NATIONAL AGRICULTURAL TECHNOLOGY PROJECT

Rainfed Agro-Ecosystem

Annual Report
2003-2004

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

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Production System Research

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500 copies
September, 2004

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Published by

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Santoshnagar, Hyderabad

Printed at: ***Heritage Print Services Pvt. Ltd.***, Hyderabad. Phone: +91 (40) 2760 2453, 27608604; Fax: +91 (40) 2762 6042

Message

The rainfed agro ecosystem received very high priority in the production system research as these areas have been by passed by green revolution and need urgent attention to improve production, productivity and achieve sustainability. On-farm participatory research being the primary strategy in this eco system, nearly 3500 field trials were conducted during the year generating and validating many location specific technologies.

Though *kharif* 2003-04 saw significant improvement in rainfall across the country compared to the worst drought of 2002, many areas and target districts covered by PSR projects still faced water deficits due to erratic rainfall distribution and therefore offered good opportunity to test technologies on natural resource management, cropping systems and crop diversification for the third successive year. Pooled analysis of 3 years data revealed significant gains in income and B:C ratios with technologies generated under the project as compared to farmer's own practice. Not only the water harvesting technologies implemented on a field scale, but also simple *in situ* moisture conservation practices like conservation furrows and compartmental bunds proved their effectiveness on farmers fields in the dry semi arid zones. However, a number of operational and input related constraints continue to limit the adoption of these technologies at field level. In this context I am happy to note that linkages have been established between PSR, TAR-IVLP and ATMA projects in different states, which permitted replication of these technologies more widely.

It is gratifying to note that more than a dozen technologies have emerged from PSR projects, which attracted the attention of private industry. The contract farming taken for sweet sorghum for ethanol production is an excellent example of the public-private partnership. Similarly, the improved jute variety *Subala* released for quality fibre would give a fillip to the jute based textile industry. Application of remote sensing technology in 12 pilot districts across the country revealed that satellite imageries can accurately locate and map conservation structures on the ground more effectively at lower cost. This will add significant value to the National Watershed Developmental Programme for Rainfed Areas (NWDPRA) in years to come. I compliment Dr.Y.S.Ramakrishna, AED and Dr.B.Venkateswarlu, PPSS for bringing out this excellent, self containing annual report for 2003-04 on the Rainfed Agro Eco system.

S.L.Mehta
National Director (NATP)

September, 2004

Foreword

Sustainable management of natural resources like soil and rainwater for improved productivity of crops and livestock holds the key for higher income and better livelihoods for the vast majority of farmers living in rainfed regions. Enhancing productivity for unit land in rainfed areas is pre-requisite for producing more pulses, oilseeds and cotton, which are in short supply in the country. The nutritious cereals predominantly grown in rainfed areas are the key to provide fodder for livestock and staple food for millions of households in drought prone areas.

The production system research under rainfed agro ecosystem addressed critical research and adoption gaps in rainfed rice, oilseeds, pulses, cotton and nutritious cereals based production systems involving 103 subprojects. The unique feature of these projects was the involvement of farmers as participants in the on-farm adaptive research (OFAR) carried out in representative villages and micro farming situations in specially identified target districts across the country. The projects covered major thrust areas like rainwater management, assessment of soil health, integrated nutrient management (INM), integrated pest management (IPM), participatory varietal improvement, post harvest technology and value addition and diversification of agriculture including agri-horticulture, agro-forestry and livestock production.

2003-04 was the third successive year of the on-farm trials. Though the rainfall received at most experimental sites was close to normal and relatively more favorably distributed compared to severe drought of 2002-03, many areas still experienced delays, breaks and early withdrawal of monsoon mainly due to the skewed distribution, subjecting the crops to abiotic and biotic stresses.

Judging from the data generated in majority of the projects, the interventions tried under several projects in a cropping system perspective provided the much needed stability of production and income to the participating farmers. In particular, the crop diversification and on-farm rainwater management strategies tried in the rainfed rice based production system of eastern India demonstrated its tremendous potential to improve the livelihoods of the people if these technologies are widely adopted with supportive institutional and extension services. It also showed the way of utilizing efficiently the rainwater which was running in to the Bay of Bengal causing enormous loss of precious soil and water.

In case of oilseeds, integration of *in situ* moisture conservation practices and INM with best variety, balanced nutrition and timely crop protection are the only ways to stabilize production in the vast dry semi arid tracts. There are excellent opportunities to enhance castor based eri silk production in

north east states by simple interventions on crop agronomy and choosing the appropriate silk worm race. Similarly, the value added products from safflower petals like natural dyes, herbal tea and cardboards have demonstrated the potential for improving economy of the system through industrial use of safflower by-products, but a critical assessment of the market acceptability and a suitable model of contract farming need to be designed which considers the interests of the farmer, the entrepreneur and the consumer.

In the pulses based production system, simple technologies were evolved which can minimize the post harvest losses by adoption of selected IPM modules to minimize the use of insecticides in field crops. However, the performance of these modules is still not consistent and considerable refinement needs to be done. The work on *desi* cottons (*arboreums*) is an outstanding example of a proper planning strategy matched with a right implementation leading to an useful product which has immense opportunities to help the rainfed farmers. The mill tests during the year confirmed that the quality of the *arboreum* cottons is as good as the best *hirsutums* and it is the best insurance against drought and pest problems. In fact it strongly points to the need for giving greater attention to *arboreum* cottons which are neglected in the past.

In the nutritious cereals based production system too, the sweet sorghum project resulted in an ideal model of contract farming which catalysed further interest among large number of distilleries and sugar mills in the states of A.P, Maharashtra and Tamil Nadu. Besides becoming a source of biofuel, it offers an alternative to sugarcane in areas where sugarcane cultivation is going down due to water scarcity. The rainwater harvesting and recycling tried on whole village catchment basis in Johranpur (H.P) in the maize based production system of sub mountain regions is another example of successful utilization of harvested rainwater for diversified and intensive farming for community benefit. This project not only improved the income level of farmers in the village but also brought social equity and harmony among the community making it as one of the best model for watershed based developmental planning in the country.

Overall, the on-farm trials during the year in different production systems confirmed the trend of the results obtained during the last two years and reinforced the need for integrating natural resource management with the best of the crop management technology to achieve significant enhancement in productivity in rainfed areas.

I compliment Dr.Y.S.Ramakrishna, AED (Rainfed) and Dr.B.Venkateswarlu, Principal Production System Scientist for brining out the third annual report for 2003-04 and all Facilitators and Principal Investigators for providing the inputs timely.

J.S. Kanwar
Chairman, SAP (Rainfed)

September, 2004

Preface

During 2003-04, location specific on farm participatory research continued to be the main strategy for PSR projects under Rainfed Agro-Ecosystem. More than 3200 on-farm trials were carried out during the year to assess and validate technologies in 5 production systems. In addition, strategic research in the areas of post harvest technology, modeling and remote sensing applications also received adequate emphasis during the year. After 3 years of trials, large number of useful technologies emerged from PSR projects which could be transferred either to TAR-IVLP/ATMA for wider diffusion or commercialization through private entrepreneurs. The interaction of the project scientists with the line departments and other extension service providers in the target districts improved significantly during the year, as a result of which more than 3200 farmers could be trained either through field based training or exposure visits. In areas such as *in situ* moisture conservation, INM and IPM, these interactions resulted in increased adoption of technologies in the target villages. 2003-04 also saw excellent interaction between different modes of NATP where in technologies and information were exchanged among PSR, Mission Mode, CGP and TAR-IVLP to derive the much needed synergy in achieving project goals. More than half a dozen success stories have emerged from PSR, which attracted the attention of regional and national press.

The excellent guidance received by the scientific advisory panel (SAP) and the cooperation of peer review teams (PRT) in monitoring and evaluations significantly contributed to the success of the programme during the year.

I sincerely acknowledge the support and guidance received from Dr.S.L.Mehta, National Director and Dr.D.P.Singh, National Coordinator from PIU, New Delhi. I wish to place on record the excellent and committed efforts put up by Dr.B.Venkateswarlu, Principal Production System Scientist, who coordinated the PSR projects effectively and also brought out the annual report on time. I also acknowledge the inputs of all the facilitators Dr.D.M.Hegde (Oilseeds), Dr.Masood Ali (Pulses), Dr.S.K.Banerjee (Cotton), Dr.D.Panda (Rainfed Rice) and Dr.S.V.Rao (Nutritious Cereals) and all the

PIs for submitting the individual project reports on time. The help and assistance of Dr.Ch.Srinivasa Rao, Sr.Scientist and Dr.G.Ramesh, Research Associate in compilation of the report and Ms.Hemlata Kapil, T-II-3 (Computer) and Ms.M.A.Rekha, Stenographer for technical assistance and word processing deserves appreciation.

The contribution of other staff members of the AED cell, particularly Mr.S.K.C.Bose, FAO, Mrs.P.Lakshmi Narasamma, Technical Officer (T-6), Mr.G.Lakshmi narayana, AAO and Mr.K.R.Sreenivasa Rao, Assistant in smooth implementation of the work during the year are thankfully acknowledged.

Y.S.Ramakrishna
AED (Rainfed)

September, 2004

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Executive Summary

In view of its vast coverage in terms of area and population, the Rainfed Agro Ecosystem received high priority for the production systems research under NATP. From more than 600 initial proposals submitted by different institutions within and outside NARS, 103 sub projects were finally approved by the Scientific Advisory Panel (SAP) in the 5 production systems i.e. rainfed rice (35), oilseeds (18), pulses (12), cotton (11) and nutritious cereals (27). As a major departure from the commodity oriented approach, these sub projects covered all components of the production system including crops, horticulture, agroforestry, livestock and fisheries. Sixty five of the 103 projects were based on on-farm adaptive research (OFAR) mode, involving farmers as equal partners in the research. The goal was to reach the unreached and improve the productivity and income from stressed environments.

2003-04 marks the third successive year in the implementation of most on-farm projects. Though the year was more favourable as compared to 2002-03 in terms of total rainfall received, many areas covered by the projects recorded deficit rainfall ranging from 10-30% of normal. This deficit coupled with skewed distribution, resulted in abiotic and biotic stresses which offered challenges and opportunities to scientists to test available technologies on farmers fields.

Results from the year across the country and production systems further reinforced the importance of rainwater management, integrated nutrient management and integrated pest management in sustaining the productivity and conservation of natural resources. Some of the technologies on moisture conservation and rainwater recycling were adopted on a wider scale by state line departments in target districts. The extensive on-farm trials on rice, jute and sorghum generated data which hastened the varietal release process resulting in identification of one variety of jute (*Subala*) and two varieties of rainfed rice (*Jagabandhu* and *Kaushalya*) for release. Similarly, more than a dozen technologies were developed and fine tuned in the area of post harvest technology which led to successful collaboration with private entrepreneurs. A total of 49 technologies finally emerged from 3 years of production system research, out of which 20 have been transferred to TAR-IVLP. In 6 districts, PSR technologies were adopted by the ATMA projects. Salient findings during 2003-04 from 5 production systems are summarized in the following paragraphs.

Rainfed Rice Based Production System

The network project on increased cropping intensity in rainfed rice based production system resulted in identification of the most profitable inter and sequence cropping systems for different land situations in Orissa, M.P. and Jharkhand. Redgram + groundnut for Ranchi and Darisai, rice + redgram at Rewa and Siddhi were found to be some of the most profitable intercropping systems for uplands. Due to the introduction of different inter and sequence cropping systems in the adopted villages, the cropping intensity increased from 105 to 128% before the start of the project (1999) to 115 to 177% in the year 2003-04. In Chhattisgarh, the area under double cropping increased significantly following the interventions made under PSR projects.

The rainwater management technology through on-farm reservoirs was evaluated for the third successive year in terms of yield of *kharif* and *rabi* crops, quantum of water storage and utilization and economic returns. The net returns from both *kharif* and *rabi* crops could pay back 45 – 70% of the initial investment on water harvesting structures in the 3rd year alone. Overall, the total initial investment of Rs.5.39 lakhs in the project area of 40 ha at Bagbhara block in Mahasamund district in Chhattisgarh could be realised in a three years period. On an average, 1 m increase in groundwater level was recorded in the project area. In a related project on management of excess rainwater in medium and low lands by storing it in the refuges around the field for fish culture in Dhenkanal district, highest fish yield of 1.86 t/ha in 180 days was realised with 15 cm weir height of the refuge. Irrespective of the treatments, growth of *C.carpio* was maximum followed by *C.mrigala* and *C.catla* in all the refuges.

The project on controlling runoff and soil loss from the hill slopes through rehabilitation with economically useful vegetation in the eastern highland zone of Koraput led to identification of suitable vegetative barriers, perennial trees/bushes for bund plantation and horti-pastural systems for controlling degradation of hill slopes. Guava-stylo and cashew-stylo (with trench) were the most effective treatments for hill slopes at Koraput and Jagdalpur.

The pilot project on using remote sensing technology for watershed planning in 7 micro watersheds under rainfed rice based production system clearly indicated that action plans prepared by using the map outputs from IRS-1C combined with ground information from NBSS&LUP can be used as effective means for prioritization of land treatments, implementation of the resource and crop related interventions in the micro watershed with considerably less investment on time and resources.

On-farm trials on integrated nutrient management in jute-rice cropping system revealed that targeted yields (TY) of jute and rice can be achieved with 100% N of TY through urea and 75% N through urea + 25% N through glyricidia/FYM. The trials helped in convincing the farmers on use

of glyricidia as an alternative to FYM which is not easily available in desired quantities. In rainfed rice on uplands and medium lands, intercropping of short duration legumes and its incorporation was found to be most acceptable INM practice among participating farmers in Orissa. From a critical analysis of the soil samples from long term fertilizer experiments carried out under different cropping systems across the country, an index for measuring soil quality was proposed. Mean weight diameter, organic carbon, available N, K and Zn and microbial biomass were identified as key indicators for measurement of soil quality across cropping systems and soil types. In a related study on soil organic pools, it emerged that balanced use of NPK or NPK with FYM were able to sustain the active pools of carbon on a long term basis.

The integrated pest management trials across 4 locations indicated that yields and B:C ratios with IPM and chemical pesticide application were comparable but significantly superior to farmers practice. A notable observation made during the year was the significant build up of natural enemy population in the rice ecosystem after 3 years of implementation of IPM modules.

On-farm adaptive trials continued for identification of best performing varieties for different land situations. *Vandana* with 2.8 t/ha yields was the best performing variety for uplands in Orissa. In medium lands, *Surendra* in Orissa, *Ranjit* in Assam produced highest yields of 3.9 and 5.16 t/ha, respectively. In Darisai, *Ravi* and *Tulasi* were found promising for uplands under improved practice but under farmers practice, *Birsa Gora* performed better. *Durga* (2.63 t/ha) and *Ambika* (2.62 t/ha) were the most promising deep water rice varieties identified for Orissa.

Based on the on-farm trials at 4 locations for 3 years, an improved strain of jute S-19 *(C.olitorius)* was released during the year as *Subala*. It gave 10% higher fibre yield over the check JRO 524.

A number of mango and litchi based agri-horticultural systems developed for eastern highlands in Orissa, Chhattisgarh and Jharkhand returned significantly higher income ranging from Rs.5000 to 8000/ha from rainfed uplands, which was significantly higher than upland rice (Rs.3000/ha). The district administration in Koraput adopted this model for popularization in predominantly tribal villages.

Following 3 years of OFTs in 7 target districts, rice – field pea for Dindori, rice-linseed for Seoni, rice – lathyrus for Mahasamund and Rajnandgaon, rice – linseed for Burdwan, rice – lathyrus for Midnapore and rice – blackgram for Khurda were identified as the best *utera* cropping sequences in terms of net monetary returns and benefit cost ratios.

The integrated paddy–fish–duck and paddy-fish-pig farming system project implemented in Jharkhand and West Bengal conclusively demonstrated that small farmers can earn a net income of Rs.5000-8000/- from an average of 0.5 and 0.1 ha of paddy and pond area, respectively with

5 – 10 ducks in the pond. This successful model was adopted by ATMA project in Dumka. However, the tribal farmers need intensive training for complete integration of all components of this farming system.

Oilseeds Based Production System

Yield advantages of 25-31% were recorded with adoption of location specific moisture conservation practices like deep ploughing, conservation furrows and broad bed and furrow system etc. combined with RDF in sunflower, castor, safflower and groundnut etc. in Alfisols and Vertisols. The benefits were 25-30% higher with high yielding varieties compared to local checks. Improved package of practices (seed soaking in 1% NaCl for 3 hours, application of FYM @ 2t/ha and sowing on the sides of the ridges in ridge and furrow method of planting) for castor production in sodic soils resulted in a net income of Rs.8000/ha as compared to Rs.5800/ha with farmers practice in Mahaboobnagar district of Andhra Pradesh. Similar yield and income advantages were recorded with safflower on saline soils of Parbhani district with the adoption of improved package.

Adoption of location specific IPM modules on castor, sunflower, safflower and mustard resulted in significantly higher economic returns and benefit cost ratios over farmers practice in 7 target districts but IPM modules completely based on non chemical approach were effective only under low to moderate pest load. Following the identification of TSV as causal agent of sunflower necrosis disease (SND), the viral coat protein gene was fully characterized during the year. Eight gene sequences of different isolates were deposited in the gene bank. Anti serum against TSV was raised and supplied to different institutions for field level diagnosis of the infected samples. For control of the stem necrosis disease in groundnut, border cropping with maize or millets was found to be most effective measure in addition to destroying *Parthenium* weeds around the fields.

Projects aimed at post harvest technology and value addition to oilseeds byproducts made good progress during the year. In case of safflower petals, the herbal tea and yellow dye could be commercialized to a limited extent by small manufactures of food products in Maharashtra. In view of the use of safflower yellow as a food dye, petals of different varieties were analysed for the presence of heavy metals. The concentration of all the heavy metals tested including Cd, Cr, Ni and Pb were within the permissible limits and As and Hg were completely absent.

Trials with milch cattle and buffaloes showed an increase in milk yield of 1.5 to 2.0 kg of milk/day/animal in experimental group fed with complete feed containing sunflower heads (up to 40%) translating into Rs.10-12 additional income/animal/day. Feeding trials using detoxified castor cake as protein source (28% of the concentrate) for a period of one year did not show any adverse effect on

the animal metabolism and digestibility. In a related project on poultry, the toxic effects of aflatoxin in poultry feeds could be minimized through use of neem bark powder (0.2%), dietary supplementation of enzyme mixture (0.05%), vitamin C (0.25%), vegetable oils (3-6%) and herbal extracts from *Emblica officinalis*, *Ocimum sanctum*, *Piper nigrum* and *Curcuma longa*.

The safflower harvester model II with a collection tray designed previously was modified to make it more versatile for harvesting other crops in safflower based cropping system. At CIAE, Coimbatore, a low cost push type harvester with a pair of bicycle wheels (with 1.7 hp, 2 stroke light weight petrol engine to cut and convey a single row of safflower crop) was also developed during the year. The field capacity was 0.051 ha/h and field efficiency 85.3%.

The foot operated vacuum packing machine designed and field tested for storing soybean seeds under vacuum (to improve the viability up to 9 months) was further improved during the year by making it power operated. At a cost of Rs.5500, this machine can be installed in villages on custom hiring basis by self help groups (SHGs) or small entrepreneurs in soybean growing areas and the investment can be recovered in two years.

For eri culture, the variety 48-1 of castor was found most suitable for eri silk production in Assam, whereas the local variety *Red petiole* supported highest cocoon production in Manipur. In Karnataka, DCH 177 was most effective as silk worm feed giving highest yields and economic returns.

Pulses Based Production System

As a component of IPM module, different intercropping systems were evaluated at IIPR, Kanpur. Chickpea + mustard intercropping system recorded the least pod borer damage and wilt incidence. In the on-farm trials, however, no significant differences were found in the yield of chickpea between different modules due to low incidence of pests during the year. In case of pigeonpea, the cost benefit ratios observed from the on-farm trials were 3.73, 2.58 and 2.67, respectively with CIPM, BIPM and farmers practice in Kanpur district where as at Sehore, BIPM recorded higher ratio (1.43) than CIPM (1.39) and farmers practice (1.22). The BIPM modules need further refinement to increase its effectiveness under high pest load.

On-farm trials in Coimbatore, Guntur, Warangal and Kanpur districts showed that integrated virus management package consisting of resistant variety, seed treatment with insecticide and boarder cropping reduced the diseases incidence by 60% and increased the seed yield by 25% over farmers practice in mungbean and urdbean.

Seed treatment with neem seed powder (5%) + latex (1%) was found to be the most effective treatment for control of root knot and cyst nematodes in chickpea in on-farm trials carried out in

Ghaziabad district for the third successive year. Summer ploughing and intercropping with sorghum caused effective suppression of soil nematode population in pigeonpea fields.

The liquid inoculant technology standardized for *Rhizobium* was also extended to *Azospirillum* and PSB during the year. Besides additional shelf life of 6 months to one year recorded over lignite based inoculant, the liquid inoculant increased the yields of chickpea ranging from 5 to 8% over carrier based inoculant.

The impact of *in situ* moisture conservation practices in maximizing returns in pulse based intercropping system was studied during the year in 6 target districts. At most locations, recommended moisture conservation practices not only improved the yields by 10-21% but also reduced the runoff and soil loss. In medium to deep Vertisols of Bijapur district, greengram-sunflower sequence cropping system with compartmental bunding during *kharif* resulted in increased yield of greengram (15 q/ha) compared to farmers' practice (11.5 q/ha). 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).

The improved and low cost storage technologies for pulses developed through a network project led by CIAE, Bhopal could save post harvest losses up to 10% in redgram, mungbean, urdbean and chickpea. These include use of vegetable oils, specially designed storage bins, treatment with sodium bicarbonate and use of solar beds. These technologies were widely popularized in 5 districts involving more than 1000 farm women. The probe cum pitfall trap technology tested in the farmers households for more than 3 years for detection of pulse beetle was transferred to M/s.KSNM Marketing Co., Coimbatore by TNAU for commercial production.

The performance of the improved dal mill developed by IIPR, Kanpur was further modified during the year by adding a twin reel type grader. The upgraded model was quite effective for all operations including grading of raw material, milling, husk separation and grading of finished products.

Cotton Based Production System

The superiority of the quality *arboreum* varieties was further confirmed during the year which recorded mean yields of 737 – 778 kg/ha across different districts, which were on par with *Bunny* and *Bt* cotton hybrids. However, farmers saved considerably on cost of cultivation (Rs.4900/ha as against Rs.10,000 for *hirsutum* hybrids). A mill test carried out with M/s.Maral Overseas Limited, Indore showed that the fibre characters of PA-255 an improved *arboreum* are comparable in all respects (length, fineness and micronaire etc.) to LRA 5166, a leading *hirsutum* variety.

Forty promising indigenous germplasm lines from *arboreum* and *barbadense* were collected from Assam, Meghalaya and Nagaland and characterized for their yield attributes and resistance to pest and diseases. Though these lines have low yield potential, they showed relatively high resistance/tolerance to leaf roller, jassids, white fly and spotted boll worm making them useful source for varietal improvement.

A regeneration and transformation protocol was standardized for quality *arboreum* varieties like PA-405 and PA-183. Putative transformants containing Cry1A(c) gene were successfully regenerated at a frequency ranging from 1.4 to 5%. The transformed plants are under further evaluation.

Arboreum cotton + sorghum intercropping performed better on upper toposequences in a watershed where as *hirsutum* cottons inter or sequence cropped with legumes gave highest net returns on middle or lower toposequences. Ridges and furrow system was found effective on all the toposequences for rainwater management. After three years of on-farm trials, 30-35% farmers in the target villages adopted the toposequence based rainwater management and cropping systems.

Enhanced moisture availability with ridge and furrow method of planting resulted in higher nutrient use efficiency both in *arboreum* and *hirsutum* varieties. Highest yields were recorded when ridge and furrow system were combined with INM (NPK 80:40:45 + 2 t FYM/ha + limiting nutrient + green manure as mulch + PSB + 2% DAP spray). In a related project, reduced tillage + BBF + 100% RDF + green manure + application of limiting nutrient gave significantly higher yield and benefit cost ratio over all other resource conservation treatments. There was also a significant increase in soil organic carbon, porosity and infiltration rate with residue incorporation.

Differential performance of recommended varieties from *arboreum* and *hirsutum* under various micro farming situations within the recommended zones indicated the need for revisiting the current varietal recommendations for different zones. Soil depth and rainfall are to be given more weightage in varietal recommendation.

Varieties from *G.arboreum* species were found to be more tolerant to salinity and sodicity as compared to *G.herbaceum* and *G.hirsutum* and intra *hirsutum* hybrids. Based on performance over locations, RAHS-14 and *Jayadhar* were found as the most promising salt tolerant varieties for saline and sodic soils in Karnataka and Madhya Pradesh.

Nutritious Cereals Based Production System

Rabi sorghum is a staple crop for millions of small farmers in drought prone areas of Maharashtra and Karnataka. An integrated production technology combining best variety, compartmental bunding and INM was evaluated in 7 target districts covering 104 farmers. The improved package consisting

of variety CSV-216-R + compartmental bunding + 60 kg N + 30 kg P_2O_5 + 3 t/ha FYM + *Azospirillum* increased the grain yields by 50% over farmers practice. Promising stay green genotypes with resistance to lodging and charcoal rot were identified, which will be utilized for further improvement of high yielding genotypes to realize more yields over M-35-1.

In view of the proven superiority of CSV-15 as the dual purpose sorghum variety in north and western parts of the country, technologies were developed to control shoot fly and stem borer during the year. Seed treatment with imidacloprid effectively controlled the shoot fly and protected against stem borer up to 50 days of germination. From feed back studies, it became evident that farmers prefer dual purpose sorghums with atleast 7 feet tall with reasonable grain yield. Further improvement of dual purpose sorghum will focus on this objective.

Studies on dynamics of *kharif* sorghum cultivation in major growing states indicated that there was a study decline in area under sorghum in all the states mainly due to higher economic returns from competing crops. During drought years, however, farmers realised the importance of *kharif* sorghum as fodder for livestock. Promoting alternate uses of sorghum could be one way of retaining area under this important crop.

In semi-arid Vertisol areas of Maharashtra and Tamil Nadu, paired row planting of pearlmillet at 30/60 cm and opening of furrows in wider row at 35 DAS was found to be a most cost effective and farmer friendly practice tried across 7 target districts. The additional net returns with this practice ranged from Rs.600-1200/ha depending on the quantum and distribution of rainfall. In 6 target districts falling in arid zone of Rajasthan, Gujarat and Haryana, ICMH-356, GHB-577 and HSB-117 were found to be the most promising pearlmillet hybrids on farmers fields recording 25-40% additional yield over local checks. Among moisture conservation practices tried, maximum grain and fodder yield were recorded with planting of pearlmillet at 60 cm, making ridge and furrow after inter culture (30 DAS) in wider row spacing (60 cm) with 50% of recommended N through fertilizer + 50% through FYM.

In view of the concerns on protein malnutrition among tribals, a number of legume intercrops (field bean, pigeonpea and cowpea) were tried in fingermillet, little millet and kodo millet. These systems recorded C:B ratios ranging from 1.5 to 2.0 as against farmers practice of sole millets or mixed cropping (1.0-1.2). On wider adoption, these simple interventions can contribute significantly to address the protein malnutrition among tribals in remote areas.

For the third successive season, improved variety (GPU-28 in Karnataka and Tamil Nadu and VL-149 in Uttaranchal) with seed treatment was found to be the most effective measure for controlling

blast in fingermillet. The management package was popularized extensively in Karnataka and Tamil Nadu through farmer's interaction meets and training programmes.

In a major network project in maize based production system in sub mountain regions of Himachal Pradesh and Punjab, harvesting runoff from entire village catchment into the existing ponds and its recycling led to significant increase in productivity, cropping intensity and crop diversification. The watershed approach successfully implemented in village Johranpur (H.P) not only improved the income level of farmers but also helped in overcoming caste divide and promoted social harmony. This successful example was covered extensively by major newspaper dailies in North India.

In view of the encouraging response obtained from market yards and fetching higher price for sorghum harvested at physiological maturity and dried, a ventilating type dryer was fabricated and field tested during the year in Parbhani district of Maharashtra with a capacity of 1.5 t/h and a breakeven output of 20-30 tons. It can be installed in major sorghum growing villages on custom hiring basis. Efforts to improve the *roti* making quality of sorghum were continued during the year by preparing suitable constructs with glutenin gene and kafirin promoter, which will be used to transform the immature embryos of sorghum identified as best explants for this purpose.

The project on using sweet sorghum as raw material for ethanol made excellent progress during the year with the identification of many promising varieties and hybrids superior to SSV-84 from field trials and undertaking contract farming projects with distilleries in Andhra Pradesh and Maharashtra. The successful pilot project carried out with M/s.Renuka Sugars in Belgaum during 2002-03 provided enough data on the viability of sweet sorghum cultivation for ethanol production. About 13 t of breeder seed of SSV-84 was produced by NRCS and distributed to 15 sugar mills in Maharashtra, Andhra Pradesh and Tamil Nadu, which resulted in 1000 ha area under contract farming.

In order to improve the efficiency of action plans preparation and identification of critical areas in watersheds, data from IRS-1-C was used in 7 pilot projects in *kharif* sorghum based production system. The performance of the conservation structures and yield data from crop interventions were recorded during the year. Quick bird multispectral maps of the structures at high resolution were obtained during the year which confirmed that remote sensing approach can be successfully used not only for planning of watershed projects but also its monitoring.

Forest and horticulture land use systems sequestered more carbon than arable crops from a study of bench mark sites in semi arid zones under different land use practices. Legume based intercropping systems sequestered more carbon followed by cereal based and cotton based ones.

The potential of agri-horticultural land use for income stabilization of farmers in drought prone areas of Maharashtra and A.P was demonstrated in traditional *kharif* sorghum areas. Simple interventions like moisture conservation practices in the basins, balanced nutrition and timely pest management significantly enhanced the yields and returns from fruit spices like *ber*, mango, sapota and custard apple. In the project on silvi pasture systems, reseeded and sown pastures exhibited their superiority over natural pastures. Supply of higher crude protein through more legume component in such pastures increased the body weight and milk production in cattle.

Among large number of live fences evaluated, *Agave* and *Acacia cassia* (chiller) were found to be most promising across different rainfall zones and soil types. In terms of economic returns, however, *Lawsonia* was superior. Most fences, however, caused competition with the field crops up to 2 m length from the bund resulting in yield declines up to 6-20% indicating the need for standardizing a proper pruning/management practices for live fences to make them compatible with field crops.

In order to improve the income of farmers taking up industrial biomass plantations of *Eucalyptus* and *Leucaena,* various intercrops were introduced during early years in Khammam district of Andhra Pradesh in collaboration with M/s.Bhadrachalam Paper Boards, a leading user of wood pulp for manufacture of paper boards in the country. Data recorded during the 3rd year (first year of cropping) indicated that higher collar girth of trees (*Eucalyptus*) was realised with farmers practice of 3 x 2 m spacing whereas paired row and triple row plantings resulted in lower tree growth but higher intercrop yields.

To reduce the cost of poultry feeds by replacing maize with sorghum, pearlmillet and fingermillet, a number of new formulations were made and tested with commercial poultry farms. Substitution of maize upto 70% with fingermillet not only reduced the cost of feed but also decreased the serum LDL cholesterol in *Vanaraja* birds. These results open up opportunities to use dietary formulations as a means of producing eggs with LDL cholesterol.

CHAPTER 1

The Rainfed Agro Ecosystem

Rainfed Agro Ecosystem covers nearly 66% of the net cultivated area supporting 40% of the India's 1000 million population and contributes 44% to the national food basket. Ninety one per cent 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. Farmers' dependence on livestock as an alternative source of income is high. However, the ecosystem as a whole is characterized by instability in biological productivity caused by aberrant weather. Farmers are resource poor with poor infrastructure and credit support. The quantum and distribution of rainfall has an over riding influence on the productivity and profitability in this agro ecosystem.

Traditionally rainfed areas are classified into distinct climatic zones known as arid, semi arid and sub humid. However, this classification does not adequately reflects the complex interplay of the large number of climatic and edaphic factors influencing the production potential of different components or sub regions within the agro ecosystem. Therefore under NATP, homogenous ecoregions with similar agro-ecological characteristics and production constraints were delineated as agro ecosystems (AES). The rainfed agro ecosystem, one of the five identified under NATP is the largest in area and also quite diverse in farming systems. The AES based research prioritization followed under NATP also marked a major departure from commodity to production system research and facilitated multi-disciplinary and multi-institutional approach in project planning and implementation. Most rainfed areas characterized by dry and wet semiarid tropical climate fall in the agro ecoregions 4 to 8 but the target domain in the rainfed agro ecosystem under NATP extended beyond these regions into sub humid zones in Orissa, West Bengal and Assam mainly to address the problems of the rainfed rice based production system in totality including the rice-jute cropping system.

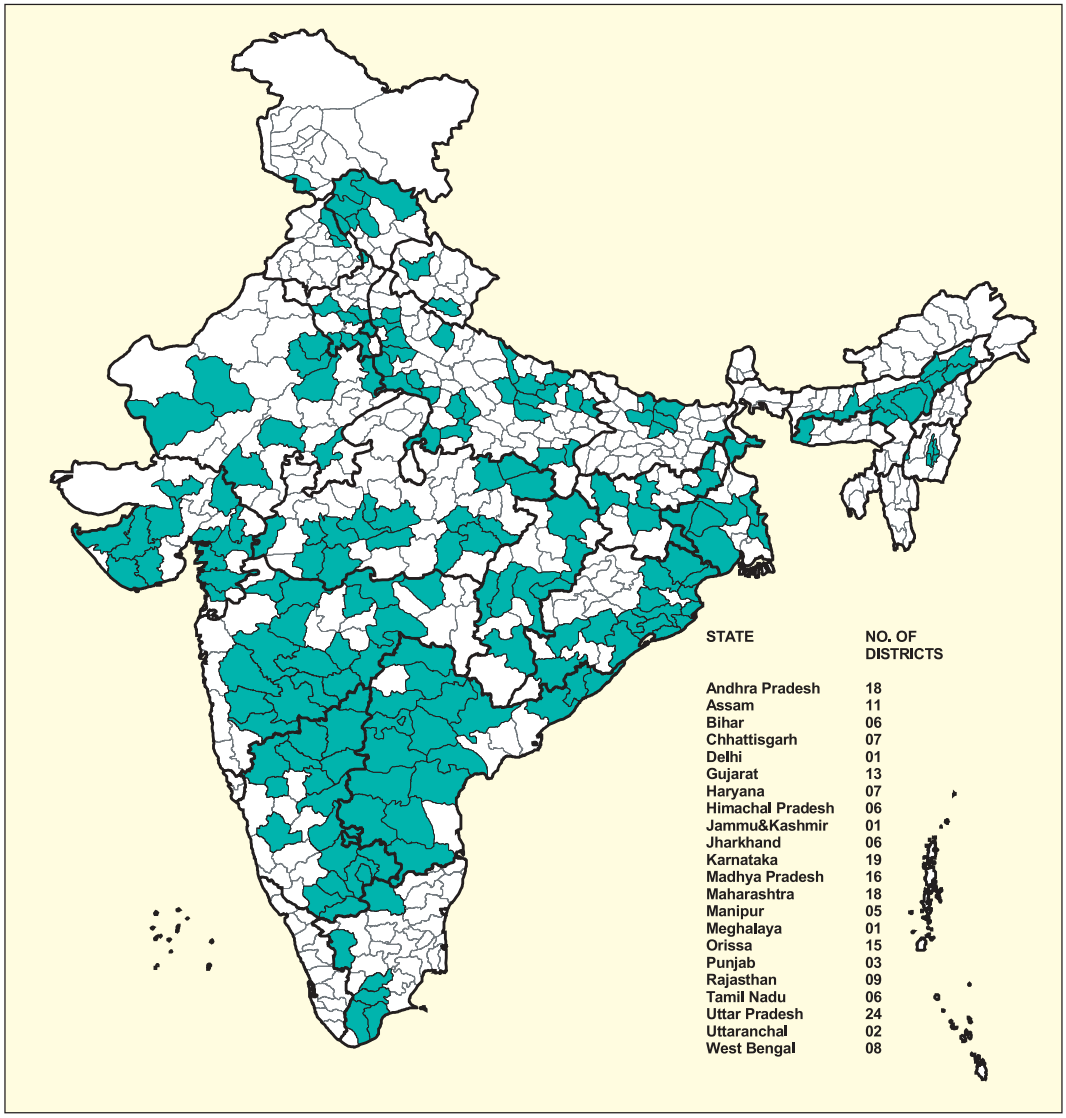
Production System Approach

Since, problems in agriculture and livestock farming in a given agro ecosystem are highly complex and need to be looked into on area basis rather than as individual components, the rainfed agro ecosystem was further sub divided into homogenous production systems. These production systems largely represent important commodities as dominant component of the cropping systems/ farming systems. The 5

production systems identified under rainfed agro ecosystem are: i) rice based ii) nutritious (coarse) cereals based iii) oilseeds based iv) pulses based and v) cotton based. The major constraints in research and technology transfer were identified based on a detailed analysis of district level data of rainfed typologies for each of the production system but for development of specific projects, the production systems have been further sub divided into homogenous clusters and specific problems identified at micro level. Individual projects were developed to address the problems of the farming system as a whole including horticulture, agro-forestry and livestock.

On-Farm Adaptive Research (OFAR)

Out of 103 sub projects initiated under Rainfed Agro Ecosystem, rainfed rice (35) and nutritious cereals (27) based production systems received high priority in view of the extent of area



Target districts of production system research under rainfed AES

coverage. The other production systems i.e. oilseeds, pulses and cotton covered 18, 12 and 11 projects, respectively. At the macro level, target districts for production system research were chosen based on defined guidelines like area, production, productivity of a crop/cropping system including livestock and the important constraints limiting the productivity in the particular district. Nearly 225 districts in 22 states were covered in the rainfed agro ecosystem. The unique feature of these projects was that 66% of the projects were implemented on farmers fields wherein recommended technologies in a given agro ecological zone were evaluated in comparison to farmers practice in a participatory manner. Each field trial was laid in five representative villages of the target district involving two farmers from each village. This way, the on-farm trials could generate statistically valid data from real farm situations instead of serving as demonstrations and enhancing the scope of its replicability to other areas within the district and the agro ecological zone. Each OFAR project also included extensive visits to farmers research plots from neighboring villages of the district. The remaining projects addressed issues like resource characterization and analysis of production and productivity trends. Among the thrust areas, natural resources management (NRM) received the highest priority followed by post harvest technology, crop improvement, IPM, INM and socio economic issues. A breakup of the PSR projects in different thrust areas is given in the following table. During 2003-04, ninety one of the 103 initially sanctioned projects were under operation. The OFAR projects during the year covered 5800 farmers in 2150 villages in 180 target districts.

Total sanctioned and subprojects under operation during 2003-04 under different production systems

Theme Area	Rainfed Rice		Oilseeds		Pulses		Cotton		Nutritious Cereals		Total	
	Sanctioned projects	Under implementation during 2003-04	Sanctioned projects	Under implementation during 2003-04	Sanctioned projects	Under implementation during 2003-04	Sanctioned projects	Under implementation during 2003-04	Sanctioned projects	Under implementation during 2003-04	Sanctioned projects	Under implementation during 2003-04
Natural Resource Management	11	10	1	0	1	1	3	3	10	10	26	24
Integrated Pest Management	3	3	3	3	4	4	0	0	2	1	12	11
Post Harvest Technology/ Value Addition	3	3	6	6	3	3	0	0	7	7	19	19
Biotech/Crop Improvement	5	5	2	2	0	0	5	5	2	1	14	13
Water Management	3	3	2	2	1	1	0	0	2	2	8	8
Integrated Plant Nutrient Management	6	5	1	1	2	2	1	1	1	1	11	10
Agro-Biodiversity	1	1	1	1	0	0	1	1	0	0	3	3
Socio Economics	3	1	2	0	1	0	1	0	3	2	10	3
Total	35	31	18	15	12	11	11	10	27	24	103	91

CHAPTER 2

Rainfed Rice Based Production System

Rainfed rice is grown on nearly 22.5 million ha constituting 50% of the gross area under rice crop. The average productivity of this crop has remained around 1.0 t/ha for many y ears. After a detailed constraint analysis, 35 sub projects were initiated on this production system out of which 31 were under operation during 2003-04. These projects addressed issues such as rainwater conservation, soil management, integrated nutrient management, participatory varietal development, crop diversification, cropping systems, IPM, model farming system and post harvest technology. Significant achievements are summarised below:

Increasing Cropping Intensity

One of the key strategies identified for rainfed rice based production system in eastern India is to increase the cropping intensity by introduction of a *rabi* crop after the harvest of *kharif* rice. Diversification of rainfed rice with relatively more remunerative pulses and oilseed crops is another approach. Earlier studies under 3 sub projects clearly indicated the possibilities of increasing cropping intensity upto 140 – 160 % with adoption of recommended production technology for *kharif* rice along with appropriate moisture conservation strategies for *rabi* cropping.

During 2003-04, 21 on-farm trials were carried out covering 90 farmers in 22 villages in 6 target districts i.e. Raipur, Ranchi, Darisai (East Singhbhum), Rewa, Dhenkanal and Sidhi. The intercropping systems found most productive for upland situation were redgram + groundnut in Ranchi (0.73 + 1.35 t/ha) and Darisai (0.68 + 0.75 t/ha), rice + redgram in Rewa (0.5+ 0.39 t/ha to 0.72 + 0.47 t/ha) and Sidhi (0.42+ 0.38 t/ha to 0.5+ 0.31 t/ha). At all locations, integrated weed management (IWM) produced significantly higher economic returns over farmers practice.

In case of medium land situation, the targeted yield (TY) practice (best variety + line sowing + fertilizer dose to achieve targeted yield) gave 48, 36 and 51 per cent higher yield of *kharif* rice over farmers practices at Raipur, Rewa, Sidhi, Ranchi and Darisai, respectively. The yield realised with TY practice ranged from 3.22 to 4.32 t/ha at different locations and the corresponding increase in net income over farmers practices ranged between 30-50 per cent. *Rabi* crops grown after rice raised with TY practice recorded higher seed yield at all

centers compared to farmers practice. Under this system, gram was found to be most promising at Raipur (0.76 t/ha), Ranchi (0.68 t/ha) and Darisai (0.72 t/ha). The net returns realised from the rainfed rice based cropping system as a whole ranged between Rs.11361-17624/- per hectare in different districts, which were significantly higher than the income derived with farmers practice.

In low lands, the TY practices for *kharif* rice realised 49, 23, 36, 39 and 67 per cent higher yield over farmer's practice in Raipur, Rewa, Sidhi, Ranchi and Darisai, respectively with absolute yield ranging between 3.56 to 5.24 t/ha. Among different *rabi* crops grown after rice with TY practice, gram and safflower at Raipur (0.82 + 0.93 t/ha) and gram at Ranchi (0.52 t/ha) were found to be more productive. The net returns from the rice based production system as a whole ranged between Rs.12145-25432/ha in low lands.

Cropping intensity in villages adopted by different centers 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 of the project 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 Chhattisgarh, the area under double cropping increased significantly during the last five years with the realization among farmers that higher profitability is possible with pulses and oilseeds as a second crop after *kharif* rice. This increased cropping intensity also provided additional

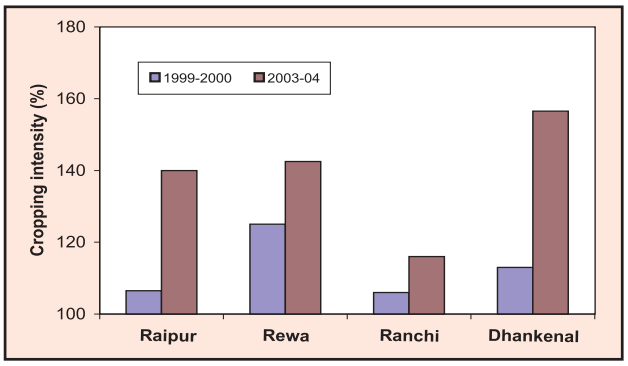


Fig.1: Change in cropping intensity in OFAR villages in four target districts before and after the project

employment to agricultural labourers and helped in checking migration.

Rainwater Harvesting and Recycling

Due to the skewed distribution of rainfall and field water losses, rainfed *kharif* rice crop in Chhattisgarh, Orissa and Jharkhand suffers from droughts leading to significant drop in yields despite the region receiving relatively higher total annual rainfall of over 1200 mm. Hence, a pilot project was taken up to harvest the surplus water through creation of on-farm reservoirs (OFRs) in a series along the slope of the rice landscape and ground water structures like dug wells and ditches in recharge areas of these OFRs. It was shown during 2001-2003 that significantly higher productivity can be realised from *kharif* rice in the area served by water harvesting structures (WHS) by saving the crop from drought through supplemental irrigation. The benefits of harvested water can be further enhanced with the adoption of improved management practices for *kharif* rice.

During 2003-04, which was characterized by uneven rainfall distribution, the harvested water

could meet complete water requirement of the *kharif* rice and also enabled taking up a second crop. Rainfed rice in low land situation receives water not only from rainfall but also from runoff from surrounding unbunded fields/lands. The rainfall and runoff so received could effectively meet the water requirement of rice and that of subsequent *rabi* crops giving substantial economic gain to the farmers when excess water was stored through on-farm reservoirs (OFRs). This process also contributed to recharge of groundwater. As a result of recharge from OFRs, the groundwater was available at shallow depth (< 1 m depth during rainy season and 2-3 m depth during winter) as a source of *in situ* water supply.

The increased returns from higher yields as well as increased cropping intensity justify the investment on water storage and groundwater structures (Table 1). The area served by water harvesting structures ranged from 37-45 ha at Bagbhara block in Chhattisgarh and 12-30 ha at other centers in Jharkhand and Orissa involving a large number of farmers at each project site. The net returns during 2003-04 from *kharif* and *rabi* represent 45 to 75% of the initial investment with improved practice and 9 to 30% with farmers practice. Along with using harvested water, adoption of improved package of practices both for *kharif* and *rabi* crops is key to recovering the initial 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. Both the experimental sites at

Table 1: Yield and economics of *kharif* and *rabi* crops in the project area covered by water harvesting structures (WHS) in different target districts (2003-04)

Target district	Block	Total area under WHS	Average productivity of *kharif* rice (q/ha)			Gross income from rice (000 Rs)		*Rabi* crops	Gross income from *rabi* crops (000 Rs)		Cost of cultivation for *rabi* and *kharif* crops in project area (000 Rs)		Total net returns from *kharif* and *rabi* crops from project area (000 Rs)		Total investment on WHS (000 Rs)	Net returns during 2003-04 as % of initial investment on WHS	
			Within the project area		Out side project area	Farmers' practice	Improved practice	Outside project area	In the project area	Outside project area	Farmers' practice	Improved practice	Outside project area	Farmers' practice	Improved practice	Outside project area		Farmers' practice	Improved practice
			Farmers' practice	Improved practice															
Mahasa-mund	Bagba-hara	39.6	40.45	48.63	30.41	801.1	963.2	602.3	*	173.4	0.0	348.6	467.1	312.9	452.6	669.4	289.4	539.2	30.3	70.5
East Singh-bhum	Ghat Shila	20.5	14.45	22.77	6.64	177.7	280.0	81.6	*	187.3	0.0	82.1	221.9	82.1	95.6	245.5	-0.5	331.9	29.0	74.1
Dindori	Dindori	24.9	19.59	33.43	14.05	243.9	416.2	174.9	*	237.1	59.5	183.1	294.7	178.1	120.3	358.5	56.3	473.6	13.5	63.8
Keonjhar	Keonjhar	23.0	26.67	38.00	21.00	374.8	533.1	295.6	*	320.2	0.0	154.1	317.6	154.1	220.7	535.7	141.5	863.0	9.2	45.7

* ***Rabi*** crops at **Bagbhara** were wheat, gram, vegetables, pea, lentil and lathyrus; at **Darisai** were brinjal, khira, kakri, sponge gourd, bottle gourd, bitter gourd, cowpea, jhinga, tomato and tinda; at **Dindori** wheat, gram, vegetables and pea and at **Keonjhar** winter rice, potato, tomato, pea, wheat, brinjal, cucurbits, chillies, radish, bengalgram, and summer maize.

Bagbhara in Chhattisgarh and Keonjhar in Orissa became models for rainwater harvesting for drought mitigation of *kharif* rice for wider adoption. Govt. of Chhattisgarh has already constructed 50 thousand OFRs so far out of the total target of 200 thousands.

Management of Excess Water in Medium and Low Lands

On-farm trials were continued during the year on management of excess water in medium and low lands by storing in refuges outside the field and integrating with fish culture. Results from previous two years indicated that both cropping intensity and net income can be enhanced by using stored water for second crop and fish culture in the refuges. The trials were carried out in all the target districts with the same treatments i.e. 3 dyke heights of refuges in medium lands and culturing four fish species i.e. *C.catla, L.rohita , C.mrigala, C.carpio* in 30:30:20:20 ratio with a population density of 20,000 fingerlings/ha. Utilising the water stored in the refuges, *rabi* crops like winter rice, pumpkin, greengram, blackgram were grown, while fruit plants like papaya and banana were raised on the enbankment of refuges.

To illustrate the results from the project, data from OFTs of Sadeiberini village, Dhenkanal district in Orissa are presented here. With near normal rainfall of 1572 mm during the year, the refuges could store 1.17, 1.40 and 1.46 m depth water in medium lands with 15, 20 and 25 cm weir heights, respectively. In all the refuges adequate water was available upto the end of April, 2004 to rear fish and provide supplemental irrigation

An ideal fish refuge with fruit plants on the embankment

to *rabi* crops. The grain yield of *kharif* rice was 4.76, 5.19 and 4.52 t/ha, respectively with 15, 20 and 25 cm weir heights, respectively. The superiority of 20 cm weir height was confirmed during the year. The highest fish yield (1.86 t/ha/180 days) was however obtained from 15 cm weir height refuge (Table 2). The other refuges recorded almost same yield of fish. Similar results were recorded in other two target districts.

Considering the overall economics of the crop and fish yields, suitable weir heights have to be followed to maximise crop/fish yields. Irrespective of multi-variate treatments, growth rate of C. *carpio* was maximum followed by C. *mrigala* and C. *catla* in all treatments. Bottom feeders (C. *carpio* and C. *mrigala)* registered better growth rate than that of *L. rohita* (column feeder) probably due to higher tolerance to oxygen depletion and suspended solids. Among bottom feeders, growth performance of C. *carpio* appears to be better than C. *mrigala* probably due to their superior feed utilizing capability. Utilizing the water stored in the refuges, the entire experimental area was brought

Table 2: Comparative growth, survival and yield of 4 cultured fish species in the refuges (medium land) in Dhenkanal district

Weir height	Species reared*	Initial MBW (g)	Final MBW (g)	PDI (g)	FSR (%)	Yield (kg)	Productivity (t/ha in 180 days)
15 cm	*C.catla*	0.94	142.40	0.78	64.70	4.70	1.86
	L.rohita	0.97	105.70	0.58	68.60	3.70	
	C.mrigala	0.91	144.40	0.80	79.40	3.90	
	C.carpio	1.10	240.00	1.32	44.10	3.60	
20 cm	*C.catla*	0.94	109.50	0.60	47.70	4.60	1.24
	L.rohita	0.97	75.00	0.41	59.00	3.90	
	C.mrigala	0.91	163.60	0.90	55.90	5.40	
	C.carpio	1.10	204.70	1.13	35.60	4.30	
25 cm	*C.catla*	0.94	93.50	0.51	56.40	2.90	1.25
	L.rohita	0.97	52.30	0.28	76.40	2.20	
	C.mrigala	0.91	166.60	0.92	64.80	4.00	
	C.carpio	1.10	160.00	0.88	40.50	2.40	
Lowland reservoir	*C.catla*	0.94	158.1	0.87	25.3	29.25	0.685
	L.rohita	0.97	113.7	0.62	27.2	22.30	
	C.mrigala	0.91	125.2	0.69	27.3	16.40	
	C.carpio	1.10	246.5	1.36	12.8	14.30	

MBW – Mean Body Weight, PDI – Per Day Increment, FSR – Final Survival Rate ; * see text for species composition

under *rabi* crops (rice, pumpkin, greengram and blackgram). Thus, the cropping intensity of the experimental site increased from 100 to 200%.

Safe Disposal of Excess Water

With an objective to check soil erosion from upper reaches and sand casting in the lower regions of sloppy lands due to high intensity rainfall, on-farm trials were carried out in Sudreju watershed of Phulbani district in Orissa by creation of different types of waste weirs for safe disposal of excess runoff. As in the previous years, three treatments i.e. brush wood structure (T_1), loose boulder structure (T_2) and control (T_3) were tried with paddy as the test crop. Each treatment was replicated 7 times in adjacent fields. Under each treatment, a waste weir of 0.5 to 0.8 m wide was provided depending on the expected runoff. Both the structures proved effective and trapped the silt carried by the runoff. This facilitated better infiltration of water in the crop fields and higher yields in the treated plots as compared to the control. The yield and yield attributes of *kharif* rice under different treatments are presented in Table 3. Loose boulder structures increased the grain and straw yields by 43.4% and 23.2% over control as against 36.9 and 19.1 % with brush wood structures. However, both these treatments were on par. From maintenance point of view, loose boulder structures were found superior.

Table 3: Yield attributes and grain yield of rice as influenced by run off control treatments during 2003-04

Treatments	Panicles/ m^2	Tillers/ m^2	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
T_1 – Brush wood structure	51	58	25.18	1.01	2.64
T_2 – Loose boulder structure	72	82	25.57	1.06	2.73
T_3 – Control	39	42	25.01	0.74	2.21
CD (0.05)	16	20	NS	0.17	0.24

Stone boulder structure across the field bund for safe disposal of excess water

Presence of conservation structures on field bunds was not only useful for arresting soil loss and increasing yield of *kharif* rice but also stored higher soil moisture in the profile. The soil moisture recorded at harvest of the *kharif* crops were 8.35, 14.36 and 12.38% in T3, T2 and T1 treatments, respectively. During 2003-04 *rabi*, an attempt was made to grow mustard, which established successfully but could not be taken upto the harvest stage due to lack of rainfall in November.

Watershed 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. A number of projects addressed these issues in different target districts and promising technologies were evaluated on farmers fields.

Soil and runoff control in hilly areas

A network project on soil and runoff control in Orissa, A.P and Chhattisgarh resulted in development of technologies for rehabilitation of degraded hillocks, identification of vegetative barriers and suitable species for bund plantation. At Koraput, least runoff and soil loss was observed with guava-stylo-trench treatment followed by cashew-stylo-trench (Table 4). The trench improved the soil moisture at all locations due to greater infiltration and runoff. Among the fruit plants, guava proved better at Koraput with 89% survival while at Jagdalpur and Bhawanipatna, cashew and *ber* were found most promising. Among the vegetative barriers tried at Koraput, *Sambuta* and *Vetiver* showed comparable performance. Hill broom showed the best performance at Bhawanipatna, Chintapalli and Jorhat. *Glyricidia* was found to be the best hedge row species at Koraput and Bhawanipatna in terms of survival, whereas mulberry and subabul exhibited superior growth at Jagdalpur. However

Hedge row of glyricidia with sambuta grass filter strip for controlling soil and water erosion in upland of Koraput district

at all the locations, Assam shade with grass supplement exhibited best performance in terms of controlling runoff and soil loss. Likewise, *Gmelina arborea* was found to be the best species for bund plantation resulting in 70-90% survival followed by teak on majority farmers fields.

Watershed planning and monitoring through remote sensing

With a view to assess the usefulness of remote sensing approach in prioritization of critical areas, preparation of action plans, implementation and monitoring of watershed based resource conservation, 7 microwatersheds in the districts of Koraput, Nayagarh (Orissa), Mahasamund (Chhattisgarh), Ranchi (Jharkhand), Purulia (West Bengal) and Jorhat (Assam) were selected as a pilot project. During 2001-02, the critical areas for prioritization of treatments were identified using maps from IRS IC / ID, LISS –III and the data generated by NBSS&LUP regional center at Kolkata. All the engineering and crop interventions were carried out during the year. The impact of conservation structures on improvement in water level and increasing cropping intensity were quantified with emphasis on uplands and medium lands. Data collected on the performance of water conservation structures in terms of storage during runoff events and the performance of mechanical and vegetative barriers in arresting soil and runoff indicated that locating these structures by using remote sensing methods was found quite satisfactory as against physical surveys. Attempts are now

Table 4: Effect of integrated land management practices for runoff and soil loss control from degraded hillocks in Koraput, Orissa

Treatment	Runoff (%)			Soil loss (t/ha)		
	2002	2003	Mean	2002	2003	Mean
Cashew+Grass+Trench	8.09	13.4	10.74	4.40	6.97	5.69
Cashew+Grass+No trench	12.97	12.7	12.81	6.90	5.81	6.36
Guava+Grass+Trench	9.35	14.3	11.83	5.20	7.78	6.49
Guava+ Grass +No trench	14.60	12.8	13.71	8.10	6.17	7.14
Cashew+Stylo+Trench	7.10	13.0	10.04	3.54	6.66	5.10
Cashew+Stylo+No trench	11.12	12.8	11.98	6.10	5.63	5.87
Guava+Stylo+Trench	5.90	10.8	8.36	3.23	3.83	3.53
Guava+Stylo+No trench	10.42	10.7	10.54	5.70	3.30	4.50

being made to use maps from high resolution Quickbird satellite for monitoring the changes in land use, crop cover and water bodies at the end of the project.

Integrated Nutrient Management

Jute-rice cropping system is quite exhaustive in terms of its nutrient requirement. Achieving targeted yields of both the crops on a sustainable basis is a major challenge in terms of nutrient management. Therefore on-farm trials were carried out at 5 locations viz. Barrackpore, Cuttack, Kendrapara, Nagaon and Katihar to identify the most suitable INM practice to achieve the targeted fibre yield of jute (2.5 to 3.0 t/ha) and grain yield of rice (3.5 to 4.0 t/ha). Results from 3 successive seasons i.e. 2001-02, 2002-03 and 2003-04 demonstrated that targeted yields (TY) can be achieved at all locations with 100% N of TY through urea and 75% through urea + 25% of N through *Glyricidia*/FYM (INM treatment). However, maximum yields for both the crops were realised with the latter treatment at Barrackpore, Kendrapara, Nagaon and Katihar, while at Cuttack the yields were at par under both the treatments (Table 5). 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 a related project on INM in uplands and medium lands for rainfed rice in Phulbani district of Orissa, 75% RDF (60-30-30 N:P:K) + 5 t/ha of FYM and intercropped blackgram produced

Table 5: Effect of different INM 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 *Glyricidia*/FYM

T_3 : 75% N of TY through urea

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

T_5 : Farmers practice

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. During the 2003-04, large number of training programmes were organized on raising green leaf manuring species like *Glyricidia,* Subabul, *Cassia,* thornless *Mimosa* and *Pongamia* on field bunds and improved methods of composting/using FYM.

Soil Quality Maintenance in Rice Based Cropping Systems

In view of the concerns of long term impact of same cropping system on soil quality, a net work project was taken up to study the impact of long term adoption of 6 rice based cropping systems at different locations on physical, chemical and biological properties of soil. 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. Two other cropping systems from semi arid zone i.e. sorghum - castor and groundnut - redgram were also included for comparison. During 2003-04, soil samples from all the locations were drawn and analysed for different parameters. The soil quality index was calculated by two methods i.e. conventional (by comparing with the fallow as base line) and statistical (giving appropriate weightage for different parameters for their importance in maintaining soil quality).

Overall results indicated that 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 for a few instances caused a net degradation in soil quality. Of the 32 parameters analysed, 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-redgram cropping systems. Treatments, which maintained high (SQI) at different locations are listed in Table 6.

Study of organic pools

Soil samples from long term fertilizer experiment (LTFE) plots were analysed for different organic pools and its dynamics from 6 locations some of which included rice based cropping systems. During the year, depth wise soil samples were analysed for different pools of carbon and related with the treatments that were followed for more than 15-20 years. 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 and Vertisol of Akola and Solapur. Balanced use of NPK sustained crop productivity, which was higher than that of control, N and NP treatments. However, integrated use of NPK along with FYM helped in maintaining

Table 6: Indicators identified for assessment of soil quality (SQI) and the best treatments which improved SQI under different cropping systems.

Location	Soil type	Cropping system	No. of years of experimentation	Best Indicators identified out of a set of 25-30	Best Management practice	SQI
Gayeshpur	Inceptisol (sandy loam)	Rice-Wheat	18	Organic C, mineralizable N, alkaline phosphatase & aryl sulphatase	• 75% N as urea + 25% N through green manure +100% PK	0.942
					• 75% N as urea + 25%N through paddy straw + 100% PK	0.877
Titabar	Entisol (clay loam)	Rice-Rice	15	Avail. K, total P, DTPA-Zn,	• 50% N urea + 50% N as FYM + 100% PK	0.81
				earthworms & % base saturation	• 100% NPK	0.80
Anantapur	Alfisol (sandy loam)	Groundnut-Redgram	19	Available P, K, Zn, microbial biomass	• 50% NPK + FYM @ 4 t/ha	1.47
				carbon, pH & water holding capacity	• 100% NPK	1.46
Varanasi	Inceptisol (sandy loam)	Rice-Lentil	19	Available P, Ca & Mg	• 100% N as FYM (10 tha^{-1})	0.93
					• 50% N as FYM (5 t ha^{-1})	0.86
					• 50% N as urea + 50% N as FYM	0.83
Hyderabad	Alfisol (sandy loam)	Sorghum-Castor	9	Available N, K, S, microbial biomass carbon & hydraulic conductivity	• *Glyricidia* loppings (GL) @ 2 t ha^{-1} fresh weight + 90 kg N ha^{-1} under conv. tillage ($CTGLN_{90}$)	1.06
					• $CTGLN_{60}$	1.01
Barrackpore	Entisol (sandy loam)	Jute-Rice-Wheat	33	Available P, total N, microbial biomass	• 100% NPK + FYM @ 10 t/ha	1.48
				carbon & mean weight diameter	• 100% NPK	1.26
Cuttack	Inceptisol (sandy clay loam)	Rice-Rice	35	Available K & dehydrogenase activity	• 100% NPK+ FYM @ 5t ha^{-1}	0.93
					• 100%NPK	0.77
Keonjhar	Inceptisol (silty clay loam)	Rice-Field pea	16	Microbial biomass carbon, microbial quotient, urease & Olsen's P	• 100% NPK + FYM 5t/ha	0.53
					• 100% NPK	0.54

Gayeshpur : N:P:K, Rice – 120:60:60, Wheat – 100:60:60; Titabar: Rice – 40:20:20; Anantapur : Groundnut – 20:40:40; Varanasi : Rice – 100% N = 50 kg N Barrackpore: Jute – 60:13:50; Rice & Wheat – 120:26:50; Cuttack: Rice – 60:40:40; Keonjhar : Rice – 80:40:40, Mustard – 40:20:20, Field pea – 20:40:40

maximum productivity and soil fertility. Thus, either NPK or NPK+FYM showed relatively higher sustainable yield as compared to control, N and NP treatments.

Continuous application of inorganic fertilizer N or NP alone could not improve active pools of carbon (soil microbial biomass C, water soluble C and water soluble carbohydrate). Balanced use of NPK along with FYM registered the highest active pool of soil organic carbon 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 Humic Acid-C was comparatively lower than Fulvic Acid-C in treatments receiving NPK and NPK + FYM possibly due to higher root biomass and regular application of newly humified manure into the soil.

Balanced fertilization enhanced the 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 (Table 7).

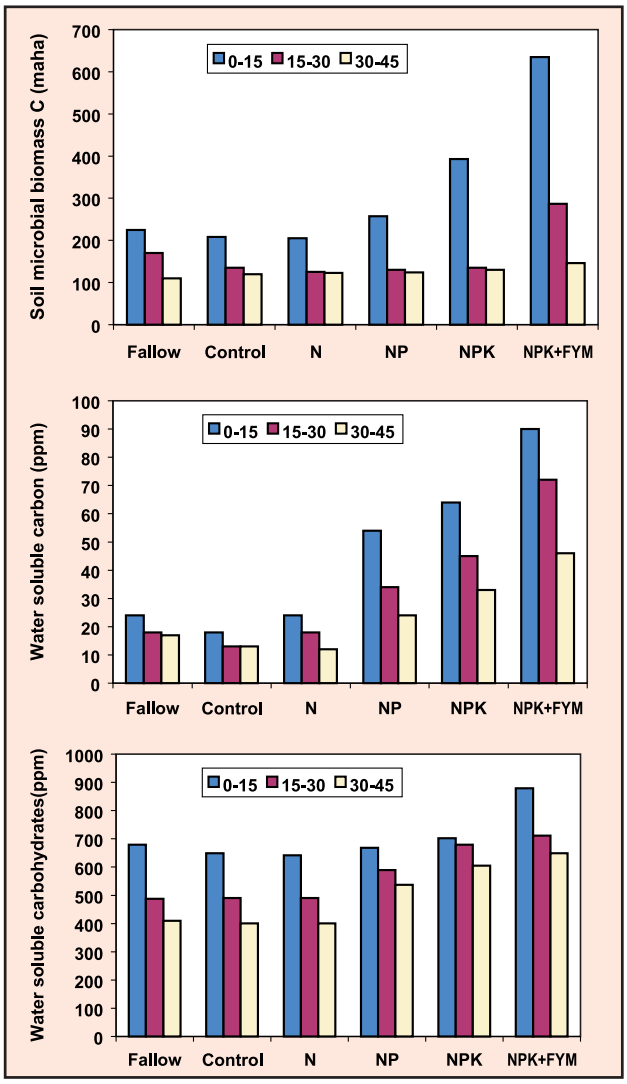


Fig 2. Active pools of carbon under different treatments in long term fertilizer experiment at Barrackpore

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 was 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.

Table 7: Influence of fertilizer and manure application and long term cropping on organic C content in surface soils at various experimental sites

Treatment	SOC Mg ha^{-1}					Increase over control (%)				
	Barrack-pore	Ranchi	Akola	Bangalore	Raipur	Barrack-pore	Ranchi	Akola	Bangalore	Raipur
Cropping system	Rice-Wheat	Soybean-Wheat	Sorghum-Wheat	Finger-millet-Maize	Rice-Wheat	Rice-Wheat	Soybean-Wheat	Sorghum-Wheat	Finger-millet-Maize	Rice-Wheat
Total cropping years	30 yrs	29 yrs	14 yrs	14 yrs	5 yrs	30 yrs	29 yrs	14 yrs	14 yrs	5 yrs
Control	11.22 (-4.40)	7.70 (-2.20)	9.90 (-0.22)	10.12 (-6.00)	13.64 (-0.44)	—	—	—	—	—
N	11.88 (-3.74)	8.80 (-1.10)	11.66 (+1.54)	16.78 (+0.66)	13.86 (-0.22)	5.80	14.29	17.77	6.52	0.80
NP	13.20 (-2.42)	9.68 (-0.22)	12.32 (+2.20)	11.22 (-4.90)	14.74 (-0.66)	17.64	25.71	24.44	10.86	6.40
NPK	14.08 (-1.54)	10.12 (+0.22)	12.98 (+2.86)	13.20 (-2.92)	15.62 (+1.54)	25.49	31.28	31.11	30.43	13.60
NPK+FYM	16.72 (+1.10)	10.78 (+0.88)	15.66 (+5.54)	16.28 (+0.16)	16.06 (+1.98)	49.01	40.00	5.55	60.86	16.80
Initial values	15.62	9.90	10.12	16.12	14.08					

N.B. The data given in parentheses indicate the increase (+) or decrease (-) in soil organic C over the initial status.

Integrated Pest and Weed Management

Insect pests and weeds cause significant yield reduction in rainfed rice. These are the primary constraints under farmers conditions in realizing the optimum yield potential. Studies during 2001-02 revealed the superiority of integrated weed and pest management in rainfed rice across several locations, but the cost benefit ratios were not significantly superior over chemical methods. During the year the additional benefits of Integrated Weed Management (IWM) and Integrated Pest Management (IPM) were also captured in order to assess the over all contribution of these strategies towards sustainable rainfed rice production.

During 2003-04, on-farm trials were carried out on IWM on 20 ha covering 80 farmers in 3 districts of Jharkhand, Orissa and U.P. The predominant weed flora in the target districts were characterized. In OFTs in Dhenkanal district, variety *Vandana* produced highest yield of 2.92 t/ha with two hand weedings at 20-25 and 40-45 DAS, which was 70% more than farmers' practice. IWM packages consisting of mechanical weed control by finger weeder at 20-25 DAS supplemented with one hand weeding or chemical

Improved variety *Vandana* with farmers' management

Improved variety *Vandana* with improved management

weed control with pre-emergence application of butachlor @ 1.25 kg a.i/ha at 3-5 DAS with one hand weeding at 40-45 DAS increased the grain yield by 68% and 49%, respectively over farmers' practice (Table 8). At Hazaribagh and Faizabad, pre-emergence application of butachlor @ 1.25 kg a.i/ha at 3-5 days after sowing combined with one hand weeding at 40-45 DAS was found to be cost effective with B:C ratio 0.70 and 2.55, respectively. Based on pooled data over locations and years, IWM (CW + HW and MW + HW) as well as twice hand weeding produced significantly higher grain yield (2.27 – 2.62 t/ha) over farmer's practice (1.39 t/ha).

On-farm trials on Integrated Pest Management (IPM) were carried out in 5 target districts of Orissa (Cuttack), Assam (Jorhat), Manipur (Imphal), A.P (Warangal) and West Bengal (Bankura) states. At each location, 5 villages were covered. Based on the results from previous trials, the three

Table 8: Effect of integrated weed management practices on weed biomass and grain yield of rice (cv. Vandana at Cuttack and Hazaribagh; NDR-97 at Faizabad)

Treatment	Grain yield (t/ha)				Cumulative dry wt. of weeds (t/ha)			Benefit : Cost ratio			
	Cuttack	Hazari-bagh	Faizabad	Mean	Cuttack	Hazari-bagh	Mean	Cuttack	Hazari-bagh	Faizabad	Mean
T_1 (CW + HW)	2.56	2.20	2.57	2.44	0.52	0.36	0.44	1.55	0.70	2.55	1.62
T_2 (MW + HW)	2.89	1.46	2.46	2.27	0.42	0.98	0.70	2.21	0.06	2.45	1.57
T_3 (2 HW)	2.92	2.19	2.74	2.62	0.34	1.11	0.73	1.38	-.02	2.29	1.22
T_4 (FP)	1.72	0.69	1.76	1.39	1.37	2.31	1.84	-	-	-	-

CW : Chemical weed control by pre-emergence application of butachlor @ 1.25 kg/ha at 3-5 DAS.
HW : Hand weeding at 40-45 DAS.
MW : Mechanical weed control with finger weeder at 20-25 DAS.
2 HW : Hand weeding twice at 20-25 and 40-45 days after sowing.
FP : Farmer's practice.

treatments repeated during 2003-04 included farmers practice (FP), scheduled treatment (ST) involving application of pesticides as a regular schedule and IPM consisting of optimized location specific pest controlled components on 1 ha plot for each treatment.

In Titabar district, stem borer, gall midge, leaf folder and case worm were recorded as major pests of rice during the year. Incidence of stem borer at 45 DAT caused 4.25 and 5.98% dead hearts (DH) in IPM and ST plots, respectively and was significantly lower than farmers' practice (11.25% DH). Similarly, incidence of gall midge at 55 DAT varied from 5.67% to 5.92 % SS in ST and IPM treatments, which were significantly lower than 7.25 per cent SS recorded in FP. Highest grain yield was recorded in the IPM treatment (5.25t/ha) followed by ST (4.72 t/ha) and FP (3.86 t/ha). The cost benefit ratios were the highest in IPM treatment (1:2.86) followed by ST (1:2.4) and FP (1:2.2) (Table 9). In Cuttack, the incidence of most of the pests was low during the year except BPH. Higher yields were recorded in the IPM treatment (6.57 to 7.44 t/ha) followed by ST (5.95 to 6.84 t/ha) and FP (4.29 to 5.18 t/ha).

In Imphal district, gall midge incidence was significantly low in IPM treatment (0.07% SS) compared to ST (3.73% SS) and FP (4.86% SS) treatment. The incidence of stem borer, leaf folder, case worm, whorl maggot and grass hopper was very low and there were no discernible differences among the treatments. Higher grain yield was recorded in ST (5.40 t/ha) compared to IPM (4.93 t/ha) and FP (4.25 t/ha). However, the net return and C:B ratio were higher with IPM (Rs.17,925/ha and 1:2.3) than ST (Rs.16,520/ha and 1:1.9) and FP (Rs.9,725/ha and 1:1.5) treatments. In Bankura district, eight major insect pests, viz., gall midge, stem borer, leaf folder, case worm, whorl maggot, green leaf hopper, grass hopper and gundhi bug were observed. Scheduled treatment (ST) showed lower incidence compared to IPM, but highest incidence was in FP. Higher grain yield was recorded in ST (4.47 t/ha) compared to IPM (4.36 t/ha) and FP (3.47 t/ha). However, the net returns and cost-benefit ratios were higher in IPM treatment (1:9.6) than the ST treatment (1:3.7). In Warangal district,

Table 9: Relative performance of different modules on grain yield of rice (t/ha) and economic returns in different target districts

Treatment	Target districts							
	Imphal		Warangal		Bankura		Titabar	
	Grain yield	B:C ratio	Grain yield	B:C ratio	Grain yield	B:C ratio	Grain yield	B:C ratio
IPM	4.93	1:2.3	5.52	1:1.8	4.36	1:9.6	5.25	1:2.8
ST	5.40	1:1.9	5.34	1:1.4	4.47	1:3.7	4.72	1:2.4
FP	4.25	1:1.5	3.42	-	3.47	-	3.86	1:2.2

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

A woman farmer in Warangal district of A.P growing WGL-14377, a gallmidge resistant variety as an IPM component

mean grain yield of 5.32 t/ha was obtained with IPM treatment as against 5.34 t/ha with ST and 3.42 t/ha with farmers' practice. The B:C ratio was higher with IPM (1:1.8) than ST treatment (1:1.4).

Build up of natural enemies

Like in the previous years, a marked increase in natural enemy population was recorded during the year in the plots where IPM was practiced. In Cuttack district, a significant increase in the population of predatory myrid bugs was noted in the OFTs in Kumarmunda village. In target villages of Imphal district, spider population was higher in FP (5.78 per 20 hills) and IPM (5.32 per 20 hills) as compared to ST treatment (5.20 per 20 hills). Overall, the natural enemy population were higher in IPM and FP than ST treatment. The population of important natural enemies was significantly higher in IPM treatment in Bankura district.

Varietal Performance in Different Land Situations

On-farm trials on varietal performance in uplands and medium lands were continued during the year for yield and water use efficiency. The OFTs were conducted in Balasore, Mayurbhunj, Purulia and Bankura districts for upland situations and Balasore, Bhadrak, Purulia and Bankura, Jorhat, Golaghat, Imphal (E) and Thoubal for medium lands. The trials covered a total of 214 ha during *kharif* and *rabi* in 39 villages of 9 districts. The main objectives were to assess the performance of varieties released and those under advanced testing for their performance under farmers conditions for yield, water use efficiency and net profit.

In uplands var. *Vandana* (90 days) recorded the highest grain yield of 2.8 t/ha and water use efficiency of 5.38 kg/ha-mm (Table 10) as against 1.15 t/ha and 2.02 kg/ha-mm obtained with the farmer's variety *Dagarkoya* in Mayurbhunj and Balasore. Performance of *Vandana* was also better than eight other entries in Purulia and Bankura. Another set of OFAR trials on combined effect of variety and management showed that the improved variety *Vandana* with improved practice (basal application of fertilizers in seed furrow behind the plough, weed control by pre-emergence application of pretilachlor and control of brown spot disease by propiconazole) recorded 54-225% increase in yield and water use efficiency over farmers' variety and farmers' practice.

Under medium land situations, the rice varieties *Surendra* and CR 749-20-2 (125-135 days) in Orissa, CR-314-5-10 (140 days) in W.B, *Ranjit* and *Basundhara* (135-150 days) in Assam and RCM-9 and CAU-S-1 (135-142 days) in Manipur gave grain yield in the range of 3.06-

5.16 t/ha with water use efficiency ranging from 4.55 to 11.4 kg/ha-mm (Table 10). Because of early maturity, cultivation of these varieties facilitated multiple cropping with utilization of higher residual soil moisture. In flood prone areas of Bhadrak, Bankura, Purulia, Golaghat, Imphal (E) and Faizabad, rice varieties like *Gayatri, Ranjit*, CAU-S-1 grown with basal application of fertilizers and post-emergence herbicide (Almix) yielded 3.25-5.6 t/ha, which were significantly higher than farmers' varieties grown with farmers' practices.

The evaluation of rice cultivars for different land situations was continued during the year in a related network project coordinated by Directorate of Rice Research, Hyderabad. Cultivars were evaluated for rainfed uplands, medium lands and low lands in Chhattisgarh, Jharkhand, Orissa and Telangana region of A.P. In Raipur district, based on pooled data of 15 farmers, IET 15969 (R 1037-649-1-1) gave better performance (2.6 to 2.8 t/ha) than rest of the genotypes in uplands. In mid lands, IET 17908 (R 1097-44-1) was better (3.4 to 4.1 t/ha) than *Mahamaya* (2.9 to 3.2 t/ha). In lowlands IET 14070 (R 650-1817) recorded higher yield (4.9-5.4 t/ha) than *Swarna* (4.5-5.0 t/ha). In all the villages and all three land situations, recommended practice of line sowing was found better than traditional practice of broadcast *biasi*. In Jagdalpur district, *Tulasi* variety performed better than the rest both under farmers and recommended practice in uplands. In lowlands, IET 14070 out yielded (3.6-4.8 t/ha) all the varieties, while *Swarna*

Table 10. Summary of the best performed rice cultivars tried under OFTs during 2003-04 for yield, WUE and net returns

Land type	District	Variety	Duration (days)	Yield (t/ha)	Grain WUE (kg/ha-mm)	[1]Water req. for 1 kg of grain (l)	Profit/ rupee invested (Rs)
Upland	Balasore	*Vandana*	90	2.80	5.38	1860	1.32
	Mayurbhunj	*Anjali*	90	2.70	5.19	1930	1.24
	Purulia & Bankura	*Vandana*	90	2.63	4.48	2232	1.47
Medium land	Balasore	CR 749-20-2	125	3.06	4.55	2200	0.78
	Bhadrak	*Surendra*	135	3.90	5.38	1860	1.30
	Purulia & Bankura	CR 314-5-10	140	3.52	4.82	2075	1.02
	Jorhat	*Basundhara*	135	4.39	8.50	1175	1.03
	Golaghat	*Ranjit*	150	5.16	9.50	1044	1.08
	Imphal (E)	RCM-9	135	4.73	10.70	939	0.43
	Thoubal	CAU-S-1	142	4.73	11.40	879	0.43

[1] Excluding runoff, seepage-percolation and conveyance losses

recorded 2.4-3.3 t/ha. Line sowing proved better than *biasi*. At Ambikapur center also, recommended practice was superior than farmers practice and genotypes IET 15969 (R 1037-649-1-1), IET 17908 (R 1097-44-1) and IET 17153 (*Jaldubi*) performed better with an yield of 1.3 t/ha, 4.2 t/ha and 4.4 t/ha in upland, midland and lowland situations, respectively.

In the OFTs conducted in Orissa, four upland varieties IET 15296 (ORS 102-4), IET 15169 (OR 1519-2), *Khandagiri* and *Vandana* were evaluated at all the four locations as under farmer's and improved practices. Of the four varieties evaluated, ORS 102-4 exhibited superior yield performance (more than 2.5 t/ha) followed by OR 1519-2 and *Khandagiri* under rainfed upland situations. OR 1519-2, owing to its consistent performance over the years, was submitted to the Orissa state varietal release committee.

In Jharkhand, on-farm adaptive trials were conducted at five villages with five farmers in each village in East Singhbhum and Ranchi districts. Highest net returns (Rs.4240/ha) were received from *Ravi* followed by *Tulasi* (Rs.2994/ha) in uplands. The lowest were in *Birsa Gora* 102 in improved practice while under farmers' practice, it performed better in comparison to *Vandana.* It gave Rs.298 more net returns than *Vandana*. In low lands, the highest grain and straw yield (46.42 & 85.31 q/ha, respectively) were observed in IET 15352 followed by *Vibhava* (38.17 q/ha). The highest net returns Rs.8379 and Rs.6815/ha was recorded in IET 15352 under improved practice and farmers' practice, respectively (Table 11). In midlands *Triguna* was most promising with highest farmers preference.

In rainfed uplands of Rangareddy, Medak and Adilabad districts of A.P., *Tulasi* (2.3 t/ha) and *Vandana* (2 t/ha) were most promising.

N responsive varieties for favourable lowlands

With an aim to optimize the crop performance under different micro farming situations of rainfed favourable low lands by matching the N application

Performance of *Triguna* on rainfed medium lands in Jharkhand (left) and *Jagabandhu* on rainfed low lands in Orissa (right)

Table 11: Yield and net returns from promising low land cultivars of rainfed rice on farmers fields in Jharkhand (*kharif* 2003)

Variety	Improved Practice				Farmers' practice			
	Grain yield (q/ha)	Straw yield (q/ha)	Total income (Rs/ha)	Net return (Rs/ha)	Grain yield (q/ha)	Straw yield (q/ha)	Total income (Rs/ha)	Net return (Rs/ha)
Vibhava	38.2	63.0	14582	4532	33.8	53.1	12700	2700
IET 15352	46.4	85.3	18429	8379	42.5	77.3	16815	6815
Swarna (c)	36.0	65.9	14277	4227	31.5	61.3	12771	2771

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 calibrated with weather, crop and soil data for simulation of grain yield of rice at different locations during 2002-03. During this year, on-farm verification trials were carried out in 11 districts falling in West Bengal, Orissa, Assam, Bihar and Chhattisgarh. 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.

Varieties for deep water conditions

On-farm trials on identifying efficient varieties and improved agronomic practices for deep water rice were continued during the year in 5 states of Orissa, Assam, Bihar, U.P and W.B covering 30 ha. and 428 farmers. At different locations, the depth of water varied from time to time due to floods and inundation. However, the OFTs could be carried out at all locations in the target districts. Rice varieties *Durga* (grain yield 2.63 t/ha) and *Ambika* (2.62 t/ha) in Orissa, KDML 105 (3.43 t/ha) and *Phanidra* (3.40 t/ha) in Assam. *Mahananda* (2.35 t/ha) in Bihar, *Barh Avarodhi* (2.76 t/ha) in U.P and *Ambika* (3.63 t/ha) and *Hanseshwari* (3.45 t/ha) in West Bengal performed better than the other varieties showing yield increase of 17-47% over local checks under rainfed deep water conditions of eastern India (Table 12).

Deep water rice variety ***Durga*** on farmers fields in Brahmagiri block of Puri district, Orissa

Table 12: Performance of improved varieties of deepwater rice varieties at different locations of eastern India

State	Variety	No. of trials	Mean yield (t/ ha)	% Increase over local variety
Orissa	Durga	31	2.63	24.06
	Sabita	31	2.47	16.51
	Ambika	31	2.62	23.58
	Bhudeb	31	2.25	6.13
	Local		2.12	
Assam	Jalashree	57	3.13	8
	KDML 105	57	3.43	18
	Panindra	57	3.40	17
	Local		2.90	
Bihar	Ambika	82	2.12	32.50
	Jalpriya	82	1.72	7.50
	Mahananda	82	2.35	46.87
	Vaidehi	82	2.06	28.75
	Local		1.60	
Uttar Pradesh	Barh Avarodhi	75	2.76	35.63
	Jal Lahri	69	2.42	18.71
	Jalpriya	75	2.48	21.78
	Panindra	69	2.10	2.69
	Local		2.04	
West Bengal	Golak	20	3.31	32.8
	Ambika	18	3.63	44.1
	Hanseswari	19	3.45	39.0
	Bhudeb	18	3.29	29.6
	Padmanath	10	1.99	-36.3
	Vaidehi	16	2.17	-30.2
	Local		2.71	

Improved variety (identified for each location) and improved agronomic practice (single basal fertilizer application @40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha and direct seeding in furrows 20 cm apart before 1st week of June or transplanting of aged seedlings of 45-50 days duration at a spacing of 20 cm x 15 cm) gave the highest yields (2.25 to 4.02 t/ha) at all the locations. Therefore, the best varieties for each location along with the improved management can be recommended for enhancing the productivity of deep water rice.

Jute Varieties for Quality Textile Fibre

On-station and on-farm trials were continued for evaluating promising cultivars of jute under rainfed conditions in 6 target districts of Assam, Bihar, Orissa and West Bengal with a view to identify superior varieties with quality fibre. In continuation of the earlier crossing work, F_2 diallels

were analysed during 2003-04. On the basis of high mean fibre yield and high single combing ability (sca) effects, 10 crosses were selected from 78 crosses studied for each of the two characters in F_2 generation. Among the selected crosses, two crosses i.e. JRO 524 x NPL/YPY/026C and KEN/DS/053C x JRO 3352 exhibited high fibre yields of 18.07 and 17.80 g/plant and high fibre percentages 8.05 and 8.04, respectively. Selected F_3 population developed from line (18) x tester (6) mating design was grown during 2003 at Barrackpore, Katihar and Nagaon. On the basis of fibre yield and fibre percentage, 5 crosses were short listed which excelled over the best check variety JRO-524 at all the locations. KEN/DS/041C x Sudan green population gave highest yield at Katihar (15.17 g/plant), Nagaon (9.48 g/plant) and 3rd rank at Barrackpore (12.5 g/plant). With regards to fibre percentage, KEN/DS/058C x JRO-524 was the best at CRIJAF (8.39) and KEN/BL/071C x KEN/DS/060C at Katihar (6.90). In F_4 generation, TAN/X/112C x JRO-3352 gave consistently higher yield at CRIJAF (13.95 g/pl), Katihar (13.53 g/pl) and Nagaon (7.20 g/pl).

Promising material of jute in the on-station trial at Barrackpore

In *Corchorus capsularis*, parents with high mean fibre yield with highly significant gca effects were observed in CHN/FJ/052C (8.73 g/pl), JRC-212 (8.12 g/pl) and NPL/KUC/032C (7.95 g/pl). On the basis of sca effects and high mean fibre yield, 10 crosses were identified in F_2 generation. Among the crosses, CHN/FJ/052C x JRC-212 recorded highest fibre yield of 11.09 g/plant, which was 66% higher than the check variety JRC-321 (6.68 g/plant). Among the best ten crosses of F_3 generation in 11 x 11 diallel set, CHN/FJ/052C x JRC 212 gave highest fibre yield at Katihar (24.17 g/pl) and Nagaon (7.12 g/pl) but at Barrackpore, the cross BZ-2-2 x NPL/KUC/094C ranked first with a yield of 12.02 g/pl.

Based on the on-farm trials, jute (*C. olitorius* L.) variety S-19 was identified for release by varietal identification committee on 15.02.04 as it produced 10.4% higher yield and better fibre quality than the check variety, JRO-524. In on-farm trials, S-19 out yielded JRO-524 (*C. olitorius*) at all centers including lead center Barrackpore (Table 13). In the jute-rice cropping system, rice cv. *Naveen* grown in sequence after jute in Hooghly in West Bengal gave higher yield (12.53%) than the check variety IET-4094. In Cuttack rice cv. *Gayatri* (4.08 t/ha) gave 7.93% higher yield than the check

Table 13: Grain yield (t/ha) of improved cultivars in jute-rice cropping system in different target districts

Variety	N. 24 Praganas	Hooghly	Cuttack	Jorhat	Samastipur
			Jute (fibre yield)		
JRO-524 (Check)	3.45	3.36	2.33	2.6	2.38
S-19(*Subala*)	3.54	3.56	2.63	2.75	2.72
			Rice (grain yield)		
Improved	2.65 (IET-4094)	4.4 (CR 749-20-2)	4.08 (*Gayatri*)	3.46 (CR 749-20-2)	3.51 (CR 749-20-2)
Check	1.9 (CRM-2007-1)	3.91 (IET-4094)	3.78 (*Durga*)	2.92 (*Luit*)	3.33 (*Rajshree*)

variety *Durga* (3.78 t/ha). *Naveen* performed better in Bihar (3.51 t/ha), Assam (3.46 t/ha) and West Bengal (4.4 t/ha) than their corresponding check varieties.

Improvement of fibre yield through RMNV

In the final year of the network project on studying the impact of RNMV (rice necrosis mosaic viruses) on improved growth of jute, on-farm trials were continued at Kendrapara, Salehpur and Nagaon. There was a marginal improvement in the fibre yield with RNMV treatment along with 50% of the recommended dose of NPK (20:10:10).

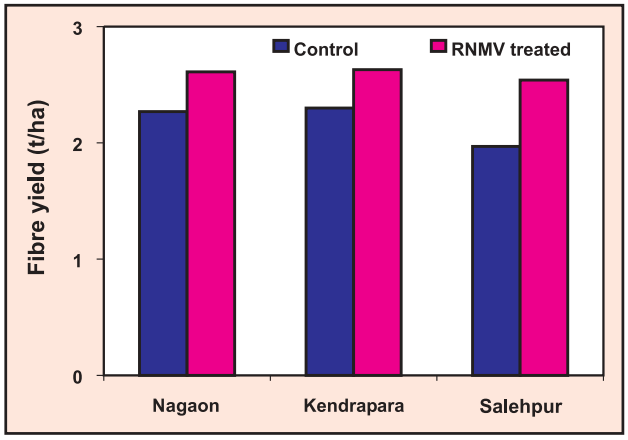


Fig. 3: Effect of RNMV treatment of jute seeds (var.JRO-524) on fibre yield at 3 locations

The RNMV technology based on results achieved for the last three years has a potential to increase the fibre production from the current level of 2 t/ha to 2.59 t/ha in Orissa and 2.6 t/ha in Assam (Fig.3). So far no adverse affects of RNMV inoculation were found on the soil or the succeeding rice crop. However, further studies are required for wider application of this technology.

Crop Diversification in Uplands: Agri-horticulture System

In order to diversify the land use under rainfed rice in uplands to more profitable fruit and vegetable crops, network experiments were carried out in 5 target districts of Orissa, M.P, Chhattisgarh and Jharkhand. A number of locally adapted but improved varieties of vegetables and spices were introduced as intercrops in the bearing orchards of mango, litchi and guava with and without filler crops. The trials were carried out on the farmers fields.

During 2003-04, cowpea was found most profitable intercrop (Rs.12,700/ha) followed by tomato (Rs.12,400/ha) and frenchbean (Rs.10,050/ha)

in bearing mango orchards in Koraput district (Table 14). In Jabalpur, ginger gave the highest net returns (Rs.57,200/ha) in bearing mango orchard, while in Ranchi, turmeric gave the highest net profit (Rs.24,300/ha) under litchi orchards. Turmeric was also very successfully grown as intercrop in mango orchards of Ranchi. Maximum returns in Ambikapur, Sarguja were obtained from sweet potato (Rs.12,077/ha) followed by cowpea and maize in litchi orchards. At Daltonganj (Jharkhand), maximum net returns were obtained from Maize (Rs.8,650/ha) followed by blackgram (Rs.6,540/ ha) in mango orchards. At Ranchi, Jabalpur and Daltonganj centers, intercropped paddy gave the lowest net returns and yield. From the data, it was evident that on sloppy uplands of the tribal districts,

Table 14. Yield and economic returns from different intercrops grown in fruit orchards in rainfed uplands of Orissa, Chhattisgarh, Jharkhand and M.P.

Treatment	Yield (t/ha) of the intercrop	Gross returns/ha (Rs)	Net returns/ha (Rs)	C : B ratio
Koraput (Orissa)				
Mango + cowpea	3.55	24,850	12,700	2.05
Mango + frenchbean	3.05	21,350	10,050	1.89
Mango + tomato	3.80	22,800	12,400	2.19
Mango + ragi	2.25	11,250	6,100	2.18
Jabalpur (Madhya Pradesh)				
Mango + ginger	1.72	1,03,200	57,200	2.24
Mango + pigeonpea	1.40	20,300	5,300	1.35
Mango + blackgram	1.10	14,100	3,100	1.28
Mango + paddy	2.80	18,120	4,420	1.32
Ambikapur (Chhattisgarh)				
Litchi + blackgram	0.25	4,625	1,957	1.73
Litchi + maize	2.07	8,913	2,765	1.45
Litchi + cowpea	2.25	9,000	3,883	1.75
Litchi + turmeric	3.15	24,800	12,077	1.94
Ranchi (Jharkhand)				
Litchi + frenchbean	2.26	11,256	6,756	2.50
Litchi + cowpea	2.50	12,468	8,968	3.56
Litchi + turmeric	7.25	43,500	24,300	2.27
Litchi + paddy	0.90	5,400	3,400	2.70
Daltonganj (Jharkhand)				
Litchi + maize	2.34	23,450	8,650	1.58
Litchi + blackgram	0.50	10,100	6,540	2.83
Litchi + okra	1.07	3,216	1,625	2.02
Litchi + paddy	0.60	2,420	1,079	1.80

The average age of fruit orchards: Koraput - 4 years, Ambikapur - 3 years, Ranchi - 7 years, Daltonganj - 4 years, Jabalpur - 4 years

vegetable and spices cultivation gave higher returns to farmers than rainfed rice and millets. However, adoption of soil conservation measures in farmers' fields is key for success of this approach.

Gopalput village of Koraput district of Orissa presents a good example for the success of this project. All the participating farmers are now earning enough to live a decent livelihood and stopped migration to towns for work. This village became a radiant center for other developmental agencies. DRDA, Koraput started construction of a water harvesting structure at a cost of Rs.2.5 lakhs. The watershed mission in the district also sanctioned a project of Rs.2.55 lakh for supply of quality planting materials to SHGs who would take up large scale planting of medicinal and aromatic plants in the watersheds in the upland paddy area. The district administration, Koraput took initiative to replicate this model in all the watersheds for efficient land use. More and more farmers of the neighboring field and village have started adopting the technology.

In a network project in 5 districts i.e. Bhubaneswar, Ranchi, Dumka, Jabalpur and Raipur, the nursery management and improved cultivation practices were tried in farmers fields for a number of vegetable crops. 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. Use of neem cake and intercropping African marigold with tomato (16:1) were also found promising IPM practices, which resulted in higher marketable yields.

Planting of African marigold in tomato as an IPM component

Improved Agro Technology for Utera Cropping

Utera cropping is a relay intercropping of hardy pulses crops like lathyrus with *kharif* rice. This is followed by most small and marginal farmers in large parts of 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, Nagaon, 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 with farmers and improved practice. Based on the results obtained during 2001-02 and 2002-03, the most promising rice varieties and its compatible *utera* crops were

tested through the on-farm trials during 2003-04 with farmers and improved package of practices. The *utera* cropping with improved package of practices showed its superiority over farmer's practice in terms of productivity, net monetary returns (NMR) and benefit cost ratio (Table 15) at all locations. Both rice and *utera* crops gave one and half to two times higher grain yield under improved practice over farmer's practice and thus, the NMR of entire cropping system also improved. Though improved practices required more investment, the profitability (benefit cost ratio) was 7 to 45 per cent higher, which justifies the higher investments.

Impact analysis in the target villages in 2003 indicated a 50% increased awareness among the farmers surveyed on the availability of better *utera* crops than currently grown by them. Majority farmers showed their preference for substituting the low value *utera* crop with high returns crop like linseed in Seoni, Burdwan and Midanpore 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.

Performance of field pea as an *utera* crop at Dindori in M.P.

Table 15. Mean grain yield and economic returns of promising rice based *utera* cropping systems (2003-04)

State	District	No. of trials	*Utera* system	Mean grain yields (t/ha)				NMR (Rs/ha)		Benefit cost ratio	
				Rice		Utera crop					
				IP	FP	IP	FP	IP	FP	IP	FP
Madhya Pradesh	Dindori	10	Rice - Field pea	4.06	2.09	0.97	0.58	13000	4250	1.76	1.35
	Senoi	10	Rice - Linseed	4.65	3.08	0.68	0.38	16450	9525	1.98	1.75
Chhattisgarh	Mahasamund	20	Rice - Lathyrus	4.78	3.21	0.61	0.43	12930	8370	1.76	1.69
	Rajnandagaon	20	Rice - Lathyrus	5.33	3.40	0.63	0.44	15960	9400	1.93	1.78
West Bengal	Burdwan	20	Rice - Linseed	4.81	3.48	0.73	0.30	17925	9920	2.05	1.82
	Midnapore	10	Rice - Lathyrus	4.69	3.27	1.24	0.69	18825	11175	2.10	1.93
Orissa	Khurda	10	Rice - Blackgram	4.31	2.96	0.80	0.32	19550	8200	2.08	1.63

IP-Improved practice; FP-Farmer's practice; NMR-Net monetary return. The farm gate price of rice, linseed, blackgram, fieldpea and lathyrus were considered as Rs.500, Rs.1500, Rs.2000, Rs.1000 and Rs.1000 per quintal, respectively.

Improving the Traditional *Biasi* System

On-farm trials on improved *biasi* system were continued during the year in 8 target districts in the states of Chhattisgarh, Jharkhand, West Bengal, Orissa and M.P covering 150 farmers in 45 villages. The main objectives were to improve the productivity and profitability of the traditional *biasi* system of rice cultivation by introducing different interventions. As in earlier years, the improved *biasi* package produced higher yields and net returns as compared to the farmers method. The improved package consisted of (i) seed rate of 100-110 kg/ha and application of pre-emergence weedicide with excess seeding in one corner of the field for gap filling after *biasi* operation. (ii) fertilizers as per location specific recommendation in the medium and low land, i.e. NPK (60:40:30 to 80:50:30 kg/ha). (iii) *biasi* operation with the improved *biasi* implement and method (spiral ploughing). The framer's traditional practice included (i) seed rate of 125-130 kg/ha without basal fertilizer and use of fertilizer during *biasi*. (ii) *biasi* ploughing by indigenous wooden plough, followed by Chalai/ Batia/Khelua (iii) Planking after Chalai. Based on the results obtained from 7 locations, the improved *biasi* produced mean grain yield of 3.00-4.29 t/ha compared to 2.33-3.73 t/ha with farmer's practice recording additional yield advantage of 24.2% (Table 16).

There was also a saving of energy with the improved *biasi* system. This practice required a total energy of 7834 MJ/ha as against 8935 MJ/ha with traditional practice, which translates to a specific energy requirement of 1.56 and 2.97 MJ/kg of rice grain produced in improved and traditional *biasi* systems, respectively. With improved practice, there was 12% saving in energy requirement. Again, the total cost of rice production was Rs. 7,981/ha with improved practice as compared to Rs. 10,471/ha with traditional practice. There was 24% saving on cost of cultivation with improved practice over the traditional *biasi.*

Comparative evaluation of different implements revealed that *tifal* developed at IGKV, Raipur and wedge plough developed at CIAE and BAU proved most effective and gave higher yields than the local plough at all locations (Table 17). The maximum yield was recorded with *tifal* (4.34 t/ha) followed by wedge plough (3.91 t/ha) and spiral method (3.54 t/ha). Additional yield of

Table 16: Average grain yield obtained with traditional and improved *biasi* system at different locations irrespective of the varieties and land situations during *kharif,* 2003

Yield (t/ha)	Locations							
	Raipur	Ambikapur	Bhawanipatna	Jagadalpur	Keonjhar	Jhargram	Darisai	Mean
Traditional *biasi*	3.73	2.23	3.29	2.93	3.4	3.53	2.30	3.07
Improved *biasi*	4.29	3.44	3.80	4.03	4.03	4.30	3.00	3.82
Advantage (%)	15.0	54.3	15.5	37.5	18.5	13.8	30.4	24.2

Improved *biasi* ploughs, tifal (left), and a farmer operating a *biasi* plough (right)

48% over the traditional implement was obtained with *tifal*. Though the draft requirement was slightly higher for *tifal* (53 kg) than the local plough (49 kg), it was well within the pulling capacity of the local bullocks. Since *tifal* could cover more area, the animal power can be efficiently utilized. The field capacity of the implement was much higher (0.8 ha) than other machines which ultimately reduced the cost of *biasi* operation (Table 18).

Table 17: Effect of *biasi* implements on paddy yield (t/ha) at different locations (Mean of 3 years : 2000-03)

Biasi implement/ method	Raipur	Ambi-kapur	Jagdal-pur	Bhawani-patna	Keonjhar	Darisai	Jhargram	Bhopal	Average yield (t/ha)	Increase %
Local plough	3.18	3.07	3.84	1.93	1.75	3.04	3.95	2.70	2.93	—
Wedge Plough	4.25	4.34	4.54	2.53	1.98	4.92	4.96	3.82	3.91	33.6
Tifal	5.39	5.18	4.78	2.61	2.25	4.95	5.02	4.56	4.34	48.1
Spiral ploughing	3.64	3.86	4.32	2.18	1.85	4.82	4.27	3.40	3.54	20.8

Table 18: Impact of *biasi* implements on plant mortality, weeding efficiency and tillering in rainfed rice

Biasi Implement	Mean plant mortality (%)	Mean weeding efficiency (%)	Field capacity ha/day
Wedge Plough	27	49	0.25
Tifal	13	60	0.80
Local Plough	32	46	0.18
CD 5%	-	3.5	0.12

Tillage and Planting Equipment

During 2003-04, on-farm trials were conducted on field evaluation and refinement of farm implement prototypes for dry and wet tillage, seeding, transplanting, fertilizer application and interculture in rainfed rice based production system. In the OFTs in Orissa, better quality seedbed at less cost was achieved by using power tiller and tractor-operated rotavator. The field capacity of tractor drawn rotavator was 0.30 to 0.34 ha/h and that of power tiller drawn rotavator was 0.14 ha/h. Cost of tillage was 10 to 25 per cent less by power tiller and tractor drawn rotavator in comparison to farmers practice. Seed drills were found superior to conventional broadcasting method with significantly higher yield and lower cost of operation. The yields were 4 to 6, 8 to 12 and 12 to 14 per cent higher in case of animal drawn, power tiller drawn and tractor drawn seed drill, respectively than broadcasting method. Self propelled 8-row rice transplanter was found to be superior to local practice in terms of cost and timeliness of operations with 10-15 per cent higher yield than traditional method.

Suitable location specific implements like 5 row seed cum fertilizer drill, lugged wheel puddler, paddy seeder and inter row crop seeder were developed through the project by different centers. Twenty field experiments in addition to 198 demonstrations on transplanter, rotavator, lugged wheel puddler, zero till drill, pre-germinated paddy seeder, cono weeder, seed cum fertilizer drill and raising of mat type nursery were conducted. One hundred sixteen manufacturers sponsored by different centers were trained at CIAE, Bhopal on manufacturing technology of agricultural implements. Eight training programmes were conducted for artisans alone.

Overcoming soil related constraints

In a related project, a number of tillage practices were tested for improvement of water storage capacity of soils, weed control and improving the yields of rice and subsequent *rabi* crops in different land situations. The trials were carried out at Bhubaneswar, G.Udaygiri, Anakapalle, Gayeshpur, Darisai, Jagdalpur, Titabar and Faizabad. The most important soil related tillage constraints found at all locations are low available water capacity, slope and low organic matter content in uplands and poor drainage in lowlands.

Grain and straw yields of upland rice were significantly increased due to improved tillage (one summer MB ploughing followed by twice presowing MB ploughing + FYM @ 5 t/ha) as compared to conventional tillage. Improved tillage reduced both soil hardness and weed growth and increased the soil moisture content, because of which the yield of upland rice increased. The B:C ratio and net profit were also maximum with improved tillage. Improved tillage (one summer ploughing by MB plough followed by twice presowing ploughing with disc plough + twice hand weeding or application of butachlor @ 1 kg a.i/ha) draustically reduced the weed growth. The grain yield, net profit and benefit cost ratio for cultivation of rice were maximum with improved tillage and chemical weed control as compared to conventional or other tillage practices.

In all the centers, puddling index of the soil was maximum and energy requirement was minimum when wet soil was twice puddled by power driven rotavator or cultivator. The grain and straw yields of rice also significantly increased due to puddling by power tiller operated rotavator or cultivator as compared to farmers' method. Puddling by locally developed bullock drawn zig-zag puddler also significantly increased the grain and straw yields of rice as compared to conventional tillage. Puddling had residual effect on seed yield of succeeding crops. As the intensity of puddling was increased, the grain yield of succeeding winter crops increased. Puddling by puddler-99 in Bhubaneswar and G. Udayagiri, by lugged wheel puddler in Gayeshpur and IADP puddler in Darisai centers resulted in significantly higher grain and straw yields of lowland rice as compared to puddling by wooden country plough or MB plough. Puddling index was also maximum and energy requirement was minimum in case of puddler-99 as compared to other locally developed puddlers.

Post Harvest Processing

The evaluation of improved methods drying and milling of rice was continued in 5 target districts during the year i.e. Cuttack, Jorhat, Imphal, Ranchi and Raipur. A total of 200 farmers were covered in 13 villages in these participatory trials. Among the drying methods tried, wire mesh rack and black polythene mat was found most acceptable methods of drying paddy at all locations. These methods proved significantly superior to farmers method of drying of paddy. More than 60% of

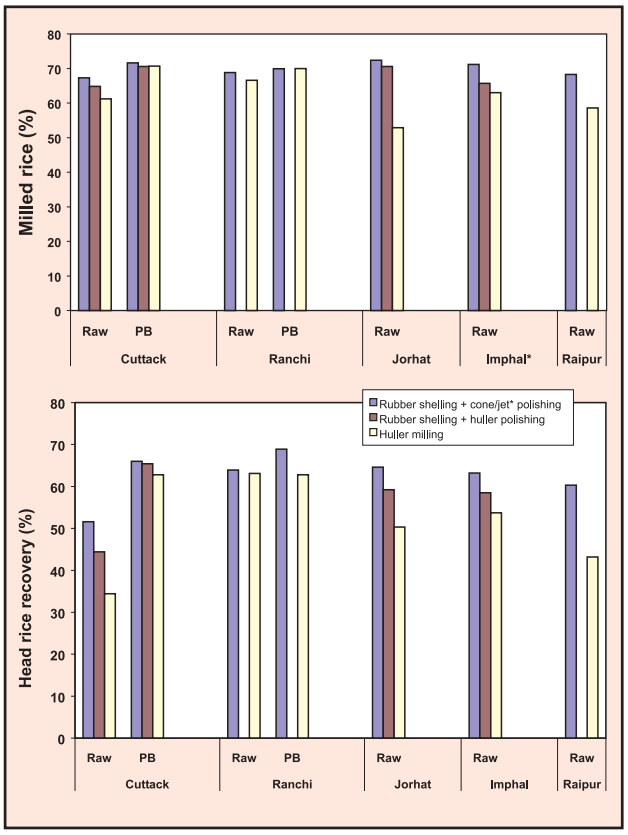


Fig 4: Effect of milling methods on average milled and head rice recovery for raw and parboiled (PB) rice

participating farmers started adopting this technology from the 3rd year onwards. For storage, RCC ring bin of 5-6 q capacity was found to be most effective and economical, which could store paddy at 12-14% moisture content for 6 months with less than 5% infestation in Keonjhar and Cuttack districts of Orissa. Paddy stored in the bins was also found suitable as seed for next year with 80% viability. Tribal farmers in Orissa and Assam found this type of bin also as elephant proof. Similarly the metal bins at all locations, improved bamboo bin (polythene lined and mud plastered) at Raipur and rat proof wooded bin at Imphal were found effective to store paddy for 6 months both

for consumption and seed purpose. By adopting these improved methods, 6-8% of the stored grain could be saved, which otherwise got lost due to insect and rat damage in traditional storage structures like gunny bags, bamboo bins etc. Trials during the year also proved that 10% extra milled rice and 12% extra head rice were realised by milling raw paddy with improved machines like rubber sheller and emery cone polisher as compared to the traditional huller milling. The additional head rice recovery was 4-5% with parboiled paddy.

Integrated Rice Based Farming System

During 2003-04, on-farm trials continued with 8 farmers on integrated farming system including fish, duck and pig rearing in rainfed rice based production system in the target districts of Ranchi and Midnapore. In both the districts, the pond water was analysed for its chemical and biological properties before stocking of ducks. In Ranchi, the samples had pH in the range of 6-7.4, alkalinity 80-140 ppm, dissolved oxygen concentration 6-6.8 ppm, free carbon dioxide 0-4 ppm and transparency 28-32 cm. Plankton concentration was almost nil. In Midnapore, the water samples showed pH in the range of 6.0-7.4, alkalinity 112-164 ppm, dissolved oxygen concentration 5.4-6.5 ppm and free carbon dioxide 2.0-6.0 ppm.

In Ranchi, in all the ponds, five species of fishes i.e. Catla, Rohu, Mrigal, Grass carp and Common carp were stocked @25,000/ha fries (or 10,000/ha fingerlings). The species ratio was selected according to the availability of feed and feeding nature of the species in the ponds. The growth of Catla, Rohu, Mrigal and Grass carp were 300-350 g, 150-200 g, 70-90 g and 120-140g, respectively in the ponds in the 7th month after stocking in fish cum duck system. The corresponding growth figures were 200-300, 100-153, 75-100 and 110-130 g in fish cum pig system. The average fish production varied from 600 to 1600 kg/ha in fish cum duck farming system and 900-1500 kg/ha in fish cum pig farming.

Desi variety of ducks were introduced @ 400/ha or as per the agricultural byproducts available to the farmers. In Ranchi, ducklings having an average weight of 500 g were distributed in the month of August 2003, which attained 1-1.5 kg in the month of November. Fifteen numbers of piglets of T&D were distributed to the farmers in the month of August, 2003 with an average weight of 11 kg. Till February (i.e. in six months) they attained an average weight of 31 kg. The yields from different components of the farming system i.e. paddy, fish and duck for 11 participating farmers in West Bengal and Jharkhand are given in Table 19.

In Midnapore, stocking of fish seeds was done in the month of August 2003 @ 25,000/ha fries in all the experimental ponds. The fish species were Catla, Rohu, Grass carp, Mrigal and Common carp. The ducklings were distributed in the month of August 2003 to the farmers with an average weight of 350 g. The upgraded black variety of piglets were distributed to the farmers in the

Table 19: Yields and income from different components of the rice-fish-duck/pig farming system for 11 participating farmers in Jharkhand and West Bengal (2003-04)

Farmer's name	Village/ block/ District/ State	Paddy area (ha)	Paddy yield (t/ha)	Pond area (ha)	Fish yield (t/ha)	No.of ducks/ pigs	Income from paddy (Rs)	Income from fish (Rs)	Income from ducks/ pigs (Rs)	Total income (Rs)	Expen-diture (Rs)	Net income (Rs/ farmer)
Bandhan Lakra	Chennai, Ranchi	0.16	4.2	0.16	0.37	2	1696	2400	3510	7606	2350	5256
Stephan Lakra	Chennai, Ranchi	0.16	4.0	0.16	0.562	2	1600	3600	3600	8800	2400	6400
Jallah	Chennai, Ranchi	0.16	4.0	0.16	0.343	2	1600	2200	3500	7100	2400	4700
Paskal Tirkey	Chennai, Ranchi	0.16	3.8	0.12	-	10	1504	1600	1500	4604	1200	3404
Dharam-pal Oraon	Khatanga, Ranchi	0.16	4.0	0.12	0.333	40	1600	6000	5000	12600	3900	8700
Gopal Hansda	Andulia, W.B.	0.2	6.8	0.04	1.10	3	7000	1500	5500	14000	4000	10000
Somrai Soren	Moglani Chawk, W.B	0.21	7.0	0.04	1.62	3	9000	1800	6200	1700	5500	11500
Kisan Hansda	Benadighi, W.B	0.2	5.8	0.03	1.34	2	7000	1300	4200	12500	4500	8000
Pitamber Singh	Badalpur, W.B	0.26	5.9	0.06	1.0	24	11000	1850	3000	15850	5900	9950
Anil Tudu	Andulia, W.B	0.29	4.9	0.03	1.0	12	8000	1600	1500	11100	3500	7600
Subluk Khan	Moglani Chawk, W.B	0.21	5.8	0.3	1.3	12	7000	1900	1800	10700	3550	7150

month of August 2003 with an average weight of 5.2-5.8 kg, which showed satisfactory growth rate.

A happy farmer in West Bengal harvests fish from the pond in the rice-fish-pig farming system

In the integrated framing system, rice crop was manured separately with pig manure and cattle manure along with chemical fertilizers, which were compared with chemical fertilizer alone and unfertilized control. Application of pig manure @ 3 t/ha + inorganic fertilizer produced higher grain (4.62 t/ha) and straw yield (5.06 t/ha) and yield attributing characters as compared to cattle manure + inorganic fertilizer (grain yield 4.16 t/ha), inorganic fertilizer (grain yield 4.36 t/ha) and control (grain yield 1.56 t/ha).

Livestock Health

Under a network project in Orissa, Jharkhand and M.P, extensive surveys were carried out in 92 villages on the prevalence of parasitic diseases and evolve simple control measures, which can be adopted at the village level. The important

diseases covered were gastro-intestinal helminths, haemoprotozoan diseases and ectoparasitic infestations in cattle, buffaloes and goats. During the year, major emphasis was laid on the transmission of nematode and trematode infections. In case of stall fed cattle, buffaloes and goats, snails like *Indoplanorbis* and *Lymnaea sp. w*ere found responsible for transmission of trematode infection in water bodies like ponds, *nalahs* and rice fields. Based on the control measures worked out during the previous two years, including mass administration of antihelmintics at 3-6 months interval, prompt disposal of dung from sheds and restriction of grazing of livestock in waterlogged areas infected by snails, considerable improvement in live stock health and productivity were demonstrated to farmers. The average benefits in terms of increase in milk yield was about Rs.7/day/cow in case of stall fed and Rs.3/day/cow in case of grazing animals. Goats treated for nematodiasis at the age of 4-5 months could fetch profit of Rs.138 per goat towards extra body weight gain, six months after treatment. Extra horsepower generated by a pair of plough bullocks treated against amphistomiasis could add to ploughing efficiency for one hour. On adoption of these control measures, the disease prevalence rate was brought down from 47% to 19% in target villages of Dhenkanal district of Orissa with similar results in other states.

CHAPTER 3

Oilseeds Based Production System

Oilseeds are primarily grown in rainfed areas where yields are stagnating for quite some time. There is an urgent need for a critical analysis of location specific constraints, refinement of available technologies and development of relevant and acceptable strategies making best use of natural resources. Accordingly, 18 subprojects were taken up under Rainfed Oilseeds Based Production System (ROPS), which were developed following a bottom up approach after the identification of critical research and adoption gaps. In total, 82 target districts spanning over 18 states have been covered under these projects. In this chapter, major research highlights of 14 projects in operation during the year 2003-04 are presented.

Moisture conservation and fertilizer management

Optimum nutrient supply and *in situ* moisture conservation are critical for maximizing oilseeds production under rainfed conditions. In order to standardise location specific modules containing suitable variety for a given micro farming situation, appropriate moisture conservation practice and nutrient management, a network project was taken up in 5 oilseeds growing districts viz. Raichur, Mahaboobnagar, Solapur, Indore and Junagadh. The project covered sunflower, castor, safflower, soybean and groundnut in respective districts and two soil types viz. Alfisols and Vertisols. During previous two years, adoption of conservation furrows + RDF recorded nearly 20% yield advantage on farmers fields across crops and soils. Improved cultivars in general proved superior compared to local checks when moisture conservation and RDF treatments were super imposed.

During the year, the best treatment (key line cultivation and opening of furrow between two rows at 40-45 DAS + RDF ie. 60-40-30 N-P_2O_5-K_2O kg/ha) was compared with farmers practice (country ploughing and inter cultivation + 30-20-15 N-P_2O_5-K_2O kg/ha) on castor in different target districts. Results from 12 OFTs on castor in five villages of Ranga Reddy and Mahaboobnagar districts revealed that improved practice gave a mean yield of 968 kg/ha in DCH-32, which was 48.4 % higher over farmer's practice with PCS-4 (652 kg/ha). This combination gave additional net returns of Rs.3513/ha over farmer's practice.

In case of sunflower grown on Vertisols in Raichur district, results from 18 OFTs (14 *Kharif*

Table 1: Yield and economic returns from castor on farmers fields in Rangareddy and Mahaboobnagar districts (n=12) with improved moisture conservation and fertilizer management (2003-04)

Treatments	Seed yield (kg/ha)	Oil content	Oil yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Farmers method of MC + FA with PCS 4	652	50.7	332	3823	5303	2.39
Rec. MC+ RDF with DCH 32	968	51.2	496	4728	8816	2.86
CD (P=0.05)	86.26	NS	42.4	—	1207.9	—

MC: Moisture Conservation, RDF: Recommended Dose of Fertilizer, FA : Fertilizer Application

and 4 *Rabi)* showed that recommended method of moisture conservation and fertilizer application (key line cultivation and opening furrow between two rows at 30-35 DAS + 35-50-35 N-P_2O_5-K_2O kg/ha) with KBSH-44 resulted in higher yield of 1312 kg/ha as against 884 kg/ha in farmer's practice (repeated harrowing and intercultivation twice + 17.5-25-17.5 N-P_2O_5-K_2O kg/ha) with MSFH-17, representing an increase of 48.4%. During *Rabi* however, the yield improvement with KBSH-44 was 35.5 per cent over farmer's practice with MSFH-17. The additional net returns during *kharif* were Rs.6825/ha over farmer's practice. Similarly, OFTs with sunflower in Alfisols of Mahaboobnagar district recorded seed yield of 788kg/ha with improved practice and KBSH-1 as compared to 641kg/ha with farmers practice (var.*Morden*).

Performance of KBSH-44 and MSFH-17 on farmers field with improved vs. farmers practice on Vertisols in Raichur district

Table 2: Economics of sunflower production with improved moisture conservation technology during *Kharif* 2003-04 on farmers fields in Raichur district (n=10).

Treatments	Seed yield (kg/ha)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Farmers method MC + FA with MSFH 17	884	15917	5473	10444	2.91
Rec. MC+RDF with KBSH 44	1312	23619	6350	17269	3.72
CD (P=0.05)	86.19	-	-	1580.6	-

MC: Moisture Conservation, RDF: Recommended Dose of Fertilizer, FA : Fertilizer Application

In Junagadh district, improved technology enhanced pod yield of groundnut by 20.5% and 23.2% in Spanish and Virginia cultivars, respectively over farmers practice (1985 and 2192 kg/ha) based on 12 OFTs. Improved technology recorded highest net returns of Rs.27,253/ha and Rs.27,924/ha. In soybean, Broad Bed and Furrow (BBF) method of *in situ* moisture conservation + RDF with variety MAUS-47 was compared with farmers practice (flatbed without fertilizer with JS 335) through 15 OFTs in Indore district. The yields under improved practice were 33.8% higher over farmers practice (2190 kg/ha). The corresponding B:C ratios were 4.23 and 3.74. Similar results were obtained with safflower in Solapur district.

INM in oilseeds based cropping system

In order to improve the productivity of oil seeds and oil content, different INM treatments were tried with major oilseed based cropping systems in eight target districts falling in M.P, Maharashtra, Karnataka, Jharkhand, Punjab, Rajasthan and A.P. The cropping systems covered were soybean-chickpea (Bhopal), greengram-safflower (Parbhani), fallow-sunflower (Latur and Raichur), castor (Mahaboobnagar), groundnut + pigeonpea (Ranchi), fallow-mustard (Bharatpur), maize-raya (Nawanshahr). During the year, the residual effects of treatments and cost benefit analysis were worked out in detail.

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 physical properties significantly. Similarly, replacing 25% or 50% of the RDF with FYM improved the yield of sunflower in Raichur and castor in Mahaboobnagar districts. In Ranchi, yields of groundnut and pigeonpea 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 centers and cropping systems in the target districts, it was concluded that application of FYM in soybean-chickpea and 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 as well as 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 (Mahaboobnagar).

Oilseeds Production in Salt Affected Soils

In view of the lower production of oilseeds in saline and sodic soils, a network project was taken up in 5 target districts in A.P, Karnataka, Gujarat, Maharashtra and U.P with a view to identify tolerant varieties and management practices that optimize yields in affected soils. Studies during 2001 and 2002 helped in identifying the best salt tolerant variety in each of the 5 oilseed crops i.e.

Performance of castor variety 48-1 on sodic soils of Mahaboobnagar district (left) and excellent growth of safflower var. S-13-5 on saline soils of Parbhani district with recommended practice of planting on ridges (right)

castor, sunflower, safflower, mustard and linseed. Improved practice (seed soaking in 1% NaCl for 3 hours, application of FYM @ 2 t/ha and sowing on the sides of the ridges in ridge and furrow method of planting) was found to be more effective in salt affected soils than farmers practice of flat bed planting.

During the year, the best treatment was compared with farmers practice in two target districts viz. Mahaboobnagar (castor) and Parbhani (safflower). The results confirmed the earlier trend of higher net returns and benefit cost ratios with improved practice over farmers practice. In 5 OFTs in Mahaboobnagar district, variety 48-1 in combination with improved management resulted significant enhancement in bean yields (1041 kg/ha) over farmers practice (779 kg/ha from *Jyoti*). Improved practice realised net returns of Rs.2850-12280/ha with a mean of Rs.8732/ha, while farmers practice accrued Rs.1610-7740/ha with a mean of Rs.5850/ha. The additional net returns were Rs.1160-5300/ha depending on the level of sodicity. Data on overall economics of oilseeds production in saline/sodic soils clearly indicate the advantage of improved management practice with all the crops studied (Table 3). The technologies were popularized through Kisan melas and exposure visits organized in the target districts during the year.

Integrated Pest Management

Since pests and diseases are major yield reducers in oilseeds based cropping systems, location specific modules developed earlier were validated on farmers fields on large plots and C:B ratios were worked out involving 6 different oilseeds based cropping systems. Based on the performance recorded during 2001 and 2002, the best treatment was compared with farmers practice during 2003-04 at selected centers. Impact on farmers income in target villages and build up of natural enemies in the crop ecosystem were also studied.

In Anantapur district, on-farm trials on groundnut + pigeonpea intercropping system on

Table 3: Economics of oilseeds production on saline/sodic soils in different target districts

Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	Addl. Returns (Rs/ha)
Castor (Mahaboobnagar)				
Improved practice	929	6718	2.07	1622
Farmers' practice	756	5096	1.93	–
Sunflower (Koppal)				
Improved practice	603	4471	1.89	1368
Farmers' practice	503	3103	1.63	–
Safflower (Parbhani)				
Improved practice	1058	9783	2.97	2663
Farmers' practice	852	7120	2.58	–
Linseed (Kanpur)				
Improved practice	701	7741	2.38	3428
Farmers practice	460	4313	2.08	–
Mustard (Banaskanta)				
Improved practice	1430	17272	3.47	1033
Farmers practice	1266	16239	3.03	–

IPM promotes natural enemies : *Coccinella septumpunctata* grub feeding on safflower aphid

25 acres revealed no significant differences in yield in IPM and conventional practice due to long dry spell and low pest incidence, but ashy weevil control was superior in IPM plots. There was a significant increase in the *Coccinellids* in IPM plots (Table 4).

However, based on 3 years OFTs, it was concluded that IPM package consisting of timely sowing, seed treatment with chloripyriphos (6 ml) and mancozeb (2.5g per kg of seed), guard crops, need based pest control and spraying carbendazim 0.05% + mancozeb 0.2% at pod filling stage on rainfed groundnut and ashy weevil management in intercrop i.e. pigeonpea resulted in significant yield increase and C:B ratios over farmers practice. As a result of the IPM technology, farmers knowledge on pest and disease identification was improved.

Table 4: Incidence of pests, diseases and natural enemies on farmers fields in Anantapur district in groundnut + pigeonpea intercropping system (2003-04)

Treatment/ module	Avg. thrips/ plant	Avg. aphids/ plant	Avg. leaf miner/ plant	RHC/ m^2	LLS/ m^2	Rust/ m^2	Coccin-ellid/ m^2	Weevils/ m^2	G.nut (kg/ha)	P.pea (kg/ha)
Module 1 (IPM)	2.12	2.21	2.02	1.02	26.8	6.43	2.87	1.49	400.40	45.8
Module II (FP)	2.29	2.72	2.52	1.31	46.8	10.87	1.00	2.24	396.17	48.4
SEM ±	0.06	0.14	0.15	0.16	2.95	1.01	0.22	0.27	1.71	1.74

LLS - Late Leaf Spot, RHC – Red Hairy Caterpillar, FP – Farmers Practice

In case of greengram-safflower system, the best IPM module resulted in a C:B ratio of 1:3.6 during the year as compared to 1:2.7 with farmers practice in Parbhani district. Similarly, IPM module recorded a C:B ratio of 1:2.79 as against 1:2.24 in farmers practice with safflower + chickpea intercropping system at Solapur.

The best IPM module on castor was evaluated in Mahaboobnagar district and the impact studied in the target villages. As a result of awareness generated among the farmers, the area under resistant variety *Jyoti* increased by 30% in all selected villages. Farmers were convinced about the effectiveness of low cost components of IPM like seed treatment with carbendazim, hand picking and destruction of egg masses/early stage larvae of *Spodoptera*, use of wilt resistant varieties, neem seed kernel extract (NSKE), bird perches and prophylactic spray of carbendazim against botrytis. There was also a significant increase in natural enemy population (Table 5). Similarly in IPM trials carried out by ANGRAU at Palem on castor, an average increase of 32% in yield was recorded in IPM treatment as compared to farmers practice.

Table 5: Effect of IPM module and farmers practice on parasitoids and predators on castor in Mahaboobnagar district of A.P. (2003-04)

Treatment	Percent parasitisation			No of predators/10 plants	
	T. chilonis	*Microplitis* sp.*	*Euplectrus* sp.	*Chrysoperla* sp.	Spiders
IPM Module I	14.00 (3.79)	63.20 (52.76)	8.80 (3.04)	6.60 (2.66)	9.20 (3.11)
IPM Module II	5.20 (2.38)	19.60 (26.00)	2.00 (1.55)	1.00 (1.19)	1.00 (1.19)
F P I	8.80 (2.98)	24.00 (29.26)	1.20 (1.25)	1.20 (1.28)	1.80 (1.49)
F P II	10.80 (3.35)	22.40 (28.21)	6.0 (2.54)	2.20 (1.62)	4.60 (2.21)
CV	14.49	8.92	15.34	14.94	18.92
CD (0.05%)	0.42	2.79	0.29	0.23	0.35

Figures in parentheses are Öx +0.5 transformed values, * Figures in parentheses are arc sign transformed values.

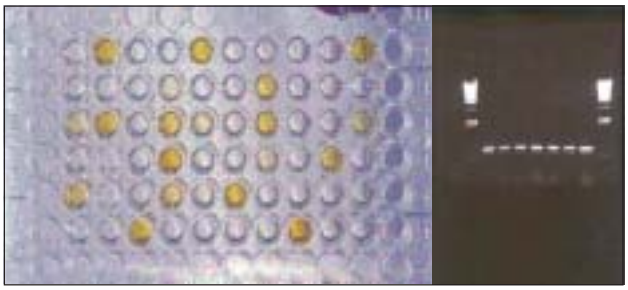
IPM module I: Proper cropping sequence + summer ploughing + removal of crop residues and alternate hosts + proper spacing + resistant varieties + seed treatment with carbendazim @ 2 g/kg + vegetative trapping and killing of RHC + NSKE (5%) + bird perches @ 5/ha + hand picking and destruction of larvae + phermone traps @ 5/ha + carbendazim (0.05%) + monocrotophos (0.05%)

IPM module II: Same as IPM module I except endosulphan (0.07%) inplace of NSKE (5%)

FP I: Use of wilt resistant variety Jyoti; **FP II:** Farmers allowed to grow varieties of their choice

Characterization of SND virus from sunflower

After its first detection in 1997, sunflower necrosis disease (SND) became a serious disease not only in sunflower but several other economically important crops in A.P, Karnataka, Maharashtra and Tamil Nadu. During 2001 and 2002, the etiology of SND was studied and the causative agent was identified as tobacco streak virus, which is ascribed to genus *Ilavirus*. During the year, the coat protein (CP) gene of TSV was characterized in detail. The CP gene is 717 nucleotides long and codes for a 238 amino and protein. The CP gene could be deployed as transgene in breeding programmes aimed at developing transgenic sunflower/groundnut. For reliable diagnosis of SND, efficient and cost effective technologies like enzyme linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR) were fully standardised. Immuno as well as nucleo-probes (polyclonal antiserum and primers) against TSV were produced, which led to the identification of cotton, groundnut, mungbean, okra, soybean, sunhemp and urdbean as the natural hosts of TSV. TSV population originating from different hosts and locations was serologically indistinguishable. The viral coat protein gene sequences of different isolates made under the project were submitted to the gene bank and accessioned (Table 6). Antiserum against TSV was supplied to DOR, Hyderabad, IIHR, Bangalore, IARI Regional Station, Pune and Syngenta India, Aurangabad to facilitate immuno detection of local isolates.



Detection of sunflower necrosis disease by ELISA (left) and Polymerase Chain Reaction (PCR) (right)

Stem necrosis disease (SND) in groundnut

First occurred as an epidemic in Anantapur district of Andhra Pradesh in 2000, the Stem

Table 6: Genebank accession numbers of viral coat protein genes of SND viral strains isolated from different crops and states

Original host	State/ Country	Acronym used	Gene Bank accession No.
Tobacco	USA	TSV-WC	X00435
Sunflower	Maharashtra	TSV-SF-Mh	AY061928
Sunflower	Karnataka	TSV-SF-Ka	AY061929
Sunflower	Andhra Pradesh	TSV-SF-Ap	AY061930
Sunflower	Tamil Nadu	TSV-SF-Tn	AF400664
Mungbean	Tamil Nadu	TSV-MB-Tn	AF515823
Cotton	Maharashtra	TSV-CT-Mh	AF515824
Sunhemp	Karnataka	TSV-SH-Ka	AF515825

Necrosis Disease (SND) received a lot of attention in view of its significant yield reducing potential in groundnut. In 2000 *kharif*, the disease affected nearly 2,25,000 ha resulting in economic loss of Rs.3 billion. A network project initiated in 2000 helped in identification of the causal agent as tobacco streak virus (TSV). A reliable diagnostic method based on ELISA was standardised for its detection. Role of *Parthenium* weed in spread of the disease was also established.

During the year, the main focus was on integrated disease management on farmers fields and creating awareness among farmers and extension functionaries. In both Anantapur and Raichur districts, 26 OFTs were organized in 13 villages, which served as demonstration points for PSND management. The evidence gathered from the trials indicated that border cropping with tall and fast growing species such as maize and other cereal crops can reduce disease incidence on groundnut. Seed treatment with imidacloprid 200 SL @ 2 ml/kg of seed gave effective control of thrips upto 30 DAS at ARS, Kadiri. Whether thrips control helps in lowering disease incidence in groundnut crop could not be ascertained under field conditions due to low natural disease pressure and severe drought conditions during 2003. In the absence of resistant varieties, farmers were advised to remove *Parthenium* weed germinated with early rains growing wild on fallow lands and field bunds. Cultivation of susceptible crops like groundnut and marigold was found to contribute to faster spread of disease.

Border cropping with maize to control peanut stem necrosis disease

Field studies with infected and mechanically inoculated plants of groundnut, sunflower and *Parthenium* failed to show seed transmission of the virus. Removal of infected groundnut plants from the fields had no effect, as the secondary spread of the disease does not occur within the groundnut crop. Fields surveys revealed that PSND occurrence in groundnut is so far confined to Andhra Pradesh and adjoining parts of Karnataka. District administration in Anantapur organized a *Parthenium* eradication programme on war footing with support from villagers, school children, Govt. officials and NGOs in most villages of the district. PSND was not noticed in Maharashtra and Gujarat.

Aflatoxin management in groundnut

Considering the significance of aflatoxin contamination problem in groundnut, an integrated project on its mapping and management was taken up in Gujarat, A.P and Karnataka covering 10 districts. Field surveys during previous years helped in identifying the incidence of aflatoxin during *kharif* and *rabi* seasons in different target districts. The integrated aflatoxin management package, which included a series of interventions from

planting to crop harvest i) summer ploughing, ii) seed treatment with carbendazim @ 2 g/kg seed iii) furrow application of *Trichoderma* (identified as effective against *A. flavus* at NRCG) amended in castor cake @ 500 kg/ha, iv) foliar spray of neem seed kernel extract at 45 DAS, v) foliar spray of carbendazim @ 0.05% + mancozeb @ 0.2% at 70 DAS, vi) drying the produce quickly to less than 7% moisture and vii) separating the diseased pods were evaluated on farmers fields.

During the year, further studies were carried out to understand the seasonal influence on aflatoxin contamination. Analysis of 135 pod samples from Saurastra region during summer 2003, indicated that nearly 64 samples were free from infection and 18% showed less than 2% infection indicating the relative safety of summer groundnut.

Seventy one on-farm trials covering 56 villages in sixteen districts were organized during the year for field level control of aflatoxin through improved crop management. The reduction in infection levels ranged from 0-10 % whereas in 34 trials, seed colonization was reduced (0-6 %). In 37 trials, there was a reduction in soil *A. flavus* population ranging from 1.0-13.8x10^3 propagules/gram as compared to control. In 41 plots, aflatoxin content was reduced to a range of 0.06 to 27.4 ppb as compared to 2.27 to 1235.96 ppb in control, The pod yield was also significantly higher (32%) in the treated plots. Out of 25 trials laid out in Chittoor district, less soil population was recorded in IP plots than FP plot at flowering and harvest stages. In Vepulabili village, seed infection was significantly less in treated plots (3 to 16%) compared to control (14 to 71%). In Nadimipalli village, the mean seed infection was from 8.2% in treated plots as compared to 20.4% in control plots. In Anantapur district, due to poor monsoon rains in the area, the 13 on-farm trials in Krishnamreddy palli and one trial in Rekulakunta village were vitiated. On-station trials at NRCG, Junagadh during 2003 revealed a significant reduction in *A.flavus* population, seed infection and pod yield with improved practices (Table 7).

Table 7: Performance of integrated aflatoxin management package during *kharif*-2003 at NRCG, Junagadh

Observation	Improved practice	Farmers practice
A.flavus population (x10^3)	1.15	4.20
Seed infection %	2	32
Seed colonization %	2	27
Pod yield g/25 plants	780	680
Aflatoxin content (ppb)	15.35	30.70

*Average of two replications

At ICRISAT center, soil *A flavus* population increased up to flowering but later was reduced in treated plots as compared to control. Seed infection was reduced to 4% in treated plots from 18.8% in farmer's practice. Similarly, the mean pod and haulm yields were significantly higher in improved practice (4150 kg/ha) as compared to farmers practice (3486 kg/ha).

Oilseeds Byproducts as Animal Feed

In order to utilize sunflower heads and castor cake as animal feed, a network project was taken

up involving 6 target districts in Karnataka, A.P, Gujarat and Maharashtra. During previous two years, complete feed formulations containing upto 40% sunflower heads and a technology for detoxification of castor cake to remove the ricin were developed. During 2003-04, these products were taken to field and its effectiveness evaluated on farmers households on milk production in cattle, buffaloes and small ruminants.

In low (2-3 kg/day) and medium (5-6 kg/day) yielding milch buffaloes in Raichur and Dharwad districts, feeding with sunflower heads based diets significantly enhanced the milk yield (Table 8). An increase of 1.54 kg of milk/day/animal corresponding to 25 % of the initial milk yield was recorded in Raichur district. The milk yield doubled from 2.67 to 4.10 kg/day/animal in low yielding animals in Dharwad. Well balanced nutrients in complete feed resulted in better quality milk in terms of fat and SNF %. The average feed intake/day was lower on feeding complete feed. Buffaloes could produce 1 kg of milk with 1.5 kg of complete feed while they needed more than 3 kg under normal feeding.

In case of milch cattle, an increase of 1.25 kg of milk per animal per day (14%) was recorded in high yielders in Ahmadnagar district while the increase was 0.67 kg in Mahaboobnagar. The average feed intake per day reduced by 20 to 25 % on feeding complete feed. Feed intake per kg of milk production decreased by 25 % when animals were fed with sunflower heads based complete feed. A net profit of Rs.20.8/day/animal was realised by the farmer. Even with low yielding buffaloes, a net profit of Rs.33/day/animal was received. The cost per kg of 4% fat corrected milk decreased by about 20% in these animals. An additional profit of Rs.12.75 was obtained per animal per day in high yielding milch cattle.

On-farm trials were undertaken at Nagarkurnool in Mahaboobnagar district to evaluate the performance of growing lambs on feeding expander extruded complete diet. Carcass and slaughter characteristics at the end of the study

Sunflower heads after deseeding (left) farmers feeding complete feed containing sunflower heads (right)

Table 8: Results of field trials on utilization of sunflower heads based complete feed with buffaloes and cattle

Parameter	Buffaloes				Cattle			
	Raichur (NIANP)		Dharwad (UAS (D))		Ahmednagar (BAIF)		Mahaboobnagar (ANGRAU)	
	Complete feed	Normal diet	Complete feed	Normal diet	Complete feed	Normal diet	Complete feed	Normal diet
No. of animals	10	10	8	8	10	7	6	6
No. of days	135	135	160	160	240	240	180	180
Initial milk yield (kg/day)	6.16	5.17	2.67	2.57	—	—	—	—
Average daily milk yield (kg/day)	7.70	5.05	4.10	1.79	9.98	8.73	5.93	5.26
4% fat corrected milk yield (kg/day)	11.85	7.47	7.09	5.04	10.57	9.51	5.94	5.59
Fat yield (g/day)	584.43	363.6	363.26	210.65	459.08	401.58	233.00	227.30
SNF yield (g/day)	699.16	444.91	394.01	261.98	842.31	739.43	605.90	536.40
Milk Composition								
Fat %	7.59	7.20	8.86	7.55	4.40	4.60	4.01	4.38
SNF %	9.08	8.81	9.61	9.39	8.47	8.47	10.22	10.30
Total solids %	16.67	16.01	18.47	16.94	12.84	13.83	9.36	11.03
Feed Intake								
Average feed intake/ day (kg)	11.06	15.28	6.00	8.00	11.13	13.83	9.36	11.03
Feed intake/kg milk production	1.44	3.02	1.46	2.86	1.12	1.58	1.57	2.09
Economics								
Expenditure on feed/day	61.45	47.76	28.00	17.50	52.31	56.58	43.67	46.26
Returns/day (Rs)	84.70	50.22	45.10	28.27	84.56	75.08	77.04	68.04
Net profit/day (Rs)	23.25	2.46	17.10	10.77	32.25	19.50	33.37	21.78
Cost per kg of 4% FCM	5.19	6.39	4.00	3.47	5.24	6.48	7.60	8.32
C:B ratio	1.38	1.05	1.61	1.61	1.62	1.34	1.76	1.47

indicated that SFH can be incorporated in complete diets up to 50% level in roughage : concentrate ratio of 60 : 40 without any adverse effect. It reduced the cost of feed per kg live weight gain and also edible meat.

Feeding trials using detoxified castor cake as sole protein source (28% of the concentrate) for a period of 10 months along with metabolism trial indicated that the detoxified castor cake could sustain a normal growth in all the animals without affecting the digestibility. The animals were slaughtered at the end of the trial. No gross lesions or histo-pathological changes were noted in vital organs of liver, spleen and testis. Field trials on *Mehsani* buffaloes in Gujarat using detoxified castor cake (10 % level of the concentrate mixture)

showed significant cost advantage without 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 castor cake based ration fed group (Rs.68.89). The return as % of feed cost was 170.68 and 194.93 in control and treated groups, respectively. Thus, buffaloes fed detoxified castor cake based rations recorded 24.25 % higher returns over control group.

Aflatoxin Control in Poultry and Livestock Feeds

Aflatoxin production in stored poultry and livestock feeds is the most common constraint affecting the health and productivity of milch animals and poultry. With the overall aim of controlling aflatoxin development in the stored feeds, a number of cost effective control measures were tried in a network project in A.P, Haryana, Karnataka and Assam. Studies during 2001-02 clearly indicated the adverse effects of aflatoxin in broilers on body weight and feed intake. Promising herbal agents and dietary supplements were identified, which could prevent aflatoxin contamination in stored feeds.

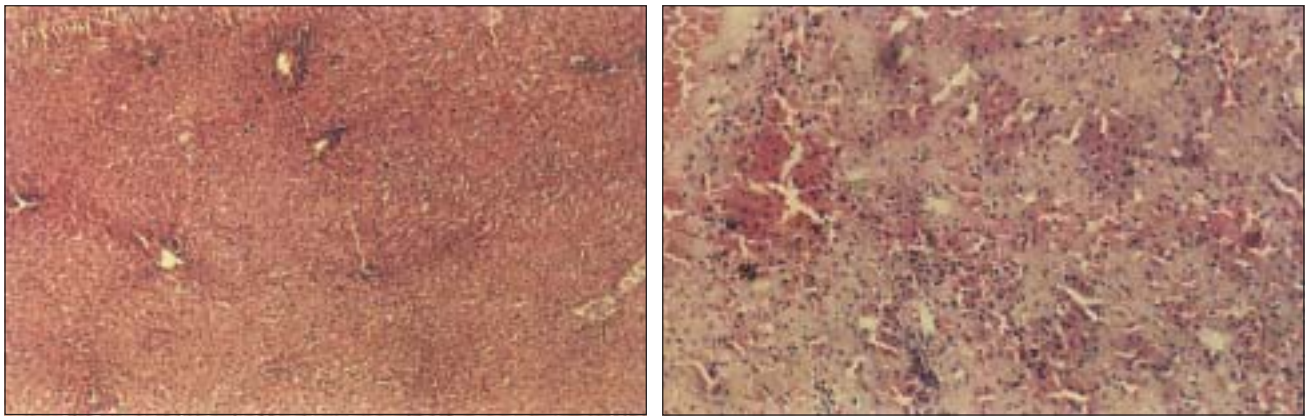
During the year, the studies focused on aflatoxin tolerance in lambs, dietary supplementation and efficacy of herbal agents in stored feeds and detoxification of aflatoxin through enzymes.

Usefulness of herbal and chemical agents

Efficacy of neem bark and citric acid (0.01 and 0.02%) to prevent fungal infestation was evaluated under semi field condition. Treated and untreated composite feeds (8 and 16% moisture) in gunny bags were stored for six months. In citric acid treated feeds, the fungal infestation was restricted upto 76% even after 6 months of storage. The use of neem bark powder at 0.02% level in feeds with 8% moisture content showed 50% reduction in aflatoxin content.

Aflatoxin tolerance in lambs

Tolerance study in lambs involving feeding of concentrate diet with 250, 500 and 1000 ppb of aflatoxin B_1 for 105 days period indicated pronounced adverse effect on feed intake and



Histo pathology of liver in lambs of control group (left) and the experimental group fed with diet containing 1000 ppb aflatoxin B_1 for 105 days (right) showing the hepato cellular degeneration

growth rate in lambs consuming 500 and 1000 ppb aflatoxin. Though feed intake was not affected, growth rate declined in lambs consuming 250 ppb aflatoxin. Total protein, albumin, urea and glutathione in plasma were reduced due to higher level of aflatoxin. Histo-pathological study showed pronounced tissue changes in liver, lungs and kidneys with feeding of 500 and 1000 ppb aflatoxin. Discontinuation of feeding showed improvement in feed intake and growth rate. After 75 days of feeding normal diet, the affected lambs showed complete recovery.

Detoxification through enzymes and herbals

In broiler chicks, counteraction of aflatoxin using enzymes (cocktail containing dehydrogenase, reductase, epoxidase and lactonase) and herbal vitamin C (mix of *Emblica officinalis* and selected medicinal herbs) was evaluated. Enzyme mixture at 0.05% in diet increased the body weight and countered the adverse effects of aflatoxin on serum protein, cholesterol and GGT activity, ready to cook yields, weight of liver, kidneys, giblet and bursa. Herbal vitamin C at 0.025% increased body weight and improved serum cholesterol content and decreased GGT activity. In a separate trial, dietary supplementation of vegetable oil (refined sunflower oil at 3-6%) showed total counteraction of ill effects of aflatoxin on body weight and feed intake in broiler chickens. Herbal agents like *Emblica officinalis (EO), Ocimum sanctum (OS), Piper nigrum (PN)* and *Curcuma longa (CL*) were tried to counteract the adverse effects of aflatoxicosis in broiler chickens in Assam. Body weight, feed intake and feed conversion efficiency in the aflatoxin fed (300 ppb) group were significantly improved when the diet was supplemented with 0.2% level of EO or OS or PN and 0.15% level of CL. Thus, dietary supplementation of enzymes (0.05%), vitamin C (0.025%), fat (3-6%) or herbal agents improved the broiler performance exposed to aflatoxicosis.

Effective storage conditions

Feeds stored in air- tight containers at below 7.5 % moisture level 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 the godown at moisture levels of 12-14% showed increase in aflatoxin production from 7-14 days of storage. Greater fungal growth and aflatoxin production were seen in gunny bags as compared to HDPE bags.

Multicrop 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 this crop. In order to over come the drudgery and improve the efficiency of harvesting, two proto types of safflower harvester were designed at UAS, Raichur and CIAE, Coimbatore. During 2001-2002, field testing of these machines was completed including long duration trials in terms of field efficacy, coverage and economics. Subsequently, the harvester was modified as multicrop harvester to make it more versatile for all crops in the safflower based cropping systems.

During the year, the benefit-cost ratio of manual harvesting and machine harvesting were computed and analysed. A minimum B:C ratio of 1.33 was observed for harvesting wheat with prototype model-I while maximum was recorded for harvesting safflower as sole crop (3.16). In case of prototype harvester model-II, the minimum B:C ratio of 1.3 was observed for wheat and while it was maximum (2.9) for harvesting 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's performance. Safflower farmers were willing to increase the area under the crop, if small capacity mechanical harvesters are made available on custom hiring basis.

At CIAE, Coimbatore, a low cost push type harvester with a pair of bicycle wheels to be pushed manually in the field with 1.7 hp 2 stroke light weight petrol engine to cut and convey a single row of safflower crop was also developed during the year. The field capacity achieved in this machine was 0.051 ha/h with a field efficiency of 85.3 %. Complete manufacturing drawings of the multi crop reaper harvester using CATIA Computer Aided Design software have been prepared.

Single row push type safflower harvester with bicycle wheels designed at CIAE, Coimbatore

Natural Dyes and Herbal Products from Safflower

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 UICT, Mumbai and MAU, Parbhani was taken up. The project focused on optimization of petal yields from farmers fields, standardising extraction technology for dyes and developing protocols for production of herbal tea from petals and cardboard from stalks. Till 2002, the basic protocols for dye extraction, varietal evaluation for petal yield and formulation of *saffo tea* were completed successfully.

During the year, dyeing trials were carried out with safflower yellow. After optimizing variables like mordanting time, concentration, colour strength and color uniformity, a standard recipe was developed. With this recipe, 2.5 kg of cotton cloth can be dyed with 1 kg of petals with excellent colour reproducibility. In order to provide choice of colours, different shades were created from basic yellow dye by manipulating the mordanting techniques. In general petals from spiny varieties yielded comparatively dark shades including smoke

Different shades produced from safflower yellow

grey, which has highest potential among natural colour shades.

Since natural colours from petals are directly used as food additive to increase its nutritive and medicinal value, the concentration of heavy metals was determined in the petals of 20 commercial varieties. As and Hg were totally absent in all the varieties (Table 9). Though Cu and Zn were present in all varieties, the concentrations were within the permissible limits. The study confirmed that safflower petals can be safely used in herbal health care products and neutraceuticals.

At MAU, Parbhani, different methods were compared for storage of harvested petals (LDPE and HDPE bags, aluminium and metal containers) HDPE bags of 200 gauge were found most suitable for retaining colour, flavour, texture and bio chemical characters of the petals. At MAU, bakery products

Table 9: Concentration (ppm) of heavy metals in petals of different varieties of safflower

Variety	Weight of sample (g)	Dilution factor	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
JSI-1	0.5	100	Nil	1	10.4	23.2	Nil	1.6	21.6	30.0
JSI-2	0.5	100	,,	-	5.6	20.6	,,	1.6	12.6	33.6
PBNS-12-1	0.5	100	,,	0.2	22.6	23.4	,,	4.6	23.4	34.6
PBNS-12-2	0.5	100	,,	0.4	-	16.4	,,	3.0	0.8	33.0
SHARDA-1	0.5	100	,,	2.4	-	14.4	,,	3.0	-	32.4
SHARDA-2	0.5	100	,,	-	-	42.2	,,	1.6	-	28.6
JSI-97-1	0.5	100	,,	1.6	8.4	24.8	,,	8.4	-	32.4
JSI-97-2	0.5	100	,,	-	2.6	22.4	,,	2.6	-	37.2
JSI-103-1	0.5	100	,,	-	1.6	17.8	,,	1.6	-	26.4
JSI-103-2	0.5	100	,,	-	3.0	18.0	,,	3.0	-	25.2
ANNE-1	0.5	100	,,	-	-	46.0	,,	-	-	26.0
ANNE-2	0.5	100	,,	-	-	28.6	,,	-	-	26.2
NARI-SH-1	0.5	100	,,	-	-	19.8	,,	-	-	20.4
NARI-SH-2	0.5	100	,,	-	-	12.6	,,	-	-	16.0
JSI-7-1	0.5	100	,,	-	-	22.4	,,	-	-	21.2
JSI-7-2	0.5	100	,,	-	-	17.4	,,	-	-	14.4
NARI-6-1	0.5	100	,,	-	-	4.8	,,	-	-	7.0
NARI-6-2	0.5	100	,,	-	-	13.4	,,	-	-	25.4
BHIMA-1	0.5	100	,,	-	-	8.4	,,	-	-	8.8
BHIMA-2	0.5	100	,,	-	-	10.4	,,	-	-	7.2

like cookies, cakes and toffees were also prepared incorporating petal powder which received an organoleptic score of 8.0 indicating high consumer acceptability.

Pharmaecological studies

Studies on pharmacological properties of safflower petals were carried out at UICT, Mumbai. The anti inflammatory properties of petals were evaluated on Wistar Albino rats using aqueous extract of safflower petals (0.64% w/v safflomin A) by oral and intra peritoneal administration, comparing with Diclofenac sodium as standard. The effectiveness of the petal extract was quantified by carrageenan induced paw edema. There was a 63% decrease in paw volume after 3 h of intraperitoneal administration of aqueous extract as compared to 79% achieved with diclofenac sodium. The anti inflammatory properties of petal extract were evident even with single dose intraperitoneal administration. Further studies are in progress.

Technology transfer

Following the exhibition of products and the process developed under the project at different trade fairs, there was immense response from small entrepreneurs to have a tie up for commercialization of the technologies. Many trade enquires were received during the Agresco meeting held at Nagpur during June, 2004. Govt. of Maharashtra has approved the herbal tea made from safflower petals for marketing in the state. An industrial trial for aqueous extraction of petals to obtain yellow dye in a powder form through spray dyeing is under process. M/s.Ishwardas Gangao, Jalna, M/s.Universal Traders, Parbhani, 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.

Improving the Viability of Soybean Seeds

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) various improved methods were tried. Earlier studies indicated that storing in mud plastered bamboo baskets, ash and sand mixture and vacuumised metallic containers contributed to improved viability. A foot operated vacuum packing machine was also designed to vacuumise the bags.

During the year, the vacuum packing machine was further improved by providing a hand operated lever system to press the edges of the sealing machine. The upper and lower platforms of the table were modified to provide adequate working space and better comfort for the user. Cost of this machine is Rs.4500-5000/-, which is within the reach of small entrepreneurs. This improved machine was successfully tested and demonstrated among farmers and entrepreneurs during various trainings, exhibitions and field visits organised by JNKVV, Jabalpur.

In addition, an electrically operated vacuum packing machine was also designed during the year to remove drudgery associated with the foot operating machine. The manually operated vacuum pump

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

was provided electrical power, but the heat sealing unit continued to be foot operated. The cost of this machine is Rs.5,500/-, which can be owned on community basis.

The GI containers were further improved for retention of vacuum both under empty and filled conditions. The problem of collapse during evacuation was prevented by providing multiple hexagonal reinforcements (2 for 5 kg and 3 for 10 kg containers) at the inner wall of the container. The lid of these containers were tightly sealed and evacuation was achieved through short metal tubes welded to the neck of the container. These containers retained vacuum for more than six months. A low cost gas filling device was designed, which helps in purging the seed container with desired gas (N_2 or CO_2) or first evacuate the containers and then fill the desired gas.

Farmers were extensively trained in collaboration with CEDMAP, Bhopal through regular extension and entrepreneurship development programmes on all improved methods of storage like using insulated storage containers (doubled walled GI bins with thermocol lining) and simple methods like sand and ash mixture.

Oilseeds Based Apiary and Eri Culture

In order to improve the seed set and yield in oilseeds crops and generate additional income to farmers, a network project was taken up on introduction of bee colonies in crops like sunflower, safflower, niger and *taramira* in the target districts of Hassan, Bangalore rural, Gadag, Dharwad in Karnataka, Parbhani and Hingoli in Maharashtra and Bawal in Haryana. During 2001 and 2002, on-farm trials indicated that keeping two bee colonies per acre was optimum for improving seed set and yields in different crops.

During the year, the economics of the system as a whole was worked out besides studying the impact of pest management practices on mortality of honeybees. In niger, plots with two and one colony/acre brought about 26.9% and 18.5% yield increase over control (no colony). This was attributed to 220% and 360% increase in hive bee activity in the respective plots over control, which in turn improved number of seeds per capitulum.

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 mean bee activity/min from zero in control to 1.64 and 1.93/head/5 flower 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 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 8.2 q/ha in plots of one and two bee colonies against 5 q/ha in the control.

The recommended package of practices (RPP) of pest management, which are heavily 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, 3.20, 0.56 and 18.20 per day in IPM plots. Increase in yield in IPM plots @ 20.6, 21.0 and 3.4 per cent over RPP was realised 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, Andhra Pradesh, Maharashtra and Haryana.

Sunflower crop with bee colonies (left); extraction of honey by the farmers in Kuttanagere watershed in Karnataka

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 planned on varietal performance in castor for leaf production, nutritive value of leaves, feed efficiency of eri races and agronomic practices for optimizing leaf yield. Earlier studies 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.

During the year, on-farm adaptive trials were continued and economics of cocoon production with farmers vs. improved package of practices was worked out. In Manipur, castor varieties like *Red Petiole* and Local Green exhibited significantly higher leaf yield than hybrids. Improved method of cultivation (fertilizer application, nipping and flower bud removal) increased the leaf yield by 40-52% over farmers practice. No significant differences on larval, pupal and cocoon parameters of local eri strain were found when fed on two promising castor varieties, i.e., Local *Red Petiole* and 48-1 grown with farmers practice. However, these parameters were significantly improved when fed

on *Red Petiole* with improved cultivation practices. In Jorhat district, however, 48-1 under recommended practice performed significantly better over Local *Red Petiole* in larval, cocoon and grainage parameters. Hence, it may be concluded that castor variety 48-1 is most suitable for eri silk production in Assam, while in Manipur, Local *Red Petiole* was most suitable. However, DCH-177 was more profitable in Karnataka.

The cost benefit ratios of cocoon production were worked out for the winter crop of 2003 with Manipur local race by ICAR Research Complex at Imphal. The highest net return (Rs.235557) and cost benefit ratio (1:15.97) were recorded with DCH-177 and minimum with 48-1 (Rs.144317 and 1:10.17) under improved practice, whereas under farmers practice, the highest net returns (Rs.140202) and cost benefit ratio (1:11.74) were recorded with Local Green (Table 10).

The eco races of eri silkworm differed significantly in respect of rearing, grainage and cocoon parameters. Assam local performed better in respect of rearing and grainage parameters with shortest larval duration, lowest larval mortality and higher effective rate of rearing and cocoon yield, whereas, Bangalore ecorace was found to be better in respect of shell weight and shell ratio.

Table 10: Economics of cocoon production using castor varieties grown under improved and farmers' practices in Manipur

Treatment	Cost of castor cultivation including worm rearing (Rs/ha)	Cocoon yield (kg/ha)	Gross returns from cocoon (Rs/ha)	Net returns (Rs)	Cost benefit ratio (CBR)
Local Red (IP)	15738	801	200165	184427	1:12.7
Local Red (FP)	13050	501	125160	112110	1: 9.6
DCH-177 (IP)	15738	1005	251295	235557	1:16.0
DCH-177 (FP)	13050	452	112877	99827	1: 8.6
Local Green (IP)	15738	825	206135	190397	1:13.1
Local Green (FP)	13050	613	153252	140202	1:11.7
48-1(IP)	15738	640	160055	144317	1:10.2
48-1(FP)	13050	428	106997	93947	1: 8.2

Price of cocoon calculated @ Rs.250/kg, FP – Farmers practice, IP – Improved practice

CHAPTER 4

Pulses Based Production System

About 90 per cent of pulses are grown under rainfed conditions mainly 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 order to address the above issues, technologies and management practices in the areas of rainwater management, INM, IPM and post harvest grain storage and processing have been evaluated on farmers fields in a cropping system perspective.

Integrated Pest and Disease Management

As a continued effort towards validation of IPM modules, 54 on-farm trials were carried out during the year on chickpea and pigeonpea based cropping systems covering 3 target districts in 3 states i.e U.P, M.P and Karnataka.

Ten promising chickpea genotypes having confirmed resistance against wilt were screened against *H. armigera*. These genotypes showed only low to moderate resistance against this insect at all the 3 locations namely Kanpur, Sehore and Gulbarga in the on-station trials. Promising accessions found were RSG 888, JG 130, ICCV 10, PDG 84-10 and JG 74. The evaluation of antagonistic fungi (AF) against chickpea wilt was continued during the year, PDBC Tv 23 and Th 10 strains of *Trichoderma* were found 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 found compatible in chickpea as evidenced by nodulation data.

In view of the promising role of cropping systems in pest management, a number of chickpea based intercropping systems were evaluated at the research stations during the year. In respect of pod damage, chickpea + mustard was found to be best at IIPR, Kanpur. At JNKVV, Sehore, chickpea + mustard and chickpea + linseed were on par. Different IPM modules were tried in all inter cropping systems as sub plots. At Kanpur, BIPM module (7.9% pod damage) was better than CIPM (9.4% pod damage). Control plots recorded 19.4% incidence. At Sehore,

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

all intercropping and management modules were at par due to low pest incidence (3-5%). Intercropping reduced wilt incidence at all locations. Chickpea + mustard with BIPM recorded chickpea seed equivalent yield of 1748 kg/ha as against 1684 kg/ha in CIPM and 1260 kg/ha in control at Kanpur. But at Sehore, CIPM was superior over BIPM (1659 and 1553 kg/ha, respectively). Similarly in case of intercrops, chickpea + linseed was superior to chickpea + mustard.

OFAR trials were continued in all 3 target districts during the year. In Kanpur, pod damage was on par with BIPM and CIPM (6-7%) as against 12.3% in farmers practice. At Sehore, due to low pod borer incidence (3-4%) no conclusion could be drawn. Wilt incidence in different modules was on par at Kanpur in BIPM and CIPM (5-6%) as against 11.7% in farmers practice. At Sehore, CIPM recorded lower incidence (11.5%) than BIPM (15.0%) as against 20.6% in control, but both BIPM and CIPM recorded equal yield over control (1163 kg/ha) at Kanpur. But at Sehore, CIPM was superior (1867 kg/ha) than BIPM (1787 kg/ha). Farmers practice recorded 1651 kg/ha pod yield (Table 1). CBR in BIPM was 1:4.02 at Kanpur and 1:3.57 at Sehore as against 1:4.29 and 1 :4.08 in CIPM, indicating that CIPM has slight edge over BIPM. Though overall, CIPM was more economical but the benefits of BIPM due to reduced pesticide use, protection of beneficial flora and fauna more than compensate for the lower CBR.

In pigeonpea, the focus was to evolve a cost effective package for control of wilt, pod fly and pod borer at Kanpur, Gulbarga and Sehore through participatory on-farm trials. BIPM, CIPM and farmers' practice were compared. Significant improvement of plant population was observed in BIPM (90-98 thousand/ha) as compared to control (85 thousands/ha). Wilt incidence ranged between 13.6 - 17.3% in all 3 treatments with no statistical difference. The efficacy of BIPM module on insect pest management was evident from the data. At Kanpur, chemo-intensive IPM module was more effective for pod borer and pod fly management than BIPM. CIPM gave 2588 kg/ha yield followed

Table 1: Effect of bio and chemo intensive IPM modules on chickpea + mustard inter cropping system on farmers fields in 2 target districts

Treatment	Yield (kg/ha)	Additional increase in yield over control (kg/ha)	Gross return s (Rs/ha)	Value of additional yield (Rs/ha)	Net returns (Rs/ha)	CBR
			Kanpur (20)*			
Bio-IPM	1729	566	25935	8490	24245	1:4.02
Chemo-IPM	1734	571	26010	8565	24455	1:4.50
Farmer Practice	1163	-	17445	-	17445	-
			Sehore (10)*			
Bio-IPM	1787	136	16638	1644	15557	1:0.52
Chemo-IPM	1867	216	17771	2611	17061	1:2.67
Farmer Practice	1651	-	15160	-	-	-

* indicate the number of on-farm trials

by 2095 kg/ha in BIPM and 1650 kg/ha in farmers practice. The corresponding CB ratios were 1:3.73, 2.58 and 2.67, respectively.

At Sehore, the yield of pigeonpea was affected due to low plant population at early stage of the crop growth. The seed yield was 352, 467 and 489 kg/ha under farmer practice, chemo-intensive and bio-intensive IPM modules, respectively. Both the modules were significantly superior to farmer practice. Pigeonpea equivalent yields under BIPM and CIPM were on par but BIPM module gave higher cost:benefit ratio (1.43) and net profit (Fig 1, Table 2).

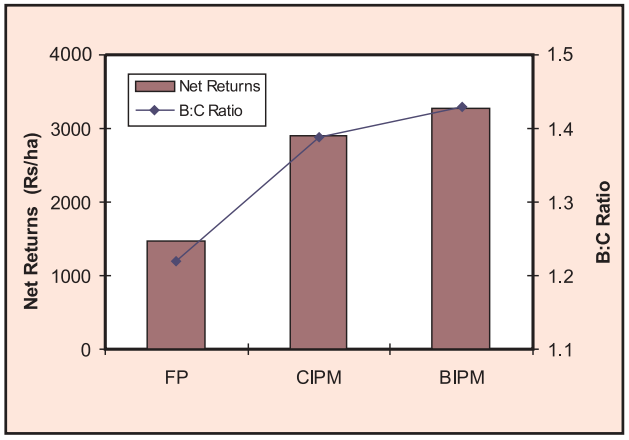


Fig. 1: Net returns and B:C ratio of pigeonpea as influenced by IPM practices at Sehore

Management of Yellow Mosaic Virus

Yellow mosaic virus (YMV) causes severe yield losses in short duration pulses like mungbean and urdbean. For better management of the disease, an integrated package was tried for the third successive year at Hyderabad, Coimbatore, Berhampur and Kanpur through participatory on-farm trials. Additionally, detailed studies on epidemiology and virus-vector relationships were carried out during the year. Initial surveys identified PBNV in Andhra Pradesh, MYMV in Uttar Pradesh, MYMV and ULCV in Tamil Nadu and MYMV and PBNV in Orissa as economically important viral diseases. These surveys formed the basis for experimentation on virus-vector relationships, vector reservoirs,

Table 2: Performance of bio and chemo intensive IPM modules on pigeonpea + sorghum inter cropping system during 2003-04

Treatment	Pigeonpea equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)	Net returns (Rs/ha)	CBR
		On IPM component	Total			
Gulbarga (5)						
Bio IPM	863	2850	4907	12945	8038	2.64
Chemo IPM	—	—	—	—	—	—
Farmers Practice	708	2675	4732	10620	5888	2.24
Sehore (9)						
Bio IPM	602	1260	7550	10838	3288	1.43
Chemo IPM	578	1070	7500	10412	2912	1.39
Farmers Practice	462	350	6855	8321	1466	1.22
Kanpur (10)						
Bio IPM	2095	1300	9597	34425	24828	2.58
Chemo IPM	2588	540	8837	41820	32983	3.73
Farmers Practice	1650	—	7552	27750	20198	2.67

Figures in parenthesis represent the number of on-farm trials

seed transmission and environmental factors causing disease spread at various locations.

During the year, NBPGR, Hyderabad carried out 4 OFTs on mungbean in Guntur and 2 in Warangal district. PBNV incidence ranged between 12.1 to 27.4 and 37.0 to 43.3 per cent in integrated management and 32.6 to 62.3 and 48.6 to 53.8 per cent in farmers practice, respectively in Guntur and Warangal. In IVM, yields ranged between 237 - 275 kg/ha compared to 167 - 192 kg/ha in sole crop in Guntur and 262-303 kg/ha compared to183-201 kg/ha yield in sole crop in Warangal (Table 3).

Table 3: Disease incidence and yields of mungbean under integrated virus management (IVM) in the OFTs in Guntur and Warangal districts of AP (2003-04)

Village and district	No. of farmers	Treatment	Virus incidence (%)		Yield (kg/ha)	Increase in yield (%)
			PBNV	MYMV		
Jonnalagadda (Guntur)	2	IVM	27.2	4.35	256	29
		Farmer's Practice	57.8	5.5	180	—
Wanaparthy (Warangal)	2	IVM	40.1	3.1	283	47
		Farmer's Practice	51.2	2.5	192	—

In Coimbatore district, data from OFTs on urdbean and mungbean showed that incidence of MYMV and ULCV were reduced by more than 50 per cent in IVM treatment, with a corresponding increase in seed yield (Table 4). Similar trend was observed in mungbean. The incidence of leaf curl was however not affected significantly.

In Kanpur district, four OFTs on mungbean and 2 in urdbean were taken up during the year. *Samrat* and IPU-94-1 were used as YMV resistant varieties in urdbean and mungbean, respectively. Farmers own seeds were the source of local genotypes. *Samrat* recorded no incidence of YMV as compared to local, which recorded 35.63 per cent incidence. IPU 94-1 was completely free from disease while local genotypes recorded 46.63 per cent incidence (Table 5).

Virus resistant urdbean variety Co-5 on farmers field at Coimbatore

Leaf curl in mungbean was 5.46 and 7.08 per cent in IPU 94-1 and local mungbean, respectively. The disease incidence was less in urdbean as compared to mungbean. Resistant varieties in both the crops recorded significantly higher seed yields over farmers local.

Table 4: Effect of integrated virus management in urdbean and mungbean at Coimbatore district (No. of farmers 5)

Treatment	Mungbean									
	KM-2					Pusa Bold				
	Disease incidence (%)			White fly	Yield	Disease incidence (%)			White fly	Yield
	MYMV	ULCV	Leaf curl	(No/plant)	(kg/ha)	MYMV	ULCV	Leaf curl	(No/plant)	(kg/ha)
Mungbean alone	14.81	7.41	12.96	5	435	7.27	5.45	10.91	6	440
Mungbean with border crop of sorghum	6.12	2.04	12.24	2	447	4.26	2.13	10.64	2	451

Treatment	Urdbean									
	Co-5					APK-1				
	Disease incidence (%)			White fly	Yield	Disease incidence (%)			White fly	Yield
	MYMV	ULCV	Leaf curl	(No/plant)	(kg/ha)	MYMV	ULCV	Leaf curl	(No/plant)	(kg/ha)
Urdbean alone	12.77	8.43	11.10	4.40	732	8.25	7.75	8.80	4.40	766
Urdbean with border crop of sorghum	5.06	3.78	9.58	1.60	751	3.92	1.54	6.85	1.00	776

Table 5 : Disease incidence and yield with improved vs farmers practice in OFTs of Kanpur district (*Kharif*, 2003)

Parameter	Mungbean*		Urdbean**	
	Improved practice	Farmers Practice	Improved practice	Farmers Practice
%YMV	0.0	35.6	0.0	46.6
% Leaf curl	5.5	7.1	1.8	2.3
% Leaf crinkle	0.0	0.0	1.8	2.2
Whitefly (mean)	1.1	3.0	12.4	13.0
Thrips (mean)	1.2	2.4	3.7	4.7
Yield (kg/ha)	775	397	819	364

* Mean of 4 trials ** Mean of 2 trials

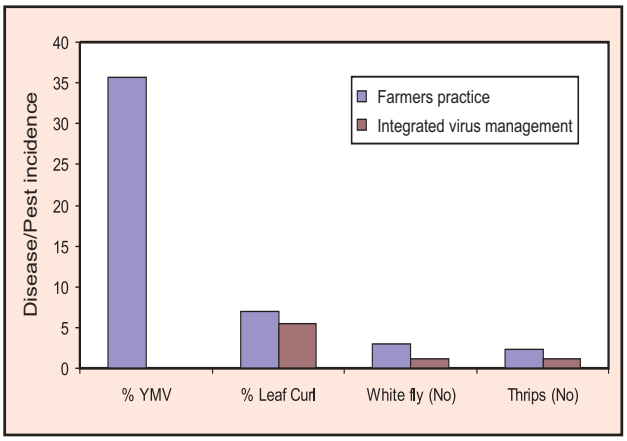


Fig. 2: Performance of IVM practices on viral disease and pest incidence of mungbean in Kanpur district

Nematode Management in Pulse Crops

Two major nematodes viz. root knot nematode, (*Meloidogyne* spp.) and cyst nematode (*Heterodera cajani)* have been known to cause severe damage to chickpea and pigeonpea even under rainfed conditions. Nematode infestation pre disposes these crops to *Fusarium* wilt even in wilt resistant cultivars. An integrated project on nematode management in chickpea and pigeonpea based cropping systems was taken up at 3 centers viz. Kanpur, Dharwad and Aligarh. Results during previous two years indicated the potential biological agents and plant based products in control of nematodes on farmer's fields.

During 2003, both on-station and on-farm trials were carried out on the field performance of the best treatments. Highest economic returns in pigeonpea were achieved in on-station trials at Aligarh with i) seed treatment with neem seed powder (5%) + latex (1%) followed by ii) seed treatment with neem seed powder iii) latex,

Highly nematode infected pigeonpea (left) and treated with neem seed powder @ 50 kg/ha as soil application (right) at Agra

iv) intercropping with pearlmillet and v) soil application of neem seed powder, respectively. Summer ploughing and seed treatment with neem seed powder was found to be the best for realising highest economic returns from pigeonpea. 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 substantially and increased the yield by two fold in UPAS-120 and 35% in cv. *Bahar* of pigeonpea.

Among different nematode management practices, summer ploughing and pigeonpea inter cropped with sorghum showed highest suppression of *M. incognita* population and lowest root-knot index followed by summer ploughing, inter cropping and ridge sowing, respectively (Table 6).

On-farm trials carried out in 2 districts showed highest cost-return ratio in seed treated with neem seed powder (5%) followed by latex (1%), dimethoate, *P.lilacinus* and soil application of neem seed powder (5%), respectively. The neem seed powder + latex also controlled the wilt complex (Table 7). Variety JG-315 showed the best performance. Soil application @ 50 kg/ha and seed treatment @ 5% w/w with neem seed powder increased the grain yield by 30% over check and reduced the nematode population upto 40%, followed by seed treatment with latex of *Calotropis procera* @ 1% v/w and *Paecilomyces lilacinus* @ 10 ml/100g seed.

Agro-technologies for Management of Intercrops

Pulses are mainly grown in intercropping systems, which provide much needed stability to small farmers. But optimum returns from recommended intercropping systems are not realised due to non-adoption of package of practices aimed at maximizing returns from component crops. In a network project, integrated crop management modules for higher economic benefits were identified, which include selection of proper variety, cropping system, IWM, INM and soil

Table 6: Effect of different management practices on population of *M. incognita* and root-knot index in pigeonpea (in 5g roots)

Treatments	Crop stage	*M. incognita*	Root-knot index
Normal planting of pigeonpea	Pre flowering	250	2.25
	Pod formation	300	2.70
	Harvest	360	3.00
Pigeonpea after summer ploughing	Pre flowering	120	1.00
	Pod formation	190	1.90
	Harvest	280	2.60
Sorghum + pigeonpea intercropping	Pre flowering	100	0.95
	Pod formation	170	1.75
	Harvest	250	2.25
Intercropping of pigeonpea + sorghum after summer ploughing	Pre flowering	80	0.75
	Pod formation	120	1.00
	Harvest	200	2.00
Planting pigeonpea on ridges	Pre flowering	180	1.85
	Pod formation	220	2.10
	Harvest	350	3.00
CD at 5% level	Pre flowering	15.2	0.16
	Pod formation	19.8	0.19
	Harvest	29.6	0.27

Table 7: Effect of different nematode management practices on yield and economics of two chickpea varieties in chickpea+mustard (6:1) intercropping system (mean of 4 villages in 2 target districts)

Treatments	Yield (kg/ha)			Cost return ratio	Gall index	Nema-todes/ 100 cc soil	Wilt incidence (%)	No. of nodules/ plant
	Chick pea	Mustard	Chickpea equivalent yield					
JG-315 – untreated	630	113	711	1:1.16	1.81	1520	16.6	7.7
JG-315 – Latex 1% + NSP 5% (ST)	782	114	864	1:1.41	1.21	1160	11.9	6.8
BG-256 – untreated	484	112	565	1:0.92	2.63	1830	34.0	3.2
BG-256 – Latex 1% + NSP 5% (ST)	607	113	688	1:1.12	2.11	1455	23.0	3.2
$LSD_{0.05}$	63	10	69	0.97	0.17	143.2	1.7	0.4

moisture conservation. To illustrate, few identified combinations have been given here. At Ranchi, intercropping of pigeonpea (BSMR-736) + pearlmillet (*Shraddha)* with ridges and furrows as moisture conservation practice + 50 % RDF + 5 t/ha FYM + biofertilizers with timely weed control recorded the highest grain yield of pigeonpea and pearlmillet (9.1 and 8.34 q/ha). The highest

Pigeonpea + soybean intercropping system with INM on farmers field in Sehore district

pigeonpea grain equivalent yield (12.85 q/ha), gross (Rs.18464 /ha) and net returns (Rs.9585.5 /ha) were also realised with this treatment. At Sehore, INM (50 % RDF + FYM @5 t/ha + biofertilizers) + Pendimethalin @ 0.75 kg a.i/ha in pigeonpea+soybean (2:4) intercropping system recorded the highest grain yield of both component crops, net returns (Rs.13321 /ha) and B:C ratio (1 :2.26). At Kanpur, the highest grain yield of chickpea (18.19 q/ha), mustard (5.91 q/ha) were realised from chickpea + mustard (6:2) intercropping system with INM (50% RDF+ 5 t/ha FYM +biofertilizers)+ IWM (Pendimethalin PE @ 0.75 kg a.i/ha) + one hand weeding at 40 DAS.) as compared to farmers practice.

Integrated Nutrient Management in Sequence Cropping

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 research station trials, their adaptation under real farm conditions have not been worked out adequately. In a net work project in 5 target districts, best INM+moisture conservation practice for most profitable pulse based production systems were identified. At Bhopal and Raisen districts, economic analysis of soybean-chickpea and soybean-lentil cultivation indicated that 75% NPK + FYM along with soil moisture conservation measure during *kharif* season was by far the most profitable treatment. Soybean-chickpea was the most productive/remunerative cropping system at Bhopal and Raisen districts. In Hamirpur district, 100% NPK + FYM + moisture conservation measure proved to be the best amongst nutrient management options and urdbean-chickpea was more productive and remunerative than sorghum-chickpea system. In Rewa and Satna districts, paddy-chickpea system was more profitable with INM practice of recommended NPK + FYM + drainage/moisture conservation. In addition to supporting higher yields, INM +moisture conservation treatments led to improved soil quality at all locations.

Liquid Biofertilizers

The liquid inoculant technology developed and field tested during the last two years for *Rhizobium* was extended for *Azotobacter, Azospirillum* and *Bacillus megaterium* (phosphate solubilizing bacteria) during 2003-04 using the cell protectants and media components. These organisms could be successfully formulated as liquid inoculants meeting the BIS specifications. On-farm trials with liquid *Rhizobium* inoculants were continued

Groundnut crop inoculated with liquid *Rhizobium* inoculant

on groundnut, soybean, redgram and chickpea (215 field trials) through 13 Krishi Vignana Kendras (KVK) in seven states. Inoculation of chickpea with LRI resulted in 4-18 per cent yield increase over uninoculated control when compared to lignite based inoculant. In groundnut, the yield increase due to LRI was 14.7 %, 7.2 % in CRI over uninoculated control at Chomu, Rajasthan. At Hiriyur (Karnataka), the yield increase was 21.7 and 16.5 per cent due to LRI and CRI, respectively over control. Similarly, the increase was 18.0 and 5.2 % in Reddypalli (A.P) and 27 and 35 per cent at Sirohi (Rajasthan) with LRI and CRI, respectively.

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 in major pulse based cropping systems.

In Nalgonda district, conservation furrow at 3m interval in castor+pigeonpea (5:1) increased the interception of runoff and resulted in 11 % additional moisture storage in the profile over farmers practice of line sowing. This increased the yield of both the 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* emerged as better package than fallow-mustard (11.5 q/ha). In medium to deep Vertisols of Bijapur district, greengram-sunflower sequence cropping 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 (135cm) for sunflower compared to farmers' practice (35 cm) gave 162 % higher yield over farmers practice (8.7 q/ha). But in greengram-*rabi* sorghum cropping system, compartmental bunding during *kharif* for greengram and incorporation of greengram residue was found to be better compared to farmers' practice. Wider row (90 cm) planting of *rabi* sorghum performed better (27.7 q/ha) compared to farmers' practice (6.7 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 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 in 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*

Performance of pigeonpea on ridge and furrow system on farmers fields in Varanasi district

(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 (planting pigeonpea on flat lands).

Safe Storage of Pulses with Low Cost Technology

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. During 2003-04, 8 on-farm trials carried out at Bhopal on pulses stored in the farmers houses revealed that higher dry matter loss (8.47%) and infestation (40%) when pulses were stored in traditional bins compared to treatment with $NaHCO_3$ and storing in metal bins (0.27% and 0.5%). IPM Package I (use of sticky traps for pest monitoring and sun drying using automatic disinfestation device)

developed and tested in 7 farmers holdings resulted in 7 to 16% damage compared to 100% damage in control after 5 months of storage whereas IPM Package II (use of sticky traps and two in one model trap) resulted in 40% damage indicating superiority of IPM Package I.

At Kanpur, results from farmers household experiments showed that inert materials such as Parad Tikri and activated charcoal powder were most effective against bruchid, whereas lime, alum and fly ash recorded moderate level of protection. Oils such as castor, mahua and mustard also offered effective protection. Plant products viz. Anona seed powder followed by neem seed kernel (NSK) and asafoetida were most effective against bruchid. On-farm trials revealed good viability (85%) of the seeds after 6 months storage.

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 helped in standardising low cost methods of pulse storage based on locally available herbal material and some advanced technique like use of traps and probes.

Commercialization of Detection Device

The probe cum pitfall trap developed, tested and demonstrated among farmers/households during the last 2 years 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. 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 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. Herbal products /oils in 4 villages in Kanpur district for 53 farmers

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

and 27 women farmers on solar bed technology in 3 villages of Hisar district.

Improved Dal Mill

To improve existing dal mill in terms of better recovery and to reduce energy consumption, three different models of dal mills were upgraded and tested at Kanpur, Bhopal and Hyderabad. Earlier results showed that IIPR dal chakki was superior to CIAE and CFTRI models for different performance parameters. During 2003, upgraded version of IIPR Dal Chakki and twin reel type grader were developed and tested. The upgraded model is powered by 1.5 HP single 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. The grading requirement in earlier model of IIPR Dal Mill was effectively met by the reel type grader developed during the year.

Rotary screen grader for raw pulses and separation of finished products

The perforated outer cage (metal sheet of 22/24 gauge) of CIAE Dal mill was found to break when hard material enters the mill, which has now been replaced by perforated cage (2 mm diameter with round hole) made up of mild steel sheet of 18 gauge. Simultaneously, *Dal* polisher and pneumatic cleaner were developed at CRIDA, Hyderabad. These modifications will improve the commercial acceptance of finished products.

CHAPTER 5

Cotton Based Production System

In view of the continued low productivity and diverse production constraints faced by the cotton based production system, individual sub projects were formulated to address important research and adoption gaps. These include identification of quality *arboreum* varieties, collection of germplasm from north east, genotypes for low input, moisture stress and salt affected soils, rainwater management and integrated nutrient management. Salient results from these sub projects are summarized below.

Germplasm Enhancement

Under this thrust area, four sub projects focused on identification of superior quality *arboreum* varieties, collection and evaluation of indigenous germplasm from hill regions, study of gossypol in cotton germplasm and development of transgenic diploid cottons.

Quality Arboreum Varieties

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 during 2001 and 2002 resulted in identification of four superior quality *arboreums* (PA-255, PA-402, DLSA-17 and MDL-2463) with high seed cotton yield and superior fibre quality. These varieties performed on par or superior to most popular *hirsutum* hybrids. During 2003-04, the OFTs were continued in all the target districts i.e. Parbhani, Dharwad, Nagpur, Khandwa, Adilabad (Mudhol) and Kovilpatti where in the best *arboreums* were compared with leading *hirsutum* hybrids including Bt cotton hybrid. The fibre and yarn qualities were also evaluated in collaboration with the textile industry.

Data from seventy seven OFTs conducted in 32 villages covering 60 farmers in the target districts are presented in Table 1. Conforming to the results obtained during 2001 and 2002, the yields of newly identified quality *arboreums* ranged from 730 (DLSA-17) to 778 kg/ha (PA-255) which were at par with *hirsutum* hybrid *Bunny* (759 kg/ha) and Bt cotton hybrid MECH-162 / 184 (895 kg/ha). PA-255 (778 kg/ha) and MDL-2463 (775 kg/ha) recorded marginal superiority over hybrid *Bunny* (759 kg/ha). However, the cost benefit ratios were higher with PA-255 (1:3.92) and MDL-2463 (1:3.12) as compared to *Bunny* (1:1.78) and Bt cotton hybrid MECH-162/ 184

Table 1 : Performance of quality *arboreum* varieties on farmers fields in comparison with *hirsutum* hybrids and Bt cotton during 2003-04

Variety	Yield (kg/ha)						Mean (kg/ha)	Returns (Rs)	B:C ratio
	Parbhani (5)	Dharwad (4)	Nagpur (6)	Khandwa (6)	Mudhol (10)	Kovilpatti (5)			
PA-402	833	844	389	1022	817	520	737	14740	2.97
DLSA-17	571	960	374	1004	1003	473	730	14600	2.94
MDL-2463	559	920	305	1175	1214	482	775	15500	3.12
PA-255	847	832	429	1163	997	495	778	19450	3.92
LH x H	–	862 (Sahana)	322 (NHH-44)	–	–	–	592	14800	1.38
Bunny	632	781	484	1064	1143	457	759	18975	1.78
MECH-162/184 (Bt)	725 (MECH -184)	1130 (MECH-162)	525 (MECH-162)	1246 (MECH-162)	1267 (MECH-12)	479 (MECH-184)	895	22375	2.36
CD	148.5	–	81.33	135.20	102.39	35.28	–	–	–

Cost of cultivation: ***arboreums*** Rs.4960, H x H hybrids Rs.10650 and Bt. hybrids Rs.9450
Market price: ***arboreums*** Rs.2000, H x H hybrids Rs.2500, Bt. hybrids Rs.2500

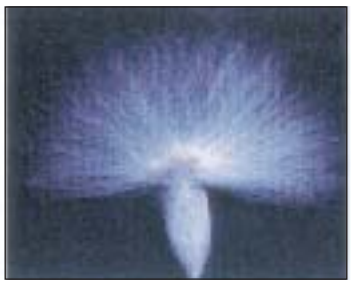
(1:2.36), mainly due to the lower cost of cultivation for *arboreums*. Three years data convincingly proved that cultivation of quality *arboreum* varieties is more beneficial to rainfed farmers.

Fibre quality assessment

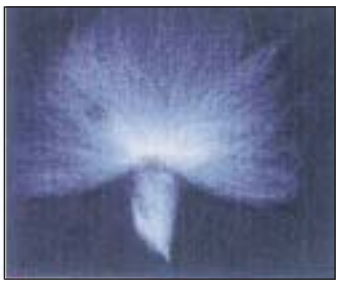
One of the limitations in popularising *arboreum* cottons is the low market price for the lint obtained by the farmers due to the poor quality image associated with *desi* cottons. The fibre and yarn qualities of quality *arboreum* PA-255 (*Parbhani Turab*) were therefore mill tested at M/s Maral Overseas Limited, Indore an 100% EOU and compared with *hirsutum* variety LRA-5166. The quality parameters as assessed by Director, CIRCOT using the advanced fibre information system are listed in Table 2. On most of the fibre and yarn parameters, PA-255 compared well with LRA-5166. These results confirm the quality superiority of the improved *arboreum* cottons paving the way for an increased thrust on *desi* cottons for rainfed areas.

Comparison of fibre length of improved ***arboreums*** (PA-255 and PA-402) with ***hirsutum*** hybrids (NH-452)

PA-255 (26.3 mm)



PA-402 (26.1 mm)



NH-452 (23.5 mm)

Table 2 : 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)	681	774
Nep (Cnt/g)	92.4	163
Seed coat Neps (um)	1038	1439
Seed coat Neps (Cnt/g)	7.3	26
Uniformity ratio	48	46
Micronaire value	4.7	4.3
Fibre strength (g/tex)	22.9	22.7
Elongation (%)	4.9	5.6
Short fibre content	9.9	12.7

In case of yarn test results also, PA-255 compared well with LRA-5166 in count strength, transozet breaking force, transozet tenacity and transozet elongation. Since *desi* cottons proved on par both in terms of yield and quality, they need to be popularised among farmers in rainfed areas. There is an urgent need for increasing seed production.

Indigenous Cottons from NEH Region

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 has been going down due to poor marketing and much 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.

During the previous two years, 23 *arboreum* and 11 *barbadense* lines were collected from different localities of Assam, Meghalaya, Mizoram and Nagaland and characterized in comparison with introduced *arboreum* varieties from other parts of the country. In general, these germplasm showed high tolerance to biotic and abiotic stresses but were of poor yield potential. Both morphological and genetic characterization was continued during 2003-04 for the existing and newly collected material during 2002. Based on two years data on yield, yield attributes and response to biotic and abiotic stresses, the germplasm has been ranked both in *G.arboreum* (Table 3) and *G.barbadense.*

In case of *arboreum* germplasm, high genetic advance was observed for no. of bolls per plant, seed cotton yield and plant height indicating

Performance of indigenous cotton germplasm from north east on research station at AAU, Diphu

Table 3 : Promising indigenous *arboreum* lines for various traits over two years (2002, 2003)

Character	Range	Cultivar ranking in descending order
	G.arboreum	
Days to flower (DAS)	71 to 86 days	Mizo White-1 and Garo-1and Mizo White-2, Pheloso-1
Plant height	197 to 207 cm	Garo Kil-1, & Phelo Chapong -2
Boll no.	17 to 18 bolls/plant	Phelosaw-1 and Pheloso-1
Boll weight	3.6 to 3.9 g	Garo Kil-2, Phelopisa, Garo-1, Karbi and Garo Kil-3
Seed cotton yield (Maximum)	641 kg/ha	Karbi
Over all insect pest resistance/tolerance	Leaf roller, jassids, whitefly and spotted boll worm	Karbi, Garo1, Garo Kil 3 and Pheloso 1
	G.barbadense	
Plant height	225 to 230cm	Phelopi-1, Fellopi 2 and Phelo Chang Chang-1
Branches/plant	12.17 to 12.33	Phelopi-1 and Fellopi 2
Boll no.	53.67 to 58.66 bolls/plant	Phelopi-1 and Phelo Chang Chang-1
Boll weight	2.5 to 2.56 g	Fellopi 2 and Phelopi 3
Seed cotton yield (Maximum)	12.45 q/ha	Fellopi 2
Ginning %	31.85 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, Phelo Chang Chang-1

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.barbadense*, 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

In view of the known importance of gossypol in cotton for biotic and abiotic stress tolerance, a study was taken up at CICR, Nagpur to characterize large number of germplasm from different species and varieties for gossypol. More than 1000 lines were analysed upto 2002 and extensive variability was found both among varieties and species. Wild cotton species exhibited more gossypol than the cultivated ones. Among the cultivated species, *G.arboreum* showed higher gossypol content followed by *G.hirsutum* and *G.herbaceum.*

In addition to completing the initial collections, the seed gossypol content of quality *arboreum* lines from MAU, Parbhani were also estimated during the year. An effort was made to correlate the gossypol content with disease resistance in selected varieties. Based on the analysis carried

Table 4 : Classification of cotton germplasm lines on the basis of seed gossypol content

Gossypol range (%)	Category	No. of germplasm lines			
		Wild species	*G. herbaceum*	*G. arboreum*	*G. hirsutum*
0.0 - 0.5	(low)	1	18	2	162
0.5 - 1.0	(medium)	3	14	24	134
1.0 - 1.5	(high)	5	nil-	31	71
> 1.5	(very high)	9	-	47	35
Total		18	32	104	402

out among all species so far, the germplasm lines have been classified as low, medium, high and very high (Table 4). 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 for pests and diseases.

Transgenic diploid cottons

In view of the growing importance of diploid cottons in rainfed areas and the availability of quality *arboreums*, an effort was made to standardise a tissue culture protocol followed by introduction of Cry1A(c) gene through *Agrobacterium* mediated gene transfer for conferring resistance to cotton boll worm. During 2001 and 2002, a successful regeneration and transformation protocol was standardised for AKA-8401 and RG-8. Transformed plants were established in the soil and fully characterised. These are straight varieties which can be used directly after necessary field trials on agronomic performance and bio safety.

During the year, efforts were made to standardise regeneration and transformation protocol 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 (95.1) followed by PA-183 (73). When the shootlets derived from multiple shoot induction were transferred to rooting medium containing 0.1 mg/l of NAA, 47.3% rooting was observed. Primary hardening was done by covering with poly bags for one week followed by transfer to soil + sand mixture (1:1). Data on the regeneration frequency of different *arboreum* cultivars on MS medium containing 2 mg/l of BAP and 4 mg/l of kinetin are presented in Fig. 1.

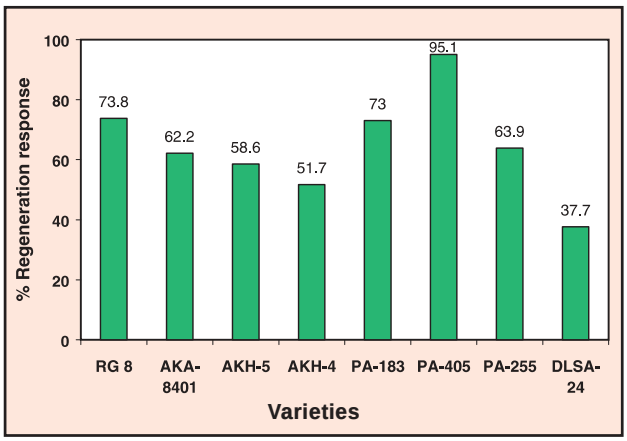


Fig. 1: Regeneration response of shoot tip explants in different cultivars of *G.arboreum* on MS+BAP (2 mg/L) + Kinetin (4 mg/L)

Table 5 : Frequency of *Agrobacterium* mediated transformation with Cry I A (C) gene in different cultivars of *abroreum* cotton

Cultivar	No. of explants co-cultivated	No.of explants regenerated	Transformation frequency (%)
RG 8	226	–	–
	30	–	–
	2301	33	1.4
	1230	30	2.4
	245	–	–
AKA-8401	500	21	4.2
	642	–	–
PA 183	1608	25	1.55
	607	–	
PA-405	937	42	4.48
PA-255	1530	26	1.69

The regenerated shoots were transformed with a gene construct Cry1A(c) obtained from NRCPB, IARI, New Delhi through *Agrobacterium* mediated gene transfer. Among the genotypes, PA-405 recorded highest transformation frequency (Table 5). These plants need to be analysed further, seed multiplied and followed up with field trials on agronomic performance.

Rainwater Management

Efficient utilization of rainwater through conservation and recycling is key to successful cotton production in rainfed areas. An integrated project in 5 target districts (Amravati, Yeotmal, Belgaum, Guntur and Vadodara) was taken up to develop suitable toposequence based cropping system for efficient use of moisture and improved productivity. The project also aimed at evolving suitable land configurations and cropping systems to minimize the affects of excess moisture. Previous results from on-farm trials indicated 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.

During 2003-04, OFTs on all toposequences were continued with 10 farmers from each toposequence. The average slopes of the selected fields ranged between 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 was compared with farmers method of sole *hirsutum* on flat bed. In the lower toposequences, *hirsutum* cotton intercropped with soybean followed by a chickpea as sequence crop was compared with

Table 6 : Yields of seed cotton and intercrops (q/ha) under different rainwater management treatments on upper toposequence in 4 target districts (2003-04)

Name of district	T_1	T_2		T_3		T_4	
	Cotton	Cotton	Sorghum	Cotton	Sorghum	Cotton	Sorghum
Yeotmal	4.99	4.32	11.66	5.56	14.54	7.76	18.85
Nagpur	5.51	6.63	–	9.21	–	9.84	–
Guntur	7.48	5.35	9.83	5.67	10.93	5.81	11.45
Vadodara	16.12	17.46	13.71	18.94	15.36	21.14	18.21

T1 : Farmers practices- sole cotton (*hirsutum*) flat bed +100% RDF
T2 : Cotton (*arboreum*) + sorghum flat bed +100 % RDF
T3 : Cotton (*arboreum*) + sorghum on ridges and furrows+100% RDF
T4 : T3 + supplemental irrigation

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.

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 better 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 cropping system in terms of CB ratio. For excess moisture situations, raised and sunken bed land configuration gave the highest seed cotton yield, gross monetary returns and CB ratio over all other treatments. Supplemental irrigation with harvested rainwater was the most effective component for improving productivity across all treatments.

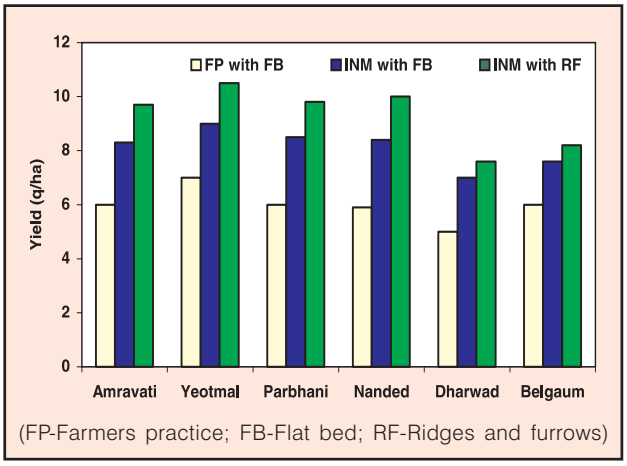
Impact study after 3 years OFTs in the target villages revealed that about 30-35% farmers adopted soybean – chickpea cropping system and use of harvested water for life saving irrigation whereas 50% farmers are now practicing ridge and furrow method of planting.

Optimizing Nutrient Supply by Enhancing Moisture Availability

In an effort to enhance nutrient use efficiency by integrating with moisture conservation, a network project was taken up in 7 target districts viz. Amravati, Yeotmal, Parbhani, Nanded (Maharashtra), Kurnool (A.P), Dharwad and Belgaum (Karnataka). For the third successive year (2003-04), the interaction of moisture conservation methods (ridge and furrow method and farmers practice) with nutrient management practices was tested viz., farmer's practice with flat bed (T_1), INM (N:P:K 80:40:45 + 2 t FYM/ha + limiting nutrient + green manure as mulch+ PSB+2 % DAP spray) with flat bed (T2), T2 + ridges and furrow system (T3). The OFTs were conducted on shallow and medium deep Vertisols with *hirsutum* hybrids and *arboreum* varieties.

Under both the soil types, the mean seed cotton yield of *hirsutums* was highest in INM treatment with ridges and furrow (RF) system followed by flat bed (FB) and farmer practice (FP) at all centers (Fig.2). The differences among treatments were statistically significant in all districts except Dharwad. Ridges and furrow system resulted in marginally higher yield of 2-3 q/ha. over flat bed system. The higher yield in INM treatment (T_3) was supported by higher no. of bolls/plant and boll weight. Significantly higher biomass and N, P uptake were also recorded in the INM treatment. The available N and P contents in the soil improved significantly after cropping.

In *arboreum* cottons grown in shallow soils, highest seed cotton yield was recorded with INM treatment (8.8 q/ha) as compared to 3.8 – 4.6 q/ha with farmers practice. Additional gross returns of Rs.3000-4000/ha could be realised by INM treatment. Ridges and furrow method was found superior to flat bed system across all the centers. Higher soil moisture was recorded in INM + RF treatment compared to farmers practice (Fig.3) and 3-5% additional moisture was stored in the profile due to the RF system. The moisture storage was further enhanced by incorporation of intercropped cowpea as green manure.



(FP-Farmers practice; FB-Flat bed; RF-Ridges and furrows)

Fig.2 : Seed cotton yield of *hirsutum* hybrid as influenced by land configuration and INM practices in medium deep soil

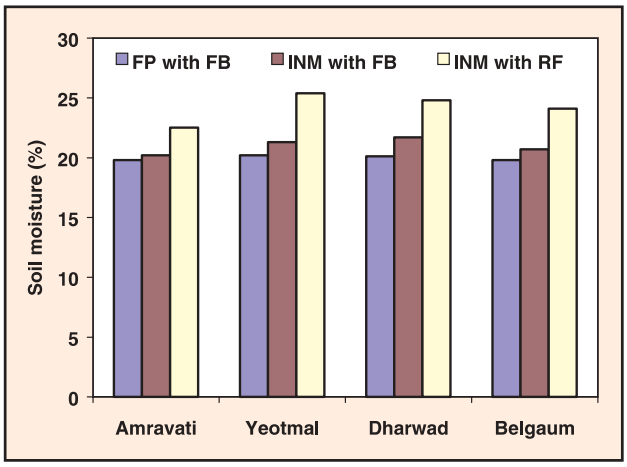


Fig.3 : Soil moisture (%) at 110 DAS in medium deep soil as influenced by land configuration and INM treatments

Tillage and Organic Residue Management

An effort was made to integrate tillage, land treatments and organic residue management to enhance cotton productivity on farmers fields and its impact on soil health. Seventy four on-farm trials were taken up in seven target districts of Khargone (M.P), Raichur (Karnataka), Junagadh (Gujarat), Khandwa (M.P), Guntur (A.P), Tuticorin (T.N) and Nagpur (M.H) in 28 villages. Four treatments i.e. Conventional tillage (CT) + flat bed method (Farmers' practice or T1), Conventional tillage + broad bed and furrow (100 cm wide flat

bed and 50 cm wide furrow on either side) + 100% RDF (T2), Reduced tillage (RT) + broad bed and furrow + 100% RDF + green manure (T3) and reduced tillage + broad bed and furrow +100% RDF + green manure + application of deficient nutrient (T4) were tried across all the target districts for the 3rd successive year during 2003-04. Reduced tillage treatment involved one harrowing and 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, the treatment 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. Treatment T4 recorded 35.9% higher seed cotton yield compared to farmers' practice (T1). Second best treatment was the one without application of deficient nutrient (T3), which recorded 25.3 % higher yield over farmers' practice (T1). Thus in most target districts, the seed cotton yields from Broad Bed and Furrow (BBF) system with reduced tillage and green manure application were significantly higher than Flat Bed (FB) system of planting with conventional tillage (farmer's practice). This may be due to combined effect of treatment in providing better aeration, drainage, moisture conservation, lower runoff and soil losses and balanced crop nutrition.

At majority of the locations, BBF along with green manure incorporation under reduced tillage

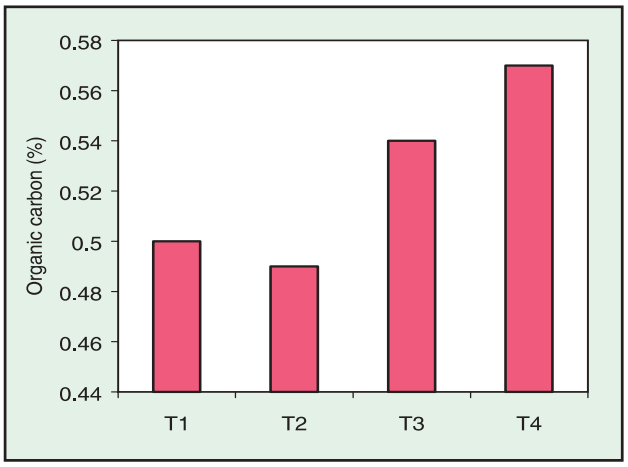


Fig.4 : Soil organic carbon (%) after two years of following tillage and INM treatment

treatments increased soil organic carbon content (Fig.4), increased soil moisture content, porosity, mean weight diameter, infiltration rate and uptake of nutrients. The above treatments also decreased the bulk density, runoff volume and soil loss. At all the locations, the highest net returns/B:C ratio were recorded under T4 treatment having BBF+ reduced tillage + 100% RDF + green manure with the application of deficient nutrient followed by T3.

Species/varietal performance under different soil depths

Different species of cotton and varieties recommended for various zones do not often exhibit optimum performance in all the micro farming situations within the recommended zone due to variations in soil depth and rainfall. In order to understand variations in performance of different species and varieties in relation to soil depth and rainfall, a network project was taken up involving 6 cooperating centers to test the performance of

well known varieties both from *arboreum* and *hirsutum*. The varieties were tested in 3 soil depths (shallow, medium and deep) and 2 rainfall situations (low and high). The overall combinations included: Deep soil + High rainfall (DH), Deep soil + Low rainfall (DL), Medium soil + High rainfall (MH), Medium soil + Low rainfall (ML), Shallow soil + High rainfall (SH), Shallow soil + Low rainfall (SL).

During the year, 169 on-farm trials were conducted covering 128 villages. The yields of best performing varieties for various combination of soil depth and rainfall are given in Table 7.

At Dharwad, *G.hirsutum* variety *Sahana* produced maximum seed cotton in deep, medium, shallow soils and high rainfall condition whereas *G.arboreum* variety DLSA-17 was found superior under deep soil and low rainfall condition. At Nagpur, *G.arboreum* variety AKA-8401 was the best performer under deep soil, high and low rainfall condition and shallow soil and low rainfall condition. Another *G.arboeum* cultivars *J.Tapti* was found best under medium soil and low rainfall, whereas intra *hirsutum* hybrids were superior under medium, shallow soil and high rainfall conditions. *G.arboreum* cultivars have more buffering capacity against rainfall irregularities compared to *G.hirsutum* varieties and hybrids.

At Khandwa, JK 4, a *hirsutum* variety, was best performer under low rainfall irrespective of soil depths. *G. arboreum* cultivars *J.Tapti* and *Sarvottam* were superior under deep, medium soil and high rainfall respectively. Inter specific hybrid DCH-32 was top yielder under shallow soil and high rainfall. At Nanded, NHH-44, a *hirsutum* hybrid was superior under deep soil conditions irrespective of rainfall whereas PA-183, a *G.arboreum* variety was best yielder under shallow soil, high as well as low rainfall. Under medium soil and high rainfall *G.arboreum* cultivar *J.Tapti* was found best where as NH-545, a *hirsutum* variety was best under medium soil and low rainfall. At Lam

Table 7: Best performing cotton genotypes under different soil depth and rainfall situations

Center	DH	DL	MH	ML	SH	SL
UAS, Dharwad	Sahana (820)	DLSA 17 (255)	Sahana (1040)	Vitiated	Sahana (1646)	Vitiated
GAU, Bharuch	G. cot 23 (1696)	G. cot 21 (1594)	G. cot 23 (2116)	G. cot H 8 (1632)	—	G. cot H 8 (1597)
JNKVV, Khandwa	J. Tapti (190)	JK 4 (133)	Sarvottam (134)	JK 4 (112)	DCH 32 (974)	JK 4 (400)
CICR, Nagpur	AKA 8401 (1800)	AKA 8401 (2100)	H 8 (1075)	J. Tapti (750)	NHH 44 (1825)	AKA 8401 (175)
MAU, Nanded	NHH 44 (706)	NHH 44 (1620)	J. Tapti (1280)	NH 545 (1128)	PA 183 (1336)	PA 183 (560)

Figures in parenthesis represent seed cotton yield (kg/ha)

(Guntur), The seed cotton yield of *Bunny* was higher in the deep soil and high rainfall whereas *Narasimha* was best under deep soil and low rainfall condition. *G. arboreum* cultivars MDL-2452 and *Aravinda* were best under medium, shallow soil and high rainfall, respectively where as intra *hirsutum* hybrid was best under medium soil and low rainfall as well as shallow soil and low rainfall. These results indicate that there is a need for refining the recommendations of different species and varieties of cotton for various agro ecological zones based on soil depth and rainfall.

Varieties for Salt Affected Soils

The network project on identification of suitable species and varieties of cotton for salt affected soils was continued during the year by conducting large scale on-farm trials on proven genotypes from earlier two years study. Rainfed cotton is grown in salt effected soils in the states of Gujarat, M.P and Karnataka with significantly lower yields. Though technologies for rehabilitation of salt effected soils are available, these are expensive and beyond the means of dryland farmers. As an alternative, efforts were made to identify tolerant cotton genotypes that can be grown in saline and sodic soils.

Four species (*G. herbaceum, G. arboreum, G. hirsutum*, and intra *hirsutum* hybrids) and 8 varieties in each genotypes were screened under rainfed conditions during 2001-02 and 2002-03 in soils with different levels of salinity and sodicity. Initial results indicated that *G herbaceum* and G. *arboreum* species were more tolerant to sodicity/ salinity as compared to G *hirsutum* and intra-*hirsutum* hybrids.

The results OFAR trials during 2003-04 revealed that seed cotton yield of *G.abroerum* were better than *G herbaceum* at Koppal and Khargone. Interestingly, higher yields were recorded in local checks than *arboreum* species at both the

Table 8 : Performance of salt tolerant varieties of arboreum and herbaceum species in two target districts during 2003-04

Target district	No. of farmers	Site characters		Species	Variety	Seed cotton yield (kg/ha)
		Parameter	Range			
Koppal (Karnataka)	10	pH ECe	8.15 - 8.35 4.12 - 4.92	Arboreum	RAHS-14 DDHC 11	554 426
				Herbaceum	PA 183 AK 235	335 372
				Check	Jayadhar	388
Khargone (M.P)	10	ESP	25-40	Arboreum	Jayadhar RAHS-14	328 281
				Herbaceum	G.cot-19 J.Tapti	269 253
				Check	Vikram	289

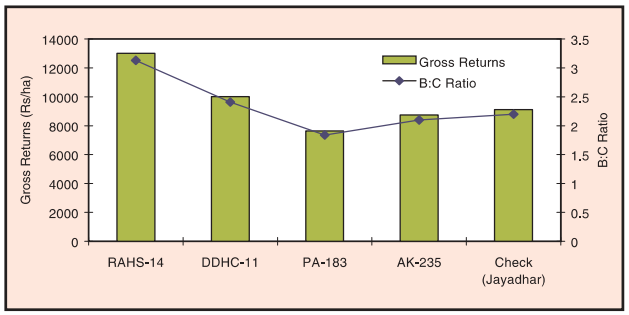


Fig.5 : Gross returns and cost benefit ratios of different cotton varieties grown on saline soils on farmers fields in Koppal, Karnataka

centers. *Jayadhar* of *G. herbaceum* which is a local check for Koppal recorded higher yields compared to other genotypes of *G.herbaceum*. However, based on over all performance, RAHS-14 of *G.arboreum* was found to be the best for saline soils at Koppal, while it was marginally inferior to *Jayadhar* at Khargone (Table 8). The B:C ratio was highest with RAHS-14 at Koppal (Fig.5).

Site Suitability Characterisation Using GIS

To map the most suitable areas for cotton cultivation in order to realise maximum productivity, a comprehensive site characterization project was taken up using GIS technology. The site suitability for growing cotton for different yield levels was assessed in 5 states i.e Andhra Pradesh, Maharashtra, Karnataka, Madhya Pradesh and Gujarat by integrating the parameters of soil (depth, erosion status, texture etc.) and climate (total and seasonal rainfall, temperature, humidity etc.) in a GIS environment. Using these criteria, 5 suitability rankings were made (highly suitable, suitable, moderately suitable, slightly suitable and not suitable).

Maps for individual parameters were developed first in GIS environment and superimposed to get the suitability maps for soil and climate parameters separately. The two maps were again superimposed to get the combined suitability map for cotton cultivation. The resultant maps for Karnataka and Gujarat are depicted in Fig.6.

Computer programs were developed to estimate the potential yields of cotton based on radiation and crop duration for different

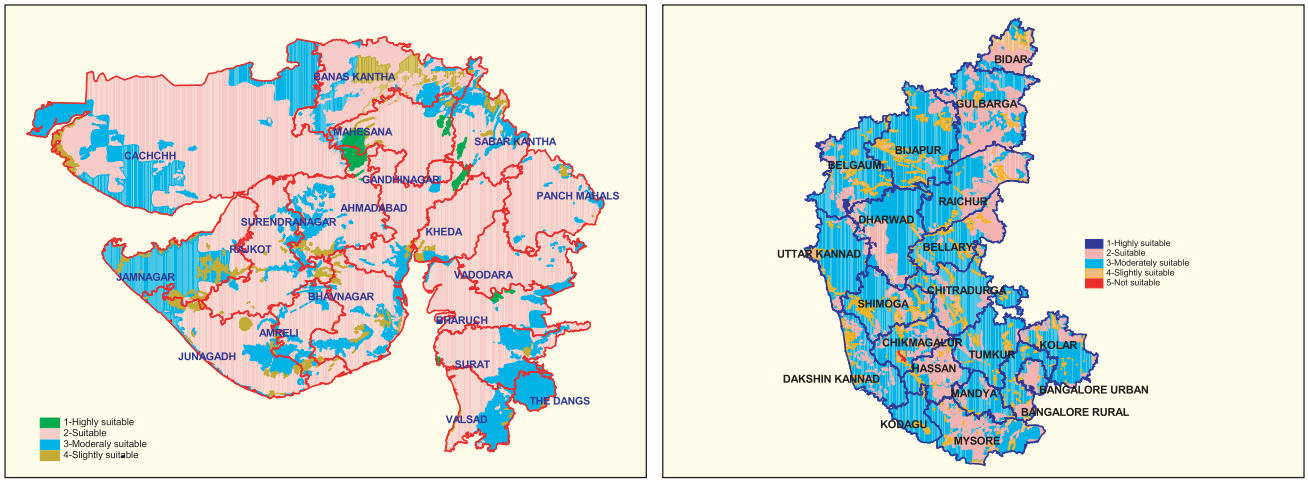


Fig.6 : Climate and soil suitability for cotton cultivation in Gujarat and Karnataka

management scenarios based on modified FAO agro-ecological zoning method. Spatial maps were generated for combinations of low, medium and high inputs with short, medium and longer durations. WOFOST, a general crop growth simulation model was used for estimating cotton yields for *Abhadita* and NHH-44 for different homogenous basic simulation units for a 10 year period from 1990-99 for Nagpur district. Data on soil depth, texture were derived from soil resource maps of NBSS&LUP. Rainfall information from different taluks was used in the simulation purpose. Other climatic data was collected from CICR, Nagpur. The basic simulation units were obtained by super imposing spatial information layers of climate, soil depth and soil type. The model was run for both drought and water logging conditions. The model could reasonably predict the yield response under different soil types and rainfall conditions. These models are likely to be useful for predicting crop yields in advance and also for decision support systems for better crop management.

CHAPTER 6

Nutritious Cereals Based Production System

Despite the falling consumption of nutritious cereals in country, these crops continue to be important as staple food for poor people in drought prone areas and as principal source of fodder for livestock. These crops are highly adapted to drought conditions. Despite the low cost of cultivation, greater yield stability, higher 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 research under this production system was to improve the productivity of *rabi* sorghum whose area has remained unchanged, identify opportunities for crop diversification in *kharif* sorghum growing areas and assess the economic potential of alternative uses for sorghum.

Improving the Productivity of *Rabi* Sorghum

Based on encouraging results achieved during earlier years on improved productivity in *rabi* sorghum by a combination of improved variety and management practices, on-farm trials were continued during the year in 7 districts i.e. Solapur, Satara and Sangli in Maharashtra, Bijapur, Raichur and Bellary in Karnataka and Kurnool in Andhra Pradesh covering 104 farmers. The improved production technology (consisting of compartmental bunding + INM + improved varieties) was compared with farmers practice in the on-farm trials. The year recorded a deficit rainfall upto 40% in the target districts of Satara, Bellary and Kurnool.

Compartmental bunding (CB) increased grain and stover yield of *rabi* sorghum to 562-1428 and 1887 - 2585 kg/ha, respectively from 520 - 1187 and 1711 - 2334 kg/ha with flat sowing in the target districts (Table 1). The grain and stover yields were 15.7 and 10.8 per cent higher due to CB than No CB (865 and 1977 kg/ha). Beneficial effect of CB was prominent in Raichur (20.3%) followed by Bijapur (16.1%), Solapur (12.2%) and Sangli (8.0%).

INM (60 kg N + 30 kg P_2O_5 + 3 t FYM/ ha + *Azospirillum*) treatment increased the grain and stover yields by 23.9 and 18.5 % compared to farmers practice of 10 kg N + 3 t/ha FYM (1077 and 1907 kg/ha) indicating the importance of optimum nutrient supply to capitalize on additional moisture stored in the profile due to CB. Among the cultivars, CSV-216R produced the highest grain yields (973 kg/ha) followed by CSH-15R

Table 1: Grain yield (kg/ha) of *rabi* sorghum as influenced by moisture conservation practice, INM and cultivars in target districts (*rabi* 2003-2004)

Treatments	Solapur	Sangli	Bijapur	Raichur	Mean
Moisture Conservation Practices					
No Compartmental Bunding	632	539	1139	1186.3	869
Compartmental Bunding (CB)	701	562	1321	1428.3	1003
CD 0.05	41.7	NS	69.6	79.5	78.0
Integrated Nutrient Management (INM)					
Farmers Practice	593	473	1085	1175	832
INM	740	628	1376	1440	1039
CD 0.05	42	70	69.6	79.5	78.0
Cultivars					
CSV 216R	712	577	1256	1354	974
CSH 15R	654	525	1285	1322	944
M 35-1	632	550	1151	1247	891
CD 0.05	54	62	33.6	35.8	35.1

(935 kg/ha) and M 35-1 (891 kg/ha). However, for stover yield, M 35-1 proved superior (2032 kg/ha). The adoption of CB + INM in combination with high yielding cultivars like CSV-216R, CSH-15R and M 35-1 increased the productivity of *rabi* sorghum by 48.7, 50.8 and 33.5 per cent, respectively compared to farmers practice. The best combination of CB + INM + CSV-216-R produced 54, 53, 50 and 32% higher yield, respectively in Raichur, Bijapur, Sangli and Solapur over farmers practice with same variety and 54, 57, 26 and 51% more

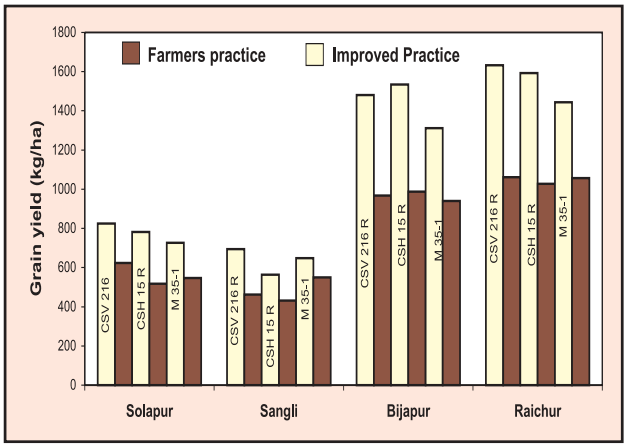


Fig.1: Grain yield in *rabi* sorghum with improved and farmers practice in four target districts

View of making compartmental bunding on farmers fields in Solapur district (left) and performance of CSV-216-R in Bijapur district (right)

over farmers practice with M-35-1 (Fig.1). The improved production technology on overall basis produced 50% higher grain yield than farmers practice. In related studies, promising 'stay green' genotypes with resistance to lodging and charcoal rot were identified at NRCS and improved agro technologies for enhancing water use efficiency were standardised at Bellary.

Dual Purpose Sorghum

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 are cultivating 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 leaf diseases. They are also susceptible to grain mold. 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 farmers' needs. On the other hand, improved varieties and hybrids are dwarf/medium, early maturing produce high grain yield but low fodder yield. Therefore, dual purpose sorghum becomes 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 mold and shoot fly.

In view of the improved performance observed with CSV-15 as a dual purpose sorghum across the country during 2001 and 2002, it was evaluated on farmers fields in all the target districts in 2003-04 both under improved and farmers practice and compared with research station checks and farmers local checks. At all the locations, superiority of CSV-15 with improved practice was evident both for grain fodder. The variety exhibited a distinct superiority particularly for fodder yield in Surat and New Delhi, whereas in other districts, the grain yield was more and fodder yield was comparable with farmers local or station checks (Table 2).

Based on pooled analysis over 3 years, the dual purpose sorghum CSV-15 recorded 54% higher grain yield over farmers local check with improved practice and 57% higher grain yield with farmers local and farmers practice. 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 shootfly and protected against stem borer upto 50 days of germination. The promising germplasm and breeding material identified during previous years for disease resistance 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 trials of 22 tall dual purpose hybrids at Surat.

Table 2: Grain and fodder yield of dual purpose sorghum under improved vs. farmers management in 5 target districts

Variety	Grain yield (t/ha)					Fodder yield (t/ha)				
	Surat	Udaipur	Indore	Maurani-pur	New Delhi	Surat	Udaipur	Indore	Maurani-pur	New Delhi
CSV-15 IP	3.66	2.27	2.40	2.54	2.60	10.20	9.70	8.80	10.40	9.40
CSV-15 FP	2.85	1.99	1.90	1.52	1.81	7.00	12.10	8.50	10.10	7.10
ST.CH IP	2.93	2.18	2.10	2.68	2.03	7.90	9.50	7.10	11.50	7.40
ST.CH FP	2.17	1.90	1.73	1.57	1.56	5.60	12.00	7.10	11.10	6.00
F LOC IP	2.65	1.42	1.55	1.61	1.53	6.90	11.70	5.10	12.30	9.10
F LOC FP	2.24	1.15	1.32	1.09	1.17	5.40	13.90	5.20	11.60	7.30

ST.CH=Station check (Surat-GJ 39, Udaipur- SU 658, Indore-SPV 1022, Mauranipur-SPV 1388 and New Delhi-GJ 39), FLOC=Farmers local, IP=Improved Practices, FP=Farmer's Practices

Egg patches of pyrilla on dual purpose sorghum leaves (left) and control of shoot fly and stem borer with Gaucho 70 WS treatment @ 10 g/kg seed (right)

From feed back studies with farmers, it was evident that they prefer dual purpose sorghums with atleast 7 feet tall with good grain. This will be the objective of further improvement.

Dynamics 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 fodder for livestock is realised by the farmers and line departments. 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-a-vis other crop/cropping systems was carried out in seven districts of Maharashtra, A.P, Karnataka and M.P (Akola, Mahaboobnagar, Adilabad, Dharwad, Belgaum, Indore and Khargone). On-farm trials were also conducted in some of these districts to compare the productivity and profitability of sorghum with its competition 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 surveyed showed negative growth in production. The decline of sorghum area at macro level has 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 has been determined by previous year area and yield of sorghum, the prices of the competing crops and the pre-sowing rainfall. According to the farmers opinion during the survey in Adilabad district, the prices of competing crops and the government policies towards cash crops were the foremost reasons for the decrease in the area under *kharif* sorghum.

The output/input ratio analysis of sorghum production revealed that 5 out of 8 target districts have a ratio of more than one, where as the other three (Adilabad, Mahaboobnagar 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. During drought years however, even sole sorghum maintained its edge mostly as a reliable source of fodder for livestock. 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 crop.

In-situ Moisture Conservation Enhances Pearlmillet Productivity

Pearlmillet is yet another important crop for dry semi arid and arid regions of the country both as staple crop and fodder for livestock. It is an ideal contingent crop for farmers in case of delay in monsoon. In two network projects, HYVs and improved moisture conservation and INM practices were evaluated individually and in combination on farmers fields in 6 target districts (Aurangabad, Beed, Ahmednagar, Dhule, Bijapur and Kovilpatti) in semi arid regions and 7 target districts (Jodhpur, Barmer, Sikar, Jhunjhunu, Banaskantha, Jamnagar and Mahendragarh) in arid region. Earlier results indicated that in both the zones wide row spacing (60 cm) of pearlmillet along with ridges and furrows combined with INM resulted in maximum crop yields on farmers fields. Both on-station and on-farm trials were continued during 2003-04 evaluating the best treatment vs. farmers practice.

In the first project covering semi arid region, paired row planting at 30/60cm, and opening of furrows in wider row at 35 DAS was found superior over opening of furrows with tied ridging and farmers practice for yield and moisture conservation at all the centers except Kovilpatti. At Kovilpatti, both the treatments were comparable and superior over farmers practice. In case of nutrient management treatments, application of 50% RDF + FYM @ 2.5 t/ha + biofertilizer recorded significantly higher grain yield over 100% RDF and farmers practice at all locations. Among the cultivars evaluated under moisture stress conditions, pearlmillet hybrid *Saburi* was found significantly superior to other entries in Aurangabad and Dhule districts whereas,

ICTP-8203 out performed all other genotypes in Bijapur district. In Kovilpatti, AIMP 92901 gave the best performance.

During the year, the best management practice i.e. paired row planting and opening of furrows along with INM was compared with farmers practice in a number of demonstrations in the target districts. More than 50% farmers who participated in the trials were willing to continue with the practice and adopt improved hybrids and varieties like *Saburi*, ICTP-8203 and AIMP 92901. Seed availability has to be ensured.

In 100 on-farm trials carried out in the arid region under the second project, ICMH-356 was found to give highest yields of 1708, 1761 and 631 kg/ha respectively in Jodhpur, Barmer and Fathepur Shekawati districts when 7 different varieties and hybrids were evaluated along with local check. 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 in Haryana, HSB-117 showed the highest yield of 1916 kg/ha.

Mixed cropping of pearlmillet and clusterbean on farmers field in Jodhpur district

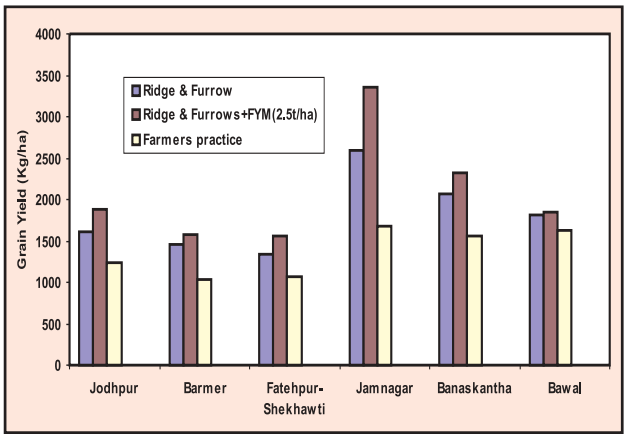


Fig.2: Grain yield of pearlmillet with different moisture conservation practices in 6 target districts

Among the moisture conservation practices tried, 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% through FYM, which was significantly superior to moisture conservation + 100% RDF and farmers practice (Fig.2). 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 pearlmillet + cluster bean were also identified for each of the target district.

Efficient Fingermillet based Cropping Systems

Fingermillet is grown by small farmers in predominantly tribal districts of A.P, Orissa, Tamil Nadu, M.P and also as a major staple crop in south Karnataka. Farmers generally grow sole fingermillet crop or mixed cropping with pulses

and oilseeds. However, due to non adoption of HYVs and improved package of practices, the yield and profitability have remained low for quite some time. In order to improve the profitability and nutritional security of vulnerable population in the districts where fingermillet is a staple crop, a variety of intercropping systems involving pulses as inter or sequence crops were tried on farmers fields. On-station and on-farm trials during earlier years indicated highest profitability from fingermillet + legume intercropping system as compared to sole crop. The OFTs were continued during 2003-04 wherein the best cropping system was compared with the farmers practice and yield and profitability worked out.

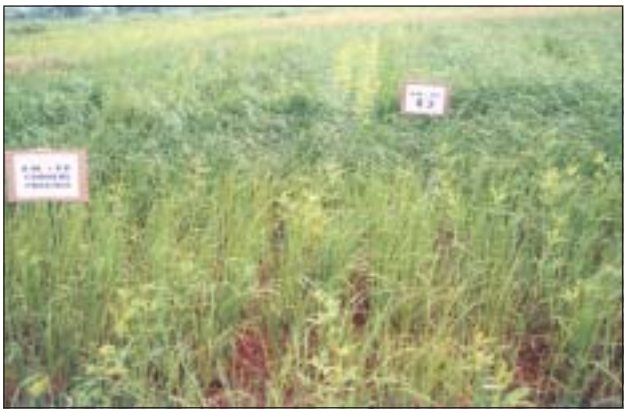
On-farm trials in Bangalore rural and Kolar districts showed significantly higher net monetary returns and BC ratio with fingermillet + pigeonpea (1:1.98) and fingermillet + fieldbean (1:1.48) as compared to the farmers practice of fingermillet + akkadi (1:1.21) system (Table 3). The results were similar for 3 continuous years despite the variations in rainfall showing the advantage of pulse intercropping instead of mixed cropping. In Ganjam district too, fingermillet + pigeonpea intercropping proved superior to sole fingermillet 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 fingermillet sequence cropping enhanced fingermillet grain equivalent yield by 150 per cent (4760 kg/ha) over sole crop of fingermillet (1902 kg/ha) based on 3 years pooled data. 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 + field bean (8:1), fingermillet + pigeonpea (8:2) were compared with monocropping of fingermillet. Fingermillet + field bean gave higher net monetary returns (Rs.18634/ha) and a B:C ratio of 2.47 over fingermillet + pigeonpea (Rs.17608/ha NMR and 2.34 B:C ratio, respectively). Lowest NMR were realised with monocropping of fingermillet (Rs.13875/ha and B:C ratio 1.98). Similarly in Vizianagarm district, fingermillet + pigeonpea (8:2) and in Dindori district of M.P, kodo millet + pigeonpea (8:2 and 2:1) and kodo millet +

Table 3: Yield and monetary returns from fingermillet and pulse intercrops in on-farm trials in Bangalore rural and Kolar districts (n=20 farmers)

Cropping System	Fingermillet grain yield (kg/ha)	Fingermillet 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	3050	6818	373	5458	11900	23579	1.98
FM + FB	2756	5482	213	4668	12200	18143	1.48
FM + AK	2647	6151	—	3100	11380	13830	1.21

FM : Fingermillet; PP : Pigeonpea; FB : Field bean; AK : Akkadi Practice



Kodomillet + pigeonpea under farmer's practice (front), Improved practice (behind) in Dindori district of M.P.

blackgram (2:1) performed significantly superior to farmers practice of mixed intercropping with kodo millet and pulses (Table 4). These trials on farmers fields generated awareness on the role of legumes both for income generation and nutritional security and if widely adopted can ensure better protein supply to the tribal communities.

Managing Blast Disease in Fingermillet

In order to develop an effective integrated blast management package for fingermillet, comprehensive studies involving characterization of the pathogen, germplasm screening and on-farm trials for testing the efficacy of integrated disease management package were carried out since 2001. Earlier results indicated that the blast pathogen induces a phytoelexin, pyrichalasin-H in the blast infected leaves and only 9 lines were found resistant from a germplasm screening 4000 lines. Field studies on blast control revealed that improved variety with improved practice were most successful in controlling both finger blast and neck blast. Discolored seed invariably carried the pathogen regardless of resistant or susceptible nature of the varieties. The resistant lines were further characterized during the year. All the lines showed lower lesion numbers and finger blast incidence, but some of them showed incidence of neck blast (Table 5).

On-farm trials were continued in Karnataka (46) and Tamil Nadu (14) with GPU-28 and in Uttaranchal (23) with VL-149. The 4 treatments tried earlier were included this year also 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

Table 4: Grain yield and monetary returns from kodo millet based intercropping systems on farmers fields in Dindori district, M.P. (Mean of 10 farmers)

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 (Broad casting)	639	111	972	4860	1360	1.39
Kodo millet + Pigeonpea (2:1)	903	239	1620	8100	2980	1.58
Kodo millet + Blackgram (2:1)	918	324	2050	10252	5226	2.04
Kodo millet + Pigeonpea (8:2)	1424	194	2006	10030	5070	2.02

Table 5: Performance of promising blast resistant germplasm of fingermillet				
Genotypes	Percent leaf area covered	Lesion number	Neck blast (%)	Finger blast (%)
GE 253	12.20	15.33	0.00	18.48
GE 325	10.66	12.66	0.00	25.00
GE 335	8.00	12.22	0.00	30.00
GE 355	11.66	12.44	0.00	18.55
GE 371	10.00	14.99	0.00	10.53
GE 387	9.10	9.77	0.00	22.59
GE 393	7.00	9.44	0.00	7.05
GE 408	7.33	10.00	0.00	19.09
GE 409	7.00	9.00	0.00	9.02
C 273 (Check)	35.00	19.55	57.50	36.28

results were similar to that of the previous years i.e. improved variety with improved practice proved better than all other treatments. Based on 5 on-farm trials in Kolar district, the farmers practice (untreated) with variety HR-911 gave an yield of 8.5 – 10.25 q/ha as against 13.75 – 15.35 q/ha with improved practice (seed treatment). Early sowing between 2nd week of June to 3rd week of July resulted in escape of the disease. The consolidated results of the OFTs between 2000-03 across 7 districts of Karnataka are given in Table 6.

Fingermillet on farmers field in Kolar district with improved practice vs. farmers practice of blast management

Table 6: Results of the on-farm trials during 2000-2003 on blast management (pooled over 3 seasons)			
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 + Untreated	0.4	1.3	2524
GUP 28 + Seed treatment with carbendazim @ 2 g/kg seed	0.1	0.6	2708

Resource Management in Maize Based Cropping System

Two network projects addressed the rainwater management issues in rainfed maize based cropping system in north west 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). Fifteen on-farm trials at each location were conducted during *kharif,* 2003 comparing the best treatment (*in situ* moisture conservation + full INM + legume intercropping) with that of farmers practice (sole maize). At all centers, the first treatment resulted in higher gross and net returns. For example in Udaipur, Nawanshahar and Jhabua districts, improved technology resulted in 213, 70 and 52 per cent higher maize equivalent yield over farmers practice, respectively. The average BC ratios across the topo sequences improved from 1.96 to 2.29 at Udaipur (Table 7). There was also improvement in soil moisture content. At Nawanshahar, the maize equivalent yield across the topo sequences increased from 28.4 to 48.3 q/ha with adoption of improved practice with corresponding increase in net income. However, the BC ratio was not significantly increased due to higher cost of cultivation.

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 – wheat were covered in the states of Haryana, Punjab, H.P, J&K, U.P and Bihar. Additional water resources generation through harvesting of surplus rainwater and recycling for life saving irrigation 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 cropping system, the maize

Table 7: Effect of improved vs. farmers practice on three topo sequences on maize equivalent yield, net returns and soil moisture content in the OFTs of Udaipur district (*kharif-2003*)

Topo-	Maize equivalent yield (q/ha)		Net returns (Rs/ha)		B:C ratio		Moisture content (%) 0-15 cm		Moisture content (%) 15-30 cm	
sequences	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
S1 (High)	10.97	35.44	6082	17773	1.69	2.06	4.79	5.62	5.45	6.17
S2(Medium)	12.35	38.96	7162	20289	1.99	2.35	5.40	6.03	6.10	6.58
S3 (Low)	13.28	40.28	7951	21187	2.21	2.45	6.01	6.54	6.69	7.10
Mean	12.20	38.21	7065	19750	1.96	2.29	5.40	6.06	6.08	6.62

T1= Farmers practice, T2=Improved practice

Farmers practice of sole maize (left) with improved practice of legume intercropping, moisture conservation and INM (right) in Udaipur district

yields prior to the projects ranged between 10-15 q/ha while the wheat crop used to fail completely two out of five years. The creation of water harvesting farm ponds and diverting the runoff into two ponds has 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 was arrested by polythene lining and the benefit cost ratios were worked out. 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 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 crop diversification. Besides increasing the diversification index among small and marginal farmers, the annual net agricultural income increased from Rs.7,448/ha before the start of the project to Rs.24,590/ha 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 8.

A water harvesting pond of 1.7 ha m capacity completely filled with the runoff water from the village catchment (left), A well grown maize crop supported with life saving irrigation and improved package of practices

Table 8: Per cent 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**

The data reveals a significant shift from maize – wheat cropping system to high value crops like mustard, urd, gram, *taramira*, tomato and fruit crops mainly due to increased water availability after the *kharif* season. During last three years, the project generated cumulative additional income of Rs.5,65,686/- as against a total investment of Rs.6 lakhs. This project clearly highlighted the key role of water resource development for success of the watershed projects in the sub mountain regions. As a spin-off, the project also bridged the caste divide in the village.

Grain Quality Improvement in *Kharif* Sorghum

Unseasonal heavy rains at maturity causes blackening of sorghum grain. Such molded grain fetches 20-40% lower price in the markets. In order to improve grain quality and obtain better returns to farmers, a technology of harvesting at physiological maturity and artificial drying was developed and field tested during 2001-02 and 2002-03 seasons in Maharashtra, Karnataka, Tamil Nadu and A.P. During the year, on-farm trials were continued on artificial drying, evaluation of grain mold resistant varieties and fabrication of a community dryer.

The technology of harvesting at physiological maturity and artificial drying was demonstrated to 18 farmers each in the districts of Mahaboobnagar, Akola, Parbhani, and Coimbatore. The high yielding hybrid / variety was grown in on acre land by each farmer, 3/4th of the crop was harvested at physiological

maturity and the produce was dried artificially with the help of suncue drier. Other 1/4th was harvested at normal maturity and sun dried (Farmer's practice). The break even output analysis showed that drying of a minimum quantity of 22, 30, 19 and 10 tonnes of grain was necessary to cover the cost of the drier during this year in Akola, Parbhani, Mahaboobnagar and Coimbatore districts, respectively (Table 9).

In view of the proven benefit of artificial drying, a low cost community dryer was designed with a capacity of 1.5 tonnes/h, which is under fabrication at MAU, Parbhani.

Most of the time when the deterioration is restricted to the surface, pearling was found to be more useful. In this process, the pericarp is polished by grinding stones and the mold infection is rubbed of. This year, pearling treatment was undertaken at two centers, Mahaboobnagar and Coimbatore. There was 14 and 50% increase in market price for pearled produce over unpearled one with a profit of Rs.340 and Rs.1840/tonne at Mahaboobnagar and Coimbatore, respectively for the pearled produce over that of unpearled produce (Farmers practice) (Table 10).

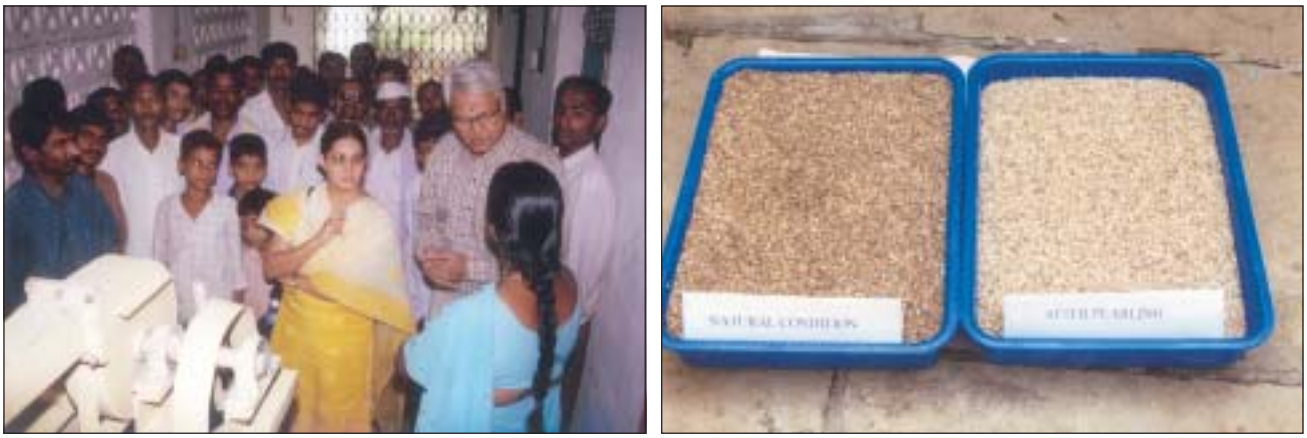
Sparying of 4% acetic acid on rain drenched sorghum also prevented deterioration of grain and fetched market value of Rs.4,200 per tonne as against Rs.3,600 per tonne obtained with farmers practice in Mahaboobnagar district.

Table 9: Market price realization for rainy season sorghum harvested at physiological maturity and artificially dried

Treatment	Akola	Parbhani	Mahaboobnagar	Coimbatore	Average
T1- Harvest at physiological maturity and artificial drying (Rs/tonne)	4500	5250	5250	7000	5500
T2-Harvest at normal maturity (Rs/tonne)	3100	4150	3650	4230	3783
Incremental return (Rs/tonne)	1400	1100	1600	27770	1717
Break even output (tones)	22	30	19	10	-
% increase	45.2	26.5	43.8	65.5	45.4

Table 10: Effect of pearling on market price of deteriorated sorghum

Treatment	Market price (Rs/t)			Price difference (Rs)	% increase	Cost of power consumption (Rs)	Profit (Rs/t)
	Pearled produce	Normal produce	SE				
Mahaboobnagar	4100	3600	250	500	14	160	340
Coimbatore	6000	4000	1000	2000	50	160	1840

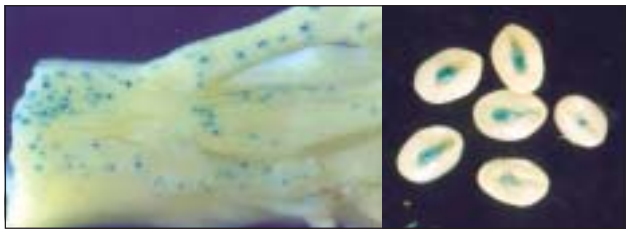


Demonstration of pearling to farmers at Parbhani (left); produce before and after pearling (right)

The evaluation of promising grain mold tolerant material was also continued during the year. SVD-9601 gave the best performance across the centers with a score of 2 as compared to 2.3, 2.4, 1.6 and 2.8 with CSV-15, CSH-16, B-58586 and CSH-9. Genetics of grain size, shape and lustre were studied by estimating the gene effects for these traits in different crosses of sorghum. Promising material are under evaluation.

Quality improvement through glutenin genes

In order to improve the shelf life and *roti* making quality of grain sorghum, both biochemical and transgenic approaches were tried. Genotypes 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. During 2002, HMW glutenin proteins were purified and corresponding genes were isolated through preparation of cDNA libraries. During the year, the transformation parameters for immature embryos of sorghum for identified varieties were standardised. Five *Agrobacterium* strains (LBA-4404, EHA-105, PGV-3101, AGL-1 and A-281) each containing plasmids (pCAMBIA-1301 pCAMBIA-2301 pCAMBIA-1304 Pbi-121 pTOK-233 pNOV-2829) were used. The fusion of kafirin promoter (isolated from sorghum) and glutenin gene is in progress.



Reporter gene (Gus) expression in bombard shoots (left) and in immature embryos of sorghum with *Agrobacterium* mediated transformation (right)

Ethanol from Sweet Sorghum

With an aim to improve economic returns from sweet sorghum, technologies were standardised to produce a number of value added products like ethanol, jaggery, syrup, starch, bakery products and paper. Based on the response from the stake holders, however, ethanol production was found to be most promising in view of the anticipated demand for ethanol as a bio fuel in the country. During the

year, on-farm testing of sweet sorghum genotypes for bio mass and juice yield was continued, linkages with the industry for pilot plant activities strengthened and breeder seed production was taken up.

Studies on maximization of biomass, brix, sucrose, juice extractability and grain yield with 18 sweet sorghum genotypes revealed that four genotypes viz. RSSV-24, NARI SSH-43, RSSV-59 and NSSV-53 proved most promising in terms of highest biomass at the milky stage of the grain. Harvesting at milky stage produced higher biomass in all the varieties, but juice volume was found to be higher during harvest at maturity. Genotypes RSSV-57, RSSV-24, NSSV-253 and NSSV-216 were found to yield higher ethanol and syrup. Pooled data on performance of 11 genotypes in the advanced varietal trial planted in June 2003 at 5 locations i.e. Akola, Rahuri, Parbhani, Phaltan and Hyderabad are given in Table 11. All the varieties produced higher biomass than the check (SSV-84) indicating the promise of identifying sweet sorghum genotypes with high biomass/ethanol production than SSV-84. The food technology division at MAU, Parbhani successfully standardised the technology for production of high fructose syrup. In order to improve the fermentation, 5 yeast strains isolated from sorghum were evaluated for their alcohol production efficiency. Strain 3 was found to be most promising.

Industrial Liasion

Based on encouraging response from pilot study with M/s.Renuka Sugars during 2002-03, the industrial liaison activities were significantly enhanced during 2003-04 through new linkages with M/s.Sagar Sugars in Chittoor, M/s.Somaiah Organo Chemicals in Maharashtra and M/s.GMR Industries in A.P. Thirteen and half tonnes of breeders seed was produced during the year and distributed to 11 distilleries/sugar industries in the country. About 1000 acres area was covered under contract farming in Andhra Pradesh. Some other leading industries who evinced interest and started collaborative trials through breeders seed supplied by NRCS include M/s.Mohan Breweries and Distilleries, Chennai

Field view of SSV-84 (left) and green canes for juice extraction (right)

Table 11: Overall performance of sweet sorghum genotypes in advanced varietal trial

Genotype	Plant Height (cm)	Biomass (t/ha)	Rank	Grain yield (q/ha)	Extraction (%)	Brix	TSS (%)	RSS (%)	Sucrose (%)
RSSV 57	300.54	42.34	1	16.93	31.36	17.9	14.28	1.41	12.62
RSSV 44	244.63	40.52	2	12.21	35.24	16.3	13.56	1.58	11.96
RSSV 46	229.92	40.06	3	12.05	37.11	16.6	13.82	1.83	11.76
NSSV 219	221.46	39.43	4	15.98	33.30	17.5	14.09	2.13	11.74
RSSV 59	261.83	37.97	5	12.41	34.10	18.3	14.71	1.97	12.31
NSSV 218	222.59	31.53	6	9.46	34.01	17.3	13.51	2.36	10.50
RSSV 58	225.73	31.51	7	8.60	34.36	18.3	14.88	1.56	13.05
RSSV 24	275.39	30.83	8	9.25	32.81	15.9	12.92	1.93	10.76
NSSV 216	247.39	29.29	9	15.74	34.69	18.4	15.16	2.07	12.87
RSSV 45	271.14	28.83	10	12.06	34.27	16.9	14.77	1.75	12.77
NARISSH 43	248.25	25.38	12	24.58	39.01	14.7	11.65	2.37	9.52
SSV 84 (C)	241.46	25.83	11	21.91	32.9	17.5	14.46	2.02	12.23
CV(%)	8.99	17.69		36.21	10.91	8.21	10.61	19.41	12.41

and M/s.Hindusthan Breweries Limited, Mumbai and M/s.Shakti Sugars Limited, Chennai.

Health Food from Millets

Standardisation of protocols for preparation of value added health foods with focus on diabetics and children was continued during the year. Fingermillet based vermicelli was formulated with different hypoglycaemic foods like *ashwagandha* root powder, *madhunasini* leaves powder, *jamum* fruit seed powder, fenugreek and seed powder and *amruthballi* leaves powder. All these vermicelli products reflected low glycaemic index when tested on diabetics. RTE fingermillet sweet and spiced micronutrient enriched mixes were prepared. Dietary intervention resulted in improvement of calcium and phosphorus status of children. RTE extruded products with 50% fingermillet resulted in slight increment in serum calcium and phosphorus of fractured 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. Recipe for barnyard and barnyard-*methi pulao* was also standardised 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/N_2 flushing enhanced shelf life of biscuits for six months and retained essential quality attributes.

Pearlmillet 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°C upto 3 months without much change in organoleptic acceptability.

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

Efforts were also made for dissemination of information on health benefits of millets to the stake holders through trainings and demonstrations. A national seminar on "Processing and utilization of pearlmillet for nutritional security" was organized at the lead center (CCSHAU, Hisar) on October 7-8, 2003. Commercialization of products through small entrepreneurs and capacity building of self help groups are continuing.

Watershed Monitoring Through Remote Sensing

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 and Nipana, Akola). During 2003-04, the prioritized land treatments for critical areas were implemented, which include construction of conservation structures and crop demonstrations. The performance of the 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. During 2003, 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

Quickbird multispectral data picture of the treated area (left) and its enlarged view (right) in Nipana watershed, Akola district showing intermittent contour trenches (ICT) and farm pond (FP)

(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 the watershed projects.

Land Use Systems for Sequestering More Carbon

With growing emphasis on identifying cropping systems/land use practices that sequester more carbon in addition to giving higher yields, a network project was taken up to assess the carbon sequestration potential of different cropping systems across semi arid regions of the country. Previously, selected bench mark sites were characterized for their fertility status. Preliminary results also indicated higher sequestration potential of horticulture based systems than crop based ones. During the year, studies were carried out on the sequestration potential of different cropping systems / land use systems and correlated with climatic parameters and site characteristics.

Data on carbon stocks under different land use systems are presented in Fig. 3. Forest ecosystem recorded highest stocks followed by horticulture and arable cropping. Among the field crops, legume-based intercropping system (Soybean/pigeonpea and greengram/pigeonpea) restored higher amount of SOC, soil microbial biomass carbon (SMBC) compared to double crop in rotation (Soybean-wheat/paddy-paddy cropping system). Cotton based cropping system either as intercropping or sequence cropping registered least improvement of SOC storage. The improvement of organic carbon under different agronomic management followed in order of High Management> Low Management > Farmers' Management. Total SOC stock in black soils (0.03 Pg mha^{-1})> SOC recorded earlier (0.024 Pg mha^{-1}) during 1980s, indicating an overall increasing trend in SOC. The active pools of soil microbial biomass carbon (SMBC) comprised 3.2 to 5.6 % of SOC in Vertisols and 1.2 to 5.7 % of SOC in Alfisols. Soil analysis from 11 longterm experimental sites of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) showed that legume based cropping systems (soybean + safflower, cotton + greengram) performed better over cereal based cropping system (6.8 g C kg^{-1} soil in legume based cropping system as against 3.4 g C kg^{-1} soil in cereal based cropping system). Addition of organic manures (eg. FYM, green manuring) along with chemical

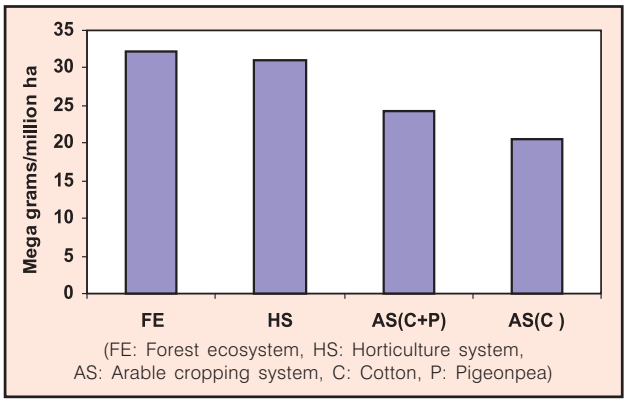


Fig.3: Carbon stocks under different land use systems

fertilizers recorded greater organic carbon content (9.5 g C kg^{-1} soil) and higher yields of 2.4 t ha^{-1} of soybean and 2.3 t ha^{-1} of safflower at Indore.

Existing models were assessed based on information available from previous publications on the requirements of the project. It was decided to use CENTURY model to assess carbon stocks at all locations covered by this project. Work on model calibration was initiated using data from a long term trial in which 15 different soil management options were subjected to detailed analysis.

Agri-horticulture Systems

To improve net returns to farmers adopting nutritious cereals, different agri horticultural systems were evaluated in a number of target districts through three network projects. Initially the status of existing orchards, intercrops grown and the scale of returns were assessed through a diagnostic survey. During the year, need based interventions were made particularly on improving the productivity of the fruit component through moisture conservation and INM. In older mango orchards of Mahaboobnagar district in A.P (more than 10 years old) pastures like *Cenchrus* and *Stylo* gave significantly higher returns without affecting the yield of fruit tree when recommended dose of nutrient application are made. In younger orchards (5-6 years old), cowpea and horsegram were found as most promising intercrops giving higher total returns and BC ratio (Table 12). *In situ* moisture conservation practices like crescent shaped basins and mulching combined with INM improved the fruit yield in 5 to 7 year old orchards from 1 tonne/ha to 3 tonnes. Similarly, the yields of ten years old orchards went up from 3 tonnes/ha to 8 tonnes.

In Sangli and Beed districts of Maharashtra, improved package of practices were introduced in the existing farmers orchards of mango, custard apple and *ber* mainly in the form of *in situ* moisture conservation and INM. Here again, significantly

Table 12: Benefit –cost ratio of different treatments in 5-7 years and >10 years old mango orchards of Mahaboobnagar district during 2003-04

Treatments	5-7 years		>10 years	
	Yield t/ha	B:C* ratio	Yield t/ha	B:C* ratio
Treatments with SWC measures				
Mango + RDF	2.86	2.98	9.29	8.41
Mango + FYM	2.83	2.94	9.86	8.93
Mango +Sorghum	2.88	2.99	10.15	9.20
Mango +Cowpea	3.00	3.12	10.12	9.16
Mango +Horsegram	2.92	3.03	9.66	8.75
Mango +Stylo	2.83	2.94	11.13	10.08
Mango +Cenchrus	2.83	2.94	11.43	10.35
Without SWC measures and other interventions				
Negative control (Farmers practices)	0.63	0.71	2.90	2.84

SWC – Soil and water conservation measures **Based on mango yields only*

higher yields were realised due to improved practices with most farmers. To illustrate, during 2003, Sri S.D.Patole a small farmer in Kavathe Mahankal village of Sangli district could realise a net profit of Rs.12,145 from one acre as against Rs.1000-2000/ha he normally earns. Sri Vijaya Ramachandra Vibhute of Panumbre village in Sangli and Sri Misal Ramakrishna Narayan of Padali village in Beed district were two other farmers who succeeded in improving their income levels through adoption of silvi-pasture and agri-silvi pasture land uses, which contributed to improved milk production from their animals.

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. In Bangalore rural, intercropping of ragi and dolichos in mango orchard resulted in additional income, which ranged from Rs.10,913 to Rs.12,230/ha. In Guntur, blackgram grown as intercrop increased mango yields and also recorded the highest yield of blackgram (5.43 t/ha) giving a net return of Rs.36,391/ha and additional income of Rs.8,581/ha to the farmer. Cluster bean as intercrop in sapota orchard recorded highest yield of 13.67 t/ha and net returns of Rs.47,478/ha as well as maximum additional income of Rs.8181/ha. In mango based intercropping system in Bijapur district, mango + groundnut recorded the highest net income of Rs.74,324/ha with an additional income of Rs.10,102/ha from intercrop. In Jabalpur district, cultivation of cowpea *(kharif)* followed by gram *(rabi)* as a sequence intercropping in mango gave maximum productivity of 109 q/ha, whereas, maximum net returns of Rs.45,433/ ha were realised when pigeonpea + tomato were grown in 2:2 paired rows as companion intercrop. Groundnut as intercrop gave highest net income Rs.46,475/ha followed by green gram (Rs.41,736/ ha) in mango orchard at Junagadh. At Ambajogai (Maharashtra) intercrops like soybean + mustard resulted in higher yield and net returns of Rs.12,743/ ha in mango from intercrops. In all the trials, adoption of *in situ* moisture conservation practices like circular basins with 5% slope and use of locally available mulches like straw and dry leaves contributed to reduced evaporation and increased fruit yield by 15-20%. Similarly use of inputs like FYM, vermi compost and biofertilizers could bring down the cost of nutrient application by 20% and improved the fruit quality.

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. Ridges and furrows + mulch was found to be the best *in situ* moisture conservation

practice registering an increase in yield ranging from 28-42% over farmers practice for different crops. Similarly, application of 50% of recommended dose as chemical fertilizer + 50% as FYM + biofertilizer performed better than 100% chemical fertilizers in terms of fruit yield and quality.

Agri-silvi and 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 target districts (Akola, Jhansi, Junagadh, Mathura and Mahaboobnagar) involving 94 farmers in 27 villages covered the establishment of pastures like *Stylosanthes hamata, Desmanthes virgatus, Panicum maximum* and *Cenchrus ciliaris* on unutilized or waste lands. After 3 years, the yield attained were 4 to 5 t DM/ha in *Cenchrus ciliaris,* 5-7 t DM/ha in *Panicum maximum* and 2-4 t DM/ha in *Stylosanthes hamata,* which were comparable with research station yields.

In third year, among trees, *Acacia nilotica* performed best in terms of survival and growth in 3 districts viz. Jhansi (survival: 92%; height: 207-241 cm; collar dia: 2.28-2.97 cm), Mathura (survival: 91%; height: 96-105 cm; collar dia: 1.24-1.45 cm) and Akola (survival: 88%; height: 105-111 cm; collar dia: 1.8-2.1 cm). In the remaining districts, *Leucaena leucocephala* performed best in terms of survival and growth over other species (Junagadh- survival: 87%, height: 171-177 cm, collar dia: 4.21-4.42 cm; Mahaboobnagar- survival:81%; height: 220-430 cm; collar dia: 1.70-3.60 cm). Reseeded and sown pastures exhibited their superiority over natural pastures in having more legume population. Highest contribution of legumes was observed in Junagadh (47.13%) followed by Jhansi (35.75%), Mahaboobnagar (34.57 %), Akola (20.65%) and Mathura (4.42%).

Supply of higher crude protein content and prolonged availability of green forage in improved systems led to increased livestock production in terms of body weight gain, age at first lambing, birth weight of lambs and livestock products. Highest gain in terms of increase over natural systems was registered in Mahaboobnagar followed by Junagadh and Jhansi.

Multipurpose bio fencing

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. Previous data indicated, *Agave*, chiller and *Lawsonia* as some promising biofences, which established successfully and offered multiple uses for farmers. During the year, observations on growth of the live fences were continued in different target districts and additional advantages of biofencing on control of runoff and soil loss were quantified. The over all performance of different species confirmed the trends observed earlier i.e. *Lawsonia inermis, Agave*

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

and *Acacia cassia* (chiller) continued to record better growth rate and establishment over other species. However during the third year, a significant negative impact of bio fence on the seasonal crop was observed up to 2 m length causing a yield decline of 6-20%. Crop fields with bio fence recorded lower runoff than control fields. Nevertheless, the multiple uses of the bio fences were evident from the data in Rangareddy district of Andhra Pradesh where leaves marketed from *Lawsonia* planted around 1 ha fetched an income of Rs.4130/ha. From data generated at Koraput center, the cost of bio fencing ranged from Rs.5 to Rs.13 per running meter, which was considerably lower than the barbed wire fencing.

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.

Inter crops like greengram and cowpea were introduced during 2nd year. Data recorded during 2003 (3rd year) revealed maximum collar girth in *Eucalyptus* with 3x2 m spacing (farmers practice) in most of the fields. This is the normal practice followed by farmers under the farm forestry model without intercrops. However, paired rows planting of 7x1.5 m and 11x1 m and triple row planting of 10 x 1.5 recorded relatively lower collar girth, which was not significantly different from farmers practice. The yield of intercrops was however significantly higher in improved practice of planting in paired rows and triple rows (Fig.4). 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.

Paired row planting of Eucalyptus with wider alleys (10 m) and intercropped cowpea

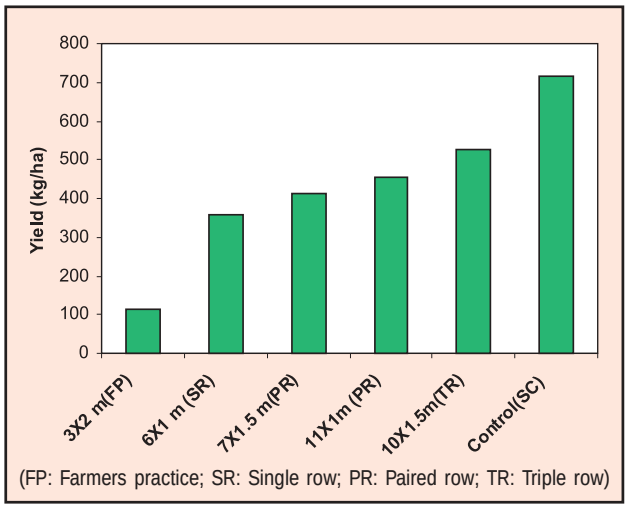


Fig.4: Yield of cowpea in Eucalyptus based agro forestry systems on farmers field in Khammam district

Nutritious Cereals in Livestock/ Poultry Nutrition

With an aim to improve the utilization of nutritious cereal grains and crop byproducts in poultry and livestock feeding, two major projects were taken up i.e. one each on poultry and milch animals. In case of poultry, studies during 2001 and 2002 revealed that up to 70% of the maize in poultry feeds can be substituted with sorghum or pearlmillet. Detailed studies continued during the year on performance of broilers and layers with substituted feed particularly with reconstituted sorghum and millets.

The reconstitution of sorghum was found beneficial in improving utilization of nutrients from broiler rations, which could replace maize completely. Reconstituted pearlmillet can be added up to 50% and 55% in starting and finishing mashes. Young broilers do not relish coarse pearlmillet during early age. Attempts in feeding ground pearlmillet (coarse variety) were not successful. Experiments with commercial broiler chicks showed that protein-mineral-vitamin concentrate could safely be diluted with white sorghum as sole cereal or pearlmillet + maize (75:25) in finishing broilers. In *Vanaraja* birds maize could be replaced completely with *bajra* or *korra* without affecting performance and ready to cook yield of chicks during initial six weeks. Fingermillet *(ragi)* could be used up to 33% replacing maize. The concentration of serum LDL cholesterol decreased by incorporation of millet based alternate energy sources in *Vanaraja* chick diet. This finding opens up possibilities of using dietary formulations as a means of producing eggs with low LDL cholesterol.

Three experiments were carried out at farmer's sheds by complete replacement of maize with pearlmillet, ragi and *korra* in iso-caloric and iso-nitrogenous commercial broilers diets. The chicks (n=2000) were randomly distributed into 20 floor pens (10 X 10 feet) @ 100 chicks in each pen. The performance of broilers and economics of broiler production are given in Table 13.

Pearlmillet can be used up to 30% in *White Leghorn* layer diets without compromising egg production and feed efficiency. Utilization of pearlmillet at this level in force-molted layer diet minimized the egg size to the desired level. The cost of feeding was also reduced on incorporation of pearlmillet in layer diets. Use of coarse cereals instead of maize had no significant influence on egg production in commercial layers and it was possible to replace maize completely in layer ration with sorghum and pearlmillet either alone or in

Table 13: Performance of broilers and cost of broiler production with millet based diets

Energy source	Wt. gain (g)	Feed/gain	Livability	Sale price (Rs/b)	Net profit*/b
Maize	2084ab	1.820ab	491/500	75.02	35.25
Bajra	2028b	1.884a	495/500	73.01	35.42
Ragi	1443c	1.874a	494/500	51.95	23.70
Korra	2136a	1.784b	495/500	76.90	37.62

* profit over feed cost

combinations. Supplementation of diets with enzyme and/or lysine did not produce any beneficial effect.

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 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 l/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% on 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 14. 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, an on-farm trial was carried out in Rangareddy district 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 T1 : Grazing on natural pasture, T2 : Grazing + supplementation with *Leucaena leucocephala* leaves @ 1 kg/ head/ day, T3 : Grazing + supplementation of *Stylosanthes hamata* hay @ 0.5 kg/head/day and T4: 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

Table 14: Ingredient composition of ration in control and experimental groups and milk yield in cows on straw based diets in Anagalapura village, Bangalore rural district

Parameters	Control		Experimental	
	Quantity (kg)	Cost (Rs)	Quantity (kg)	Cost (Rs)
Fingermillet 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

village followed by night shelter within the compound of households.

Weighed quantities of supplements were offered in the shed at 5:00 pm and the actual intake was recorded. The experiment continued for 60 days during September 25 to November 14, 2003. The highest body weight gain of kids was recorded due to *Leuceana leucocephala* supplementation followed by concentrate and *Stylosanthes hamata* hay(Table 15). 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 supplementing coarse cereal crop residues with locally available supplements in a cost effective manner.

Table 15: Live weight gain and partial budget analysis in kids grazed on natural pasture and supplemented with *Luecaena leucocephala, Stylosanthes hamata* and concentrate

Variable	Treatments			
	T1	T2	T3	T4
Growth rate				
Initial body wt. (kg)	15.33 ± 0.52	16.35 ± 0.61	16.07 ± 0.44	15.42 ± 0.50
Final body 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 7

Monitoring and Evaluation

During the year, the OFTs were continued in more than 45 PSR projects as per the technical programme while in the remaining, the best treatment were tried with farmer vs. improved practice. In case of concluded projects also the PIs/ CCPIs conducted surveys in the target villages and collected information on farmers perception on the interventions tried. In addition to the regular visit of AED and PPSS to the implementation centers for participation in the site committees and annual workshops, peer review teams with SAP members and external experts were constituted for on site review of projects as per PME guidelines. External reviews of the projects under AED as a whole were done by the world bank team in January 2004. Achievements, impact, success stories from PSR and TAR-IVLP projects were presented through a poster session and discussed during the satellite symposium held during March 2004 at Hyderabad. A brief summary of these activities is presented in this chapter. Details of the peer reviews undertaken are given in annexure VI.

Monitoring by PRTs

The PRT examined the draft report of ROPS-14 on impact evaluation of watershed management technologies during 11th–16th June 2003 at CRIDA. The team recommended that the project team may consider, the variations in priorities and focus among the watershed projects implemented by the different agencies i.e. biophysical vs. socio economic. The evaluation may accordingly be made in relation to the objective. The revised guidelines of the Ministry of Agriculture need to be considered under watershed plus programme and final evaluation be done accordingly. The capacity building effort of the programme also need to be adequately documented.

The review team which visited the OFTs under ROPS-12, ROPS-16 and ROPS-08 in Mahaboobnagar district of Andhra Pradesh during 8th–9th September 2003, found the conduct of the trials quite satisfactory as per the technical programme and the response of the participatory farmer encouraging. The team particularly noted that the performance of castor hybrids and simple moisture conservation technologies like conservation furrows have potential for wider adoption among the farmers. The team suggested that seed production of castor hybrids like DCH-32 and DCH-177 may be taken up on large scale by associating with private seed industries.

The OFTs under MPUAT, Udaipur and RAU, Bikaner were reviewed by peer review team

by Dr.H.P.Singh, former Director, CRIDA during 8th –9th October, 2003. The team found that the technology of wide rows spacing (60cm) of pearlmillet and making ridges and furrows 30 days after sowing performed well on farmers fields in arid districts of Jodhpur and Barmer. The committee suggested to take up large scale production of ridger seeder and exchange of best performing varieties among the centers.

A PRT led by Dr.I.C.Mahapatra, member SAP reviewed five PSR projects in target districts of Orissa during 21st to 24th November, 2003. In all soil and water conservation projects, the team strongly recommended strengthening of earthen bunds through grass turfing and contour bunds with agro-forestry species. On the soil quality assessment, it was suggested that mere quantifying the quality as SQI is not adequate, and it should be followed up with determination of carbon sequestration through different cropping system. In case of improved jute variety, the team recommended for its evaluation involving more farmers. On post harvest technology of paddy, the team observed good response from the farmers on use of black polythene sheet and recommended for its wide popularization. The project on deep-water rice was also reviewed by the team, which expressed satisfaction that varieties are being tried in real deep water areas of Brahamagiri and Kanas blocks of Puri district. It was recommended that the results from this project may be used to develop an interdepartmental collaborative project involving irrigation engineering, OUAT and CRRI, Cuttack to tackle the problem of drainage. The survival of paddy seeds from deep water areas for next year planting need to be investigated.

TAR-IVLP National Workshop

A national workshop on TAR-IVLP projects was organized during 22-23, December, 2003 at CRIDA, Hyderabad. The meet reviewed the progress of all projects in different agro ecosystems and finalized the technical programme during the extended period of 2004-05. Dr. P. Das, DDG (Extension) chaired the final session on finalization of technical

Field day organized at Sanabandhakera village of Brahmagiri block of Puri district to expose the farmers on deep water rice technology

programme and mid course correction. The meeting stressed that technical interventions under TAR should not be mere demonstrations, but specific component of the technology that was refined need to be highlighted. List of technologies that emerged from PSR which need to be refined by TAR were presented by the Principal Production System Scientists (PPSS) of all agro-ecosystem directorates.

Review by World Bank Team

A World Bank team which reviewed various bank funded projects in Andhra Pradesh visited CRIDA on 23 January, 2004 and reviewed the progress of work under Rainfed Agro Ecosystem of NATP. The team consisted of Dr.P.S.Sidhu, Sr. Agricultural Specialist, Dr.Connie Bernard, Sector Director, Dr.Robert S.Epworth, Sr.Agriculturist. In a 3 hour meeting, Dr.S.L.Mehta, National Director, NATP apprised the team of the achievements of the NATP project so far on different indicators *viz.,* technologies developed in different modes of research, technology dissemination, organization and management reforms and human resource development. As the Phase-I of the project is drawing to a close, the project helped in institutionalizing a new and innovative method of inter institutional and inter disciplinary project development and a scientific monitoring and evaluation system which gave a fillip to the research system in NARS, Dr.Mehta said.

Dr.Y.S.Ramakrishna, AED (Rainfed) made a summary presentation of the achievements under Rainfed Agro Ecosystem. Dr.B.Venkateswarlu, PPSS, AED (Rainfed), Dr.D.M.Hegde, Facilitator (Oilseeds), Dr.N.Seetharama, Director, NRCS, Principal Investigators of selected projects in Rainfed Agro Ecosystem and farmers from the nearby districts who were involved in the on-farm trials also participated in the discussions. The posters of 10 best projects under AED rainfed were arranged and visiting experts particularly Dr.Epworth and Dr.Bernard interacted with the PIs and the CCPIs in detail. The team expressed their satisfaction on the direction of the project and achievement so far under rainfed agro ecosystem.

Review meeting of the World Bank team with National Director, AED (Rainfed) and other scientists

Interaction of Dr.Robert S Epworth with PI of RNPS-24 and farmers who participated in the Project

Satellite Symposium on Rainfed Agro Ecosystem

A National symposium cum exhibition on "Enhancing productivity and sustainability in Rainfed Agro Ecosystem" was held at ANGRAU, Hyderabad on 24-26 March, 2004 under the auspicious of NATP. The main objectives of the symposium were to highlight the achievements and usable technologies generated under rainfed AES to a larger group of stakeholders. The event consisted of symposium with status papers and progress reports and an exhibition wherein all the 100 principal investigators of PSR and 24 PIs of TAR-IVLP projects explained the progress of work and technologies generated and refined. Officials from State Department of Agriculture, Directors of Research of SAUs, Project Directors of ATMA also participated in the symposium. The symposium identified projects which need to be upscaled through horizontal expansion during 2004-05. Some of the progressive farmers who participated in the on-farm research also shared their experience. Three best posters from PSR and three from TAR-IVLP were given prizes appreciating their achievements.

Inauguration of the satellite symposium (left) and interaction of the SAP chairmen (Drs. J.S. Kanwar and M.V. Rao) and experts at the poster exhibition (right)

The following projects/posters were adjudged for receiving the first and second prizes in the category of PSR and TAR-IVLP projects as selected by a duly constituted selection committee headed by Dr.K.V.Raman, Chairman, SAP (Irrigated) and Dr.S.A.Patil, Vice Chancellor, UAS, Dharwad, Dr.S.N.Puri, Vice Chancellor, MPKV, Rahuri and Dr.D.P.Singh, National Coordinator (PSR) as members.

First Prize (PSR)

RRPS-04 : Rainwater management strategies for drought alleviation	Dr.A.R.Pal, IGKV, Raipur and his project team

Second Prize (PSR)

ROPS-01 : Utilization of safflower petals for natural dye and herbal health care products	Dr.P.V.Varadarajan, CIRCOT, Mumbai and his project team

Consolation/ Appreciation (PSR)

RRPS-09 : Integrated management of fish, pig and duck culture in rice based farming system	Dr.A.K.Singh, BAU, Ranchi and his project team
ROPS-07 : Develop suitable technology to make use of sunflower heads and castor cake as animal feed	Dr.K.S.Ramachandra, NIANP, Bangalore and his project team
RCPS-07 : Promotion of productive high quality *arboreum* cotton to meet the needs of marginal cultivators of rainfed ecosystem vis-à-vis textile industry	Dr.L.A.Deshpandey, MAU, Parbhani and his project team
RRPS-24 : Participatory and integrated assessment of natural resources and evaluation of alternative sustainable land management options for tribal dominant watershed	Dr.U.S.Patnaik, CSWCRTI, Koraput and his project team
RNPS-24 : Developing sorghum as an efficient biomass and bio-energy crop and value addition to rain damaged *kharif* grain	Dr.V.Ratnavathi, NRCS, Hyderabad and her project team

First Prize (TAR-IVLP)

RFIVLP-01 : Technology assessment and refinement through institute-village linkage programme in Ranchi district (Jharkhand)	Dr.R.P.Singh 'Ratan', BAU, Ranchi and his project team

Second Prize (TAR-IVLP)

RFIVLP-21 : Technology assessment and refinement through institute-village linkage programme in Dharwad (Karnataka)	Dr.S.A.Patil, UAS, Dharwad and his project team
RFIVLP-06 : Technology assessment and refinement through institute-village linkage programme in Solapur district (Maharashtra)	Dr.G.Y.Parlekar, MPKV, Solapur and his project team

The certificates were given away by Dr.S.L.Mehta, National Director and Chairman of the Concluding Session to all the prize winners. As a token of encouragement to the scientists, the National Director declared that the scientists whose posters have won the prizes would be given priority while proposing the names for advanced training.

Dr.S.L.Mehta, National Director, NATP giving away the prizes for the best posters

Annexure I

Technology Transfer and Commercialization

The production system research (PSR) resulted in a number of technologies that can be commercialized by small and medium entrepreneurs. In some case, the commercialization already started and in others the process is in progress. The list of technologies with potential for private partnership and the current status of commercialization is given below:

Name of the technology	Private partners evincing interest in collaboration/commercialization	Current status of the partnership/ commercialization
Sweet sorghum cultivation and alcohol production from cane	This project generated good interest among large number of entrepreneurs in A.P., Tamil Nadu, Maharashtra and Karnataka in view of high prospects for sorghum as alternate raw material for ethanol. Many firms evinced interest and carried out field trials with breeder seed provided by NRCS. These include M/s.Renuka Sugars, Belgaum, M/s.Sagar Sugars, Chittoor, M/s.Praj Industries, Pune, M/s.G.M.R.Vasavi Industries, Hyderabad, M/s.Mohan Breweries, Chennai, M/s.COLANAC International, Chennai	One contract farming project completed with 600 acres in Belgaum. Two other projects are under way in Chittoor and Srikakulam districts of A.P. All the distilleries are highly exited about the prospects of sweet sorghum but the feasibility of cultivation, suitable areas, crushing sorghum without overlapping with sugarcane season are issues to be addressed.
Yellow dye from safflower petals	CIRCOT, Mumbai successfully standardised the extraction for red and yellow dyes from petals. Small firms like M/s.BEC Foods, Raipur, M/s.Raita Sweet Mart, Parbhani, M/s.Bikaner Sweet Mart, Parbhani, M/s.Bombay Sweet Mart, Parbhani showed interest in the technology.	The safety of safflower dyes are well known. Likely to pick up demand in future. A pilot trial with 50 kg safflower for extraction of yellow dye in powdered form through spray drying planned during October, 2004. Upscaling the process and availability of large volume of petals major issues. Contract farming may be the option.
Herbal tea from safflower	The herbal tea formulation was evaluated organoleptically and exhibited at several food technology fairs in Maharashtra during the last two years. M/s.Eco Save Systems, Mumbai, M/s.Eswardas Gangao, Jalana, M/s.Manik Kharat and M/s.Anand Rawale Aurangabad, M/s.Shard Gore, M/s.Virage Enterprises and M/s.Universal Traders, Parbhani, M/s.K.Jagan and co, Hyderabad evinced interest for commercial production	As such the formulation is ready for commercialization but further improvement in making it as a "tea bag" product with acceptable flavour will be required. Clinical trials for confirming anti diabetic properties in collaboration with medical professionals will give further value to the product.

Name of the technology	Private partners evincing interest in collaboration/commercialization	Current status of the partnership/ commercialization
Cardboards from safflower stalks	Stalks from safflower can be successfully used for cardboards. A commercial trial production was carried out in Nagpur with 2 tons of safflower stalks.	The strength of the board and its commercial acceptability need to be evaluated through market surveys.
Detoxification technology for castor cake	Castor cake after detoxification can be used as livestock feed. The detoxification technology developed under ROPS-7 project generated interest in firms like M/s.Jayanth Oil Mills, Vadodara, M/s.Banaskantha Dairy Cooperatives, Gujarat	While the commercial viability of the technology is proved, long term feeding studies are required to prove the non toxic nature or the cake
Complete feed from sunflower heads	This is a technology to make feed formulation for livestock from sunflower heads which otherwise go waste. This simple technology can be adopted at village level by women self help groups and small entrepreneurs. Two self help groups M/s.Shiva Sai SHG, A.P. and M/s.Devagara, SHG, Maharashtra already took up village level production during 2003. M/s.Narendra Traders, Raichur has agreed for collaboration for large scale production of pellets through extrusion technology.	The technology has high prospects in districts like Raichur, which produce largest sunflower crop in the country. However, an integrated strategy linking with rural development programmes are necessary to popularize the technology among women entrepreneurs in the villages.
Pit fall probes for insect trapping	This is a set of small devices developed by TNAU, Coimbatore to detect and trap the beetles in stored pulses. Though simple, but very useful in minimizing the post harvest household losses. Technology has already been commercialized through an MoU between TNAU and M/s.K.S.N.M. Marketing, Coimbatore	A large number of small units can come up all over the country on the Coimbatore model.
Quality *arboreum* cottons	Superior stapled *arboreums* like PA-255, MDL-2463 and DLSA-17 were liked by the farmers. In view of the reluctance of the open market to pay good price to the *arboreums* in comparison to *hirsutums* fibre quality test assessment was taken up with M/s.Maral Overseas, Indore. M/s.Gadag Cooperative Spinning Mills, Hulkoti, Karnataka	Based on the results of the mill test, extensive extension and publicity efforts are required to popularize the new varieties.
Diabetic health foods from fingermillet	A large number of diabetic formulations were prepared from fingermillet and pearlmillet which were evaluated for their glycemic index. Exhibited at several fairs and melas in north India. M/s.NRDC, New Delhi and M/s.Godraj Plant Biotech, Mumbai showed interest for collaboration.	Diabetic foods is a growing market. A totally business like approach fully focused on generating clinical information is required to make further progress.

Name of the technology	Private partners evincing interest in collaboration/commercialization	Current status of the partnership/ commercialization
Grain drying technology for *kharif* sorghum	Through a vetilating type grain drier harvested sorghum can be dried without getting the mold. With this technology farmers in Maharashtra could get 20-30% additional price in the open market. The simple drying of the harvested grain can be done in the tobacco barns or a highly sophisticated grain dryers. M/s.J.K. Seeds, Maharashtra showed interest to install large number of such machines in major sorghum growing areas on custom hiring areas.	This technology can be promoted only through custom hiring basis or owners of abandoned tobacco barns in A.P., can take up drying of sorghum on rental basis.
Foot operated vacuum packing machine	This machine can create vacuum for storing soybean seeds which improves the viability. CEDMAP, Bhopal showed interest for commercialization of the technology.	Further follow up is required to identify small entrepreneurs in soybean growing districts of M.P. This is an ideal case for promoting custom hiring services for soybean farmers.
Liquid biofertilizer production technology	Liquid biofertilizer is a new technology for a production of Rhizobium, Azospirillum and PSB, which improves the shelf life by avoiding contaminants problem associated with the use of lignite. M/s. Plant Rich Chemicals and Fertilizers, Kottayam, Kerala showed interest on technology transfer.	An MoU is likely to be signed by the UAS, Bangalore and the firm once the terms and conditions are finalised.

Annexure II

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Annexure III

Human Resource Development

A) Training Abroad

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training	Place of the training
1.	RPPS-05	Dr.S.D.Deshpandey	CIAE, Bhopal	Improved grain storage methods in pulses	May 8-23, 2003	Oklahoma State University, Still water, USA
2.	ROPS-17	Dr Suseelendra Desai Junagadh	NRCG, in oilseeds	Management of Aflatoxin	May 13-27, 2003	National Peanut Research Laboratory, Dawson, USA
3.	RNPS-24	Dr C V Ratnavathi	NRCS, Hyderabad	Improving grain quality in Soghum	July 9-23, 2003	Purdue University, Indiana, USA
4.	ROPS-08	Dr B Subbarayudu	NRCS, Hyderabad	IPM in Oilseeds	June 15-27, 2003	Michigan State University, Michigan, USA
5.	ROPS-08	Dr P Lakshmi Reddy	RRS, Ananthapur	IPM in Oilseeds	June 15-27, 2003	Michigan State University, Michigan, USA
6.	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
7.	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
8.	RNPS-17	Dr M Chandra-sekharaiah	NIANP, Bangalore	Recent advances in ruminant nutrition	June 16 – July 6, 2003	International Feed Resources Institute, The Macaulay Institute, Scotland, UK
9.	ROPS-12	Dr G.Pratibha	CRIDA, Hyderabad	Oilseed cropping systems for sustainable production	July 28 – August 10, 2003	USDA, Mandan, North Dakota, USA
10.	ROPS-12	Dr P Padmavathi	DOR, Hyderabad	Oilseed cropping systems for sustainable production	July 28 – August 10, 2003	USDA, Mandan, North Dakota, USA
11.	RPPS-03	Dr B Sarat Babu	NBPGR (RS), Hyderabad	Integrated management of viral diseases		The State University of New Jersy, USA
12.	ROPS-11	Dr.N.S.Bhogal	NRCRM, Bharatpur	Soil Science and Plant Nutrition	September 8-19, 2003	Massey University , New Zealand.
13.	RCPS-04	Dr.Ch.Srinivasa Rao	CRIDA, Hyderabad	Soil Science and Plant Nutrition	September 8-19, 2003	Massey University , New Zealand.

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training	Place of the training
14.	RRPS-16	Dr.(Mrs.)G.Jayasree	ANGRAU, Hyderabad	Tillage requirements for rainfed rice production	September 29 – October 12, 2003	Ohio State Univ., USA
15.	RRPS-16	Dr.T.D.Pandey	IGKV, Jagdalpur	Tillage requirements for rainfed rice production	September 29 – October 12, 2003	Ohio State Univ., USA
16.	RRPS-16	Dr.(Mrs.) N.G.Barua	AAU, Jorhat	Tillage requirements for rainfed rice production	September 29 – October 12, 2003	Ohio State Univ., USA
17.	RRPS-16	Dr.S.Sarkar	BCKV, Gayeshpur	Tillage requirements for rainfed rice production	September 29 – October 12, 2003	Ohio State Univ., USA
18.	ROPS-07	Dr.K.S.Ramachandra	NIANP, Bangalore	Modern Animal feed manufacturing and feed formulations	October 20-31, 2003	IPC, Livestock, The Netherlands
19.	ROPS-07	Dr.D.Nagalaxmi	ANGRAU, Hyderabad	Modern Animal feed manufacturing and feed formulations	October 20-31, 2003	IPC, Livestock, The Netherlands
20.	RRPS-20	Dr U K Mandal	CRIDA, Hyderabad	Planning for suitable land resource management	October 6-19, 2003	Ohio State Univ., USA
21.	RNPS-02	Dr V. Ramesh	CRIDA, Hyderabad	Carbon sequestration under different land uses	October 22 – November 5, 2003	Oregon State University, Oregon , USA
22.	RPPS-01	Dr. G P Brahma-prakash	UAS, Bangalore	Liquid rhizobium technology and recent techniques in biological nitrogen fixation	November 24-December 7, 2003	Bowling Green State University, Ohio, USA
23.	RPPS-10	Er Shakir Ali	CSWCRTI, Kota	Community based integrated watershed management	November 10-28, 2003	International Institute of Rural Reconstruction, Philippines

B) Training in India

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training	Place of the training
1.	RNPS-12	Dr.K.S.Datta	GAU, Junagadh	Farming Systems Approach	December 15-24, 2003	NAARM, Hyderabad
2	RNPS-09	Dr NN Reddy	CRIDA, Hyderabad	Internet based information systems in agriculture	November 11-20, 2003	NAARM, Hyderabad

Annexure IV

Farmers Training and Awareness Generation

Project Code	Location	Nature of the activity	Date	No. of farmers attended
RRPS-09	Chaibasa	Training organized for farmers sponsored by ATMA	For 8 days	20
	Dumka, Ranchi	Training organized for farmers, sponsored by ATMA	For 8 days	40
	Ranchi/Hazaribagh	Training organized for farmers	For 15 days	8
	Bokaro	Training organized for farmers, sponsored by Sanskar, NGO	For 8 days	5
	Ranchi	Exposure visit	For 1 day	20 farmers
RRPS-11	Boida village, Phulbani	Field day	23rd August, 2003	
	OUAT Bhubaneswar	Workshop	27th August, 2003	
RRPS-23	Naransinghpur field office, Dist. Bhadrak	Field day	25th January, 2004	
RRPS-31	CRRI, Cuttack	Demonstration of Improved rice milling technology	23rd February, 2004	50 farmers & 2 entre-preneurs
RRPS-34		Farmers interaction meeting	25th June 2003	65
		Farmers interaction meeting	18th January 2004	45
RRPS-35	Mahamada village, Pusa block of Samastipur district.	Field day	8th November, 2003	—
	Sanabandhakera Bramhagiri block, Puri	Field day	22nd November	—
	Bahikhowagaon, Bokakhat block, Golaghat		12th December 2003	—
ROPS-12	Shakavad, Maharashtra	Field Day	18th September, 2003	200 farmers
	Rajapur, Maharashtra	Group Discussion	8th September, 2003	15 farmers
	Simrol, Maharashtra	Field day	6th September, 2003	150 farmers
RPPS-05	Lambakheda Golkhedi, Entkhedi, Bhopal	Demonstration of Improved grain storage technology	June, 2003 July, 2003	55 70
RCPS-07	Adilabad, Andhra Pradesh	Farmer-Scientist interaction on cotton	June, 2003 July, 2003	250 300

Project Code	Location	Nature of the activity	Date	No. of farmers attended
RNPS-09	Amarachinta, Mahaboobnagar	Pruning and training of orchard crops	7 – 8th Aug' 03	30
		Preparation of compost and biodynamic products at PJP	12th Aug' 03	34
		Profile modification and pit filling for raising orchard crops at Nellikondi	14th Aug' 03	35
		Agri-hortisystems and fruit growing for extension officers at Nellore district.	3rd Nov' 03	50
RNPS-12	GAU, Rajkot, Gujarat	Kisan Mela	July 29-August 3, 2003,	215
	GAU, Junagadh, Gujarat	Kisan Mela	October 7-11, 2003,	457
	IGFRI, Jhansi, U.P	Kisan Mela	November 1, 2003	45
	ANGRAU, Mahaboobnagar, A.P	Visit of shepherds	November 11, 2003	100
	ANGRAU, Mahaboobnagar, A.P	Visit of shepherds	November 11, 2003	200
	ANGRAU, Mahaboobnagar, A.P	Village watershed committees	November 28, 2003	34
	ANGRAU, Mahaboobnagar, A.P	Farmers undergoing training under Animal Husbandry Department (AP)	November 29, 2003	7 Groups
	ANGRAU, Mahaboobnagar, A.P	Training of farmers rearing sheep	December 1, 2003,	20
	GAU, Junagadh, Gujarat	Fourth Interactive Project Workshop (RNPS-12)	December 15-24, 2003,	40
	Villages in Jhansi, U.P	Shodh Yatra in NATP villages (Jhansi)	February 3, 2004	96
	IGFRI, Jhansi, U.P	Kisan Mela	March 22, 2004,	347
RNPS-19	CSWCRTI, Chandigarh	Farmer's group from Jharkhand	1st May, 2003	10
		Watershed Development Team members from Kullu (H.P.)	20th June, 2003	30
		CAT officials from Nischar, Kinnaur (H.P.)	22nd July, 2003	23
		Delegates from International Water Management Institute, African countries	1st March, 2004	4

Annexure V

Project wise Budget Utilization during 2003-04

Rainfed Rice based production system

Sl. No.	Project title with code	Budget allocation		Utilization*
		Total	2003-2004	
1.	Georeferenced resource inventory preparation for rice ecosystem (RRPS-01)	77.10850	0.30025	0.30025
2.	Socio economic dynamics of charges in rice production system in Eastern India (RRPS-02)	102.19350	0.97300	0.97300
3.	Crop management strategies to increase cropping intensity (RRPS-03)	137.45050	23.74271	23.56004
4.	Rain water management strategies for drought alleviation (RRPS-04)	129.85000	12.77125	22.07647
5.	Management of excess water in medium and low lands for sustainable productivity and delineation of problem area (RRPS-05)	59.43200	3.78500	8.86169
6.	Study of production mix, resource utilization, risk management and technological intervention in watershed development programmes (RRPS-06)	73.21500	0.56150	0.56150
7.	Strategies for restoration/rehabilitation of degraded watersheds (RRPS-07)	41.64000	1.25000	3.47035
8.	Development of fruit based land use systems in watersheds (RRPS-08)	115.89600	32.17813	18.28881
9.	Integrated management through fish, pig and duck culture in rice farming system (RRPS-09)	60.55300	7.99620	13.76895
10.	Evaluation of cultivars for Rainfed Rice Production System (RRPS-10)	168.53800	11.88000	20.60495
11.	Integrated plant nutrient management strategies for different soil moisture regimes (RRPS-11)	112.18400	7.50000	9.68356
12.	Sustainable livestock production system for rainfed rice areas (RRPS-12)	183.73400	11.36988	11.36988
13.	Control of parasitic diseases of grazing and stall-fed livestock in Bihar, Orissa, West Bengal and Madhya Pradesh (RRPS-13)	133.29360	15.05978	15.05978

Sl. No.	Project title with code	Budget allocation		Utilization*
		Total	2003-2004	
14.	Agro techniques for vegetable cultivation and storage (RRPS-14)	105.10400	5.80105	5.80105
15.	Identification of microbial inoculants for moisture and temperature stress to improve their survival in plough layers in order to enhance in order to enhance the productivity of legumes and cereals in rainfed ecosystem (RRPS-15)	5.00000	0.00000	0.00000
16.	Soil tillage requirement for rainfed rice production system (RRPS-16)	171.43580	39.05340	33.29741
17.	Development of regional scale watershed plans and methodologies for identification of critical areas for prioritised land treatment in the watersheds (RRPS-17)	183.51800	33.83410	32.74563
18.	Study on weed and pest incidence dynamics in relation to ecologies and its impact on economic losses for developing (RRPS-18)	45.73100	14.40750	8.74356
19.	Organic pools and dynamics in relation to land use tillage and agronomic practices for maintenance of soil (RRPS-19)	166.49750	22.10250	19.95441
20.	Assessment and improvement of soil quality and resilience for rainfed production system (RRPS-20)	141.32770	34.78205	36.47027
21.	Improving the traditional biasi system (RRPS-21)	115.55180	12.16865	15.26581
22.	New approaches to integrated pest management in rainfed rice based production system (RRPS-22)	136.77850	30.16769	24.37466
23.	Evaluation of cultivars of major crops of rainfed eco system for increased water use efficiency (RRPS-23)	139.08792	26.92959	22.62680
24.	Participatory and integrated assessment of natural resources and evolution of alternated sustainable land management options for tribal dominant watershed (RRPS-24)	151.17750	34.61250	17.20926
25.	Application of crop simulation models to develop crop and nitrogen management strategies for increasing rice productivity under rainfed favourable low land situations of Eastern India (RRPS-25)	56.04110	6.88660	6.88660
26.	Improvement of jute through rice necrosis mosaic virus technology for sustainable yield and quality under jute-rice production system (RRPS-26)	92.61325	7.53125	7.67598
27.	Development of improved jute cultivars in rainfed agro ecosystem for quality textile fibre (RRPS-27)	116.17246	17.62127	18.46500
28.	Integrated nutrient management on yield targeting for jute-rice production system (RRPS-28)	108.33500	13.85201	11.16346
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)	78.58920	7.43420	9.79326

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
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)	45.70000	4.35271	4.35271
31.	Improve indigenous technology for milling, drying and storage of rice (RRPS-31)	126.82400	32.17775	14.90314
32.	Near real-time monitoring of agrometeorological conditions for contingency planning in Andhra Pradesh (RRPS-32)	58.06900	17.76340	7.03093
33.	Develop and promote prototype of implements for Tillage and Seeding in participation with local manufactures/ artisals (RRPS-33)	124.67335	9.53973	17.16368
34.	Development of agrotechniques for sustainable productivity of rice based utera cropping system (RRPS-34)	77.64625	17.28875	16.49978
35.	On-farm evaluation of deep water rice varieties and production technologies in rainfed eco system of eastern India (RRPS-35)	52.33060	13.32915	17.57910
	Total	**3693.29203**	**531.00355**	**496.58173**

Oilseeds based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
36.	Value addition of safflower petals for natural dyes and herbal health care products (ROPS-01)	100.42000	19.77600	10.89750
37.	Identification, characterisation and delineation of agroeconomic constraints of oilseed based production system in rainfed eco systems (ROPS-02)	55.40850	1.04167	1.04167
38.	Retaining viability in soybean by providing appropriate physiological environment and seed storage structures (ROPS-03)	48.58800	6.26600	6.12535
39.	Management of castor for rearing eri silk worm (ROPS-04)	83.71050	18.38283	15.85244
40.	Study of harvesting practices and development of multi crop harvester for inter cropping system with safflower under rainfed farming (ROPS-05)	51.13260	5.50440	4.84156
41.	Identification and management of sunflower necrosis disease (ROPS-06)	23.88000	2.91500	4.23295
42.	Develop suitable technology to make use of sunflower heads and castor cake as animal feed (ROPS-07)	103.87100	16.43459	21.17681
43.	Development of IPM modules for oilseed based production system (ROPS-08)	184.93025	32.35755	29.64191
44.	Promotion and development of apiary for improving the productivity of cross pollinated oilseed crop systems (ROPS-09)	96.07750	13.82975	9.28837

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
45.	Identification of research gaps in intercropping systems under rainfed conditions in India (ROPS-10)	50.36600	0.86871	0.86871
46.	Nutrient management practices for important oilseed based cropping systems for improving yield and oil output under rainfed conditions (ROPS-11)	190.32100	16.94500	14.35064
47.	Evaluation of cultivars of major oilseed crops of the production system for moisture and nutrient constraints in different soil types (ROPS-12)	126.25700	35.20240	32.30521
48.	Documentation and analysis of indigenous methods of in-situ moisture conservation and runoff management (ROPS-13)	25.68100	0.67664	0.67664
49.	Impacts of watershed management on sustainability of land productivity and socio economic status (ROPS-14)	87.59000	9.04376	9.04376
50.	Measures to counteract/detoxify aflatoxins in oilseeds and nutrition coarse cereals based poultry and livestock feeds (ROPS-15)	148.31600	27.58840	19.35388
51.	Improving oilseed productivity through identification of genotypes and management under saline conditions with farmers participations (ROPS-16)	126.39000	28.62200	18.35681
52.	Aflatoxin contamination in groundnut: Mapping and management in Gujarat, Andhra Pradesh and adjoining areas (ROPS-17)	56.67900	5.24300	15.70874
53.	An Integrated approach to control stem necrosis disease of groundnut (ROPS-18)	42.57400	13.29040	15.27701
	Total	**1602.19235**	**253.9881**	**229.03996**

Pulses based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
54.	Increasing the shelf life quality and effectiveness of rhizobial inoculant and optimising BNF in pulses (RPPS-01)	35.82300	8.57900	8.57005
55.	Integrated management of plant nematodes/soil pathogens in pulses based cropping system (RPPS-02)	85.29920	17.12989	16.40755
56.	Integrated management of the viral disease problems of mungbean (Vigna radiata) and urd bean (Vigna mungo) (RPPS-03)	80.29463	7.31400	13.10588
57.	Upgradation and evaluation of mini dal mill (RPPS-04)	60.01500	6.60500	8.46954
58.	Low cost technology for safe storage of pulses (RPPS-05)	53.47000	5.50000	8.40876
59.	Improvement of components of agrotechnologies for management of intercrops (RPPS-06)	158.18000	15.96450	20.80427
60.	Development of bio-intensive IPM modules in chickpea against Helicoverpa armigera, wilt and dry root rot (RPPS-07)	105.68100	20.09700	18.52406

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
61.	Development of bio-intensive IPM modules against pest complex, wilt and phytophthora blight in pigeonpea intercropping systems (RPPS-08)	77.70500	14.70800	13.57432
62.	Agro-economic characterisation, constraint analysis and delineation of efficient ecozones using soil type and rainfall data in chickpea and pigeonpea based cropping systems (RPPS-09)	31.99985	0.00000	0.00000
63.	Evaluation and improvement of Indigenious methods of moisture conservation and runoff management (RPPS-10)	162.32500	46.35026	30.02492
64.	Integrated nutrient management in major pulse based cropping systems and identification of the most productive and remunerative systems management (RPPS-11)	72.23500	5.61100	6.01048
65.	Utilisation of by-products of pulses, oilseeds along with coarse cereal grains for intensive goat production (RPPS-12)	123.29450	13.49043	15.30662
	Total	**1046.32218**	**161.34908**	**159.20645**

Cotton based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
66.	Agro economic characterisation and constraint analysis of rainfed cotton based production systems in relation to soil, rainfall and socio economic factors (RCPS-01)	36.87450	0.37260	0.24065
67.	Optimising nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system (RCPS-02)	123.61250	21.29050	19.94247
68.	Assessment of gossypol content in cotton germplasm (RCPS-03)	24.47200	0.80000	2.72333
69.	Delineating the efficient productive zones for cotton production system using GIS based crop models (RCPS-04)	60.61050	4.55000	10.23256
70.	Rain water conservation, harvesting and recycling/ recharging techniques for enhanced productivity of cotton based cropping system (RCPS-05)	115.01000	21.92930	14.68629
71.	Improving cotton productivity in salt affected soils through identification of species/genotypes and farmers participation (RCPS-06)	78.38600	5.94911	5.94911
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)	99.39500	25.65650	21.25009
73.	Characterisation and identification of productive and high quality cotton species/genotypes including G.herbaceum suitable approaches adopting farmers participatory for different rainfed agroecological situations (RCPS-08)	141.41650	44.23422	33.91678

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
74.	Develop and evaluate production technology for the indigenous cotton of NE region (RCPS-09)	24.67045	3.10045	5.57662
75.	Development of B.T.transgenic diploid cotton against bollworm (RCPS-10)	19.88770	2.38920	3.55537
76.	Impact of tillage, land treatment and organic residue; management on soil health, drainage and crop productivity of rainfed cotton based system (RCPS-11)	93.42100	12.64650	12.13903
	Total	817.75615	142.91838	130.2123

Nutritious Cereals based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
77.	Processing of millets for value addition and development of health foods (RNPS-01)	102.84750	20.30450	17.48848
78.	Development of regional scale watershed plans and methodologies for identification of critical areas for prioritised land treatment in the watersheds of oilseeds, pulses, cotton and nutritious cereals production systems (RNPS-02)	149.59100	48.29400	35.86968
79.	Developing live fencing systems for soil and water conservation, crop diversification and sustaining productivity in rainfed regions (RNPS-03)	189.24050	27.79550	27.52267
80.	Strengthening of research on integrated management of blast of fingermillet (Eleusine coracana Gaertn) (RNPS-04)	82.56597	12.57269	12.18579
81.	Refining small millets based cropping systems for augmenting supply of legumes (Grain/Vegetables) (RNPS-05)	89.53600	12.86650	16.03567
82.	Development of national data base on rainfed pearlmillet and fingermillet for research, planning and policy making (RNPS-06)	34.29000	0.52288	0.52288
83.	A Critical Analysis of changing scenario of sorghum in *kharif* sorghum growing areas (RNPS-07)	54.90150	21.40050	13.64462
84.	Evaluation/Improvement of dual types of sorghum and make available indigenous cultivars like by farmers (RNPS-08)	115.86750	16.26250	19.19926
85.	Develop agri-horiculture and agroforestry systems in *kharif* sorghum area decreasing region for overall sustainablility of the production systems (RNPS-09)	113.76550	27.96644	27.89371
86.	Management strategies for improving *rabi* sorghum productivity (RNPS-10)	143.68600	13.78150	28.29469
87.	Improving productivity of rainfed maize based cropping system with rainwater management on watershed (micro) basis (RNPS-11)	127.39550	4.50000	20.54020
88.	Studies on development of silvopasture system for improving livestock productivity in rainfed region (RNPS-12)	150.89250	32.65391	25.53615

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2003-2004	Utilization*
89.	Forecasting and management of diseases and insects in sorghum cropping system perspectives (RNPS-13)	25.87150	0.88313	0.88313
90.	On-farm research for enhancing productivity of pearlmillet in vertisol of semi-arid tropics (RNPS-14)	87.88500	7.50000	13.73950
91.	On-farm research for enhancing productivity for pearlmillet in arid regions of India (RNPS-15)	72.28650	8.00000	15.54407
92.	Utilisation of coarse cereals and byproducts of oilseed based cropping systems for poultry production (RNPS-16)	148.20400	27.04850	24.95362
93.	Improving the Utilization of coarse cereal crop residues by strategic supplementation for livestock feeding (RNPS-17)	134.27800	12.90000	20.65810
94.	Resource characterisation and socio-economic constraint analysis of productivity in the maize based crop production system (RNPS-18)	83.63600	1.07944	1.07944
95.	Rainwater management on watershed (micro) basis in sub-montane region (RNPS-19)	164.86850	33.00970	30.67089
96.	Improvement of roti making quality and shelf life of grain sorghum (RNPS-20)	151.65000	28.01050	27.09480
97.	Improving productivity and profitability of rainfed fruit based, production system based cropping system in low productive environments (RNPS-21)	166.53600	20.66841	22.18177
98.	Improving the productivity and profitability of vegetable crops under rainfed agro ecosystems (RNPS-22)	145.66200	13.07750	16.36284
99.	Total grain quality management of *kharif* sorghum (RNPS-23)	199.72750	21.07980	36.90203
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)	188.83100	16.81100	35.98299
101.	Identifying systems for carbon sequestration and increased productivity in semi-arid tropical environments (RNPS-25)	179.38250	13.28134	26.05879
102.	Developing sustainable alternate land use systems for industrial biomass production from drylands (RNPS-26)	19.97000	1.95800	2.41020
103.	Efficient clonal propogation of high value horticultural and forest species for dryland agriculture (RNPS-27)	71.12985	9.48070	3.36473
	Total	**3194.49782**	**453.70894**	**522.6207**

* Expenditure is based on SoE and includes the carryover budget from 2002-03 also.

Annexure VI

No. of On-farm Trials Carried Out and Villages Covered 2003-04

Production system	No.of on-farm projects	Area covered (ha)	No.of on-farm trials	No.of villages
Rainfed Rice	27	738	1539	1292
Oilseeds	10	286	468	243
Pulses	8	121	234	102
Cotton	7	152	531	128
Nutritious Cereals	16	928	728	385
Total	**68**	**2225**	**3500**	**2150**

Annexure VII

List of Technologies Generated under PSR

Sl. No.	Name of the technology	Brief Description
	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 to be followed.
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 realised through fish culture in the refuges by maintaining optimum dyke height.
6.	Mango + upland rice agri horticultural system	Meant for rainfed uplands of Koraput and Jagdalpur districts and also Ranchi and Palmau 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 district of Orissa where higher income can be realised 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.8000-1000/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 provides stability of yield during drought in Orissa.
10.	Integrated nutrient management with incorporation of legume intercrop in rainfed rice	As the 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.

Sl. No.	Name of the technology	Brief Description
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.
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 Orissa and pre-emergence application of butachlor @ 1.25 kg ai/ha, 3-5 DAS and one hand weeding 40-45 DAS for Jharkhand and U.P.
14.	Integrated pest management in rainfed rice	An integrated package consisting of resistant variety monitoring of pest population through pheromones 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 and difficult to harvest by humans and 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 indirectly helped in 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 for 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.

Sl. No.	Name of the technology	Brief Description
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 standardised which effectively controls the disease.
	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 mungbean and urdbean	Integrated package of tolerant variety and need based vector control for effective control of yellow mosaic virus in short duration pulses. Pulse growing areas of Orissa, A.P. and Tamil Nadu.
32.	Use of 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 the 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. Help 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.

Sl. No.	Name of the technology	Brief Description
		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 standardised 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 standardised 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 grasses/legumes in native pastures to improve the productivity of animals.
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 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 biofuel. 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 VIII

SAP Meetings and Agenda Covered
(From April, 2003 – March, 2004)

Sl.No. of the Meeting	Dates and Venue	Major Agenda
34	May 28, 2003, CRIDA, Hyderabad	Review of final reports of concluded projects and extension of other projects, finalisation of technical programme.
35	September 26-27, 2003, CRIDA, Hyderabad	Organizing the satellite symposium at AED level and half yearly progress report.
36	March 24, 2004, CRIDA, Hyderabad	Review of final reports of closed projects. Approval for expansion of a activities under on-going projects

Annexure IX

Details of the Peer Reviews of PSR Projects

Dates	Type of Review	Projects reviewed	Location	Review team
11-16th June, 2003	Field visit and desk review	ROPS-14	Manchal and Maheshwaram watersheds in A.P	Dr.J.Venkateswarlu Dr.M.S.Rama Mohan Rao Dr.B.Venkateswarlu
8th September, 2003	Field visit and farmers interaction	ROPS-8, 12 & 16	Mahaboobnagar, Ranga Reddy in A.P	Dr.P.S.Reddy Dr.H.P.Singh Dr.K.D.Sharma Dr.B.Venkateswarlu
29th September to 2nd October, 2003	Field visit and farmers interaction	RNPS-11, RNPS-15	Udaipur, Bhilwara, Jodhpur, Barmer in Rajasthan	Dr.H.P.Singh Dr.R.K.Agarwal Dr.Y.S.Ramakrishna
21st to 24th November, 2003	Field visit and farmers interaction	RRPS-17, 20, 27, 31 and 35	Kendrapara, Puri, Cuttack in Orissa	Dr.I.C.Mahapatra Dr.J.K.Roy Dr.M.A.Shankar Dr.P.K.Mahapatra

Annexure X

Members of Scientific Advisory Panel (SAP) and Facilitators (as on 31.3.2004)

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	Member
Dr B K Soni, Ex-DDG (Animal Sciences), ICAR	Member (Upto September, 2003)
Dr.S.Bislaiah, Former Vice Chancellor, UAS (B)	Member
Dr.S.N.Puri, Vice-Chancellor, MPKVV, Rahuri	Member
Dr.P.K.Singh, Vice-Chancellor, CSAUA & T, Kanpur	Member (From October, 2003)
Dr.P.S.Reddy, Director (Retd.), DOR, Hyderabad	Member
Dr.O.P.Pareek, Director (Retd.), CIAH, Bikaner	Member (From October, 2003)
Dr P Das, Director, RPRC, Bhubaneswar	Member (Upto September, 2003)
Dr.R.K.Gupta, Director of Research, JNKVV, Jabalpur	Member (Upto September, 2003)

Officers from ICAR

Dr.D.P.Singh, National Coordinator (PSR)	Member
Shri B.L Jangira, Director (Finance), ICAR, New Delhi	Member (From October, 2003)
Dr H P Singh, AED (RF)	Member (Upto June 2003)
Dr.Y.S.Ramakrishna, AED (RF)	Member (From July, 2003)
Dr.B.Venkateswarlu, PPSS	Member Secretary

Facilitators

Dr D M Hegde, Director, DOR	Facilitator (Oilseeds)
Dr. Masood Ali, Director, IIPR	Facilitator (Pulses)
Dr S K Benerjee, Principal Scientist, CICR	Facilitator (Cotton)
Dr D Panda, Principal Scientist, CRRI	Facilitator (Rainfed Rice)
Dr S V Rao, Principal Scientist, NRCS	Facilitator (Nutritious Cereals)

Annexure XI

Staff of Agro Ecosystem Directorate
(As on March, 2004)

Sl. No.	Name	Designation
1.	Dr.Y.S.Ramakrishna	Agro Ecosystem Director
2.	Dr.B.Venkateswarlu	Principal Production System Scientist
3.	Dr.G.Subba Reddy	Principal Scientist (Agronomy) *
4.	Dr.Ch.Srinivasa Rao	Senior Scientist (Soil Science)**
5.	Sri S.K.C.Bose	Finance and Accounts Officer
6.	Sri G.Lakshminarayana	Assistant Administrative Officer **
7.	Smt.P.Lakshminarasamma	Technical Officer
8.	Sri P.Chandrashekar	Technical Officer
9.	Smt. Hemlatha Kapil	Technical Assistant**
10.	Smt. M.A.Rekha	Junior Stenographer **
11.	Sri K.R.Srinivas Rao	Assistant
		Contractual Staff
12.	Dr.G.Ramesh	Research Associate
13.	Sri V.Srinivas	Senior Research Fellow
14.	Sri M.D.Mazharulla	Stenographer-II
15.	Sri V.Krishna Murthy	Stenographer-II
16.	Sri Jayakanth	Stenographer-II
17.	Sri Suresh Kanth Shukla	DEO
18.	Sri Y.Bhaskara Chari	DEO
19.	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.

Annexure XII

Budget of AED at a Glance for 2003-04

(Rs. in lakhs)

Head of expenditure	Remitted by PIU to AED	Released by AED during year	Expenditure incurred based on SoE
PSR	985.16300	1093.55398*	1524.73946
IVLP	150.81200	122.94284	132.88496
O&M	93.17000	—	86.13196
Total	**1229.14500**	**1206.49682**	**1743.75638**

* Rs.10.00 lakhs released to PIU towards centralized purchase through RITES

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