.29
RDF+Cowpea	2.86	0.80	0.87	1.98	1.63	9.38	10.42	7.66	7.74	8.80
RDF+Horsegram	2.81	0.83	0.92	1.81	1.60	9.11	10.31	7.30	7.64	8.59
RDF + Stylo	2.90	0.81	0.97	1.83	1.62	10.60	10.27	8.61	7.47	9.24
RDF+ *Cenchrus*	2.54	0.79	0.98	1.76	1.52	9.19	10.45	7.89	7.26	8.70
II. Farmer's practice (without RDF& SWC)	0.74	0.55	0.38	0.59	0.56	2.72	3.85	2.28	2.27	2.78
CD (0.05)	0.56	0.09	0.23	0.73	0.44	1.85	0.59	0.53	1.22	0.85

*M-Mahaboobnagar, R-Ranga Reddy, B-Beed, S-Sangli
SWC= Soil moisture conservation, RDF= Recommended dose of fertilizers

with 5% slope along with ragi straw mulch at Bangalore, Bijapur, Guntur, Jabalpur, Junagadh while 5% inverted circular basin with locally available mulch at Dhule recorded the highest yields. To illustrate, the economic benefit of *in situ* moisture conservation measures in mango in Guntur district are presented in Fig.7. Among various INM treatments tried, 75% recommended dose of fertilizers + 25 kg FYM + 5 kg vermi compost was found to be optimum combination at most locations.

In a related project, important vegetable crops were evaluated for their productivity on farmers fields in 6 target districts i.e. Junagadh, Rajkot, Amreli, Akola, Bangalore, Raichur, Coimbatore, Erode, Kurnool, Mahaboobnagar and Rangareddy. The trials included verietal evaluation, benefits of location specific *in situ* moisture conservation and INM. For each location, the best varieties with highest yield were identified. These include *Arka Lohit* and *Jayanthi* in chillies, *Pusa Navbahar* and *Gauri* in cluster bean, *Arka Anamika* and *Parbhani Kranthi* in okra. In particular annual drumstick var. PKM-1 and vegetable pigeonpea var. Hy-3C were found most promising and readily acceptable to the farmers in A.P. and Karnataka. Ridges and furrows + mulch was found to be the best moisture conservation practice an increasing the yield in the range from 28-42% over farmers

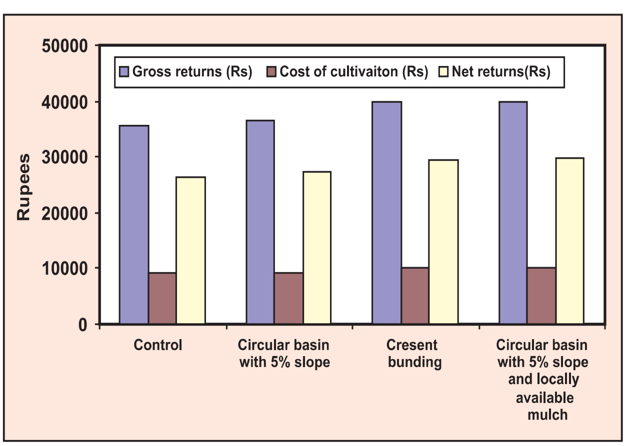


Fig.7 : Economics of *in-situ* water harvesting and low cost mulching in mango in Guntur district

practice in different crops. Similarly, application of 50% RDF + 50% FYM + biofertiliser performed better than 100% chemical fertilizers in terms of fruit yield and quality.

Silvi pasture systems

Recognising the importance of silvi pasture in drought prone areas, an effort was made to introduce improved systems on farmers fields, study its establishment and performance of livestock grazing on these pastures. On-farm trials carried out in 5 agro ecological zones i.e. Central Maharashtra plateau (Akola), Bhundelkhand (Jhansi), South Saurashtra (Junagadh), Southern Telangana (Mahaboobnagar) and South Western Semi-arid zone (Mathura) involving 112 farmers in 45 villages on establishment of silvi pasture mostly on degraded lands. A total of 45 ha of silvi pasture was established successfully at research stations and 30 ha. of farmers unutilized wastelands were upgraded through introduction of improved species.

The best performing trees were *Acacia nilotica* at Akola and Jhansi, *Dalbergia sissoo* at Mathura, *Leucaena leucocephala* at Junagadh and Mahabubnagar. In the pastures, highest production was recorded in sown systems at Akola (*Cenchrus ciliaris* and *Cenchrus setigerus*), Jhansi (*Cenchrus ciliaris* and *Cenchrus setigerus*), Junagadh (*Cenchrus ciliaris* and *Dichanthium caricosum*) and Mahabubnagar (*Cenchrus ciliaris* and *Panicum maximum*) and reseeded systems at Mathura (*Cenchrus ciliaris* and *Cenchrus setigerus*).

The legume population was higher in sown systems at all the centers when compared to reseeded systems. The relative proportion of such species in different systems governed the quality of forage. Sown systems on account of relatively high proportion of legumes maintained better quality. After one growing season, the lambs gained better body weight in the sown systems at most the centers. In the subsequent years, adult sheep exhibited

Agri horti system (mango + greengram) on farmers fields in Junagadh district of Gujarat

Pusa Navbahar, a clusterbean variety on farmers fields with adoption of soil and moisture conservation at Akola

better gains in body weight and other parameters in the sown systems. Silvi pasture systems also significantly improved soil organic carbon and available nitrogen at all the centers.

On farmers' unutilized wastelands, highest dry forage production with improved grasses and legumes was harvested at Junagadh (10.36 t/ha) followed by at Mahabubnagar (7.84 t/ha), Jhansi (5.76 t/ha), Mathura (5.19 t/ha) and Akola (1.35 t/ha). This was 361%, 163%, 107% and 76% higher respectively over farmers local vegetation. This visible success attracted the attention of several stake holders in the target districts. Seven government organizations, 10 NGOs, 2 SHGs and 153 farmers came forward to convert an area of 4280 ha into improved silvipasture system by the technology generated under the project.

Multipurpose live fences

In view of the problem of open grazing, establishment of horticulture or silvipasture systems is a major challenge on wastelands, and even on farmers fields. In view of the high cost of barbed wire fencing, an effort was made to identify suitable live fences for different agro climatic conditions through a network project. Sixteen species were evaluated on farmers fields in 6 targets districts (Jhansi, Koraput, Bellary, Dharwad, Parbhani and Rangareddy) falling in semi arid climatic zone. The establishment pattern, competition with the crop and cost of establishment and maintenance were compared vis-à-vis barbed wire fencing.

Based on overall results for 3 years, *Lawsonia inermis, Agave spp., Acacia concinna* and *Acacia cassia* (Chillar) were found to the most promising live fences across centers, mainly based on their establishment and multiple economic uses. Ridge method of planting showed better survival of all the species compared to flat planting. *Agave spp.* recorded the highest root shoot ratio and canopy density.

From third year onwards, all the live fences competed with the seasonal crops. Overall the crop yield was lower by 6.5 to 25 % upto 2 m from the live fence. Considerable reduction in runoff and soil loss was observed with all these species. The cost of live fencing including establishment and maintenance was considerably lower as compared to barbed wire fencing. At Jhansi, the total cost of live fencing with agave was Rs.35/- for running meter as against Rs.82/- for barbed wire fencing. At Koraput, the live fencing cost was much less at Rs.14/meter length as against Rs.117/- for wire fencing in view of the remoteness of the area. Similar cost advantages of live fences were recorded at Rahuri and Parbhani centers.

Supportive studies on botanical animal deterrants carried out at ANGRAU, Hyderabad indicated that the most common tannins found in leaves of the live fencing species were para coumaric acid, benzoic acid, pelargonidin, chlorogenic acid etc. Gel separated crude extracts when sprayed on forest vegetation showed repellant effect on bullacks, sheep and goat at 6% concentration. Among different crude extracts, leaves of *Ailanthus* showed high deterrence followed by *Sapindus*, *Tectona*, and *Cassia fistula*. When compared to goats and sheep, bullocks showed higher deterrence to the spraying of crude extracts even at lower concentrations ie. 2 and 4 percent. The crude extracts when sprayed on the plants at 6 % persisted upto 6 days.

Industrial biomass plantation

Fast growing trees like *Eucalyptus* and *Leucaena* are used as pulp wood raw material. Farmers grow these trees under farm forestry model in which they have to wait for the returns for 3-5 years. In an effort to provide immediate income and improve the soil fertility by legume intercropping in the interspaces of the tree rows, participatory on-farm trials were taken up in Khammam district of A.P. in collaboration with ITC, Bhadrachalam, a leading Paper board manufacturer.

Based on the field performance, *Leucaena* var.K-636 was found to be comparable for biomass production to the best *Eucalyptus* clones identifies by ITC, Bhadrachalam. Data on different planting pattern and geometry of *Eucalyptus* and the intercrop yields, revealed that farmers method of planting (3:2 m spacing) and improved methods tried in the project ie paired row planting of 7x1.5 m and 11x1 m and triple row planting of 10 x 1.5 resulted in comparable growth of the tree in terms of height and collar girth. The yield of intercrops was however significantly higher in improved method of planting in paired rows and triple rows. In triple row planting, the tree growth was poor in the middle row. Considering the over all biomass production in the system and economic returns, early results indicate that paired row planting with intercrop may be more rewarding than farmers practice both in terms of returns and sustaining the soil fertility.

Nutritious cereals as livestock/ poultry feed ingredients

Although nutritious cereals are well known feed ingredients for livestock, their low digestibility and poor quality has remained a major challenge. Similarly, due to continued shortage of maize for production of poultry feed, nutritious cereals like sorghum, pearlmillet and finger millet emerged as potential substitutes. Two network projects were taken up, one each on livestock and poultry to develop and test different feed combinations containing nutritious cereal grains and stocks as major ingredients. In the first project, various combination of poultry

Lawsonia as live fence for maize in Rangareddy district, A.P.

Paired row planting of Eucalyptus with wider alleys (10 m) and intercropped cowpea diets using sorghum and millets were used and the performance of broiler and layers was assessed. Birds used in commercial poultry industry and backyard poultry were studied.

Broiler diets

Whole pearlmillet (bajra) grain in broiler diet could safely and economically be incorporated upto 32% (w/w) replacing 50% of maize. Similarly, white, brown and red sorghum (jowar) could be incorporated in broiler diets replacing about 75%, 50% and 25% of maize, respectively, while fingermillet (ragi) could be used at lower level in broiler diet replacing not more than 25% of maize. Combinations of maize, pearlmillet and sorghum @33% each or maize, pearlmillet, sorghum and fingermillet @ 25% each could support the boriler growth and feed efficiency. Foxtail millet (*korra*) can replace yellow maize totally without affecting growth and economic traits. Inclusion of 30% w/w pearlmillet, 5% w/w rapeseed meal and 10% w/w sunflower seed meal or 30% pearlmillet, 10% rapeseed meal (RSM) and 10% sunflower seed meal (SSM) replacing maize and soybean meal partially rendered economic broiler production. Moreover, inclusion of sorghum (replacing 75% maize) along with 10% RSM and 5% SSM or 10% RSM and 10% SSM (w/w) resulted in economic broiler production.

Layer diets

In maize-soy diet, sorghum could replace 100 & 75% of maize and Kodo could replace 50% & 15%, respectively, in starter and grower (egg type) diets. Raising starting chickens on diets containing pearlmillet and/or sorghum replacing maize partially (50 and 75%, respectively) or completely and sunflower seed meal and mustard meal replacing soybean meal partly was found to be economical. Complete replacement of maize with sorghum rendered economical egg production although a diet containing 50% sorghum instead of maize was most beneficial. Combination of groundnut meal and niger meal in 75:25 ratio could substitute for soybean meal completely in maize-pearlmillet (50:50) based diet which supported optimum egg production in laying hens in backyard poultry.

Data from a feeding trial with day old *Vencob* male broiler chicks are presented in Table 17. Besides superior weight gain and feed conversion ratio, the fat accumulation was higher with minor millets indicating better energy value.

Use of sunflower deoiled cake up to 35% in the broiler diet by replacing 2/3rd of the soybean meal reduced the serum LDL cholesterol and increased HDL cholesterol with out affecting the body weight gain.

Nutritious cereals also can support backyard poultry and organic production of birds as seen from data presented in Table 18. The performance and feed cost for *Vanaraja* birds fed on fingermillet and pearlmillet was comparable to that of maize and the feed cost was relatively lower, particularly with pearlmillet.

There has been high stakeholder interest on the cost effective feeds formulated in the project. Since the ingredients are based on locally available coarse cereal and oilseed byproducts, it can give a fillip to the decentralized poultry production. Formal linkages have been established with veterinary directorates and poultry farmers associations in the states of Gujarat, Haryana, U.P. and Uttaranchal.

Improving digestibillity of crop residues

Another project addressed the low digestibility of coarse cereal crop residues for livestock. By including optimum level of locally available nitrogen supplements with cereal crop residues, both *in vitro* digestibility and feeding trials were carried out with cattle, sheep and buffalos in different target districts. In Bangalore rural district, feeding

Table 17 : Performance and certain blood parameters in broilers fed fingermillet at 42 d						
Ingredient (%)	Weight gain, g/b	Feed/ gain	Mean yield %	Serum cholesterol	HDL cholesterol	Serum triglyceride
Maize 100	1661[a]	1.873[c]	72.75	131	85[a]	34.9[b]
Finger millet 25	1560[ab]	1.902[bc]	73.44	126	76[a]	48.0[a]
Fingermillet 50	1487[bc]	1.970[abc]	72.52	124	58[b]	39.1b
Fingermillet 75	1382[c]	2.010[ab]	73.05	129	65[b]	33.7[b]
Fingermillet 100	1481[bc]	2.026[a]	73.15	114	66[b]	36.4[b]
$P\leq$	0.01	0.01	NS	NS	0.01	0.01

Means with common superscript in a column did not differ significantly ($P\leq0.01$)

trial with 110 cross bred cows revealed that animals fed with fingermillet straw supplemented with limiting nutrients recorded an increase in milk yield of 1-1.2 ltrs/cow/day; the feed cost reduced from Rs.3.6/day and farmers income increased by Rs.13-15/cow/day. The digestibility of organic matter and crude fibre of fingermillet straw was significantly higher in animals fed with limiting nutrients through locally available supplements. In this trial, animals in control group were fed with basal diet and supplements such as groundnut cake and wheat bran as practiced by the farmers. Animals in the experimental group were fed basal diet with groundnut cake, wheat bran and maize grain (50% of the wheat bran was replaced with maize grain).

The advantage of supplementing limiting nutrients for milk production in cows fed with fingermillet straw in Anagalapura village of Bangalore rural district is illustrated in Table 19. Similar beneficial effects of supplementation with limiting nutrient sources in pearlmillet straw for cattle in Ahmednagar and rice straw in Khurda district were observed.

Local goats and sheep which graze on natural pastures record slow weight gain due to nutritional deficiency. In order to correct this deficiency, OFT was carried out in Rangareddy of district A.P. with local sheep and goats. Forty weaned kids of three months age were selected from the flock of four farmers and grouped on the basis of their body weight and designated as T_1: Grazing on natural pasture, T_2: Grazing + Supplementation with *Leucaena leucocephala* leaves @ 1 kg/ head/day, T_3: Grazing + Supplementation of *Stylosanthes hamata* hay @ Ω kg/head/day and T_4: Grazing + Supplementation of concentrate @ 200g/ head/ day. The animals were allowed to graze on community grazing lands from 9:00 am to 5:00 pm as per normal grazing practice prevalent in village followed

Table 18 : Performance and feed cost (Rs./kg wt. gain) at 7 weeks age in *Vanaraja* chicks					
Energy source	Body wt. Gain, g	Food intake, g/d	Feed/ gain	Feed cost (Rs.)/wt. gain	Livability %
Yellow maize	1486[a]	99.9[a]	2.879[ab]	18.22	87.64
Pearlmillet	1394[a]	91.7[a]	2.777[b]	15.52	96.63
Fingermillet	1517[a]	97.8[a]	3.048[a]	18.19	95.45
Sorghum	1383[a]	96.9[a]	2.937[ab]	17.27	95.51
SEM*	44.21	3.13	0.404		

[ab] Means with different superscripts in a column differ significantly ($P\leq0.05$)

Table 19 : Ingredient composition of ration in control and experimental groups and milk yield on straw based diets in Anagalapura village, Bangalore rural district

Parameters	Control		Experimental	
	Quantity (kg)	Cost (Rs)	Quantity (kg)	Cost (Rs)
Finger millet straw	*Ad lib*	—	*Ad lib*	—
Wheat bran	3.69	23.99	1.95	12.68
Groundnut cake	1.06	12.72	0.95	11.40
Maize grain	—	—	2.0	9.00
Total feed cost	—	36.71	—	33.08
Milk yield	8.64	86.40	9.82	98.20

by night shelter within the compound of households.

Weighed quantities of supplements were offered in the shed at 5:00 p.m. and the actual intake was recorded. The experiment continued for 60 days. The highest body weight gain of kids was recorded due to *Leuceana leucocephala* supplementation followed by concentrate and *Stylosanthes hamata* hay (Table 20). Cost benefit ratio was also higher due to *Leucaena* supplementation as compared to Stylo hay or concentrate. The study revealed that tree foliage or forage legume could play a major role as supplements to improve the productivity of goats reared on natural pastures.

The over all results indicate immense opportunities of fortifying coarse cereal crop residues with locally available supplements in a cost effective manner.

Table 20: Live weight gain and partial budget analysis in kids grazed on natural pasture and supplemented with *Leucaena leucocephala*, *Stylosanthes hamata* and concentrate in Ranga Reddy district, A.P.

Variable	Treatments			
	T_1	T_2	T_3	T_4
Growth rate				
Initial B. Wt., kg	15.33 ± 0.52	16.35 ± 0.61	16.07 ± 0.44	15.42 ± 0.50
Final B. Wt., kg	18.73 ± 0.76	22.20 ± 0.65	20.67 ± 0.71	20.94 ± 0.59
Gain, g/d	56.67± 7.70	97.51 ± 6.90	76.67 ± 6.80	92.00 ± 5.60
DM intake from Supplements, g/d	—	350 ± 48	380 ± 59	190 ± 00
Total	500 ± 57	830 ± 63	700 ± 66	770 ± 49
Partial budget analysis				
Intake of supplements, kg	—	60	30	12
Total cost of feed, Rs	—	60	60	72
Total return, Rs.	1405	1665	1550	1571
Net return, Rs.	1405	1605	1490	1499
Net return over control, Rs.	—	200	85	94
C : B ratio	—	3.33	1.42	1.31

Cost of Feed: Concentrate @ Rs. 6.00/kg; Leucaena @ Rs. 1/kg; Stylo hay @ Rs. 2/kg;
Cost animals @ Rs. 75/kg live weight.

CHAPTER 4

Technology Transfer and Commercialization

From 103 sub projects taken up under AED (Rainfed), a number of usable technologies with higher B:C ratios than farmers practice were evolved in different production systems. Efforts were made to expose large number of farmers to these technologies through formal training, field visits and krishi melas. In projects related to post harvest technology and value addition, few technologies have been transferred to private entrepreneurs and others are being evaluated further.

4.1 Production Technologies Validated on Farmers Fields

Based on the network research carried out in 225 target districts for 5 years, 49 technologies were developed which can be used for improving the crop and animal productivity in the target domain. These include new varieties, improved cropping systems, INM, IPM, water management, farming systems livestock health and post harvest processing and value addition. A list of such technologies and the target domain for extension is given in **Annexure I**.

4.1.1 Farmer's training

On-farm research in the target districts enabled extensive exposure to the farmers and development departments on the potential of different technologies (**Annexure III & IV for details**). Between 2001 to 2005, 2465 farmers were trained on project related technologies, general *kharif* and *rabi* production practices, livestock management, crop disease control, horticulture, water conservation and home science. Out of these, 200 were women. In target districts where ATMA projects were located, 8-15 days structured training programmes were organized by the lead/cooperating institutions for farmers sponsored by ATMA. Kisan melas, field days and interaction meets covered 22,488 farmers (3,606 women) in 10 states.

4.2 Technologies with Commercialization Potential

The project teams started dialogue with private entrepreneurs and self help groups in cases where a potential was seen for scale up and transfer of promising technologies and in few cases formal agreements have been signed. A brief narrative of the most important ones:

4.2.1 Fuel alcohol from sweet sorghum

In view of the encouraging results obtained with sweet sorghum as raw material for alcohol, efforts were made to commercialize the technologies through pilot studies. The crop can produces upto 30-50 tons of cane and 1.5 to 2.5 t of grain /ha/ year with 2-3 protective irrigations. With an output of 50 liters ethanol/ton, it yields 2000-2500 liters of fuel grade ethanol/ha.

Based on AICRP trials, SSV-84 and RSSV-9, two improved varieties have been released for cultivation and few other promising varieties with higher biomass yield have been tested under the project. The alcohol recovery and economics were

Commercial cultivation of sweet sorghum (SSV-84) canes, harvesting and pilot plant for ethanol production

tested through 2 pilot projects one each in Belgaum district with M/s.Renuka Sugars and other in Chittoor district with M/s.Sagar Sugars. The experiences from these projects revealed that ethanol can be produced from sweet sorghum at a price of Rs.13.50/ltr. as against Rs.15.40 from molasses. Farmers earned a net income of Rs.6000-7000/ acre in 4 months. Encouraged by these successes, many other sugar industries like M/s.Shakti Sugars in Tamil Nadu and M/s.Praj Industries and M/s.Godavari Sugars in Maharashtra initiated contract farming around the factories during 2004.

A stakeholders meeting on sweet sorghum utilization was organized on 28th August, 2004 at CRIDA, Hyderabad under the auspices of the Rainfed Agro Ecosystem Directorate of NATP. The meeting was attended by 20 scientists from ICAR, SAUs and autonomous research institutes, 45 representatives from distillery and sugar industries in A.P., Tamil Nadu, Karnataka and Maharashtra, three NGOs, five progressive farmers, 12 officials from the State Department of Agriculture and Sugar of Andhra Pradesh Government. The meeting was chaired by Dr.S.L.Mehta, National Director, NATP, Dr.N.Raghuveera Reddy, Hon'ble Minister of Agriculture, Government of A.P. was the Chief Guest. The meeting discussed the potential of sweet sorghum as a raw material for ethanol production mainly based on the work carried out under NATP, the economics of cultivation, ethanol production and public-private partnership in upscaling the results.

The meeting resolved to strengthen the collaboration between ICAR/SAUs with the private sector to take forward this important success for the benefit of rainfed farmers. The ICAR/SAUs system will primarily focus on research on new varietal development and seed production while the industries will taken up pilot production of ethanol and process optimization for efficient recovery. It was further decided that this crop may be encouraged only in selected areas through contract

Stake holders meeting on sweet sorghum utilization held on 28th August, 2004

farming so that the farmers who grow the crop do not face hardship in marketing. The National Research Centre for Sorghum (NRCS) which produced about 13 tons of breeder seed during 2003-04 has to double its efforts and in collaboration with SAUs increase the seed production to at least 150-200 tones in the coming years to meet the growing demand. A plan for decentralized seed production of released varieties should be drawn up in collaboration with SAUs and progressive farmers.

The meeting concluded that sweet sorghum offers high potential to produce ethanol in a more environmental friendly manner and meet the expected demand for ethanol in view of the Govt. of India's decision for mixing 5% ethanol in petrol. In view of lower water requirement, ethanol production based on sweet sorghum offers scope for reviving some of the sick sugar mills closed due to shortage of cane/water. This needs a national policy thrust during Xth five year plan as crop diversification strategy.

As a follow up action two more interaction meetings were held at NRCS, Hyderabad on December 29, 2004 and April 20, 2005. besides the project scientists, senior officers from the state Govt. of AP and Maharashtra, 31 industry representatives were present. The meeting discussed various issues regarding the technical and policy initiatives needed to realize optimum yields of sweet sorghum and also produce ethanol cost affectively. It was resolved that a cautious approach may be followed and promote the crop only in better soils with provision for one or two irrigations.

Preliminary contacts have been established with distilleries and breweries in Maharashtra and Tamil Nadu on production of portable ethanol from moulded sorghum grain and lagar bear from broken sorghum. Many KVKs and NGOs in AP have taken up the production of syrup from sweet sorghum cane.

4.2.2 Natural dyes, herbal tea and cardboards from safflower

Following the standardization of the process for natural yellow dye extraction and herbal tea formulation at CIRCOT, Mumbai and MAU, Parbhani, efforts were made to transfer these technologies to private entrepreneurs. Many trade enquires were received during the Agresco meeting held at Nagpur in June 2004 on textile dye from petals. Government of Maharashtra has approved the herbal tea made from safflower petals for marketing in the state. M/s.Ishwardas Gangao, Jalna, M/s.Universal Traders, and M/s.Virage Enterprises, Parbhani showed interest in herbal tea technology, while many snack food manufacturers including M/s.Haldi Ram of Nagpur were keen to use the natural dyes in their products. An industrial trial for aqueous extraction of petals to obtain yellow dye in powder form through spray dying is under process.

A stake holder meeting was organized at CIRCOT, Mumbai on 21-9-2004 to discuss all

Safflower yellow dye extracted from petals

Herbal tea from safflower petals

Commercial size particle board from safflower stalk

issues related to the potential of the technology and its upscaling. It was clear from the meeting that the grey shade produced by using the basic yellow colour from petals has maximum potential for the eco textiles which is basically niche market. More studies are needed on pharmaceutical application of yellow dye. Small entrepreneurs preferred to use safflower yellow in snack foods. Representative from M/s.Arvind Mills, one of the largest denim manufacturers in India expressed his willingness to participate in a pilot dyeing trial and requested CIRCOT to provide enough safflower yellow extract to dye 500 m cloth.

After thorough discussion it emerged that based on the current cost of petal collection and dye extraction, it might cost Rs.4-5/- per dyeing one meter cloth which was acceptable to the textile industry. However, representatives from NGOs and niche players in natural colour markets preferred to use the petals directly instead of using the extract. The meeting recommended that MAU, Parbhani and CIRCOT, Mumbai will initiate a contract farming project on 1000 acres in Solapur district of Maharashtra, by providing seed material of non spiny varieties to all the farmers and supply the petal extract to M/s.Arvind Mills for large scale dyeing trials. The meeting also resolved that the herbal tea has great potential based on the organoleptic scores of 8-9 generated during the last 3 years. Although it can be promoted directly as dia tea, data on its hypoglycemic effects need to be generated in collaboration with medical colleges with Maharashtra. The cardboards produced from stalks have met the BIS standards and therefore can be promoted in the country as eco products through trade fairs.

4.2.3 Complete feed products from oilseed byproducts

The technology of complete feed manufacture by using sunflower heads developed by scientists from NIANP, Bangalore attracted the attention of the entrepreneurs in Karnataka, A.P. and Gujarat. Following the feeding trials with cows, buffaloes and sheep, the safety, improved nutrient availability and digestibility of these formulations became evident. From 2003 onwards entrepreneurs in Vadodora and Raichur started collaborating with the scientists. The grinder and mixer based technology for sunflower based feed was transferred to Shiv Sai Self Help Group in Devgra village of Chakur taluk in Latur district. M/s.Narendra traders in Raichur after getting convinced with the technology are currently doing a market survey for the product before signing the MOU. The technology for detoxification of castor cake was transferred to M/s.Jayanth Oil Mills, Vadodora who are the largest castor processing industry in the country. A pilot production of 5 tons of castor meal was carried out by adopting the technology during 2003-04. After assessing the efficacy of technology, the firm is in the process of setting up a pilot plant of 10-20 t/day with an investment

Demonstration of the pulverization and mixing of the sunflower head based feeds at Palem in Mahboobnagar district of AP to small entrepreneurs and farmer in November 2004

of 40-50 lakhs. The process flow diagram along with machinery details were provided to the company in August, 2004. The work is under process.

The Banaskantha Dairy Cooperative, Gujarat, a large manufacturer of cattle feed in the cooperative sector also showed interest in the technology. However, both these organizations are awaiting the data from feeding trials, which are currently in progress in Mehasana district of Gujarat. The national council of applied economic research (NCAER), New Delhi, evaluated the impact of the technology developed under the project and rated as ***highly successful*** and strongly recommended for upscaling in the target domain through public-private partnership and banks.

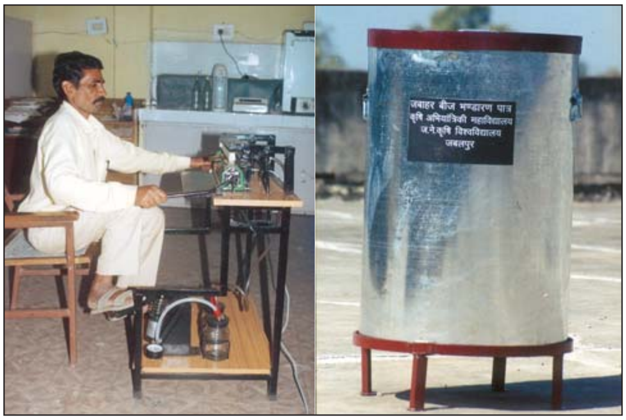
4.2.4 Insect traps for pulse beetle control

The probe-cum-pitfall trap developed, tested and demonstrated among farmers/households during 2002 and 2003 resulted in reducing the grain damage by 3.5 times compared to traditional storage. The technology was transferred from TNAU to M/s. K.S.N.M. Marketing, Coimbatore for commercial production in December, 2003. Initial feed back from the firm indicate an encouraging response for the product in Tamil Nadu. The firm is also interested to introduce the product in Karnataka and Andhra Pradesh. Simultaneously, TNAU is also organizing training programmes and awareness campaigns on use of these traps among women self help groups. The trap is also being popularized by University of Agricultural Sciences (UAS), Dharwad in Karnataka under UAS-CIDA Project and under 'Grama Bhandar Yojana' scheme of Govt. of India in rural godowns in Tamil Nadu.

4.2.5 Vaccumised bag technology for storing soybean seeds

Though the low cost storage in mud plastered bamboo baskets was found to improve the soybean seed viability, storage in metallic poly bags under

Hon'ble Vice Chancellor of TNAU signing MoU with M/s. KSNM Marketing for transfer of technology for production of Insect traps on 30th December, 2003 in Coimbatore



Foot operated vacuum packaging machine (left) and double walled thermocol filled GI container (right)

vacuum received more encouraging response from farmers in Madhya Pradesh. The vacuumising machine designed in 2002 by JNKVV, Jabalpur was further improved during 2003 based on the feed back from the users. The foot operated machine costs Rs.4500-5000/- while the electrical version costs Rs.5,500/-. A low cost gas filling device was also designed which goes as an attachment with the vacuum packing machine. Pilot trials near Jabalpur indicated that the cost of the machine can be recovered in one year by operating at 50% capacity during the season. The CEDMAP (Council for Entrepreneur Development in Madhya Pradesh), Bhopal collaborated with JNKVV, Jabalpur for popularizing the machine through training programmes and exposure to small entrepreneurs in Madhya Pradesh. Depending on the response from the farmers, the technology will be transferred by JNKVV to prospective entrepreneurs either directly or through CEDMAP.

4.2.6. Liquid biofertiliser

This technology standardized at UAS, Bangalore provides a viable alternative to the carrier based inoculants of *Rhizobium*, *Azospirilium* and PSB which suffer from contamination and poor shelf life during storage. Since liquid biofertilisers are completely sterile from manufacturing to final use, higher counts are maintained than the existing carrier based inoculants. M/s.Plant Rich Chemicals and Fertilisers, Kottayam, Kerala showed interest on technology. The know-how is available on non-exclusive basis to any entrepreneurs in the country.

Liquid Rhizobium inoculant

CHAPTER 5

Monitoring and Evaluation

A structured monitoring and evaluation (M&E) system was followed for review of PSR projects during the last 5 years. It was mainly based on the "**Guidelines for monitoring and concurrent evaluation of sub projects under NATP**" brought out by IASRI and PIU, NATP. Rigorous concurrent monitoring was the key factor responsible for focused and timely implementation of the sub projects, which resulted in many technologies despite the involvement of several scientists from different institutions in a network mode. Within the overall M&E guidelines, the SAP developed specific criteria of evaluation and periodicity of review of the on-farm projects. The M&E of PSR projects consisted of the following:

- Annual workshops of sub projects by the PIs.
- Annual production system level workshop organized by the AED.
- Site committee meetings for internal review of the projects at SAU/ICAR institute level.
- Visit of peer review teams, agro ecosystem director and PPSS.
- Review by special missions constituted by PIU.

As a major departure from the regular ICAR projects, each of the approved project document contained indicators of performance and progress assessment. These criteria helped the PIs/CCPIs to remain focused on the major goals of the project and activity milestones set to achieve these goals. Each project team met once in a year at one of the centers to review the progress and finalize the technical programme for the next year. In 25% of the projects, 2-3 workshops were also held in an year. In total, 620 annual workshops were organized under AED rainfed by the PIs during the last 5 years. The proceedings of these workshops were discussed in the SAP meetings which helped in keeping track of the progress and major constraints faced by the PIs/CCPIs.

5.1 Monitoring Mechanisms and Indicators

Concurrent monitoring was done through peer review teams (PRTs). These team were constituted each year by the SAP to visit and review the projects on random basis. The review includes site visit, interaction with the farmers and scientists, organizing the workshop/ field day involving stake holders and review meetings at the university/institute heatquaters where the PI/CCPIs of all the projects presented the progress report before the PRT and also submitted written document in the performa finalized by the AED office and sent in advance to the PI/ CCPIs. These perfomae are filled in advance and submitted to the PRT through the nodal officer. The main monitorable indicators considered were physical (procurement of equipment, infrastructure, renovation etc.), technical (progress on activity milestones as set out in the initial document) and financial (progress on expenditure against the sanctioned budget). Each of the indicators were given weighted score and a composite score was derived for each project six monthly and annually.

5.2 Initial External Reviews

During October 2000, a World Bank sponsored review team led by Dr.Jim Ryan reviewed the PSR and ATMA projects in Orissa, Chhattisgarh and A.P. In this preliminary review (submitted in the form of a report entitled ***"Review of Rainfed Production Systems Research"***, the team appreciated the on-farm research mode adopted by the rainfed AES but insisted on more bottom-up approach in development of the technical programme by the PIs/CCPIs. A workshop on project review mechanism was organized at CRIDA on 28^{th} April, 2001 which was attended by Dr.Ashok Seth and Dr.P.S.Sidhu from the World Bank. It recommended that researchable issues identified under SREP's in ATMA districts may be given priority for PSR projects. The importance of matching the macro and micro level priorities was also emphasized. The workshop strongly recommended to institutionalize a well structured peer review mechanism. Accordingly, AED (Rainfed) in 2002 prepared a matrix of problems listed by SREP documents and PSR projects already initiated. The outputs from such projects will be made available to the ATMAs. The peer review mechanism suggested was also put in place subsequently.

5.3 Peer Review Teams

Approval of most PSR projects and finalization of technical programme was completed by 2000. From 2001, a peer review mechanism was initiated according to the PME guidelines. A sensitization workshop on monitoring and evaluation for the PIs and Nodal officers of all participating institutions was organized at CRIDA during 27-28 August, 2001. Thereafter a number of peer review teams (PRTs) were constituted to evaluate the projects. Since most of the projects under rainfed AED were in OFAR mode, the teams were requested to visit the target villages, examine the experimental treatments and interact with the scientists and participating farmers. A minimum of 25% of the approved projects were reviewed each year while selected projects with high impact were chosen for in depth assessment during the last year (2004-05). The yearwise PRT's constituted and number of sub projects reviewed are given in the following Table (see **Annexure X** for more details).

Year wise PRTs constitute and sub projects reviewed

Year	No. of PRTs constituted	No. of sub projects reviewed
2001-02	12	59
2002-03	10	42
2003-04	6	31
2004-05	6	12

Following each visit, the PRT's were required to submit a project wise evaluation report which were considered in the next SAP meeting. The PRT's mainly focused on:

- Whether the on-farm trials have been taken up in target villages as approved by the SAP?
- Whether the treatments and replications were imposed as per the lay out and approved technical programme?
- Whether the data collection is carried out as per the minimum data set required?
- Whether farmers' participation was ensured in the field experimentation?
- The extent of cooperation between the PIs and CCPIs and internal monitoring mechanism at the concerned Institute/University.
- The progress on physical, financial indicators and technical milestones.

Observations and recommendations

Some observations/recommendations made by PRT's during 2001 and 2002 are summarized below:

The PRTs observed that despite the constraints on mobility, most PIs/CCPIs conducted adaptive trials on farmers fields (even in remote areas) with commitment and dedication. In 60%-70% of the cases, they were able to fully implement the technical programme approved by SAP. In other cases, there were some deviations in the technical programme either due to logistic difficulties in conducting required number of OFTs or due to revision of the treatments following the advise of the concerned Director's of Research/Site Committees. These were reviewed by the SAP after the visits. In few cases the farmers practice (FP) treatment was not clearly defined/followed as advised by SAP. In about 15% of projects, the PRTs found that the site committees were not playing active role in monitoring of projects, although reviews are done regularly. In case of network projects involving many SAUs, the PIs found difficulty in coordinating with many CCPIs due to poor inter connectivity. Synergy between the on-going programmes of the SAUs and NATP projects was found wanting in few cases.

Recommendations

- On farm trials should be conducted at least in 5 villages with two farmers in each villages, so that the data can be statistically analyzed.
- Each PI of the network project should visit all the centers at least once in the crop season.
- Greater interaction is needed between AED, nodal officers and Senior Officers of the SAUs on the financial and technical management of the projects.
- The annual reports of the PSR Projects should contain statistically analysed crop data, which can be presented and discussed at the annual workshops.
- Greater awareness is needed among the PIs on the methods and objectives of the monitoring and evaluation (M&E) process.
- The scientists, concerned (PIs/CCPIs) should be personally involved in during planting time, treatment imposition and data collection.
- In the treatments on recommended package of practices, the recommended packages given by the concerned ZRC should followed.
- In projects related to watershed development, the ridge line of the watershed need to be properly identified.
- Farmers in target villages should be chosen in such a way, as to represent different soil type/micro farming situations.
- The list of villages and names of farmers and bench mark data of experimental fields should be invariably included in the annual reports.
- Farmers practice should be clearly defined and included in the annual technical report.
- There should not be more than one replication on same farmers field.
- The mechanism of internal monitoring should be strengthened within each Institution/ University.
- The Associate Director of Research and other scientists of the Zonal Agricultural Research Station established under NARP should be fully involved both in execution, monitoring and evaluation of PSR projects.
- The PI should be encouraged to organize *Kisan Melas* (Farmer's Fair) to successful trials so that a wider impact is possible in the target district.

The reports of the PRTs were discussed in the SAP meetings in detail and suitable

Visit of the peer review team to on-farm trials and interaction with the farmers in Karnataka (Tumkur) and Orissa (Koraput)

recommendations were made regarding changes in technical programme or mid term corrections etc. which were conveyed to the PIs/CCPIs and followed up by the Principal Production System Scientist. The peer review mechanism ensured a fairly satisfactory implementation of the large-scale on-farm research under rainfed AES and generate data from farmer's micro farming situations. Though the PME manual was designed for ranking the projects through a quantitative weighted scoring, most PRTs preferred to give a qualitative assessment of the projects than scoring.

5.4 Site Committees

Since the projects under rainfed AES covered more than 400 scientists in 29 SAUs, 36 ICAR Institutes and 12 other organizations including Central/state Government institutions, NGOs and international organizations, monitoring of projects at institutional level was quite important. The site committees are mandated to carry out the internal monitoring. In PSR projects, which essentially addressed location specific needs in different states, the involvement of site committees was more critical than other projects. Most ICAR institutes/ SAUs have constituted site committees as per NATP guidelines. However, the functioning of these committees has been mixed. More than 60% SAUs and Institutes conducted regular meetings (at least once in a year) and forwarded the proceedings and recommendations to the AED while at other institutions the meetings were either not organized or no information was given to the AED. The site committees worked more actively at SAUs than ICAR institutes based on the number of meetings held and proceedings forwarded to the AED. The year-wise meetings organized is given in the following table. From large number of proceedings of the site committee meeting analysed by the SAP, it appeared that the meetings were held primarily for monitoring the projects but a serious effort to utilize the outcome of the projects and develop strong linkages within different programmes at Institute/SAU level to avoid duplication was missing. Accordingly suitable directions were given by the AED to the site committees.

Year wise number of site committee meetings held

Year	No. of site committee meetings held*
2001	16
2002	28
2003	22
2004	8 (Till August, 2004)

* Based on proceedings received by the AED

5.5 State Level Coordination Committees

According to NATP guidelines, each state need to constitute an apex state level coordination committee chaired by the Vice Chancellor of the SAU or the Director of the ICAR Institute to ensure over all coordination and linkages between projects under different modes of NATP in a given state and also with the core programmes of ICAR/SAUs. In ATMA districts, the committee also needs to ensure linkages between PSR, TAR and ATMA. Only two such committees i.e. Orissa and A.P. were constituted in Orissa, it was chaired by Director, CRRI and in AP by Vice Chancellor, ANGRAU. In case of Orissa, 6 state level meetings were organized which were chaired by the Director, CRRI which had effective participation of all stakeholders including Project Directors of ATMA which enhanced the flow of PSR outputs into ATMA projects in Koraput and Khurda districts. One meeting was held in AP which brought together all stake holders. In other states the Vice Chancellors of SAUs and Nodal Officers had informal consultation with other agencies operating the project. Constitution and effective functioning of these committees in all states could have certainly improved the uptake of outputs from PSR projects into the development schemes in the state.

5.6 Annual Production System Workshops

In addition to the regular monitoring by AED and PPSS through need based visits to the centers for participation in the individual project workshops, 5 annual workshops were held each year since 2001 to 2003 for each of the production system for annual review of the work and approval of the technical programme for the next year. These workshops were chaired by the SAP Chairman or the National Director and attended by all PIs and selected CCPIs. The PIs presented the progress of work in detail which were commented by SAP members and experts from the PRTs. Specific recommendations made at these workshops are forwarded to the PIs and followed up by the PPSS. These workshops helped in compiling the work done report for the year, individual production system level annual reports and the combined annual report of the AED.

5.7 Satellite Symposium

For the year 2004, one combined national symposium was held for all the production systems in the form of a satellite symposium at ANGRAU, Hyderabad during March, 2004. This symposium discussed all issues related to productivity and sustainability in rainfed agro ecosystem. All the

Annual workshop 2002-03 held at CICR, Nagpur on April 18-19, 2003 for review of PSR projects

Inauguration of the satellite symposium (left) and interaction of the SAP chairmen and experts at the poster exhibition (right)

stakeholders including scientists, SAP members, officers from PIU, farmers, NGOs, Project Directors of ATMA's, officers from state line departments and private sector representatives have participated from all over the country. This symposium showcased the technologies generated from the production system research in the form of a poster session and facilitated interaction among stakeholders. A brochure on the *"Programme and technologies generated under Rainfed AES"* brought out by the AED was released on the occasion. The unique feature of this workshop was the participation by the farmers involved in on-farm research who articulated their experiences on the merits or demerits of the technology in his micro farming situation.

5.8 Intermediate Indicators

The progress of implementation of the activity milestones both in terms of intermediate and terminal indicators was monitored by various mechanisms described above. More than 60% of the projects required extension of time for a period ranging from 3 months to 1 year in order to fulfill the objectives and milestones. This was required mainly because most projects under rainfed AES were on-farm and severe drought of *kharif* 2002 significantly impacted the experiments at many locations. This resulted in continuing the experiments for one more season i.e. 2003 or 2004 to generate a minimum of 3 years field data. With the extension, 80% projects achieved the milestones while in the remaining 20, some components of the project could not be taken up either due to delay in procurement of equipments or other external factors beyond the control of PIs/ CCPIs. Except 22 projects which aimed at understanding the production system and analyzing policy issues the remaining 81 projects resulted in generation of new knowledge/technologies. A list of 49 specific technologies that can be adopted by the farmers are provided in **Annexure I.**

CHAPTER 6

Linkages

During the implementation of projects, the AED could establish effective linkages between the projects under PSR and other programmes at the state level. This enabled two way flow of technologies and information between participating scientists and institutions. As such most of the projects (94) involved more than one institution as cooperators. 22, 19, 20 and 30 percent of the projects had 3, 4, 5 and more 5 institutions, respectively. As such 66 of the 103 subprojects had direct linkages with farmers because of the participatory on-farm research adopted in the project. The linkages with other research and developmental programmes are summarized below:

6.1 With Core Programmes

Since projects under PSR were developed essentially to fill critical research gaps in identified production systems, it was important to have strong linkages with the core programmes of the ICAR/SAUs under different All India Coordinated Research Projects. At the Institute level the nodal officers ensured that the technical programme of the PSR projects at the respective university/institute is discussed together with the programme of AICRP so that maximum synergy is derived and duplication avoided. At the AED level, the coordinators of relevant projects were invited for the annual workshops of the production systems, but the participation was not satisfactory. However, the annual reports of the PSR were regularly sent to all the DDGs, ADGs and project coordinators in order to keep the officers in charge of the core programmes informed about the technical programme and major outcome of the PSR projects. This linkage was quite useful in avoiding duplication and saving on resources.

6.2 With Other Modes of NATP

Sixteen of the 49 technologies developed under PSR were transferred to TAR-IVLP programme at different centers for assessment and refinement. Similarly, two technologies were transferred to Mission mode projects on Farm Mechanization and IPM. The PPSS regularly attended the interaction workshops organized by PIU on thematic areas like biotechnology and IPM and ensured that some of the outputs from the mission mode projects were utilized in development/modification of annual technical programme of PSR projects. Since the PSR and TAR-IVLP projects started simultaneously and are likely to conclude at same time, some of the technologies came out of PSR need to be assessed and refined through other mechanisms/regular extension programmes of NARS.

6.3 With ATMA

Of the 24 ATMA districts approved under NATP initially, PSR projects under rainfed AES were located in 8 districts (Adilabad, Prakasham, Kurnool, Khurda, Koraput, Amravathi, Dumka and Ahmednagar). Following a joint meeting between AED Rainfed and MANAGE, it was

Sl.No.	Name of the technology from PSR projects	Adopted in the ATMA district
1.	Introduction of improved arboreum cotton varieties	Adilabad, A.P.
2.	Rainfed vegetable cultivation technology	Khurda, Orissa
3.	In situ moisture conservation technology for pearlmillet in Vertisols	Aurangabad, Maharashtra
4.	Fruit based land use systems for tribal farmers	Koraput, Orissa
5.	Paddy-fish-duck farming system	Dumka, Jharkhand
6.	Rainwater management for cotton based production system	Amravathi, Maharashtra

decided that all the Project Directors of ATMA in these 8 districts will be exposed to the PSR and TAR-IVLP projects on a regular basis. Based on the advice of the experts from World Bank at the interface meeting organized at MANAGE, a matrix was prepared by PPSS aligning the micro and macro level priorities identified through SREPs and the AED level. Due to these efforts, many PSR technologies were taken up for wider diffusion through ATMAs Some specific examples include:

However, as the PSR projects have concluded by 2005 and the results are available with NARS, the existing and new ATMA's to be started in XI plan should fully utilized the technologies generated under PSR mode of NATP.

6.4 With State Line Departments

As most of the PIs/CCPIs of PSR projects are located at the Zonal Agricultural Research Stations (ZARS) of SAU's, there was a greater interaction with the officials of the State Line Departments at the district level. This facilitated better linkages for technology transfer. To illustrate, the technology package for *rabi* sorghum involving variety, compartmental bunding and INM developed under RNPS-10 was adopted by the Government of Maharashtra to be tried on 500 ha. as a pilot project during 2004-05 under drought prone areas programme. Similarly in Koraput district, the district administration decided to extend the fruit based land use system module standardized under RRPS-8 by OUAT to 500 farm families in two years. The on-farm reservoirs technology of rainwater harvesting has already been adopted by the Government of Chhattisgarh on large scale. The Government of A.P. and Tamil Nadu constituted expert teams to study the feasibility of sweet sorghum cultivation as raw material for ethanol production following a successful contract farming project under taken under RNPS-24. The paddy-fish-duck farming system was also taken up for large scale adoption in 6 districts in Jharkhand.

6.5 With Private Sector

The PSR projects also resulted in development of technologies, which could be commercialized by private entrepreneurs. Two technologies have already been commercialized and others are at various stages of negotiation. A detailed account of technology transfer process is given in Chapter 4.0. In addition to the entrepreneurs who have been working with the scientists since 2003, the satellite symposium held in March, 2004, at ANGRAU, Hyderabad helped in speeding up this process. The respective Universities/Institutions are expected to depict these technologies at various stakeholders meets, further refine them, generate additional data where required and follow up with the interested entrepreneurs.

CHAPTER 7

Impact

The PSR projects made significant impact in the target villages among the participating farmers and in some cases in the neighboring villages through kisan melas and exposure visits. The actual and potential impact of the promising technologies on various parameters is described below.

7.1 Adoption Levels and Gains

In 15 of the 66 subprojects, based on on-farm research, adoption and impact studies are carried out during 2003-04 and 2004-05 in the target villages and 3-5 neighboring villages. In technologies related to *in situ* moisture conservation and water harvesting, the level of adoption in the target villages ranged between 20-30% after 3 years. Similarly the yield gains were 35-40% translating to a net gain of Rs.1500-Rs.2000/ha depending on the crop. Nearly 36% of the farmers in the target villages of Maharashtra have adopted the technology of ridge and furrow method and gained and additional income of Rs.1000-Rs.1500/ha/year. In case of on-farm water harvesting technology through OFRs in Chattisgarh which proved quite popular with the farmers, adoption by individual farmers is not possible as it involves area based planning and implementation, besides capital intensive. Forty eight percent of farmers surveyed are willing to contribute their share of funds and labour component in the structures. Such interventions are necessarily to be triggered by the Government organizations or NGOs.

Farmers (25) in Akola and Parbhani districts of Maharashtra who adopted the grain drying technology of *kharif* sorghum gained Rs.800-Rs.1500 /ha during 2003 which convinced them to own the machine on custom hiring basis. Seventy five farmers in the salt affected districts in Maharashtra and Karnataka realized an additional benefit of Rs.1200-1800/ha/year by growing newly identified salt tolerant cotton varieties in place of traditional ones. More than 150 farmers who adopted quality arboreum cottons in Parbhani, Adilabad, Nanded and Dharwad districts during 2001-03 harvested comparable yield as that of hirsutum (759 kg/ha) hybrids with 40% reduction in cost of cultivation, which amounted to Rs.2000-Rs.4000/ha. This became a success story and has immense potential to be scaled up the target domain.

The National Center for Agricultural Economics and Policy Research (NCAP) evaluated 3 PSR projects under rainfed AED which deal with rain water management in rice based production system, improved *biasi* cultivation technology for rainfed low land rice and high yielding *arboreum* cotton varieties are computed an yield advantage of 67, 24 and 4% respectively over farmers practice. However, the impact of many of the technologies will be known when the adoption rate increases through intensification of developmental efforts through ATMA and other extension service providers in the target area. The National Council of Applied Economic Research (NCAER) also found a favorable benefit cost ratio of sunflower heads based livestock feed technology in Karnataka.

7.2 Impact on Small, Marginal and Tribal Farmers

More than 15 sub projects in 5 production systems focused on problems related to small and marginal farmers and drought prone areas. Technologies and package of practices emerged from these projects can help in upgrading the productivity if matching extension efforts and efficient input/credit delivery mechanisms are ensured. To illustrate;

- *In situ* moisture conservation practices like conservation furrows and deep tillage in oilseed crops, ridge and furrow system for rainfed cotton are simple technologies that can be adopted by small farmers in many districts of Maharashtra, Karnataka, Tamil Nadu and A.P. With little or no additional input, it can help them gain 20-30% additional yield over their existing practice.
- Silvi-pasture techniques like appropriate grass establishment in natural pastures were successfully demonstrated on nearly 50 farmers fields in Gujarat, U.P., A.P. and Maharashtra. This package has won the appreciation of the animal husbandry departments of the respective states. With some efforts on social fencing, this technology can help in rehabilitation of degraded areas and also provide feed and fodder to livestock including small ruminants, owned by poor farmers.
- The safflower harvester developed by UAS, Raichur and CIAE, Coimbatore helps in avoiding the pain and hardship in harvesting a spiny crop like safflower, thus reducing drudgery among farm women.
- The technology for rehabilitation of hillocks through horti-pasture and vegetative live fences tried in the eastern highlands of Koraput and Jagdalpur districts (and extended to other plain areas) contributed to arresting soil erosion from hills and generating income from fruit component for local communities during off season. The district administration in Koraput adopted the approach in the tribal development programmes.
- The application of remote sensing to planning and monitoring of watershed projects was successfully tested in a number of production systems. This approach can reduce time, resources and man power involved in watershed projects besides contributing to quality data collection and monitoring. This technique can considerably improve the efficiency of National Watershed Development Programmes for Rainfed Areas (NWDPRA).
- The topo sequence based rainwater management technology combined with INM increased the rainfed maize productivity by 25-30% over farmers practice in eastern Rajasthan, Gujarat and Western M.P. The adopted farmers realized significantly higher maize productivity during 2002 drought year. Wide adoption of this technology can ensure stability of production in the large rainfed maize belt of eastern Rajasthan and Gujarat, one of the most drought prone areas of the country.
- Superior varieties and tailor made agronomic practices for castor in north east helped in improving the cocoon production of eri silk

worm which resulted in 20-25% additional income to the farm women in Manipur and Assam, in two target districts.

- A number of income generation opportunities which emerged from the house hold and farm level interventions like apiary and eri culture have potential to improve the livelihoods of women.

7.3 Impact on Social and Gender Equity

With strong presence of social scientists in the SAP and inclusion of social issues at the prioritization level, social and gender equity issues were successfully addressed in the PSR projects. While selection of the participating farmers, preference was given for those who were not the beneficiaries of the past extension programmes of the Government or NGOs. It was ensured that 25-30% of the participating farmers in the on-farm research were women and weaker sections. Special exposure visits and melas were organized for women farmers where relevant and in the general events also adequate participation of women (up to 25%) also ensured. More 25% cooperating centers were located in areas dominated by tribal farmers. In all projects related to preservation of grain after harvest, the trials were carried out with women farmers in the households.

7.4 Impact on Environmental Protection

More than 12 sub projects addressed issues related to soil loss and runoff control on sloppy areas, integrated nutrient management and integrated pest management all of which are aimed at improving the productivity with minimum impact on environment and resource base. The on-farm participatory trials could convince the farmers about these alternative options. However, for its wider adoption, easy availability of these inputs are needed. To illustrate:

- Different IPM modules evaluated in rainfed rice based cropping systems in 5 states, 6 oilseed based cropping systems in 7 states and 2 pulse based cropping systems in 4 states conclusively demonstrated the effectiveness of bio intensive IPM module which focused on resistant varieties, cultural and bio control methods in controlling major pests for minimizing yield losses. However, the available modules could not completely protect the crop with high pest intensity. Nevertheless the bio intensive modules were far superior and cost effective compared to farmers practice. A 60% reduction in pesticide use was noted due to the adoption of IPM. When IPM modules were adopted for 3 continuous years, a significant build up of natural enemies like spiders, coccinellids and myrid bugs were observed in the rice ecosystem in Orissa, Assam and Manipur.
- Six sub projects in the production systems of rainfed rice, oilseeds, pulses and cotton demonstrated the superiority of integrated nutrient management practices over complete dependence on chemical fertilizers. In view of the shortage of FYM, the projects explored the possibility of alternative options like raising green leaf producing plants on bunds, incorporation of intercropped green manure crops and use of bio fertilizers. The impact of long term mono cropping or sequence crops on the soil properties clearly indicated the deterioration in soil health unless a legume is included in the rotation or balanced fertilization is practiced in the cropping system. The INM options however need to be further refined through TAR-IVLP programme.
- The network project on carbon sequestration at 28 benchmark sites in SAT India clearly

identified the land use practices and cropping systems with high sequestration potential. This preliminary data laid the foundation for carbon sequestraion research in India and identifying the opportunities for earning carbon credits in agriculture, industry and plantation sectors

- Two PSR subprojects also contributed to bio diversity conservation through germplasm collection of indigenous cotton (28) in north east region and medicinal plants (121) in rainfed rice based production system of Chhattisgarh and Madhya Pradesh. These databases and materials will be further utilized in crop breeding programmes and the mission mode project on agro biodiversity.

7.5 Public-Private Partnership

The production system research (PSR) resulted in 12 technologies with potential for commercialization in collaboration with private entrepreneurs. The progress in transferring these technologies to stakeholders is described in Chapter 4.

7.6 Patents Filed/Granted and Diagnostic Kits Developed

Efforts are under way to file patent for the pitfall cum probe trap designed for pulse beetle detection and design protection for safflower harvester. The following techniques resulted in generating material/data which could be developed as diagnostic kits.

7.7 Impact on Research Quality

Considerable improvement was noted in the quality of project development, and data collection mainly due to the rigorous peer review system and detailed exercise done by the Scientific Advisory Panel (SAP) in identification of priority areas and formulating need based network projects. The base documents prepared by AED (Rainfed) on the target districts and the prioritization of critical problems in each production system was of great help in focusing the sub projects on the most relevant issues of concern to the agro ecosystem. Further, emphasis on on-farm participatory research in the Rainfed agro ecosystem resulted in extensive data generation on improved vs. farmers practice under farmers own situation which made the results more relevant to the farmers and certainly would result in greater adoption and conviction among farmers. The selection of target villages/locations was made in such a way that the most common farming system of the area is represented and the results can be extrapolated more effectively. **The field manual on on-farm adaptive research** (OFAR) helped the scientists in rigorous data collection and statistical analysis. Large number of national and international publications were brought out during the period. The year wise research publications in national and international journals and other publications like bulletins/brochures brought out is given in the Table (next page).

Nearly 100 bulletins/brochures were distributed to more than 5000 stakeholders across

Name of the technique	Details
Peroxidase estimation assay	This is a technique to measure peroxidase activity in jute plants by an antigen – anti body reaction which indirectly estimates lignin content. This method is more sensitive than existing colorimetric assay. It is developed by the Biochemistry Department of Calcutta University under RRPS-27.
Detection of sunflower necrosis virus in infected plant samples	A technique was standardized for ELISA, WB and PCR to detect tobacco streak virus (TSV) the causative agent of SND. The technique has been standardized by Division of Virology, IARI under ROPS-06 and can be developed as a kit.

Details of publications made under PSR projects					
Year	Research papers in national journals	Research papers in international journals	Papers presented seminar/ in symposia/ conferences	Books, monographs, bulletins, brochures, folders etc., published	CDs, multimedia, films produced
2000-2001	5	Nil	12	1	Nil
2001-2002	29	3	74	5	Nil
2002-2003	59	2	80	54	Nil
2003-2004	52	5	82	26	10
2004-2005	42	7	30*	28	7
Total	**187**	**17**	**278**	**114**	**17**

the country in Line departments, ATMAs, research organizations and NGOs thus creating a wide impact in terms of information flow. 278 papers were presented at different seminars, symposia and conferences.

The projects aimed at basic and strategic research resulted in good number of research publications (204) in reputed journals (see **Annexure VI**). Interaction of project scientists with in and different modes of research under NATP also contributed to exchange of ideas and quality publications. Fifty scientists were trained in different countries on advanced techniques in their field of specialization keeping the goals of the project in mind. This skill improvement also helped in better design of experiments, and quality publications. Thus, the production system research under NATP with all the associated institutional mechanisms definitely improved the quality of location specific applied research and its relevance to field level problems.

7.8 Impact on Research Processes in NARS

The production system research introduced a new paradigm of multi-institutional eco region based approach and made a clear impact on the mind set of scientists in terms of focusing on specific problems of the area and total production system perspective rather than single commodities. The farmer participatory approach gave further in sights into the problems of each micro farming situation and design appropriate solutions. In the model followed, the experimental treatments were finalized by the scientists based on the over all problems of the target district in order to have greater replicability of the outputs. However, a quick PRA and prior consultation with the farmers in the target villages would have been more useful in improving the treatment design further. A beginning was made by the OFAR, to work with the farmers which can be sustained with out much efforts in the regular programmes of the NARS if only participatory research is made mandatory and research trials are designed accordingly by respective institutions of the NARS. Though on a limited scale, excellent private participation was ensured in PSR projects particularly those dealing with post harvest technology and value addition which resulted in some successful agreements/ MoUs for commercialization.

7.8 Human Resource Development

The PSR projects provided opportunities for skill development of scientists and technicians in NARS. A total of 150 scientists were trained in India and/or abroad on specific project related techniques. In case of domestic training, the CCPIs/ associates at the cooperating centers were trained at the lead center or at one of the advance centers on subjects like modeling, carbon sequestration, livestock management and fodder production, IPM and watershed management. This enabled in cross learning among the participants which resulted in introduction of latest tools in experimental design and analysis in on-farm research projects. Twenty five per cent of the scientists trained within India utilized the programmes offered by teams of excellence and mission mode projects under NATP. The year wise number of scientists trained in India and abroad is given in following table.

Project related trainings of scientists in India and abroad

Year	With in India	Abroad	Total
2000-2001	6	1	7
2001-2002	32	Nil	32
2002-2003	28	19	47
2003-2004	13	24	37
2004-2005	15	10	25
Total	**94**	**54**	**148**

Good progress was made in organizing foreign training for young scientists. The trainings were organized for 2-4 weeks duration at some of the leading institutions like Michigan State University (USA), Ohio State University, (USA), IRRI (Phillipines), PTC (Netherlands), The Macaulay Institute (Scotland), Texas A&M University (USA), Oregeon University (USA), Kansas State University (USA), Massey University (New zealand), Flinders University (Australia) and Deutsche Sammlungvon Mikroorganismen Und Zellkulturen gmbH (Germany). The areas covered were conservation farming, carbon sequestration, modeling, post harvest technology for millets, soil management, IPM, participatory varietal development and ground water monitoring. Of the 54 scientists trained abroad, 10 have organized trainings in India on return to other team members and scientists working in similar area in NARS. Twenty scientists acted as resource persons in ICAR summer institutes / winter schools and shared their experiences. Few others applied the techniques/ tools in development of models based on data generated under the projects and also are planning to initiate new projects.

CHAPTER 8

Lessons Learnt

The rainfed agro ecosystem research involving 400 nodes (cooperating scientists of individual sub projects) implemented for 5 years helped in drawing many lessons. This was the first major effort of eco-region based production system research implemented across the country involving 77 institutions. As commented by the external review missions and many stake-holders within the country, the on-farm adaptive research (OFAR) mode followed in the project was one of the key innovations that helped in testing large number of diverse technologies under farmers micro farming situations and understand its potential and constraints. The target district approach for locating projects, particularly followed in rainfed AES also paid rich dividends in terms of understanding the problems of the farming system in the district and strategies for improvement. At the same time, coordinating with large number of participating scientists from the AED also posed problems of coordination, to some extent due to the lack of inter connectivity with some of the nodes. Nevertheless for addressing location specific problems of the farming systems, the eco-region based research appears to be an ideal model.

The structured approach followed in project development, including a systematic problem identification, prioritization and designing a clear technical programme with milestones and monitoring indicators made an excellent impact on the mind set of scientists on timely implementation of the project. This approach needs to be continued in the regular programmes of the Institutes/Universities. At some of the Institute/Universities, the much needed linkage between the PSR projects and the AICRP centers was missing mainly due to the not so active role played by the site committees. The institution of site committees is most important innovation made under NATP which needs to be continued and nurtured in future as ensuring proper linkages and avoiding duplication is critical to ensure best utilization of scarce resources available for research. Although the PIMSNET system could not be fully implemented during the project period, the peer review system of monitoring and evaluation and rigorous review at the annual workshops resulted in a qualitative improvement in data collection, interpretation and reporting.

The delay in procurement of equipments did affect the performance of projects where these inputs were critical. On human resource development, the rainfed AES made good progress by training 94 scientists in India and 54 abroad, but it was still much lower than targeted. Overall, the production system research under NATP introduced pluralism into the system, enabled tackling complex field problems through well-designed on-farm research and reduced the adoption lag by at least 2 years because of the farmer participatory approach followed. However, this model needs to be institutionalized in the regular ICAR programmes funded through network projects and CESS fund schemes etc. Otherwise, there is a risk of continuing with the existing commodity/discipline-wise approach where as the livelihoods of most farmers in rainfed areas are never linked to a single crop or animal but the entire farming system.

CHAPTER 9

Acronyms

AED	Agro Ecosystem Directorate
AES	Agro-Eco System
AICRP	All India Coordinated Research Project
ANGRAU	Acharya N.G. Ranga Agricultural University
ATMA	Agricultural Technology Management Agency
BIPM	Bio-intensive IPM
BIS	Bureau of Indian Standards
C:B	Cost Benefit Ratio
CCPI	Cooperating Center Principal Investigator
cDNA	Complementary Deoxyribo Nucleic Acid
CEDMAP	Council for Entrepreneur Development In Madhya Pradesh
CI	Cropping Intensity
CIAE	Central Institute of Agricultural Engineering
CIPM	Chemo-intensive IPM
CIRCOT	Central Institute for Research on Cotton Technology
Co-PI	Co- Principal Investigator
CRIDA	Central Research Institute for Dryland Agriculture
CRRI	Central Rice Research Institute
DAP	Days After Planting
DAT	Days After Transplanting
DH	Damaged Hills
DL	Damaged Leaves
ELISA	Enzyme Linked Immuno Sorbant Assay
FA-C	Fulvic Acid-Carbon
FLDs	Front Line Demonstrations
FP	Farmers Practice / Farm Pond
FYM	Farm Yard Manure
GOI	Government of India
HA-C	Humic Acid-Carbon
HMW	High Molecular Weight
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
ICT	Intermittent Contour Trenches
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
INM	Integrated Nutrient Management
IP	Improved Practice
IPM	Integrated Pest Management
IRS	Indian Remote Sensing
IRRI	International Rice Research Institute
IWDP	Integrated Watershed Development Programme
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidhyalaya
KVK	Krishi Vigyan Kendra
LDL	Low Density Lipid
LISS	Linear Image Self Sensor
LTFE	Long Term Fertilizer Experiment
M & E	Monitoring And Evaluation
MANAGE	National Institute of Agricultural Extension Management
MAU	Marathwada Agricultural University
MWD	Mean Weight Diameter
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NATP	National Agricultural Technology Project

NCAP	National Center for Agricultural Economics and Policy
NGO	Non Governmental Organization
NIANP	National Institute of Animal Nutrition and Physiology
NRCS	National Research Center for Sorghum
NRM	Natural Resource Management
NWDPRA	National Watershed Development Project for Rainfed Areas
OFAR	On-Farm Adaptive Research
OFR	On-Farm Reservoirs
OFT	On-Farm Trials
PAN	Panchromatic
PCR	Polymerase Chain Reaction
PI	Principal Investigator
PIU	Project Implementation Unit
PPSS	Principal Production System Scientist
PRA	Participatory Rural Appraisal
PRT	Peer Review Team
PSB	Phosphate Solubilizing Bacteria
PSR	Production System Research
RCPS	Rainfed Cotton based Production System
RDF	Recommended Dose of Fertilizers
RF	Rainfed
RNPS	Rainfed Nutritious Cereals based Production System
ROPS	Rainfed Oilseeds based Production System
RPPS	Rainfed Pulses based Production System
RRPS	Rainfed Rice based Production System
SAP	Scientific Advisory Panel
SAT	Semi Arid Tropics
SAUs	State Agricultural Universities
SC	Site Committee
SHG	Self Help Groups
SMBC	Soil Microbial Biomass Carbon
SND	Sunflower Necrosis Disease
SOC	Soil Organic Carbon
SQI	Soil Quality Index
SREP	Strategic Research and Extension Plans
SS	Silver Shoot
TAR-IVLP	Technology Assessment and Refinement through Institute Village Linkage Programme
TNAU	Tamil Nadu Agricultural University
TSV	Tobacco Streak Virus
UAS	University of Agricultural Sciences
CIDA	Canadian International Development Agency
WB	Western Blotting
WHS	Water Harvesting Structures
ZARS	Zonal Agricultural Research Station

Annexure I

List of Technologies Developed/ Validated in 5 Production Systems

Sl. No.	Name of the technology	Brief description and application domain
Rainfed Rice Based Production System		
1.	Sequence cropping of vegetables, pulses and oilseeds in rice fallows	This technology enables raising a second crop in several districts of Chhattisgarh, M.P and Orissa after rainfed *kharif* rice. It involves package of practices for *kharif* rice, choice of *rabi* crop and moisture conservation practices during *rabi*.
2.	Intercropping of upland rice + pigeonpea (5:2)	This intercropping system yields 30-45% higher net returns than rainfed rice and higher stability for uplands in Chhattisgarh, Jharkhand and Orissa.
3.	Pigeonpea + groundnut intercropping system (2:6)	This intercropping system yields 20-25% higher net returns than rainfed rice for uplands in Jharkhand and Orissa.
4.	Rainwater harvesting and recycling through *dabris*	This technology involves construction of on-farm reservoirs along the slope, which help in harvesting surplus water in recharge areas and recycling during drought period in *kharif* or for a second crop. Relevant in more than 60 districts of Chhattisgarh, Orissa and Jharkhand.
5.	Utilisation of excess rainwater in medium and low lands for second crop and fish culture	This technology is mainly suitable for Dhenkanal and Mayurbhunj districts of Orissa wherein additional income can be realized through fish culture in the refugees by maintaining optimum weir height.
6.	Mango + upland rice agri horticultural system	Meant for rainfed uplands of Koraput and Jagdalpur districts and also Ranchi and Palamau districts of Jharkhand to diversify from rainfed rice and to provide stability to income.
7.	Mango + ginger/turmeric agri horticultural system	Meant for rainfed uplands of Koraput and Phulbani districts of Orissa, where higher income can be realized through high value intercrops in mango.
8.	Rice-fish-duck/pig farming system	Ranchi district of Jharkhand and Midnapore district of West Bengal where small ponds exists on farmers fields. By this integrated system, the farmers can get Rs.8000-10000/ha/year as against Rs.4000-5000/ha/year with rice alone
9.	Improved upland rice varieties for aberrant weather	Varieties like Vandana with greater adaptability to uplands provide stability of yield during drought in Orissa.
10.	Integrated nutrient management with incorporation of legume intercrop in rainfed rice	As small farmers rarely use recommended dose of fertilizers, this system of legume intercropping and incorporation helps in sustaining crop yields with out external inputs in rainfed rice growing areas of Orissa and Jharkhand.
11.	Management of parasitic diseases (nematodes and trematodes) in buffaloes	A set of disease control methods based on anti helmenthic compounds and dose optimization that effectively control the parasitic diseases in buffaloes in Orissa and Chhattisgarh.
12.	Use of bullock drawn puddler 99 for improved yield of rainfed rice in low lands	An improved puddler designed by OUAT, Bhubaneswar, which helps in achieving higher puddling index and better crop stand with 15-20% higher yield in transplanted rice in Orissa and Chhattisgarh.

Sl. No.	Name of the technology	Brief description and application domain
13.	Integrated weed management in upland rice	A package of integrated weed management practice including weeding by a finger weeder 20-25 DAS supplemented with one hand weeding at 40-45 DAS for upland rice in Orissa and pre-emergence application of butachlor @1.25 kg a.i/ha at 3-5 DAS and one hand weeding at 40-45 DAS in Jharkhand and U.P.
14.	Integrated pest management in rainfed rice	An integrated package consisting of resistant variety, monitoring of pest population through pheremones and non chemical methods of pest suppression to minimize the use of toxic chemicals by farmers. Can be adopted in Assam, Manipur, Orissa and West Bengal.
15.	Improved *biasi* method of cultivation	An improved system of *biasi* cultivation of rainfed low land rice including the use of a *biasi* plough *tifal* for optimum plant stand and yield in Chhattisgarh and Jharkhand.
16.	Storage of paddy in RCC ring bin	Saving of post harvest losses upto 10% by storing paddy in RCC ring bins in high humidity areas of Assam, Manipur and Orissa.
17.	Inter row crop seeder for rice and green manure crop	An implement useful for inter row rice seeding and planting of green manure crop simultaneously for Orissa and Assam.
18.	Sprouted rice seeder	An implement for seeding sprouted rice for better nursery productivity for transplanted rice in Orissa and Chhattisgarh.
Oilseeds Based Production System		
19.	Cultivation of non spiny varieties of safflower	Non spiny varieties of safflowers like JSI-7, NARI-6, JSI-97 identified for cultivation in Maharashtra and Karnataka. Ideal for production of petals for extraction of natural dyes and herbal tea.
20.	Use of safflower (multicrop) harvester	A multicrop harvester useful for harvesting safflower, which is a spiny crop useful for safflower growing areas of Karnataka and Maharashtra.
21.	Improved technology for storing soybean seeds to increase viability	Soybean seeds lose viability before the next planting season. The improved technology of storing in mud plastered bamboo baskets or vacuumised metallic containers improves the viability by 3 months. Useful for soybean farmers in M.P.
22.	Improved technology for production of eri silkworm	The improved technology for cultivation of Red petiole and 48-1 varieties of castor in north east India helped in higher leaf production and more eri silk production in Assam and Manipur.
23.	Feeding of livestock with sunflower head based complete feed	This technology helps in successful utilization of sunflower heads, which otherwise go waste by making them as complete feed in the form of pellets or powder for feeding cows and buffaloes. Relevant in all sunflower growing states.
24.	IPM modules for sunflower, safflower, mustard and groundnut	Detailed modules for management of major pests in these crops. Help in saving on cost of pesticides and improved eco system.
25.	INM in oilseed based cropping systems	INM modules for soybean based cropping systems to minimize the cost of chemical fertilizers and achieve higher stability in production. Relevant for all oilseed growing areas
26.	*In situ* moisture conservation technology in castor and groundnut	A technology for *in situ* conservation of moisture by opening a conservation furrow of 30 cm. deep after every 3 rows. Low cost and can be done by the farmers with a wooden plough. For all red soil areas.
27.	Production technology for castor, groundnut, safflower and linseed for saline and sodic soils	This technology of planting pre-soaked seeds (1% NaCl for 3 hours) on the side of the ridges and spot application of FYM (2 t/ha) enables successful cultivation of oilseed crops like castor, sunflower and linseed in saline and sodic soils in A.P., Maharashtra, Gujarat and U.P.
28.	Integrated management of groundnut stem necrosis	The stem necrosis disease emerged as an epidemic during 2000 in A.P. A package consisting of eradication of *Parthenium,* destroying affected plants and vector control was standardized, which effectively controls the disease.

Sl. No.	Name of the technology	Brief description and application domain
Pulses Based Production System		
29.	Liquid *Rhizobium* inoculant for pulses	An alternative method of producing *Rhizobium* inoculant with improved shelf life of 6 months and better counts at the time of using.
30.	Non pesticidal control of soil nematodes	An eco friendly method of nematode control by soil application of neem seed powder (50 kg/ha) for control of root knot and cyst nematode in chickpea and pigeonpea. Useful for nematode infested areas of U.P.
31.	Management of MYMV in mung bean and urd bean	Integrated package of tolerant variety and need based vector control for effective control of yellow mosaic virus in short duration pulses. Relevant for pulse growing areas of Orissa, A.P. and Tamil Nadu.
32.	Improved mini dal mill	An improved version of IIPR dal mill with a pre grader to improve the recovery of dal (pigeonpea, chickpea) by 5-10%.
33.	Pitfall trap for monitoring and control of pulse beetle	A set of two devices that effectively trap beetles in pulses and indicate the infection levels. This helps women in households to dry pulses and minimize the insect damage.
34.	Integrated crop management technology for pigeonpea based intercropping systems	An integrated crop management practice (ICM) for optimizing production and returns from pigeonpea and chickpea based cropping systems. Mainly consists of moisture conservation, INM and IWM.
35.	Bio intensive IPM modules for pigeonpea and chickpea	Detailed modules for management of major pests in these crops. Helps in saving on cost of pesticides and improved eco system.
Cotton Based Production System		
36.	Rainwater management in cotton on toposequences in a watershed	Ridge and furrow system of soil management, which conserves rainwater and improves nutrient use efficiency, particularly on upper toposequences. Relevant for all cotton growing areas of Maharashtra, Karnataka and A.P.
37.	Improved arboreum varieties of cotton	Superior quality arboreums like MDL 2463, DLSA-17 and PA-402 for A.P., Karnataka and Maharashtra with comparable yields to that of hirsutums but lower cost of cultivation and greater stability during drought years. Boon for rainfed farmers.
Nutritious Cereals Based Production System		
38.	Establishment and management of live fences around the crop fields	A number of location specific live fences like *Agave, Lawsonia* and Chiller were identified for protecting crops from stray cattle. Can be adopted in all states.
39.	Integrated management of blast disease in fingermillet	Blast is a serious disease of fingermillet in Karnataka. An integrated package of resistant variety and seed treatment was standardized, which can help farmers achieve 25-30% higher yields.
40.	Fingermillet based intercropping systems with legumes for improved returns	Six different fingermillet based cropping systems were identified, which include a number of legumes like pigeonpea, field bean and blackgram to improve the economic returns and nutritional security of tribal farmers of A.P., Karnataka and Tamil Nadu.
41.	Cultivation of dual purpose sorghum variety CSV-15	CSV-15 an improved dual purpose sorghum variety was identified for its high grain and fodder yield.
42.	Improved production technology for *rabi* sorghum	Compartmental bunding + INM + improved variety (CSV-216R) was standardized as the best package for optimum yields of *rabi* sorghum in Maharashtra and Karnataka.
43.	Rain water management technology in maize based cropping system	Technology for harvesting rainwater through *in situ* moisture conservation and INM and harvesting the rainwater from the entire village catchment into a pond and recycling for maize crop during *kharif* and fruit crops during *rabi* to improve the returns in rainfed maize growing areas of H.P., Rajasthan and Gujarat.
44.	Establishment of improved silvi pasture systems for small ruminants	Involves technology for establishment of grass and legumes in native pastures to improve the productivity of animals.

Sl. No.	Name of the technology	Brief description and application domain
45.	Moisture conservation and nutrient management technology for pearlmillet	Paired row planting (30/60 cm) and opening of furrows in wider rows at 35 DAS + INM gives 25-30% higher productivity in pearlmillet in a number of semi arid and arid pearlmillet growing districts.
46.	Feeding of poultry with substitute rations to reduce the cost of production	Sorghum, fingermillet and pearlmillet as substitutes for maize upto 50% not only reduce the cost of feed for poultry but also produce eggs with low LDL cholesterol.
47.	Technology of physiological harvesting and grain drying in *kharif* sorghum	A technology for harvesting sorghum at physiological maturity and drying the grain to minimize grain mold and fetch higher price to the farmers in Maharashtra and A.P.
48.	Cultivation of high yielding sweet sorghum genotypes	Identification of high biomass producing sweet sorghum varieties (SSV-84) as a raw material for ethanol production as a bio fuel. Relevant for A.P., Karnataka, Maharashtra and Tamil Nadu.
49.	Preparation of value added products like syrup, jaggery and cake from sweet sorghum	All relevant states

Annexure II

Number of On-farm Trials Undertaken, Area Covered Under PSR

Year	On station trials #	On farm trials #	Area covered (Ha)	Number of farmers covered	Number of villages covered	Number of districts covered
2000-01	293	1417	638	2237	560	80
2001-02	339	3800	1282	4200	2400	200
2002-03	445	4500	2682	8500	3060	225
2003-04	86	3500	2225	5800	2150	150
2004-05	1	276	309	335	131	19

Annexure III

Farmers Training

Sl. No.	Nature of the activity	Duration/ Dates	Venue	No. of farmers' trained
1.	Beekeeping as a cottage industry	May 10, 2000	Giriyal, Dharwad	12
2.	Beekeeping as an entrepreneurship activity	July 12, 2000	Dharwad	10
3.	Scope and prospects of beekeeping	October 7-10, 2000	Dharwad	12
4.	Utilization of honey bees for pollination	August 12, 2001	Hulkoti	8
5.	Four training programmes on bee keeping	2001	KVK, Ambajogai	100
6.	Training programme on bakery products	September, 2001	Yashwani Mahila Mandal Federation, Bangalore	45*
7.	Scope and prospects of beekeeping	October 4-7, 2001	Dharwad	8
8.	Seven training programmes on seed treatment for wilt disease management	April, June, July, Aug, Sept, Oct., December 2001	AMU, Aligarh	150
9.	Ten training programmes on seed treatment for wilt disease management	2002	AMU, Aligarh	200
10.	Bakery training programme	Febraury, 2002	Women Development Corporation, Karnataka	30*
11.	Beekeeping as an agribusiness activity	May 8, 2002	Dharwad	12
12.	Practical beekeeping	June 2, 2002	Dharwad	8
13.	Utilization of honeybees for pollination of sunflower	June 13, 2002	Mundargi	12
14.	Pre-season farmer's training programme on peanut stem necrosis disease	June, 2002	ARS, Anantapur	73
15.	Training programme on Agri-horticulture	June, 2002	Ambajogai, Beed	24+10*
16.	Pre *Rabi* farmers training	September, 2002	Bansapal, Keonjhar	25
17.	Scope and prospects of beekeeping	October 5-7, 2002	Dharwad	
18.	Training cum Demonstration at OFT	July, December, 2002, February, 2003	Narasinghpur, Bhadark	250
19.	Training cum Demonstration at OFT	July, December, 2002, February, 2003	Routrapur, Balasore	75
20.	Training programme on bee keeping for prisoners	December 2002	Parbhani	11
21.	Farmers Training on jute varieties	December, 2002	Teghoria, North 24 Paraganas, West Bengal	20
22.	Eight training programmes on seed treatment for wilt disease management	2003	AMU, Aligarh	105
23.	Different species of honey bees and their role in pollination	January 25, 2003	Dharwad	8

Sl. No.	Nature of the activity	Duration/ Dates	Venue	No. of farmers' trained
24.	One day training programme on blast management in finger millet	January, 2003	Chunchunkuppe, Bangalore rural	35+15*
25.	Intercropping in fruit crops	March 29, 2003	Digol-Amba	47+21
26.	Apiculture training programme	March 30, 2003	Z.P. Beed for Z.P. Officials and farmers	120
27.	Organic farming with fruit crops	May 11, 2003	Sakud	98+17
28.	Farmers Training on agri-horticulture	September, 2002	Hessaraghatta, Bangalore	40+20*
29.	Integrated Nutrient Management in Sorghum	November 6-8, 2003	UAS, Dharwad	50
30.	Farmers training on livestock production	November 29, 2003	LRS, ANGRAU, Mahabubnagar	7 Groups
31.	Training on sheep rearing	December 1, 2003	LRS, ANGRAU, Mahabubnagar	20
32.	Management of Sheep and Goat in agri-horti and agri-silvi systems	December 18, 2003	Taluk Seed Farm, Ambajogai	14+02
33.	Training organized for farmers by ATMA	For 8 days	Chaibasa, Jharkhand	20
34.	Training organized for farmers by ATMA	For 8 days	Dumka, Jharkhand	40
35.	Training organized for farmers by ATMA	For 15 days	Ranchi, Jharkhand	8
36.	Training organized for farmers by Sanskar, NGO	For 8 days	Bokaro, Jharkhand	5
37.	Training organized for farmers by ATMA	For 8 days	Chaibasa, Jharkhand	20
38.	Training on pruning in orchard crops	August 7-8, 2003	Amarachinta, Mahabubnagar	30
39.	Training Programme on water conservation	April, May 2002, January, February, March, 2003	CSWCRTI, RS, Chandigarh	160+20*
40.	Eight training programmes on seed treatment for wilt disease management	2003	AMU, Aligarh	105
41.	Integrated Nutrient Management in Cereals	January 28 - February 4, 2004	UAS, Dharwad	50
42.	Integrated Nutrient Management in Agriculture	February 25, 2004	UAS, Dharwad	50
43.	Cultivation of spices in fruit crops	March 31, 2004	Digol-Amba	51+07*
44.	Nine training programmes on seed treatment for wilt disease management	2004	AMU, Aligarh	150
45.	Fertilizer application and preparation of ridges and furrows	—	Amla village, Amravati	15+20*

* indicates women farmers

Annexure IV

Kisan Melas, Interaction Meets, Field Days and Other Extension Activities

Sl. No	Nature of the activity	Date/Month/ Year	Venue	No. of farmers
1.	Vichar Goshti	May, 2001	Mangaliyani, Gujarat	100
2.	Field Day	August, 2001	Karkalpahad village, Mahabubnagar Dist.	300
3.	Kisan Mela	August, 2001	Raipur	150
4.	Exposure visit	September, 2001	CRURRS, Hazaribagh	200
5.	Field Day	September, 2001	Jhabua district	150
6.	Field Day	September, 2001	Kanhadvas village of Bawal, Haryana	150
7.	Farmers' Day	September, 2001	Jharbelda of Keonjhar district	600
8.	Field Day	October, 2001	Gopalput, Orissa	250
9.	Krishi Mela	November, 2001	Sabubereni village in Dhenkanal District	500
10.	Field Day	November, 2001	Banam village, Srikakulam district	110
11.	Field Day	November, 2001	Panabaraja of Khurda district, Orissa	200
12.	Demonstration on finger millet based processed foods	November, 2001	Bakery Training Unit, Bangalore	100*
13.	Kisan Mela	January, 2002	Aurad village, Maharashtra	200
14.	Demonstration on baby food	January, 2002	FTI, UAS, Bangalore	40*
15.	Kisan Mela on IPM practices	February 12-13, 2002	RARS, Palem, Mahabubnagar	2000
16.	Krishak Divas	March, 2002	Badgaon, Raipur	150
17.	Farmers' field school	March, 2002	Wazirpur, Haryana	125
18.	Kisan Mela	March 22-23, 2002	CCSHAU, Hisar	20,000
19.	Krishi Mela	March 30, 2002	Kumaragiri village, Tuticorin	150
20.	Krishi Mela	March, 2002	Kumaragiri, Tuticorin	100+50*
21.	Field Day	April 8, 2002	Gopalpur, Nevadih block	90+20*
22.	Vichar Goshti	April, 2002	Kevadra and Vanthli, Junagadh	16+4*
23.	Farmer-scientist interaction	April, 2002	Turakapalli, Mahabubnagar	22
24.	Krishi Mela on fingermillet	May, 2002	GBPUAT, Ranichauri	400+100*
25.	Farmers' Day	May 20, 2002	Pahadi block, Mirzapur	190+70*
26.	Kisan Sangosthi	May, 2002	Tihari, Orissa	50
27.	Farmer-scientist interaction on oilseed cultivation	May, June, July, August, September, October, 2002	Mahabubnagar, A.P.	35+15*
28.	Farmers' Day	June 8, 2002	Sindhora, Bharpura block	120+50*
29.	Farmers' interaction & Field day	June, October, 2002	Kandabindha, Dhenkanal	120
30.	Farmer scientist interaction	July, 2002	Ratatal ,Bhopal	54
31.	Interaction with farmers	July, 2002	Hebballi, Dharwad	16+4*

Sl. No	Nature of the activity	Date/Month/ Year	Venue	No. of farmers
32.	Vichar Goshti	July, October, 2002 February, 2003	Ramdhari, Amarchgadh, Kenedipur, Madhupur and Kevadra, Junagadh	60+15*
33.	Vichar Goshti and Field Day	July, September, 2002	Manihari, Jabalpur	100+30*
34.	Interaction and Vichar Goshti	July, September, 2002	Sarsawan, Jabalpur	230+30*
35.	Vichar Goshti	July, September, 2002	Gudgawan, Jabalpur	220+20*
36.	Field Day	August 28, 2002	Chenduli, Bharpura block	75+15*
37.	Demonstration	August, September, 2002	Mehgavan, Jabalpur	135+25*
38.	Vichar Gosthi & Field day	August, September, 2002	Nibhora, Jabalpur	200+50*
39.	Farmers' Day	August, December, 2002	CRIJAF, Barrackpore	70+40*
40.	Farmers' visit to OFTs	August, 2002	Tad Borgaon, Parbhani,	50
41.	Farmer-scientist interaction on cotton	August, October, 2002, June, July 2003	Adilabad , A.P	540+10*
42.	Demonstration of INM and moisture conservation	August, September, December, 2002, January, 2003	Palem,Vattem, Bijnepalli, Mahabubnagar	56
43.	Field Day on IPM	September, 2002	Karkalpahad, Mahaboobnagar	250+50*
44.	Farmers' Day	September 6, 2002	Pahadi block, Mirzapur	165+40*
45.	Farmers' Day	September 7, 2002	Gunegal Research Farm, Gunegal Ranga Reddy	204 + 36*
46.	Farmer-scientist interaction	September, 2002	ANGRAU, Nandyal	35+5*
47.	Farmers' Day	September, 2002	Samdari village, Jodhpur	60
48.	Field Day with exhibition & Krishak mela	September, 2002	Gopalput, Orissa	40+20*
49.	Farmers' field school	October, 2002	Boyapur, Mahabubnagar	50
50.	Demonstration of feed pellets preparation from pulse by-products	October, 2002	CIRG, Makhdoom	35+15*
51.	Krishi Mela	October 7, 2002	Ganesapuram village, Coimbatore	75*
52.	Farmers' Day	October, 2002	Sudenahalli, Hassan	50+20*
53.	IPM impact over farmers practices	October 4, 2002	Boyapur village, Mahabubnagar	
54.	Field Day	October 21, 2002	Sudenahalli village, Hassan	
55.	Krishi Mela	October, 2002	Ganesapuram, Coimbatore	60
56.	Field Day	November 8, 2002	Kotwa, Nevadih block	40+15*
57.	Field Day	November, 2002	Kasiadihi ,Dhenkanal	50
58.	Demonstration of applying $NaHCO_3$	November 22, December 12, 2002	Lambakheda village	15
59.	Demonstration of improved grain storage	November, December, 2002, January, June, July, 2003	Lambakheda, Golkhedi and Entkhedi, Bhopal	90+35*
60.	Farmers' Day	December, 2002	CRIJAF, Barrackpore	40+10*
61.	Farmers' Meet	December 28-29, 2002	Ganesapuram Chemman and Chettipalayam Villages	25*

Sl. No	Nature of the activity	Date/Month/ Year	Venue	No. of farmers
62.	Farmers' Meet	December 19, 2002	Ghabraha village, Kanpur District	120
63.	Kisan Diwas	December, 2002	Nagala Kewal, Bharatpur	350+100*
64.	Farmer-scientist interaction	December, 2002	Gangavathi, Koppal	50
65.	Field Day on groundnut	December, 2002	ARS, Kadiri	36
66.	Exposure visit on grain storage	December, 2002	Ganesapuram, Chemman and Chettipalayam, Coimbatore	70+30*
67.	Exposure visit on pulse bettle control	December, 2002	Ghabraha, Kanpur	80+40*
68.	Exposure visit on pulse beetle control	December, 2002	IIPR, Kanpur	100+50*
69.	Exposure visit on INM	December, 2002	UAS, Dharwad	60+35*
70.	Field Day	December, 2002	Hirehonnalli, Dharwad	140+60*
71.	Krishi Mela	December, 2002	ARS, Mudhol	1500+500*
72.	Krishi Mela on INM and moisture conservation in Cotton	December, 2002	CICR, Nagpur	25+15*
73.	Farmer-scientist interaction	January, 2003	Motichandur, Patan	25
74.	Women entrepreneurship development programme	January, 2003	College of Home Sci., MAU,Parbhani	250*
75.	Exhibition on safflower by-products organized by Women Development Corporation	January, 2003	Parbhani, Maharashtra	100*
76.	Farmer-scientist interaction on oilseed cultivation	January, 2003	Allapur, Parbhani	50
77.	Demonstration of applying $NaHCO_3$	January 23, 2003	Golkhedi village	22
78.	Demonstration of applying $NaHCO_3$	January 23, 2003	Entkhedi village	5
79.	Krishi Mela	January, 2003	Kovilpatti	130+70*
80.	Krishi Mela	January, 2003	Raichur	500+100*
81.	Krishi Mela	January 20, 2003	Raichur	600
82.	Krishi Mela	January 30, 2003	Kovilpatti	200
83.	Krishi Mela	January 23, 2003	Sevasagar Auditorium, Chunchunkuppe, Bangalore rural district	50
84.	Krishi Mela	February 14,2003	KVK Farmers Training Centre, Kandali Hasan district	62
85.	Farmers' Day	February 10, 2003	Padri, Bharpura block	160+48*
86.	Farmers' Day	February 18, 2003	Mahuasala, Bah block	90+60*
87.	Exhibition and Krishak mela	February, 2003	Chianki, Jharkhand	80+35*
88.	Farmer -scientist interaction on management of castor semi-looper	February, 2003	Marchikal & Buddasamudram, Mahabubnagar	25+25*
89.	Field Day on groundnut	February, 2003	Gananyakana halli, Chitradurga	70+20*
90.	Field Day	March 2003	Keredi, Kandhamahal	110+15*
91.	Safflower Shetkari Mela	March, 2003	Tadborgaon, Parbhani	200+100*
92.	Farmers' Day	March 5, 2003	Pahadi block, Mirzapur	200+60*
93.	Krishi Mela	March 6-8, 2003	CSAU&T, Kanpur	250
94.	Kisan Mela	March 16-17, 2003	CCS HAU, Hisar.	1000
95.	Krishi Mela	March 27, 2003	JDA Office Auditorium, Tumkur	60
96.	Krishi Mela	March, 2003	CCSHAU, Hisar	200+50*
97.	Farmer-scientist interaction	March, 2003	MAU, Parbhani	30+10*

Sl. No	Nature of the activity	Date/Month/ Year	Venue	No. of farmers
98.	Farmer's group meeting	May 1, 2003	Jharkhand	8+2*
99.	Visit of watershed Development Team members from Kullu (H.P.)	June 20, 2003	CSWCRTI, Chandigarh	25+5*
100.	Interaction & Vichar ghosthi	July, 2003	Sarsawan, Jabalpur	855+30*
101.	Kisan Mela	July 29-August 3, 2003	GAU, Rajkot	180+35*
102.	Demonstration of profile modification and pit filling for raising orchard crops	August 4, 2003	Nellikondi, Mahabubnagar	25+10*
103.	Field Day	August 23, 2003	Boida village, Phulbani	200+50*
104.	Field Day	September 6, 2003	Simrol	125+5*
105.	Group Discussion	September 8, 2003	Rajapur	10+5*
106.	Farmers Day	September 13, 2003	Gunegal Research Farm, Gunegal Ranga Reddy district	222+53*
107.	Field Day	September 18, 2003	Shakavadi	155+25*
108.	Kisan Mela	October 7-11, 2003	GAU, Junagadh	380+75*
109.	Field Day	October 20, 2003	Uchangi, Tumkur district	200
110.	Field Day	October 30, 2003	Ganapathihalli, Bangalore Rural district	150
111.	Kisan Mela	November 1, 2003	IGFRI, Jhansi	45
112.	Field Day	November 8, 2003	Mahamada, Samastipur	160+20*
113.	Visit of shepherds	November 11, 2003	LRS, ANGRAU, Mahbubnagar	100
114.	Visit of shepherds	November 11, 2003	LRS, ANGRAU, Mahbubnagar	170+30*
115.	Krishi Mela	November 13, 2003	Bharathavalli, Hasan	71
116.	Krishi Mela	November 14, 2003	Gejihalli, Hasan	130
117.	Krishi Mela	November 15, 2003	Chikktotalkere, Tumkur	90
118.	Krishi Mela	November 20, 2003	Sevasagar Auditorium, Chunchunkuppe Bangalore Rural district	63
119.	Krishi Mela	November 21, 2003	Balegere, Tumkur	65
120.	Krishi Mela	November 25, 2003	ARS, Honavelle, Shimoga	80
121.	Krishi Mela	November 28, 2003	Basavanapura, Devanahalli taluk Bangalore Rural district	75
122.	Field Day	November 22, 2003	Sanabandhakera village, Puri, Orissa	180+40*
123.	Field Day	December 12, 2003	Bahikhowagaon village, Gholaghat district	130+10*
124.	Field Day	January 25, 2004	Narasinghpur, Bhadrak	130+57*
125.	Shodh Yatra in NATP villages	February 3, 2004	Villages in Jhansi	96
126.	Demonstration of improved rice milling technology	February 23, 2004	CRRI, Cuttack	50
127.	Kisan Mela	March 22, 2004	IGFRI, Jhansi	290+57*

* *Indicate women farmers*

Annexure V

List of Documents Brought Out by AED (Rainfed) While Formulating and Implementing PSR Projects

Sl. No.	Title	Month and Year	No. of pages
1.	District Based Research Prioritization in Rainfed Rice Based Production System	December, 1998	146
2.	Research Prioritization in Four Rainfed Crop Based Production Systems	July, 1999	252
3.	Atlas of Rainfed Production Systems	January, 2000	54
4.	Monitoring and Evaluation of Rainfed Production System Research	April, 2001	50
5.	Reports on Review of Rainfed Production Systems	April, 2001	196
6.	A report submitted to the World Bank Supervision Mission	September, 2001	55
7.	Technical Programme for Rainfed Rice Based Production System (Volume-I)	December, 2001	138
8.	Technical Programme for Oilseeds, Pulses, Cotton and Nutritious Cereals Based Production System (Volume-II)	December, 2001	185
9.	A status report on Monitoring and Evaluation of Rainfed Agro Ecosystem	January, 2002	21
10.	Annual Report (2000-01) – Pulses Based Production System	February, 2002	34
11.	A progress report on Implementation and Monitoring of PSR projects under Rainfed AED for Mid Term Review	March, 2002	58
12.	Field Manual for On-Farm Adaptive Research	April, 2002	29
13.	Annual Report (2001-02) – Pulses Based Production System	July, 2002	49
14.	Annual Report (2001-02) – Oilseeds Based Production System	July, 2002	79
15.	Annual Report (2001-02) – Cotton Based Production System	September, 2002	112
16.	Annual Report (2001-02) – Nutritious Cereals Based Production System	November, 2002	98
17.	Annual Report (2001-02) – Rainfed Rice Based Production System	November, 2002	74
18.	Annual Report (2001-02) – Rainfed Agro Ecosystem (PSR)	December, 2002	92
19.	Annual Report (2001-02) – Rainfed Agro Ecosystem (TAR-IVLP)	May, 2003	94
20.	Annual Report (2002-03) – Rainfed Agro Ecosystem (PSR)	November, 2003	142
21.	Success stories of TAR-IVLP	December 2003	32
22.	Annual Report (2002-03) – Rainfed Agro Ecosystem (TAR-IVLP)	March, 2004	97
23.	Achievements at a Glance – Rainfed Agro Ecosystem (PSR, TAR-IVLP)	March, 2004	8 + 8
24.	Annual Report (2003-04) – Rainfed Agro Ecosystem	September, 2004	150
25.	Project completion report	September, 2004	85
26.	Annual Report 2003-04- TAR-IVLP	October, 2004	90
27.	TAR-IVLP- Technical bulletin, NATP, CRIDA	April, 2005	54
28.	Completion Report of Rainfed Agro-Ecosystem (PSR), 1999-2004	October, 2005	202
29.	Completion Report of TAR-IVLP	November, 2005	

Annexure VI

Research Publications

National Journals

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Annexure VII

List of Brochures, Bulletins, CDs and Other Extension Material Produced

1. A folder on "Low Cost Technology for Safe Storage of Pulses", CIAE, Bhopal, June 2000, pp:6.
2. A Book on "Ragi based Nutri-Rich Recipes" UAS, Hebbal, Bangalore, 2002, pp:55.
3. A folder on "Gliricidia: An improved organic fertilizer for jute-rice cropping system", CRIJAF, Barrackpore, 2002, pp:4 (Bangla).
4. A Book on "Sorghum based Nutri-Rich Recipe", MPKV, Pune, 2002, pp:34.
5. A technical bulletin on "New Approaches to Integrated Pest Management in Rainfed Rice Based Production Systems", CRRI, Cuttack, 2002, pp:4.
6. A folder on "Integrated pest and weed management in rainfed rice cultivation", CRRI Cuttack, August 2002, pp:4 (Oriya).
7. A folder on "Integrated Pest Management for Upland Rice", CRRI, Cuttack, September 2002, pp: 4.
8. A book on "Dividends from soil and water conservation practices", CRIDA, Hyderabad, December, 2002, pp:40.
9. A book on "Soil and water conservation in semi arid India" , CRIDA, December, 2002, pp:151.
10. A folder on "Oilseed Cultivars for Efficient Moisture and Nutrient Use", DOR, Hyderabad, 2003, pp: 6.
11. A folder on "Technology for Oilseeds in Salt Affected Soils", DOR, Hyderabad, 2003, pp: 6.
12. A bulletin on " Integrated pest management in Castor" DOR, Hyderabad, 2003, pp:10 (Telugu).
13. A technical report on "*In vitro* evaluation of various feed pellets and their production potential in lactating Indian goats", CIRG, Mathura, 2003, pp: 34.
14. A technical report on " Response of feeding complete broiler rations in different Indian kids for optimum growth and quality chevon production", CIRG, Mathura, 2003, pp: 34.
15. A folder on "Voluntary nutrients intake and growth performance in native kids under different starter rations", CIRG, Mathura, 2003, pp: 18.
16. A folder on "Development and evaluation of milk replacers in kids under different geo-climatic regions of India", CIRG, Mathura, 2003, pp: 18.
17. A folder on "RCC ring bin", CRRI, Cuttack, 2003, pp: 4.
18. A folder on "RCC ring bin", CRRI, Cuttack, 2003, pp: 4 (Oriya).
19. A folder on "RCC ring bin for safe storage of paddy", CRRI, Cuttack, 2003, pp: 4.
20. A information booklet on "Supplementary foods from processed pearl millet", Dept. of Foods & Nutrition, CCS, HAU, Hisar, 2003, pp:7.
21. A recipe book on "Diversified products from ragi rice", UAS, Bangalore,2003, pp:29.
22. A training book on "Weaning foods from fingermillet- a guide to mother", UAS, Bangalore, 2003, pp:49.
23. A information booklet on "Weaning and supplementary Food from Malted and Roasted Pearl Millet", CCS, HAU, Hisar, 2003, pp:7.
24. A information booklet of "Value Added Products from Processed Pearl Millet", CCS, HAU, Hisar,2003, pp:13.
25. A success story folder on "Promotion of productive high quality G. arboreum cotton to meet the needs of cultivators of rainfed ecosystem vis-ˆ-vis textile industry" CRS, MAU, Parbhani, 2003, pp:6.
26. A folder on "Tillage, nutrient and organic residue management in cotton + pigeon pea strip intercropping" CICR, Nagpur. 2003, pp:6.
27. A book on "Endoparasites and their control in cattle", OUAT, Bhubaneswar, 2003, pp:90.
28. A book on "Oilseed production in salt affected soils", DOR, Hyderabad, 2003, pp:37.
29. A book on "Diseases of finger millet", UAS, Bangalore, 2003, pp:126.
30. A book on "Integrated pest management for rapeseed-mustard", HAU, Hisar, 2003, pp:35.
31. A book on "Benefits of coarse cereals to diabetic", Pantnagar, Uttaranchal, 2003, pp:39 (Hindi).

32. A book on "Integrated pest management in castor", DOR, Hyderabad, 2003, pp:52.
33. A folder on "Tillage, nutrient and organic residue management in cotton + pigeon pea strip intercropping" CICR, Nagpur. 2003, pp:6(Hindi).
34. A technical bulletin on "Sunflower Necrosis Disease – An Emerging Viral Problem", IARI, New Delhi, January 2003, pp:11.
35. A book on "Fingermillet- for the management of diabeties", UAS, Bangalore, February 2003, pp:56.
36. A Book on "Value Addition of Safflower Petals fro Natural Dyes and Herbal Healthcare Products", CIRCOT, Mumbai, March, 2003, pp:10.
37. A folder on " Utera cultivation : Package of practices", CRRI, Cuttack, August, 2003 pp: 4.
38. A success story folder on "Improving the Utilization of Coarse Cereal Crop Residues by Strategic Supplementation for Livestock Feeding" NIANP, Bangalore, 2003, pp:5.
39. A folder on "On-farm research for enhancing the productivity of pearlmillet in arid regions" ARS, RAU, Mandor-Jodhpur, 2003, pp:4.
40. A folder on "On-farm research for enhancing the productivity of pearlmillet in arid regions" ARS, RAU, Mandor-Jodhpur, 2003, pp:4 (Hindi).
41. A folder on "Moisture conservation techniques for higher productivity of rainfed pearlmillet", ARS, RAU, Mandor-Jodhpur, 2003, pp:4 (Hindi).
42. A folder on "Suitable Castor verities for rainfed Cultivation. Moisture and Nutrient Management, DOR, Hyderabad, 2003 (Telugu).
43. A folder on "Suitable Castor verities for Saline soils and Management Practices", DOR, Hyderabad, 2003, pp:6 .(Telugu).
44. A Information bulletin on "Castor Integrated Pest Management" ANGRAU, Palem, 2003, pp:16 (Telugu).
45. A folder on "Identifying Systems for Carbon Sequestration and Increased Productivity in Semi-Arid Tropical Environments",ICRISAT, Hyderabad, 2003,pp:4.
46. A folder on "Measures to counteract/detoxify aflatoxin in oilseeds and nutritious coarse cereals-based poultry and livestock feeds" PDP, Hyderabad, 2003, pp:6.
47. A book on " Gliricidia-Unique Organic manure in yield targeting for jute-Rice Production system", CRIJAF, Barrackpore, 2003, pp-14.
48. A bulletin on "Improvement of jute through rice necrosis mosaic virus technology for sustainable yield and quality under jute-rice production system" CRIJAF, Barrackpore, 2003, pp-12.
49. A folder on " Development of fruit based land use system in watershed – At a glance", RRTTS, OUAT, Koraput, 2003, pp:6.
50. A bulletin on "Integrated pest management in Castor" DOR, Hyderabad, 2003, pp:10.
51. A folder on "Integrated pest management of fingermillet", UAS, GKVK, Bangalore, 2003, pp:8.
52. A folder on "Poverty to prosperity through horticultural based land use system in watershed- a case study", RRTTS, OUAT, Koraput, 2003, pp:4.
53. A folder on "Agroforestry on field bund", OUAT, Bhubaneshwar, 2003, pp:6.
54. A technical bulletin on "New Approaches to Integrated Pest Management in Rainfed Rice Based Production systems of West Bengal", BCKV, Kalyani & DRR, Hyderabad, 2003, pp:4.
55. A leaflet on "Integrated management through fish-duck and pig culture in rainfed rice-farming systems", BAU, Kanke Jharkhand, 2003, pp:6.
56. A leaflet on "Integrated management through fish-duck and pig culture in rainfed rice-farming systems", BAU, Kanke Jharkhand, 2003, pp:6. (Bangla).
57. A book on "Biofence practices in India" NRCAF, Jhansi, 2003, pp:105.
58. A book on "Sunflower in India" DOR, Hyderabad, 2003, pp:112.
59. A book on "Ethano medicinal diversity used by tribals of central India", JNKVV, Jabalpur, 2003, pp:250.
60. A information bulletin on " Peanut Stem Necrosis: a new disease of groundnut in India", ICRISAT, Hyderabad, 2003, pp:12.
61. A book on "Socioeconomic Dynamics of Rice production systems in Jharkhand State", CRURRS, Hazaribagh, 2003, pp:138.
62. A folder on " Design and construction of tank cum well system for micro level water resource development", WTCER, Bhubaneswar, 2003, pp:6.
63. A research bulletin on " Crop diversification technology in rainfed upland rice of eastern India for increased productivity and rainwater use efficiency" WTCER, Bhubaneswar, 2003, pp:50.
64. An information bulletin on "Integrated Control of Safflower diseases & pests", MAU, Parbhani, 2003, pp:12 (Marathi).
65. A folder on "Integrated nutrient Management for Rainfed Cotton Crop", MAU, Parbhani, 2003, pp:6 (Marathi).
66. A folder on " Protection of natural resources and employment generation through watershed

development programme", WTCER, Bhubaneswar, 2003, pp:8 (Oriya).

67. A folder on "Intercropping in fruit orchard in Orissa", OUAT, Koraput, 2003, pp:6 (Oriya).

68. A folder on "Crop diversification in rainfed upland in eastern India", WTCER, Bhubaneswar, 2003, pp:6 (Oriya).

69. An information bulletin on "INM for rainfed rice production system", OUAT, Bhubaneswar, 2003, pp:22 (Oriya).

70. A folder on " Utera cultivation : Package of practices", CRRI, Cuttack, August, 2003 pp: 4 (Oriya).

71. A pamphlet on "Combating a New Virus Menace in Groundnut", ICRISAT-NARS, Hyderabad, August, 2003, pp:2.

72. A success story folder on "Assessment on Gossypol Content in Cotton Germplasm" CICR, Nagpur, August, 2003, pp:8.

73. A folder on " Integrated crop management for rainfed upland rice'. CRRI, Cuttack, August, 2003, pp:4.

74. A folder on "Meat Goats – Rearing & Diet", PGIVAS, Akola, August 2003, pp:6 (Marathi).

75. A folder on "Whole stick livestock feed from Agricultural – Produce", PGIVAS, Akola August, 2003, pp:6 (Marathi).

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77. A technical bulletin on "Rainfed Cotton Production Technology and Water Management", August 2003, pp:13 (Marathi).

78. A folder on " Oilseed production after the harvesting of rainfed rice", CRRI, Cuttack, September 2003, pp:4 (Oriya).

79. A folder on "Integrated weed management for rainfed upland rice", CRRI, Cuttack, September, 2003, pp:4.

80. A technical report on "Sweet Sorghum Stalk: A suitable raw material for fuel alcohol production" NRCS, Hyderabad, September, 2003, pp: 8.

81. A folder on " Development of agro techniques for sustainable productivity in rice-based utera cropping system", CRRI, Cuttack, September 2003, pp: 4.

82. A folder on "Intercropping greengram in *rabi* redgram-results from field research", ANGRAU, Lam, Guntur, September 2003, pp: 12 (Telugu).

83. A folder on " Application of crop simulation models to develop crop and nitrogen management strategies for increasing rice productivity under rainfed favorable lowland situations of eastern India", CRRI, Cuttack, September, 2003. pp:4.

84. A folder on "S-19, A promising jute cultivar under rainfed condition", CRRI, Cuttack, October, 2003, pp:4.

85. A book on " Alternative farming system for Rice-Based Rainfed up-lands" RRTTS, OUAT, Koraput, October, 2003, pp:19.

86. A bulletin on "Industrial utilization of sorghum in India-Status and prospects", NRCS, Hyderabad, October 2003, pp:16.

87. A folder on " Integrated Management of plant nematodes/Soil Pathogens in pulses based cropping systems", IARI, New Delhi, November, 2003, pp: 8.

88. A technical bulletin on "Agro-techniques for management of pigeon pea +sorghum intercropping system under rainfed conditions" JNKVV, Jabalpur, December,2003, pp:12 (Hindi).

89. A folder on "Low Cost Technology for Safe Storage of Pulses", CIAE, Bhopal, December 2003, pp:4.

90. A bulletin on "Changing scenario of sorghum cultivation in India- A comprehensive economic analysis", NRCS, Hyderabad, December 2003, pp:19.

91. A success story folder on "Ranjit: A high yielding rice variety for shallow rainfed lowlands of Orissa", CRRI, Cuttak, December, 2003. pp:4.

92. A Book on "Fingermillet blast (*Pyricularia grisea* (Cke.) Sacc) and its management", UAS, GKVK, Bangalore,2004, pp:127.

93. A technical bulletin on "Improved Agro-techniques of Rice-based Utera Cropping Systems in India" JNKVV,Jabalpur, 2004, pp:12.

94. A folder on "Alternate Uses of Sorghum" NRC for Sorghum, Hyderabad, 2004, pp:4 (Hindi).

95. A folder on "Alternate Uses of Sorghum" NRC for Sorghum, Hyderabad, 2004, pp:6 (Telugu).

96. A folder on "Fingermillet blast (*Pyricularia grisea* (Cke.) Sacc) and its management", UAS, GKVK, Bangalore, 2004, pp:8 (Kannada).

97. A folder on "Improved indigenous technology for drying, storage and milling of rice", CRRI, Cuttack, March, 2004, pp:4.

98. A folder on "Management Practices for Profitable rainfed Sunflower" CRIDA, Hyderabad, March, 2004, pp:6 (Telugu).

99. A book on "Oilseed cultivars for moisture and nutrient stress",DOR, Hyderabad, March 2004, pp:37.

100. A bulletin on "Export performance, competitiveness and future prospects of Indian sorghum", NRCS, Hyderabad, March 2004, pp:12.

101. A book on "Macro and micro level changes in consumption of nutritious cereals in India", NRCS, Hyderabad, June,2004, pp:52.

102. A folder on "Peanut stem necrosis disease", ICRISAT, Hyderabad, 2004, pp:2.
103. A research bulletin on "Microlevel water resource development through rainwater management for drought mitigation in sub-humid plateau areas of eastern India".
104. A folder on "Improved package of practices for safflower", MPKV, Solapur, 2003, pp:6 (Marathi).
105. A folder on "Groundnut cultivation under moisture and nutrient stress condition", NRCG, Junagadh, 2003, pp:6 (Gujrathi).
106. A leaflet on "Integrated management through fish-duck and pig culture in rainfed rice-farming systems", BAU, Kanke Jharkhand, 2003, pp:6. (Hindi).
107. A book on "Integrated management through fish-duck and pig culture in rainfed rice-farming systems", BAU, Kanke Jharkhand, 2004, pp:53 (Hindi).
108. A book on "Integrated management through fish-duck and pig culture in rainfed rice-farming systems", BAU, Kanke Jharkhand, 2003, pp:46.(Bangla).
109. A folder on "Integrated management through fish-duck and pig culture in rainfed rice-farming systems", BAU, Kanke Jharkhand, 2003, pp:4 (Hindi).
110. A folder on "Rainwater management for enhancig land and water productivity", WTCER, Bhubaneswar, 2004, pp:4 (Oriya/ English/Hindi).
111. A folder on "Management of excess water in medium and low land for sustaninable productivity", WTCER, Bhubaneswar, 2004, pp:6.
112. A book on "Feedstuffs for livestock and poultry",CARI, Izatnagar, 2004, pp:232.
113. A research bulletin on "Management of excess rainwater in medium and lowlands for sustainable productivity", WTCER, Bhubaneswar, 2005, pp:24.

CD's/Video films produced

1. Video film on "Liquid bio-fertilizers production technology (RPPS-01)" UAS, Bangalore.
2. Video film on "Production technology of yarn and weaning of cotton (RCPS-09) "by CICR, Nagpur.
3. Video film on "Fish, duck and pig culture in rainfed rice farming system (RRPS-09)" by BAU, Ranchi.
4. Video film on "Development of fruit based land use systems in watersheds (RRPS-08)" by OUAT,Koraput.
5. Video film on " Kalamkari printing on Ponduru cotton-A 400 years industry in AP (RCPS-09)" by CICR, Nagpur.
6. Video film on "Control of parasitic diseases of grazing and stall-fed livestock in Bihar, Orissa, West Bengal and Madhya Pradesh (RRPS-13)" by OUAT, Bhubaneswar.
7. Video film on " Rice based three crop system in rainfed areas (RRPS-23)" by OUAT, Bhubaneswar.
8. Video film on "New approaches integrated pest management in rainfed rice based production system (RRPS-22)" by BCKV, Kalyani.
9. Video film on "Develop and evaluate production technology for indigenous cotton of N.E. region (RCPS-09)" by AAU, Dhipu.
10. Video film on "Rain water management strategies for drought alleviation (RRPS-04)", by IGKV, Raipur.
11. Video film on "Improving the traditional biasi system (RRPS-21)" by IGKV, Raipur.
12. Video film on "Efficient oilseed cultivars for moisture and nutrient stress (ROPS-12)", by DOR, Hyderabad.
13. Video film on "Biofertilizer use in cotton, organic dyeing and hand printing (RCPS-09)".
14. Video film on "*Sone Ki Khan* (ROPS-01)", by CIRCOT, Mumbai.
15. Video film on "Success story (RNPS-09)", by CRIDA, Hyderabad.
16. Video film on "*Kisan ki hum dum, desi kapas* (RCPS-07)", MAU, Parbhani.
17. Video film on "Sunflower heads: a newer livestock feed resource (ROPS-07)", by NAINP, Bangalore.

Annexure VIII

List of Sub-Projects under PSR Mode along with Implementing Institutes, PI's, CCPI's and Budget Utilized

Rainfed Rice based production system

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
1	Georeferenced resource inventory preparation for rice ecosystem (RRPS-01)	**Dr.G.G.S.N.Rao**	**CRIDA**	Hyderabad	15.51
		Dr.S.Pasupalak	OUAT	Bhubaneswar	4.69
		Dr.A.Saha	BCKV	Mohanpur	5.19
		Dr.A.S.R.A.S.Shastri	IGKV	Raipur	3.85
		Dr.Upendra Shankar	JNKV	Jabalpur	4.81
		Dr.K.K.Nath	AAU	Jorhat	5.37
		Dr.P.Tripathi	NDUAT	Faizabad	5.17
		Dr.A.Wadood	BAU	Ranchi	4.38
			Total		**48.99**
2	Socio economic dynamics of charges in rice production system in Eastern India (RRPS-02)	**Dr.B.C.Barah**	**NCAP**	New Delhi	12.41
		Dr.A.K.Koshta	IGKV	Raipur	5.68
		Dr.R.K.Singh	CRURRS	Hazaribagh	7.18
		Dr.J.Thakur	RAU	Samastipur	6.95
		Dr.D.Naik	OUAT	Bhubaneswar	7.36
		Dr.P.Samal	CRRI	Cuttack	5.06
		Dr.B.V.S.Sisodia	NDUAT	Faizabad	5.92
		Dr.N.K. Saha	Govt. of WB	Kolkata	1.97
		Dr.B.C.Bhoumick	AAU	Jorhat	5.96
		Dr. M.G. Nema	JNKV	Jabalpur	4.35
			Total		**62.86**
3	Crop management strategies to increase cropping intensity (RRPS-03)	**Dr.R.S.Tripathi**	**IGKV**	Raipur	35.25
		Dr.R.P.Pandey	JNKV	Rewa	26.49
		Dr.Gauranga Kar	WTCER	Bhubaneswar	23.79
		Dr.B.K.Sahu	OUAT	Bhubaneswar	10.97
		Dr.A.Rafey	BAU	Ranchi	16.81
			Total		**113.32**
4	Rain water management strategies for drought alleviation (RRPS-04)	**Dr.A.R.Pal**	**IGKV**	Raipur	49.72
		Dr.R.C.Srivastava	WTCER	Bhubaneswar	34.50
		Er.D.K.Rusia	BAU	Ranchi	22.98
		Er.O.P. Dubey	JNKV	Jabalpur	34.33
			Total		**141.55**
5	Management of excess water in medium and low lands for sustainable productivity and delineation of problem area (RRPS-05)	**Dr.B.K.James**	**WTCER**	Bhubaneswar	15.18
		Er.S.K.Sahoo	OUAT	Bhubaneswar	8.09
		Dr.S.K.Pyasi/ Dr.P.Dwivedi	BAU	Ranchi	12.85
		Dr.Y.K.Tiwari	JNKV	Jabalpur	10.41
			Total		**46.53**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
6	Study of production mix, resource utilization, risk management and technological intervention in watershed development programmes (RRPS-06)	**Dr.P.Nanda**	**WTCER**	Bhubaneswar	12.12
		Dr.M.A.A.Beig/Dr.B.Bhuyan	OUAT	Bhubaneswar	9.82
		Dr.R.P.Singh	BAU	Ranchi	9.92
		Dr.S.P.Gupta	IGKV	Raipur	9.28
			Total		**41.14**
7	Strategies for restoration/ rehabilitation of degraded watersheds (RRPS-07)	**Dr.K.N.Sharma**	**OUAT**	Bhubaneswar	**18.39**
8	Development of fruit based land use systems in watersheds (RRPS-08)	**Dr.Sabyasachi Rath**	**OUAT**	Sunabeda	34.11
		Dr.Prashant Kumar	BAU	Palamu	18.23
		Dr.R.V.Singh	CHES	Ranchi	13.29
		Dr.P.K.Jain	JNKV	Jabalpur	18.10
		Dr.Vijay Kumar	IGKV	Ambikapur	14.09
			Total		**97.83**
9	Integrated management through fish, pig and duck culture in rice farming system (RRPS-09)	**Dr.A.K.Singh**	**BAU**	Ranchi	50.28
		Dr.M.S.Chari	IGKV	Anjora, Durg	14.41
		Dr.T.K.Gosh	WBUAFS	Nadia, WB	28.08
			Total		**92.76**
10	Evaluation of cultivars for rainfed rice production system (RRPS-10)	**Dr.L.V.Subba Rao**	**DRR**	Hyderabad	35.09
		Dr.R.K. Mishra	IGKV	Raipur	27.15
		Dr.N.S.Tomar	IGKV	Raigarh	7.44
		Dr.A.T.Roy	OUAT	Bhubaneswar	45.81
		Dr.M.S.Yadava	BAU	Ranchi	18.69
			Total		**134.19**
11	Integrated plant nutrient management strategies for different soil moisture regimes (RRPS-11)	**Dr.H.K.Senapati**	**OUAT**	Bhubaneswar	23.21
		Dr.S.K.Patil	IGKV	Raipur	26.35
		Dr.Surendra Singh	BAU	Ranchi	24.39
			Total		**73.95**
12	Sustainable livestock production system for rainfed rice areas (RRPS-12)	**Dr.S.Rajagopal**	**IGKV**	Anjora, Durg	50.20
		Dr.P.C.Samal	OUAT	Bhubaneswar	16.59
		Dr.A.K.Sinha/Dr.A.P.Sinha	BAU	Ranchi	28.31
			Total		**95.11**
13	Control of parasitic diseases of grazing and stall-fed livestock in Bihar, Orissa, West Bengal and Madhya Pradesh (RRPS-13)	**Dr.N.Sahoo**	**OUAT**	Bhubaneswar	39.18
		Dr.Sushovan Roy	IGKV	Anjora, Durg	36.10
		Dr.K.D.Prasad	BAU	Ranchi	16.35
			Total		**91.63**
14	Agro techniques for vegetable cultivation and storage (RRPS-14)	**Dr.P.Mahapatra**	**OUAT**	Bhubaneswar	9.43
		Dr.Y.C.Dwivedi	JNKV	Jabalpur	11.44
		Dr.D.A.Sarnaik	IGKV	Raipur	10.54
		Dr.B.M.Choudhary	BAU	Ranchi	8.72
		Dr.Rajesh Kumar/ Dr.K.K.Prasad	BAU	Dumka	4.95
			Total		**45.09**
15	Identification of microbial inoculants for moisture and temperature stress to improve their survival in plough layers in order to enhance the productivity of legumes and cereals in rainfed ecosystem (RRPS-15)	**Dr.S.B.Gupta**	**IGKV**	Raipur	2.66
		Dr.Alok Adholeya	TERI	New Delhi	2.56
			Total		**5.22**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
16	Soil tillage requirement for rainfed rice production system (RRPS-16)	**Dr.B.K.Mishra**	**OUAT**	Bhubaneswar	26.16
		Dr.S.S.Sengar/Dr.T.D.Pandey	IGKV	Jagdalpur	13.25
		Dr.M.R.Mishra	OUAT	G.Udaigiri	5.30
		Dr.S.Karmakar/ Dr.B.K.Agrawala	BAU	Darisai	13.34
		Dr.S.Sarkar	BCKV	Gayespur, WB	17.23
		Dr.M.R.Verma/ Prof. R.B.Sharma	NDUAT	Kumarganj	13.27
		Dr(Mrs) N.G.Barua	AAU	Titabar	16.23
		Dr.G.Jayashree	ANGRAU	Hyderabad	20.36
			Total		**125.15**
17	Development of regional scale watershed plans and methodologies for identification of critical areas for prioritized land treatment in the watersheds (RRPS-17)	**Dr.B.R.M.Rao**	**NRSA**	Hyderabad	34.19
		Dr.A.L. Rathore	IGKV	Raipur	18.56
		Dr.Sushma Sudhishri	CSWCRTI	Sunabeda	17.44
		Dr.N. Sahoo	WTCER	Bhubaneswar	13.26
		Dr. Dipak Sarkar	NBSSLUP	Kolkata	19.96
		Dr.S. Malik	BCKV	Gayespur, WB	11.82
		Dr.S.K.Pal	BAU	Ranchi	11.62
		Dr.S. Vadivelu	NBSSLUP	Jorhat	3.82
		Dr.P.C.Bora	AAU	Jorhat	15.06
			Total		**145.72**
18	Study on weed and pest dynamics in relation to different rainfed rice growing areas and to develop effective weed control measures (RRPS-18)	**Dr.B.T.S.Moorthy/ Dr.G.N.Mishra/ Dr.Sanjay Saha**	**CRRI**	Cutack	11.37
		Dr.D.Maiti	CRURRS	Hazaribagh	9.12
		Dr.R.D. Vaishya	NDUAT	Faizabad	7.54
			Total		**28.03**
19	Organic pools and dynamics in relation to land use tillage and agronomic practices for maintenance of soil (RRPS-19)	**Dr.Anand Swaroop/ Dr.M.V.Singh**	**IISS**	Bhopal	36.39
		Dr.B.Mishra	BAU	Ranchi	7.54
		Dr.H.N.Ravankar	PDKV	Akola	6.62
		Dr.A.R.Bangar/ Dr.A.L.Pharande	MPKV	Solapur	7.46
		Dr.K.Sudhir	UAS	Bangalore	7.59
		Dr.Anurag	IGKV	Raipur	6.09
		Dr.B.A.Golakia	JAU	Junagadh	7.79
			Total		**79.49**
20	Assessment and improvement of soil quality and resilience for rainfed production system (RRPS-20)	**Dr.B.Mandal**	**BCKV**	Kalyani	42.70
		Dr.N.C.Talukdar	AAU	Jorhat	8.98
		Dr.K.K.Rout	OUAT	Bhubaneswar	11.34
		Dr.J.Chaudhury	CRIJAF	Kolkata	9.47
		Dr.A.P.Singh	BHU	Varanasi	9.59
		Dr.T.Yellamanda Reddy/ Dr.D.Balaguravaiah	ANGRAU	Anantapur,AP	9.57
		Dr.K.L.Sharma	CRIDA	Hyderabad	18.54
		Dr.R.N.Samantaray	CRRI	Cuttack	12.11
			Total		**122.30**
21	Improving the traditional biasis system (RRPS-21)	**Dr.B.P.Mishra**	**IGKV**	Raipur	18.12
		Dr.A.K.Swarnakar/ Dr.K.L.Nandeha	IGKV	Jagdalpur	6.58
		Dr.R.K.Mishra	IGKV	Ambikapur	9.05
		Dr.B.N.Prasad	BAU	Ranchi	3.97

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
		Dr.B.C.Sahoo	OUAT	Keonjhar	10.71
		Er.A.K.Rout	OUAT	Bhawanipatna	4.58
		Dr.S.K.Rautaray	CIAE	Bhopal	8.03
		Er. D.Saha	BCKV	Nadia, WB	6.21
			Total		67.26
22	New approaches to integrated pest management in rainfed rice based production system (RRPS-22)	**Dr.I.C.Pasalu**	**DRR**	Hyderabad	15.26
		Dr.R.C.Dani	CRRI	Cuttack	14.87
		Dr.D.K.Bora	AAU	Titabar	14.797
		Dr.M.Premjit Singh	CAU	Imphal	21.187
		Dr.P.S.Reddy	ANGRAU	Warangal, AP	5.377
		Dr.Y.S.Ramakrishna	CRIDA	Hyderabad	13.537
		Dr.C.R.Satpathi	BCKV	Kalyani	20.827
			Total		**105.83**
23	Evaluation of cultivars of major crops of rainfed eco system for increased water use efficiency (RRPS-23)	**Dr.P.C.Mohapatra**	**CRRI**	Cuttack	42.99
		Dr.K.K.Sharma	AAU	Jorhat	16.35
		Dr.H. Sen	BCKV	Nadia	17.19
		Dr.G.R.Singh	NDUAT	Faizabad	14.24
		Dr.A.I.Singh/Dr.L.N. Singh	CAU	Imphal	16.79
			Total		**107.57**
24	Participatory and integrated assessment of natural resources and evolution of alternated sustainable land management options for tribal dominant watershed (RRPS-24)	**Dr.U.S.Patnaik**	**CSWCRTI**	Sunabeda	24.38
		Dr.D.S.Thakur	IGKV	Jagdalpur	19.88
		Dr.P.S.S. Murthy	ANGRAU	Chintapalli,AP	19.85
		Dr.B.B. Bhol/Dr.S.S.Patra	OUAT	Bhawanipatna	10.37
		Dr.K.N. Das	AAU	Jorhat	13.61
			Total		**88.11**
25	Application of crop simulation models to develop crop and nitrogen management strategies for increasing rice productivity under rainfed favorable low land situations of Eastern India (RRPS-25)	**Dr.R.N.Dash**	**CRRI & Operating Centers**	Cuttack	38.88
26	Improvement of jute through rice necrosis mosaic virus technology for sustainable yield and quality under jute-rice production system (RRPS-26)	Dr.S.K.Ghosh	CRIJAF	Barrackpore	54.14
		Dr.S.K.Mohanty	CRRI	Cuttack	1.53
		Dr.D.J.Chattopadhyay	Cal.Univ.	Kolkata	4.14
		Dr.B.K.Guha/Dr.D.Pathak	AAU	Nawgaon	0.93
		Dr.R.K.Paikaray	OUAT	Kendrapara	1.04
			Total		**61.78**
27	Development of improved jute cultivars in rainfed agro ecosystem for quality textile fiber (RRPS-27)	**Dr.M.K.Sinha**	**CRIJAF**	Barrackpore	48.52
		Dr.B.K.Das	NIRJAFT	Kolkata	6.05
		Dr.A.Ghosh	CRRI	Cuttack	2.92
		Dr.M.Rahman	RAU	Katihar, Bihar	8.47
		Dr.P.K.Das	AAU	Nawgaon	6.79
		Dr.L.D.Mishra	OUAT	Kendrapara	3.65
		Dr.K.Chakrabarty	Cal.Univ.	Kolkata	12.20
		Dr.Arunav Goswamy	ISI	Kolkata	12.12
			Total		**100.73**
28	Integrated nutrient management on yield targeting for jute-rice production system (RRPS-28)	**Dr.P.K.Ray**	**CRIJAF**	Barrackpore	23.00
		Dr.A.Ghosh	CRRI	Cuttack	8.54
		Dr.V.K.Mishra	RAU	Katihar, Bihar	10.11
		Dr.B.Guha	AAU	Jorhat	4.54
		Dr.R.K.Paikray	OUAT	Kendrapara	8.92
			Total		**55.11**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
29	Development of rice based agroforestry systems and management practices for yield improvement on field bunds and fallow marginal lands using MPTs (Sesbania/ Glyricidia and other) and grasses (RRPS-29)	**Dr.Debadatta Mishra**	**OUAT**	Bhubaneswar	26.83
		Dr.S.L.Swamy	IGKV	Raipur	17.50
		Dr.A.K.S.Parihar	NDUAT	Faizabad	17.59
			Total		**61.93**
30	Survey, evaluation and documentation of medicinal plants for their chemical profile of active ingredients having medicinal value used by tribals of Madhya Pradesh (RRPS-30)	**Dr.S.K.Gangrade**	**JNKV**	Indore	**30.45**
31	Improve indigenous technology for milling, drying & storage of rice (RRPS-31)	**Dr.P.Mishra**	**CRRI**	Cuttack	15.36
		Er.A.Borah	AAU	Jorhat	11.29
		Dr.Y.J.Singh	CAU	Imphal	13.27
		Dr.D.K.Singh	BAU	Ranchi	8.03
		Dr.S.Patel	IGKV	Raipur	10.42
			Total		**58.40**
32	Near real-time monitoring of agro meteorological conditions for contingency planning in Andhra Pradesh (RRPS-32)	**Dr.A.V.R.Kesava Rao**	**CRIDA**	Hyderabad	27.99
		Director	Dir.E & Stat	Hyderabad	6.47
		Commissioner	Govt. of AP	Hyderabad	3.90
		Dr.D.Raji Reddy	ANGRAU	Hyderabad	4.16
			Total		**42.52**
33	Develop and promote prototype of implements for Tillage and Seeding in participation with local manufactures/ artisals (RRPS-33)	**Dr.S.Swain**	**OUAT**	Bhubaneswar	19.29
		Er. Md.Quasim	IGKV	Raipur	13.68
		Er.R.C.Tiwari	NDUAT	Faizabad	10.89
		Dr.R.B.Ram	RAU	Pusa, Bihar	9.91
		Dr.P.C.Bhattacharya	AAU	Jorhat	15.00
		Dr.S.K.Routray	CIAE	Bhopal	11.60
			Total		**80.37**
34	Development of agro techniques for sustainable productivity of rice based utera cropping system (RRPS-34)	**Dr.S.P.Kurchania/ Dr.R.S.Sharma**	**JNKV**	Jabalpur	13.06
		Dr.G.K.Shrivastava	IGAU	Raipur	10.12
		Dr.Sanjoy Saha	CRRI	Cuttack	6.92
		Sri.W. Aind	BAU	Ranchi	6.10
		Dr.K.Thakuria	AAU	Jorhat	7.18
		Dr.S.S.Mondal	BCKV	Mohanpur,WB	13.78
			Total		**57.16**
35	On-farm evaluation of deep water rice varieties and production technologies in rainfed eco system of eastern India (RRPS-35)	**Dr.B.N.Singh/ Dr.M.Nagaraju**	**CRRI**	Cuttack	16.74
		Dr.S.B.Mishra	RAU	Pusa, Bihar	11.78
		Dr.T.Ahmed	AAU	Assam	10.34
		Dr.S.Malik/Dr.S.N.Sen	RRS	Chinsurah	11.51
		Dr.J.R.Dwivedi/Dr.R.V.Singh	CRS	Baharich	11.05
			Total		**61.43**

Oilseeds based production system

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
36.	Value addition of safflower petals for natural dyes and herbal health care products (ROPS-01)	**Dr.P.V.Varadarajan**	**CIRCOT**	Mumbai	20.11
		Prof.P.N.Satwadhar	MAU	Parbhani	22.67
		Dr.K.S.Laddha	UDCT	Mumbai	22.79
			Total		**65.57**
37.	Identification, characterization and delineation of agroeconomic constraints of oilseed based production system in rainfed eco system (ROPS-02)	**Dr.P.Krishnan**	**NBSS&LUP**	Hebbal	22.70
		Dr.S.V.Ramana Rao	DOR	Hyderabad	6.76
		Dr.N.N.Srivastava	CRIDA	Hyderabad	3.96
			Total		**33.42**
38.	Retaining viability in soybean by providing appropriate physio-logical environment and seed storage structures (ROPS-03)	**Dr.C.K.Teckchandani**	**JNKV**	Jabalpur	24.08
		Dr.R.P.Saxena/ Dr.J.P.Pandey	GBPUA&T	Pantnagar	13.64
			Total		**37.73**
39.	Management of castor for rearing eri silk worm (ROPS-04)	**Dr.M.Premjit Singh**	**CAU**	Imphal	24.39
		Mr.L.C.Dutta	AAU	Jorhat	16.57
		Dr.R.Govindan	UAS (B)	Chintamani	16.98
		Dr.S.V. Nagachan	ICAR R Comp	Imphal	13.56
			Total		**71.50**
40.	Study of harvesting practices and development of multi crop harvester for inter cropping system with safflower under rainfed farming (ROPS-05)	**Dr.T.Guruswamy**	**UAS (D)**	Raichur	15.43
		Dr.S.J.K.Annamalai	CIAE	Coimbatore	14.49
			Total		**29.92**
41.	Identification and management of sunflower necrosis disease (ROPS-06)	**Dr.R.K.Jain**	**IARI**	New Delhi	**21.02**
42.	Develop suitable technology to make use of sunflower heads and castor cake as animal feed (ROPS-07)	**Dr.K.S. Ramachandra**	**NIANP**	Bangalore	20.62
		Dr.Narsimha Reddy	ANGRAU	Hyderabad	35.52
		Dr.D.G. Naik/Dr.J.A.Mulla	UAS	Dharwad	17.42
		Dr.Subhash Parnerkar	Anand AU	Anand	15.05
		Shri V.C.Badve	BAIF	Urulikanchan	39.20
			Total		**127.82**
43.	Development of IPM modules for oilseed based production system (ROPS-08)	**Dr.(Mrs.).Saroj Singh**	**NCIPM**	New Delhi	26.91
		Dr.Pramod Katti	UAS	Raichur	12.96
		Dr.J.Satyanarayana/ Dr.R.Sudhakar	ANGRAU	Palem, AP	10.43
		Dr.P.Lakshmi Reddy	ANGRAU	Anantapur, AP	14.36
		Dr.D.S.Suryawanshi	MAU	Parbhani	13.07
		Dr.G.Y.Parlekar	MPKV	Solapur	12.03
		Dr.Sunil Joshi/ Dr.P. Mohan Raj	PDBC	Bangalore	10.13
		Dr.H.Basappa	DOR	Hyderabad	12.85
		Dr. Rohilla	CCSHAU	Hisar	1.13
		Dr.Mrs.S.Indira	NRCS	Hyderabad	15.51
		Dr.G.D. Agarkar	PDKV	Akola	10.89
			Total		**140.29**
44.	Promotion and development of apiary for improving the productivity of cross pollinated oilseed crop systems (ROPS-09)	**Dr.N.S.Bhat**	**UAS**	Bangalore	21.03
		Dr. S. Virakmath	UAS	Dharwad	13.88
		Dr.R.C. Sihag	CCSHAU	Hisar	7.45
		Dr. S.N. Kulkarni	MAU	Parbhani	9.56
			Total		**51.91**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
45.	Identification of research gaps in intercropping systems under rainfed conditions in India (ROPS-10)	**Dr.J.V.Rao**	**CRIDA & Operating Centers**	Hyderabad	**37.23**
46.	Nutrient management practices for important oilseed based cropping systems for improving yield and oil output under rainfed conditions (ROPS-11)	**Dr.J.K.Saha**	**IISS**	Bhopal	23.10
		Dr.A.S.Dhawan/ Prof. M.K. Kalegore	MAU (L)	Latur,MS	17.10
		Dr.A.S. Karle	MAU (P)	Parbhani, MS	11.39
		Dr.Bhoori Singh	NRCRM	Bharatpur	18.55
		Dr.Raghav Thakur	BAU	Ranchi	5.92
		Dr.H.S. Sur/Dr.C.B.Singh	ZRS, PAU	Nawan Shahar	13.03
		Dr.G.Bhupal Raj	ANGRAU	Hyderabad	18.32
		Mr.H.T.Chandranath	UAS (D)	Raichur	15.71
			Total		**123.12**
47.	Evaluation of cultivars of major oilseed crops of the production system for moisture and nutrient constraints in different soil types (ROPS-12)	**Dr.B.N.Reddy**	**DOR**	Hyderabad	51.10
		Dr.G.Pratibha	CRIDA	Hyderabad	18.52
		Dr.Devi Dayal	NRCG	Junagadh	15.51
		Dr.A.Ramesh	NRCS (Soy)	Indore	13.69
		Dr.P.B.Gawand	MPKV	Solapur	17.87
			Total		**116.69**
48.	Documentation and analysis of indigenous methods of *insitu* moisture conservation and runoff management (ROPS-13)	**Dr.P.K. Mishra**	**CRIDA / Operating Centers**	Hyderabad	**25.32**
49.	Impacts of watershed management on sustainability of land productivity and socio economic status(ROPS-14)	**Dr.G.Sastry**	**CRIDA**	Hyderabad	**63.32**
		Dr.Y.V.R.Reddy	CSWCRTI	Dehradun	
		Dr.Omprakash	Dehradun		
50.	Measures to counteract/ etoxify aflatoxins in oilseeds and nutrition coarse cereals based poultry and livestock feeds (ROPS-15)	**Dr.M.V.L.N.Raju**	**PDP**	Hyderabad	28.85
		Dr.N. Saxena	CIRB	Hisar	26.41
		Dr.N.K.S.Gowda	NIANP	Bangalore	14.56
		Dr.Deben Sapcota	AAU	Khanapara	20.63
			Total		**90.45**
51.	Improving oilseed productivity through identification of genotypes and management under saline conditions with farmers participations (ROPS-16)	**Dr.C.V. Raghavaiah**	**DOR**	Hyderabad	23.01
		Dr.S.D.More	MAU	Parbhani	18.57
		Mr.M. Hebbara	ARS,(D)	Gangavati	18.66
		Dr.A.N.Tewari/Dr.V.S.Verma	CSAUAT	Kanpur	17.36
		Dr.M.K.Patel	SKDAU	Dantiwada	14.86
			Total		**92.46**
52.	Aflatoxin contamination in groundnut: Mapping and management in Gujarat, Andhra Pradesh and adjoining areas (ROPS-17)	**Dr.Suseelendra Desai**	**NRCG**	Junagadh	28.53
		Dr.S.N.Nigam	ICRISAT	Hyderabad	16.85
		Dr.R.R.Khandar	JAU	Junagadh	8.34
			Total		**53.72**
53.	An Integrated approach to control stem necrosis disease of groundnut (ROPS-18)	**Dr.S.N.Nigam**	**ICRISAT**	Hyderabad	18.69
		Dr.R.D.V.J.Prasada Rao	NBPGR	Hyderabad	7.81
		Dr.K.S.S.Naik	ANGRAU	Hyderabad	7.34
		Dr.A.Bandyopadhyaya/ Dr.M.P.Ghewande	NRCG	Junagadh	6.75
			Total		**40.60**

Pulses based production system

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
54.	Increasing the shelf life quality and effectiveness of rhizobial inoculant and optimising BNF in pulses (RPPS-01)	**Dr.S.V.Hegde/ Dr.G.P.Brahmaprakash**	**UAS**	Bangalore	**32.12**
55.	Integrated management of plant nematodes/soil pathogens in pulses based cropping system(RPPS-02)	**Dr.S.D. Mishra**	**IARI**	New Delhi	22.32
		Dr.S.S.Ali	IIPR	Kanpur	22.20
		Dr.S.Lingaraju	UAS	Dharwad	21.44
		Dr.Akhtar Haseeb	AMU	Aligarh	21.12
			Total		**87.08**
56.	Integrated management of the viral disease problems of mungbean (Vigna radiata) and urd bean (Vigna mungo) (RPPS-03)	**Dr.R.D.V.J.Prasada Rao**	**NBPGR**	Hyderabad	16.18
		Dr.Naimuddin	IIPR	Kanpur	14.11
		Dr.T.Ganapathy	TNAU	Coimbatore	14.67
		Dr.P.K.Swain	OUAT	Ganjam	9.16
			Total		**54.11**
57.	Upgradation and evaluation of mini dal mill (RPPS-04)	**Dr.R.R.Lal**	**IIPR**	Kanpur	18.83
		Dr.K.M.Sahay	CIAE	Bhopal	7.09
		Dr.B.Sanjeeva Reddy	CRIDA	Hyderabad	8.83
			Total		**34.75**
58.	Low cost technology for safe storage of pulses (RPPS-05)	**Dr.S.D.Deshpande**	**CIAE**	Bhopal	16.39
		Dr.S.Mohan	TNAU	Coimbatore	8.11
		Dr.Y.S.Rathore/ Dr.C.P.Yadava	IIPR	Kanpur	7.97
		Dr.Shiv Kumal Singal	CCSHAU	Hisar	5.04
			Total		**37.51**
59.	Improvement of components of agro-technologies for management of intercrops (RPPS-06)	**Dr.Subhash Sinde/ Dr.C.B.Gaikwad**	**MPKV**	Rahuri	22.67
		Dr.M.D.Vyas	JNKV	Sehore	13.85
		Dr.D.R. Vashi/ Dr.R.M.Machhi	JAU	Bharuch	12.88
		Dr.M.Murali Rao	ANGRAU	Guntur,AP	13.68
		Dr.M.P.Potdar	UAS	Gulbarga	16.86
		Dr.R.B.Dhale/ Dr.R.S.Nandanwar	PDKV	Amaravati	12.69
		Dr.R.L. Arya	IIPR	Kanpur	11.78
		Dr.G.P. Srivastava	BAU	Ranchi	4.29
			Total		**108.71**
60.	Development of bio-intensive IPM modules in chickpea against Helicoverpa armigera, wilt and dry root rot (RPPS-07)	**Dr.R. Ahmed**	**IIPR**	Kanpur	31.24
		Dr. D.K. Sidde Gowda/ Dr. Udikeri	ARS,UAS	Gulbarga	21.04
		Dr.Mrs.C.R Ballal	PDBC	Bangalore	17.00
		Dr.K.V.V. Prasad/ Dr.S.K.Srivastava	JNKV	Sehore	17.31
			Total		**86.60**
61.	Development of bio-intensive IPM modules against pest complex, wilt and phytophthora blight in pigeonpea intercropping systems (RPPS-08)	**Dr.R.G. Chaudhary**	**IIPR**	Kanpur	25.72
		Dr.Yelshetty Suhas	UAS(D)	Gulbarga	23.45
		Dr.S.C.Aggarwal/ Dr.S.K.Srivastava	JNKV	Sehore	15.43
			Total		**64.60**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
62.	Agro-economic characterization, constraint analysis and delineation of efficient ecozones using soil type and rainfall data in chickpea and pigeonpea based cropping systems (RPPS-09)	**Dr.G.R.M. Shankar**	**CRIDA**	Hyderabad	4.59
		Dr.K.S.Gajbhiye	NBSSLUP	Nagpur	2.48
		Dr.I.P.S.Yadav	IIPR	Kanpur	3.12
		Dr.G.P.Gupta	JNKV	Jabalpur	2.42
		Dr.P.S.Dharmaraj	UAS (D)	Gulbarga	3.35
		Dr.V.N. Autkar	PDKV	Akola	3.46
			Total		**19.43**
63.	Evaluation and improvement of Indigenous methods of moisture Indigenous methods of moisture conservation and runoff management (RPPS-10)	**DrM.V.Padmanabhan/ Dr.K.D.Sarma/ Dr.B.M.K.Reddy**	**CRIDA**	Hyderabad	27.76
		Dr.M.B. Guled	RRS,UAS(D)	Bijapur	14.54
		Dr.G.S. Rajput	JNKV	Jabalpur	16.50
		Er. Shakir Ali	CSWCRTI	Kota	11.59
		Prof.D.B. Bhanavase	MPKV	Solapur	13.96
		Prof.S.R. Singh	BHU	Varanasi	18.26
		Dr. R.C. Yadav	CSWCRTI	Agra	12.61
			Total		**115.22**
64.	Integrated nutrient management in major pulse based cropping systems and identification of the most productive and remunerative systems management (RPPS-11)	**Dr.A.K. Biswas**	**IISS**	Bhopal	18.83
		Dr.Ch.Srinivasa Rao/ Dr.K.K.Singh	IIPR	Kanpur	12.61
		Dr.U.S. Gupta/ Dr.D.P.Dubey	JNKV	Rewa	16.21
			Total		**47.65**
65.	Utilisation of by-products of pulses, oilseeds along with coarse cereal grains for intensive goat production (RPPS-12)	**Dr.T.K.Dutta**	**CIRG**	Mathura	33.32
		Dr.V.B. Shettar	UAS (D)	Bidar	20.40
		Dr.D.H.Rekhate	MAFSU	Akola	21.79
		Dr.T. Janardhan Reddy	ANGRAU	Hyderabad	21.15
			Total		**96.66**

Cotton based production system

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
66.	Agro economic characterization and constraint analysis of rainfed cotton based production systems in relation to soil, rainfall and socio economic factors (RCPS-01)	**Dr.O.Challa**	**NBSS&LUP**	Nagpur	11.08
		Dr.C.S. Bose	ANGRAU	Hyderabad	3.86
		Dr.S.M. Mundinamani	UAS (D)	Dharwad	3.78
		Dr.G.P.Saraf	JNKV	Indore	3.51
		Dr.P.Rama Sundaram	CICR	Nagpur	7.38
			Total		**29.61**
67.	Optimizing nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system (RCPS-02)	**Dr.Jagvir Singh**	**CICR**	Nagpur	22.91
		Dr.S.D.More/ Dr.A.S. Dhawan	MAU	Parbhani	16.55
		Dr.K.Srinivas	CRIDA	Hyderabad	13.46
		Dr.D. Damodhar Reddy	IISS	Bhopal	11.78
		Dr.K.Veerabhadra Rao	ANGRAU	Nandyal, AP	15.03
		Dr.B.C.Patil	UAS	Dharwad	15.55
			Total		**95.28**
68.	Assessment of gossypol content in cotton germplasm (RCPS-03)	**Dr.Mukta Chakrabarty**	**CICR**	Nagpur	**19.70**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
69.	Delineating the efficient productive zones for cotton production system using GIS based crop models (RCPS-04)	**Dr.K.V.Rao**	**CRIDA**	Hyderabad	21.66
		Dr.S.Chatterji	NBSS&LUP	Nagpur	8.11
		Dr.S.Vennila	CICR	Nagpur	8.46
		Dr.M.V.R.Sesha Sai/ Sri. M.V. Krishna Rao	NRSA	Hyderabad	8.60
			Total		**46.83**
70.	Rain water conservation, harvesting and recycling/ recharging techniques for enhan-ced productivity of cotton based cropping system(RCPS-05)	**Dr.B.A.Lakhdive/ Dr.D.S.Sonkusale**	**ZARS, MAU**	Yavatmal	21.60
		Dr.H.L.Halemani	ARS,UAS(D)	Dharwad	19.81
		Dr.Mujeebkhan	ANGRAU	Guntur, AP	18.50
		Dr.V.K.Sood/Sri.J.S.Doshi	Anand AU	Anand	18.34
		Dr.K.S.Bhaskar	CICR	Nagpur	23.48
			Total		**101.74**
71.	Improving cotton productivity in salt affected soils through identification of species/ genotypes and farmers participation (RCPS-06)	**Dr.S.G.Patil**	**UAS (D)**	Dharwad	27.87
		Dr.O.P.Sharma	JNKV	Indore	23.08
		Dr.S. Acharya	Anand AU	Viramgam	18.37
			Total		**69.32**
72.	Promotion of productive high quality G.arboreum cotton to meet the needs of marginal cultivators of rainfed ecosystem vis-à-vis textile industry (RCPS-07)	**Dr.L.A. Desh Pandey**	**MAU**	Parbhani	30.72
		Prof.V.N. Kulkarni	ARS,UAS(D)	Dharwad	21.26
		Dr.V.N.Waghmore	CICR	Nagpur	13.70
		Dr.G.K.Kotu	JNKV	Khandwa	12.42
		Dr.T.Pradeep	ANGRAU	Mudhol, AP	13.26
		Dr.N. Muppidathi	TNAU	Kovilpatti	12.46
			Total		**103.82**
73.	Characterization and identification of productive and high quality cotton species/genotypes including G.herbaceum suitable approaches adopting farmers participatory for different rainfed agro ecological situations (RCPS-08)	**Dr.B.M.Khadi**	**ARS,UAS(D)**	Dharwad	30.59
		Dr.A.S.Ansingkar	MAU	Nanded	23.50
		Dr.Vinita Gotmare	CICR	Nagpur	20.22
		Dr.G.S.Patel	JAU	Junagadh	10.84
		Dr.K.C.Mandloi/ Dr.G.K. Koutu	CRS/JNKV	Khandwa	21.77
		Dr.S. Ratna Kumari	ANGRAU	Guntur, AP	23.13
			Total		**130.06**
74.	Develop and evaluate production technology for the indigenous cotton of NE region (RCPS-09)	**Dr.Ashutosh Roy**	**AAU**	Diphu	9.14
		Dr.A. Ravinder Raju	CICR	Nagpur	8.82
			Total		**17.96**
75.	Development of B.T. transgenic diploid cotton against bollworm (RCPS-10)	**Dr.S.B.Nandeshwar**	**CICR**	Nagpur	**18.36**
76.	Impact of tillage, land treatment and organic residue; management on soil health, drainage and crop productivity of rainfed cotton based system (RCPS-11)	**Dr.R.S.Chaudhary**	**IISS**	Bhopal	11.34
		Dr.R.A. Shetty	UAS (D)	Raichur	8.53
		Dr.V.D. Khanpara	JAU	Junagadh	6.21
		Dr.R.A. Sharma	JNKV	Indore	9.58
		Dr.N.S. Rao	ANGRAU	Guntur, AP	8.74
		Dr.S.Subramaniam/ Dr.S.Subbaiah	TNAU	Kovilpatti	9.12
		Dr. Blaise	CICR	Nagpur	9.40
			Total		**62.93**

Nutritious Cereals based production system

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
77.	Processing of millets for value addition and development of health foods (RNPS-01)	**Dr.(Mrs.)Salil Sehgal**	**CCSHAU**	Hisar	21.12
		Dr.Mustari Begum	UAS	Bangalore	22.04
		Dr.Saritha Srivastava	GBPUAT	Pantnagar	15.54
		Dr.S.M.Naikare	MPKV	Pune	18.48
			Total		**77.19**
78.	Development of regional scale watershed plans and methodologies for identification of critical areas for prioritized land treatment in the watersheds of oilseeds, pulses, cotton and nutritious cereals production systems (RNPS-02)	**Dr.B.R.M.Rao**	**NRSA**	Hyderabad	30.54
		Dr.P.K.Mishra	CRIDA	Hyderabad	23.93
		Dr.S.C.Deshmukh/ Dr.J.S.Raghu	JNKV	Indore	25.19
		Dr.A.N.Deshpande	MPKV	Solapur	32.70
		Sri R.L.Gawande	PDKV	Akola	26.75
		Dr.M.Malik	NAU	Navsari	11.41
			Total		**150.52**
79.	Developing live fencing systems for soil and water conservation, crop diversification and sustaining productivity in rainfed regions (RNPS-03)	**Dr. Prasidhi Rai**	**NRCAF**	Jhansi	19.37
		Dr.V.K.Mishra	JNKV	Indore	12.44
		Er.M.S.Pendke	MAU	Parbhani	11.11
		Er.N.A.Jadhav	MPKV	Rahuri	12.48
		Dr.B. Srimannarayana	ANGRAU	Hyderabad	50.82
		Dr.S.K.Nalathwatmath	CSWCRTI	Bellary	10.11
		Dr.B.S.Nadagoudar	UAS (D)	Dharwad	10.06
		Dr.P.R.Choudhary	CSWCRTI	Koraput	8.07
			Total		**134.46**
80.	Strengthening of research on integrated management of blast of finger millet (Eleusine coracana Gaertn) (RNPS-04)	**Dr.T.B.Anil Kumar/ M.Suresh G.Mantur**	**UAS**	Bangalore	31.41
		Dr.J.Kumar	GBPUAT	Ranichuri	34.47
		Dr.A.Ramanathan	TNAU	Coimbatore	12.53
			Total		**78.41**
81.	Refining small millets based cropping systems for augmenting supply of legumes (Grain/ Vegetables) (RNPS-05)	**Dr.K.T.K.Gowda**	**UAS**	Bangalore	19.90
		Dr.K.Rama Moorthy	TNAU	Coimbatore	11.94
		Dr.O.P.Dubey	JNKV	Dindori	9.40
		Dr.T.Venkateswar Rao	ANGRAU	Vizianagaram	9.87
		Dr.B.K. Jena	OUAT	Ganjam	8.05
			Total		**59.16**
82.	Development of national data base on rainfed pearlmillet and fingermillet for research, planning and policy making (RNPS-06)	**Dr.B.Dayakar Rao**	**NRCS**	Hyderabad	14.28
		Dr.M.V.S.Gowda/ Dr.S. Surya Prakash	UAS	Bangalore	6.32
		Dr.S.J.Patil	MPKV	Pune	6.60
		Dr.A.Usha Rani Ahuja	CAZRI	Jodhphpur	4.67
			Total		**31.87**
83.	A Critical Analysis of changing scenario of sorghum in *kharif* sorghum growing areas (RNPS-07)	**Dr.M.H.Rao/ Dr.B.Dayakar Rao**	**NRCS**	Hyderabad	24.18
		Dr.Sanjay S.Wanjari	PDKV	Akola	8.93
		Dr.M.D.Kachapur/ Dr.V.V.Angadi/ Dr.S.S. Angade	UAS (D)	Dharwad	10.18
		Dr.V.S.Gautam	JNKV	Indore	9.61
			Total		**52.91**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
84.	Evaluation/Improvement of dual types of sorghum and make available indigenous cultivars like by farmers (RNPS-08)	**Dr.R.H.Patel/ Dr.D.R.Vashi/ Dr.M.S.Desai**	**NAU**	Surat	30.79
		Dr.Latha Chaudhary	MPUA&T	Udaipur	15.31
		Dr.P.N. Ghadewekar	JNKV	Indore	13.74
		Dr.V.S.Singh	CSAUA&T	Jhansi	13.60
		Dr.Prem Kishore	IARI	New Delhi	14.86
			Total		**88.30**
85.	Develop agri-horiculture and agro-forestry systems in *kharif* sorghum area decreasing region for overall sustainability of the production system (RNPS-09)	**Dr.N.N.Reddy**	**CRIDA**	Hyderabad	45.69
		Dr.L.G.Giri Rao	ANGRAU	Hyderabad	21.79
		Dr.D.V.Devgiri	MPKV	Ambajogai	27.58
		Dr.B.V.Ghodki/ Dr.B.G.Hiwale	MAU	Ambajogai	17.36
			Total		**112.42**
86.	Management strategies for improving *rabi* sorghum productivity (RNPS-10)	**Dr.M.S.Raut**	**CRS, NRCS**	Solapur	26.06
		Dr.M.S.Rama Mohan Rao/ Dr.S.K.Nalatwadmath	CSWCRTI	Bellary	21.99
		Prof. M.D.Shinde	MPKV	Mohol	12.59
		Dr.M.S.Patil/Dr.B.D.Biradar	RARS, UAS(D)	Bijapur	24.75
		Dr.S.S.Rao	NRCS	Hyderabad	31.68
			Total		**117.08**
87.	Improving productivity of rainfed maize based cropping system with rain-water management on watershed (micro) basis (RNPS-11)	**Dr.B.L.Gaur**	**MPUA&T**	Udaipur	34.68
		Dr.P.M. Jain	MPUA&T	Bhilwara	10.36
		Dr.S.N. Goyal	Anand AU	Godhra	10.53
		Dr.G.R.Ambavatia	JNKV	Jhabua	9.88
		Dr.H.S.Sur/Dr.A.S.Toor/ Dr. Virendar Sardana	PAU	Nawanshahar	9.64
		Dr.A. Srinivas	ANGRAU	Karimnagar,AP	11.50
			Total		**86.60**
88.	Studies on development of silvipasture system for improving livestock productivity in rainfed region (RNPS-12)	**Dr.M.M.Roy**	**IGFRI**	Jhansi	29.48
		Mr. Prabhat Tripathi	CIRG	Mathura	19.94
		Dr.I.A. Khan/Dr.S.M.Taley	PDKV	Akola	23.36
		Dr.K.S. Dutta	JAU	Junagadh	16.93
		Dr.B. Ekambaram	ANGRAU	Mahabubnagar	22.40
			Total		**112.11**
89.	Forecasting and management of diseases and insects in sorghum cropping system perspectives (RNPS-13)	**Dr.N.D.Das**	**CRIDA**	Hyderabad	11.20
		Dr.M. Ramaiah	TNAU	Coimbatore	6.86
			Total		**18.06**
90.	On-farm research for enhancing productivity of pearlmillet in Vertisol of semi-arid tropics(RNPS-14)	**Dr.V.S.Shinde/ Dr.B.N. Chavan**	**MAU**	Aurangabad	23.49
		Dr.B.S. Toradmal	MPKV	Ahmednagar	16.53
		Dr.S.B. Kalaghatagi	UAS (D)	Bijapur	14.84
		Dr.V. Ganesa Raja	TNAU	Kovilpatti	13.36
			Total		**68.22**
91.	On-farm research for enhancing productivity for pearlmillet in arid regions of India (RNPS-15)	**Dr.Makhan Lal**	**RAU**	Mandor	15.65
		Dr.A.S.Rathor/ Shri Maan Singh	RAU	F.Sekhawati	12.07
		Dr.H.R. Khaffi	JAU	Jamnagar	12.98
		Dr.Joginder Singh	CCSHAU	Bawal	15.61
			Total		**56.30**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
92.	Utilisation of coarse cereals and by-products of oilseed based cropping systems for poultry production (RNPS-16)	**Dr.A.B. Mandal**	**CARI**	Bareily	49.94
		Dr.S.K. Singh	JNKV	JNKV	27.45
		Dr.Anwar Ali Shah	MAU	Parbhani	28.70
		Dr.S.V.Rama Rao	PDP	Hyderabad	17.93
		Dr. Nirmal Barua	AAU	Guwahati	18.83
			Total		**142.86**
93.	Improving the Utilization of coarse cereal crop residues by strategic supplementation for livestock feeding (RNPS-17)	**Dr.K.T.Sampath**	**NIANP**	Bangalore	14.65
		Dr.A.K. Mishra	CRIDA	Hyderabad	20.93
		Dr.B.K. Sahu	OUAT	Bhubaneswar	15.71
		Dr.R.N. Dhore	MAFSU	Akola	22.46
		Dr. (Mrs) .P.R. Nisal	BAIF	Urulikanchan	22.39
			Total		**96.13**
94.	Resource characterization and socio-economic constraint analysis of productivity in the maize based crop production system (RNPS-18)	**Dr.P.C.Kanthaliya**	**MPUA&T**	Udaipur	20.12
		Dr.V.R. Bhatt	AAU,Anand	Anand	3.59
		Dr. P.K. Awasthi	JNKV	Jabalpur	4.42
		Dr.R.A. Singh	CSUAST	Kanpur	5.63
		Dr.S. Pashupalak	OUAT	Bhubaneswar	3.89
		Dr.B.K. Singh	BAU	Ranchi	4.14
		Dr.Rajeswara Reddy	ANGRAU	Hyderabad	4.85
		Dr.N. Nagaraj	UAS (B)	Mandya	5.46
		Dr.A.S. Joshi	PAU	Ludhiana	3.52
			Total		**55.61**
95.	Rainwater management on watershed (micro) basis in sub-montane region (RNPS-19)	**Dr.R.P.Yadav**	**CSWCRTI**	Chandigarh	53.49
		Dr. K.R. Sharma	SKUAST	Jammu	22.07
		Dr.M.S. Hadda	PAU	Ludhiana	23.73
		Dr.S.N. Jha/ Sh.S.K. Chaudhary	KVK	Madhubani	26.78
		Dr.T.P.S.Katiyar/ Dr.P.N.Dwivedi	NDUAT	Kumarganj	12.00
			Total		**138.07**
96.	Improvement of roti making quality and shelf life of grain sorghum (RNPS-20)	**Dr.G.K. Garg/ Dr.V.K.Khanna**	**GBPUAT**	Pantnagar	65.12
		Dr.S.V. Rao	NRCS	Hyderabad	45.01
			Total		**110.13**
97.	Improving productivity and profitability of rainfed fruit based, production system based cropping system in low productive environments (RNPS-21)	**Dr.B.Prasanna Kumar**	**IIHR**	Bangalore	22.02
		Dr.D.R. Patil	RRS, (D)	Bijapur	22.54
		Dr.S.G. Sarwade	MAU	Parbhani	17.79
		Dr.Y. Rama Rao	ANGRAU	Guntur,AP	12.31
		Dr.D.R.Patil	MPKV	Dhule	22.26
		Dr.R.S. Chovatia	JAU	Junagadh	14.48
		Dr.B.S. Baghel	JNKV	Jabalpur	11.46
			Total		**122.86**
98.	Improving the productivity and profitability of vegetable crops under rainfed agro ecosystems (RNPS-22)	**Dr.M.Prabhakar**	**IIHR**	Bangalore	23.51
		Dr.D.G. Giri Rao	PDKV	Akola	17.94
		Dr. T.B. Alloli	RRS,(D)	Raichur	20.80
		Dr.M.A. Vaddoria	JAU	Junagadh	16.42
		Dr.C. Sai Reddy/ Dr.I. Prabhakar Reddy	ANGRAU	Hyderabad	16.39
		Dr.D. V. Thatham	TNAU	Coimbatore	17.58
			Total		**112.64**

Sl. No.	Project Title with code	PI/CCPI	Center	Place	Budget (Rs. In lakhs)
99.	Total grain quality management of *kharif* sorghum (RNPS-23)	**Dr.S.Audi Lakshmi**	**NRCS**	Hyderabad	89.66
		Dr. T.B. Garud/ Dr.R.B.Solanke	MAU	Parbhani	25.53
		Dr.N.Y.Nayakar	UAS (D)	Dharwad	19.02
		Dr.S.B. Atale/ Prof. H.G.Kandalkar	PDKV	Akola	13.83
		Dr.P.V. Veerabadhran/ Dr.N.M.Ganesan/	TNAU	Coimbatore	14.57
		Dr.K.G.Moorthy Dr.C.P.Raman/ Dr.M.L.N.Murthy	IGSMRI	Hyderabad	9.45
		Dr.P.D. Gaikwad	JNKV	Indore	11.48
			Total		**183.55**
100.	Developing sorghum as an efficient biomass and bio-energy crop and providing value addition to the rain damaged *kharif* grain for creating industrial demand (RNPS-24)	**Dr.S.Bala Ravi/ Dr.C.V.Ratnavati**	**NRCS**	Hyderabad	99.61
		Dr.Wankhede	MAU	Parbhani	19.03
		Dr.R.B. Somani/ Dr.Sanjay Bhuyan	PDKV	Akola	23.36
		Dr.B.N. Narkhede/ Dr.J.V.Patil	MPKV	Rahuri	19.29
		Dr.Nandini Nimbkar	NARI	Phaltan	26.95
			Total		**188.24**
101.	Identifying systems for carbon sequestration and increased productivity in semi-arid tropical environments (RNPS-25)	**Dr.S.P.Wani**	**ICRISAT**	Hyderabad	76.72
		Dr.Gangadhar Rao/ Dr.M.Vanaja/ Dr.V. Ramesh	CRIDA	Hyderabad	38.37
		Dr.D.M.C.Manna	IISS	Bhopal	15.75
		Dr.T.Battacharyya	NBSS&LUP	Nagpur	27.41
			Total		**158.25**
102.	Developing sustainable alternate land use systems for industrial biomass production from drylands (RNPS-26)	**Dr.J.V.N.S.Prasad**	**CRIDA**	Hyderabad	14.54
103.	Efficient clonal propagation of high value horticultural and forest species for dryland agriculture (RNPS-27)	**Dr.G.M.Reddy**	**GM Reddy Foundation**	Hyderabad	37.55
		Dr.B.M.K. Reddy	CRIDA	Hyderabad	0.64
			Total		**38.19**

Annexure IX

Details of SAP Meetings Held and Agenda Covered

Sl.No. of SAP meeting	Dates and Venue	Major Agenda
1.	December 15, 1998, NCAP	Research priorities and programmes on rainfed rice production system were reviewed
2.	January 17-19, 1999, CRIDA	Unified research project proposals were reviewed
3.	March 4-7, 1999, CRIDA	Financial allocation for production system research and availability of facilities at ZARS/RARS for AED for implementing projects were discussed
4.	April 13-14, 1999, CRIDA	Seven projects for the approval under rainfed rice based production system were considered
5.	June 1-2, 1999, CRIDA	13 TAR-IVLP projects reviewed
6.	October 11-12, 1999	Oilseeds based production system projects reviewed
7.	November 2-3, 1999, CRIDA	Pulses based production system projects reviewed
8.	November 17-18, 1999, CICR	Cotton based production system projects reviewed
9.	November 19-20, 1999	Nutritious Cereals based production system projects reviewed
10.	December 21-23, 1999, CRRI,	Rice based production system projects reviewed
11.	January 24-25, 2000, CRIDA	Revised Oilseeds, Pulses, Cotton and Rice projects were discussed
12.	February 23-24, 2000	Revised Oilseeds, Pulses, Cotton, Coarse cereals and Rice projects were discussed
13.	February 25-26, 2000 , CRIDA	Revised Oilseeds, Pulses, Cotton, Coarse cereals and Rice projects were discussed
14.	April 10-11, 2000 , CRIDA	Revised Oilseeds, Pulses, Cotton, Coarse cereals and Rice projects were discussed
15.	May 15-16, 2000 , CRIDA	Revised projects reviewed
16.	June 5-6, 2000 , CRIDA	Revised projects reviewed
17.	June 28-29, 2000	Revised projects reviewed
18.	August 14, 2000	Revised projects reviewed
19.	October 6, 2000	New projects reviewed
20.	December 8-9, 2000	New projects reviewed
21.	January 22, 2001	Monitoring and evaluation of projects were discussed
22.	April 10-12, 2001	Annual progress of oilseeds production system research was reviewed
23.	May 16-18, 2001	Technical programme and methodology for on-farm research was discussed
24.	May 27-30, 2001	Technical programme of OFAR projects finalized and interaction workshop conducted
25.	June 6-7, 2001	Revised work plans for OFAR projects were finalized

Sl.No. of SAP meeting	Dates and Venue	Major Agenda
26.	July 11-12, 2001	Monitoring and evaluation scheme for PSR projects was finalized
27.	September 8, 2001	PSR projects for peer review were selected.
28.	November, 23-24, 2001	Feed back from the peer review of OFAR projects was considered
29.	Feb 18-19, 2002	Reports of Peer Review Teams of the second phase were discussed.
30.	April 5 and 19, 2002	Special project on "Farming Systems Research" was considered and annual progress was reviewed
31.	July 12-13, 2002	Progress of the Project was reviewed, peer review reports were discussed and guidelines on HRD for scientists were discussed
—	August 16, 2002	Special SAP Meeting conducted for discussion on drought situation during *kharif* 2002
32.	November 25-26, 2002	Peer review reports and format for preparation of final reports were discussed
33.	March 28, 2003, CRIDA	Annual workshops schedule were finalized and extension of project proposals was discussed
34.	May 28, 2003, CRIDA	Completion reports of projects terminated and extension of projects were discussed
35.	September 26-27, 2003 , CRIDA	Planning of organizing the satellite symposium at AED level was discussed
36.	March 24, 2004 , ANGRAU	Review of final reports was discussed
37.	July 27-28, 2004, CRIDA	Peer review schedule for 2004 *kharif* was finalized
38.	December 28, CRIDA	To consider project completion report (PCR) of Phase I, identify promising technologies for upscling

Annexure X

Details of Peer Review Teams, Places Visited and Projects Reviewed

Dates	Type of Review	Projects reviewed	Location	Review team
24-28 Sept. 2001	Field visit and presentation	RNPS-04 and 05 ROPS- 04, 05, 08, 09, 12 and 17 RPPS-01, RRPS-19	Karnataka and Andhra Pradesh	Dr.J.S.Kanwar, Dr.M.V.R.Prasad Dr.Vidhyabushnam Dr.B.R.Hegde, Dr.D.M.Hegde,
25-29 Sept. 2001	Field visit and presentation	RRPS-3, 4, 9, 10, 16, 17,21,33, 34	Chhattisgarh	Dr.P.S.Reddy Dr.K.V.G.K.Rao Dr. U.Prasada Rao, Dr.U.S.Victor
26-28 Sept. 2001	Field visit and presentation	RNPS-7, 22, 23, 24 ROPS-8, RCPS-2, 3, 4, 5, 7, 8, 9, 10, 11	Maharasthra	Dr.N.G.P.Rao Dr.J.Venkateswarlu Dr.N.K.Umrani Dr.S.K.Banerjee Dr.M.H.Rao
19-22 Sept. 2001 30 Sept. 2001 1 Nov. 2001	Field visit and presentation	RRPS-3, 4, 5, 9, 10,11,16,21,23 RRPS-14,29, RRPS-5,	Jharkhand and Orissa	Dr.I.C.Mahapatra, Dr.J.K.Roy Dr.S.N.Pradhan Dr.G.G.S.N.Rao
20-21 Sept. 2001 4-8 Oct., 2001 19 Oct., 2001 17, Nov, 2001	Field visit and presentation	RRPS-4,6,10 RRPS-7,8,10,11, 16,17,21,24 RRPS-33, RRPS-3	Orissa	Dr.P.K.Mahapatra Dr.S.N.Behera Dr.S.K.Mohanty
13-18 Oct., 2001	Field visit and presentation	RRPS-19, ROPS-10, 13 RPPS-6, RCPS-5, 8, 11 RNPS-2, 8, 11, 12, 15, 18, 21, 22	Gujarat	Dr.R.K.Gupta, Dr.V.M.Bhan Dr.K.D.Sharma
2-6 Oct., 2001	Field visit and presentation	RNPS-19	Punjab and Himachal Pradesh	Dr.J.S.Kanwar,
29 Oct. to 1 Nov., 2001	Field visit and presentation	RNPS-8, 11, 18	Rajasthan	Dr.J.S.Kanwar,
24 – 25 Nov., 2001	Desk review	RRPS-1, 2, 25,32 ROPS-2,10,13,14 RPPS-9, RCPS-1,4 RNPS-2,6,7,18	Database projects reviewed at CRIDA	Dr.S.Bisalaiah Dr.M.A.Singlachar Dr.R.K.Aggarwal Dr.B.V.Ramana Rao
3-8 Dec., 2001	Field visit and presentation	ROPS-6,8, RPPS-2 RNPS-8	Delhi	Dr.I.C.Mahapatra, Dr.H.C.Aggarwal Dr.K.G.Mukherjee

Dates	Type of Review	Projects reviewed	Location	Review team
4-9 Jan, 2002	Field visit and presentation	RRPS-16,17, 20, 22, 23, 27, 34	West Bengal	Dr.N.N.Goswami, Dr.U.Prasada Rao Dr.S.K.Mohanty Dr.B.Venkateswarlu
11-14 Feb, 2002	Field visit and presentation	RRPs-19, ROPS-8,10, 12,13, RNPS-2,9,10	Maharastra and Karnataka	Dr.J.S.Kanwar Dr.N.G.P.Rao Dr.H.P.Singh Dr K P R Vittal
19-20 April, 2002	Desk review	ROPS-14	CRIDA, Hyderabad	Dr.R.K.Gupta Dr.B.R.Hegde Dr.P.K.Joshi
7-8 May, 2002	Desk review	ROPS-17	NRCG, Junagadh	Dr.P.S.Reddy Dr.D.M.Hegde Dr.M.S.Basu
26-30 August, 2002	Field visit and Presentation	24 sub projects in rainfed rice based production system	Ranchi, Darisai and Dumka in Jharkhand and Barrackpore in West Bengal	Dr.J.S.Kanwar Dr.I.C.Mahapatra Dr.S.K.Mohanty Dr.U.Prasada Rao Dr.H.P.Singh Dr.B.N.Singh
24 - 28 September, 2002	Field visit and Presentation	19 sub projects in rainfed rice based production system	Titabar and Jorhat in Assam	Dr.J.S.Kanwar Dr.R.P.Singh Dr. U.Prasada Rao Dr.S.K.Mohanty Dr.S.R.Singh
3-6 October, 2002	Field visit	16 sub projects in rainfed rice based production system	In 9 target districts of Orissa	Dr. I.C. Mahapatra Dr. B.N. Singh Dr. S. Pathak Dr. J.K. Roy Dr. S.K. Mohanty Dr. S.R. Singh
7-10 October, 2002	Field visit and Presentation	18 sub projects in nutritious cereals and oilseeds based production system	Kolar, Tumkur and Bangalore districts of Karnataka	Dr.J.S.Kanwar Dr.B.R.Hegde Dr.U.Prasada Rao Dr.V.Veerabhadraiah Dr.D.M.Hegde Dr.Sreenath Dixit
16-21 October, 2002	Field visit and Presentation	22 sub projects in nutritious cereals, oilseeds, pulse and cotton based production system	CIRCOT, Mumbai and NRCG, Junagadh, Rajkot and Khed Brahma in Gujarat	Dr.P.S.Reddy, Dr.D.M.Hegde, Dr.B.Venkateswarlu Dr.K.D.Sharma
3-6 December, 2002	Field visit and farmers interaction	2 sub projects in cotton based production system	Adilabad district of A.P. and Nanded in M.P.	Dr.N.G.P.Rao Dr.C.P.Ghonsikar Dr.M.H.Rao, Dr.S.S.Balloli
27-28 December, 2002	Presentation and desk review	2 sub projects in rainfed rice and nutritious cereals based production systems dealing with remote sensing application	NBSSLUP, Regional Station, Kolkata	Dr.J.S.Kanwar Dr.N.N.Goswami Dr.R.K.Gupta Dr.D.P.Singh Dr.B.Venkateswarlu

Dates	Type of Review	Projects reviewed	Location	Review team
7-8 February, 2003	Field visit and desk review	Sub project No. RPPS-10 of pulse based production system	CRIDA, Hyderabad	Dr.B.K.James Dr.U.Prasada Rao, Dr.B.Venkateswarlu
16-17 February, 2003	Presentation and desk review	Special review of *rabi* sorghum work under NATP	College of Agriculture, MPKVV, Pune	Dr.J.S.Kanwar Dr.N.G.P.Rao Dr.H.P.Singh Dr.B.Venkateswarlu
11-16th June, 2003	Field visit and desk review	ROPS-14	Manchal and Maheshwaram watersheds	Dr.J.Venkateswarlu, Dr.M.S.Rama Mohan Rao Dr.B.Venkateswarlu,
8th September, 2003	Field visit and desk review	ROPS-8, 12 & 16	Mahaboobnagar and Ranga Reddy district	Dr.P.S.Reddy Dr.H.P.Singh, Dr.K.D.Sharma Dr.B.Venkateswarlu
29th September to 2nd October, 2003	Field visit and desk review	RNPS-11, RNPS-15	Udaipur	Dr.H.P.Singh Dr.R.K.Agarwal Dr.Y.S.Ramakrishna
21st to 24th November, 2003	Field visit and desk review	RRPS-17, 20, 27, 31 and 35	Orissa	Dr.I.C.Mahapatra Dr.J.K.Roy Dr.M.A.Shankar Dr.P.K.Mahapatra
13th - 14th August, 2004	Field visit	RNPS-19	Johranpur watershed in HP	Dr J S Kanwar
19th – 20th September, 2004	Field visit	RNPS-02	Gaulipalasia Watershed in Indore district	Dr J S Kanwar Dr M A Shankar Dr Ch Srinivasa Rao
21 September, 2004	Participation in stake holders meeting on safflower petal utilization	ROPS-01	CIRCOT, Mumbai	Dr.J.S.Kanwar Dr.B.Venkateswarlu
26th - 30th September, 2004	Field visit	RRPS-03, RRPS-04 RRPS-05	Keonjhar (Orissa) Bhaghbara (Chhattisgarh)	Dr I C Mahapatra Dr S N Pradhan Dr P K Mahapatra Dr D Panda
3rd – 5th October, 2004	Field visit and participation in stakeholders meeting on rice-fish-duck farming system	RRPS-9, RRPS-17, RRPS-3	Ranchi, Jharkhand	Dr.N.N.Goswami Dr.S.R.Singh Dr.G.Subba Reddy

Annexure XI

Project Formulation, Review Workshops and Meetings Organized by the AED (RF)

Sl.No	Item	Dates and Venue
1.	Meeting to review the research proposals for funding under NATP	August 5-9, 1997, CRIDA, Hyd
2.	First Interaction workshop on Rainfed Rice Production System	November 12-14, 1997,CRIDA, Hyd
3.	Group meeting of Co-principal investigators on Mission mode project Land use planning	December 16-17, 1997, CRIDA, Hyd
4.	Rainfed rice production system workshop	December 23-25, 1997, CRIDA, Hyd
5.	Rainfed Rice Production system Workshop for unification of the project proposals	April 8-15, 1998, CRIDA, Hyd
6.	Interaction Workshop on ICAR-ICRISAT Projects	December 17-18, 1998 held at ICRISAT
7.	Pre Workshop for other Production Systems	May 25-31, 1999, NATP Hqtrs, New Delhi
8.	Prioritization Workshop	June 1-3, 1999, CRIDA, Hyd
9.	Interaction workshop on Oilseed based production system	September 25-30, 1999, DOR/ CRIDA, Hyd
10.	Interaction workshop on Pulse based production system	October 4-8, 1999, CRIDA, Hyd
11.	Interaction workshop on Nutrition (Coarse) Cereals based production system	October, 13-16, 1999, RCS/CRIDA/PDP, Hyd
12.	Interaction workshop on Cotton based production system	October 25-30, 1999, CICR, Nagpur
13.	Interaction workshop on Rainfed Rice based production system for North Eastern Region	November 11-14, 1999, CRIDA, Hyd
14.	Interaction workshop on Pearlmillet based production system	November 26-28, 1999, CRIDA, Hyd
15.	Interaction workshop on Fingerlmillet based production system	December 6-8, 1999, CRIDA, Hyd
16.	Interaction workshop on Agroforestry	January 18-19, 2000, IIHR, Bangalore
17.	Interaction workshop on Animal Science and Livestock	January 20-21, 2000, NIANP, Bangalore
18.	NATP Launch Workshop	June 28, 2000, CRIDA, Hyderabad
19.	Characterisation of Resources Sub-Project Group Meeting Cutting Across Production Systems	Held at CRIDA, Hyderabad, August 29-30, 2000
20.	Nodal Officers Meeting	September 4, 2000, CRIDA, Hyderabad
21.	Half yearly review meeting of Rainfed Rice PSR sub-projects	December 15-16, 2000 held at CRRI, Cuttack
22.	Half yearly review meeting of Rainfed Cotton PSR sub-projects	December 28-29, 2000 held at CICR, Nagpur
23.	Training cum Workshop on Procurement of Equipment conducted by M/s.RITES	February 6, 2001 held at CRIDA, Hyderabad
24.	Half yearly review meeting of Rainfed Pulses PSR sub-projects	February 21-22, 2001 held at IIPR, Kanpur
25.	NATP Rainfed Agro Ecosystem Review Workshop on INM, WM, Tillage, Residue Management etc. cutting across PSR	February 26-28, 2001, CRIDA, Hyderabad
26.	Review meeting of Rainfed Nutritious Cereals based PRS	April 2-4, 2001, CRIDA, Hyderabad
27.	Review meeting of Rainfed Oilseed based PRS	April 10-12, 2001, DOR, Hyderabad
28.	Annual workshop of NATP Long Term Fertility Trials related to NATP, INM theme	July 10-11, 2001, CRIDA, Hyderabad

Sl.No	Item	Dates and Venue
29.	Sensitization workshop on Monitoring and Evaluation of Rainfed PSR	August 27-28, 2001, CRIDA, Hyderabad
30.	First AP State Coordination Committee Meeting of NATP	August 28, 2001, CRIDA, Hyderabad
31.	Third State Level Coordination Committee Meeting of Orissa	September 4, 2001, CRRI, Cuttack
32.	Coordination meeting with Officer In-charge, ATMA projects regarding SREP to match the areas covered by PSR projects as against the research gaps identified by ATMA	November 17, 2001, CRIDA, Hyderabad
33.	Fourth State Level Coordination Committee of Orissa	December 01, 2001, WTCER, Bhubaneswar
34.	AP State Level Work shop on "Innovations in technology dissemination (ITD) component"	Jubilee Hall, Hyderabad
35.	PIMS Workshop for AED staff	January 16, 2002, CRIDA, Hyderabad
36.	Annual Workshop on Rainfed Rice based PSR projects	19-21st March, 2002 held at CRRI, Cuttack
37.	Annual Workshop on Rainfed Oilseeds based PSR projects	April 4-5, 2002 held at DOR, Hyderabad
38.	Fifth State Level Coordination Committee of Orissa	April 5, 2002 at Khurda
39.	Annual Workshop on Rainfed Pulses based PSR projects	18-19 April, 2002 held at CRIDA, Hyderabad
40.	Annual Workshop on Rainfed Nutritious Cereals based PSR projects	6-7 May, 2002 held at CRIDA, Hyderabad
41.	Annual Workshop on Rainfed Cotton based PSR projects	8th May, 2002 held at CRIDA, Hyderabad
42.	Sixth State Level Coordination Committee of Orissa	June 10, 2002 at CRRI, Cuttack
43.	Annual Review Workshop of TAR-IVLP	3-5 September, 2002, UAS, Dharwad
44.	Seventh State Level Coordination Committee of Orissa	September 9, 2002 at Gopalpur in Ganjam district
45.	Eighth State Level Coordination Committee of Orissa	December 20, 2002 at OUAT, Bhubaneswar
46.	Annual Review Workshop of TAR-IVLP	March 21-22, 2003, IIPR, Kanpur
47.	Annual Workshop on Cotton and Nutritious Cereals based PSR projects	18-19th April, 2003 held at CICR, Nagpur
48.	Annual Workshop on Rainfed Rice, Oilseeds and Pulses based PSR projects	23-25th April, 2003 held at CRIDA, Hyderabad
49.	Review of Mission Mode project on IPM	20-21 June, 2003 held at CRIDA, Hyderabad
50.	National Review Workshop on TAR-IVLP	22-23rd December, 2003 at CRIDA, Hyderabad
51.	Review of AED (Rainfed) by World Bank expert team	January 23, 2004 at CRIDA, Hyderabad
52.	National Symposium cum Exhibition on "Enhancing productivity and sustainability in Rainfed Agro Ecosystem"	March 24-26, 2004 at ANGRAU, Hyderabad
53.	Meeting of the World Bank review mission.	24-25 May, 2004 at New Delhi
54.	Review of PSR projects in eastern states by World Bank expert team	27 May, 2004 at CRIJAF, Barrackpore
55.	Review of Mission Mode project on Mechanization	5 June, 2004 at CRIDA, Hyderabad
56.	Sensitisation Workshop on PIMS for PIs of PSR projects	12-13 July, 2004 at NAARM, Hyderabad
57.	A training programme on "Methodology of collection, documentation and validation of indigenous technical knowledge"	17th July to 6th August, 2004 at CRIDA, Hyderabad
58.	A stake holders meeting on sweet sorghum	28th August, 2004 at CRIDA, Hyderabad
59.	A stake holders meeting on safflower	21st September, 2004 at CIRCOT, Mumbai
60.	Interaction Workshop on Grain Drying Technology	2nd November, 2004, MAU, Parbhani
61.	ICR Review Mission of Rainfed Agro Eco system by World Bank Team	19th November, 2004 at CRIDA, Hyderabad
62.	Final review meeting of NATP projects	20-21st May, 2005 at CRIDA, Hyderabad

Annexure XII

Training of Project Scientists in India and Abroad

a) Training Abroad

S. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training / Conferences	Location of the training
1	RNPS-10	Dr S L Patil	CSWCRTI, Bellary	Soil and moisture conservation	July 2-7, 2000 (conference)	Texas, USA
2	ROPS-08	Dr.(Mrs.)Saroj Singh	NCIPM, New Delhi	Agro-ecology, Integrated Pest Management and Sustainable Agriculture	June 16-28, 2002	Michigan State University, East Lansing, Michigan, USA
3	ROPS-08	Dr.Surender Kumar	NCIPM, New Delhi	Agro-ecology, Integrated Pest Management and Sustainable Agriculture	June 16-28, 2002	Michigan State University, East Lansing, Michigan, USA
4	ROPS-08	Dr.H.Basappa	DOR, Hyderabad	Agro-ecology, Integrated Pest Management and Sustainable Agriculture	June 24-July 6, 2002	Michigan State University, East Lansing, Michigan, USA
5	RNPS-06	Dr.B.Dayakar Rao	NRCS, Hyderabad	Socio-Economic Interactive Database Management	September 14 - 27, 2002	Texas A&M University, College Station,Texas, USA
6	RNPS-06	Dr.S.Surya Prakash	USA, Bangalore	Socio-Economic Interactive Database Management	September 14 - 27, 2002	Texas A&M University, College Station,Texas, USA
7	RNPS-06	Dr.(Mrs)Usha Rani Ahuja	CAZRI, Jodhpur	Socio-Economic Interactive Database Management	September 24 – October 5, 2002	Texas A&M University, College Station,Texas, USA
8	RPPS-02	Dr.S.Lingaraju	UAS, Dharwad	Integrated management of plant nematodes	September 17 – October 2, 02	University of Florida, Quincy, USA
9	RPPS-02	Dr.Aktar Haseeb	AMU, Aligarh	Integrated management of plant nematodes	September 17 – October 2, 02	University of Florida, Quincy, USA
10	RNPS-10	Dr.S.S.Rao	NRCS, Hyderabad	Crop simulation modeling in sorghum	October 23 – November 06, 2002	Kansas State University, Manhattan, Kansas, USA
11	RNPS-23	Dr.(Mrs.)S.Audi Lakshmi	NRCS, Hyderabad	Grain quality management in sorghum	September 15–28, 2002	Texas A&M University, College Station,Texas, USA
12	RNPS-23	Dr.(Mrs.)Aruna C.Reddy	NRCS, Hyderabad	Grain quality management in sorghum	September 15–28, 2002	Texas A&M University, College Station,Texas, USA
13	RCPS-04	Dr.K.V.Rao	CRIDA, Hyderabad	GIS and Simulation Modeling, Soil and Water Resources characterization	December 2 – 22, 2002	Department of Natural Resources & Mines, Queensland, Australia

S. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training / Conferences	Location of the training
14	ROPS-13	Dr.P.K.Mishra	CRIDA, Hyderabad	GIS and Simulation Modeling, Soil and Water Resources characterization	December 2 – 22, 2002	Department of Natural Resources & Mines, Queensland, Australia
15	RRPS-22	Dr.Gururaj Katti	DRR, Hyderabad	IPM Technology in Rice	January 27 – February 7, 2003	IRRI, Manila, Philippines
16	RRPS-22	Dr.M.P.Singh	CAU, Imphal	IPM Technology in Rice	January 27 – February 7, 2003	IRRI, Manila, Philippines
17	RRPS-22	Dr.D.K.Bora	AAU, Assam	IPM technolgoy in Rice	January 27 – February 7, 2003	IRRI, Manila, Philippines
18	RRPS-22	Dr.C.R.Satpathi	BCKV, Kalyani	IPM technolgoy in Rice	January 27 - February 7, 2003	IRRI, Manila, Philippines
19	RRPS-25	Dr.(Mrs) M.Vanaja	CRIDA, Hyderabad	Impact of climate change on crop productivity	February 15 – 28, 2003	US Water Conservation Laboratory, USDA, Arizoma, USA.
20	RPPS-03	Dr T Ganapathi	TNAU, Coimbatore	Detection and Identification of Plants Viruses	March 03 – 17, 2003	Deutsche Sammlung von Mikroorganismen und Zellkulturen gmbH, Division of Plant Virology, Braunshweig, Germany
21	RPPS-05	Dr.S.D.Deshpandey	CIAE, Bhopal	Improved grain storage methods in pulses	May 8-23, 2003	Oklahoma State University, Still water, USA
22	ROPS-17	Dr Suseelendra Desai	NRCG, Junagadh	Management of Aflatoxin in oilseeds	May 13-27, 2003	National Peanut Research Laboratory, Dawson, USA
23	RNPS-24	Dr C V Ratnavathi	NRCS, Hyderabad	Improving grain quality in Soghum	July 9-23, 2003	Purdue University, Indiana, USA
24	ROPS-08	Dr B Subbarayudu	NRCS, Hyderabad	IPM in Oilseeds	June 15-27, 2003	Michigan State University, Michigan, USA
25	ROPS-08	Dr P Lakshmi Reddy	RRS, Ananthapur	IPM in Oilseeds	June 15-27, 2003	Michigan State University, Michigan, USA
26	RNPS-17	Dr A K Misra	CRIDA, Hyderabad	Recent advances in ruminant nutrition	June 16 – July 6, 2003	International Feed Resources Institute, The Macaulay Institute, Scotland, UK
27	RNPS-17	Dr R N Dhore	PDKV, Akola	Recent advances in ruminant nutrition	June 16 – July 6, 2003	International Feed Resources Institute, The Macaulay Institute, Scotland, UK
28	RNPS-17	Dr M Chandrasekharaiah	NIANP, Bangalore	Recent advances in ruminant nutrition	June 16 – July 6, 2003	International Feed Resources Institute, The Macaulay Institute, Scotland, UK
29	ROPS-12	Dr G.Pratibha	CRIDA, Hyderabad	Oilseed cropping systems for sustainable production	July 28 – August 10, 2003	USDA, Mandan, North Dakota, USA
30	ROPS-12	Dr P Padmavathi	DOR, Hyderabad	Oilseed cropping systems for sustainable production	July 28 – August 10, 2003	USDA, Mandan, North Dakota, USA
31	RPPS-03	Dr B Sarat Babu	NBPGR (RS), Hyderabad	Integrated management of viral diseases	August 18-29, 2003	The State University of New Jersy, USA

S. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training / Conferences	Location of the training
32	ROPS-11	Dr.N.S.Bhogal	NRCRM, Bharatpur	Soil Science and Plant Nutrition	September 8 – 19, 2003	Massey University, New Zealand
33	RCPS-04	Dr.Ch.Srinivasa Rao	CRIDA, Hyderabad	Soil Science and Plant Nutrition	September 8 – 19, 2003	Massey University, New Zealand
34	RRPS-16	Dr.(Mrs.)G.Jayasree	ANGRAU, Hyderabad	Tillage requirements for rainfed rice production	September 29- October 12, 2003	Ohio State University, USA
35	RRPS-16	Dr.T.D.Pandey	IGKV, Jagdalpur	Tillage requirements for rainfed rice production	September 29- October 12, 2003	Ohio State University, USA
36	RRPS-16	Dr.A.K.Dash	OUAT, Bhubaneswar	Tillage requirements for rainfed rice production	September 29- October 12, 2003	Ohio State University, USA
37	RRPS-16	Dr.(Mrs.) N.G.Barua	AAU, Jorhat	Tillage requirements for rainfed rice production	September 29- October 12, 2003	Ohio State University, USA
38	RRPS-16	Dr.S.Sarkar	BCKV, Gayeshpur	Tillage requirements for rainfed rice production	September 29- October 12, 2003	Ohio State University, USA
39	ROPS-07	Dr.K.S.Ramachandra	NIANP, Bangalore	Modern Animal feed manufacturing and feed formulations	October 20 – 31, 2003	IPC, Livestock, The Netherlands
40	ROPS-07	Dr.D.Nagalaxmi	ANGRAU, Hyderabad	Modern Animal feed manufacturing and feed formulations	October 20 – 31, 2003	IPC, Livestock, The Netherlands
41	RRPS-20	Dr U K Mandal	CRIDA, Hyderabad	Planning for suitable land resource management	October 6- 19, 2003	Ohio State University, USA
42	RNPS-02	Dr V. Ramesh	CRIDA, Hyderabad	Carbon sequestration under different land uses	October 22 – November 5, 2003	Oregon State University, Oregon, USA
43	RPPS-01	Dr. G P Brahmaprakash	UAS, Bangalore	Liquid rhizobium technology and recent techniques in biological nitrogen fixation	November 24 – December 7, 2003	Bowling Green State University, Ohio, USA
44	RPPS-10	Er Shakir Ali	CSWCRTI, Kota	Community based integrated watershed management	November 10 – 28, 2003	International Institute of Rural Reconstruction, Philippines
45	RNPS-09	Dr N N Reddy	CRIDA, Hyderabad	Land degradation and sustainable rural livelihoods : Field assessment	April 20 – May 3, 2004	Overseas Development Group, UK and Spain
46	RNPS-09	Dr D V Devgire	MPKV, Solapur	Land degradation and sustainable rural livelihoods : Field assessment	April 20 – May 3, 2004	Overseas Development Group, UK and Spain
47	RNPS-07	Dr S S Angadi	UAS, Dharwad	Concepts of sustainable crop production	August 9-23, 2004	University of Newcastle, UK
48	RRPS-27	Dr Amal Ghosh	CRRI, Cuttack	Rice Production System	September 6-17, 2004	IRRI, Philippines
49	RRPS-17	Dr Susama Sudhisri	CSWCRTI, Koraput	Soil and Water Conservation and Management	October 11-25, 2004	Ohio State University, USA

S. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training / Conferences	Location of the training
50	RRPS-17	Dr.P.C.Bora	AAU, Jorhat	Soil and Water Conservation and Management	October 11-25, 2004	Ohio State University, USA
51	RRPS-04	Dr.R.C.Srivastava	WTCER, Bhubaneswar	Ground water recharge	October 5-16, 2004	Centre for Groundwater Studies, Australia
52	RRPS-04	Dr.O.P.Dubey	JNKVV, Dindori	Ground water recharge	October 5-16, 2004	Centre for Groundwater Studies, Australia
53	RRPS-04	Dr.D.K.Rusia	BAU, Ranchi	Ground water recharge	October 5-16, 2004	Centre for Groundwater Studies, Australia
54	RRPS-04	Dr.G.P.Pali	IGKV, Raipur	Ground water recharge	October 5-16, 2004	Centre for Groundwater Studies, Australia
55	RNPS-09	Dr.G.Rajeshwar Rao	CRIDA, Hyd.	Sustainable nutrient management of agroforestry/ forestry systems	October 18-31, 2004	Massey University, New Zealand

B) Training in India

S. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training /	Location of the training
1.	RRPS-25	Dr J S Urkurkar Dr H P Tripathi Dr R B Thakur Dr B K Mishra Dr A K Ghosh Dr Binod Kumar	IGAU, Raipur NDUAT, Faizabad RAU, Pusa OUAT, Bhubhaneswar RRS, Chinsura BAU, Ranchi	Application of crop simulation models for rice production	15-30 December, 2000	CRRI, Cuttack
2.	RRPS-17	Dr.S.Susama Sudhisri Dr.Anchal Das	CSWCRTI, Koraput	Appraisal course on remote sensing	October 29 – November 9 2001	
3.	RRPS-25	Dr.Trinath Pradhan Dr.Amalan Ghosh Dr.P.Krishnan	OUAT, Bhubaneswar RRS, Chinsura,WB CRRI, Cuttack	Modelling growth and yield of crops	March 20 - April 9, 2001	CASS, IARI, New Delhi
4.	RPPS-03	Nine technical staff	NBPGR RS, Hyderabad	ELISA for vector identification	March 2001	NBPGR, Hyderabad
5.	RPPS-05	15 project scientists from all co-operating centers		Storage and seed entomology	November 2-22, 2001	CCSHAU, Hissar
6.	ROPS-08	Mr.Manoj Kumar	NCIPM, New Delhi	Mass production technology by bio control agents	January 19 –28, 2002	NCIPM, New Delhi
7.	RCPS-05	Dr.V.K.Sood	GAU, Anand	Crop modeling	February 13 – March 14, 2002	CASAM, Pune
8.	RNPS-11	Ms.Kiran Gaur	MPUAT, Udiapur	Statistical quality control/ SPC software	February 11 – 13, 2002	IIQM, Jaipur

S. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training /	Location of the training
9.	RCPS-01	Dr O Challa Dr GP Saraf Dr S M Mundinamani	NBSS&LUP, Nagpur	Statistical Analysis for Socio-economic Research data	April 30-May 4, 2002	NAARM, Hyderabad
10.	RNPS-09	Dr.D.V.Devigire	ZARS, Solapur	Short-course on arid fruits	1 month	NRCAH, Bikaner
11.	RNPS-12	Dr.B.Ekambaram, CCPI	ANGRAU, Mahabubnagar	a. Participatory approaches livestock development b. Village adoption & bimonthly TGIU visits	June 24 -29, 2002 October 10 – 11, 2002	NIRD, Hyderabad TNAU, Coimbatore
12.	RNPS-24	Dr.C.V.Ratnavati, PI	NRCS, Hyderabad	Trouble shooting and maintenance of gas chromatograph	February 7-9, 2003	Perkin Elmer Instruments, Hyderabad
13.	RNPS-25	Dr.V.Ramesh Dr.(Mrs.)M.Vanaja Dr.M.C.Manna Dr.Tapas Bhattacharya Dr.D.K.Pal Dr.S.K.Ray Dr.M.V.Venugopalan Dr.T.J.Rego Dr.K.V.Padmaja	CRIDA, Hyderabad IISS, Bhopal NBSSLUP, Nagpur ICRISAT, Hyderabad	Carbon Simulation Modelling	April 10, 2002	NBSS & LUP, Nagpur
14.	RPPS-04	Dr.R.R.Lal, PI	IIPR, Kanpur	Use of computer technology in agricultural research	February 14-22, 2003	IIPR, Kanpur
15.	RRPS-21	Dr.B.P.Mishra Dr.K.L.Nandeha Mr.Rusia Er. D.Saha	IGKV, Raipur Jagdalpur, Chhatisgarh BAU, Ranchi BCKV, Mohanpur	Instrumentation and testing of Agril. Machinery	August 19-31, 2002	CIAE, Bhopal
16.	RRPS-23 RRPS-31	Ms Bhagyalatha Dhar Aruanashu Datta Puspendra Singh A. Kiran Kumar Singh Ms.Heisama Nanita Devi Ms. Lydia Zimic	CRRI, Cuttack BCKV, Kalyani NDUAT, Faizabad CAU, Imphal	Production technology of rice and rice based crops	September 20 -25, 2002	CRRI, Cuttack
17.	RRPS-25	Dr.P.Krishnan	CRRI, Cuttack	Modelling growth and yield of crops	March 27-April 17, 2002	CASS, IARI, New Delhi
18.	RNPS-12	Dr.K.S.Dutta	GAU, Junagadh	Farming systems approach	December, 15-24 2003	NAARM, Hyderabad
19.	RNPS-12	All project staff	GAU, Junagadh	Interactive workshop on silvo pasture	November 12-13 2003	GAU, Junagadh

Annexure XIII

Listing of Equipments / Civil Works Costing Over Rs.3 lakhs

a) Equipment

Project Code	Center	Name of the Equipment	Cost of the equipment (Rs.)
RRPS-9	IGKV, Durg, Anjora	Portable pH/ISE meter (Orion make) along with electrodes and accessories.	3,44,568/-
RRPS-27	CRIJAF, (B) L.C	• Microscope • Photosynthesis system (RITES)	3,20,00/- More than Rs.10 lakhs
RRPS-27	ISI	• P.C.R. • Microscope	5,20,000/- 3,15,000/-
RRPS-28	CRIJAF, (B) L.C.	• Auto analyzer FIA with star • 5000 analyser with accessories, PC, UPS, scanner & software (RITES)	$ 29,500 14,75000/-
ROPS-7	BAIFDRF, Urulikanchan	Fully automatic GEHARD soxtherm fat estimation model 30E	4,40,059/-
ROPS-8	NRCS, Hyderabad	Fermenter with independent controls	3,36,200/-
ROPS-11	IISS, (B)L.C.	Digestion block	3,72,062/-
ROPS-11	NRCRM, Bharatpur	Nitrogen digestion, distillation and titration unit	4,16,479/-
ROPS-15	PDP,Hyd. L.C.	Fluorescence detector and other accessories for HPLC	6,83,308/-
ROPS-15	CIRB, Hissar	Fluorescence detector and other accessories for HPLC	7,00,000/-
ROPS-15	NIANP,Bangalore	HPLC	12,00,000/-
ROPS-15	AAU, Khanapara	HPLC	12,00,000/-
ROPS-16	UAS(D), Karnataka	Steady state Porometer	3,44,190/-
ROPS-17	NRCG, (Jugdh)L.C.	Florescence Detector	3,18,900/-
RPPS-1	UAS, (B)	Flurescent phase contrast microscope with attachments	3,42,964/-
RPPS-8	IIPR, (K)L.C.	Triancular Microscope	More than 3,00,000/-
RPPS-11	IISS,(B)L.C.	Nitrogen distillation unit	3,00,000/-
RCPS-5	PDKV, (A) L.C.	Automatic weather station recorder with metos compact with solar panel and charging module with necessary attachment and accessories	3,30,591/-
RCPS-5	UAS, ARS, Dharwad	• TDR with printer and data logger • Imported kjeldhal digestion and distillation system	4,23,675/- 4,67,515/-
RCPS-6	UAS (D)L.C.	EM probe	3,81,333/-
RCPS-6	GAU, Viramgam	EM probe	5,45,184/-
RCPS-6	JNKV, Indore	EM probe	6,37,386/-

Project Code	Center	Name of the Equipment	Cost of the equipment (Rs.)
RNPS-8	GAU, Surat	UV Spectrophotometer	6,38,000/-
RNPS-10	NRCS, Hyderabad	Neutron moisture meter probe	3,21,762/-
RNPS-16	PDP, Hyderabad	Microwave muffle furnace	$ 8584
RNPS-17	BAIF, Urlikanchan, Pune	Fiberatec system on 1020 Hot & cold extraction, Company foss tecator	4,10,860/-
RNPS-19	CSWCRTI, Regional station, Chandigarh	RITES- Atomic Absorption Spectrophotometer	11,00,000/-
RNPS-20	GBPUAT, Pantnagar	• Refrigerated microcentrifuge • Elisa reader • Thermal cycler	
		Through RITES • Capillary Electrophoresis • Mixograph • Refrigerated centrifuge	 20,00,000/- 11,00,000/- 10,00,000/-
RNPS-20	NRCS, Hyderabad	• Deep feezer (-80) • Particle Delivery system Gene gun 1000 • Trangenic glass house with 3 chambers	3,25,465/- 9,52,781/- 7,87,500/-
RNPS-24	NRCS, Hyderabad	• Gas Chromatograph • Tractor:TAFE Massey Fergusson 5245 • Electrophoresis unit • Titration unit	7,21,958/- 3,55,000/- 6,08,350/- 3,00,000/-
RNPS-25	NBSSLUP, Nagpur	• Atomic Absorption Spectrophotometer • Floormodel International centrifuge	7,00,158/- 6,78,686/-
RNPS-25	IISS, Bhoopal	Aurotritretor	4, 40,309/-

B. Civil works

Project Code	Center	Name of the Civil works	Cost (Rs.)
RNPS-4	UAS, (B) L.C.	Construction of green house	3,00,000/-
RNPS-19	CSWCRTI, Chandigarh	Fencing of watershed at research station	4,00,000/-
RNPS-27	GM Reddy Research Foundation, Hyderabad	Development of infra structure facilities for lab and green house	14,00,000/-

Annexure XIV

Chronology of the PSR Projects Approved under Rainfed AES

Production system	Proposals received	No.of projects approved year wise				Total Amount (Rs. in crores)
		1999-2000	2000-2001	2001-2002	Total	
Rainfed Rice	210	14	19	2	35	36.92
Oilseeds	90	-	17	1	18	16.02
Pulses	70	-	12	-	12	10.46
Cotton	80	-	11	-	11	8.18
Nutritious Cereals	200	-	25	2	27	31.97
Total	**650**	**14**	**84**	**5**	**103**	**103.55**

Thematic and Production System-wise Classification of the PSR Projects Approved Under Rainfed AES

Production System Theme Area	Rainfed Rice	Oilseeds	Pulses	Cotton	Nutritious Cereals	Total
Natural Resource Management	11	1	1	3	10	26
Integrated Pest Management	3	3	4	0	2	12
Post Harvest Technology/Value Addition	3	6	3	0	7	19
Biotech/Crop Improvement	5	2	0	5	2	14
Rain Water Management	3	2	1	0	2	8
Integrated Plant Nutrient Management	6	1	2	1	1	11
Agro-Biodiversity	1	1	0	1	0	3
Socio Economics	3	2	1	1	3	10
Total	**35**	**18**	**12**	**11**	**27**	**103**

Institution-wise Classification of PSR Projects Approved Under Rainfed AES

Organisation	No.of sub projects	Budget sanctioned (Rs.in lakhs)
ICAR Institutes	135	3634.79
State Agricultural Universities	309	6242.97
Departments of Government of India	04	117.37
State Government Departments	05	29.35
General Universities	05	67.57
Non Government Organisations	06	160.12
International Organisations	03	103.33
Total	**466**	**10355.50**

Annexure XV

Constitution of SAP and Subsequent Changes

Initial constitution on 8-06-1998

Dr.J.S.Kanwar, DDG (Emeritus), ICRISAT,	Chairman
Dr.N.G.P.Rao, Former Chairman, ASRB	Member
Dr.I.C.Mahapatra, Former Vice Chancellor, OUAT, Bhubaneshwar	Member
Dr.J.C.Katyal, Director, NAARM, Hyderabad	Member
Dr.Joseph Thomas, Adviser, SPIC, Chennai	Member
Dr.S.Chellaiah, Director, NARDI, Hyderabad	Member
Dr.P.K.Khosla, Director (Extension), HPVV, Palampur	Member
Dr.D.N.Jha, Director, NCAP, New Delhi	Member
Dr.B.K.Soni, DDG (Retd.) ICAR	Member
Officers from ICAR	
Dr.S.K.Goel, Finance and Accounts Officer, DOR, Hyderabad	Member
Dr.R.K.Gupta, National Coordinator (NATP)	Member
Dr.H.P.Singh, AED (Rainfed)	Member
Dr.K.P.R.Vittal, PPSS, AED (RF)	Member Secretary

Reconstituted on 6-09-2000

Dr.J.S.Kanwar, DDG (Emeritus), ICRISAT	Chairman
Dr.N.G.P.Rao, Former Chairman, ASRB	Member
Dr.I.C.Mahapatra, Former Vice Chancellor, OUAT, Bhubaneshwar	Member
Dr.B.K.Soni, DDG (Retd.) ICAR	Member
Dr.N.N.Goswami, Jt.Director (Retd.), IARI	Member
Dr.S.N.Puri, Vice Chancellor, MPKVV, Rahuri	Member
Dr.P.Das, Director, RPRC, Bhubaneswar	ember
Dr.R.K.Gupta, Director of Research, JNKVV, Jabalpur	Member
Officers from ICAR	
Financial adviser (DARE) or his/her representative	Member
Dr.A.K.Raheja, National Coordinator (NATP)	Member
Dr.H.P.Singh, AED (RF)	Member
Dr.K.P.R.Vittal, PPSS, AES(Rainfed)	Member Secretary

Reconstituted on 26-06-2001

Dr.J.S.Kanwar, DDG (Emeritus), ICRISAT	Chairman
Dr.N.G.P.Rao, Former Chairman, ASRB	Vice Chairman
Dr.I.C.Mahapatra, Former Vice Chancellor, OUAT, Bhubaneshwar	Member
Dr.B.K.Soni, DDG (Retd.) ICAR	Member
Dr.N.N.Goswami, Jt.Director (Retd.), IARI, New Delhi	Member
Dr.S.Bislaiah, Former Vice Chancellor, UAS, Bangalore	Member
Dr.S.N.Puri, Vice Chancellor, MPKVV, Rahuri	Member
Dr.P.S.Reddy, Ex Director, DOR, Hyderabad	Member
Dr.P.Das, Director, RPRC, Bhubaneswar	Member
Dr.R.K.Gupta, Director of Research, JNKVV, Jabalpur	Member
Officers from ICAR	
Financial adviser (DARE) or his/her representative	Member
Dr.A.K.Raheja, National Coordinator (NATP)	Member
Dr.H.P.Singh, AED (RF)	Member
Dr.K.P.R.Vittal, PPSS, AES (Rainfed), up to 3/9/2001	Member Secretary
Dr B. Venkateswarlu, PPSS, AES (Rainfed) from 4/9/2001	Member Secretary

Reconstituted on 1-10-2003

Dr.J.S.Kanwar, DDG (Emeritus), ICRISAT	Chairman
Dr.N.G.P.Rao, Former Chairman, ASRB	Vice Chairman
Dr.I.C.Mahapatra, Former Vice Chancellor, OUAT, Bhubaneshwar	Member
Dr.N.N.Goswami, Jt.Director (Retd.), IARI, New Delhi	Member
Dr.S.Bislaiah, Former Vice Chancellor, UAS, Bangalore	Member
Dr.S.N.Puri, Vice Chancellor, MPKVV, Rahuri	Member
Dr.P.K.Singh, Vice Chancellor, CSAUA & T, Kanpur	Member
Dr.P.S.Reddy, Ex Director, DOR, Hyderabad	Member
Dr.O.P.Pareek, Ex.Director (CIAH), Bikaner	Member
Officers from ICAR	
Dr.D.P.Singh, NC (PSR)	Member
Shri B.L Jangira, Director (Finance), ICAR, New Delhi	Member
Dr.Y.S.Ramakrishna, AED (RF)	Member
Dr.B.Venkateswarlu, PPSS	Member Secretary

Annexure XVI

Facilitators for Different Production Systems

Sl.No.	Production System	Name of the Facilitator
1.	Rainfed Rice	Dr.S.K.Mohanty (upto October, 2001) Dr.B.N.Singh (upto January, 2003) Dr.Devraj Panda (from Feb, 2003)
2.	Oilseeds	Dr.D.M.Hegde
3.	Pulses	Dr.Masood Ali
4.	Cotton	Dr.S.K.Banerjee
5.	Nutritious Cereals	Dr.B.S.Rana (upto January, 2002) Dr.M.H.Rao (upto June, 2002) Dr.S.Indira (upto July, 2003) Dr.S.V.Rao (from August, 2003)

Annexure XVII

Staff of Agro Ecosystem Directorate

Sl.No.	Name	Designation
1.	Dr.H.P.Singh	Agro Ecosystem Director (up to 30th May, 2003)
2.	Dr.Y.S.Ramakrishna	Agro Ecosystem Director (from 31st May 2003)
3.	Dr. K.P.R.Vittal	Principal Production System Scientist (Up to 3-9-2001)
4.	Dr.B.Venkateswarlu	Principal Production System Scientist (From 4-9-2001)
5.	Dr.G.Subba Reddy	Principal Scientist (Agronomy) *
6.	Dr.Ch.Srinivasa Rao	Sr.Scientist (Soil Science)
7.	Sri S.K.C.Bose	Finance and Accounts Officer
8.	Sri G.Lakshminarayana	Assistant Administrative Officer **
9.	Smt.P.Lakshminarasamma	Technical Officer
10.	Sri P.Chandrashekar	Technical Officer
11.	Smt. Hemlata Kapil	Technical Assistant**
12.	Smt. M.A. Rekha	Junior Stenographer **
13.	Sri K.R Srinivas Rao	Assistant
Contractual Staff		
14.	Dr G.Ramesh	Research Associate
15.	Sri Jayakanth	Stenographer –II
16.	Sri Suresh Kanth Shukla	DEO
17.	Sri Y Bhaskara Chari	DEO*
18.	Sri D. Sridhar	Driver

*Involved in assisting the AED for coordinating the TAR-IVLP programme.
***Staff of CRIDA assisting the NATP cell for the effective implementation of project*