Rainfed Agro-Ecosystem

Production Systems Research

Annual Report
2002-03

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Message

The rainfed agro ecosystem is one of the largest components of the production systems research under NATP. This ecosystem is most diverse in terms of natural resources, farming systems and livestock and also quite challenging for technology development and transfer. With 103 PSR and 24 TAR-IVLP projects, the rainfed agro ecosystem covered thousands of farmers across the length and breadth of the country. Participatory on-farm research has been the main strength of the projects in this agro ecosystem.

The worst drought experienced during *kharif* 2002 posed both challenges and opportunities to the scientists working in the rainfed agro ecosystem. In large number of on-farm trials, the scientists could demonstrate the viability and economic feasibility of water conservation technologies on an operational scale. At the same time the continued vulnerability of crop production at many locations due to drought pointed to many research and extension gaps which need to be addressed in future not only under NATP but in the regular programmes as well.

It is gratifying to note that some of the technologies on water harvesting demonstrated on an operational scale in participation of the farmers particularly in the states of Chhattisgarh and Jharkhand convinced the respective State Governments to come forward with schemes for wider replication. I am happy to note that projects in the area of post harvest technology have made excellent progress and the scientists began to collaborate with entrepreneurs for possible commercialization. This public – private partnership is vital for achieving the much needed value addition in our agriculture.

I would like to complement Dr.H.P.Singh, Dr.Y.S.Ramakrishna, AEDs and Dr.B.Venkateswarlu, Principal Production System Scientist for bringing out this comprehensive report reflecting the progress of production system research under rainfed agro ecosystem.

S.L.Mehta
National Director (NATP)

November, 2003

Foreword

Rainfed agro ecosystem occupies the largest cultivated area in the country and produces most of the pulses, oilseeds, sorghum, pearlmillet, minor millets and cotton. It holds the key to wiping out the shortage of pulses, oilseeds and increasing export opportunities of nutritious cereals.

Recognizing the needs of the resource poor farmers and tribals living in these regions, a number of multi disciplinary projects were taken up under the production system research mode of NATP. After many reviews, the SAP identified 103 projects with emphasis on systems approach rather than commodity oriented projects and on-farm instead of on-station research with the goal of reaching the un-reached. Rain water management on watershed basis, INM, IPM and improved cropping systems became the thrust areas of the on-farm research.

The experience of last three years, particularly of 2002-03, which was a drought year, provided enough evidence of the relevance and usefulness of this approach. This was a year of challenge as well as of opportunity. Challenge because of wide spread drought and opportunity to confirm the superiority of the practices found suitable during the previous 2 years. In the upland paddy areas, diversification of cropping and in the low land areas, integrated farming system with efficient on-farm rain water management were found most remunerative. Crop diversification into agri-horticulture or integrated farming system instead of mono cropping resulted in stabilizing farmers income during the drought year. Integration of livestock and fish with cropping combined with rain water management were the key for this success.

Oilseed research in the target districts led to identification of suitable cultivars for salt affected soils, integrated nutrient and pest management strategies. Castor varieties for producing eri-silk in north east states and safflower as a dual purpose crop i.e. seeds and natural colours seem to offer for good potential for income generation and export. Research on chickpea and pigeonpea indicated the synergestic effects of integrated pest, nutrient and rain water management. Intercropping of pigeonpea + sorghum emerged as the best option for pest management instead of intensive pesticide use.

In cotton based production system, the superiority of *desi* cottons (arboreums) over american hirsutums was proved in all target districts during the low rainfall year. The indications are that *desi* cottons has vast unrealized potential and needs attention for further improvement even through biotechnology approaches.

The nutritious cereal research revealed that soil and rain water management such as broad bed and furrow system and toposequence based land management combined with integrated nutrient management and improved varieties help in yield stabilization during drought. However, *rabi* sorghum needs more intensive research. *Kharif* sorghum offers high potential for alternative uses such as bio fuel and other value added foods. I wish to appreciate the dedicated efforts of the AED (Rainfed), PPSS, Facilitators and others involved in the project and willing cooperation of the farmers besides the valuable advice provided by the members of the SAP through critical reviews and field visits.

I am confident to say that the NATP project has undoubtedly demonstrated that the rainfed ecosystem can become the granary of pulses, oilseeds, nutritious cereals and even medicinal plants provided, we adopt a pragmatic approach and sustained commitment in research and technology transfer.

J.S. Kanwar
Chairman, SAP (Rainfed)

November, 2003

Preface

The production systems research (PSR) under rainfed agro ecosystem progressed further during the year 2002-03 with continued focus on location specific on-farm participatory research. The on-farm research covered more than 6000 farmers in 3000 villages. Despite being a severe drought year, the adaptive research carried out during 2002-03 proved that integrated soil, rain water, nutrient, pest and crop management practices combined with improved varieties can provide stable yields and returns to the farmers in all the major production systems. Crop diversification into agri-horticulture, horti-pasture and integrated crop – livestock – fishery systems proved more remunerative during the unfavourable season as compared to monocropping.

During the year, an extensive review of the projects was carried out by the SAP and Peer Review Teams (PRTs) through workshops and field visits. It was heartening to note that many of the Principal and Co-Principal Investigators made efforts to establish linkages with TAR-IVLP, ATMA and other developmental programmes in the respective target districts for wide diffusion of the technologies. I am happy to note that in the area of post harvest technology, a public-private partnership for technology scale up and commercialization are emerging in many projects. The on-farm trials also acted as major demonstration points for large number of farmers who visited the experimental sites during the season. Some of the technologies developed under the projects on rain water management were adopted by the state governments in the drought relief programmes and it is hoped that during the coming years many such usable technologies in crop production, natural resource management, livestock production and post harvest technology would emerge as the projects draw to a close.

The continued guidance and supervision by the Scientific Advisory Panel (SAP) was responsible for successful steering of the programme during the year. Responding to the severe drought situation that prevailed during the year in many of the target districts, the SAP made modifications in the technical programme so that necessary contingent strategies would emerge to minimize the drought effects. The direction provided by Dr.S.L.Mehta, National Director and the excellent technical support provided by Dr.D.P.Singh, National Coordinator (PSR) helped in smooth implementation of this large programme at the AED level.

I must acknowledge the excellent effort put in by Dr.B.Venkateswarlu, Principal Production System Scientist who coordinated at the AED programme efficiently and also brought out this annual report synthesizing the progress of 103 diverse research projects. All the Facilitators of the 5 production systems, Dr.D.M.Hegde (Oilseeds), Dr.Masood Ali (Pulses), Dr.S.K.Banerjee (Cotton), Dr.D.Panda (Rainfed Rice) and Dr.(Mrs.) S.Indira (Nutritious Cereals), have put in their best efforts to coordinate and prepare the progress reports within their respective domains. All the Principal and Co-Principal Investigators, and above all the participating farmers deserve full appreciation for implementing this large on-farm research programme so successfully.

I also acknowledge the contributions of all the staff of AED cell at CRIDA, particularly Mr.S.K.C.Bose, FAO, Mrs.P.Lakshmi Narasamma, Technical Officer, Mr.G.Lakshmi Narayana, AAO, Mrs.Hemlata Kapil, T-II-3, Mr.K.R.Sreenivasa Rao, Assistant, Mrs. M.A.Rekha, Stenographer, Grade-III for smooth implementation of the programme at the directorate during the year.

H.P. Singh
AED (Rainfed)

May, 2003

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Executive Summary

In the production system research (PSR), the Rainfed Agro Eco System received high emphasis in view of the critical importance of rainfed agriculture in the country. Out of few hundred projects submitted by the scientists, after critical examination and revision, 103 projects were finally approved by the Scientific Advisory Panel (SAP) in the PSR mode under 5 production systems i.e. rainfed rice (35), oilseeds (18), pulses (12), cotton (11) and nutritious cereals (27). The projects were developed based on a formal constraint analysis and research prioritization in the respective target domains. Addressing the problems of the production system as a whole rather than single commodities as the target and on-farm rather than on-station research were the unique approaches followed in the PSR mode. The goal was to reach the unreached and focus on stressed enviroments.

2002-03 has been an eventful year in the implementation of the PSR projects. The severe drought during *kharif* season affected several on-farm trials in major states but it also provided an opportunity to demonstrate the viability and cost effectiveness of drought management and contingent strategies on farmers fields. Major areas in Karnataka, Chhattisgarh, Orissa, Jharkhand and A.P faced rainfall deficit upto 55%. However, the rain water harvesting and recycling approaches followed in many of the on-farm trials could save the crop and produce significantly more yield and economic returns to participating farmers as compared to neighbouring fields.

Similarly, crop diversification projects in many states demonstrated that stable income is realised from agri-horticulture and horti-pasture systems during drought compared to *kharif* cropping alone. In states like Chhattisgarh and M.P, the success of the water management and watershed projects could convince the development departments to include the models developed under the projects in the drought relief programmes. Making the best use of rain water with integrated nutrient and crop management produced the best results on farmers fields. Projects in the area of post harvest technology and value addition have moved a step forward towards commercialization in collaboration with entrepreneurs. A total of 57 technologies have been identified as outputs of PSR research to be refined under TAR-IVLP. Salient findings during 2002-03 from 5 production systems are summarized in the following paragraphs.

Rainfed Rice Based Production System

The project on rain water management through on-farm water harvesting structures in Chhattisgarh, Orissa and Jharkhand progressed further during the year, wherein the *kharif* crop in the service area could be saved from drought/crop failure by utilizing the harvested water from On-Farm Reservoirs (OFRs). Even during the drought year, the cropping intensity could be increased upto 140% at Bagbhara in Chhattisgarh and 115% at Keonjhar in Orissa. The cumulative additional returns as a percentage of the cost of water harvesting structures ranged from 28-49% in farmers practice to 71% with improved practice indicating that yields and profitability are higher when harvested water is used along with improved crop management practices. The success of the approach persuaded the Govt. of Chhattisgarh to take up a massive programme of constructing 2 lakh OFRs in a period of 3 years.

Similarly, in the excess rain water management project in Dhenkanal and Mayurbhunj districts of Orissa, by devoting 4-5% of the cultivable table land to fish refugees, 14-15% of additional rice equivalent yield was realised. The average fish yield in refugees was more than 1000 kg/ha as against the national average of 500 – 600 kg/ha of Indian major carp in the rice-fish integrated system. The crop diversification projects in eastern states further reinforced the importance of using rice fallows for a second crop to utilize the residual moisture and harvested water during *rabi* when the *kharif* crop failed in large areas in 2002-03. In uplands, rice + pigeonpea (5:2) and pigeonpea + groundnut (2:6) were more profitable than upland rice in several trials in Orissa and Jharkhand. The OFTs on *utera* cropping confirmed that planting of *utera* crop 2 weeks after flowering of rice and leaving 20 cm height stubble at harvest results in better establishment of the *utera* crop.

The integrated rice-fish-duck and rice-fish-pig farming system model tested with 15 farmers in Jharkhand, Chhattisgarh and West Bengal successfully demonstrated the technical feasibility and economic viability of the approach for improving the livelihood of the tribal farmers. The return for rupee invested was 3.17 to 3.75 in rice-fish-duck and 3.48 to 3.79 in rice-fish-pig system with different farmers. To have this integrated farming system sustained over a long period, the number of ducks should be based on the resources of the farmers rather than the pond area alone.

Inclusion of vegetables in rice based cropping system in uplands of Koraput district in Orissa and Jagdalpur and Ambikapur in Chhattisgarh provided much needed stability and additional income of Rs.5000/ha during the year. Even high value crops like ginger and turmeric could be raised by the tribals under rainfed conditions. However, moisture conservation through mulching was the key for success of this approach. The agri-horticultural systems successfully demonstrated in the Gopalput village of Koraput district, Orissa as an alternative to upland rice attracted the attention of the development departments/banks and a wider diffusion of these technologies is likely in coming years.

The importance of integrated nutrient management in rice based cropping system was confirmed during the year with 25 farmer participatory trials wherein the cost benefit ratio with 75% RDF + 5t FYM/ha + greengram incorporation was 2.4 while the farmers practice recorded only 1.5 to 1.6. Analysis of crop yields and soil samples from long term fertilizer plots of the rice based cropping systems revealed that soil fertility and crop productivity could be sustained over a long period of 20 years or more only when recommended NPK are supplemented with FYM (> 5t/ha) or green manuring. An index of soil quality (SQI) developed in a related project also confirmed the importance of organic manures in maintenance of soil productivity in continuous rice based cropping systems.

Extensive farmer participatory varietal evaluation in Orissa, Chhattisgarh and Jharkhand resulted in the identification of promising rice varieties for different micro farming situations. IET 14100 was released during 2002 as *Jagabandhu* by Orissa State Seed Sub Committee for cultivation in rainfed low lands. In case of jute, S-19, a promising high fibre quality variety was identified which attained an ISI fibre quality grade of TD_2+13%. This was recommended for pre release trials. Extensive on-farm trials in 27 districts of 5 states resulted in identification of promising deep water rice varieties like *Durga, Kishori, Sarala* and *Vaidehi* in Orissa and *Ranjit, Bahadur, Prafulla, Panindra* and *Jalashree* in Assam.

In IPM trials on rainfed rice, the yield levels of IPM module and scheduled based treatments were at par across the target districts but the cost benefit ratios were more with IPM modules. After 3 years of implementing the IPM module, a significant build up of natural enemies like coccinellids, spiders and dragon flies was observed in the rice ecosystem.

Post harvest losses upto 10% of the paddy could be avoided by use of improved storage structures in humid areas of Orissa, Assam and Manipur. Similarly, improved tillage and seeding implements saved cost of cultivation by 10-15% in upland paddy.

Oilseeds Based Production System

Majority on-farm trials on sunflower and groundnut suffered heavily due to drought in Karnataka and Gujarat. Across the states, the yield levels in the OFTs fell up to 50% compared to the normal years. The pest and disease incidence was also relatively low during the year due to dry conditions.

In view of the lower pest incidence, the differences between bio-intensive and chemo-intensive IPM modules were not significant during the year, but there was a significant build up of natural enemies in the continuously treated BIPM plots for 3 years. Interactive CD-ROM data bases on pest management information system were developed for mustard, groundnut and sunflower which will be useful for extension functionaries in the field.

The casual agent of the sunflower necrosis disease (SND) was identified as tobacco streak virus (TSV) based on coat protein gene sequence. ELISA based diagnostic test was standardized for quick detection of the virus. The integrated package of groundnut cultivation for control of aflatoxin in Andhra Pradesh and Gujarat resulted in only a marginal increase in pod yield. No significant differences were found in the population of *Aspergillus flavus* in the plots where improved practices or control i.e. farmers practice were followed.

Despite the rainfall deficit, the on-farm trials on integrated nutrient management revealed that 100% RDF + 2 t of FYM was most profitable in a number of oilseed based cropping systems like i) soybean-chickpea, ii) greengram – safflower, iii) fallow-sunflower, iv) groundnut + pigeonpea and v) fallow-mustard. Integration of moisture conservation practices and integrated nutrient management (INM) paid rich dividends during *kharif* 2002 wherein the fertilizer use efficiency increased significantly in sunflower, groundnut and safflower both in Alfisols and Vertisols when the limited moisture was conserved through *in situ* measures. In saline and sodic soils, the yield and returns from oilseeds crops like castor, sunflower, mustard and linseed could be significantly enhanced by seed soaking in 1% NaCl solution for 3 hours before sowing, application of 2 t FYM/ha and sowing the seeds on the side of the ridges. *Bio* 902 in mustard, P64A43 in sunflower, *Sweta* in linseed and 48-1 in castor were some of the salt tolerant varieties found in these trials.

Seed viability in soybean could be enhanced upto 60% for 9 month period by storing in vacuum sealed metalised poly bags as compared to only 20-40% with the farmers method of gunny bag storage. A low cost foot operated vacuum packing machine was designed at JNKVV, Jabalpur which can be installed at village level on custom hiring basis in soybean growing areas.

Sunflower heads based complete feed (upto 40%) did not have any adverse effect on lactating animals after 90 days of feeding. There was a significant increase in the drymatter intake and body weight gain in the experimental group as compared to the control animals. Autoclaving and lime (4%) treatment of castor cake reduced the ricin content upto 95% and the detoxified cake was fed to sheep as sole protein source without any adverse effect. Extensive survey of animal and poultry feeds across the state showed that more than 50% of the samples stored under ambient conditions got contaminated by aflatoxins. In view of the high sensitivity of chicks to aflatoxicosis, broiler chicken diets were fortified with higher levels of methionine (0.8%) to counter the ill effects of aflatoxins.

Castor variety 48-1 in Assam and local variety *Red petiole* in Manipur were found most suitable for eri silk production in north eastern regions. The quality and quantity of leaf production in both the varieties was more when improved agronomic practices were followed, which ultimately supported better cocoon and shell yield and number of DFL/ha.

Keeping two bee colonies/acre increased the yield of sunflower, safflower and niger by 45, 23 and 23% respectively in an oilseeds based apiary system in Karnataka, Maharashtra and Haryana. The per cent grain filling increased from 85 to 94 in sunflower due to bee pollination. The net gain from additional yield + honey in a safflower apiary system in Parbhani district was Rs.1,908/acre.

The safflower harvester designed during 2001-02 was further developed as a multi crop harvester. A collection tray was added to collect the harvested crop. Though the field coverage of the improved model with tray was marginally lower than the earlier model, the lower field losses more than compensated. The improved prototype requires only 29 man hours/ha as compared to 170 man hours required with manual harvesting.

The red and yellow dyes extracted from safflower petals were further characterized during the year for colour retention. Dyeing trials with colours extracted from 5 commercial varieties revealed that the intensity was maximum with JSI-7 (7.3 k/s) followed by JSI-97 (6 k/s). As with yield of petals, the non spiny varieties fared better than spiny varieties for colour intensity also. Colour retention tests showed that about 90% colour was retained for two months in food items with 1% dye solution. A technique for improved stability of the yellow dye was standardized by adsorbing on calcium carbonate.

Pulses Based Production System

Major pulse crops like pigeonpea and chickpea were affected due to abnormal weather conditions like drought and frost in most of the on-farm trials. The pest and disease incidence was low but the year 2002-03 provided an opportunity to test the response of cultivars to drought and the impact of *in situ* moisture conservation on yield stability.

In chickpea, chemo-intensive IPM module was found beneficial under high pest load, while under low to moderate loads, both i.e. chemo and bio-intensive modules were on par. When compared to farmers practice, however, bio-intensive module resulted in more yields, higher benefit cost ratio and significantly lower (upto 70%) use of pesticides. Intercropping of pigeonpea + sorghum (2:2) was found most effective component of the IPM module in pigeonpea based cropping systems.

A package consisting of resistant variety, seed treatment and intercropping was found effective in controlling yellow mosaic virus in mungbean in 19 villages in Tamil Nadu, Orissa, U.P and A.P. For control of root knot and cyst nematodes, seed treatment with neem seed powder @ 5% was found to be the best treatment as compared to chemicals and fungal antagonists at Aligarh, Ghaziabad and Gulbarga.

Integrated nutrient management of 75% RDF + FYM 2.5 t/ha combined with *in situ* moisture conservation resulted in maximising the yields and benefit cost ratio in soybean- chickpea and soybean-lentil cropping systems in Bhopal, Rewa and Satna districts. The liquid rhizobium inoculant formulation developed as an alternative to carrier based inoculant showed better shelf life and maintained the required population upto 360 days. A low cost method for storing the liquid inoculant in a pitcher filled with wet paddy straw was standardized during the year.

Among different *in situ* moisture conservation methods tested for pigeonpea in Vertisols at Bijapur, deep ploughing + residue incorporation + conservation furrow was found to give the highest yield 569 kg/ha and cost benefit ratio.

On-farm testing of integrated crop management (ICM) package including INM, IWM and recommended intercropping in 8 target districts (Sehore, Ranchi, Gulbarga, Kanpur, Ahmednagar, Amaravati, Bharuch and Guntur) revealed that highest pigeonpea equivalent yield (1627 kg/ha) and benefit cost ratio (2.31) were realized with the system consisting of intercropping of pigeonpea + soybean (2:4) + 50% RDF + 5 t FYM/ha + biofertilizers + pendimethalin in Sehore district, while pigeonpea + sesamum (1:2) system with 50% RDF + 5 t FYM/ha + pendimethalin + one hand weeding at 45 DAS gave maximum pigeonpea equivalent yield (1870 kg/ha) and BC ratio (2.28) at Gulbarga. Similar results were obtained at other locations.

Pigeonpea and chickpea could be safely stored upto 6 months in metallic bins and treated with 4% $NaHCO_3$. Among different edible and non edible oils tested, coconut, mahua and mustard oils (6-9%) were found effective against bruchids. A simple method of solar drying on improved floor mat covered with a black polythene sheet helped in safe storage of chickpea upto 180 days in Haryana. The improved dal mill designed by IIPR was further modified during the year by increasing the shaft diameter and bearing width to over come the problem of uneven wearing of rubber disk. A pre-grader for raw grain and a grader for finished product were added to improve the utility of the mill.

Starter kid rations by using pulse and oilseed by-products were formulated and found effective for increasing the body weight gain in goats. A complete feed consisting of 50% redgram straw, 10% subabul leaves, 14% groundnut cake, 8% maize, 9% wheat bran, 2% redgram chunni, 2% rice polish, 2% molasses, 2% mineral mixture and 1% salt (13.76% CP and 55.77% TDN) was found superior for lactating goats (does) in A.P. A milk replacer containing 9% soybean meal with 24% CP was found palatable at all the centers and can be used safely for rearing young kids (20-90 days).

Cotton Based Production System

Due to deficit rainfall in major cotton growing states, the productivity levels were 20-40% lower during the year. However, the incidence of pest and diseases including american bollworm and sucking pests were considerably low. Toposequence based rain water management helped significantly in stabilizing the yields on farmers fields at several locations.

On-farm trials on quality *arboreums* were continued during the year with 26 farmers in 4 states. During this drought year, the superiority of *arboreum* cottons over *hirsutums* was most prominent. The *arboreum* variety PA-255 recorded seed cotton yield of 1137 kg/ha followed by DLSA-17 (1072 kg/ha), PA-402 (1039 kg/ha) and MDL-2463 (1033 kg/ha) registering an increase of 35 – 50% over *hirsutum* checks. These varieties have also passed the mill test recording superior span length (2.5%) of 27.0 in DLSA-17 as against 26.3 in CPD-431 and micronaire of 4.5 and 4.3, respectively. Tissue culture regeneration and transformation protocol were standardized for *arboreums* like AKH-4, AKA-5 and RG-8 and putative transformants were produced with CRY 1 A (b) and CRY 1 A (c) genes with an objective of producing *arboreums* with *Bt* gene. High adaptability of *arboreums* to diverse micro farming situations was also confirmed through another network project carried out in 26 districts with combination of shallow, medium and deep soils and low and high rainfall.

Large number of indigenous cotton germplasm from all the three species of cotton were collected from north eastern region. *Phelopi-1* from *G.barbadense* was found most promising in terms of tolerance to leaf roller while *Karbi* and *Garo-1* from *G.arboreum* recorded minimum infestation of spotted bollworm. Wild cotton germplasm like *G.lobatum, G.soudanens* and *G.thurberi* had higher gossypol content than the cultivated species. High gossypol germplasm are likely to be useful in breeding for tolerance to biotic and abiotic stresses.

Efficient cotton based sequence and intercropping systems were identified for Vidarbha region of Maharashtra depending on the toposequence in a watershed. In upper toposequence, *arboreum* species were found suitable as compared to *hirsutums* while for middle and lower toposequences, intercropping with legumes gave higher gross returns. In all the toposequences, ridge and furrow system was found beneficial over flat sowing.

Among different tillage treatments tried, broad bed and furrow + reduced tillage + 100% RDF + green manuring was most profitable for rainfed cotton in Nagpur and Tuticorin districts. Likewise, INM module of soil test based NPK + 2 t FYM/ha + limiting nutrient + green manuring was the best treatment for sustaining cotton productivity in shallow soils. The returns from INM improved further when ridge and furrow system was adopted.

Salt tolerant genotypes both in *G.arboreum* and *G.hirsutum* were identified based on trials on farmers fields with different levels of salinity and sodicity. In Surendranagar, G-Cot 21 of *G.herbaceum* was found to be the most promising, while *J.Tapti* of *G.arboreum* performed better over others in sodic Vertisols in Khargone district in M.P. RAHS-14 produced highest seed cotton yield 597 kg/ha in saline Vertisols of Koppal district in Karnataka.

A study on constraints affecting cotton productivity in 4 states revealed that farmers need better varieties for shallow soils, a strengthened extension system and improved market infrastructure and price support.

Nutritious Cereals Based Production System

Nutritious cereals performed relatively well during 2002 drought in most of the on-farm trials except maize in eastern Rajasthan, pearlmillet in Gujarat and Rajasthan and fingermillet in Karnataka, which suffered from severe drought. But even under worst drought conditions, these crops showed greater resilience.

A combination of superior variety of *rabi* sorghum (CSV-216 R), compartmental bunding and INM resulted in higher yields in Bijapur, Solapur and Bellary districts. The benefits of compartmental bunding were evident during the year even with lower carry over moisture from *kharif*. Lodging of CSV-216 R was a major constraint recorded through interaction with the farmers. The superiority of CSV-15 as the best dual purpose sorghum variety was once again confirmed during the year based on on-farm trials in 8 districts. PFGS-97 was found to be resistant to stem borer and pyrilla from among 1000 germplasm lines screened.

The advantages of moisture conservation + INM on pearlmillet production were evident both in the semi-arid and arid regions. Paired row planting (30/60 cm) and opening of furrows in wider rows at 35 DAS + 50% RDF + 2.5 t FYM/ha + *Azospirillum* resulted in highest yield of 2538 and 1938 kg/ha in Bijapur and Tuticorin districts, respectively with similar results from Aurangabad and Beed districts. In arid areas of Gujarat and Rajasthan, ridge and furrow after interculture (30 DAS) in wide row spacing (60 cm) with 50% recommended N through fertilizers and 50% through FYM was found most profitable.

Tribal farmers in Dharmapuri, Berhampur, Vizianagaram and Dindori districts realized pearlmillet equivalent yield of 2500-3500/ha when pigeonpea and field bean are intercropped with fingermillet as compared to 1500-2000 kg/ha with sole pearlmillet. This not only improved their income but also provided better nutritional security. Resistant variety (GPU-28) + seed treatment with fungicide was found as the best option for controlling fingermillet blast on farmer's fields in Karnataka and Tamil Nadu. Eleven promising blast resistant lines were found from a screening of 150 germplasm. *Pyrichalasin-H,* a pathotoxin was isolated and purified from *Pyricularia grisea* for the first time at GBPUAT, Ranichauri.

Rain water conservation on a watershed basis in sub-mountain regions of Himachal Pradesh and Punjab successfully demonstrated increased cropping intensity and crop diversification and more income in otherwise mono cropped areas. Similarly, in eastern Rajasthan, toposequence wise rain water management could improve maize productivity by 25-30% over farmers practice.

To improve the effectiveness of implementation watershed projects, remote sensing data from IRS-IC/ID (PAN and LISS III) were utilized to prepare action plans for prioritized areas within the micro watershed. A pilot project in 4 states in the nutritious cereals based production system clearly showed that the action plans prepared through remote sensing match well with those made after ground survey.

Soil samples from 28 bench mark sites in India from different cropping systems were analysed to assess the carbon sequestration potential of different land use practices over a 20 year period. Forest, horticultural and agri-horticultural land uses sequestered more carbon followed by intercropping systems involving legumes and sole crops of cereals.

In the area of post harvest technology, an improved ventilating type grain dryer was fabricated and field tested for quick drying of molded sorghum. It costs Rs.0.35 to dry a kg of grain and the dried sorghum fetched 30% additional market price. Following the successful demonstration of the potential of sweet sorghum for alcohol production during 2001, a pilot project was taken up in Belgaum district on 600 acres during the year to demonstrate the economic feasibility of cultivation and alcohol extraction with M/s.Renuka Sugars. Many distilleries in south and central India evinced interest in collaborating on this project. A number of diabetic foods were prepared from fingermillet and evaluated organoleptically. Foods from barnyard and foxtail millet also showed lower glycemic indices indicating their suitability for diabetic population.

Many agri-horticulture and silvi pasture models involving nutritious cereals like sorghum, pearlmillet and fingermillet were tried across different target districts in the country. These systems offered greater stability to production and income in drought prone areas of Maharashtra, Andhra Pradesh and Gujarat.

CHAPTER

1

The Rainfed Agro Ecosystem

Rainfed Agro Ecosystem occupies an important place in Indian agriculture. It 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. In view of the great differences in rainfall and moisture storage capacity of soils, cropping intensity and income from agriculture or livestock farming depict high variation. Farmers' dependence on livestock as an alternative source of income is very high. However, the ecosystem as a whole is characterized by instability in biological productivity caused essentially by aberrant weather. Farmers are resource poor with poor infrastructure and credit support. The quantum and distribution of rainfall has an over riding influence among all factors in determining the productivity and profitability from the crops or livestock production.

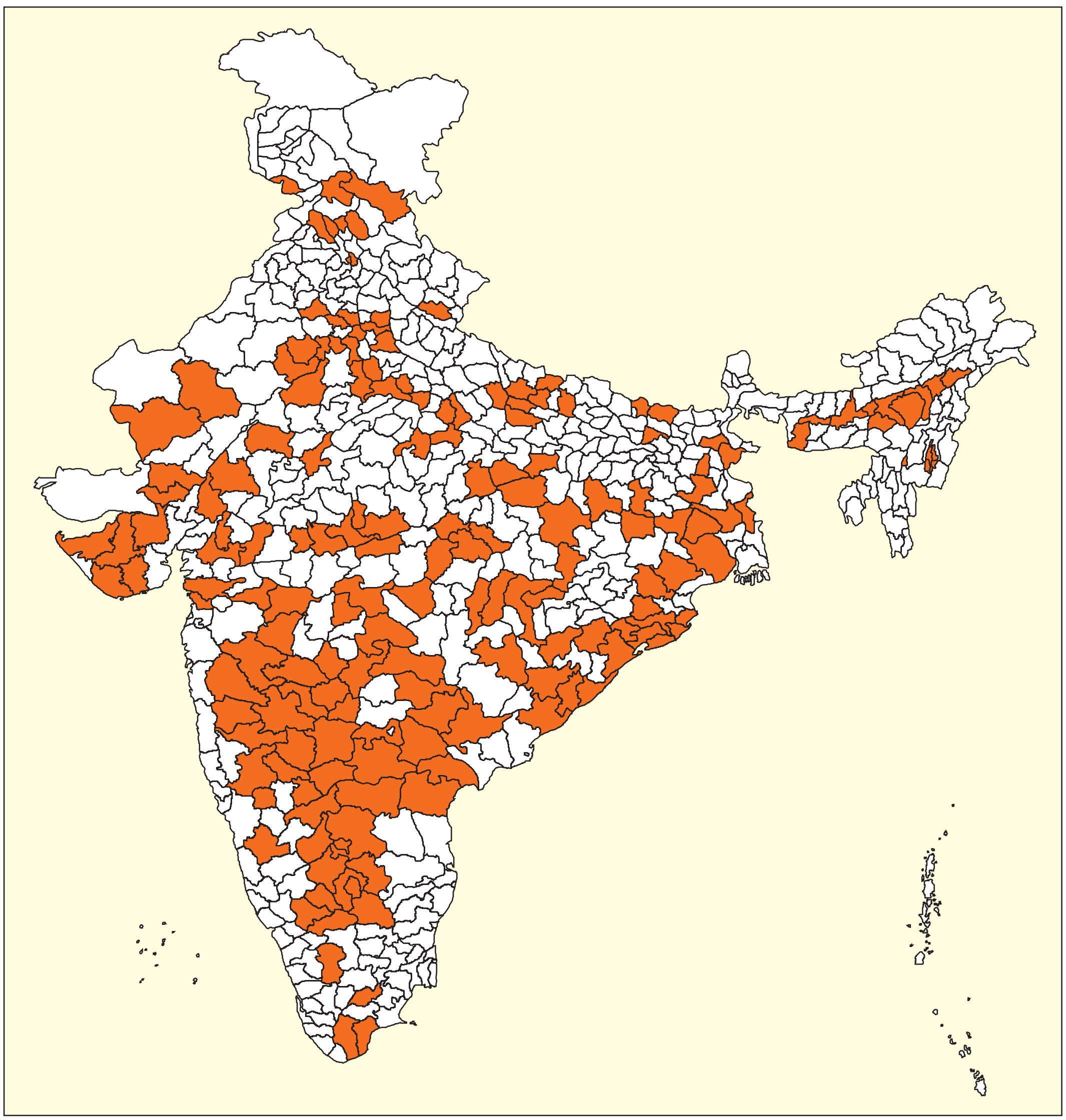
The Target Domain

Following a new paradigm of research prioritization under NATP, homogenous eco-regions with similar agro-ecological characteristics and production constraints were delineated as agro ecosystems. The rainfed agro ecosystem, one of the five identified under NATP is the largest in area and also quite diverse in farming systems. Traditionally rainfed areas are classified into distinct climatic zones known as arid, semi arid and sub humid. However, this classification no longer adequately reflected 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. This eco region faces high risk and returns on investment are low and uncertain.

The agro ecosystem 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 semi-arid 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.

The Production Systems

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 in to homogenous production systems. These production systems largely represent important commodities as dominant component of the cropping systems/ farming systems. In this approach, the problems of all the components like crops, cropping systems, livestock, fisheries, pastures and degraded lands can be addressed in totality. 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



Target districts of production system research under rainfed AES 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, agroforestry and livestock instead of crops alone.

Participatory On-farm Research

Out of 103 sub projects initiated under Rainfed Agro Ecosystem, the rainfed rice (35) and nutrititious cereals (27) production systems received high priority in view of the extent of area 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 that are limiting the productivity in the particular district. Nearly 225 districts in 30 states covered in the rainfed agro ecosystem. The unique feature of these projects lies in the fact 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 the research plot of farmers from neighbouring 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 received the highest priority followed by post harvest technology, crop improvement, IPM, INM and socio0economic issues. A detailed breakup of the PSR projects in different thrust areas is given in the following table.

Thematic and Production System wise Classification of the PSR Projects Approved Under Rainfed AES

Theme Area	Rainfed Rice	Oilseeds	Pulses	Cotton	Nutritious Cereals	Total
Natural Resource Management	11	1	1	3	10	26
Integrated Pest Management	3	3	4	0	2	12
Post Harvest Technology/ Value Addition	3	6	3	0	7	19
Biotech/Crop Improvement	5	2	0	5	2	14
Water Management	3	2	1	0	2	8
Integrated Plant Nutrient Management	6	1	2	1	1	11
Agro-Biodiversity	1	1	0	1	0	3
Socio Economics	3	2	1	1	3	10
Total	**35**	**18**	**12**	**11**	**27**	**103**

CHAPTER

2

Rainfed Rice Based Production System

A total 35 sub projects were in operation during the year in rainfed rice based production system. These projects addressed issues such as participatory varietal development, rain water management, integrated nutrient management, crop diversification, cropping systems, IPM, crop-livestock-fisheries integrated farming system, agro forestry and post harvest technology. The characterization of the production system and constraint analysis was also taken up during the year. Significant achievements are summarised below:

Rain Water Management for Drought Mitigation

Managing rain water is crucial for stabilizing the rainfed rice production in Chhattisgarh, Madhya Pradesh, Orissa, and Jharkhand. Most of these states receive relatively high rainfall (>1200 mm) and yet *kharif* rice suffers from dry spells mainly due to poor water management. Conservation and utilization of harvested rain water during dry spells or for a second crop is considered an important strategy in this regard. Through a network project in all these states, rain water was harvested through construction of small scale water harvesting structures (WHS) called OFRs on farmers fields along the slope of the given rice landscape for storage of excess rainfall and ground water structures like dug wells and ditches in recharge areas. Earlier studies indicated the promise of this approach in Chhattisgarh and Orissa. Quantification of rain water stored and the impact on the crop were studied during the year.

Although rainfed rice during *kharif* 2002 suffered due to drought in the target districts, the WHS constructed in the project area saved 45 ha of rice at Bhaghbara (Chhattisgarh), 27 ha at Dindori (MP), 21 ha at Keonjhar (Orissa) and 11 ha at Darisai (Jharkhand). The cropping intensity increased up to 140% at Bagbhara, 150% at Dindori and 115% at Keonjhar. The returns from increased crop yield and cropping intensity were higher during drought years than normal years. Adoption of improved practices resulted in higher returns from crops than farmers practice (Table 1). The unique feature of this approach lies in utilizing the excess rain water which goes as runoff through recharge of the water harvesting structures. The success of OFR approach received attention of the farmers in the target districts, media as well as respective state Governments. The

Table 1: Performance of water harvesting structures and economic returns for farmers in 3 states

Location	Farmers	Area (ha)	Yield of paddy (q/ha) With out WHS	Yield of paddy (q/ha) With WHS FP	Yield of paddy (q/ha) With WHS IP	Net returns over control (000 Rs) FP	Net returns over control (000 Rs) IP	Cost of WHS (000 Rs.)
Bagbhara, Chhattisgarh	39	45.4	2.4	39.3	51.2	391.4	633.1	502.6
Dindori, MP	41	26.9	12.1	17.6	30.4	56.9	227.4	473.6
Darisai, Jharkhand	60	18.3	7.5	–	37.1	–	228.3	331.9

FP – Farmers Practice; IP – Improved Practice

OFR in Upland

OFR in Midland

OFR in Lowland

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

Government of Chhattisgarh has initiated a programme to construct 2 lakh OFRs on farmers fields under the drought relief programme and the IGKV has been providing the technical support.

Similarly the OFR technology was successful in Keonjhar district in Orissa, as evidenced by the yield and additional returns (Table 2). At this site, the service area of 18 and 23 ha for 2001-02 and 2002-03 respectively was covered by the WHS, which cost Rs.8,63,000/-. The *rabi* area covered was 2.18 ha for 2001-02 and 4.10 ha for 2002-03 which provided returns of Rs.21,916/- and Rs.1,29,150/- respectively. The corresponding net returns from *kharif* cropping were Rs.78,040/- and Rs.2,00,360/-. Including some returns from the other uses of water, the total net additional returns from the WHS were Rs.1,05,456/- for 2001-02 and Rs.3,33,010/- for 2002-03 representing 12.2% and 38.58% of the cost of WHS. While the OFR technology helps the farmers during drought year, the benefits during normal year are much more both from *kharif* and *rabi* cropping as more and more farmers tend to adopt recommended package of practices with assured water availability. This clearly indicates that adoption of improved crop management practices combined with water harvesting gives quicker pay offs on the investment made on WHS.

Table 2: Yield and economic returns under different treatments with water harvesting structures in Keonjhar district (WTCER, Bhubaneshwar)

Treatment	Yield of unmilled Rice (q/ha)		Estimated additional gross returns over control (Rs./ha)		Area (ha) under different treatments within the command	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
T1	21.3	15.2	-	-	-	-
T2	23.0	23.0	940	4930	5	5
T3	26.8	28.0	3260	7720	3	3
T4	30.5	28.2	5320	8170	3	5
T5	35.2	36.2	8300	13120	7	10

T1 = Control without OFR
T2 = Farmers' practice with local variety and no fertilizer use
T3 = Farmers' practice with seeded local rice variety and RDF
T4 = Farmers' practice with transplanted local rice variety and RDF
T5 = HYV, transplanted with RDF

Management of Excess Water in Medium and Lowlands

Excess rain water during *kharif* in medium and lowlands can be stored in refugees outside the rice fields to integrate with fish farming. Maintaining optimum weir height is the key to successful implementation of this strategy. Earlier studies from a network project taken up in Dhenkanal (Orissa), Ranchi (Jharkhand), Jabalpur (M.P) and Mayurbhunj (Orissa) districts indicated that stored water in refugees can be used for fish culture and also for raising a *rabi* crop. Results during the year in all the target districts confirmed that rice yields and total income through rice-fish integration can be significantly enhanced by storing excess water in the refugees, particularly in medium lands.

In Sadeiberini village of Mahisapat watershed in Dhenkanal, successful *kharif* cropping could be done during 2002 by all the 6 participating farmers fields despite the severe drought (728 mm rainfall received as against the normal of 1400 mm). This was possible due to supplemental irrigation of 17 cm from harvested runoff from the refugees. Weir (dyke) height of 25 cm gave maximum rice yield. Catla, Rohu, Mrigal and Indian major carp were the fish grown in the refugees with 1127 kg/ha yield recorded in 8 months which was equivalent to 12.7 t/ha of paddy. Interestingly with increase in weir height, the crop yield increased but the fish production decreased (Table 3).

By devoting 4-5% of the cultivable table land into fish refugees/small tanks, 14-15% additional rice equivalent yields can be obtained by adopting the technology generated under the project. The national average of Indian major carp production under rice-fish integration is about 500-600 kg/ha/year, while the average yield obtained under the project is more than 1000 kg/ha indicating the superiority of this approach. In Ranchi district,

A small refugee supported with a masonary weir at the end of medium land on farmers field in Orissa

the harvested water was used for fish rearing as supplemental irrigation was not needed for the crop. Twenty centimetre dyke height produced maximum crop and fish yield at this location. In Jabalpur and Mayurbhunj, harvested water was utilized for supplemental irrigation and fish culture and the returns were comparable to that obtained in Dhenkanal.

Table 3: Effect of weir height of refugees in medium land plots on rice, fish and total (rice equivalent) yield in Dhenkanal district, Orissa

Weir height (cm)	Area allocated for refugee as % of rice field	Rice yield (t/ha)	Rice + fish yield (Rice equivalent) (t/ha)
15	4.20	5.13	5.86
20	6.25	5.25	5.99
25	7.80	5.75	6.63

Conservation structures in uplands

Designing low cost technologies for gully control and field bund protection for safe disposal of excess runoff are key to successful management of degraded watersheds. The excess water has to be disposed off without loss of top soil. Low cost structure made from locally available materials were tried at Sudreju village of Khajuripada block in Phulbani district. Loose boulder structure proved to be the best temporary means for gully protection in upper and middle reaches followed by brush wood structures. For field bund stabilization also, loose boulder structure was economical in terms of cost, silt deposition, sand casting and increasing the crop yields. Continuous Contour V ditches (CCVD) at 10 m horizontal interval was found to be the best treatment for supporting the growth of plantation crops in uplands.

Resource Characterisation Through Remote Sensing/GIS

Remote sensing techniques were utilized to carry out resource inventory surveys, prepare action plans, identify critical areas and suitable land treatments/crop planning for different areas within the micro watershed in order to improve the efficiency of planning and implementation of watershed development projects. In a pilot project taken up at 6 watersheds in the states of Orissa, Chhattisgarh, Jharkhand, Assam and West Bengal, thematic maps of soil, water and vegetation were prepared in 1:50,000 and 1:12,500 scale using satellite data outputs from IRS-I C/I D.

From each of the major watersheds, one prioritized micro-watershed was selected and studied in detail using IRS-LISS III and PAN merged satellite data. All the natural resources were assessed in detail with intensive ground truthing. From detailed soil map, critical areas were marked in the prioritized micro-watershed map and suitable actionable items were identified for implementation. These include construction of water harvesting structures, soil conservation measures, crop production, horticulture and plantation activities. The implementation of the action plans is in progress from *kharif* 2002 and *rabi* 2002-03.

Preliminary assessment of the crop yield data and water resources collected in the structures indicated that the action plans have been fairly successful indicating that remote sensing data can be used for prioritization and designing of treatments for areas with in the micro-watershed and preparation of suitable action plans.

Contingency planning through weather monitoring

Based on daily and weekly weather data for all the mandals in Andhra Pradesh, weekly water balance were computed using visual basic programme. These data were used to prepare thematic maps on rainfall variability and the probability of mild, moderate and severe droughts. This value added information was used in collaboration with the Department of Agriculture, Govt. of Andhra Pradesh to implement contingent strategy on not only the choice of crop but also its management after planting. This collaborative effort paid rich dividend during the drought year of 2002 and can be replicated in other states in future.

Integrated Nutrient Management

Integrated nutrient management (INM) package for rainfed rice was validated on farmers fields through 45 on-farm trials in 3 districts i.e. Phulbani in Orissa, East Singhbhum in Jharkhand and Durg in Chhattisgarh with the main objective of supplementing part of the chemical fertilizers with locally available manurial resources. Different treatments with partial substitution of recommended dose of fertilizers with FYM and FYM + green manuring were compared with farmers practice. Earlier results indicated that upto 25% of the recommended dose of fertilizers can be substituted with application of FYM or green manuring with legumes.

During *kharif* 2002, application of 75% of RDF + 5t FYM and intercropped blackgram / greengram as green manure or mulch produced 2.46 and 2.38 t/ha of rice yield in Phulbani and East Singhbhum districts, respectively compared to 1.12 and 1.10 t/ha with farmers practice and 1.56, 1.69 t/ha with 100% RDF. Integrated use of 75% RDF (60:30:30), + 5t FYM and *in situ* green manure (dhaincha/sunhemp) in medium land transplanted rice produced grain yield of 5.03 and 3.96 t/ha in Phulbani and East Singhbhum, respectively compared to the yield of 3.39 and 1.96 t/ha with farmers practice and 4.42, 3.57 t/ha with 100% RDF. Higher productivity of rice with IPNS in all the target districts was due to more efficient uptake and use of nutrients, particularly NPK. There was considerable improvement in the availability of N, P and K in soils after the harvest of the crop in INM plots. Highest benefit : cost ratio of 1.34 and 1.34 for upland (Table 4) and 1.89 and 1.45 in medium land were realized by farmers in Phulbani and East Singhbhum, respectively with INM technology.

Table 4: Yield, net returns and B C ratio with the adoption of INM on farmers fields with upland rice

District	No. of On-farm trials	Treatments	Grain yield (t/ha)	Net returns (Rs.)	B:C ratio
Phulbani (Orissa)	7	T1 : Farmers Practice (2 t FYM + 10 kg N)	1.12	695	1:1.11
		T2 : 100% RDF (60:40:30)	1.56	418	1:1.05
		T3 : 75% RDF + 5t FYM/ha	1.94	1641	1:1.17
		T4 : 75% RDF + 5t FYM/ha + Intercropped greengram	2.46	1820	1:1.15
		T5 : 100% RDF + 5t FYM/ha + Intercropped greengram	3.03	4281	1:1.34
East Singhbhum (Jharkhand)	7	T1 : Farmers Practice (2 t FYM/ha + 10 kg N/ha)	1.1	201	1:1.04
		T2 : 100% RDF (60:40:30)	1.69	749	1:1.13
		T3 : 75% RDF + 5t FYM/ha	2.09	1314	1:1.19
		T4 : 75% RDF + 5t FYM/ha + Intercropped greengram	2.38	1991	1:1.28
		T5 : 100% RDF + 5t FYM/ha + Intercropped greengram	2.73	2620	1:1.34

Upland rice with INM and intercropped green manure crop on farmers field in Phulbani district, Orissa

Jute rice cropping system

On-farm trials in five districts of Assam, Bihar, Orissa and West Bengal indicated that targeted yields of jute and rice were achieved with 75% nitrogen through urea + 25% through FYM or *Glyricidia* loppings in a jute-rice cropping system. The yields and gross returns were more with INM treatment but the profitability was more with 100% N as urea. The available N content of the soil increased significantly at all the locations after five years of continuous jute-rice system in treatments with soil test based nutrient application or INM (inorganic + organic). Soil organic carbon improved by 10-21% at different locations in the INM treatment whereas in chemical fertilizer plots, no significant change was recorded. Similar improvements were noted in available P and K in fields where INM practice was followed. The participating farmers were encouraged to plant *Glyricidia* on field bunds to produce sufficient leaf material, but small size bunds and operational constraints limited its adoption. Alternatively, canal bunds were suggested as ideal sites for planting *Glyricidia* in a staggered manner so that the leaf material can be harvested at different stages of cropping season.

Simulation model for N management

On-station experiments at 9 locations with 4 nitrogen levels and 4 varieties for 3 years resulted in development of a crop simulation model ORYZA 1N to optimize nitrogen use under rainfed low land rice in eastern India. ORYZA 1 N assisted in the selection of rice variety, N dose and its time of application. The model helped in development of a new approach for N management for locations differing in weather and soil characteristics. The varieties selected by the model were *Ranjit* at Dhenkanal, Hooghly and Jorhat districts, *Savitri* at Khurda district, *Khitish* at Nadia district, *Swarna* at Gonda and Basti districts, *Mahsuri* at Ranchi district and *Rajshree* at Muzaffarpur district. The N dose was 80 to 120 kg N/ha and its timing of application was 4 splits. The farmer's practice consists of variety *Swarna* at Dhenkanal, Khurda and Hooghly districts, *Mahsuri* at Gonda, Basti and Jorhat districts, *Lalat* at Nadia district, *Parwal* at Muzaffarpur district and *Kanak* at Ranchi district, N level of 40 to 60 kg/ha applied in 2 splits.

A verification trial was conducted on 78 farmers' fields in 15 villages of 9 districts during 2002 *kharif* to validate the model. The model based N-application was superior to farmers' practice in 7 districts covering 59 test farms. The maximum grain yield of rice due to new model based N-use was 5.98 t/ha across the locations, where as farmers practice produced maximum grain yield of 4.37 t/ha. The differences in varietal performances largely resulted from the genetic differences in plant nitrogen use efficiency and N harvesting index. These findings open up possibilities of matching varieties and N management recommendations, so that optimum returns can be obtained per unit of N applied in rainfed low land rice farming.

Soil Quality Maintenance

Maintenance of soil quality is pre requisite for sustaining yields in rice based cropping system. Soil analyses from long term cropping system experimental plots revealed a greater deterioration of soil quality in the rice based crop sequence, cropping systems even with application of chemical fertilizers (NPK) at recommended level. Only when NPK and FYM (> 5 t/ha) is applied continuously, the soil quality could be maintained. A quantitative criterion known as Soil Quality Index (SQI) was developed based on 38 physical, chemical and biological parameters from long term experimental plots. This index indicates an improvement or degradation of soil quality over a period of time. The SQI decreased in all plots irrespective of the cropping systems when chemical fertilizers alone were applied, while it showed improvement when chemical fertilizers + FYM were applied. Further work during 2002-03 showed that only 7 parameters i.e. mean weight diameter (MWD), organic carbon content, available N, K and Zn and microbial biomass are adequate to derive the index for routine calculation of SQI. Using these parameters, the SQI was worked out for a number of cropping sequences all over the country to know the aggradative or degradative influence of different cropping systems. These indices are likely to be useful for development of decision support systems on input management in large areas.

In a related project, different pools of soil organic carbon (SOC) were assessed in relation to cropping systems, tillage and land use practices. Application of fertilizer NPK either alone or in combination with FYM maintained higher quantity of carbon pools at the surface soil (0-15 cm depth). This indicated that the organic pools of C,N,P and S are maintained in rhizosphere zone and thereby sustaining soil quality and productivity. Surface layer had higher status of organic carbon compared to lower layers. Crop yield data from long term fertilizer trial plots showed that productivity is declining more in N, NP and control treatments compared to NPK. However, maximum yield was observed on a continuous basis with the application of NPK + FYM (> 5 t/ha). Similarly, maximum improvement in soil organic carbon was also recorded with NPK + FYM and NPK compared to all other treatments. To illustrate, data from experimental plots of continuous rice-wheat-jute rotation for 29 years at Barrackpore indicated a depletion of total soil organic carbon from initial level except in case of 100% NPK + FYM (Fig 1). Carbon mineralisation rate was maximum in treatments receiving both NPK + FYM followed by NPK, NP and N indicating that regular application of organic manure helps

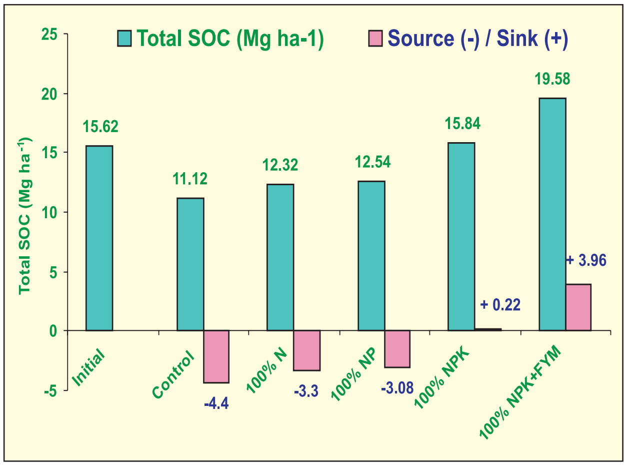


Fig 1: Total SOC and net change (Mg ha^{-1}) after 29 years under rice-wheat-jute cultivation at Barrackpore

in sustaining soil organic carbon and nutrient mineralisation processes. These results emphasize the importance of integrated nutrient management, particularly addition of significant quantities of organic manures to maintain rice productivity on long term basis.

Increasing Cropping Intensity

One of the key strategies to increase cropping intensity and income in rainfed rice based production system is to have a second crop after rice either by utilizing the harvested water or moisture conservation during *rabi*. Diversification of rainfed rice during *kharif* through rice based intercropping or substitution with oilseeds and pulses is yet another approach. Earlier studies from the project on increasing cropping intensity in Chhattisgarh, Orissa, M.P and Jharkhand indicated the possibility of growing an assured *rabi* crop by adoption of water conservation technology and advancing the planting dates of *kharif* rice. Rice + redgram (5:2) intercropping system was also found to have highest

Chickpea intercropped with coriander as *rabi* crop after rice on farmers fields at Rewa

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

potential to improve the income as compared to rainfed rice, particularly on uplands.

A total of 46 on-farm trials were carried out in 7 target districts on different intercropping systems during the year. In uplands, intercropping of rice + redgram/sesamum in Mahasamund, rice + sesamum at Rewa and redgram + groundnut in Dhenkanal and Ranchi were found more profitable combinations. Under midland situation, the improved practice gave 35.64%, 15.01%, 36.04% and 26.77% higher rice yield, respectively in Mahasamund, Ranchi, Darisai and Dhenkanal districts over farmers practice. Promising *rabi* crops have been identified based on OFTs during 2002. Adoption of improved practice resulted in higher yield of *rabi* crops in all districts over farmer's practice (Table 5).

Table 5: Yields of promising *rabi* crops after rice on farmers fields in 6 target districts under farmers vs. improved management practices (*rabi*, 2002)

Target district	*Rabi* crop	Yield (q/ha)	
		Farmers practice	Improved practice
Mahasamund (Chhattisgarh)	Chickpea	6.16	6.97
	Safflower	6.16	7.18
Dhenkanal (Orissa)	Chickpea	2.00	2.78
	Blackgram	3.25	5.24
	Greengram	3.75	5.57
Rewa (M.P)	Chickpea	10.67	11.04
	Lentil	7.65	8.05
Sidhi (M.P)	Chickpea	9.82	10.00
	Lentil	7.05	7.52
Ranchi (Jharkhand)	Chickpea	3.50	7.75
	Linseed	1.50	2.50
Darisai (Jharkhand)	Chickpea	5.70	8.04
	Linseed	2.48	3.41

Rice Based *Utera* Cropping

On-farm trials on *utera* cropping were continued during the year with focus on optimizing the yields from *utera* crop and working out the cost benefit analysis. On the basis of productivity and net returns from entire cropping system, linseed proved to be the most suitable *utera* crop for Burdwan and Midnapore districts of West Bengal, Nagaon and Morigaon districts of Assam, Dumka and Godda districts of Jharkhand and Seoni district of Madhya Pradesh. Lathyrus was most profitable in Mahasamund and Rajnandgaon districts of Chhattisgarh as well as Kamrup district of Assam. Fieldpea in Dindori (Madhya Pradesh) and blackgram in Khurda (Orissa) proved superior over the other crops for net returns.

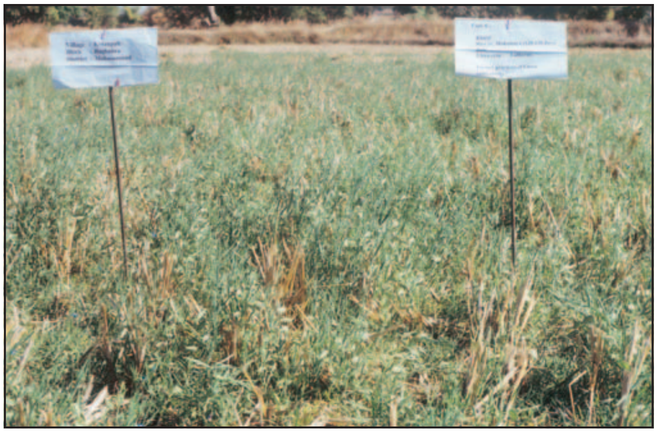
The most suitable time for *utera* crop is two weeks after flowering of preceding rice which assures a better *utera* crop stand. Application of recommended dose of fertilizer (RDF) to rice in addition to 20 kg P_2O_5/ha of *utera* crop (to rice) not only improved the yield of rice but also increased the yield of *utera* crop at all centres. Harvesting of rice by leaving 20 cm height stubble proved more favourable for conserving soil moisture and better establishment and yield of *utera* crops at all centers (Table 6). However, 10 cm height stubble of rice was found suitable for blackgram as *utera*

Table 6 : Mean grain yield of rice and *utera* crops under various sowing techniques in different target districts (*rabi,* 2002)

Treatment	Rice yield (q/ha)	Utera yield (q/ha)	Net returns (Rs/ha)	B:C ratio	Rice yield (q/ha)	Utera yield (q/ha)	Net returns (Rs/ha)	B:C ratio	Rice yield (q/ha)	Utera yield (q/ha)	Net returns (Rs/ha)	B:C ratio
	Seoni (120)				Rajnandgaon (120)				Midnapore (120)			
T_1	44.60	5.57	15655	2.04	29.58	3.46	4902	1.26	45.65	8.70	18265	2.21
T_2	43.80	5.56	15240	2.02	33.12	4.29	6708	1.45	45.92	4.84	10380	1.69
T_3	45.10	6.38	17100	2.14	32.46	4.85	7050	1.47	46.84	1156	22292	2.48
T_4	44.50	5.68	15770	2.05	33.03	3.21	5367	1.36	46.65	9.78	20061	2.32
T_5	44.90	5.25	15295	2.02	33.64	3.98	6596	1.44	45.87	7.93	17461	2.16
	Khurda (90)				Nagaon (100)				Dumka			
T_1	34.80	3.71	9820	1.65	44.89	5.30	14805	1.79	37.62	4.64	13358	1.30
T_2	35.10	6.30	15150	2.01	44.89	5.21	13697	1.91	37.62	5.03	13787	1.34
T_3	36.90	6.94	17330	2.15	44.89	5.47	15009	2.00	37.62	5.29	14073	1.37
T_4	37.40	4.49	11180	1.75	44.89	4.74	14133	1.94	37.62	3.66	12280	1.20
T_5	36.60	3.24	9780	1.65	44.89	3.01	12057	1.80	37.62	3.98	12552	1.21

T_1 Farmers practice of *utera* crop sowing
T_2 *Utera* sowing 1 week after flowering of rice
T_3 *Utera* sowing 2 weeks after flowering of rice
T_4 *Utera* sowing 3 weeks after flowering of rice
T_5 Sowing after minimum tillage

Values in parentheses indicate number of farmers




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

crop in Khurda (Orissa). The *utera* crops tried were fieldpea/lathyrus in Seoni, lathyrus in Rajnandgaon, lathyrus/linseed in Midnapore, blackgram in Khurda, lathyrus in Nagaon and Dumka.

Crop Diversification in Uplands

In order to augment the income from uplands, efforts were made to introduce alternate crops in place or along with *kharif* rice in intercropping systems. In a project piloted by WTCER, Bhubaneshwar, the economic returns from a number of alternate crops were compared with rice in uplands, while in medium and low lands, the cost effectiveness of improved package of practices was evaluated on rainfed rice. During 2002 *kharif*, despite severe drought, farmers could get significantly higher returns through crop diversification in Jharbelda village of Keonjhar district in Orissa. Intercropping of pigeonpea and groundnut in 2:6 ratio resulted in 7.94 q of pigeonpea and 9.1 q of groundnut yields. The combined returns were significantly higher as compared to paddy alone. Socio-economic studies on impact of watershed management in Ranchi and Dhenkanal districts clearly revealed that the adoption of improved technology, particularly the high yielding varieties was significantly higher in villages covered with the watershed programme. The cropping intensity on an average increased from 90-106% to 120 to 153%.

Fruit based land use system

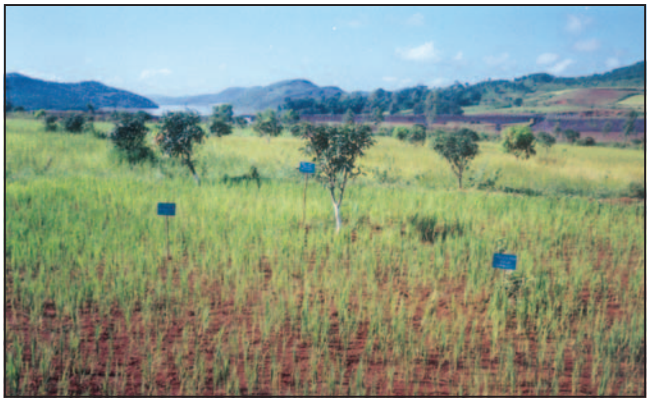
Yields and economic returns are quite low from upland rice in the tribal districts of Orissa, Chhattisgarh and Jharkhand due to uneven topography, non adoption of water conservation methods and poor crop management. An effort was made to diversify the land use into agri-horticultural system through extensive on-farm trials involving tribal farmers in 5 districts i.e. Koraput, Sarguja, Jabalpur, Chianki and Ranchi. Cowpea, french bean, ginger and turmeric were grown as intercrops in both bearing and pre bearing mango orchards with and without filler crops. Rainfed rice was also grown as an intercrop in the mango orchard for the comparison of yield and economic returns.

The severe drought of *kharif* 2002 resulted in poor returns from rainfed rice but vegetables like french bean and cowpea and pulses like blackgram performed well. At Semiliguda in Koraput district, ginger was found most profitable intercrop (28,000/ha) followed by cowpea (5,050/ha) and french bean (4,900/ha) in 7 year old bearing mango orchard. In Jabalpur district also, ginger gave the highest net returns while in Ranchi, turmeric gave the highest yields followed by cowpea. Maximum returns in Sarguja were obtained from cowpea (Rs.5724/ha) followed by maize, sweet potato and blackgram. At Chianki in Jharkhand, maximum net returns were obtained from maize followed by blackgram and okra. At all the centers, yields and net returns from intercrop paddy were the lowest. Two years data indicated that on sloppy lands in tribal districts, vegetable cultivation is more fetching to farmers than rainfed rice. On an average, the participating farmers realized Rs.5000/ha of additional income. The yield and economic returns from different intercrops in a bearing mango orchard are given in Table 7. The success of the project in Gopalput village of Koraput

Table 7: Yield and economic returns from different intercrops in bearing mango orchard at Gopalput in Koraput district of Orissa (mean of 6 farmers)

Crop	Crop yield (q/ha)	Paddy equivalent yield (q/ha)	Gross returns (Rs.)	Net returns (Rs.)	C:B ratio
Ginger	52.00	195.00	78,000	28,000	1.56
French bean	30.20	37.75	15,100	4,900	1.48
Cowpea	32.50	40.62	16,250	5,050	1.45
Tomato	35.00	35.00	14,000	4,500	1.47
Paddy	18.00	18.00	7,200	2,200	1.44

Prices considered; Cowpea, French bean Rs.5/kg; Tomato, Paddy Rs.4/kg; Ginger Rs.15/kg.



Rainfed rice and cowpea in bearing mango orchard on farmers fields in Gopalput village of Koraput district

district was illustrated from Shri Pitambar Majhi, a small farmer whose income increased from Rs.3500/- before the project to more than Rs.10,000/- after three years. This attracted the attention of district administration and developmental agencies. IFFCO for instance, has decided take up developmental programmes in the district based on this model.

Rainfed vegetable production on uplands

In another network project in Orissa, Chhattisgarh and Jharkhand, 40 on-farm trials were carried out in 10 villages to evaluate improved vs. farmers practices of vegetable cultivation. Low cost nursery management techniques like formalin (1%) treatment of nursery beds, moisture conservation through paddy straw, dry grass, polythene mulching etc. were tested for improving the productivity and returns. Improved nursery management practices resulted in 20-25% more healthy seedlings in brinjal, chillies, tomato, onion and cauliflower. Cultivation of sweet potato *var. Pusa Samrat* during *kharif* in place of rice resulted in significantly higher returns over upland rice. With a production of 21 t/ha sweet potato cultivation resulted in a net income of Rs.43,355/ha and a CB ratio of 2.07 as compared to Rs.6070/ha and 1.51 with paddy. Among different mulches tried for moisture conservation in ginger and turmeric in Khurda district, paddy straw mulching produced maximum yield of 16.3 t/ha of ginger as compared to 12.2 t/ha in control. Thus, a combination of improved nursery bed management and moisture conservation practices resulted in higher returns from rainfed vegetable crops compared to upland rice.

Ginger cultivation in uplands with paddy straw mulching on farmers fields in Khurda district of Orissa

Natural Resources Management in Hilly and Tribal Areas

Management of soil and rain water is a major challenge in hilly areas because of high slopes and degraded lands. In a network project involving 112 farmers in 5 tribal districts of A.P, Orissa, Chhattisgarh and Assam suitable vegetative and engineering measures were evaluated for different topographies within the watershed. Entry point activities during 2001 helped in enlisting farmers cooperation in the conservation works. The key interventions included establishing vegetative barriers to stabilize the minature bunds on slopping arable

Cashew + stylo horti-pastoral system for hillock rehabilitation in Koraput district

lands and rehabilitation of the degraded hillocks through revegetation.

Continuous contour trenching on the hillocks prevented runoff and soil loss at all the locations. Guava + stylo supported with a trench was found to be the best means of hillock rehabilitation in Koraput district, whereas in Jagdalpur, cashew with Dinanath grass was found to be ideal. Among the vegetative barriers, the growth and establishment of vettiver was significantly superior to sambuta and lemon grass in Koraput district. However, at Chintapalli in A.P hill broom performed better than vettiver and *Citronella*. Among the hedge rows tried on hill slopes, Assam shade (*Indigofera teyssamani*) was superior to *Glyricidia* and perennial pigeonpea in Koraput. *Glyricidia* with local grass at Bhawanipatna, perennial pigeonpea with *Citronella* in Jorhat, jatropha with vettiver at Chintapalli were the other hedge row species found suitable for sloppy lands. *Gmelina arborea* showed the best survival among trees evaluated for field bund plantation at Koraput, while *Bixa orellana* was most promising at Chintapalli in A.P. *Tikhur*, *Basil*, Long pepper, *Centella*, *Bryophyllum*, *Lipidium* and *Senna* were some of the medicinal plants which survived well in the hilly areas and also accepted by the farmers.

Rice based agroforestry system

Annual crops or multi purpose trees can be grown on field bunds of rice fields to produce additional returns with marginal investment on seed. Blackgram and pigeonpea grown on field bunds in double rows produced 8.75 and 12.12 kg of seed respectively per 100 m bund length on farmers fields in Nayagarh district translating to Rs.590/- and Rs.655/ha of additional income. *Acacia mangium,* a fast growing tree legume @ 80-100 trees/ha was found most promising in Nayagarh and Dhenkanal districts. The pruned biomass from one year old trees was 2 – 3 kg/tree. Similarly, *Gmelina arborea* and *Delbergia sissoo* were promising tree species found for field bund plantation in Raipur and Faizabad districts, respectively.

Medicinal Plant Biodiversity in Rice Ecosystem

Tribal areas are rich in medicinal plant diversity. A comprehensive survey of 40 districts inhabitated by tribals in M.P and Chhattisgarh were carried out for 2 years for documenting medicinal plant biodiversity. Nearly 400 plant species were collected and the herbaria prepared. The traditional use of these plants and the useful parts were described based on extensive discussions with the local tribals. After careful taxonomic assessment, a publication containing the description of each of the collected species, useful part and the location of collection was brought out. Five training programmes were conducted for the tribals on the *in situ* conservation of the rare and endangered species. The live collections are being maintained at JNKVV, Indore for further characterization.

Farmer Participatory Varietal Selection

Despite many rainfed rice varieties having been recommended for different land types, their adoption remains quite low and most farmers are still cultivating traditional varieties. In order to select varieties suitable to different micro farming situations, participatory varietal evaluation was carried out in Chhattisgarh, Orissa and Jharkhand. The cultures were evaluated under farmers and improved management. Trials during 2000-01 and 2001-02 helped in identification of several promising cultures in all the three states. These were further evaluated in 2002-03. In Orissa, 24 OFTs were conducted in 10 villages. ORS 102-4 (IET 15296, 2.4 t/ha), OR 1513-3 (2.6 t/ha) and OR 1519-2 (IET 15169, 2.5 t/ha) out yielded the check variety *Tulasi* (1.9 t/ha). Based on OFAR results, IET 14100 was released during 2002 as *Jagabandhu* by Orissa State Seed Sub Committee for cultivation under rainfed lowlands.

In Chhattisgarh, from OFTs conducted in 14 villages involving 46 farmers in Raipur, Mahasamund, Bastar, Sarguja and Raigarh districts, R 1037-649-1-1 (lET 15969, 3.1 t/ha) and *Danteshwari* (3.7 t/ha) out yielded other varieties in rainfed uplands. *Poornima* (2.4 to 3.1 t/ha) though released in 1996 for uplands in Chhattisgarh gained popularity among the marginal and poor farmers due to the extensive OFTs carried out in the project and its field tolerance to pests and diseases. It covered more than 10,000 acres in Mahasamund district alone. R 1057-1631-1 (lET 1669, 7.42 t/ha) and R 741-1-155-2-1-1 (lET 15178, 5.4 t/ha) out yielded *Mahamaya* (4.0 to 5.0 t/ha) in rainfed midlands. In rainfed lowlands, R 304 -34 (lET 13310) is being proposed for release in Chhattisgarh with the name *Kaushalya*. Results of OFTS in villages covering 14 farmers in Darisai (Jharkhand) revealed that *Ravi* (2.8 t/ ha) and *Krishna Hamsa* (2.5 t/ha) recorded high yields over the check variety BC 101 (1.8 t/ha) owing to their tolerance to drought and blast and high number of effective tillers.

OFTs in 3 states revealed that recommended varieties are not performing uniformly across all micro farming situations and there is a need to identify more acceptable cultivars through

Jagabandhu (IET-14100) – released for rainfed low lands in Orissa participatory evaluation. Improved management practice gave higher yields over farmer practice even with local varieties emphasizing the importance of better crop management in yield stabilization, particularly during drought years.

Varietal performance with farmers vs. improved management

The yield and water use efficiency of rainfed rice varieties with farmers vs. improved management were evaluated through on-farm trials conducted in 10 villages of 9 districts in Orissa, Assam, West Bengal, U.P and Manipur. Variety *Vandana* in target districts of Orissa and W.B. and var. *Tombung* in Manipur recorded higher grain yield (2.30 - 4.02 t/ha) and greater water use efficiency (3.7 - 9.3 kg/ha/mm) than the farmer's variety (grain yield : 1.01 - 3.55 t/ha; WUE : 1.72 - 7.77 kg/ha/mm) under upland conditions. In Jorhat and Golaghat districts of Assam, however, var. *Vandana* did not perform better than the farmer's variety *Kalaahu.* Improved package of practices always resulted in consistently higher yields in improved and farmers varieties. The improved package of practices for upland rice included line sowing behind plough, basal dressing of fertilizers, seed treatment with bavistin, balanced use of fertilizers (NPK – 40:20:20), application of pre-emergence herbicide pretilachlor supplemented with one weeding with finger weeder, control of brown spot with Tilt and timely harvesting.

In case of medium land situations, improved variety *Surendra* in Orissa, *Swarna* in West Bengal, *Vasundhara* in Assam, RCM-9 in Manipur and M-36 in eastern U.P. with improved package of practices registered higher grain yield (3.42-4.51 t/ha) and water use efficiency (5.03-8.28 kg/ha/mm) than the farmer's variety with farmer's practice (grain yield : 2.13-3.63 t/ha, WUE : 2.0-6.1 kg/ha/mm) at all the centres. The improved package of practices for medium land rice included overnight seedling root dip in chloripyriphos before transplanting and balanced use of fertilizers (NPK – 60:30:30).

Under flood prone lowland conditions, the improved variety *Sarala* in Orissa, CR-1017 in West Bengal, *Ranjeet* in Assam and *Jal lahari* in eastern U.P with improved package of practices also produced higher grain yield of rice (2.87 - 6.12 t/ha) and greater water use efficiency (3.6 - 14.3 kg/ha/mm) compared with farmer's management (grain yield 1.04 - 3.91 t/ha and WUE : 1.6 - 9.6 kg/ha/mm). The improved management practices for the flood prone lowland rice included sowing seeds before mid June and basal placement of all the fertilizers in seed furrows behind plough, balanced use of fertilizers (NPK– 40:20:20), application of post-emergence weedicide Almix and timely harvesting.

Deep water rice

On-farm trials were conducted on varietal evaluation and improvement of agronomic practices for deep water rice during *kharif* 2002 covering 116 hectares and 1200 farmers in 27 districts of eastern states, viz., Orissa, Assam, Bihar, West Bengal and U.P. The early drought (July 5 - August

15) in Orissa, early flood for about 15-20 days in Assam and Bihar and drought followed by flood during tillering stage in U.P and West Bengal influenced the performance of the entries. Data from on-farm trials revealed superiority of cv. *Durga, Kishori, Sarala* and *Vaidehi* in Orissa with grain yields of 2.15 - 2.73 t/ha (20 - 43% increase over the check), *Ranjit, Bahadur, Prafulla, Panidra* and *Jalashree* in Assam with grain yields of 3.24 - 3.64 t/ha (20 - 30% increase over check), *Mahananda*, *Rajshree* and *Ranjit* in Bihar with grain yields of 3.12 - 3.36 t/ha (41 - 48% increase over check) *Rajshree, Bahadur* and *Jal lahari* in Uttar Pradesh with grain yields of 2.44 - 2.56 t/ha (26 - 35% increase over check) and *Jitendra, Rajshree, Ranjit, Ambika, Sarala* and *Bahadur* in West Bengal with grain yields of 3.40 - 3.94 t/ha (15 -17% increase).

Transplanting with 30 - 40 days old rice seedlings at 20 cm x 15 cm spacing and basal application of fertilizers @ 40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha at the time of final puddling in Orissa, Assam, U.P and Bihar and nursery fertilization, use of old (55 days) seedlings and basal fertilizer application @ 40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha at final puddling were found as suitable agronomic practice in West Bengal for deep water ecosystem. Averaged over 138 trials in 4 states, the mean rice yield in deep water situation increased by 0.68 t/ha (34% increase) with the use of improved variety and improved practice as compared to local variety and farmers' practice.

Jute Varieties with Superior Fibre Quality

With an aim to develop jute varieties with quality fibre, the crossing and evaluation of progeny both in *C.capsularis* and *C.olitorius* was continued during the year. In *C.capsularis,* 10 promising crosses were identified in F1 generation for fibre yield and yield components. Among these CHN/FJ/052 x JRC-212 gave highest fibre yield of 11.63 g/plant, which was 24.12% higher than the best check variety JRC-212 (9.37 g/plant). On the basis of range, mean and variance, 10 best F2 crosses were selected for yield and yield components, which will be carried forward to F3 generation next year for multilocational evaluation and selection. From F1 and F2 generations, two crosses (CHN/FJ/052 x JRC-212 and NPL/KDC/032 x RC-212) were identified with consistent high yield in both generations. In *C.olitorius*, 5 crosses i.e. JRO-524 x JRO-3352, KEN/DS/053 x JRS-3352, KEN/DS/060C x TAN/X/112C, KEN/DS/053 C x NPL/YPY/026C and JRO-524 x JRO-3670 showed superior fibre yield of 20.46, 17.01, 14.55, 13.18 and 12.55 g/plant at Barrackpore, which was significantly more than the check cultivar JRO-524 (11.4 g/plant).

In OFTs at Barrackpore, Nagaon and Kendrapara, varieties JRO-524 and S-19 were found most promising among all entries. The fibre quality characters of S-19 were better than JRO-524 (Table 8). Considering the yield and fibre quality, S-19 has been recommended for pre release trials (adaptive) by the All India Coordinated Project on Jute and Allied Fibres.

Table 8 : Comparative quality characters of JRO-524 and S-19 of *C.oiltorius*

Treatment	Root content	Defect %	Fibre tenacity (g/Tex)	Fibre fineness (Tex)	ISI grade
S-19	0.0	0.03	30.5	2.9	TD_2 + 13%
JRO-524	5.0	0.03	29.1	3.3	TD_2 – 13%

As a part of the project, a tissue culture protocol for jute has been standardized at ISI, Kolkata using 3 - 5 day oil coleoptile tip as the primary explant for the first time in the world. Through this protocol, true to type plantlets can be produced within two months. This technique will be useful in molecular breeding of jute. A technique for determination of lignin through assay of peroxidise enzyme was standardized at Kolkata University. This will be useful for quick determination of fibre quality at seedling stage to screen large population of segregating material.

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

RNMV to improve jute yields

Earlier results indicated that rice necrosis mosaic virus (RNMV) can increase the growth of jute plant and improve the fibre yield. Seeds of jute treated with RNMV exhibited superior field performance at the on-station trials. On-farm trials during the year at Nagaon (Assam) showed the virus energized plants produced 6% additional yield over control, while at Kendrapara in Orissa, the yield improvement was upto 14%. There was a significant decrease in the incidence of insects and pests in RNMV energized jute plants. Mass culturing technique of RNMV was standardized at CRIJAF, Barrackpore. The total RNA content of the virus energized jute plants and the esterase activity were significantly higher over control plants. So far, no adverse effect of growing virus energized jute crop was found on the soil biota and the succeeding rice crop.

Integrated Pest Management

Next to cotton, maximum pesticides are used in India on paddy. To cut down the use of pesticides, location specific IPM modules have been evolved for rainfed rice but several constraints limit the adoption of the modules on farmers fields. In 5 target districts i.e. Jorhat, Imphal, Bankura, Cuttack and Warangal location specific IPM modules vis-à-vis scheduled based treatments were evaluated through 175 OFTs, to quantify the impact of natural biological control, its cost effectiveness and identifying constraints at community level adoption of IPM. Previous results indicated high variability on the efficacy of IPM modules depending on the pest load and the weather conditions. Trials during the year focused on the benefit cost ratios of different modules and study pest - natural enemy relationships. At each site, there were three treatments viz., i) Farmers practice, ii) Scheduled Treatment (ST) and iii) IPM treatment. The yields and cost benefit ratios on the farmers fields in different target districts are given in Table 9.

In Cuttack district, scheduled based protection showed less pest incidence, but the total cost of plant protection was less in IPM treatment resulting in higher cost benefit ratio (1:3.1) than scheduled treatment (1:1.7) and farmers practice (no returns). There was a high acceptance of Tricho cards and pheromone traps in this district. At Titabar (Jorhat district), also the returns were highest in IPM treatment (1:4.2) followed by ST (1:3.7) and least in farmers practice (1:2.9). The higher returns in IPM were also due to superior variety and better crop management in terms of balanced fertilization, optimum population etc. Farmers in Assam are convinced about the superiority of var. *Ranjit* over *Mashuri*. In Bankura district, scheduled treatment gave maximum yield but IPM treatment was economically more profitable (1:1.74). Across the villages in Imphal district, higher average grain yield was recorded in scheduled treatment (4.59 t/ha) compared to IPM (4.33 t/ha) and farmers practice (4.06 t/ha). However, the cost - benefit ratio were higher in IPM treatment mainly due to high investment on pesticides in schedule based

Table 9: Grain yield and cost benefit ratio of rainfed rice as influenced by different treatments on farmers fields in target districts of Orissa, West Bengal, Assam, Manipur and A.P.

Treatment	Location/Target districts									
	Cuttack (75)		Titabar (25)		Bankura (25)		Imphal (25)		Warangal (20)	
	Grain yield (t/ha)	CBR	Grain yield (t/ha)	CBR	Grain yield (t/ha)	CBR	Grain yield (t/ha)	CBR	Grain yield (t/ha)	CBR
Integrated pest management (IPM)	5.42	1:4.15	5.97	1:4.20	4.75	1:1.74	4.06	1:14.06	3.52	1:3.04
Scheduled treatment (ST)	4.71	1:2.27	5.62	1:3.72	4.90	1:1.54	4.59	1:0.33	2.62	1:1.84
Farmers practice (FP)	3.35	-	4.87	1:2.95	4.10	1:1.42	4.33	-	3.00	1:1.87

Figures in parentheses indicate number of farmers participated in the trials.

treatment. The gallmidge resistant variety, CAU-1 found high acceptance as an IPM component with the farmers in Manipur.

Based on the OFTs, it was evident, that though scheduled treatment gave highest yields across the centers, the cost benefit ratios were higher in IPM treatment. There was increase in awareness among the farmers on advantages of specific components of IPM module like tolerant varieties against gallmidge and BPH, use of pheromone traps against yellow stem borer, release of biocontrol agents like *Trichograma* egg parasitoid against leaf folder and cultural practices like balanced nutrition, formation of alley ways and water management. Besides yield and cost benefit ratios, the population of natural enemies increased due to IPM treatments.

The pest incidence was low in IPM and scheduled treatments compared to farmers practice. Among natural enemies, highest number of dragon flies, damsel flies, ground beetles and coccinelids were observed in farmers practice followed by IPM

A farmer fixing phermone trap as IPM treatment in Kandabinda village, Dhenkanal district, Orissa

treatment at Tatabar (Table 10). But higher number of spiders were recorded in IPM treatment which are important for control of insect pests. Least natural enemy population was recorded in pesticide plots.

Weed management in upland rice

In a related project, integrated weed management package was tested in 60 OFTs in Dhenkanal, Hazaribagh and Faizabad districts. In Dhenkanal, mechanical weed control by finger

Table 10: Pest incidence and natural enemy population in rainfed rice eco system at 55 DAT on farmers fields in Titabar, Assam under IPM vs. scheduled treatments.

Treatment	Pest incidence				Incidence of natural enemies (No./100 hills)			
	Stem borer (% DH)	Gallmidge (% SS)	Leaf folder (% DL)	Case worm (% DL)	Spiders	Dragon flies and damsel flies	Ground beetles	Coccinellids
IPM	2.10	6.23	0.89	2.69	9.40	18.50	9.50	11.60
ST	2.02	5.79	1.42	2.58	4.10	17.00	5.70	9.10
FP	4.57	7.19	5.57	2.90	7.80	23.60	10.70	13.60

DH – Damaged Hills ; DL – Damaged Leaves; SS – Silver Shoots

Table 11 : Performance of effective weed control treatment in upland rice on farmers fields in Hazaribagh district (mean of 10 farmers).

Treatment	Grain yield (t/ha)	Weed control efficiency (%)	Additional yield (t/ha) over farmers' practice	Incremental B:C ratio
Chemical control by butachlor* at 3-5 DAS + one hand weeding at 40-45 DAS	2.06	87	1.67	1.74
Mechanical control by finger weeder, 15-20 DAS + one hand weeding	1.55	65	1.16	1.33
Two hand weedings at 20-25 and 40-45 DAS	1.99	52	1.6	0.97
Farmers' practice	0.39	-	-	-

* pre emergence application @ 1.25-1.5 kg a.i/ha.

weeder at 20-25 DAS combined with one hand weeding was found to be cost effective with an yield gain of 64% over farmer's management and an incremental B:C ratio of 3.20. In Hazaribagh and Faizabad districts, pre-emergence application of butachlor @ 1.5 kg a.i./ha at 3-5 DAS combined with one hand weeding at 35-40 DAS was the cost effective practice with B:C ratio 1.74 and 1.55, respectively (Table 11).

Improved *Biasi* System

Biasi is a traditional method of rice cultivation common in eastern and central India where farmers broadcast the paddy and incorporate excess plant population through a process of thinning carried out by a country plough. A series of improvements were made in this traditional system of rice cultivation (followed in more than 4 m ha in the country) through use of improved implements, reduced seed rate and balanced nutrition etc. This improved *biasi* system not only improves the yields but also reduces the cost of cultivation. The improved system has been tried on 130 farmers fields covering 30 ha in 34 villages of 10 districts in 5 states (Chhattisgarh, M.P, Orissa, Jharkhand and West Bengal). Earlier results indicated the advantage of the *biasi* plough *trifal* in maintaining optimum plant population and improved yields of rice as compared to the spiral ploughing with a wooden country plough. Due to severe drought during 2002, the traditional *biasi* operation was delayed in Chhattisgarh and Jharkhand due to lack of adequate water depth in the field. The line seeding of dry rice under improved *biasi* system gave comparatively better yields over the farmers practice of broadcast *biasi*. *Trifal* and wedge plough were the two *biasi* implements evaluated during the year along with other components of the *biasi* system like seed rate and suitable variety. At Ambikapur, *trifal* was found to be more effective and economic over other implements. It minimized plant damage, operational cost (Rs.175/ha) and resulted in higher BC ratio as compared to country plough (Table 12). In Mahasamund, there was a

Trifal, a bullock drawn *biasi* implement developed by IGKV, Raipur

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

Table 12: Cost and returns with improved biasi implement on farmers fields in Surguja district of Chattishgarh (Mean of 13 farmers)

Plough	Yield (t/ha)		Cost of production (Rs./ha)	Gross returns* (Rs/ha)	Net returns* (Rs/ha)	Benefit/ Cost ratio
	Grain	Straw				
Desi (spiral ploughing)	3.48	3.86	8227	19520	11293	1.37
Trifal (3 tyned plough)	3.65*	4.07	7535	20495	12960	2.13*
Farmers practice	3.12	3.41	7925	17450	9525	1.20

*Price of paddy @Rs.4500/ton and for straw Rs.1000/ton.

31% yield advantage (50 q/ha) over the country plough (38 q/ha).

The improved *biasi* system consisting of dry seeding of rice using seed drill + basal fertilizer application + weedicide + ambika paddy weeder gave significantly higher yield by 20-42% at different centers over farmers practice even under adverse weather conditions during 2002-03. However on a three year basis (2000-01, 2001-02 and 2002-03), the average yield benefits due to improved *biasi* have ranged between 20-30% across the districts and additional returns of 15-22%. Feed back survey of the participating farmers indicated 45% of the 256 farmers surveyed in Mahasamund and Bilaspur districts are following the improved biasi system with economic gains of 20-36% over the traditional method. Similarly, 62-73% of the 228 farmers surveyed in Jhargram in Midnapore district are also following the improved system. Improved *biasi* system also performed better at other centers like Darisai, Keonjhar and Bhopal.

Tillage and Seeding Implements

Tillage related soil constraints limit the productivity of rainfed rice in different land types.

Twenty six on-farm trials were carried out in Orissa, A.P, West Bengal, Jharkhand, Chhattisgarh, Assam and U.P covering 210 farmers on improved tillage practices and implements in order to increase the soil water storage capacity, control weeds, achieve better puddling index and improve crop productivity. In uplands, twice MB ploughing along with two hand weedings reduced weed growth (weed number 16.2/m^2) and significantly increased grain yield (30.11 q/ha) as compared to farmers practice (weed number 61/m^2, yield : 21.7 q/ha). In low land rice, grain and straw yield of rice significantly increased by puddling with power operated rotavator as compared to farmers method of puddling by wooden country plough. The higher puddling intensity achieved with rotavator also had a beneficial effect on the succeeding crop. There was a high acceptability of rotavator among participating farmers in the target districts.

As a substitute to the expensive power tiller, a number of locally developed puddlers were evaluated in different target districts. Puddler 99 in Orissa, lugged wheel puddler in West Bengal and IADP puddler in Jharkhand proved significantly superior as compared to wooden country plough or MB plough. The main advantage of these puddlers lies in similar efficiency to power tiller at lower costs. The cost benefit ratios with the country plough, locally developed puddler and power tiller for low land rice is given in Table 13. The Implements Factory of the Agricultural Engineering Department, Govt. of Orissa is producing the Puddler 99 on commercial scale.

In a related project, a number of tillage and seeding equipments for rice have been evaluated through 120 on-farm trials in 42 villages of 10 districts in Orissa, M.P, U.P, Bihar and Assam. Better quality of seed bed was achieved at lower cost by using power tiller and tractor operated rotavator. Cost of tillage with tractor drawn rotavator was 20-30% less than the traditional method. The cost benefit ratios with different tillage implements on farmers fields in Khurda district is presented in Table 14. The rice yield with tractor drawn rotavator was 4.15 - 4.35 t/ha as compared to 3.5 - 3.8 t/ha with farmers practice. Seed drills drawn

Table 13: Benefit-cost ratio of rainfed low land rice production with local and improved puddlers

Location and state	Country Plough	Local Puddler	Power Tiller
Bhubaneshwar, Orissa	1.34	1.51	1.57
G.Udayagiri, Orissa	1.57	1.78	1.76
Gayeshpur, West Bengal	1.29	1.96	1.85
Titabar, Assam	1.90	2.18	2.20
Darisai, Jharkhand	1.89	2.24	2.25
Faizabad, U.P.	1.88	2.00	2.09
Jagdalpur, Chhattisgarh	1.39	1.47	1.73

Table 14: Cost of production, income and CB ratio with different tillage implements on farmers fields in Khurda district, Orissa

Treatment	Cost of tillage Rs/ha	Cost of production Rs/ha	Income Rs/ha	CB Ratio
Power tiller rotavator	1250	18844	25543	1:1.35
Tractor drawn rotavator	1086	18784	26543	1:1.41
Traditional method	1525	18921	25303	1:1.33

Training of artisans from SSI units on maintenance of agricultural implements at CIAE, Bhopal

by bullocks, power tiller and tractor were found superior to conventional broadcasting method with yield increase ranging from 4.1 to 12.3%. Self-propelled 8 row rice transplanter was found to be superior to local practice in terms of cost, timeliness of operations and yield. The cost of transplanting was 30% less than the traditional method with 10-15% higher yield across locations.

Artisans from 23 SSI units from different states were trained on manufacture and maintenance of improved implements developed under the project. Twenty four trainings were organized for 260 farmers on mat type paddy nursery raising technique, puddling, operation and maintenance of seed drills and self propelled rice transplanter.

Post Harvest Technology

To minimize losses during storage and milling, improved drying and milling methods for rice were evaluated involving with 200 farmers in 8 districts of Assam, Chhattisgarh, Jharkhand, Manipur and Orissa. In Jorhat district, drying paddy on wire mesh racks and black polythene sheet recorded higher rate of drying of 1.7 and 1.4 per cent/hr, respectively as compared to farmers method of drying (on ground). The head rice recovery was 2-4% higher for paddy dried on racks and polythene sheets as compared to soil surface. Similar results were recorded in other target districts.

For storage of rice, RCC ring bins and metal bins were found more effective than farmers method in Keonjhar, Cuttack and Raipur districts. However, as a low cost alternative, mud plastered bamboo bins were found suitable for storing paddy in humid regions. The RCC ring bin and metal bins were found to be completely rat proof. Farmers could save 6-8% grain by using these improved structures. Improved rice milling through rubber sheller and cone polisher could successfully replace the huller in raw rice milling. These rubber sheller type machines can be installed at

Improved paddy storage structures : RCC Ring bin in Cuttack district (left) and rat proof wooden storage structure in Imphal district (right)

village level at low cost. Ten to fifteen per cent of the extra head rice recovery was possible by using these machines.

Integrated Rice-Fish-Duck Farming System

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

During 2002-03, data on crop yields and income from ducks/pigs was computed for all the 15 farmers in 3 states. Results from most ponds indicated significant improvement in fish production particularly the bottom feeders with the addition of duck manure. The local ducks attained a body weight of 1.0 to 1.6 kg in 6-7 months from initial weight of 0.4 kg. In some ponds, there was a high mortality of ducks during cropping season possibly due to the consumption of pesticides applied to rice crop. Hence, farmers were advised not to allow ducks in the agricultural fields during the crop season.

Common carp was found to be the most suitable fish species for this integrated system. The returns per rupee invested was Rs. 3.17-3.75 in fish-cum-duck system and Rs. 3.48-3.79 in fish-cum-pig system with different farmers in the three states. Comparatively, the returns from fish-cum-pig farming were more over fish-cum-duck farming. The number of pigs/ducks to be kept should not be on the basis of water area but on the resources of the farmer with focus on efficient resource use rather than maximising income. The model developed under the project is being tried in the ATMA project in Dumka district of Jharkhand. The development departments in the state also evinced keen interest to include this as financial assistance scheme with banks.

Integrated rice-fish-duck/pig farming system in Jharkhand and West Bengal

Livestock Production and Health

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

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

From field level during trials, oxyclozanide and triclabendazole against trematodes, fenbendazole and albendazole against nematodes were found to be effective anthelmintics. Quinopyramine, buparvaquone and diminazine were found efficacious against blood protozoans. Ivermectin, deltamethrin and flumethrin could control ectoparasitic infestation. Package of practices advised for control of helminthic diseases include (i) Mass administration of effective anthelmintics at 3-6 months interval (ii) Prompt disposal of dung from sheds/fields to compost pits and (iii) prohibition/restricted grazing of livestock in water logged areas infested by snails. Adoption of package of practices significantly brought down the prevalence rate of helminthic infection both in stall-fed and grazing animals of sample villages. An increase of 10.20 to 15.95% and 5.58 to 11.66% in milk production was recorded in stall-fed and grazing cattle, respectively (Table 15).

Improving Rainfed Rice Productivity : Policy Options

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

Table 15: Average milk yield gain in stall fed and grazing lactating cows after anthelminthic treatment in 3 states.

State	Treatment	Average milk yield in kg					
		Trematode infected			Nematode infected		
		Pre-treatment 7 days	Post treatment 60 days	% increase/ decrease	Pre-treatment 7 days	Post treatment 60 days	% increase/ decrease
				Stall fed			
Orissa	Treated	4.90	5.40	+10.20	4.20	4.87	+15.95
	Untreated	4.85	4.70	-3.09	4.10	3.90	-4.87
Chhattisgarh	Treated	5.30	5.94	+12.08	5.25	6.00	+14.28
	Untreated	5.25	4.90	-6.66	5.20	4.80	-7.69
Jharkhand	Treated	5.50	6.12	+11.27	5.38	6.18	+14.86
	Untreated	5.50	4.78	-13.09	5.40	4.90	-9.25
				Grazing			
Orissa	Treated	1.30	1.40	+7.69	1.20	1.30	+8.33
	Untreated	1.28	1.20	-6.25	1.19	1.00	-15.96
Chhattisgarh	Treated	2.15	2.27	+5.58	2.10	3.28	+8.57
	Untreated	2.10	2.00	-4.76	2.12	1.91	-9.90
Jharkhand	Treated	2.50	2.78	+11.20	2.40	2.68	+11.66
	Untreated	2.52	2.30	-8.73	2.35	2.10	-10.63

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

CHAPTER

3

Oilseeds Based Production System

Oilseed crops are grown both during *kharif* and *rabi* seasons under sole, inter and sequence cropping systems. Due to biotic and abiotic stresses and absence of major break throughs in varietal development, the productivity continues to remain low. Though price fluctuations have an impact on input use and productivity, the non-adoption of improved practices is also a major cause for lower yields. Therefore under NATP, problems related to varietal performance, moisture conservation, IPM, INM and post harvest processing have been addressed.

IPM Modules for Oilseed Based Cropping Systems

The recommended IPM modules of different oilseed crops in sole, inter and sequence cropping systems were evaluated in large plots of 1 acre or above and compared with farmers practice. The trials were carried out in 39 villages involving 134 farmers covering 242 acres in 7 target districts.

Table 1: Yield and C:B ratios with IPM modules and farmers practice in major oilseed based cropping systems in 7 districts

Districts	No. of villages	No. of farmers	Area covered (acres)	Crop/ Cropping System	Yield (kg/ha)		C:B ratio	
					Farmers practice	IPM	Farmers practice	IPM
Gurgaon (Haryana)	1	13	99	Mustard	1313	1325	1:1.93	1:2.00
Anantapur (A.P)	5	25	53	Groundnut + Pigeonpea	570 68	827 97	1:1.15	1:1.28
Raichur (Karnataka)	6	14	28	Groundnut + Sunflower	584 235	632 398	1:1.35	1:1.68
Parbhani (Maharashtra)	3	15	30	Safflower + mungbean	810	1525	1:5.10	1:7.10
Solapur (Maharashtra)	5	20	8	Safflower + Chickpea	512 687	672 962	1:2.45	1:2.90
Ranga Reddy (A.P)	5	10	40	Castor	398	542	1:2.21	1:3.04
Mahaboobnagar (A.P)	5	16	40	Castor + Pigeonpea	670	760	1:1.30	1:2.00

Demonstration of seed treatment with *Trichoderma viride* at farmers' field in Maharashtra

Farmers' field school in Palem, Mahaboobnagar district, A.P.

The IPM module varied at each location depending on the cropping system and the major pests prevalent in the area. The location specific modules from pre-sowing to harvesting were validated for the 3rd consecutive year and the cost benefit ratios worked out. Previous results indicated the superiority of IPM module in terms of yield and CB ratio over farmers practice, but it was on par with scheduled based treatment in most of the trials.

IPM modules proved their superiority across the locations during 2002-03. The incidence of pests and diseases was relatively low during 2002-03 and hence the cost benefit ratios are relatively low (Table 1). The highest C:B ratio was recorded with safflower in Parbhani district followed by castor in Ranga Reddy district.

Pest Management Information System (PMIS) on mustard

Eleven farmer trainings, exposure visits, field schools were organized at different locations. A guide to identification of key pests and their natural enemies was prepared for the cropping systems in the target districts. A CD-ROM database for mustard pests and their management (PMIS) was produced, which was well received by the extension functionaries in the field. Similar databases are under preparation for groundnut and safflower.

Integrated Nutrient Management in Oilseed Based Cropping Systems

Though a number of INM packages have been recommended for various oilseed crops and cropping systems, the farm level adoption has been quite low. In order to understand the constraints and the potential benefits at farmers level, extensive on-farm trials were conducted in 8 major oilseed growing districts in M.P, Maharashtra, Karnataka, Jharkhand, Punjab, Rajasthan and A.P. The major focus of these OFTs was on evaluating recommended package for the cropping system as a whole in the district instead of single crop. Being a drought year, the absolute yields were low during 2002 at several locations. However, the superiority of INM treatments both in terms of yield and BC ratios was observed.

Under soybean – chickpea system on 15 farmers fields in Bhopal district, highest yield was obtained with the application of 100% RDF (20:25:40 kg NPS/ha) along with 2 t FYM/ha. The grain and oil yields were 43.7% and 62.4% higher as compared to farmers practice (50 kg DAP/ha). The increase with 100% RDF was 24 and 30%. In fallow-sunflower system in Raichur district, significantly higher seed yield (10.2 q/ha) was obtained with RDF (35:50:35:20 kg NPKS/ha) + FYM @ 2t/ha with soil moisture conservation (opening furrow after 2 rows) which is 38% higher than farmers practice of 15:25:15 kg NPK/ha (7.4 q/ha). Oil yield of 3.72 q/ha was recorded with RDF + FYM + SMC, which was significantly higher (44%) than farmers practice (2.58 q/ha).

Similarly, 100% RDF + FYM or 75% RDF + FYM consistently produced more yield, oil and net returns over farmers practice (sub optimum nutrient application) with fallow-mustard cropping system in Bharatpur district, fallow-sunflower system in Latur, castor monocropping in Mahaboobnagar, greengram – safflower in Parbhani, groundnut + pigeonpea in Ranchi and maize – raya in Nawanshahr (Punjab). Based on two years data, the best INM treatment for each of the cropping systems tested in different target districts are given in Table 2.

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

Table 2: Most profitable INM treatment for oilseeds based cropping systems in target districts

Target district	Cropping systems	Most profitable INM treatment
Bhopal	Soybean – chickpea	100% RDF (20:25:0) + 2 t/ha FYM to soybean and 50% RDF to chickpea(30:25:0)
Parbhani	Greengram - safflower	Greengram incorporation before sowing + 75% RDF(40:20:0) + SMC
Latur	Fallow – sunflower	100% RDF(60:40:40)+FYM @ 2 t/ha +SMC
Raichur	Fallow – sunflower	100% RDF(60:40:40)+FYM @ 2 t/ha +SMC
Mahaboobnagar	Castor	Cowpea incorporation after first picking and 75% RDF (60:40:30 + 20 S kg/ha)
Ranchi	Groundnut + pigeonpea	100% RDF + lime @2 t/ha + FYM@2 t/ha + SMC (RDF = 10:20:15 for both crops)
Bharatpur	Fallow-mustard	Green manuring with sesbania and FYM @ 2 t/ha + 75% RDF(80:40:0 + 20kg S/ha)
Nawanshahr	Maize – raya	100% RDF + S @ 20 kg/ha + SMC (RDF = 80:40:0 kg for maize; 37:20:0 for raya)

SMC = Soil moisture conservation, RDF = Recommended dose of fertilisers

The additional economic returns with each of the cropping systems with RDF and best INM treatment over farmers practice are given in Table 3.

Survey conducted in 9 districts showed that rainfed farmers in general apply less fertilizer (about half of the recommended dose) to oilseed crops. One hundred and seventeen on-farm trials conducted under this project in the year 2002-03 in 34 villages clearly indicated that application of recommended doses of fertilizers can significantly boost the yield of oilseed crops over farmers practice of sub optimum nutrient use. The yield increase varied from 0.40 q/ha in case of sunflower in Latur

Table 3: Additional returns due to RDF and best INM practice in target districts (No. of farmers 117)

District	Cropping system	Additional returns (Rs) over farmers practice with	
		RDF	Best INM treatment
Bhopal	Soybean - chickpea	3306	5584
Parbhani	Greengram - safflower	827	3219
Latur	Fallow - sunflower	339	2711
Raichur	Fallow - sunflower	1729	3036
Ranchi	Groundnut + pigeonpea	15427	23809
Mahaboobnagar	Castor monocropping	918	1438
Bharatpur	Fallow - mustard	1404	4728
Nawanshahr	Maize - raya	904	2077

to 3.65 q/ha in case of mustard in Bharatpur. As expected, rainfall pattern influenced the yields significantly. Introducing soil moisture conservation treatments (opening furrows after every 4-6 rows of crops) resulted in significant increase in yield and net return in sunflower system in Latur (77 kg seed/ha and Rs.1014/ha) and in greengram - safflower system at Parbhani (95 kg seed/ha and Rs.1053/ha) over RDF alone. Significant increase in moisture content in the root zone was recorded due to adoption of moisture conservation measures.

Integration of Moisture Conservation and INM

Since oilseed crops are grown on relatively low fertile soils, application of deficient nutrients and *in situ* moisture conservation practices are essential for optimum yields. However, most often, the benefits of INM and moisture conservation are inconsistent across locations and the response varies with the yield potential of the varieties. In a comprehensive project in 5 major oilseed growing districts (Junagadh, Raichur, Indore, Solapur and Mahaboobnagar) the relative contribution of variety, INM and moisture conservation were assessed in 5 oilseed crops viz. groundnut, sunflower, soybean, safflower and castor in 2 major soil types i.e. Alfisols and Vertisols.

During the previous year, significant yield gains were recorded due to moisture conservation and nutrient management practices, more so in shallow soils. *Kharif* 2002, being a drought year, enabled to test the true impact of moisture conservation treatments in all the target districts, which received deficit rainfall up to 50%. Moisture conservation practices and fertilizer application were found to be distinctly superior to farmers practice in all the crops (Table 4). However, the degree of response varied with soils and the crops. Based on data of two years (2001-02 and 2002-03), recommended moisture conservation and fertilizer application resulted in 25% increase in seed yield of castor over farmers practice in Mahaboobnagar district. Castor hybrid DCH-32 was found distinctly superior (18%) to check cultivar PCS-4. Sunflower crop raised on Vertisols as well as Alfisols responded well to both recommended moisture conservation and fertilizer application with increased yield to the extent of 17% and 16.4% in Alfisols and Vertisols, respectively. The hybrid KBSH-44 in Vertisols and KBSH-1 in Alfisols were distinctly superior to the check cultivars for both seed and oil yields.

In groundnut (Vertisols), recommended moisture conservation and fertilizer application significantly improved pod yield as compared with the farmers practice in Gujarat. Improved cultivars GG-13 in Virginia and GG-5 in Spanish gave significantly higher groundnut pod yield of 2144 kg/ha, and 2004 kg/ha, respectively over local checks. In Alfisols, cultivar K-134 was found distinctly superior to check JL-24 in Ananthapur district. In soybean, cultivar MAUS-47 recorded higher seed yield and net returns under recommended fertilizer and moisture conservation practice as compared with farmers practice. Safflower hybrid DSH-129 produced higher seed yield with

Table 4: Yield and net returns of 5 oilseeds crops in target districts with recommended vs. farmers method of moisture conservation and nutrient management

Crop	Target district	Soil type	Grain/pod yield (kg/ha)			Net returns (Rs/ha)		
			Farmer method of MC+ FA	Farmer method of MC+ RDF	Reco. MC+ RDF	Farmers method of MC+ FA	Farmers method of MC+ RDF	Reco. MC+ RDF
Castor	Mahaboobnagar	Vertisol	1029	1066	1254	8923	8542	10644
Sunflower (*Kharif*)	Raichur	Vertisol	767	848	1188	9255	8951	14763
Sunflower (*Rabi*)	Raichur	Vertisol	805	871	937	9919	9348	10356
Sunflower	Mahaboobnagar	Alfisol	1059	1211	1422	6270	7344	9168
Groundnut (Spanish)	Junagadh	Vertisol	1763	1798	1979	21278	21359	23767
Groundnut (Varginia)	Junagadh	Vertisol	1886	2088	2146	23306	26519	27040
Soybean	Indore	Vertisol	1487	1593	1669	10184	11011	11293
Safflower (Low P)	Solapur	Vertisol	1140	1295	1390	15491	17948	19313
Safflower (Medium/ high P)	Solapur	Vertisol	1256	1413	1515	17926	20137	21618

MC = Moisture conservation RDF = Recommended dose of fertilizer FA=Fertilizer application

recommended fertilizer application along with moisture conservation practice.

Though recommended moisture conservation and fertilizer application at all locations resulted in higher yield and net returns, but the cost benefit ratios were not significantly different over farmers practice. Since there is need for improving the productivity of oilseeds in rainfed areas, the Government should support water conservation programme particularly through National Watershed Development Project for Rainfed Areas (NWDPRA).

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

Documentation of Indigenous Water Conservation Practices and Impact of Watershed Projects

Farmers in rainfed areas adopt numerous indigenous moisture conservation practices in all the cropping systems, more so in oilseeds, which are grown in drought prone areas. With a view to document and improve such practices, a survey was conducted at 19 locations representing the target domains of the all India coordinated project on dryland agriculture. After a two year intensive survey, 140 ITKs practiced by farmers in different AESRs were listed. Each ITK was documented in terms of its adoption, utility and scope for further improvement. The awareness level of farmers on moisture conservation practices in villages covered under the watershed projects and those not covered was also quantified. In general, the awareness was low and farmers perceive that water conservation practices are not cost effective if they have to do on their own. Community approach in adoption of moisture conservation practices was also found to be lacking.

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

Optimizing Oilseeds Productivity in Saline and Alkaline Soils

Soil salinity and alkalinity are important constraints for realizing optimum yields in oilseed crops in several districts of Andhra Pradesh, Karnataka, Gujarat, Maharashtra and U.P. From previous studies, large number of salt tolerant genotypes have been identified in sunflower, safflower, castor, linseed and mustard through on-farm trials. During the year, an improved crop management package aimed at minimizing the impact of soil salinity/alkalinity has been evaluated in comparison to the farmers practice, besides continuing the varietal evaluation. The improved package consisted of seed soaking in 1% NaCl solution for 3 hours, application of FYM @ 2 t/ha and sowing on the side of the ridge in ridge and furrow method of planting. While farmers practice included flat bed method of sowing.

The improved method of planting clearly proved superior across different locations with

Performance of linseed var. Swetha on farmers fields (saline) with farmers practice (left) and improved practice (right) at Kanpur

varying degrees of salinity. In sodic soils of Mahaboobnagar district, the improved practice resulted in significantly higher yields in castor bean (1302 kg/ha) than farmers method of seeding. However, oil content was not influenced by management practice. The genotype 48-1 (1291 kg/ha) out yielded DCS 9 (1178 kg/ha) and *Kranti* (1076 kg/ha).

In Koppal district of Karnataka, sunflower genotypes KBSH-1 and P64A43 performed significantly superior under improved practice compared to farmer's practice (flat bed/ drill sowing of *Morden*) on fields with salinity ranging from 4.5 to 5.8 dSm^{-1}. The mean seed yield was highest with P64A43 (10.70 q/ha) followed by KBSH-1 (10.63 q/ha) in ridge and furrow method compared to flat bed method. In Kanpur district with linseed, recommended practice (line/ drill sowing, application of 2t FYM/ha about a month before sowing and crop residue mulching) resulted in improved germination, drymatter and seed yields per plant over farmers practice. More

Table 5: Effect of improved package of practices on productivity of different oilseed crops in saline/sodic soils

Target District	Crop	No of farmers	Soil salinity/ level EC(dSm^{-1})	Grain yield (kg/ha)		Increase over farmers practice (%)
				Farmers Practice	Improved Practice	
Mahaboobnagar	Castor	7	0.25-0.67	1062	1302	22.6
Koppal	Sunflower	7	4.50-5.80	785	947	20.6
Parbhani	Safflower	11	2.03-9.03	837	1058	26.4
Banaskanta	Mustard	10	4.10-8.50	1248	1424	14.1
Kanpur	Linseed	12	0.20-0.88	456	677	48.5

Soils in Mahaboobnagar are sodic (ESP 18.7 to 70.3) number of capsules per branch and higher number of seeds per capsule contributed to the increased yields. In Banaskantha district, application of castor cake @ 1 t/ha increased seed yield of mustard by 14%. The variety *Bio* 902 gave significantly higher seed yield by 5.57 and 8.63 per cent over GM 2 and *Varuna*, respectively. In Parbhani district of Maharashtra, the seed yield of safflower was maximum upto EC 4.20 dSm^{-1} and declined thereafter sharply upto EC 9.03 dSm^{-1}. Recommended practice on an average resulted in 26% higher safflower yield over farmers practice (Table 5).

Currently, oilseed crops are raised on flat bed using conventional practice. Adoption of improved technology tested under real farm situations in this project would ameliorate the salt stress experienced by these crops and can result in higher productivity.

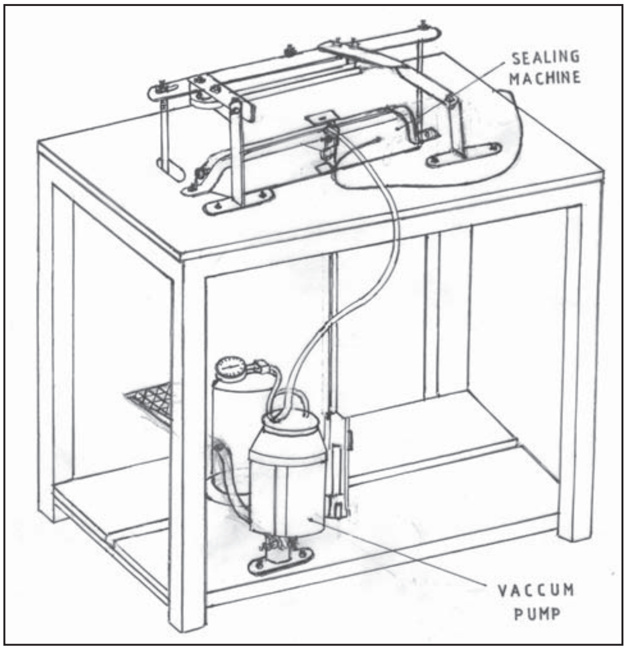
Enhancing Seed Viability in Soybean

Soybean seeds have a low viability and farmers face difficulties in storing seed in viable conditions till the next planting season. In order to develop better storage conditions that retain maximum viability for a period of 9 months, a number of low cost devices and structures were evaluated at farmers households in Jabalpur district of M.P. During the previous year, the optimum environmental conditions (moisture, temperature and pressure) for longer viability were identified. Soybean seed stored at 6% moisture and 200 mm Hg pressure retained highest viability. Among various storage devices tried, highest viability was retained with vacuumised double walled GI bins. These bins are however expensive, metalised poly bags (300 gauge) and laminated LDPE bags successfully retained vacuum in long term storage. The impact of vacuumised storage on average germination after one year is given in Table 6.

However, vacuumisation in GI containers and metalised poly bags has remained a major constraint in rural areas. To address this problem, a low cost foot operated vacuum packing machine (Cost : Rs.3500/- to Rs.4000/-) was designed and field tested during the year. It can be

Table 6: Viability of soybean seeds stored in vacuumised metalised poly bags and laminated LDPE bags

Packing Material	Average germination % after					
	6 months		9 months		12 months	
	Vacuumised	Control	Vacuumised	Control	Vacuumised	Control
Metalised polyester bags	66.4	62.3	62.8	56.8	60.5	54.0
Laminated LDPE bags	65.6	61.0	60.3	56.1	59.2	53.3



Foot operated vacuum packing machine for vacuum sealing of poly bags (capacity 80-100 bags/hour)

operated without electricity and can be maintained at the village level. Extensive exposure on this machine was made to the farmers and entrepreneurs in Jabalpur district. Small entrepreneurs/progressive farmers can own this machine and make available to farmers on custom hiring. CEDMAP, Bhopal and industrial centers in different districts have expressed interest in popularizing this technology in soybean growing districts.

Alternatively, a low cost technology of storing seeds in sand (upto 40%) filled in mud plastered bamboo basket was also found highly successful and acceptable to the farmers. The storage conditions were further improved during the year by replacing sand with ash (40%). After 9 months of storage, 65% germination was recorded with ash mixing (Table 7). These are simple practices, the farmers can adopt in their households. When stored in bags, stacking load also influenced the viability.

Table 7: Effect of sand and ash mixing on seed viability of two soybean varieties after 9 months of storage

Variety	Average Germination % with					
	20%		30%		40%	
	Sand	Ash	Sand	Ash	Sand	Ash
JS 90	54.6	57.2	60.3	62.0	65.2	67.4
JS 335	51.5	54.6	57.8	57.3	61.9	62.5

Maximum of 4 bags could be stacked without significant impact on the viability. The viability loses drastically if more bags are stacked.

Increasing Yields in Oilseed Crops Through Apiary

Honeybees improve pollination, besides providing supplementary income to the farmers through honey. When integrated with oilseeds based cropping systems, apiary improve the yield and profitability, particularly in crops like sunflower. Results during 2001-02 demonstrated that two bee colonies/acre is the optimum for having a significant impact on crop yields. On-farm trials on large plots were continued during this year in Karnataka, Maharashtra and Haryana with two colonies/acre uniformly across the cropping system. The yield improvements noted were 45% in sunflower, 23% in safflower and 32% in niger (Fig 1). The higher yield was mainly due to better seed set. The per cent grain filling increased from 85 to 94% in sunflower due to bee pollination. The economic returns to farmers from honey and additional yield of oilseed crops in four districts is given in Table 8. In Parbhani district, the yield of safflower increased by 92 kg/acre due to apiary and a honey yield of

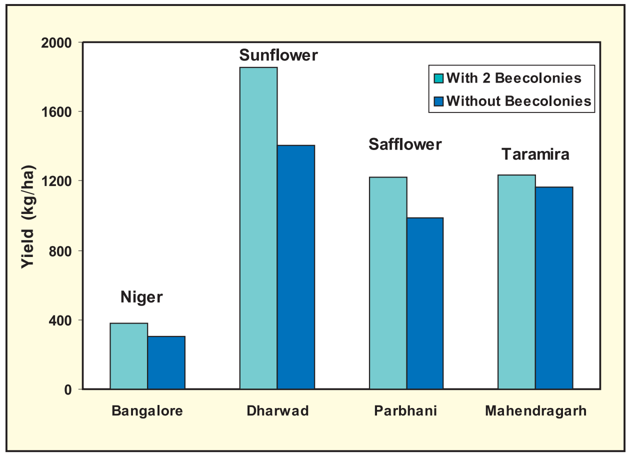


Fig 1: Effect of bee colonies on yield of oil seed crops on farmers fields in different target districts

Table 8: Additional income due to increased yield and honey from apiary on farmers fields

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

Apiary in sunflower on farmers fields in Hulkoti village, Gadag district, Karnataka

2.48 kg/acre was recorded. The net gain from the additional seed yield and honey were Rs.1900/acre.

To meet the food requirement of bees during lean season, 20 diets were tested for their palatability at Bangalore. Pollen supplement containing 10 parts of soyflour, 1 part each of skimmed milk powder, egg albumin, yeast, pollen, fish powder, honey, glycerin in equal amounts of sugar syrup and pollen substitute formulated with 10 parts of soyflour, one part of skimmed milk powder, egg albumin, yeast in equal amount of sugar syrup had higher palatability over control. Two month feeding sustained 682, 594 and 495 m^2 brood area in supplement, substitute and control colonies, respectively.

Improving Eri Silk Production in North Eastern Regions

Rearing of eri silk worm is a source of livelihood for large number of farmers in north east India, particularly in Assam and Manipur. Over the years, little effort has been made to improve the productivity of eri silk through improved feed material. Castor leaves are the chief source of feed for eri silk worm. Extensive on-farm trials carried out in Jorhat and Imphal districts helped in standardizing management practices for optimizing productivity of castor both on the plains and hills.

In Manipur district, maximum leaf yield of castor was recorded after 105 days of sowing. Among different varieties tried, the performance of *Red petiole* variety was superior to 48-1. Improved method of cultivation including fertilizer application, nipping and flower bud removal had produced increased yields in both the varieties over farmers practice. No significant differences on larval, pupal and cocoon parameters of local strain of eri silk worm were found when fed on two castor varieties i.e. *Red petiole* and 48-1 grown with farmers practice. However, the cocoon yield, shell yield and number of DFLs/ha were significantly higher when fed on *Red petiole* as compared to 48-1 when improved

Performance of castor (*Red petiole*) of Langol Hill, Imphal

Spinning of eri silk by women farmer in Manipur

A hand woven traditional eri shawl

Table 9: Cocoon parameters of eri silkworm (white Manipur local) with two castor varieties during winter (October to December, 2002)

Treatment	Cocoon yield (kg/ha)	Shell yield (kg/ha)	Number of DFLs/ha
Red petiole (FP)	126.52	12.06	152.47
Red petiole (IP)	495.50	64.02	793.99
48-1 (FP)	161.09	12.48	194.06
48-1 (IP)	392.57	47.24	543.93
CD (0.05)	69.04	8.82	87.66

FP-Farmers Practice; IP-Improved Practice

cultivation practices were followed (Table 9). In Jorhat district, however, 48-1 under recommended practices performed significantly better over *Red petiole* on larval, cocoon and grainage parameters. In other words, while castor var. 48-1 was most suitable for eri silk production at Jorhat while in Manipur, best results were obtained with variety *Red petiole*. In both cases, however higher returns were obtained even with local silkworm strains, if improved cultivation practices are followed (Fig 2).

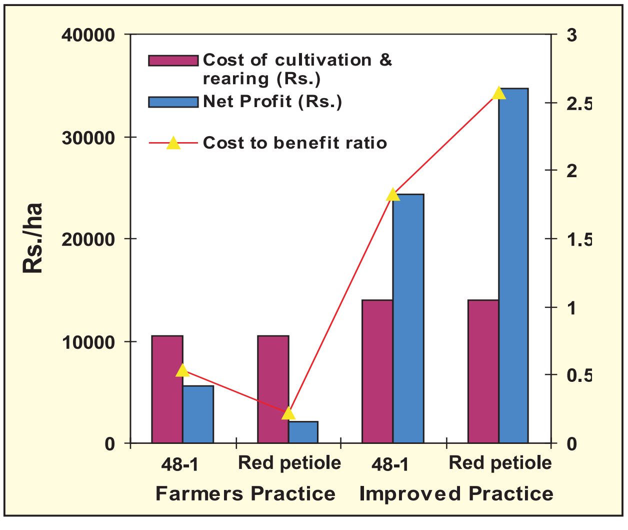


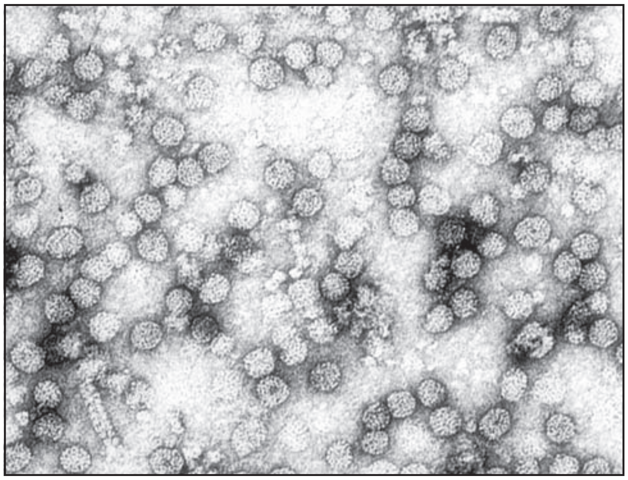
Fig 2: Cost:Benefit ratio of cocoon production under two cultivation practices in Imphal district

Etiology of Sunflower Necrosis Disease

Sunflower necrosis (SND) has recently become a significant yield reducing disease in parts of A.P, Karnataka, Maharashtra and Tamil Nadu. No definite measures could be recommended for management of this disease in the absence of clear information on its etiology. An integrated project aimed at identifying and characterizing the virus, studying its transmission and developing a diagnostic kit was taken up at IARI, New Delhi.

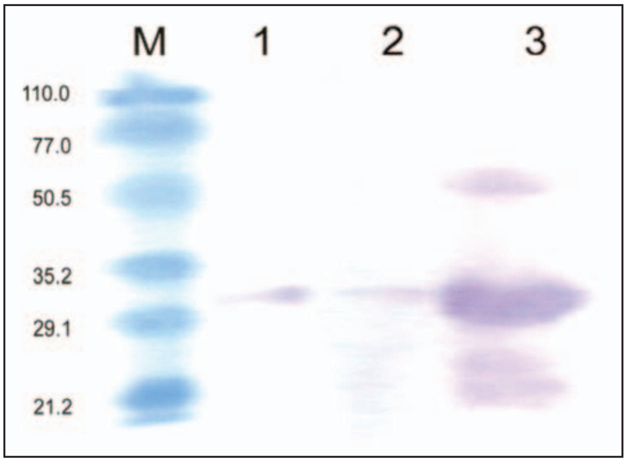
The casual agent of SND was identified as tobacco streak virus (TSV) on the basis of coat protein gene sequence. Cotton, groundnut, mungbean, okra, soybean, sunhemp and urdbean were identified as its natural hosts. ELISA and PCR tests confirmed that the virus has moved from sunflower to other hosts and therefore became economically more important in sunflower growing states. Polyclonal antiserum and c-DNA probes for rapid and reliable diagnosis of SND using enzyme linked immunosorbent assay (ELISA), dot immuno binding assay (DIBA), western blot

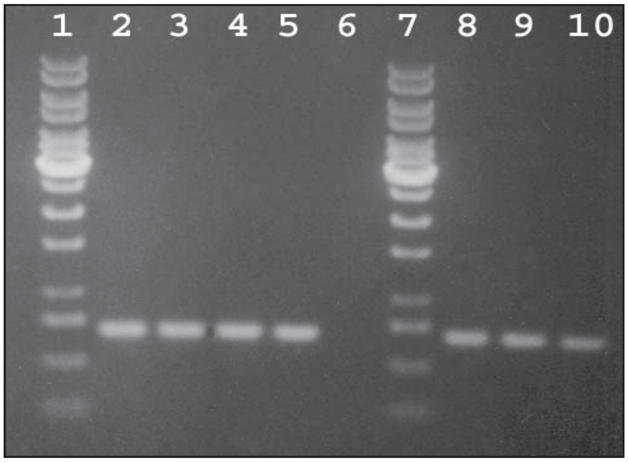
Symptoms of sunflower necrosis disease



Electron micrograph of purified TSV causing sunflower necrosis

(WB), polymerase chain reaction (PCR) and nucleic acid spot hybridization (NASH) assays have been developed. TSV does not appear to be seed borne in sunflower, as it was not detected in seeds of the seven sunflower genotypes tested, PAC 1091 (0/360), KBSH-1(0/531), JKSF-51 (0/82), POC-1 (0/1076), PS-21 (0/90), ZSH1 (0/524) and ZSH 9760 (0/434) by ELISA. Coat protein (CP) genes of TSV isolates originating from sunflower (Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu), cotton (Maharashtra), mungbean (Tamil Nadu) and sunhemp (Karnataka) when cloned and sequenced showed conservation up to 100%. CP gene sequences were submitted to the Gene Bank at NBPGR vide accession Nos. AY061928-930, AF400664 and AF515823-825. As a future strategy, CP gene could be deployed as transgene to develop virus resistant transgenic sunflower and groundnut.





Diagnostic methods for quick detection of TSV

Further Understanding of Groundnut Stem Necrosis Disease

Peanut stem necrosis disease (PSND) played a havoc during *kharif* 2000 in Andhra Pradesh and Karnataka causing severe economic losses to farmers. A project was taken up to study the etiology and control measures for this new and emerging disease. Previous results indicated that PSND is caused by tobacco streak virus (TSV), which is spread by the host *Parthenium.* Further, studies during 2002 indicated that the virus is not seed transmitted. Screening large number of cultivars in the glass house did not reveal any resistant material to TSV. However, at lower virus concentration (1:1000), some cultivars like ICGV 92267, ICGS 37, U 1-2-1 and TMV 10 showed tolerance.

Extensive farmers field surveys in A.P, Karnataka, Gujarat and Maharashtra were carried out during 2002 for the incidence of PSND. Due to severe drought during the year, the incidence was negligible (<5%). However, given the presence of the host weeds all through the year, the disease has potential to reoccur again in an epidemic proportion and hence the control measures including weed removal have been popularized among the farmers. Due to prolonged drought, the field screening of germplasm could not be carried out during the year.

Aflatoxin in Groundnut : Mapping and Management

Groundnut is an important oilseed crop frequently infected with aflatoxin. The post harvest infection of groundnut pods and seed by *Aspergillus flavus* is the major cause of this problem. Since, aflatoxin has now become a major technical barrier for export in groundnut kernels, a network project was taken up to assess the extent of the problem and apply various management practices for its control through farmers participation in Gujarat and A.P.

In the survey of seed samples, after harvest, more than 50% samples from Gujarat were found to contain aflatoxin of more than 50 ppb, whereas in A.P and Karnataka, majority samples had relatively low level of aflatoxin (Table 10).

The incidence and the quantity of the toxin was much higher in the monsoon crop as compared to the pre monsoon season. From a large number

Table 10: Aflatoxin content in samples of seeds collected from Gujarat, A.P and Karnataka

State	Number of samples showing aflatoxin content (ppb)						
	0-10	11-20	21-30	31-40	41-50	> 50	Total
Gujarat	31	19	15	5	7	145	222
A.P and Karnataka	144	42	37	30	12	63	328
Total	**175**	**61**	**52**	**35**	**19**	**208**	**550**

of genotypes screened for resistance, 9 genotypes were free from infection or showed negligible infection. These include ICGV 01161, ICGV 01162, ICGV 01163, ICGV 01158, ICGV 01105, ICGV 01149, ICGV 01115, ICGV 01126 and ICGV 01093. However, the agronomic suitability of these varieties for different locations needs to be ascertained.

An integrated package for control of aflatoxin including a number of interventions from sowing till harvest was tried at different locations in Gujarat (65 OFTs in Junagadh and Jamnagar districts) and A.P (40 OFTs in Ananthapur). No significant differences were found for the soil population of *A. flavus* in the improved vs. farmers practice. The survival of *Trichoderma viride* was not encouraging in the farmers fields. Only, a marginal increase in yield was observed in the improved practice as compared to farmers practice in some villages (Table 11). Aflatoxin contamination is more of a quality problem rather than yield decreasing constraint. Therefore, the benefits of the improved package of practices have to be assessed in terms of quality of the produce rather than yield.

Table 11: Effect of improved vs. farmers practice of aflatoxin management on pod yield on farmers fields in four villages in A.P. (*kharif* 2002)

Name of the village	Yield (kg/ha)	
	Improved practice	Farmers practice
Amudalakona	730	580
Thotavaripalli	530	550
Ragannagaripalli	370	330
Kalyam	600	690
Mean	560	540

Sunflower Heads and Castor Cake as Animal Feed

The potential of using sunflower heads as sole roughage component and detoxified castor cake as protein source were studied to utilize these under utilized/ unutilized oilseed by-products. The estimated availability of sunflower heads and castor cake are 11 and 5.9 lakh tons, respectively. Field surveys indicated that sunflower heads are largely wasted after harvest of the crop, while castor cake is used as an organic fertilizer/soil amendment. Sunflower heads with a proximate composition of protein (7.2 – 11.6%), crude fibre (17.69 – 33.12%), fat (2.4 – 7.4%) and neutral detergent fibre (26.7 – 52.07) is superior to many of the commonly used roughages like fingermillet straw, paddy straw, sorghum stover, maize stover etc.

Studies during earlier years indicated that sunflower heads can be incorporated as sole roughage component upto 40% in the complete feeds for milch animals. Similarly, castor cake can be utilized in the feed after detoxification for removing the ricin. The complete feed pellets with 40% SFH were prepared by extrusion process and fed to the animals successfully. Further, studies on feeding with different levels of sunflower heads were carried out both at research station and with farmers' animals in the target districts. Sheep showed a greater preference to sunflower heads followed by buffaloes, goats and cattle. The on-station trials with lactating animals revealed that SFH as a sole

Table 12: Performance of lactating animals fed on SFH based complete diets

Parameter	Control group	Experimental group
No. of animals	6	6
No. of days of experiment	90	90
Average body weight (kg)	374.2	357.2
Drymatter intake (kg/animal/day)	8.29	8.53
Milk yield (kg/day)	5.83	5.88
Fat %	4.5	4.6

roughage component can be incorporated upto 40% of the complete feed without affecting the performance of the animals as indicated by the milk yield (Table 12).

Castor cake being rich in protein (30-36%) is a good supplement in animal feed but the presence of toxic compounds like ricinin and allergin have limited its use as animal feed in the past. Therefore, efforts were made to develop techniques for removing the ricin. Commercially available cakes like deoiled cake, toasted cake, deoiled pellets, deoiled meal and expeller cake obtained from different oil mills were analysed for *in vitro* digestibility and ricin content. Generally, castor whole fruits are directly crushed for oil due to which the cake is rich in fibre and lignin. To over come this problem, manual dehulling of the whole seed and solvent extract of the kernel were tried. Alternately, grinding and sieving of toasted castor cake was tried to obtain high kernel-low hulls fines and high hulls-low kernel residue. Both these methods reduced the fibre and lignin content but increased the concentration of ricin, which is not desirable.

Feeding of sunflower head based complete feed to dairy cattle

Simultaneously, various physical and chemical measures were evaluated to detoxify the castor cake. Among the physical methods, autoclaving (15 psi, 60 min) was the best which eliminated the ricin to trace (Fig 3). Boiling the cake decreased the ricin content by 90%, soaking in water for 3 h by 65% confirming that ricin is water soluble and maximum reduction up to 85% can be achieved by 5 h soaking. Among different chemical methods, lime (4%) and sodium hydroxide (1%) treatments were the most effective which could reduce the toxin by 80-90%. The detoxified castor cake was incorporated in sheep diet as sole protein source without any adverse effect. However, the detoxification technology has to be scaled up to commercial level.

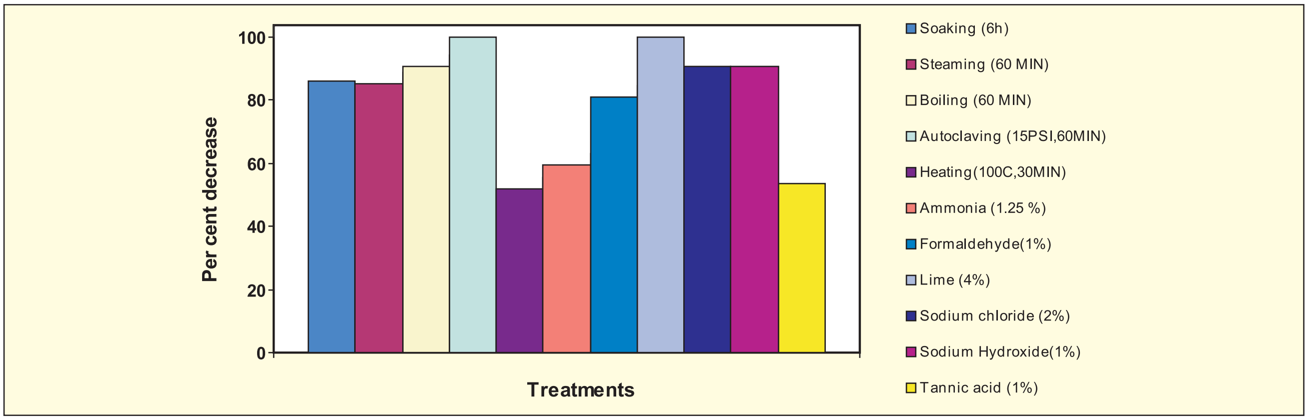


Fig 3: Effect of physical and chemical treatments on removal of ricin from castor cake

Aflatoxin in Animal and Poultry Feeds

Aflatoxin development in poultry and animal feeds during storage has become a major health hazard in the country. This problem is particularly severe in parts of the country where high humidity exists during storage. To evolve cost effective control measures which can be adopted at the farmers level, various strategies have been tested at Bangalore, Hisar, Hyderabad and Guwahati for different types of feeds. Previous results indicated that chicks are highly sensitive to aflatoxicosis and a survey revealed that aflatoxin contamination of oil meals is one of the major constraint in its export. More than 50% of the samples stored under ambient conditions were found to contain an average aflatoxin content of 168 ppb. Neem bark extract 10% and propionic acid @ 0.1 to 0.5% were found to be effective low cost treatments to counter aflatoxin development in the feeds. During the year, further studies were carried out with an expanded list of chemical and herbal agents and also the possibility of countering the aflatoxin caused effects through dietary supplementation.

Incorporation of citric acid (0.2% w/v) among the chemicals and neem bark powder (1%) among herbals were found to be the most potential low cost measures to counter aflatoxins in the feeds by achieving 90 and 85% control, respectively (Table 13).

Dietary inclusion of *Spirulina*, furazolidone and esterified-glucomannan (0.05 to 0.1%) partially alleviated the adverse effects of aflatoxin on commercial broiler chicken. Fortifying the broiler diet with higher levels of methionine (0.8%) could totally counter the ill effects of aflatoxin on various performance and health parameters. This could emerge as an important strategy to minimize the

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

Table 13: Effect of various chemical and herbal agents on aflatoxin content in feed during storage					
Chemical agent	**Concentration (%)**	**Aflatoxin content at 28 days (ppm)**	**Herbal agent**	**Concentration (%)**	**Aflatoxin content at 28 days (ppm)**
Propionic acid	Control	60.16	Neem bark powder	Control	75.64
	0.04	31.36 (47.9)		1	10.93 (85.5)
	0.2	27.08 (55.0)		2	8.83 (88.3)
Sodium benzoate	Control	67.30	Annona seeds powder	Control	53.02
	0.04	35.20 (47.7)		1	43.04 (18.8)
	0.2	29.97 (55.5)		2	39.32 (25.8)
Citric acid	Control	35.08	Neem seeds powder	Control	54.67
	0.04	4.62 (86.8)		1	43.44 (20.5)
	0.2	3.56 (89.9)		2	42.38 (22.5)
Benzoic acid	Control	38.23	Rai seed powder	Control	52.43
	0.04	16.54 (56.7)		1	38.39 (26.8)
	0.2	11.54 (69.8)		2	37.44 (28.6)
			Neem leaves powder	Control	51.78
				1	42.59 (17.8)
				2	39.09 (24.5)

Figures in parentheses indicate per cent reduction in aflatoxin over control.

aflatoxin problem on animals and poultry cost effectively.

Improved Harvester for Safflower

Safflower harvesting involves lot of drudgery due to spines and became a major cause for steady decline in area under this crop. Efforts were made to develop an efficient harvester which can be used for harvesting safflower in sole/intercropping and related crops in the safflower growing areas. The model (Model 1) developed during 2001 was extensively tested in Raichur and Gulbarga districts of Karnataka and found quite acceptable to the farmers. During the year, an improved model (Model

Multi-crop safflower harvester with collection tray

Discharging the safflower crop by lifting the tray

2) was designed and field tested in two villages of Raichur district. The performance of the machine was also compared with manual harvesting.

An additional attachment of a collection tray was fitted to the right side of the multi crop harvester to collect the harvested crop at the delivery end and avoid labour in collecting the crop. The field capacity of the harvester was 0.1351 and 0.1586 ha/h with tray and without tray attachment, respectively while a manual (sickle) labour could cover 0.0155 ha/h. The harvester with and without collection tray attachment could cover 8.7 and 10.2 times more area, respectively than manual sickle harvesting. Though the field coverage with improved model was marginally lower, the lower field losses more than compensated for this.

The cost of operation per hectare for harvesting safflower as an intercrop with the machine was Rs.638 and Rs.666/ha with and without tray attachment, respectively which was lower by 25.81 and 23.14% over manual harvesting. Data on comparative cost of harvesting by prototype II and the manual harvesting are given in Table 14. The saving in labour was also significantly higher (Fig 4). The breakeven point (BEP) for the harvester is 21.38 ha and 23.8 ha per annum with and without tray attachments, respectively and the pay back period is 3.14 years at an annual usage of 400 ha.

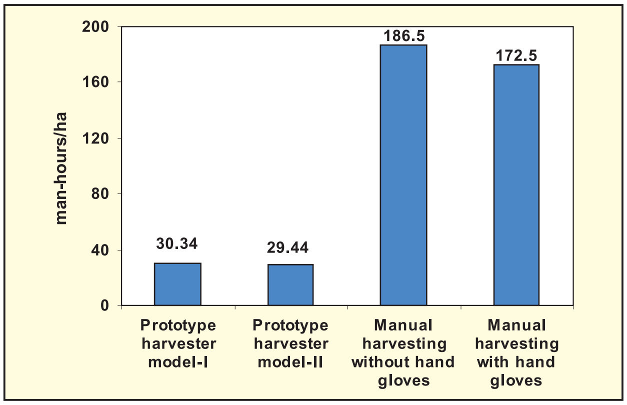


Fig 4: Average labour requirement with different methods of harvesting of safflower as sole crop

Table 14: Total cost (Rs/ha) of harvesting of safflower with prototype harvester model II in two villages of Raichur district

Particulars	Eklaspur	Manslapur	Mean
Machine harvesting with manual collection and heaping			
Normal Period	451	463	457
Peak Period	530	544	537
Manual harvesting with sickle with out hand gloves			
Normal Period	900	962	931
Peak Period	1499	1602	1551
Manual harvesting with sickle with hand gloves			
Normal Period	835	887	861
Peak Period	1391	1477	1434

Total cost includes cost of harvesting, collection and heaping.
Labour wages during normal period Rs.30/day and peak period Rs.50/day.
Unit cost of operation = Rs.63.19/hour

The push type harvester developed last year was further modified with reciprocating cutter bar and with pair of belt conveyors and star wheel assembly. The machine performed well except that the ground wheels need improvement for better traction in the fields with deeper and wider cracks and crevices. The field capacity achieved was 0.051 ha/h with a field efficiency of 85.3 per cent and field losses of 0.25 per cent.

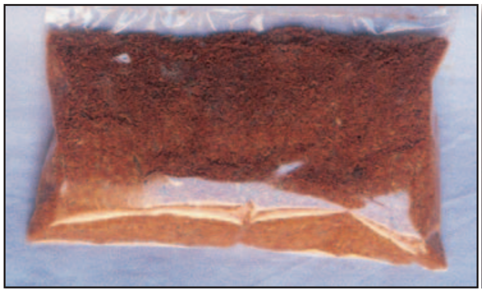
Value Added Products From Safflower

Safflower is an important oilseed crop grown largely in Maharashtra and few districts in Andhra Pradesh and Karnataka. The returns from this crop have remained low over the years due to stagnant productivity and lack of product diversification. Experiments during 2001-02 revealed the potential of different spiny and non-spiny varieties to produce petals yielding natural dyes. During 2002, further work in this area at CIRCOT and UDCT, Mumbai and MAU, Parbhani led to standardization of technique for extraction of yellow dye using enzymatic and fermentation methods. However, the colour retention with dye extracted with these methods was inferior to conventional extraction. Dyeing trials with 5 commercial varieties of safflower revealed that the intensity was maximum with JSI-7 (K/S value of 7.3) in case of yellow dye (Table 15). As with yield of petals, the non-spiny varieties fared better than spiny varieties for colour intensity also. *Bhima,* though a high yielding variety was found to be poor with a K/S value of just 1.3.

Table 15: Dyeing characteristics of different varieties of safflower

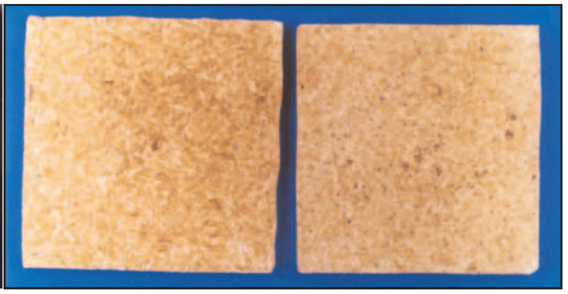
Variety	K/S values
JSI-7 (New)	7.3
NARI-6	5.2
JSI-103	5.4
Bhima (Spiny variety)	1.3
JSI-97	6.0

Toxicological and colour retention tests were carried out with different food items to asses the potential of these dyes as food colour. About 90 per cent colour retention was recorded for 2 months in food items with 1 per cent dye solution. Safflower petal powder was successfully incorporated in the preparation of bakery and dairy products, imparting an attractive yellow colour without adversely effecting texture and taste. Organoleptic evaluation gave an



Herbal tea from safflower petals

Safflower yellow dye adsorbed on calcium carbonate



Cardboards made from safflower stalks conforming to BIS standards acceptability score of 8.0 to 9.0. Phyto-chemical studies in different parts of safflower resulted in identification of novel alkaloids and steroids of pharmaceutical importance. Animal studies are in progress with different pharmacological preparations containing active chemicals derived from flower. Particle board and card board were prepared from safflower stalks through wet process without using any resin which confirmed to BIS standards. Efforts are under way to upscale the processes through private sector participation.

Analysis of Production Constraints in Major Oilseed Growing Districts

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

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

Specific constraints in adoption of inter cropping systems

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

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

- Lack of suitable seeding machinery for timely planting of intercrops in the recommended row ratios and geometry.
- Non inclusion of staple crop of the region in some of the recommended systems leading to lack of adoption by the farmers.
- Lack of awareness on the best intercropping system for that area and the non availability of seeds of the intercrop.
- Open grazing of the long duration crop after the harvest of first crop.
- Lack of proper INM and IPM recommendations for the system as a whole leading to realization of sub optimum yield potential.
- Lack of marketing facilities and remunerative prices to one or both of the intercrops, particularly if it is not a staple crop.

CHAPTER

4

Pulses Based Production System

Pulses are grown on about 23 m ha, predominantly under rainfed conditions. These crops are extensively grown in inter and sequence cropping systems all over the country under different rainfall and soil conditions. Pulse production has remained more or less stagnant for the last many decades. 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 the main constraints. In the pulse based production system, technologies and management practices in the areas of integrated pest management, IPNS and rain water management were evaluated on farmers fields in a cropping system perspective. Issues related to post harvest grain storage and by-product utilization have also been addressed.

Integrated Pest and Disease Management

Pests and diseases are major yield reducing constraints in pulse based production system. As a continued effort towards validation of IPM modules, 32 on-farm trials covering an area of 26 ha and 64 on-farm trials covering an area of 65 ha were carried out on chickpea and pigeonpea based cropping systems, respectively in 6 districts each. Additionally, germplasm evaluation for tolerance to major insect pests and diseases and performance of bio agents were examined. Chickpea cultivars like *Avarodhi*, JG 74, JG 130, JG 315, GBS 964, GBS 963, ICC 506 and black chickpea (*Gulbarga local*) exhibited moderate resistance to *H.armigera* and recorded significantly lower incidence of wilt caused by *Fusarium oxysporum* and root rot caused by *Rhizoctonia bataticola.* JSC 6 and JG 74 recorded least egg laying by the moths.

Intercropping was found as the most effective pest and disease management strategy under farmers condition. Considerably, lower pod damage and higher returns were recorded when chickpea was intercropped with mustard or safflower. A low cost technique for mass production of *Trichoderma* has been standardized and promising strains were identified based on field performance from local strains isolated at Kanpur and Bangalore. *Trichoderma* sp. was found compatible with *Rhizobium* and no adverse effect was found on nodulation with strains of *T.viride* or *T.harzianum*.

On-farm trials were conducted in 6 districts (Kanpur, Unnao, Gulbarga, Bidar, Sehore,

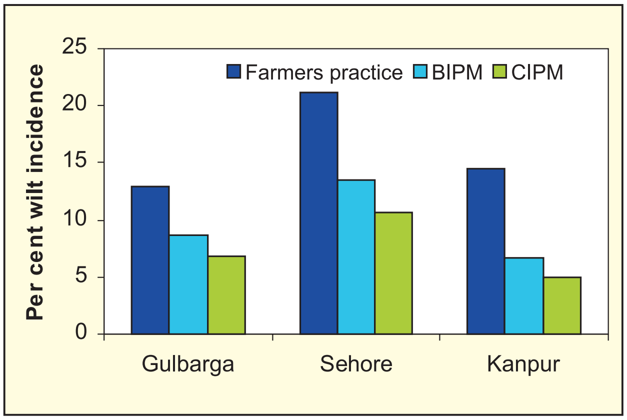


Fig 1: Effect of IPM modules on wilt incidence in chickpea on farmers fields

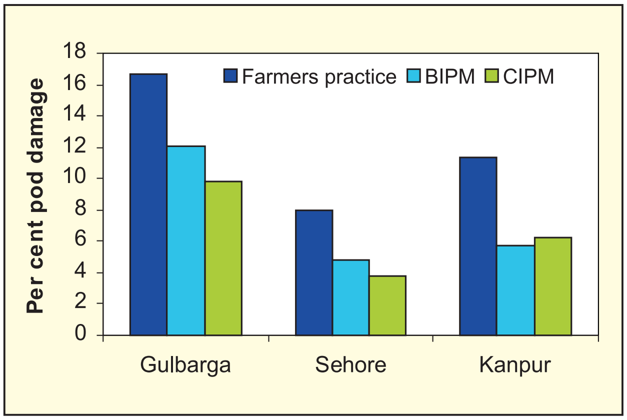


Fig 2: Effect of IPM modules on pod borer damage in chickpea on farmers fields

Hashangabad) of U.P, Karnataka and M.P with three treatments i.e. i) bio-intensive IPM (BIPM), ii) chemo-intensive IPM (CIPM) and iii) farmers practice (FP). Based on data from 10 locations in Gulbarga district, the wilt incidence was significantly lower in CIPM (6.82%) than BIPM (8.71%) and farmers practice (12.97%) and pod damage was 9.83% in CIPM, 12.02% in BIPM and 16.63% in farmers practice (Fig 1 & 2). Thus about 32.84% wilt could be avoided in BIPM and 47.41% in CIPM.

In Kanpur district, BIPM module was found better than CIPM. Pod damage under BIPM was 5.70%, 6.25% in CIPM and 11.39% in farmers practice. The wilt incidence under BIPM was 6.65%, CIPM was 4.95% compared to 14.51% under farmers practice.

The yield and economic returns from OFTs are presented in Table 1. At Gulbarga, a CB ratio of 1:2.66 was recorded in BIPM as against 1:6.46 in CIPM. Previous results at Gulbarga also showed the same trend where chemo-intensive module recorded higher cost benefit ratio, which is mainly due to high pest pressure in this area. At other centers too, CIPM showed marginal superiority over BIPM for C:B ratio. Therefore, further refinement of BIPM is required to make it more cost effective.

In pigeonpea, the focus was to evolve a cost effective package for control of pod borer. Besides testing the bio and chemo-intensive IPM modules in all the target districts, *Ha* NPV and *Trichoderma* strains were tested for field performance and compatibility with other components of the IPM. Among different treatments tried for controlling wilt and pod borer incidence, intercropping pigeonpea + sorghum (2:2 or 1:2) was found to be most effective. Sorghum intercropping reduced pathogen population in the soil by 58 % over sole pigeonpea.

Similarly, use of wilt resistant variety (*Maruti*), seed treatment with *Trichoderma harzianum* @ 10 g/kg seed effectively reduced the wilt in pigeonpea to 1.0 to 1.5%. Among

Table 1: Yield and returns of IPM modules on chickpea on farmers fields in 6 districts

Treatments	Yield (kg/ha)	Cost of cultivation (Rs/ha)			Gross returns	Net returns	CBR
		Common	On IPM component	Total	(Rs/ha)	(Rs/ha)	
Kanpur, Unno (12)							
Bio IPM	1862	5511	1730	7241	27930	20689	1:2.24
Chemo IPM	1812	5511	1505	7016	27315	20299	1:2.32
Farmers practice	1488	5511	—	5511	22320	16809	—
Sehore, Hoshangabad (10)							
Bio IPM	1625	4989	852	6343	24375	18032	1:1.37
Chemo IPM	1757	4989	1354	5841	26355	20514	1:2.70
Farmers practice	1496	5575	—	5575	22440	16865	—
Gulbarga, Bidar (10)							
Bio IPM	1320	2447	1450	3897	21120	19670	1:2.66
Chemo IPM	1436	2447	978	3325	22976	22131	1:6.46
Farmers practice	1053	1950	1040	—	16848	15808	—

Figures in parenthesis represent number of farmers

different entomo-pathogenic bioagents, insect growth regulatory chemicals tried on pod borer, bioagents proved superior to farmers practice, but are not as effective as chemicals. Diflubenzuron and *Ha* NPV were found to be most effective in these 2 groups based on the two years data (Table 2).

Based on OFTs in 3 districts, bio-intensive and chemo-intensive IPM modules were rated on par. However, BIPM module was more effective and economical where the pest load was low to moderate whereas, CIPM was effective under high pest load. To be more effective, the IPM modules have to be linked to the weather based pest forewarning systems.

At Gulbarga, highest C:B ratio was recorded with chemo-intensive IPM (4.10) followed by BIPM (3.47) and farmers practice (1.15) (Table 3). In Sehore, both CIPM and BIPM were found on par against farmers practice with the C:B ratios of 1.84, 1.78 and 1.36, respectively.

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

Table 2: Effect of entomo-pathogens and insect growth regulators on pod borer incidence in pigeonpea

Product	% Pod damage		Yield (kg/ha)	
	2001	2002	2001	2002
Diflubenzuron 1 kg	27	38	861	623
B.bassiana	26	70	805	41
N.releyi	—	65	—	47
M.anisople	—	64	—	45
Ha NPV 250 LE	25	48	832	556
Monochrotophos	26	62	811	104
No spray	32	90	679	0
CD at 5%	2.6	8.5	101	128

Table 3: Effect of bio and chemo-intensive IPM modules on pigeonpea + sorghum intercropping system on farmers fields

Treatment	Yield (kg/ha)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Gulbarga (20)					
Farmer's practice	719	11864	5522	6342	1.15
BIPM	1179	19454	4352	15172	3.47
CIPM	1324	21846	4282	17564	4.10
Sehore (22)					
Farmer's practice	1009	16147	6850	9297	1.36
BIPM	1296	20735	7450	13285	1.78
CIPM	1331	21292	7500	13792	1.84
Kanpur* (22)					
Farmer's practice	386	8790	7300	1490	1.20
BIPM	551	11265	10340	925	1.08
CIPM	624	12360	9100	3260	1.35

*Module evaluated under pod borer outbreak. Values in parantheses indicate number of farmers participated.

Pest infected (left) and protected pigeonpea with IPM (right) on farmers field in Kanpur

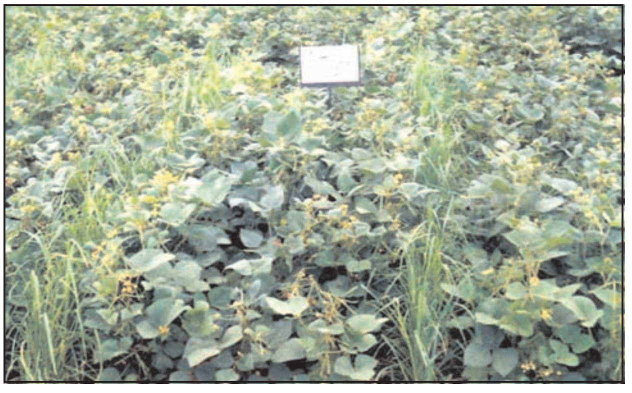
Control of Yellow Mosaic Virus

Yellow mosaic virus takes heavy toll in short duration pulses like mungbean and urdbean. An integrated package for controlling mungbean yellow mosaic virus (MYMV) was tried for the second year at 19 locations. The package consisted of resistant variety, seed treatment and intercropping. *Narendra Mung-1,* VGG-77, Co-6, TM-96-2 and PDM 84-143 in mung bean and IPU-94-1, ADT-5, *Vamban* 3, VBG 55, PU-30 and KU–300 in urdbean were found most effective against MYMV across locations.

At Vamban in Tamil Nadu, seven row boundary crop of fingermillet/sorghum around mungbean or urdbean and seed treatment with Gaucho followed by spray with imidacloprid after 30 days were the other components of the integrated package, At Berhampur, seed treatment with imidacloprid, inter cropping with fingermillet (3:1) and spray with imidacloprid at 5ml/l after 30 DAS resulted in significant reduction of viral infection. The yield increase in integrated package over sole crop in var. *Dhauli* was 13% and var. TARM-1 was 16% at Berhampur. Overall, integrated virus management package has found high acceptability with farmers in OFTs in mungbean.

Nematode Control in Pulse Crops

In an integrated project on control of nematodes in pigeonpea and chickpea based cropping systems at 8 locations in India, seed treatment with neem seed powder @ 5% w/w was found to be the most effective followed by soil application of neem seed powder @ 50 kg/ha, dimethoate @0.8% v/w, *Paecilomyces lilacinus* @10^8 spores/kg seed and latex of *Calotropis procera* @ 1% v/w. Highest seed yield of pigeonpea and lowest juvenile population of *Heterodera cajani* were recorded with seed treatment of pigeonpea with neem seed powder @5% w/w (Table 4). The population of *Heterodera cajani* in soil were also lower in treated neem seed powder plots as compared to chemicals. However, at 70 DAS latex treatment recorded lower population.



Crop stand of mungbean under farmers practice (left) and integrated management package (right) on farmers fields in Berhampur district of Orissa

Table 4: Biological and chemical methods of nematode control in pigeonpea in on-farm trials in 3 districts

Treatments	District	No of farmers	Seed yield (kg/ha)	Population of *Heterodera cajani*/200 cc soil	
				Cyst	Juveniles
Seed treatment with neem seed powder @5%w/w	Ghaziabad	10	1500	06	275
	Aligarh		1428	53	300
	Gulbarga		996	11	45
Latex of *Calotropis procera*@1%	Ghaziabad	10	766	11	450
	Aligarh		883	11	420
	Gulbarga		1034	20	52
Dimethoate 8ml/kg	Ghaziabad	10	667	16	725
	Aligarh		903	78	400
	Gulbarga		986	28	88
Soil application of neem seed powder @ 50Kg/ha	Ghaziabad	10	1400	09	425
	Aligarh		1524	52	160
	Gulbarga		896	22	52
Control	Ghaziabad	10	600	24	875
	Aligarh		417	94	350
	Gulbarga		670	20	112

In OFTs in Kanpur, chickpea plants with neem seed powder and latex treatment recorded higher nodulation and lower gall index as compared to diamethoate. Inter cropping of pigeonpea + pearlmillet tried in Aligarh district was not found effective in nematode control while pigeonpea + sesamum inter cropping (1:1) was quite effective in controlling both root knot and cyst nematodes in Dharwad district.

Integrated Nutrient Management in Sequence Cropping

Although, the advantages of INM have been adequately demonstrated in on-station research, the constraints and profitability under real farm situations have rarely been worked out. Moreover, the integration of INM with moisture conservation in a cropping system perspective has been lacking. In a net work project covering five major pulse growing districts in MP and UP (Bhopal, Raisen, Satna, Rewa and Hamirpur) yield and profitability of soybean-chickpea, soybean-lentil and paddy- chickpea cropping systems were worked out through 60 OFTs in 15 villages. In each of the farmers fields, five treatments were tested during *kharif* season; T1: Farmers' practice; T2: Recommended NPKZn; T3: 75% Recommended NPK + FYM @2.5 t/ha; T4: 75% Recommended NPK + FYM @2.5 t/ha + soil moisture conservation measure (SMC); T5: 100% recommended NPK + FYM @2.5 t/ha + soil moisture conservation measure.

Soybean–chickpea in Bhopal, Rewa and Satna districts of M.P and urdbean- chickpea in Hamirpur of U.P were found more remunerative under farmers conditions. In Rewa and Satna, 100% NPK + FYM 2.5 t/ha + SMC gave highest mean profit of Rs.19,297/- from soybean and Rs.17,635/- from chickpea in the soybean-chickpea sequence. However, in paddy-chickpea sequence, 100% NPKZn gave highest profit Rs.10,420/- from paddy (upland) and 75%+NPK+ FYM+SMC gave highest profit (Rs 17,784/-) in chickpea.

Highest mean profit of Rs.18,723/- under soybean-chickpea system was realized in T_4, which is significantly more over all other treatments, whereas in soybean-lentil system, the highest profit (Rs.12,209/-) was obtained in T_5, which was on par with other treatments except farmers practice (Table 5). In both the systems, nutrient management improved the net profit as compared to farmer's practice. With all nutrient management treatments, soybean-chickpea system returned higher profits than other systems under farmers conditions.

In a drought year, farmers could harvest 12-25% more chickpea and 15-28% more lentil through proper nutrient management in Bhopal and Raisen district. In Rewa and Satna, yield increased in chickpea by 60% over the farmer's practice.

Liquid Rhizobium Inoculant for Improved Shelf Life

Survival of adequate population of *Bradyrhizobium* has been a major constraint in carrier based inoculants in the country due to

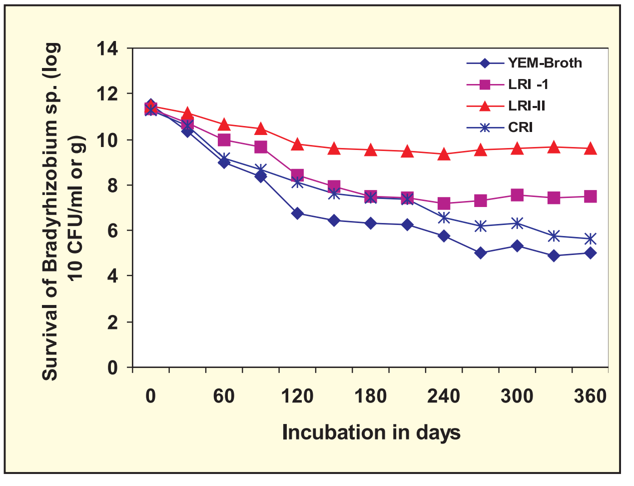
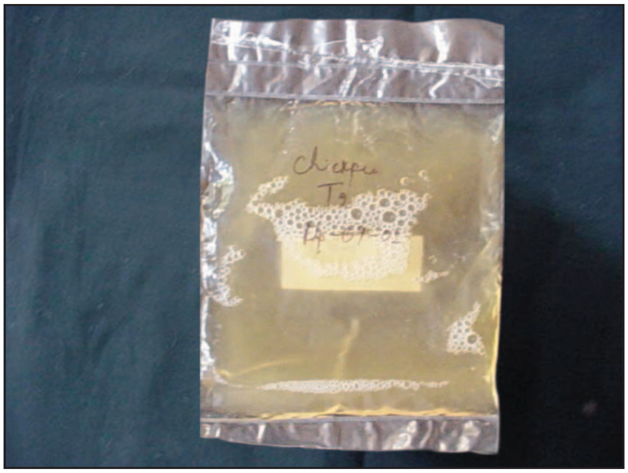


Fig 3: Effect of different inoculant formulations on the shelf life of *Bradyrhizobium sp.*

Table 5: Economic analysis of soybean-chickpea and soybean-lentil systems

Treatments	Soybean-Chickpea			Soybean-lentil		
	Cost (Rs/ha)	Profit (Rs/ha)	CB ratio	Cost (Rs/ha)	Profit (Rs/ha)	CB ratio
T1	15292	14720	1:1.96	13657	9690	1:1.71
T2	15912	16876	1:2.06	14277	11577	1:1.81
T3	16127	16561	1:2.03	14492	11306	1:1.78
T4	16177	18723	1:2.16	14542	11251	1:1.77
T5	16562	16456	1:1.99	14927	12209	1:1.82
CD (P=0.05)		1756	0.11	—	1344	0.09

*see text for treatment details



Liquid Rhizobium Inoculant

Liquid inoculant stored with wet paddy straw in a pitcher

contaminants and poor storage. In order to improve the shelf life, an alternative method of inoculant production i.e. Liquid *Rhizobium* Inoculant (LRI) was produced and its shelf life worked out. Previous results indicated the superiority of LRI over carrier based inoculant for shelf life and the field performance was on par. Studies during the year focused on further characterization of LRI during long term storage. When studied upto 360 days, LRI maintained significantly higher population of *Bradyrhizobium* over CRI (Fig 3). Among different

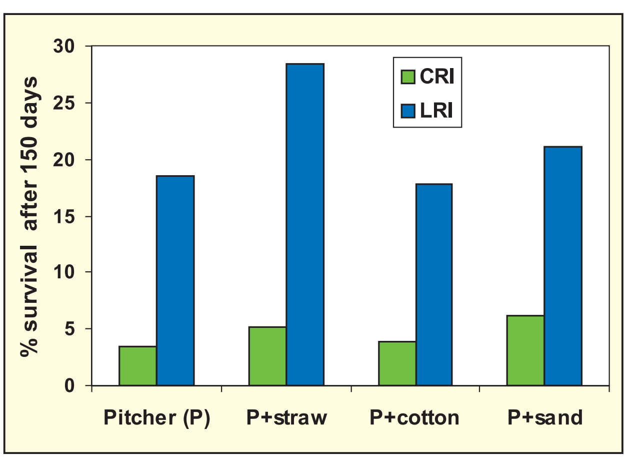


Fig 4: Survival of liquid and carrier based rhizobium inoculants under low cost storage methods

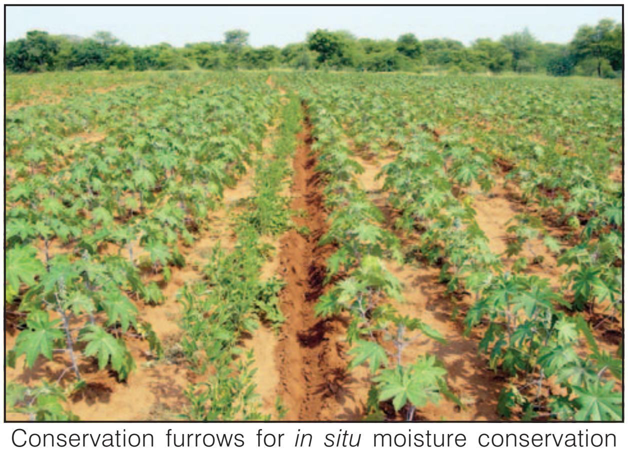
low cost storage methods tried, the best results were obtained when the liquid inoculant was stored with wet paddy straw in a pitcher (Fig 4).

Forty five on-farm trials were conducted during 2002-03 on groundnut, soybean, pigeonpea and chickpea in 7 states to assess the field performance of LRI. LRI performed better than carrier based rhizobium inoculant (CRI) in terms of yield in all four crops. The mean yield increase with LRI and CRI over uninoculated control was 17 and 7% in groundnut, 15 and 8% in soybean, 22 and 14% in pigeonpea and 12 and 10% in chickpea, respectively. There was an improved survival of rhizobia on seed when inoculated with LRI and higher nodulation compared to CRI.

In situ Moisture Conservation in Pulse Based Cropping Systems

Farmers have been using various indigenous moisture conservation practices (ITK) in pulse cultivation. The performance of such ITKs in comparison to improved recommended practices were evaluated in 107 on-farm trials in 7 districts viz., Nalgonda, Agra, Bijapur, Jabalpur, Mirzapur, Solapur and Kota on major pulse based cropping systems.

The advantages of moisture conservation practices were variable across locations depending on the rainfall. In Nalgonda district of A.P, which faced 55% rainfall deficit during *kharif* 2002, conservation furrows after 3 meter interval in pigeonpea+castor intercropping system recorded higher moisture storage through out the season and resulted in 12% higher yields of pigeonpea and castor over farmers practice. At Bijapur, the yield of pigeonpea was significantly higher (569 kg/ha) with deep ploughing + residue incorporation + conservation furrow than deep ploughing + residue incorporation (506 kg/ha) and cross ploughing by country plough (446 kg/ha). In Solapur district, which received 645 mm of rainfall in 19 rainy days as against normal of 722 mm, ploughing across the slope + conservation furrow at 90 cm interval + intercropping of sunflower and pigeonpea (2:1) recorded the highest soil moisture storage and seed yield of both the component crops (344 and 267 kg/ha, respectively) among all the traditional and improved moisture conservation practices followed. Planting of pigeonpea on ridges on medium lands recorded 13% higher yield over flat sowing in Mirzapur district. When conservation tillage was combined with ridge and furrow plantation the yield increase went upto 52%. The results across the centers showed that *in situ* moisture conservation measures help in realizing small but consistent yield gains under severe drought conditions both under semi-arid and sub-humid conditions.



Conservation furrows for *in situ* moisture conservation in castor + pigeonpea intercropping system on farmer's field in Nalgonda district, A.P.

Optimizing Returns From Pulse Based Intercropping Systems

Pulses are usually grown in intercropping systems which provides the much needed stability to small farmers. But often, optimum returns from recommended intercropping systems are not realized due to non adoption of package of practices aimed at maximizing returns from both component crops. Though several package of practices in pulse based inter cropping systems have been evolved, they have rarely been tested on farmers fields for their cost effectiveness. Hence, in a comprehensive project in 7 districts, nutrient, moisture and weed management packages have been evaluated as integrated crop management (ICM) package and compared with farmers practice (130 farmers). The over all results revealed that despite the higher costs on inputs and labour, adoption of ICM was more profitable than farmers practice (Table 6).

Table 6: Yield and profitability in pigeonpea and chickpea based intercropping systems on farmers fields with improved (INM+IWM+MC) and farmers practice

Target district	No.of farmers	Cropping system	Pigeonpea/ chickpea equivalent yield (kg/ha)	B:C ratio
Sehore	15	**Pigeonpea (PP)+ Soybean (2:4)**		
		Farmers practice	884	1.77
		PP + soybean (2:4) + RDF	1464	1.88
		PP + soybean (2:4) + 50% RDF + FYM 5 t/ha + biofertilizers	1535	2.01
		PP + soybean (2:4) + 50% RDF + FYM 5 t/ha + biofertilizers + pendimethalin @ 0.75 kg a.i./ha	1627	2.31
Ranchi	12	**Pigeonpea + Rice (1:5)**		
		Farmers practice	774	1.67
		ICS (RDF) + moisture conservation (MC)	1145	1.63
		ICS + MC +50% RDF + 5 t FYM/ha+ Biofertilizers	1151	1.73
		ICS + MCT + INM + IWM(Pendimethalin1.5kg/ha + one hand weeding (HW) at 45 DAS	1347	1.78
Gulbarga	20	**Pigeonpea + Sesamum (1:2)**		
		Farmers practice	1205	1.91
		PP + Sesamum (1:2) with 100% RDF	1437	2.26
		PP + Sesamum (1:2) with 50% RDF + FYM @ 5 t/ha	1627	2.08
		T_3 + Pendimethalin @ 1.5 kg a.i./ha + 1 HW (45 DAS)	1870	2.28
Kanpur	20	**Chickpea + Mustard (6:2)**		
		Farmers practices (inter/mixed cropping)	1123	2.14
		ICS + RDF	1627	2.01
		ICS + INM (50% RDF + 5 t FYM/ha + biofertilizer)	2057	2.26
		ICS + INM (as in T3) + IWM (Pendimethalin @ 0.75 kg a.i. + one HW at 40 DAS)	2537	2.33

ICS: Intercropping system INM : Integrated nutrient management IWM : Integrated weed management

In Sehore district, inter cropping of pigeonpea + soybean (2:4) with ridges and furrows, 50% RDF + 5 t FYM/ha along with biofertilizers and weed control (pendimethalin @ 0.75 kg a.i/ha) recorded highest pigeonpea equivalent yield of 16.27 q/ha with the B:C ratio of 2.31. At Ranchi, intercropping of pigeonpea + rice along with moisture conservation, INM and IWM recorded pigeonpea equivalent yield of 13.5 q/ha with B:C ratio of 1.78 and the yield levels with this package was 72 % higher over farmers practice. In Guntur, intercropping of pigeonpea + mungbean at 1:3 ratio with 100% RDF + moisture conservation recorded the highest net returns (Rs.8352/ha) as against farmers practice (Rs.6975/ha). In Kanpur, chickpea + mustard (6:2) + INM (50%RDF +

Recommended intercropping systems with best management practices (INM, SMC, IWM) on farmers fields : Pigeonpea + sesamum in Gulbarga district (left) and pigeonpea + mungbean in Guntur district (right)

FYM 5 t/ha + biofertilizers) + IWM (pendimethalin @0.75 kg a.i + one HW at 40 DAS) recorded highest chickpea equivalent yield of 2537 kg/ha with a B:C ratio of 2.33 over farmers practice (1123 kg/ha and 2.14).

Low Cost Technology for Safe Storage of Pulses

Stored grain pests in pulses cause up to 30% losses in farmers households mainly due to high moisture and improper storage conditions. In a network project in Tamil Nadu, Uttar Pradesh and Haryana, a number of storage structures and chemical/herbal measures were tested in farmers households to minimize the losses due to pulse beetle. Previous results indicated that simple devices like pit fall traps can be used by the farmers to detect the infection level and take corrective measures like drying the grain in the sun. During the year, different low cost storage structures and treatment methods were tested under farmers conditions.

Survey in Bhopal district indicated that majority farmers store pulses in gunny bags and traditional mud bins leading to 12 – 15% losses. An improved metallic bin was designed and compared with farmers traditional bins. Treatment of grain with 4% $NaHCO_3$ was also tested as a protectant. Very low infestation was detected for the samples stored in metallic bins (1.5%), particularly when treated with $NaHCO_3$. Pigeonpea grains could be safely stored upto 180 days with $NaHCO_3$ treatment in metallic bins as compared to 120 days in traditional bins. In Coimbatore district, the probe traps and pit fall traps were combined as a single unit and extensively tested in farmers households. The two in one model was found to be more effective in trapping the beetles.

In Kanpur district, inert materials like lime, cow dung ash, alum, soap stone, fly ash, river sand and activated charcoal powder and paddy straw ash were tested in different doses to control the bruchids in pigeonpea. Activated charcoal (3-6%) was found to be the best followed by lime and alum. Among different edible and non-edible oils tested, coconut, mahua and mustard oils (6-9%) were found to be effective against bruchid in pigeonpea. Annona seed powder and NSK powder (6-9 g/kg) were also found quite effective against bruchids in pigeonpea. In Hisar district, groundnut oil @ 3.75 ml/kg + turmeric powder @ 1.75 g/

Demonstration of Pitfall Trap to control pulse beetle under on-farm conditions in Coimbatore district, Tamil Nadu

kg, mustard oil @ 3.75 ml + turmeric powder @ 1.75 g/kg, neem oil @ 10 ml/kg and 7 cm sand covering on chickpea grain proved very effective in protecting from the infestation of pulse beetle *Callosobruchus sp*. upto 180 days. A simple method of solar drying on a improved floor mat/ covered with a black polythene sheet was designed and successfully tested at Hisar. With this technology, pulses could be stored upto 180 days.

Improved Dal Mill for Better Recovery

Dal milling is an important way to add value to pulses and improve the profitability to farmers. To improve existing dal mill in terms of better recovery, quality and to reduce energy consumption three different models of dal mills were upgraded and tested at Kanpur, Bhopal and Hyderabad. Previous results indicated that IIPR dal chakki was superior to CIAE and CFTRI models for key parameters studied. During 2002, the IIPR dal mill was modified to address some of the important defects detected earlier. Increasing the shaft diameter and the bearing width addressed the problem of uneven wearing of rubber discs. A pre-grader for raw grain, a grader for finished product, speed reduction unit were added to improve the utility of the mill. At CRIDA, a pulse grain pre-treater cum dal polishing unit was designed and fabricated to improve the marketability of finished product. At CIAE, Bhopal power operated cleaner/grader with a 400 kg/hr capacity has been fabricated. This cleaner contributes to low pollution inside the milling premises and maintains a healthy environment.

With upgradation of these dal mills, quality of finished product as well as working efficiency have improved significantly. Pre-milling treatment of pulse grain had also influenced the dal recovery and dehusking efficiency. Maximum finished

Modified IIPR dal mill (left) and dal polishing machine designed by CRIDA (right) product recovery for pigeonpea was obtained with oil and water treatment. So far, 180 IIPR Dal Chakkis have been sold to the farmers indicating the high acceptability of the IIPR model. As an entrepreneurship development effort, the existing dal mill with a farmer in Settur village of Anantapur district was modified to mill pigeonpea. With little modification of replacing the existing roller and providing an extra sieve set and a dal polisher, the farmer improved his income substantially. A comprehensive entrepreneurship development programmes under progress to popularize the modified versions of the dal mills.

Pulse By-products in Goat Production

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

At CIRG, Mathura, the kid starter ration made from 82 % by-product of pulses and oil seeds (redgram chuni - 30 parts, gram chuni-12 parts, til cake- 20 parts, linseed cake-10 parts, and mustard cake-10 parts) having 20% crude protein and 65% total digestible nutrients (TDN) resulted in maximum average daily weight gain (58 g/h/d) with minimum cost of feed/kg body weight gain (Rs. 29.76/-) when offered *ad libidum* along with redgram straw and available green fodder as compared to other feed combinations. Finisher ration containing 44 % by-product of oil seeds and pulses (linseed cake-12 parts, til cake-15 parts, redgram chuni-9 parts, gram chuni-8 parts) having 15 % crude protein and 75 % TDN offered @ 2% body weight to *Barbari* goats along with redgram straw *ad libdtum* and available green fodder @ 300-400 g/h/d produced 58 gm average daily body weight gain with a feed cost of Rs. 36.43/kg body weight gain and good quality meat and meat products. Good quality kofta could be prepared and can be stored upto 4 months from the meat of the animals fed on above finisher ration.

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

Feeding of goats with complete pelleted diets containing redgram straw

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

Agro Economic Constraints in Pulses Production

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

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

CHAPTER

5

Cotton Based Production System

In the cotton based production system, critical production constraints in rainfed areas were addressed. In view of the stagnant productivity, emphasis was laid on identification of genotypes for low input and moisture conservation on toposequences. *Desi* cottons received higher emphasis in breeding and adaptation studies. The other projects included integrated nutrient management and performance evaluation in soils with different depths and rainfall patterns. Genotypes tolerant to saline and sodic conditions were evaluated on farmer's fields. The significance of gossypol content in cotton germplasm was examined.

Performance of Quality *Arboreums*

Tetraploid *hirsutum* cottons currently occupy 72% of the cotton growing area leaving 28% under *desi* cottons. However, steadily increasing cost of cultivation of *hirsutum* hybrids has been posing problems to cotton growers particularly in rainfed areas. In a network project in central and south India, the performance of *arboreum* (*desi*) varieties was evaluated extensively on farmers fields for yield and fibre quality in comparison to the popular *hirsutum* varieties and hybrids. Previous results indicated either on par yield or marginal superiority of *arboreum* varieties over *hirsutum* and intra-*hirsutum* hybrids at several locations tested.

The trials were continued during this year with 26 OFTs covering 10 ha in 4 states. The yield and quality parameters of promising *arboreum* cultivars based on previous years data were compared with the locally predominant hybrids. Based on the OFTs in 6 districts, the quality *arboreum* strain PA-255 recorded highest seed cotton yield of 1137 kg/ha followed by DLSA-17 (1072 kg/ha), PA-402 (1039 kg/ha) and MDL-2463 (1032 kg/ha.) The per cent increase for seed cotton yield ranged from 40.2 (MDL-2463) to 54.4 (PA-255) over local *hirsutum* checks from 37.6 to 51.6 over local h x h hybrids and from 14.2 to 25.9 over *Bunny*, a leading private sector hybrid (Table 1). The performance of quality *arboreums* was either on par or marginally superior to the *Bt.* cotton *Mech*-162 during 2002-03.

Another major concern for *desi* cottons has been the lower price fetched in the markets due to quality problems. The improved *arboreums*

Table 1: Performance of *arboreum* varieties in comparison with *hirsutum* varieties and hybrids on-farmers fields in 6 target districts (Figures in parentheses represent the number of farmers)

Variety	Seed cotton yield (kg/ha)						Mean
	Parbhani (4)	Nagpur (5)	Khandwa (5)	Dharwad (3)	Kovilpatti (4)	Adilabad (5)	(26)
PA-402	1960	766	1602	745	361	805	1039
MDL-2463	1817	766	1121	812	436	1240	1032
DLSA-17	1527	869	1232	815	-	920	1072
PA-255	1855	810	1959	686	443	1069	1137
Local Arboreum check	1520	605	1664	686	345	1195	1002
Local Hirsutum check	1235	439	960	756	297	731	736
Hirsutum hybrid check	1627	602	485	755	292	742	750
Bunny	1720	606	268	902	-	1020	903

Diploid cotton: No sprays for sucking pests and 0 to 2 sprays for bollworm control. Tetraploid cotton: 2 to 3 sprays for sucking pests and 4 to 6 sprays for bollworm control.

developed in the project showed on par quality parameters with the *hirsutum* varieties/hybrids for span length, fibre strength and micronaire (Table 2).

Table 2: Fibre properties of quality *arboreum* (DLSA-17) in comparison with *G.hirsutum* variety (CPD-431) grown on farmers fields in Dharwad district.

Variety	GOT (%)	2.5% span length (mm)	Micronaire	Strength (g/tex)	Uniformity ratio (%)	Seed Index (g)
DLSA-17	37.2	27.0	4.50	22.8	49.5	7.2
CPD-431	37.3	26.3	4.30	19.7	49.5	9.6

Comparison of DLSA-17 (*G. arboreum)* and DHH-11 (Hybrid) on farmers fields at Dharwad, Karnataka

PA-255, an improved *arboreum* variety on farmers fields in Parbhani, Maharashtra

The cost of cultivation of *arboreum* cottons was low compared to the *hirsutums* as a result of which the BC ratios with *arboreums* were 1:2.87 as compared to 1:0.9 for *hirsutum* hybrids/ varieties. Thus the higher monetory benefit and ecological advantage of lower pesticide use justifies promoting *arboreum* cottons in rainfed areas, since these varieties have greater tolerance to abiotic stresses and possess comparable fibre quality with hybrids.

Indigenous Germplasm from NEH Region

A number of indigenous cotton cultivars of *G.arboreum* and *G.barbadense* are grown by local farmers on hill slopes in north eastern states since long time. 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 valuable germplasm is being lost. At AAU, Diphu an effort was made to collect and characterize indigenous cotton germplasm of north eastern hill (NEH) regions.

Thirty five indigenous cotton germplasm were collected from various cotton growing areas of NE region. Out of these, 24 were *arboreum* cottons and 11 were *barbadense* cottons.

Eighteen *arboreum* lines were evaluated during *kharif* 2002-03 for quantitative traits like days to flower, plant height, number of bolls per plant, boll weight and seed cotton yield. The maximum plant height was recorded in *Garo Kil-1* (204.7cm) and *Phelo Chapong* (191.7 cm). Number of bolls/plant was maximum in *Phelosaw-1* (17 bolls). Maximum boll weight was recorded in *Phelopisa* (3.33g), *Garo-1* (3.30g) followed by *Garo Kil-2* (3.23g). Seed cotton yield was maximum in *Karbi* (646.7 kg/ha).

Significant differences were recorded among the *barbadense* cultivars also for the traits studied (Table 3). *Phelopi-1* showed maximum plant height

Indigenous *arboreum* cotton germplasm of north eastern India, *Garo 1* from Meghalaya and *Karbi* from Assam

Table 3: Mean performances of ten *barbadense* cultivars for various quantitative traits during 2002-2003 at Diphu, Assam.

Sl. No.	Accession No.	Cultivar	Plant height (cm)	Branches/ plant	No. of bolls/ plant	Boll weight (g)	Seed cotton yield (q/ha)	Ginning per cent
1	AAUBC 01201	Phelopi-1	239	12.67	58	2.01	11.77	31.61
2	AAUBC 01202	Phelopi-3	203	10.67	40	2.58	10.63	24.38
3	AAUBC 01203	Phelo Cheng Cheng-1	219	11.00	54	2.01	11.60	29.89
4	AAUBC 01204	Phelo Cheng Cheng-2	179	6.00	35	2.44	6.23	24.12
5	AAUBC 01205	Fellopi-1	180	6.33	33	2.23	6.15	29.33
6	AAUBC 01206	Phelokangther	188	6.33	41	1.80	5.50	25.83
7	AAUBC 01207	Phelosaw-4	205	8.67	38	1.63	7.88	32.37
8	AAUBC 01208	Karbi-Phelo-2	213	7.33	40	2.03	7.20	32.46
9	AAUBC 01209	Fellopi-2	226	13.00	47	2.61	13.42	24.96
10	AAUBC 01210	Phelo Chang Chang-3	200	6.33	32	1.69	5.90	29.44

(239cm) where as maximum number of bolls per plant was recorded in *Phelopi-1* (58/plant) exhibited the highest seed cotton yield of 13.42q/ha and ginning percentage was maximum in *Karbi-Phelo-2* (32.46%).

In indigenous *arboreum* cotton germplasm, leaf roller infestation was lowest in *Karbi*. The minimum whitefly population (whiteflies/5split cages) was recorded in *Karbi* and *Garo-1*. Minimum infestation of spotted bollworm was recorded in *Karbi* (8.40 and 6.90 on 80 and 100 DAS). The overall insect pest incidence was less in *Karbi* and *Garo-1*. Among *barbadense* germplasm, minimum leaf roller infestation was recorded in *Fellopi-2* (6.60 %).

Gossypol Content in Cotton Germplasm

Gossypol is an important bio-chemical in cotton seeds. It has toxic properties when present in the cake and oil, while in plant parts it offers protection from insects. In order to identify germplasm lines with high gossypol content which can be used in the breeding programme, an extensive analysis was carried out in different plant parts of more than 1000 lines. During 2001-02, the estimation method was standardized. Maximum content was found in seeds followed by flowers>bolls squares>leaves. Further, analysis during 2002-03 indicated high variability both among species and varieties within a species. *G.arboreum* collections had maximum gossypol content followed by *G.hirsutum* and *G.herbaceum.* Wild cotton species contained high gossypol content (Table 4). A data base for 300 samples has been prepared after repeat analysis which is likely to be useful for breeders for selecting lines with desirable range of gossypol.

Table 4: Wild cotton germplasm with high gossypol content

Germplasm line	Gossypol (%)
G.lobatum	3.2818
G.soudanens	3.8387
G.thurberi	3.2728
G.mariegalante	2.9443
G.trilobum	2.2618
G.palmeri	2.1275

Genetic Transformation of Diploid Cottons

Considering the growing importance of diploid cottons in rainfed areas, an effort was made to introduce insect resistant *Bt* genes in to diploid varieties through genetic transformation. To achieve this, a regeneration protocol for *G.arboreum* varieties like AKH-4, AKA-5 and RG-8 was standardized during the previous year and putative transformants were produced carrying the CRY 1 A(b) and CRY 1 A(c) genes. During the year, the transformed plants were subjected to further evaluation to confirm the gene integration by the protein assays through ELISA. The most successful gene expression was recorded in the variety RG-8. The seeds collected from these transformed plants are being evaluated

Transgenic diploid cotton variety
AKA-8401 with CRY 1A(c) gene

under field conditions. Based on encouraging results with few varieties tried, the newly developed long staple *arboreum* cottons evolved at UAS, Dharwad and MAU, Parbhani were also included for regeneration and transformation during the year. These include PA-405, PA-255 and PA-183. Among all the cultivars, percentage regeneration was higher (97.2) in PA-405 followed by RG-8 and AKA-8401. Putative transformants of RG-8 and PA-405 are currently being established in the soil.

Rain water Management on Toposequences

Optimum utilization of rain water through conservation and recycling is the key to successful cotton production in rainfed areas. On-farm trials in 5 target districts (Amaravati, Yavatmal, Belgaum, Guntur and Vadodara) in Maharashtra, Karnataka, A.P. and Gujarat were taken up for testing the runoff management methods on different toposequences in a watershed. On upper toposequence, ridges and furrow method of planting and intercropping with sorghum was compared with farmers practice. While on middle and lower toposequences, the harvested water was recycled for supplemental irrigation in the improved method vs. flat bed planting of sole cotton under farmers management. Earlier results indicated that ridges and furrows method of cultivation significantly helped in improved productivity particularly on upper toposequences. During 2002-03, OFTs on all the toposequences were continued involving treatments for water conservation and excess moisture management. Ten farmers were involved for each toposequence with average slopes of fields ranging from 2-5%. The salient results are:

- In upper toposequence *arboreum* species were found beneficial as compared to *hirsutums*. Inclusion of sorghum as an intercrop in *arboreum* cotton was found superior over sole *hirsutum* cotton.
- Cotton based intercropping systems were found superior over sole cotton in middle toposequence.
- In lower toposequence, cotton + soybean – chickpea sequence cropping was found economically beneficial as compared to sole cotton. Under cotton – chickpea sequence cropping, chickpea under irrigated condition was the next superior cropping pattern.
- In all the toposequences, moisture conservation measures such as ridges and furrows and contour sowing were found beneficial in conserving the soil moisture as compared to flat sowing.
- One or two supplemental irrigations from harvested rain water increased the yield and monetary returns by 50-75%.
- Intercropping of *hirsutum* cotton + mungbean / blackgram / soybean/ pigeonpea, 100% RDF + soil moisture conservation through ridges and furrows or contour planting increased the cotton equivalent yield and net returns significantly compared to sole cotton on sloppy lands.

Due to improved productivity, better economic gains were recorded by the participating farmers in all the target districts. To illustrate, the gross returns with improved management practices on the upper toposequence were Rs.27,990/ha as compared to Rs.10,375/ha with farmers practice in Yavatmal district. The returns were Rs.23,112/ ha and Rs.13,995/ha on middle toposequence and Rs.37,467/ha and Rs.12,024/ha on lower toposequences with improved management and farmers practice, respectively.

Improving Cotton Productivity in Salt Affected Soils

Rainfed cotton is grown in salt effected soils particularly in the states of Gujarat and Karnataka with significantly lower yields. Though technologies for rehabilitation of salt effected soils are available, these are quite expensive and beyond the means of dryland farmers. As an alternative, efforts have been made to identify tolerant cotton genotypes that can be grown in saline and sodic soils. On-farm trials were carried out in 4 districts (Koppal, Raichur, Surendranagar and Khargone) involving 67 farmers in 49 villages. Salt tolerant genotypes in both *G.arboreum* and *G.herbaceum* were tested along with local checks. Based on the on-station screening of genotypes during 2001-02, the best performing varieties were included in on-farm trials during 2002-03.

Two best varieties in each species were included in the OFTs on farmers fields with ESP ranging from 26-35 at Khargone (sodic); EC of 4-6 dS/m and ESP of 28-32 in Surendranagar (sodic) and EC of 3.82-5.20 in Koppal district (saline). In Surendranagar, *G.cot* 21 of *G.herbaceum* was found most promising, while *J. Tapti* of *G.arboreum* performed significantly superior over others in sodic Vertisols in Khargone district. RAHS-14 produced the highest seed cotton yield in saline Vertisols of Koppal district in Karnataka (Fig 1).

Data on economic returns in Koppal and Khargone district are given in Table 5. Significantly higher net returns and BC ratio

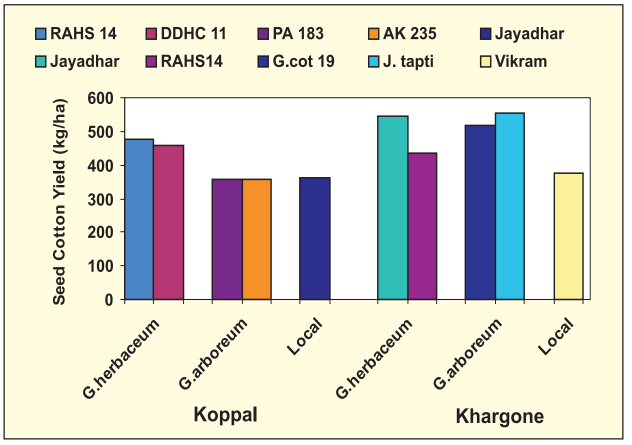


Fig 1: Performance of cotton varieties and species in salt affected soils

Table 5 : Yield and economic returns from different salt tolerant cotton genotypes in the on-farm trials in Koppal and Khargone districts

Genotype	Average yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Koppal, Karnataka			
RAHS-14	477	9779	2.35
DDHC-11	459	9410	2.26
PA-183	357	7319	1.76
AK-235	356	7298	1.75
Local check (Jayadhar)	362	7421	1.78
Khargone, M.P			
Jayadhar	544	11152	2.41
RAHS 14	434	8897	1.92
G.Cot 19	517	10599	2.29
J Tapti	554	11357	2.45
Local check (Vikram)	376	7708	1.66

Performance of RAHS 14 on farmers fields in saline Vertisols in Koppal district, Karnataka

Performance of of G Cot 21 in sodic Vertisols in Surendranagar district, Gujarat

were recorded with the tolerant varieties in both the districts as compared with local checks. The on-farm trials created high impact among farmers on the performance of salt tolerant genotypes and 50% of the farmers who are exposed during 2001-02 and 2002-03 were willing to adopt the tolerant varieties based on a survey in the target districts.

Tillage and Moisture Conservation Studies

Optimum tillage, moisture conservation and nutrient management are key to successful cotton production in rainfed areas. An effort was made to integrate these technologies and workout the cost benefit ratio on the farmers fields and study the soil health parameters. Seventy four on-farm trials were taken up in 28 villages of 7 target districts i.e Khargone, Khandwa, Raichur, Junagadh, Guntur, Tuticorin and Nagpur. The four treatments tried were: T_1 (conventional tillage (CT) + flat bed method (farmers' practice)), T_2 (conventional tillage + broad bed and furrow (BBF) + 100% RDF), T_3 (reduced tillage (RT) + BBF + 100% RDF + green manure (GM)), T_4 (reduced tillage + BBF + 100% RDF + green manure + deficient nutrient).

At all the locations, the treatment T_4 yielded the highest seed cotton, whereas at Khargone T_4 was at par with T_3. The seed cotton yield was 37% higher in T_4 over farmers' practice. 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 (farmers' practice) at most locations. The BBF along with green manure incorporation under reduced tillage treatments resulted in increased soil organic carbon content, soil moisture, porosity, mean weight diameter, infiltration and nutrient uptake. The above treatments also decreased in the bulk density, runoff volume and soil loss (Fig 2). At all the locations, the highest net returns/B:C ratio was recorded with BBF+reduced tillage + 100% RDF + green manure with the application of deficient nutrient (Table 6).

Table 6: Effect of tillage and nutrient management on seed cotton yield (kg/ha) at 7 locations

Treatments	Khargone	Khandwa	Junagadh	Tuticorin	Nagpur	Raichur	Guntur	Mean
T_1	960	975	533	543	589	475	1507	797
T_2	996	1063	622	605	739	561	1676	895
T_3	1150	1188	675	687	813	633	1745	984
T_4	1182	1370	752	705	884	689	1819	1057
CD (5%)	111	118	45	19		21	292	

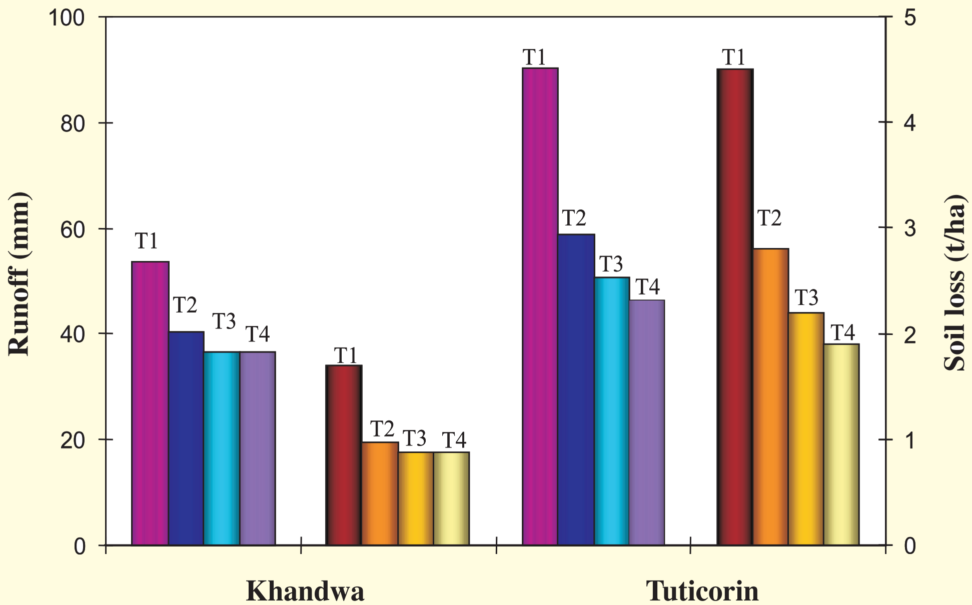


Fig 2: Runoff and soil loss in cotton on farmers fields with different tillage and land treatments

Optimising Nutrient Use

In an effort to enhance nutrient use efficiency by integrating with moisture conservation, a network project was taken up at 7 districts i.e. Dharwad, Belgaum, Kurnool, Parbhani, Nanded, Yavatmal and Amaravati where interaction of two moisture conservation treatments (ridge and furrow method and farmers practice) was tested with four nutrient management practices viz. farmers practice (T_1), RDF (T_2), soil test based NPK + 2 t FYM/ha (T_3) and T_3 + limiting nutrient and green manure (T_4). Trials were carried out both in shallow and medium deep Vertisols. A total of 122 on-farm trials were organized during the year involving *hirsutum* hybrids and *arboreum* varieties. At all locations except Dharwad, soil test based NPK + 2 t FYM/ha + limiting nutrient + green manuring (T_4) gave maximum seed cotton yield over all other treatments. The advantage of moisture conservation was significant only in shallow soils. Seed cotton yield

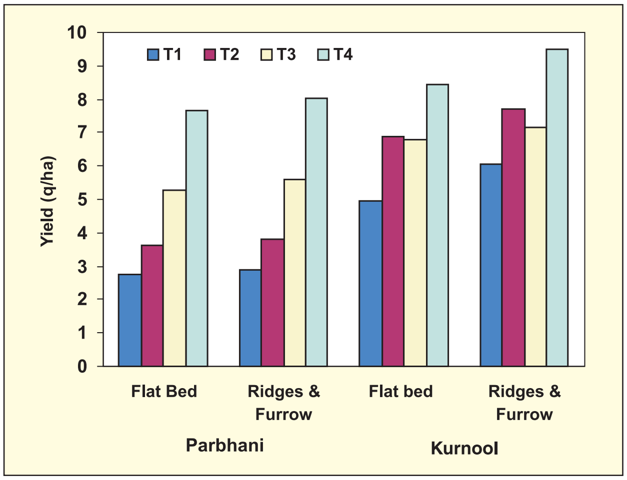


Fig 3: Effect of integrated nutrient management and land configurations on seed cotton yield on farmer's fields in two districts (n=40)

in the OFTs in Parbhani and Kurnool districts was maximum with T_4, which further improved with adoption of ridge and furrow method at Kurnool (Fig 3). At all the locations, ridge and furrow method of planting resulted in high moisture storage in the soil profile. Integrated nutrient management which included FYM and legume incorporation/mulching resulted in higher available N and P in the soil which resulted in higher seed cotton. Experience from two years of on-farm trials in the target districts showed that integrated nutrient management combined with ridge and furrow method of cultivation provides the much needed stability to cotton productivity, particularly in low rainfall shallow soil regions.

Ridge and furrow method of cotton cultivation on farmer's fields in Parbhani district

Impact of Soil Depth and Rainfall on Species/Varietal Performance

Although cotton varieties are released in different zones based on multilocational evaluation, the performance of varieties within a zone still exhibits high variability due to different micro farming situations of soil depth and rainfall. In a network project, the performance of different *arboreum* and *hirsutum* varieties was tested in 3 soil depths (shallow, medium and deep) and 2 rainfall situations (low and high) to understand the potential differences in yields and relate with the bio-physical constraints. Two hundred and twenty on-farm trials were conducted during the year covering 71 ha in 67 villages of 26 districts. The over all yield data revealed that there is a wide adaptability of *G.arboreum* genotypes to both high and low rainfall conditions. In shallow soil low rainfall, medium soil low rainfall situations in Karnataka, *G.herbaceum* recorded higher yields. Similarly, in medium soil high rainfall and shallow soil low rainfall situations of Gujarat, *G.herbaceum* varieties recorded higher seed cotton yield. The performance of inter specific hybrids were comparatively low except in medium soil high rainfall area. The depth of the soil had pronounced effect on seed cotton yield. Cultivated genotypes of *G.arboreum* species exhibited good response to higher availability of moisture by producing more yield in comparison with low rainfall situations.

In view of the results from the project, there is a need for reviewing the species and varietal choice for different cotton growing zones. The currently grown species under different micro farming situations of soil type and rainfall and the suggested choice based on the results from the project in different states is presented in Table 7.

Table 7: Current species choice of cotton in four states and suggested change based on performance under micro farming situations.

	Karnataka		Gujarat	
Situation	Species currently being used	Suggested choice based on OFTs	Species currently being used	Suggested choice based on OFTs
DH	HB & HH	G.arboreum HH & HB G.hirsutum	G.herbaceum, Hybrids	G.arboreum, G.herbaceum
DL	G.herbaceum, Hybrids (HH)	G.herbaceum G.arboreum	G.herbaceum, Hybrids G.arboreum	G.hirsutum, Hybrids, G.arboreum
MH	HB & HH	G.hirsutum, HB & HH G.arboreum	G.herbaceum, Hybrids	G.arboreum, Hybrids
ML	G.herbaceum, G.arboreum	G.herbaceum	G.herbaceum, Hybrids	G.arboreum, Hybrids
SH	HB	G.hirsutum HB and HH	—	—
SL	G.herbaceum	G.herbaceum, G.arboreum	G.herbaceum, Hybrids	G.arboreum, Hybrids
	Madhya Pradesh		**Maharashtra (Vidharba)**	
DH	G.hirsutum Hybrids	G.arboreum Hybrids	Hybrids	G.arboreum
DL	G.arboreum, G.hirsutum Hybrids	G.arboreum, G.hirsutum Hybrids	Hybrids, G.hirsutum	G.arboreum, G.herbaceum
MH	G.hirsutum Hybrids	G.arboreum Hybrids	Intrahirsutum	Hybrids
ML	G.arboreum, G.hirsutum Hybrids	G.arboreum, G.hirsutum Hybrids	G.arboreum Hybrids	G.arboreum
SH	G.herbaceum, G.hirsutum	G.arboreum, G.hirsutum	Hybrids, G.hirsutum	Hybrids, Intrahirsutum
SL	G.arboreum, G.hirsutum Hybrids	G.arboreum, G.hirsutum Hybrids	G.arboreum, G.hirsutum, Hybrids	G.arboreum

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

Characterisation of Cotton Production Zones

A comprehensive project on resource characterization of the cotton growing areas in 5 major states (A.P, Maharashtra, Karnataka, Gujarat and M.P) resulted in identification of major constraints in realizing optimum yields. The climatic and soil resources data for the above states has been digitized. Data from all India trials has been utilized for working out the relation between resource constraints and productivity. Crop suitability analysis for all states has been completed using spacially generated maps on soil and climatic parameters based on law of minimum criteria and summation. The suitability maps for A.P and Maharashtra are given in Figure 4. A methodology has been developed to predict the yields of cotton for a given district as affected by environmental and soil related constraints like droughts and floods using the WOFOST, a simulation model. With these tools, it is possible to identify appropriate interventions to improve the productivity in zones, which are moderately suitable.

Agro-economic Constraints in Cotton Production

The agro-economic characterization and constraints analysis of rainfed cotton based production system were carried out in 21 rainfed cotton growing district in 6 states covering 50 agro eco sub-regions. Ten districts were studied in detail and 11 for supplementary information. Suitability maps have been prepared upto tehsil level based on soil and climate data using GIS. The gap between the potential yield and actual yield realized by different categories of farmers were determined based on survey of 1410 farmers in 125 villages. The potential yield of cotton cultivars ranged

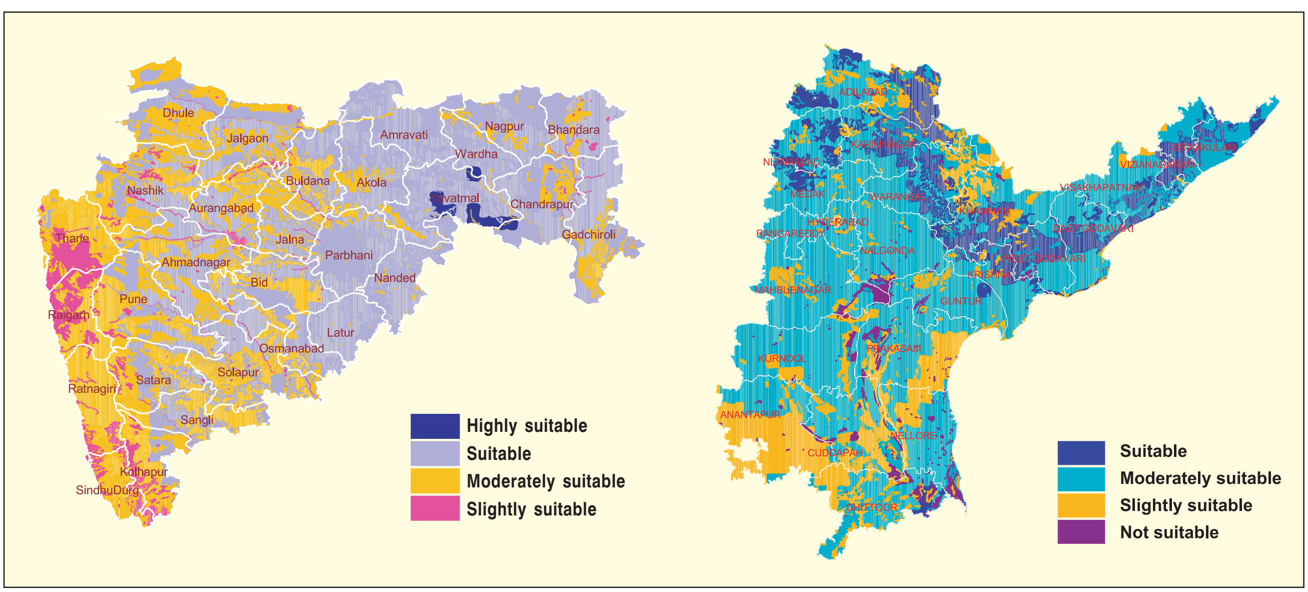


Fig 4: Climate & Soil suitability for cotton cultivation in Maharashtra (left) and A.P (right)

between 8 q ha^{-1} in Dharwad (cv *Jayadhar*) to 30 q ha^{-1} in Guntur (cv *Bunny*) (Table 8). The realized yields varied between 3.62 q ha^{-1} in Vadodara to 30 q ha^{-1}in Guntur.

Wide yield gaps were found in all major cultivars grown in different parts of the country. The relative yield gap as percentage of potential yield was highest in Vadodara (cv H-10) where, as much as 77 per cent of potential yield remains unrealized. The realized yields were closer to potential yield in Dharwad. No relationship between farm size and yield gap was found. The yield gap in the districts was related to soil and rainfall variation and socio-economic variables. Farm size,

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

Districts (AESR)	Variety	Potential yield (q/ha)	Farmer Category: Small Yield (q/ha)	Small Gap (q/ha)	Small % Gap	Medium Yield (q/ha)	Medium Gap (q/ha)	Medium % Gap	Large Yield (q/ha)	Large Gap (q/ha)	Large % Gap	Overall Yield (q/ha)	Overall Gap (q/ha)	Overall % Gap
Surendranagar (2.4)	0-13	14	5.92	8.08	57.71	4.87	9.13	65.21	5.68	8.32	59.43	5.49	8.51	60.79
	Devirnj	14	10.04	3.96	28.29	9.48	4.52	32.29	4.74	9.26	66.14	8.09	5.91	42.21
	H-6	15	5.92	9.08	60.53	9.14	5.86	39.06	8.05	9.92	66.13	6.71	8.29	55.26
Vadodara (5.2)	Digvijay	14	3.67	10.33	73.79	4.79	9.21	65.79	3.88	10.12	72.29	4.11	9.89	70.64
	H-8	15	3.74	11.26	75.07	7.68	7.32	48.80	4.04	10.96	73.07	6.60	8.40	56.0
	H-10	16	4.08	11.92	74.5	3.68	12.32	77.00	3.44	12.56	78.50	3.62	12.38	77.38
Khandwa (5.2)	H-8	18	10.20	7.80	43.33	9.25	8.75	48.61	10.20	7.80	43.33	9.88	8.12	45.11
	JKH-I	20	14.00	6.00	30.00	10.25	9.75	48.75	10.80	9.20	46.00	11.68	8.32	41.60
	Khandwa-2	16	9.11	6.89	43.06	9.20	6.80	42.25	12.50	3.50	21.88	10.27	5.73	35.81
	D-9	18	9.11	8.89	49.39	10.00	8.00	44.44	10.30	7.70	42.78	9.80	8.20	45.56
	Vikram	14	9.00	5.00	35.71	8.74	6.26	44.71	9.80	7.74	55.29	9.18	4.82	34.43
Khargone (5.2)	H-8	18	10.20	7.80	43.33	9.25	8.75	48.61	10.20	7.80	43.33	9.88	8.12	45.11
	JKH-I	20	14.00	6.00	30.00	10.25	9.75	48.75	10.80	9.20	46.00	11.68	8.32	41.60
	Khandwa-2	16	9.40	6.89	43.06	8.75	7.25	45.31	9.60	6.40	40.00	9.25	6.75	42.18
	D-9	18	9.11	8.89	49.39	10.00	8.00	44.44	10.30	7.70	42.78	9.80	8.20	45.56
	Vikram	14	9.00	5.00	35.71	8.74	6.26	44.71	9.80	4.20	30.00	9.18	4.82	34.43
Nanded (6.2)	NHH-44	18	3.81	14.19	78.83	4.88	13.78	76.56	5.91	9.09	67.17	4.86	13.14	73.00
	JK-2	15	-	-	-	8.12	6.88	45.87	9.00	6.00	40.00	8.56	6.44	42.93
	Rasi	15	9.88	5.12	34.13	3.76	11.24	74.93	7.90	7.10	47.33	7.18	7.82	52.13
Amravati (6.3)	Ankur-651	15	5.09	9.94	66.06	5.79	9.21	61.40	5.32	9.68	64.53	5.40	9.60	64.00
	NHH-44	14	4.96	9.04	64.57	5.51	8.49	60.64	5.29	8.71	62.21	5.25	8.75	62.50
	AHH-468	16	4.68	11.32	70.75	4.69	11.31	70.69	3.42	12.58	78.62	4.26	9.74	73.38
Yavatmal (6.3)	NHH-44	16	6.63	9.37	58.56	6.49	9.51	59.44	8.81	7.19	44.94	7.31	8.69	54.13
	Ankur-651	15	7.20	7.80	52.00	7.25	7.75	51.67	6.55	8.45	56.33	7.00	8.00	53.33
	H-8	15	6.07	8.93	59.53	5.11	9.89	65.93	6.13	8.87	59.13	5.77	9.23	61.53
Jalgaon (6.3)	Ankur-651	21	7.84	13.16	62.67	9.49	11.51	54.81	7.40	13.60	64.76	8.24	12.76	60.76
	NHH-44	20	6.60	13.40	67.00	8.13	11.87	59.35	8.81	11.19	55.95	7.85	12.15	60.75
	Bunny	21	8.39	12.61	60.05	7.16	13.84	65.90	10.08	10.92	52.00	8.81	12.19	58.05
Dharwad (6.4)	Jayadhar	8	5.10	2.90	36.30	5.40	2.60	32.50	5.60	2.4	29.40	5.40	2.60	32.8
Guntur (7.3)	Bunny	30	16.4	13.6	45.30	14.50	15.50	51.80	15.80	14.20	47.50	15.50	14.50	48.20
	Desi	12	7.6	4.4	36.70	8.2	3.80	31.70	9.10	2.90	24.20	8.30	3.70	30.80

potassium, pH, $CaCO_3$, Cu, Fe, pesticide use showed negative relationship with yield, while N, P, Zn, soil depth showed positive relationship. Cost of the seed has emerged as a major constraint in adoption of HYV among poor farmers. Poor price realization affects all categories of farmers. Based on productivity and profitability trends, cotton will continue to be major crop in all districts studied except Jalgaon and Guntur where it is likely to be partly replaced by more profitable crops like chillies.

Some recommendations that emerged from the study to improve cotton productivity

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

CHAPTER

6

Nutritious Cereal Based Production System

Nutritious cereals like sorghum, pearlmillet and fingermillet are staple crops for millions of poor people in arid and semi arid regions. These crops are highly adapted to drought conditions and are also the major source of fodder for livestock. However, in recent years the productivity and profitability have remained stagnant due to slow pace of adoption of improved technologies and poor market demand. Under PSR, therefore greater attention was focused on resource management problems to stabilize the yields during drought periods and identify the possibilities of crop diversification and value addition.

Changing Scenario of Nutritious Cereal Cultivation

There has been a steady decline in the area under *kharif* sorghum over the last three decades, despite substantial improvements in productivity through the introduction of HYVs. At all India level, significant replacement of *kharif* sorghum area took place with competing crops. In order to understand the reasons for this phenomenon, a district level critical analysis was carried out using the time series and farm survey data.

The results of the compound growth rate analysis on area, production and yield of *kharif* sorghum in 8 target districts of Maharashtra, Andhra Pradesh, Karnataka and M.P indicated that the area decreased in all states continuously. While Belgaum district in Karnataka still retained highest area of 75%, Khargaone in M.P retained only 4.34% of the previous area. Among other things, the area under *kharif* sorghum is determined by the pre sowing rainfall and the prices of the competing crops. The output/input analysis of sorghum (*kharif*) production revealed that 5 (Nanded, Khargaone, Indore, Belgaum and Dharwad) 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. Though the ratio was found more than one in some districts when compared to other competing crops, it was still less profitable.

Among the various strategies examined to increase the area under *kharif* sorghum, intercropping with pigeonpea has emerged as the most important strategy. This system could successfully compete with soybean in M.P and cotton in Maharashtra and Karnataka. Sole *kharif* sorghum even with the best productivity will not be able to compete with other crops in any of the states studied. In a related project, a comprehensive data base on sorghum (*kharif* and *rabi*) pearlmillet and fingermillet was developed between 1970-1988 for major growing areas in the country. The output/input ratios of these crops with that of the competing crops have been worked out. The major crops, which replaced sorghum, include pulses, maize, cotton, groundnut, castor and sunflower. A critical analysis of the dynamics of crop shift during the last three decades clearly brought out a need for diversification of the use of sorghum and other nutritious cereals into value added products (fodder, poultry feed and bioenergy etc.).

Enhancing the Productivity of *Rabi* Sorghum

Rabi sorghum is an important staple crop for millions of people in Maharashtra and Karnataka. Though there has been a steady decline in the area under *kharif* sorghum over a last three decades, the area under *rabi* remained more or less constant. The productivity also has not improved significantly. Unlike in *kharif*, HYVs did not make much impact on the productivity during *rabi*. Since *rabi* sorghum is grown with residual moisture, resource management becomes critical in enhancing productivity along with HYVs. Improved package of practices combining the best variety with resource management technology have been evaluated on farmers fields in 35 villages covering 7 districts. On-farm trials were conducted in Maharashtra (Solapur, Sangli, Satara), Karnataka (Bellary, Bijapur and Raichur) and A.P (Kurnool) which together cover two million ha area under the crop.

Integration of moisture conservation practice like compartmental bunding (CB) with other components is the key approach in these trials. Adoption of CB + INM increased the productivity in different *rabi* sorghum cultivars by 33 to 38% over farmers practice (Table 1). When this technology was combined with the best variety (CSV-216 R), the yield increase was 72, 51, 30, 75, 64, 46 and 49%, respectively in Bellary, Bijapur, Raichur, Kurnool, Sangli, Satara and Solapur districts respectively. The corresponding yield gain with CSH-15R was 63, 44,10, 63, 42, 29 and 40%, respectively over farmers practice. A combination of CB + INM + CSV-216R recorded the highest net returns (Rs.5131 per ha in Bellary and Rs.5049 per ha in Kurnool) compared with no CB + FP (Rs.2108 and 2589 per ha).

The drought during *kharif* 2002, left significantly lower carry over soil moisture to the *rabi* planting season at all the locations. There was a deficit of rainfall varying from 30-40% compared to normal. The crop also experienced stress from flowering to grain filling stage. This provided an

Performance of *rabi* sorghum on farmers fields with compartmental bunding + INM in Jath village of Sangli district, Maharashtra

Table 1: Performance of improved production technology for *rabi* sorghum on farmer's fields in 7 target districts (mean of 100 farmers)

District	Grain yield (kg/ha)							
	Improved production technology (CB + INM)			Mean	Farmers practice			Mean
	CSV-216R	CSH-15R	M 35-1		CSV-216 R	CSH-15R	M 35-1	
Bellary	1443	1364	1258	1355	950	884	837	890
Bijapur	1594	1525	1429	1516	1103	1060	1058	1074
Raichur	1867	1571	1564	1667	1476	1380	1433	1430
Kurnool	1461	1360	1284	1368	971	901	836	902
Sangli	1290	1115	1105	1170	934	845	787	855
Satara	1098	969	959	1009	840	790	750	793
Solapur	1683	1576	1492	1583	1334	1135	1128	1199
Mean	**1491**	**1354**	**1298**	**1381**	**1086**	**999**	**976**	**1020**

opportunity to test the performance of moisture conservation practices on farmers fields. From the OFTs in all target districts, participating farmers received significantly higher net returns, upto Rs.2000/ha with adoption of improved technology (Fig 1).

On-station trials on screening for drought tolerance at NRCS, Hyderabad showed significant differences in grain yield ranging from 1859-5094 kg/ha among different entries. CRS-4 (5094 kg/ha) exhibited best performance yielding 26% higher than check, M35-1 (4031 kg/ha).

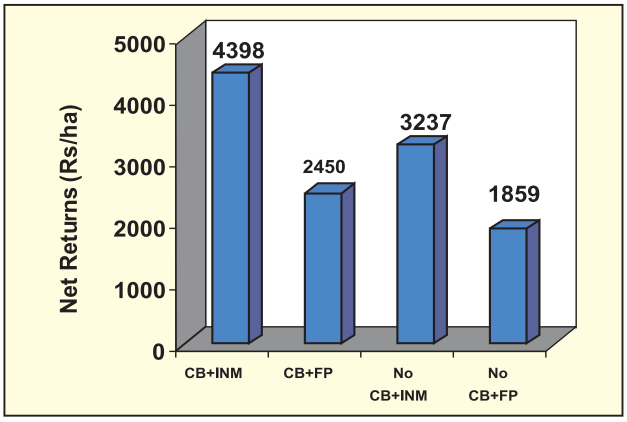


Fig 1: Net returns from imrpoved production technology for *rabi* sorghum (mean of Bellary & Kurnool districts)

Participatory Breeding for Dual Purpose Varieties

A comprehensive evaluation and selection of dual purpose sorghum was made in 8 districts (Surat, Bharuch, Indore, Dewas, Chittorgarh, Rajsamund, Jhansi and Hamirpur) in 4 states (Gujarat, M.P, Rajasthan and U.P). The entries were tested both under improved and farmers management. From 10 on-farm trials in Surat and Bharuch districts, CSV-15 scored high both for grain and fodder, whereas in Indore, SPV-1022 gave highest yield under farmers practice and CSV-15 scored better under improved practice. In Rajasthan, despite the severe drought during 2002, CSV-15 produced highest fodder yield among all the entries tested in Chittorgarh district. SPV-1388 and CSV-15 performed well in on-farm trials in Jhansi and Hamirpur. The fodder yield was significantly more in all varieties

Table 2: Performance of dual purpose sorghum genotypes with improved vs. farmers management in 5 districts

Location	Varieties	Fodder yield (q/ha)					
		Surat	Udaipur	Indore	Mauranipur	New Delhi	Mean
Improved	CSV15	95	98	94	111	92	98
Practice	SPV1022	78	71	84	111	90	87
	GJ39	71	91	65	128	72	85
	SU658	72	96	69	116	86	88
	SPV1388	72	79	-	117	89	83
	Local sorghum (Farmer's choice)	55	54	60	128	95	78
Farmer's	CSV15	73	71	111	105	73	87
Practice	SPV1022	53	51	89	104	73	74
	GJ39	53	62	73	120	57	73
	SU658	46	73	78	110	68	75
	SPV 1388	55	56	-	112	73	74
	Local sorghum (Farmer's choice)	39	41	59	121	79	68

with improved practice (Table 2). Overall the performance of CSV-15 was superior as it produced high fodder yield both under farmers and improved management. Socio-economic surveys indicated that dual purpose sorghum was more acceptable to the farmers than local sorghums. In general, plant type of 2 m height was preferred.

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

PFGS-97, resistant to shoot fly, stem borer and pyrilla — DJ 6514, shootfly susceptible check

In an effort to further improve the dual purpose genotypes, more than 1000 germplasm lines collected from all the centers were screened for yield and resistance to stem borer and pyrilla. PFGS-97 was found resistant to stem borer and pyrilla. This need further evaluation for agronomic potential. Seed treatment with imidacloprid @ 10 g/kg also effectively controlled the shoot fly in dual purpose varieties.

Moisture Conservation to Improve Pearlmillet Productivity

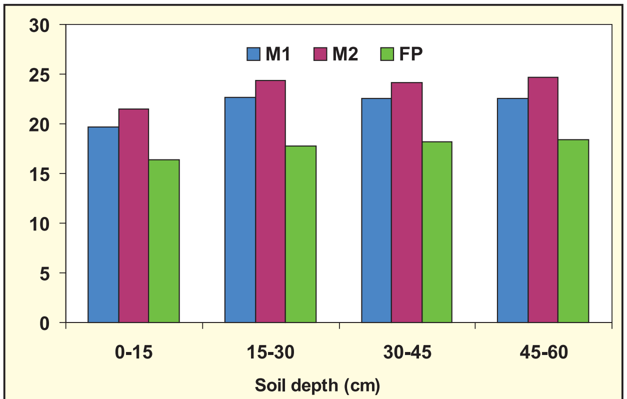
Pearlmillet is a staple crop for millions of people in arid and semi arid regions. Despite the introduction of many HYVs and hybrids, the yield gap between research stations and farmers fields remains high. The genetic potential of the improved varieties is not being realized under farmers conditions due to poor crop management. Therefore on-farm participatory research in Aurangabad, Dhule, Beed, Ahmednagar, Bijapur and Tuticorin districts was carried out where in recommended HYVs were evaluated under farmers practice and improved practice (moisture conservation + INM) in large plots of one acre. The treatments were finalized based on the on-station research carried out in the previous years.

During 2002-03, prolonged moisture stress caused a significant reduction in the yield in most target districts. However, improved management practices of moisture conservation + INM could improve the yields and produce significantly more over farmers practice. On farmers fields in Aurangabad and Beed districts, highest grain yield was recorded with paired row planting at 30/60 cm and opening of furrows in wider rows at 35 DAS over ridges and furrows with tied ridging. Similarly, INM treatment with 50% RDF + 2.5 t/ha of FYM + biofertiliser produced significantly higher yield over 100% RDF. Similar results were obtained in Bijapur district on relatively deep soils (Table 3). In Tuticorin district, highest grain yield and net income was realized with ridges and furrows + 50% RDF + 2.5 t/ha of FYM + biofertiliser. The increase in yield with this treatment was 43% over farmers practice. Both the conservation methods recorded higher moisture storage in the profile as compared to farmers practice (Fig 2).

Under arid conditions, where pearlmillet is an important crop, on-farm trials in Banaskantha and Jamnagar (Gujarat), Mahendragarh (Haryana), Jodhpur, Barmer, Sikar and Jhunjhunu (Rajasthan) clearly proved the advantages of wide row spacing during 2002 (a severe drought year recording more than 50% deficit in rainfall). In Rajasthan and Gujarat ridge and furrow after interculture (30 DAS) in wide row spacing (60 cm) with 50%

Table 3: Performance of moisture conservation technology in pearlmillet on farmers fields in Bijapur and Tuticorin districts

Treatment	Bijapur			Tuticorin		
	Grain yield (kg/ha)	Net returns (Rs/ha)	B.C. ratio	Grain yield (kg/ha)	Net returns (Rs/ha)	B.C. ratio
Ridges and furrows with tied ridging + 100% RDF	2000	4100	1.69	1806	6336	2.36
Ridges and furrows with tied ridging + 50% RDF + FYM @ 2.5t/ha + Bio-fertilizer	2200	5200	1.89	1988	7403	2.64
Paired row planting 30/60 cm with opening furrows in wider rows at 35 DAS + 100% RDF	2455	6375	2.08	1716	5696	2.24
Paired row planting 30/60 cm with opening furrows in wider rows at 35 DAS +50% RDF + FYM @ 2.5t/ha + Bio-fertilizer	2538	6890	2.18	1938	7103	2.57
Farmers practice	1000	2070	1.70	1387	3972	1.91



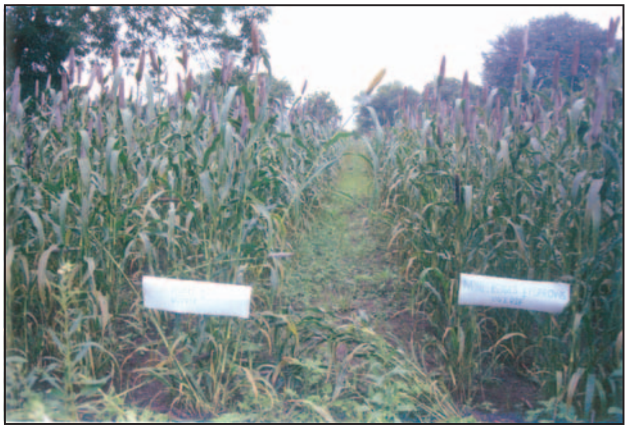
M1:Ridges and furrows with tied ridging; M2:Paired row planting at 30/60 cm and opening of furrows in wider rows at 30 DAS; FP:Farmers Practice

Fig 2: Effect of conservation practices on soil moisture content at tillering stage at Aurangabad

of recommended N through chemical fertilizers and 50% through organic manure was found most profitable and acceptable to the farmers, while in Haryana, both the moisture conservation practices were on par. In all the districts, mixed cropping of pearlmillet with clusterbean gave higher pearlmillet equivalent yield and net returns. This system offered more stability during low rainfall years.

On-farm trials in pearlmillet growing districts both in arid and semi arid zones clearly proved the value of moisture conservation

Mixed cropping of pearlmillet (ICMH-356) + clusterbean (RGC-936) on farmers fields in Banaskanta district



Effect of moisture conservation + INM on pearlmillet in farmers fields of Aurangabad district

technologies and its integration with suitable variety and INM for stabilizing the yields during drought years.

Enhanced Returns From Small Millet Based Cropping Systems

Fingermillet, kodomillet and littlemillet are generally grown in tribal areas in mixed cropping systems. The tribals in these areas suffer from malnutrition due to inadequate protein supply. Hence an attempt was made to introduce a variety of food legumes in tribal areas of Berhampur, Vizianagaram, Dharmapuri, Dindori and Bangalore rural districts through farmer participatory on-farm research. Both grain and vegetable legumes were tried in inter and sequence cropping systems. Despite the drought during *kharif* 2002 in target districts of Karnataka, Tamil Nadu and A.P, intercropping systems with legume component proved more beneficial to farmers. The trials also helped in identifying pigeonpea variety that gives maximum returns and also acceptable to farmers, such as UPAS-120 for Berhampur and Dindori, VPN-1 for Dharmapuri and LRG-30 for Vizianagaram.

Trials on 15 farmers fields in Magadi taluk of Bangalore rural district revealed that intercropping of fingermillet + field bean gave highest monetory returns of Rs.23,253/ha followed by fingermillet + pigeonpea (Rs.19,389/ha) and farmers practice (Rs.16,724/ha). In tribal villages of Berhampur, intercropping of fingermillet and pigeonpea (8:2) gave an additional 260 kg fingermillet grain

Kodomillet (DPS-19) and pigeonpea (UPAS-120), a promising intercropping system in Dindori district, M.P.

A view of ragi + pigeonpea intercropping in OFAR trial in Mudalapalya village, Bangalore rural district

Table 4: Yield and economics of intercropping systems on farmer's fields of Ganjam and Gajapati districts of Orissa, *Kharif*, 2002 (mean of 16 farmers)

Treatments	Grain yield (kg/ha)		Fingermillet grain equivalent yield (kg/ha)*	Gross monetory returns (Rs/ha)
	Fingermillet	Pigeonpea		
Fingermillet (FM) sole crop (farmer's practice)	1367	-	2013	10,063
Fingermillet + pigeonpea (8:2)	1180	182	2272	11,361

* includes straw value

equivalent yield over farmers practice. This fetched the farmer an additional Rs.400/ha. Data from OFTs in Ganjam and Gajapati districts of Orissa on fingermillet + pigeonpea intercropping system clearly represented this trend (Table 4). In Dindori district, the GMR was Rs.3205/ha with kodomillet alone while when inter cropped with pigeonpea (2:1) and blackgram it increased to Rs.8255/ha and Rs.8355/ha, respectively.

In Vizianagaram district, results from 18 farmers fields showed that fingermillet grain equivalent yield increased substantially due to inter cropping of pigeonpea than sole crop of fingermillet with RDF and farmers practice (Fig 3).

Based on the 3 years OFTs, fingermillet + pigeonpea intercropping in 8:2 row proportion was found to be most profitable both at research station and farmers fields in the target districts. By adopting this system, 1-1.5 lakh tons of pigeonpea could be produced additionally in these states. For southern Karnataka and parts of Tamil Nadu, fingermillet + field bean (vegetable/grain) system is another profitable option found acceptable

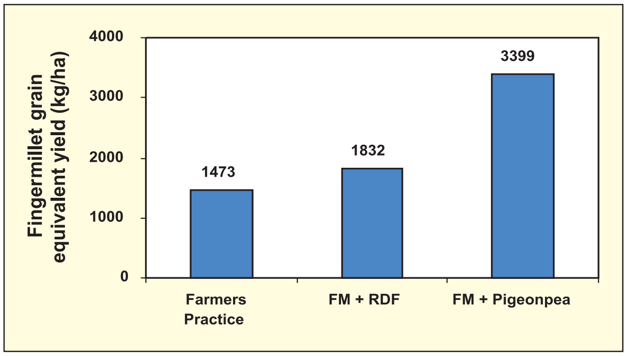


Fig 3: Yield of fingermillet (FM) and pigeonpea on farmers fields in Vizianagaram district, A.P.

to farmers. Similarly, blackgram as intercrop in kodo and littlemillet in Dindori district were most remunerative.

Integrated Blast Management in Fingermillet

An integrated package of blast management was tried on farmer's fields in Karnataka and Tamil Nadu in view its serious yield limiting potential in these states. The approach involves identification of resistant germplasm and seed treatment. From the evaluation of 150 lines during 2001, 56 were advanced for screening during 2002 and finally 11 lines were found most promising both for neck blast and finger blast resistance. The leaf cum cuticle thickness was higher in resistant genotypes. From large number of OFTs involving farmers vs. improved practice, a combination of improved variety with seed treatment emerged as the best option in all 4 districts of Karnataka and 1 district of Tamil Nadu (Table 5).

The gross benefit ranged from Rs.1672/- to Rs.7360/ha in Karnataka and Rs.5932/- in Tamil Nadu. A patho toxin, Pyrichalasin-H was purified and characterized from *Pyricularia grisea* for the first time in the world. This would help in further understanding the etiology and control measures for this important disease.

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

Rain water Management in Maize Based Cropping System

In order to achieve stability of production in the maize based cropping system during drought years, improved moisture conservation and INM practices were evaluated through participatory on-farm research in 5 major maize growing states of Rajasthan (Bhilwara, Udaipur), Punjab (Nawanshahr), M.P (Jhabua), Gujarat (Panchmahal) and A.P (Karimnagar). The severe drought of 2002 *kharif* provided ideal condition to assess performance of water conservation technology on

Table 5: Blast incidence and yield of fingermillet on farmers fields in Karnataka and Tamil Nadu under farmers vs improved management

Treatment	Kolar			Chitradurga			Chamarajanagar			Hassan			Dharmapuri		
	NB (%)	FB (%)	Yield (kg/ha)	NB (%)	FB (%)	Yield (kg/ha)	NB (%)	FB (%)	Yield (kg/ha)	NB (%)	FB (%)	Yield (kg/ha)	NB (%)	FB (%)	Yield (kg/ha)
T_1	11	12.5	1615	4.2	4.0	1390	4.6	1.6	1360	6.3	8.3	2360	5.1	10.5	1553
T_2	8.5	9.33	1657	0.5	0.5	1588	1.5	1.1	1540	1.0	3.0	2753	4.3	8.6	1618
T_3	0.17	1.08	3005	0	0.5	2035	0	0.6	1753	0.7	1.3	3586	2.0	4.4	2907
T_4	0	0.77	3055	0	0	2275	0	0.2	1803	0	0	4200	1.1	3.2	3036

NB – Neck blast; FB-Finger blast

T_1 Farmers variety + untreated seed

T_2 Farmers variety + seed treatment with carbendazim @ 2 g/kg seed

T_3 GPU-28 + untreated seed

T_4 GPU-28 + Seed treatment with carbendazim @ 2 g/kg seed farmers fields. The performance of crop under moisture conservation and INM was significantly superior to farmers practice across all the centers. The yield difference was more during 2002 as compared to the previous years. Data across the target districts revealed that the highest mean maize equivalent yield of 29.4 q/ha was realized with 100% INM + moisture conservation with legume intercropping (Table 6) followed by moisture conservation + INM. The importance of moisture conservation and balanced nutrition was quite evident at all locations.

The net returns also followed the same trend (Fig 4). The net returns and yields from lower toposequences were significantly higher compared to middle and upper toposequences which was mainly due to higher moisture storage in the profile upto 30 cm depth. The data further revealed that the role of *in situ* moisture conservation + INM is more important for upper toposequence. The higher yields of maize during the drought year were obtained mainly due to additional moisture available in the profile due to conservation measures.

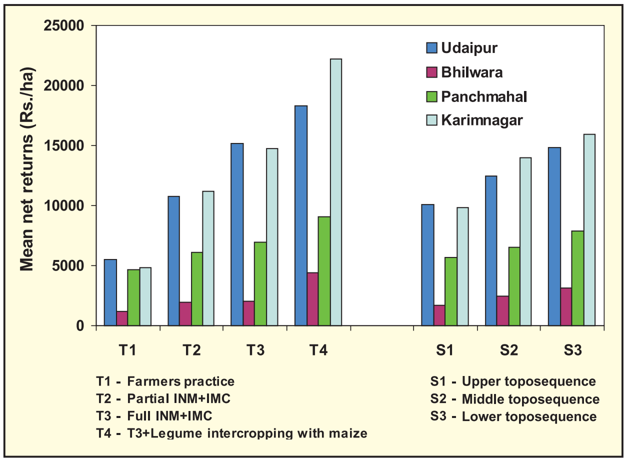


Fig 4 :Effect of moisture conservation and INM and toposequence on net returns from maize

Similarly, another net work project investigated the advantages of rain water management on watershed basis in relatively high rainfall areas of

Table 6: Effect of moisture conservation + INM and topo-sequences on mean maize equivalent grain yield on farmers fields in 6 target districts

Treatments	Mean maize equivalent grain yield (kg/ha)						
	Udaipur	Bhilwara	Nawanshahr	Jhabua	Panchmahal	Karimnagar	Mean
T_1	879	798	907	1122	1310	2395	1235
T_2	1827	1082	1043	1374	1567	3859	1792
T_3	2615	1204	1250	1679	1834	5288	2312
T_4	3136	1702	1883	2093	2007	6794	2940
S_1	1822	1095	1575	1168	1522	3904	1848
S_2	2123	1194	1348	1650	1654	4677	2108
S_3	2418	1301	890	1883	1861	5121	2246

T_1 Farmers practice
T_2 *In situ* moisture conservation with partial INM
T_3 *In situ* moisture conservation with full INM
T_4 T_3 + legume intercropping
S_1 Upper toposequence
S_2 Middle toposequence
S_3 Lower toposequence

Farmers practice

Moisture conservation + INM

Impact of moisture conservation and INM on maize in farmers field, Bhilwara district, Rajasthan

Himachal Pradesh (Johranpur), Uttar Pradesh (Siddarth Nagar), Haryana (Panchkuala), Punjab (Hoshiarpur), Bihar(Madhubani), J&K(Churgal Khanna). It demonstrated that watershed approach controlled soil and nutrient loss significantly by diversion and safe storage of water in ponds and also increased farmers income through crop diversification. The major highlights from this project are:

- Quantum jump in yield of wheat due to critical irrigations from harvested rain water. Wheat yield increased from 13.5 to 36.0 q/ha during *rabi* 2002.
- After implementation of the project, mean annual agricultural income per ha. in the watershed area increased from Rs.7,448/- to Rs.24,590/-.
- Availability of water resources motivated the farmers to adopt remunerative cropping sequences and alternative land use, which caused a major shift in cropping patterns. The area under maize-wheat cropping sequence came down from 91 to 48 per cent in 3 years (Table 7).

Table 7: Area under different cropping systems before and after the project in Johranpur watershed (20 ha), H.P

Cropping system	Before (1998-99)		After (2002-03)	
	Area (ha)	Per cent	Area (ha)	Per cent
Maize-wheat	15.0	90.0	8.0	48.5
Orchard	0.5	3.0	2.1	12.7
Tomato	-	-	1.0	6.1
Legume-wheat	-	-	2.8	17.0
Sorghum-mustard	-	-	0.6	3.5
Maize-mustard	-	-	1.0	6.1
Fallow	1.0	6.1	1.0	6.1
Total	**16.5**		**16.5**	

- The watershed societies provided a social platform for planning and management. Krishi Vikas Sangh – a watershed society at Johranpur in Solan district could successfully institutionalize the mechanism of storing the harvested rain water.

Constraints in Rainfed Maize Based Production System

A comprehensive study covering bio-physical and socio-economic constraints in maize based production system was carried out in 70 target districts in the country falling in M.P(21), Rajasthan (15), U.P(11), Orissa(6), A.P(5), Gujarat(3), Karnataka(3), Jharkhand(3) and Punjab(3). A critical analysis of the climatic and soil parameters, inputs, credit and marketing aspects was done to identify major constraints and opportunities for increasing the returns. Some important suggestions emerged are:

- Popularization of short duration composites and pulses as intercrops where duration of growing season is less than 105 days. There is a need for short duration hybrids suitable to such areas.
- Adoption and popularization of soil fertility based fertilizer recommendation at micro level.
- Establishment of maize processing units for value added products, especially in tribal areas of Rajasthan and Gujarat, to have an impact on livelihoods of these farmers.
- Small and marginal farmers invariably use lower inputs like fertilizers and pesticides. Better credit support will enhance input use by these farmers and result in higher productivity.
- Introduction of crop insurance programme in districts where the rainfall fluctuations are high.
- Maize should replace paddy in chronically water shortage districts.

Application of Remote Sensing for Mapping Natural Resources in Watersheds

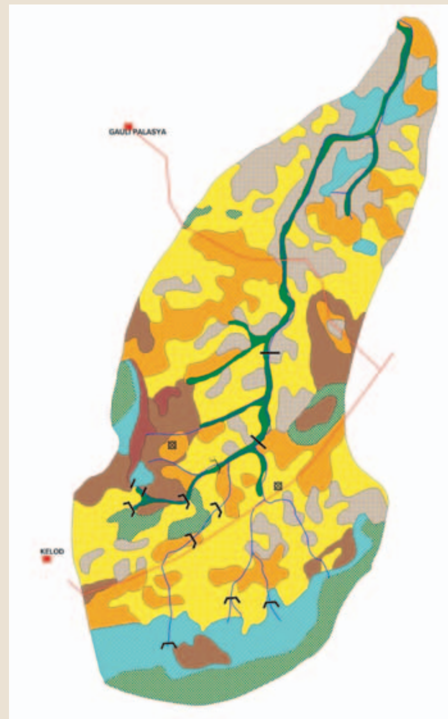
Watershed based land use planning is yet another key approach for development of rainfed areas. It involves survey and characterization of resources, identification of target areas, preparation of action plans and implementation. In view of the large and heterogeneous areas involved in the larger watersheds, considerable time and resources are required to prepare the action plans. In order to speed up this work and improve its effectiveness, a network project in 5 target districts of M.P, A.P, Maharashtra and Gujarat was takenup where remote sensing data from IRS-IC/ID (PAN and LISS-III) was utilized for mapping natural resources on a 1:12,500 scale and prepare action plans.

Micro-watersheds for prioritized land treatments were identified in 5 of the selected watersheds based on the maps prepared from the remote sensing data. The information on hydrogeology and other soil parameters were super imposed on the base soil maps and composite maps were generated containing all the information on the suitability and limitations of the areas for different land uses. During 2002-03 the action plans were prepared for prioritized areas within a representative micro-watershed in each of the

Map showing identification of critical areas and action plans in Gaulipalasiya Micro Watershed

Critical areas with identified problems

- Very shallow, Mod. Steeply sloping, severe erosion
- Very shallow, very gently sloping,moderate erosion
- Moderately shallow, very gently slopping, moderate erosion
- Deep, very gently sloping, moderate erosion
- Normal



Action plan for the critical areas

- Soybean, potato- wheat optimum use of fertilizer (N)
- Soybean / kharif vegetables- potato (N)
- Graded bunds :soybean – pigeonpea (4:2) soybean + jowar (P 3)
- Soybean / groundnut –potato/ gram/ linseed (P 3)
- Soybean / groundnut / maize / urd; contour cultivation (P 3)
- Silvipastoral system (P1)
- Silvi-horti system
- Straightening of natural water course and protection of banks
- Farm ponds
- Check dam
- Percolation tank
- Gully plug
- Road
- Settlement

selected watersheds in target districts. Successful implementation of these action plans and the impact created in terms of additional water resource generation and increased crop production clearly indicated that remote sensing data can be successfully used for watershed development projects at different stages like resource characterization and preparation of action plans. This approach considerably reduces the time and resources involved in the watershed development projects.

Carbon Sequestration Under Different Land Use Systems

Sustainability of agriculture, particularly in arid and semi-arid regions largely depends on the maintenance of soil quality over a long period of time. Soil organic carbon (SOC) is considered as the most important indicator of long term change in soil quality. Adoption of cropping systems and land use practices that result in net addition to the carbon stock in the soil has emerged as an important strategy for sustaining agriculture in fragile areas. A comprehensive project involving 28 bench mark sites in India to study the potential of different cropping systems and management practices in sequestering carbon revealed that the type of cropping system in a given location has a significant impact on the carbon sequestration. For example, intercropping systems involving legumes and non-legumes sequestered more carbon than sole crops. Forest ecosystem even under low management sequestered more carbon than arable cropping. However, under arable cropping high management (application of need based nutrients + addition of farm yard manure + crop residue incorporation) resulted in higher build up of carbon stock as compared to low management and farmers practice. The organic and inorganic carbon stocks under a horticultural land use system in Nagpur district of Maharashtra after 20 years of cropping are given in Figure 5.

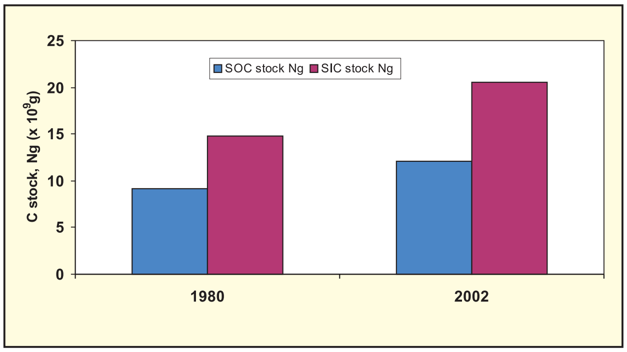


Fig 5: Changes in carbon stock over 20 years in 150 cm profile in horticultural land use system in Nagpur district

Improving Grain Quality in Sorghum

One of the reasons for the steady decline in area under *kharif* sorghum is the low grain quality due to deterioration caused by unseasonal rains. In a network project in 6 districts of A.P, Maharashtra, Karnataka, M.P and Tamil Nadu, the technology of artificial drying of grain after harvesting at physiological maturity was tried to increase the quality and market acceptability of *kharif* sorghum. Results during 2001-02 indicated the superiority of grain subjected to this technology, which fetched 30% more market price. During 2002, the incidence of grain mold was relatively low due to drought conditions. Therefore, the benefit due to higher market value was not significant during this year (Average additional market price was 9.4%). Based on the grain harvested during *kharif* 2001, which was severely molded, the artificial drying technology was tried at all the locations by using a ventilating dryer. The market price obtained for the dried grain was significantly higher (Table 8). The ventilating type drier can be owned by panchayats or farmers clubs at village level and can be supplied to farmers on custom hiring basis. About 131 q of sorghum grain has to be dried per year to recover the fixed cost of the dryer. Alternatively, a low cost drying technology was also tried by using tobacco barns through which the moisture content of the sorghum grain could be brought from 28% to 16% in 24 hours. Farm waste was used as the fuel. It took 24 hours to dry 2 tons of sorghum grain at an operational cost of 35 paise/kg of grain.

Economic analysis of the grain drying technology in Mahaboobnagar district indicated an incremental return of Rs.250 /q at a break even out put of 131 q/year. The cost of the drier was Rs.1,50,000 and the fixed and variable costs (18 tons capacity) were Rs.30,000 and Rs.3,875 per year, respectively. The life span of the drier was considered as 15 years.

Improving roti making quality by introduction of glutenin genes

In another project, an attempt is being made to improve the *roti* making quality of sorghum flour by incorporating glutenin genes from wheat into sorghum through genetic transformation. During the year, the high molecular weight glutenin proteins were isolated and characterized. The preparation of cDNA library of wheat is under progress in order to isolate HMW genes.

Table 8: Incremental returns to farmers by artificial drying of sorghum grain after harvesting at physiological maturity

Target district	Market prices for the year 2001-02 (Rs/q)		Additional returns (Rs/q)	Market prices for the year 2002-03 (Rs/q)		Additional returns (Rs/q)
	Harvested at physiological maturity	Harvested at normal maturity		Harvested at physiological maturity	Harvested at normal maturity	
Mahaboobnagar	551.39	301.39	250.00	460.00	420.00	40.00
Parbhani	405.28	269.72	135.56	512.50	482.60	29.90
Akola	399.72	241.94	157.78	472.00	426.00	46.00
Dharwad	-	-	-	545.75	504.75	41.00
Indore	-	-	-	412.50	358.50	54.00
Coimbatore	807.20	583.06	224.14	-	-	-
Mean	**540.90**	**349.03**	**191.87**	**480.55**	**438.37**	**42.18**

The operational cost for 100 hours is Rs.3876/-, which includes Rs.2988 for diesel, Rs.625/- for wages and Rs.263/- for power.

*During 2002-03, the incidence of grain mold was less and hence the price difference was not significant

Simultaneously, an efficient regeneration and transformation protocol was standardized for two varieties of sorghum (WB-4, M 35-1) to transfer the 1 A x1 glutenin gene by bombardment method using PDS 1000 gene gun.

Sorghum as a Raw Material for Bio-energy

Towards diversifying the use of grain sorghum, a comprehensive project was taken up to assess the potential of sweet sorghum as source of bio energy. It involved cultivar evaluation for biomass and juice extractability and estimating alcohol yield at laboratory and pilot plant level. Previous work pointed to high yield potential of 4 cultivars and economic viability at laboratory level. During the year, multilocation evaluation of cultivars revealed that NSS 104, RSSV 47 and NSS 208 were most efficient for cane yield and juice extractability. Based on trials at 6 locations (Hyderabad, Akola, Parbhani, Rahuri, Anakapalle, Phaltan and Virinjipuram), June and February plantings were found ideal for maximum biomass and high sugar content in sweet sorghum.

Linkages with the industry

Based on encouraging results from laboratory level studies, a pilot trial in collaboration with M/s Renuka Sugars at Munoli in Belgaum district was taken up for production of 95% ethanol from sweet sorghum juice. Two varieties (SSV 74 and SSV 84) and one hybrid (*Madhura*) were grown on 600 acres under rainfed conditions. One hundred and twenty five hectares located in 66 villages around the factory were covered with variety SSV 84 involving 157 farmers. The

SSV-84, a promising sweet sorghum variety

A 60 KL capacity fermentor used in pilot study on alcohol at M/s Renuka Sugars, Belgaum average cane yield was 25 t/ha and grain yield was 2 t/ha. The brix 18% which was brought down to 12% for fermentation. About 112 t of cane was used in a fermentor of 60 KL capacity. After 48 h of fermentation, the recovery of ethanol was approximately 9% of the juice. The bagasse produced was 46%, which was used for generation of electricity.

Following this success, M/s Praj Industries, Pune a leading firm in the area of alcohol fermentation also expressed their interest in taking trials on sweet sorghum, primarily to assess the possibilities of using of sweet sorghum cane in the lean season. NRCS supplied 40 kg seed of SSV 84 in February 2003, for collaborative trials. All India Distillers Association, New Delhi and M/s Seagram Distilleries, Maharashtra have also expressed interest in this area. The seeds of high starch (65-70%) hybrid suitable for *kharif* season were provided to All India Natural Distiller's Association, and state level associations in Maharashtra and Andhra Pradesh for preliminary trials.

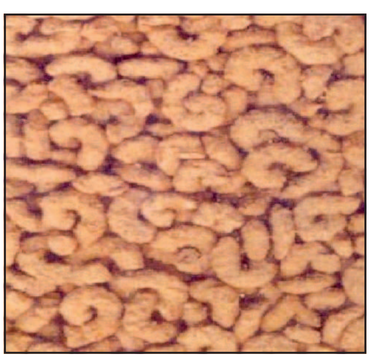
Health Foods from Sorghum and Millets

Sorghum, pearlmillet, fingermillet and barnyard millet are now recognized as nutritious cereals. Variety of value added products from pearlmillet and fingermillet were prepared and evaluated for digestibility and organoleptic score since 2000. During 2002-03 emphasis was laid on preparation of diabetic foods from fingermillet and sorghum.


Barnyard millet biscuit


Diabetic biscuit from malted sorghum


Fingermillet based baked products


Fingermillet based snacks


Fingermillet vermicelli


Pearlmillet pasta

Value added products from sorghum and millets

Fingermillet based vermicelli was formulated with different hypoglycaemic foods like *ashwagandha* root powder, *madhunasini* leaf powder, jamun fruit seed powder, fenugreek seed powder and *amruthballi* leaves powder. All these vermicelli products reflected low glycemic index when tested on diabetics. Biscuits for diabetics were prepared from barnyard and foxtail millets and tested for sensory evaluation, shelf life and glycemic index. Both the millet based biscuits reflected lower glycemic ends. Recipe for barnyard and barnyard-methi pulao was also standardized for diabetics. Malted sorghum was used for development of diabetic biscuits. These biscuits had excellent taste, flavour, colour, texture, appearance and nutritional profile. Shelf life study was also conducted in multi layered laminated pouch using vacuumisation and N_2 flush which enhanced shelf life of biscuits for about 6 months by retaining essential quality attributes.

Other supplementary foods were also prepared from millets. These include vermicelli with soya flour from pearlmillet, ready to eat extruded products from fingermillets in combination with de fatted soya flour and skimmed milk powder. Dietary intervention reflected improvement in serum calcium and phosphorus in volunteered children. A number of other snack foods and baked products were also prepared from pearlmillet and blanched pearlmillet flour. More than 150 farm women were trained on the recipes at all the cooperating centers. Efforts are under way to tie up with prospective entrepreneurs for the pilot scale manufacture of these products.

Diversification in Nutritious Cereals Based Production System

To improve the profitability of the cereal based production system in rainfed areas, a number of diversification strategies have been evaluated across the country with major focus on agri-horticulture. The main objective is to generate supplementary income for farmers by growing suitable intercrops in young orchards and adopt water harvesting and INM techniques for optimizing the productivity of the fruit component. Among various intercropping systems tried at Doddagangawadi watershed of Bangalore rural district in Karnataka, mango+dolichos gave the highest additional net returns of Rs.14,323/ha followed by mango+fingermillet+ dolichos (Rs.6,291/-) and mango+fingermillet (Rs.4,150/-). The corresponding benefit - cost ratios were 4.02, 1.79 and 1.47. In Junagadh district, mango intercropped with groundnut recorded the highest net income (Rs.49,364/-). In Guntur district, mango + blackgram gave the highest net returns (Rs.42,070/-). The returns from on-farm trials in Bijapur district were highest with mango + groundnut followed by mango + sunflower and mango + sorghum.

Moisture conservation treatments significantly improved the productivity of fruit plants in case of custard apple, mango, guava and sapota at different locations. Highest fruit yield and net income per ha was obtained in most cases with the treatment of circular basin with 5% slope and application of locally available mulch. The net realization from the moisture conservation

Table 9: Yield and economic returns in custard apple with different moisture conservation practices on farmer's fields in Junagadh district, Gujarat

Treatments	Fruit yield (kg/ha)	Gross income (Rs/ha)	Total cost (Rs/ha)	Net income (Rs/ha)
Control	8575	60025	24900	35125
Circular basin with 5 % slope	8675	60725	25300	35425
Crescent bunding	9175	64225	25700	38525
Circular basin with 5 % slope and locally available mulch	9712	67987	27000	40987

technology in Junagadh district for custard apple is given in Table 9.

In another network project, a number of rainfed vegetable crops have been evaluated on farmers fields for their yield and monetary returns. These include HYV, moisture conservation and INM. The vegetables included were chillies, clusterbean, cowpea, dolichos and okra. Despite the deficiency of rainfall by 20-40% at different locations during the year, moisture conservation technology helped in yield stabilization in case of rainfed vegetables. Among all conservation practices, ridges and furrows + mulching proved most cost effective followed by ridges and furrows and flat bed.

A third network project looked at the existing agri-horticulture and horti-pasture systems and evaluated possible interventions to improve their productivity. Field surveys clearly revealed that the farmers perceive agri-horticulture and agro-forestry systems as insurance against drought. The preferred crops are *kharif* sorghum, cowpea, horsegram, *Stylosanthes hamata* and *Cenchrus ciliaris* in mango/custard apple/ber/pomegranate orchards as these systems fulfill the fodder needs for livestock. The requirement

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

Pusa Navbahar, a clusterbean variety on farmers fields with adoption of soil and moisture conservation at Akola of animal component figured heavily in the farmers minds in all the districts while preferring the agroforestry system. There is a clear trend in all districts where farmers are moving away from coarse cereals towards alternate land use systems. However, adoption of soil and moisture conservation technology and INM are key to achieve reasonable returns from such options.

In Mahaboobnagar and Ranga Reddy districts of Andhra Pradesh and Sangli and Beed districts of Maharastra, agri-horticultural and silvi pastural systems are already practiced by large number of farmers. While 15-20% farmers are including one or more fruit component in the production system, only less than 2% farmers grew fodders as part of their cropping system. More and more farmers are taking up plantation of non-horticultural trees like teak, neem, *Gmelina, Dalbergia, Hardwickia* and *Acacia* in recent times due to their low maintenance cost besides mango, guava, citrus, custard apple, papaya and pomegranate were the important fruit crops in farming systems.

To improve productivity of the existing orchards and maximizing income, intercrops like sorghum, cowpea, horsegram, and stylo were introduced in mango orchards. On-farm trials with different age group orchards conclusively demonstrated that the net income of farmers even in drought year can be substantially improved by adoption of agri-horticultural system with improved package of practices. To illustrate, Mr. Patole Shivaji Dyanu, a poor farmer in scarce rainfall zone of Sangali district could earn a net income of Rs.43,000/acre from *ber* orchard both during 2001 and 2002 with the adoption of improved technology (moisture conservation + INM and introduction of intercrops). This has created major impact among farmers in the district.

In yet another study, the possibility of growing an intercrop in the industrial plantations meant for pulp wood have been examined in Bhadrachalam, Khammam district of A.P. Farmers usually grow fast growing trees like *Leucaena* and eucalyptus in monoculture and do not get any income up to 4 years for their livelihood. On-farm trials showed that wider row spacing of 6 x 1 m, 7 x 1.5 m (paired rows) and 11 x 1 m (paired row) can substantially reduce the competition, thus producing an intercrop and also producing biomass from trees as compared to farmers practice of close spacing (3 x 2 m).

Establishment of Silvi Pastures on Farmers Fields

Although livestock rearing is an important source of livelihood in rainfed areas, shortage and low quality of grazing lands has been a major constraint. Successful models of silvipasture systems to support different categories of livestock hardly exist for different micro-farming situations. In a major network project involving 63 farmers in 24 villages of 5 target districts (Jhansi, Mathura, Akola, Junagadh and Mahaboobnagar), a model silvipasture system was developed wherein one third was used for grazing small ruminants and the remaining two thirds was used for harvesting and feeding to the livestock.

Participatory approach followed in this project was fairly successful in ensuring farmers cooperation for establishment of the silvipasture under open conditions. Higher herbage yields (particularly the legume component) with improved management (both under natural and reseeded conditions) was partly responsible for convincing the farmers on the importance of silvipasture. Highest acceptability was found in Mahaboobnagar district of A.P, which is the most drought prone.

Farmers' response towards introduced pasture on production and quality revealed that *Stylosanthes hamata* was the preferred species for most situations. Among grasses, *Panicum maximum* (varieties: *Colonial* and *Hamil*) and *Cenchrus ciliaris* were the choices for most of the places. Other species like *Stylosanthes scabra, Cenchrus setigerus* and *Dicanthium coricosum* were also preferred, although on a lower scale. Another leguminous species, *Desmanthus virgatus* incorporated in the silvipasture at Jhansi was rated high by the farmers on account of its quick regeneration ability and forage quality to improve milk yield and fat content. Farmers response in Jhansi district to various tree and pasture species in terms of their production and quality are given in Table 10. *Desmanthus virgatus* and *Panicum maximum* scored high on both parameters.

On farmers' fields, most successful tree/fruit species were *Acacia nilotica*, *Dalbergia sissoo, Emblica officinalis* and *Zizyphus mauritiana* at Jhansi; *Leucaena leucocephala, Azadirachta indica, Ailanthus excelsa* and *Acacia nilotica* at Mathura; *Sizigium cuminis, Annona squamosa, Emblica officinalis* and *Acacia nilotica* at Akola; *Leucaena leucocephala, Zizyphus mauritiana, Acacia nilotica* and *Tectona grandis* at Junagadh and *Leucaena leucocephala and Acacia nilotica* at Mahaboobnagar. Highest pasture production on farmers' field was recorded in *Panicum maximum* var. *colonial* (9.20 t drymatter/ha), *Cenchrus ciliaris* (2.25 t drymatter/ha) and *Stylosanthes hamata* (4.30 t drymatter/ha) at Mahaboobnagar (Table 11).

Table 10 : Response of farmers to introduced pasture species in Jhansi district (n=19)

Species	Production	Quality (Scale 1-10)
Stylosanthes hamata	7	8
Stylosanthes scabra	5	7
Cenchrus ciliaris	7	7
Cenchrus setigerus	5	6
Panicum maximum	9	8
Desmanthus virgatus	7	9

Table 11: Mean pasture yield (t/ha) obtained on farmers' field in Mahaboobnagar district, A.P

Parameters	*Panicum maximum*	*Cenchrus ciliaris*	*Stylosanthes hamata*
Green herbage	27.20	7.50	12.40
Drymatter (t/ha)	9.20	2.25	4.30

Grazing of sheep on a *stylo* pasture in mango orchard on farmers fields in Dharmapur village of Mahaboobnagar district, A.P.

Low Cost, Multipurpose Bio Fencing

Establishment of introduced planting material has remained a major challenge in horticulture and agroforestry due to open grazing in the off-season. In view of the high cost of permanent barbed wire fencing, farmers were looking forward to a low cost live fencing to protect the crops/ planting material.

Evaluation of 15 species of live fencing material across 8 locations both at on-station and on-farm revealed that the suitability and establishment of live fence species is highly location specific. For example, the survival of *Agave* was highest in Jhansi, Hyderabad, Parbhani, Rahuri and Dharwad districts whereas *Jatropha curcas* was superior in Koraput and Indore. Among several shrub species tested, the performance of *Lawsonia* was found to be superior at Jhansi and Hyderabad whereas *Agave* performed well at Parbhani, Rahuri and Dharwad. At Rahuri, growth of *Caesalpinia banducella* was found to be better compared to others. *Agave* was found to be effective for conserving soil and water at Jhansi, Parbhani and Koraput whereas *Prosopis* was superior at Indore. The yield of intercrops in live fencing systems was highest with Karonda at Jhansi and Parbhani and with *Prosopis* at Indore. Based on overall data, *Lawsonia inermis* was found to be the best live fence at most locations, whereas in Orissa *Agave* was the best. However, further studies on competition with crops and economic utilization are needed.

Ridge method of planting was better than flat planting for all fencing material resulting in better survival and growth of the fence but also causing less competition to agricultural crops. In general, the cost of live fencing, including the establishment and maintenance was found to be lower than barbed wire fencing across all the centers. It ranged from Rs.22/- to Rs.45/- for meter length as against Rs.100/- to Rs.200/- for barbed wire fencing. The economic products from these fences like leaves of *Lawsonia* are additional sources of income which add further advantage.

Live fence of *Agave* sp + *C.bonducella* around pearlmillet crop in Rahuri district

In a related study, a number of tree species were screened for the presence of animal deterrent chemicals like gallic acid, pyrogallol and catechol. *Cassia siamia* contained the highest quantity of catechol while gallic acid was maximum in *Dalbergia sissoo, Cassia fistula, Cassia siamia* and *Annona* in that order. Significant quantity of pyrogallol was found only in *Cassia siamia.*

Coarse (Nutritious) Cereals as Poultry Feed Ingredients

Maize and soybean meal are the most commonly used raw materials in poultry feeds.

Due to frequent shortage of raw material, the feed cost has been increasing steadily causing hardship to the poultry farmers. Moreover these materials are not readily available in areas where other crops like sorghum, pearlmillet, fingermillet and kodo millet are grown. In order to substitute maize with locally available coarse cereals and alternate sources of protein, a number of feed combinations were tried both for broilers and layers with the overall objective of making the rural poultry production economical.

Replacement of 50% of dietary maize with pearlmillet, and soybean meal with a combination of rapeseed meal (solvent extracted) and sunflower seed meal (undecorticated, solvent extracted) each at 5 or 10% level of diet, supported optimum growth, feed utilization efficiency and meat production in broilers. Inclusion of 30% pearlmillet, 5% rapeseed meal and 10% sunflower seed meal or 30% pearlmillet, 10% rapeseed meal and 10% sunflower seed meals replacing maize and soybean meal partly rendered economic broiler production.

Use of sorghum, replacing 75% of dietary maize and rapeseed meal (5% or 10% w/w) and sunflower meal (5% or 10% w/w) replacing soybean meal partly supported optimum gain and feed efficiency of broiler chickens similar to that of maize-soybean based control. Inclusion of sorghum (replacing 75% maize) along with 10% rapeseed meal and 5% sunflower seed meal or 10% rapeseed meal and 10% sunflower seed meal (w/w) resulted in economic broiler production. Addition of red sorghum in broiler diets replacing whole maize depressed growth and feed utilization during starting phase of broiler chicks but had no adverse effect thereafter. Supplementation of methionine improved growth. The tannin content reduced by 30% (2.3% to 1.6%) by reconstitution process but it did not improve the broiler performance.

The safflower cake could be included up to 5% level safely along with soybean meal in maize, pearlmillet and sorghum based diet. The diet containing 50% maize, 25% sorghum and 25% pearlmillet as source of cereals, soybean meal (SBM) and 5% safflower cake was superior in terms of performance and economics of broiler production. Superior gain in body weight and net profit could be achieved from broiler chicken fed diets with 33% maize, 33% sorghum and 33% pearlmillet along with SBM as a sole protein source or with 5% safflower meal. Small millet (*Setaria italica*) can be incorporated safely replacing 50% of dietary maize of broiler diets. The use of *rice kani* (broken rice) @ 10% w/w replacing maize or with 7.5% w/w mustard oil cake supported optimum growth, feed utilization and reduced the feed cost of broiler production. Use of sorghum instead of maize reduced the cost of feed for egg production, while use of kodomillet increased the feed cost of egg production. Complete replacement of maize with sorghum was possible for economical egg production, but a diet containing 50% sorghum instead of maize was most beneficial. As compared to sole maize, 75% sorghum or 25% kodomillet replacing maize was more economical. Combination of groundnut meal and ram-til meal in 75:25 ratio was suitable for economic egg production in Madhya Pradesh.

Nutritious Cereal Crop Residues in Milk Production

Low digestibility and deficiency of nutrients are some of the constraints for achieving optimum milk yield from livestock fed on coarse cereal crop residue based rations. In order to achieve higher milk production from such rations, locally available feed supplements were tried to supply the limiting nutrients in 5 target districts of 4 states (A.P, Orissa, Maharashtra and Karnataka) through a farmer participatory project. The crop residues used in the trial were, sorghum in A.P and Maharashtra, pearlmillet in Maharashtra, fingermillet in Karnataka and paddy straw in Orissa.

In Bangalore rural district of Karnataka, by providing the limiting nutrients through maize grain @ 2 kg/cow/day, the milk yield of the cows fed on fingermillet straw based ration increased from 1 to 1.2 liters/cow/day and the feed cost was reduced to Rs.2.70/- to Rs.3.76/cow/day and the farmers income increased by Rs.13/- to Rs.15/ cow/day (Table 12). The results from Pune district of Maharashtra indicated that replacement of wheat bran (2 kg/cow/day) with groundnut cake @ 0.8 kg/cow/day on pearlmillet straw based diet in crossbred cows increased the milk yield by 0.4 l/ cow/day and the feed cost was reduced by Rs. 6/ cow/day.

On-farm trial with buffaloes in Akola district revealed that when sorghum straw based diets were supplemented with mineral mixture and crushed jowar @ 600 g/cow/day, there was an increase of milk yield by 0.3 liters/day. In Bhubaneshwar

Table 12: Feed cost and milk yield in control and experimental animal fed on fodder (green grass)+ straw based diet in Anagalapura village, Bangalore rural district

Parameters	Control		Experimental	
	Quantity (kg)	Cost (Rs)	Quantity (kg)	Cost (Rs)
Green grass+ fingermillet straw	*Ad lib*		*Ad lib*	
Wheat bran	3.40	22.10	1.79	11.64
Groundnut cake	0.85	10.20	0.80	9.60
Maize grain	—	—	2.00	9.00
Total feed cost (Rs/animal/day)		32.30		30.24
Milk yield (l/day)	8.68	86.80	10.15	101.50

Buffalo fed on sorghum straw + concentrate + crushed sorghum (0.6 kg/day) in Barshitakli village of Akola district, Maharashtra

district, supplementation of deoiled groundnut cake @ 30 g RDN/kg DOM to a paddy straw based ration improved the performance of the bullocks significantly. At CRIDA, Hyderabad, the impact of supplementation on growth rates in lambs under open grazing was studied. Highest live weight gain (79 g/day/animal with groundnut cake; 60 g/day with rice bran; 38 g/day under natural grazing) and highest cost benefit ratio was recorded through groundnut cake supplementation @ 1% of the body weight (2.20) followed by rice bran supplementation (1.65).

These participatory trials conclusively demonstrated that both milk yield and performance of animals can be improved significantly by supplementing with locally available feed sources in a cost effective manner.

CHAPTER

7

Monitoring and Evaluation

Extensive monitoring and evaluation of PSR projects was carried out during the year through duly constituted peer review teams by the Scientific Advisory Panel (SAP). The monitoring included desk reviews, annual workshops, site committee meetings and field visits to on-farm trials. Reports of the review teams were discussed by the SAP and relevant suggestions given to the PIs/CCPIs and nodal officers on improvement of the programme and to have effective linkages with other programmes within and outside NATP at the SAU/Institute level. The details of the peer reviews carried out are given in Annexure VI.

The project on Impact of watershed management and sustainability on land productivity and socio economic status (ROPS-14) was reviewed during 19-20 April, 2002. The review team made specific recommendations on items of data to be included in the final report and the classification of watershed according to the implementing agencies so that the outputs of this project should help in effective implementation of the NWDPRA and to introduce the need based changes in future projects on watershed development. In view of the emergence of aflatoxin contamination of groundnut kernels as an important non tarrif barrier, a special review of the aflatoxin management in groundnut (ROPS-17) project was made at NRCG, Junagadh during May, 2002. The committee made specific suggestion to focus the survey work in few districts and identify the cultural practices followed by the farmers that contribute to the aflatoxin contamination.

A comprehensive review of the sub projects in Jharkhand during 26-31 August, 2002 revealed that many projects in rainfed rice based production system were implemented well under the supervision of Dr.A.K.Sarkar, Nodal Officer. The projects related to rain water management successfully demonstrated that with efficient conservation of surplus runoff during *kharif* and recycling it during *rabi*, the cropping intensity can be increased. The committee recommended that a community approach need to be followed for introduce a second crop successfully (during *rabi*) to avoid the stray cattle menace. The projects related to horticulture are not being integrated into the rice based production system, the committee, commented. The team further recommended that the performance of improved varieties should be tested both under farmers and improved management to recognize opportunities to improve yields even with a local variety but with better management in areas where spread of HYVs has been poor due to weak seed production chain.

Following a comprehensive of the projects under AAU, Jorhat during September, 2002, the on-farm trials around Titabar research station are implemented well and the technologies have gained the confidence of the farmers. While the over all implementation of the crop based projects was found good at AAU, livestock and engineering projects needed considerable improvement. There should be greater interaction of the NATP project team members with the relevant faculty members of the university.

The on-farm trials in Orissa were affected by drought and there was considerable delay in planting. The PRT visited farmers fields in two sub groups in Dhenkanal, Kendrapara, Keonjhar, Phulbani, Bhadrak, Kalahandi, Balasore and Mayurbhunj districts. Besides many project specific recommendations made by the committee pointing out the gaps, it was also recommended that the farmers practice may be clearly defined and not more than one replication to be laid on single farmers field. The recommended practice treatment should be same as that recommended for the zone by the ZREAC.

The drought of 2002 affected many of the on-farm trials in Karnataka. However, the review team could see in some projects a considerable superiority of the crop stand and performance where improved management practices like *in situ* conservation of moisture and timely planting were followed. Strong linkages with TAR-IVLP and ATMA were recommended to widely test the successful drought management strategies emerged from the on-farm trials. The university was advised to bring out a special report on the extent and impact of drought and how the involvement of the participating farmers in the project helped them to overcome the negative effects and to what extent.

The review team recommended collaboration with industry for the value addition project on safflower (ROPS-1) and concentrate on making eco friendly paper. A suggestion was also made to estimate the pesticide residues, if any, in safflower petals meant for extracting food dyes. The implementation of the projects under GAU, Gujarat were found quite satisfactory by the review team, particularly those under agri-horticultural systems in Surashtra and *desi* cottons in Banaskantha. A greater coordination with the regular AICRPs on these commodities

Visit of the peer review team to on-farm trials and interaction with the farmers in Karnataka and stronger linkages with livestock scientists in the university was suggested.

The peer review team which visited the cotton based projects at Mudhol in Adilabad, A.P and Nanded district in Maharashtra found high acceptability of *arboreum* varieties by the farmers. Consistently superior performance was recorded over *hirsutums* by most of the participating farmers. The review team recommended quality evaluation of the lint through a mill test on superior *arboreums.* The superior qualities of *arboreums* may be publicized widely among farmers. A well attended farmers meet at Mudhol was addressed by Dr.N.G.P.Rao, Member, SAP. The committee further recommended closer interaction of the project team with the breeders at Central Cotton Research, Naded who developed diploid x tetraploid crosses which showed resistance to sucking pests and bollworms.

A special PRT meeting on 27-28 December, 2002 at NBSSLUP, Regional Station, Kolkata reviewed the technical programme of the projects related to the application of remote sensing techniques to the planning and implementation of watershed development project (RNPS-2 and RRPS-17). The team observed that it was a first major attempt to prepare action plans based on maps derived from IRS satellite, which will have immense implications in saving on time and resources in watershed development projects in the country. The project team was advised to focus more on the bio-physical criteria while determining the treatments for prioritized areas with in the micro watershed.

Dr. N.G.P. Rao (SAP member) addressing farmers fair at Mudhol on popularizing *desi* cottons

Two day review meeting on *rabi* sorghum on 16th February, 2003 at Pune not only reviewed the work carried out under NATP project on *rabi* sorghum but also the over all developments in varietal development and resource management under different other programmes in Maharashtra and Karnataka. While the progress made in the project on development of an integrated package for *rabi* sorghum involving improved variety and compartmental bunding made some impact, the other important issues like lodging of the HYVs need to be addressed. The 'stay green' trait has to be incorporated into the breeding material.

Monitoring of the PSR projects was also done through site committee meetings. The AED and PPSS have attended the site committee meetings during the year at NDUAT, Faizabad (10th May, 2002), MPUAT, Udaipur (21st July, 2002), AAU, Jorhat (15-16 July, 2002), MAU, Parbhani (26-28 September, 2002), MPKV, Rahuri (4-5 December, 2002), CRIJAF, Barrackpore (6th March, 2003). Project-wise reviews and general

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

recommendations were made on improvement of the technical programme and linkages between PSR and TAR-IVLP projects in each of these states.

At the end of the year (2002-03) all the PSR projects were reviewed by Dr.S.L.Mehta, National Director, NATP in two separate workshops organized at CICR, Nagpur on 18-19 April, 2003 (Cotton and Nutritious cereals based projects) and at CRIDA, Hyderabad on 23-25 April, 2003 (Rainfed Rice, Oilseeds, and Pulses based projects). Dr.J.S.Kanwar, Chairman, SAP, members of the SAP and experts from the PRTs were also present. Specific recommendations were made on each of the projects regarding further continuation during 2003 and beyond and results of practical value were identified which should be taken up by TAR-IVLP programme. Fifteen success stories were identified from PSR projects for recording video films in digital format.

The entire information on PSR projects was entered into the PIMS module during the year and submitted to IASRI to prepare a centralized websites to enable PME activities at the national level.

CHAPTER

8

Linkages

Concerted efforts were made by the agro ecosystem directorate during the year to facilitate strong linkages among different components of NATP, both at the directorate and the implementing institutions.

With TAR-IVLP

At the directorate level, efforts were made to identify technologies that emerged from PSR projects to be refined through TAR-IVLP. A significant over lap was found between PSR and TAR-IVLP in the choice of technologies tested on farmers fields. Therefore, an effort was made during the year to modify/introduce the improved elements of the recommended package of practices that resulted from PSR projects into TAR-IVLP. The list of technologies from PSR were discussed at the TAR-IVLP annual workshops at UAS, Dharwad on 3-5 September, 2002 and IIPR, Kanpur on 21-22 March, 2003. After the PSR annual workshops during April 2003, the final list of technologies from PSR mode were compiled production system wise (Annexure-IV). Considering the interventions already included in the 2003-04 technical programme of the remaining technologies will be taken up during 2004-05.

During 2003-04, some important interventions adopted by TAR-IVLP include the cultivation of non-spiny varieties of safflower, sweet sorghum varieties and *arboreum* cotton. Some of the catchment level technologies in eastern states like Chhattisgarh and Orissa on on-farm rain water management need greater resources and infrastructure to be tried under TAR-IVLP. Therefore, an alternative model where in such technologies can be directly tried through ATMA involving the scientists from PSR and TAR-IVLP modes needs to be explored.

With ATMA and SAMETI

The strategic linkages established by the rainfed AED with ATMA continued during the year with focus on Orissa and Jharkhand. The SREP reports prepared by MANAGE for all the approved ATMA districts were reviewed at the directorate. It was found that many of the issues are already being addressed either through PSR or TAR-IVLP. The remaining issues relate to infrastructure and policy development. Therefore, efforts were made to establish linkages at the state level between scientists working in PSR/TAR-IVLP mode and those involved in the ATMA at the district level. List of specific technologies available addressing the researchable issues listed in the SREPs for Khurda (Orissa) and Dumka (Jharkhand) were provided by CRRI, Cuttak and BAU, Jharkhand. The rice-fish-duck farming system model developed under PSR project at BAU Ranchi was adopted by the ATMA, Dumka. Similarly, efforts are under way to include the popularization of quality *arboreum* cottons evolved by MAU, Parbhani in the relevant ATMA district of Maharashtra.

In Orissa, four state level co-ordination meetings between different modes of NATP were organized during April (5^{th}), June (10^{th}), September (9^{th}) and December (20^{th}) of 2002 at Khurda, Cuttak, Gopalpur (Ganjam) and Bhubaneswar, respectively. Issues related to co-ordination between different modes of NATP were discussed and specific technologies available from research institutes were listed which can be adopted by ATMA districts in Orissa. The district Collectors, Project Directors of ATMA and the concerned principal investigators of the PSR/TAR-IVLP projects participated in these meetings. In addition to the findings from NATP, the other technologies from regular research projects under OUAT addressing the issues listed in the SREPs of the four ATMA districts in Orissa were also discussed and finalized.

In Jharkhand, the nodal officer NATP at BAU, Ranchi has maintained continued liasion with ATMA and SAMETI projects in the state and provided the needed technical support from time to time. The PPSS from AED rainfed at CRIDA, participated as a faculty and explained the linkages between PSR and SAMETI in a training workshop organized by SAMETI, A.P on market led extension for subject matter experts working in ATMA projects during 20-24 May, 2002 at Hyderabad. Necessary information on the research findings in the respective SAUs was provided to the project directors of ATMA in the concerned states by the nodal officers as and when needed.

With Private Sector

During the year, the project teams in the area of post harvest technology and value edition established good collaboration with number of private entrepreneurs, in order to pilot test and commercialize the technologies. The ventilating type grain dryer for sorghum, herbal tea and natural colours from safflower petals and alcohol production from sweet sorghum are few important examples. The list of promising technologies involving collaboration with private sectors are given in chapter 11.

With AICRPs

The results of the PSR projects were made available to the project coordinators of AICRPs through reports. Project coordinators of relevant crop and NRM projects have also been participating in finalizing the technical programme of the PSR projects both at the AED level and at the implementation institutions. Some of the promising varieties of rainfed rice (*Jagabandhu*) and Jute (S-19) in Orissa and West Bengal which were identified under PSR projects were either approved for release or for prerelease trials under AICRPs. The work on *rabi* sorghum under NATP was also discussed through a combined workshop with AICRP scientists at Pune to achieve greater integration and synergy.

CHAPTER

9

Human Resource Development

As an effort to upgrade the skills of scientists implementing the projects, extensive training opportunities both in India and abroad were provided during the year. A list of such foreign and domestic trainings are given below.

A) Training abroad

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training/ Conferences	Location of the training
1.	ROPS-08	Dr.(Mrs.)Saroj Singh	NCIPM, New Delhi	Agro-ecology, Integrated Pest Management and Sustainable Agriculture	June 16-28, 2002	Michigan State University, USA
2.	ROPS-08	Dr.Surender Kumar	NCIPM, New Delhi	-do-	-do-	-do-
3.	ROPS-08	Dr.H.Basappa	DOR, Hyderabad	-do-	June 24- July 6, 2002	-do-
4.	RNPS-06	Dr.B.Dayakar Rao	NRCS, Hyderabad	Socio-Economic Interactive Database Management	September 14-27, 2002	Texas A&M University, USA
5.	RNPS-06	Dr.S.Surya Prakash	UAS, Bangalore	-do-	-do-	-do-
6.	RNPS-06	Dr.(Mrs)Usha Rani Ahuja	CAZRI, Jodhpur	-do-	-do-	-do-
7.	RPPS-02	Dr.S.Lingaraju	UAS, Dharwad	Integrated management of plant nematodes	September 17- October 2, 2002	Univ. of Florida, Quincy, USA
8.	RPPS-02	Dr.Aktar Haseeb	AMU, Aligarh	-do-	-do-	-do-
9.	RNPS-10	Dr.S.S.Rao	NRCS, Hyderabad	Crop simulation modeling in sorghum	October 23 – November 06, 2002	Kansas State University, Manhattan, USA
10.	RNPS-23	Dr.(Mrs.)S.Audi Lakshmi	NRCS, Hyderabad	Grain quality management in sorghum	September 15-28, 2002	Texas A&M University, USA

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training/ Conferences	Location of the training
11.	RNPS-23	Dr.(Mrs.)Aruna C.Reddy	NRCS, Hyderabad	Grain quality management in sorghum	September 15-28, 2002	Texas A&M University, USA
12.	RCPS-04	Dr.K.V.Rao	CRIDA, Hyderabad	GIS and Simulation Modeling, Soil and Water Resources characterization	December 2-22, 2002	Department of Natural Resources, Queensland, Australia
13.	ROPS-13	Dr.P.K.Mishra	CRIDA, Hyderabad	-do-	-do-	-do-
14.	RRPS-22	Dr.Gururaj Katti	DRR, Hyderabad	IPM technolgoy in Rice	January 27 – February 7, 2003	IRRI, Manila, Philippines
15.	RRPS-22	Dr.M.P.Singh	CAU, Imphal	-do-	-do-	-do-
16.	RRPS-22	Dr.D.K.Bora	AAU, Assam	-do-	-do-	-do-
17.	RRPS-22	Dr.C.R.Satpathi	BCKV, Kalyani	-do-	-do-	-do-
18.	RRPS-25	Dr.(Mrs) M.Vanaja	CRIDA, Hyderabad	Impact of climate change on crop productivity	February 15 – 28, 2003	US Water Conservation Laboratory, USDA, Arizona, USA
19.	RPPS-03	Dr.T.Ganapathi	TNAU, Coimbatore	Detection and Identification of Plant Viruses	March 3 – 17, 2003	Deutsche Sammlung von Mikroorganismen und Zellkulturen gmbh, Braunshweig, Germany

B) Training within India

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training	Location of the training
1.	RCPS-01	Dr O Challa Dr GP Saraf Dr S M Mundinamani	NBSS&LUP, Nagpur	Statistical Analysis for Socio-economic Research data	April 30 - May 4, 2002	NAARM, Hyderabad
2.	RNPS-09	Dr.D.V.Devgire	ZARS, Solapur	Short-course on arid fruits	1 month	NRCAH, Bikaner

Sl. No.	Project code	Name of the Scientist	Affiliation	Subject	Duration of training/ Conferences	Location of the training
3.	RNPS-12	Dr.B.Ekambaram, CCPI	ANGRAU, Mahaboobnagar	a) Participatory approaches livestock development	June 24-29, 2002	NIRD, Hyderabad
				b) Village adoption & bimonthly T&V visits	October 10-11, 2002	ANGRAU, Hyderabad
4.	RNPS-24	Dr.C.V.Ratnavati, PI	NRCS, Hyderabad	Trouble shooting and maintenance of gas chromatograph	February 7-9, 2003	Perkin Elmer Instruments, Hyderabad
5.	RNPS-25	Dr.V.Ramesh Dr.(Mrs.)M.Vanaja	CRIDA, Hyderabad	Carbon Simulation Modelling	April 10, 2002	NBSS & LUP, Nagpur
		Dr.M.C.Manna	IISS, Bhopal			
		Dr.Tapas Bhattacharya Dr.D.K.Pal Dr.S.K.Ray Dr.M.V.Venugopalan	NBSSLUP, Nagpur			
		Dr.T.J.Rego Dr.K.V.Padmaja	ICRISAT, Hyderabad			
6.	RPPS-04	Dr.R.R.Lal, PI	IIPR, Kanpur	Use of information technology in agricultural research	February 14-22, 2003	IIPR, Kanpur
7.	RRPS-21	Dr.B.P.Mishra Dr.K.L.Nandeha Mr.Rusia Er. D.Saha	IGKV, Raipur IGKV, Jagdalpur BAU, Ranchi BCKV, Mohanpur	Instrumentation and testing of agricultural machinery	August 19-31, 2002	CIAE, Bhopal
8.	RRPS-23 RRPS-31	Ms.Bhagyalatha Dhar Mr.Aruanashu Datta Mr.Puspendra Singh Mr.A. Kiran Kumar Singh Ms.Heisama Nanita Devi Ms.Lydia Zimic	CRRI, Cuttack BCKV, Kalyani NDUAT, Faizabad CAU, Imphal	Production technology of rice and rice based crops	September 20-25, 2002	CRRI, Cuttack
9.	RRPS-25	Dr.P.Krishnan	CRRI, Cuttack	Modelling growth and yield of crops	March 27 - April 17, 2002	CASS, IARI, New Delhi

CHAPTER

10

Farmers Trainings and Awareness Generation Activities

The following training and awareness generation activities were organized for farmers under different projects.

Project #	Location	Nature of the activity	Date	No. of farmers' attended
RRPS-06	Bansapal, Keonjhar	Pre *Rabi* farmers training	September, 2002	25
	Gopalput, Orissa	Field Day with exhibition & Krishak mela	September, 2002	60
	Tihari, Orissa	Kisan Sangosthi	May, 2002	50
	Chianki, Jharkhand	Exhibition and Krishak mela	February, 2003	115
RRPS-11	Keredi, Kandhamahal	Field day	March 2003	120
RRPS 18	Kandabindha, Dhenkanal	Farmers' interaction & Field day	June, October, 2002	120
RRPS-23	Narasinghpur, Bhadark	Training cum Demonstration at OFT	July, December, 2002, February, 2003	250
	Routrapur, Balasore	Training cum Demonstration at OFT	July, December, 2002, February, 2003	75
RRPS 25	Kasiadihi ,Dhenkanal	Field Day	November, 2002	50
RRPS-27	CRIJAF, Barrackpore	Farmers Day	December, 2002	50
RRPS-28	CRIJAF, Barrackpore	Farmers Day	August, December, 2002	110
	Teghoria, North 24 Paraganas, West Bengal	Farmers Training	December, 2002	20
ROPS-01	College of Home Sci., MAU,Parbhani, Maharashtra	Women's Entrepreneurship development programme	January, 2003	250
	Parbhani, Maharashtra	Exhibition on safflower by-products organized by Women Development Corporation	January, 2003	100
	Tadborgaom, Parbhani	Safflower Shetkari Melava	March, 2003	300
ROPS-08	Wazirpur, Haryana	Farmers' field school	March, 2002	125
	ANGRAU, Anantpur	Farmers' field school		
	Boyapur, Mahaboobnagar	Farmers' field school	October, 2002	50
	Tad Borgaon, Parbhani,	Farmers visit to OFT	August, 2002	50
	Karkalpahad, Mahaboobnagar	Field Day on IPM	September, 2002	300

Project #	Location	Nature of the activity	Date	No. of farmers' attended
ROPS-11	Ratatal, Bhopal	Farmer scientist interaction	July, 2002	54
	Palem, Vattem, Bijnepalli Mahaboobnagar	Demonstration of INM and moisture conservation	August, September, December, 2002, January, 2003	56
	Nagala Kewal, Bharatpur	Kisan Diwas	December, 2002	450
ROPS-16	Marchikal & Buddasamudram, Mahaboobnagar	Farmer scientist interaction on . management of castor	February, 2003	25+25
	Allapur, Parbhani	Farmer scientist interaction	January, 2003	50
	Gangavathi, Koppal	Farmer scientist interaction	December, 2002	50
	Motichandur, Patan	Farmer scientist interaction	January, 2003	25
ROPS-18	Turakapalli, Mahaboobnagar	Farmer scientist interaction	April, 2002	22
	ARS, Anantapur	Pre-season farmer's training programme on peanut stem necrosis disease in groundnut	June, 2002	73
	ARS, Kadiri	Field Day	December, 2002	36
RPPS-01	Gananyakana halli, Chutrdurga	Field Day	February, 2003	90
RPPS-05	Lambakheda, Golkhedi and Entkhedi, Bhopal	Demonstration of improved grain storage	November, December, 2002, January, June, July, 2003	125
	Ganesapuram, Coimbatore	Krishi Mela	October, 2002	60
	Ganesapuram, Chemman and Chettipalayam, Coimbatore	Exposure visit on grain storage techniques	December, 2002	100
	Ghabraha, Kanpur	Exposure visit on pulse beetle control	December, 2002	120
	IIPR , Kanpur	-do-	December, 2002	150
	CCSHAU, Hisar	Krishi Mela	March, 2003	250
RPPS-12	CIRG, Makhdoom	Demonstration of feed pellets preparation from pulse by-products	October, 2002	50
RCPS-2002	CICR, Nagpur	Krishi Mela on INM and moisture conservation in cotton	December, 2002	40
	MAU, Parbhani	Farmer scientist interaction	March, 2003	40
	UAS, Dharwad	Exposure meeting on INM	December, 2002	95
	ANGRAU, Nandyal	Farmer scientist interaction	September, 2002	40
RCPS-08	Hirehonnalli , Dharwad	Field Day	December, 2002	200
	Hebballi, Dharwad	Interaction with farmers	July, 2002	20
RCPS-07	ARS, Mudhol	Krishi Mela	December, 2002	2000
RCPS-11	Kumarchagiri, Tuticorin	Krishi Mela	March, 2002	150
	Kovilpatti	Krishi Mela	January, 2003	200
	Raichur	Krishi Mela	January, 2003	600

Project #	Location	Nature of the activity	Date	No. of farmers' attended
RNPS-04	Chunchunkuppe, Bangalore rural	One day training programme on blast management in fingermillet	January, 2003	50
	Sudenahalli, Hassan	Farmers Day	October, 2002	60
	GBPUAT, Ranichauri	Krishi Mela on fingermillet.	May, 2002	500
RNPS-07	Adilabad, A.P	Farmer scientist interaction	August, October, 2002 June, July 2003	50
	Mahaboobnagar	Farmer scientist interaction	May, June, July, August, September, October, 2002	50
RNPS-19	CSWCRTI, RS, Chandigarh	Training programme on water conservation	April, May 2002, January, February, March, 2003	180
RNPS-21	Manihari, Jabalpur	Vichar ghosthi & Field Day	July, September, 2002	130
	Sarsawan, Jabalpur	Interaction & Vichar ghosthi	July, September, 2002	260
	Gudgawan, Jabalpur	Vichar ghosthi	July, September, 2002	240
	Mehgavan, Jabalpur	Demonstration	August, September, 2002	170
	Nibhora, Jabalpur	Vichar ghosthi & Field Day	August, September, 2002	250
	Sarsawan, Jabalpur	Interaction & Vichar ghosthi	July, 2003	85
	Ambajogai, Beed	Training programme on Agri-horticulture	June, 2002	34
	Custard apple Res. Sta., Ambajogai	Krishi Mela	January, 2003	60
	Kevadra and Vanthli, Juneagadh	Vichar gosthi	April, 2002	20
	Ramdhari, Amarchgadh, Kenedipur, Madhupur and Kevadra, Junagadh	Vichar gosthi	July, October, 2002 February, 2003	75
RNPS-22	Hessaraghatta, Bangalore	Farmers Training	September, 2002	60

CHAPTER

11

Progress on Scale up and Commercialisation of Promising Technologies/ Products/ Processes

Name of the technology	Collaboration under process with
Alcohol from sweet sorghum	M/s.Renuka Sugars, Belgaum
	M/s.Praj Industries, Pune
	M/s.G.M.R.Vasavi Industries, Hyd
	M/s.Mohan Breweries, Chennai
Yellow dye from safflower petals	M/s.BEC Foods, Raipur
Herbal tea from safflower	M/s.Eco Save Systems, Mumbai
Cardboards from safflower stalks	M/s.Amar Plantations, Mumbai
Detoxification technology for castor cake	M/s.Jayanth Oil Mills, Vadodara
	M/s.Vetcare India, Mumbai
Pit fall probes for insect trapping	M/s.K.S.N.M. Marketing, Coimbatore
Mill tests on fibre quality of *arboreums*	M/s.Maral Overseas, Indore
	M/s.Gadag Cooperative Spinning Mills, Hulkoti, Karnataka
Diabetic health foods from fingermillet	NRDC, New Delhi
	M/s.Godrej Plant Biotech, Mumbai
Grain drying technology for *kharif* sorghum	M/s.J.K. Seeds, Maharashtra
Bullock drawn puddler 99	Implements Factory, Govt. of Orissa and Agricultural Engineering Department
Foot operated vacuum packing machine	CEDMAP, Bhopal

CHAPTER

12

Publications

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Annexure I

Institution wise classification of PSR projects approved under Rainfed AES

Organisation	No.of lead/ cooperating centres	Budget sanctioned (Rs. in lakhs)
ICAR Institutes	135	3634.79
State Agricultural Universities	309	6242.97
Departments of Government of India	04	117.37
State Government Departments	05	29.35
General Universities	05	67.57
Non Government Organisations	06	160.12
International Organisations	03	103.33
Total	**466**	**10355.50**

Annexure II

List of Projects with Budget

Rainfed Rice based production system

(Rs. in lakhs)

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
1.	Georeferenced resource inventory preparation for rainfed rice ecosystem (RRPS-01) Dr. G.G.S.N. Rao, CRIDA, Hyderabad	77.10850	—	7.20227
2.	Socio economic dynamics of changes in rice production system in Eastern India (RRPS-02) Dr. B.C. Barah, NCAP, New Delhi	102.19350	—	13.43550
3.	Crop management strategies to increase cropping intensity (RRPS-03) Dr. R.S. Tripathi, IGKV, Raipur	137.45050	21.73800	22.76283
4.	Rain water management strategies for drought alleviation (RRPS-04) Dr. A.R. Pal, IGKV, Raipur	129.85000	20.23750	26.84868
5.	Management of excess water in medium and low lands for sustainable productivity and delineation of problem area (RRPS-05) Dr. B.K. James, WTCER, Bhubaneswar	59.43200	8.73800	8.56755
6.	Study of production mix, resource utilization, risk management and technological intervention in watershed development programmes (RRPS-06) Dr. P. Nanda, WTCER, Bhubaneswar	73.21500	—	12.87570
7.	Strategies for restoration/rehabilitaion of degraded watersheds (RRPS-07) Dr. K.N. Sharma, OUAT, Bhubaneswar	41.64000	3.63000	8.90203
8.	Development of fruit based land use systems in watersheds (RRPS-08) Dr. Sabyasachi Rath, RRTTS, OUAT, Koraput	115.89600	17.02500	22.02500
9.	Integrated management through fish, pig and duck culture in rice farming system (RRPS-09) Dr. A.K. Singh, BAU, Ranchi	60.55300	8.77950	15.91769
10.	Evaluation of cultivars for rainfed rice production system (RRPS-10) Dr. L.V. Subba Rao, DRR, Hyderabad	168.53800	25.24700	37.35583

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
11.	Integrated plant nutrient management strategies for different soil moisture regimes (RRPS-11) Dr. H.K. Senapati, OUAT, Bhubaneswar	112.18400	19.79600	24.82531
12.	Sustainable livestock production system for rainfed rice areas (RRPS-12) Dr. Rajagopal, IGKV, Durg	183.73400	19.85850	26.21446
13.	Control of parasitic diseases of grazing and stall-fed livestock in Bihar, Orissa, West Bengal and Madhya Pradesh (RRPS-13) Dr. N. Sahoo, OUAT, Bhubaneswar	133.29360	21.26680	26.14670
14.	Agro techniques for vegetable cultivation and storage (RRPS-14) Dr. P. Mahapatra, OUAT, Bhubaneswar	105.10400	15.27600	19.79563
15.	Identification of microbial inoculants for moisture and temperature stress to improve their survival in plough layers in order to enhance the productivity of legumes and cereals in rainfed ecosystem (RRPS-15) Dr. S.B. Gupta, IGKV, Raipur	5.00000	0.00000	0.00000
16.	Soil tillage requirement for rainfed rice production system (RRPS-16) Dr. B.K. Mishra, OUAT, Bhubaneswar	171.43580	22.21580	51.12269
17.	Development of regional scale watershed plans and methodologies for identification of critical areas for prioritised land treatment in the watersheds (RRPS-17) Dr. B.R.M. Rao, NRSA, Hyderabad/ Dr. Dipak Sarkar, NBSS & LUP, Kolkata	183.51800	43.43900	40.89054
18.	Study on weed and pest incidence dynamics in realation to ecologies and its impact on economic losses for developing effective control measures (RRPS-18) Dr. Sanjay Saha, CRRI, Cuttack	45.73100	8.59850	7.46047
19.	Organic pools and dynamics in relation to land use tillage and agronomic practices for maintenance of soil fertility (RRPS-19) Dr. M.V. Singh, IISS, Bhopal	166.49750	40.46500	28.09443
20.	Assessment and improvement of soil quality and resilience for rainfed production system (RRPS-20) Dr. Biswapati Mandal, BCKV, Kalyani	141.32770	20.52830	26.76189
21.	Improving the traditional biasi system (RRPS-21) Dr. P. Mishra, IGKV, Raipur	115.55180	22.85105	20.55802
22.	New approaches to integrated pest management in rainfed rice based production system (RRPS-22) Dr. I.C. Pasalu, DRR, Hyderabad	136.77850	41.54400	29.53260
23.	Evaluation of cultivars of major crops of rainfed eco system for increased water use efficiency (RRPS-23) Dr. P.C. Mohapatra, CRRI, Cuttack	139.08792	23.93626	38.49329

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
24.	Participatory and integrated assessment of natural resources and evolution of alternate sustainable land management options for tribal dominant watersheds (RRPS-24) Dr. U.S. Patnaik, CSWCRTI, Koraput	151.17750	21.76000	23.88778
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) Dr. R.N. Dash, CRRI, Cuttack	56.04110	11.993730	16.13589
26.	Improvement of jute through rice necrosis mosaic virus technology for sustainable yield and quality under jute-rice production system (RRPS-26) Dr. S.K. Ghosh, CRIJAF, Barrackpore	92.61325	19.60150	10.11536
27.	Development of improved jute cultivars in rainfed agro ecosystem for quality textile fibre (RRPS-27) Dr. M.K. Sinha, CRIJAF, Barrackpore	116.17246	22.63546	25.48668
28.	Integrated nutrient management on yield targeting for jute-rice production system (RRPS-28) Dr. P.K. Roy, CRIJAF, Barrackpore	108.33500	21.51350	24.18283
29.	Development of rice based agroforestry systems and management practices for yield improvement on field bunds and fallow marginal lands using MPTs (*Sesbania*/*Glyricidia* and other) and grasses (RRPS-29) Dr. D. Mishra, OUAT, Bhubaneswar	78.58920	10.25500	29.67475
30.	Survey, evaluation and documentation of medicinal plants for their chemical profile of active ingredients having medicinal value used by tribals of Madhya Pradesh (RRPS-30) Dr. S.K. Gangrade, JNKVV, Indore	45.70000	—	7.38007
31.	Improve indigenous technology for milling, drying and storage of rice (RRPS-31) Dr. P. Mishra, CRRI, Cuttack	126.82400	25.88800	22.88361
32.	Near real-time monitoring of agrometeorological conditions for contingency planning in Andhra Pradesh (RRPS-32) Dr. A.V.R. Kesava Rao, CRIDA, Hyderabad	58.06900	9.04300	14.82508
33.	Develop and promote prototype of implements for tillage and seeding in participation with local manufactures/artisans (RRPS-33) Dr. S. Swain, OUAT, Bhubaneswar	124.67335	18.91445	37.20939
34.	Development of agrotechniques for sustainable productivity of rice based utera cropping system (RRPS-34) Dr. S.P. Kurchania, JNKVV, Jabalpur	77.64625	32.85850	16.86002
35.	On-farm evaluation of deep water rice varieties and production technologies in rainfed eco system of eastern India (RRPS-35) Dr. M. Nagaraju, CRRI, Cuttack	52.33060	20.56440	19.74524
	Total	**3693.29203**	**619.19775**	**764.17581**

Oilseeds based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
36.	Value addition of safflower petals for natural dyes and herbal health care products (ROPS-01) Dr. P.V. Varadharajan, CIRCOT, Mumbai	100.42000	10.49450	26.46920
37.	Identification, characterisation and delineation of agroeconomic constraints of oilseed based production system in rainfed eco systems (ROPS-02) Dr. P. Krishnan, NBSS & LUP, Bangalore	55.40850	—	12.64406
38.	Retaining viability in soybean by providing appropriate physiological environment and seed storage structures (ROPS-03) Dr. C.K. Teckchandani, JNKVV, Jabalpur	48.58800	6.07800	10.06332
39.	Management of castor for rearing eri silk worm (ROPS-04) Dr. M. Premjit Singh, CAU, Imphal	83.71050	14.61550	16.36820
40.	Study of harvesting practices and development of multi crop harvester for intercropping system with safflower under rainfed farming (ROPS-05) Dr. T. Guruswamy, UAS (D), Raichur	51.13260	3.39130	3.55395
41.	Identification and management of sunflower necrosis disease (ROPS-06) Dr. R.K. Jain, IARI, New Delhi	23.88000	7.06500	5.65286
42.	Develop suitable technology to make use of sunflower heads and castor cake as animal feed (ROPS-07) Dr. K.S. Ramachandra, NIANP, Bangalore	103.87100	21.18400	22.67577
43.	Development of IPM modules for oilseed based production system (ROPS-08) Dr. Saroj Singh, NCIPM, New Delhi	184.93025	51.59740	42.26907
44.	Promotion and development of apiary for improving the productivity of cross pollinated oilseed crop systems (ROPS-09) Dr. N.S. Bhat, UAS, Bangalore	96.07750	17.72925	14.03323
45.	Identification of research gaps in intercropping systems under rainfed conditions in India (ROPS-10) Dr. J.V. Rao, CRIDA, Hyderabad	50.36600	—	12.19378
46.	Nutrient management practices for important oilseed based cropping systems for improving yield and oil output under rainfed conditions (ROPS-11) Dr. J.K. Saha, IISS, Bhopal	190.32100	49.73050	33.17674
47.	Evaluation of cultivars of major oilseed crops of the production system for moisture and nutrient constraints in different soil types (ROPS-12) Dr. B.N. Reddy, DOR, Hyderabad	126.25700	24.54050	26.93210
48.	Documentation and analysis of indigenous methods of *in situ* moisture conservation and runoff management (ROPS-13) Dr. P.K. Mishra, CRIDA, Hyderabad	25.68100	—	11.42945

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
49.	Impacts of watershed management on sustainability of land productivity and socio economic status (ROPS-14) Dr. G. Sastry, CRIDA, Hyderabad	87.59000	—	21.67648
50.	Measures to counteract/detoxify aflatoxins in oilseeds and nutrition coarse cereals based poultry and livestock feeds (ROPS-15) Dr. M.V.L.N. Raju, PDP, Hyderabad	148.31600	21.18400	17.45043
51.	Improving oilseed productivity through identification of genotypes and management under saline conditions with farmers participation (ROPS-16) Dr. C.V. Raghavaiah, DOR, Hyderabad	126.39000	33.13700	24.47142
52.	Aflatoxin contamination in groundnut: Mapping and management in Gujarat, Andhra Pradesh and adjoining areas (ROPS-17) Dr. Susheelendra Desai, NRCG, Junagadh	56.67900	15.51750	12.27271
53.	An Integrated approach to control stem necrosis disease of groundnut (ROPS-18) Dr. S.N. Nigam, ICRISAT, Hyderabad	42.57400	14.27700	10.71436
	Total	**1602.19235**	**290.54145**	**324.04713**

Pulses based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
54.	Increasing the shelf life quality and effectiveness of rhizobial inoculant and optimising BNF in pulses (RPPS-01) Dr. G.P. Brahma Prakash, UAS, Bangalore	35.82300	4.92800	6.71486
55.	Integrated management of plant nematodes/soil pathogens in pulses based cropping systems (RPPS-02) Dr. S.D. Mishra, IARI, New Delhi	85.29920	14.60925	17.33819
56.	Integrated management of the viral disease problems of mungbean (*Vigna radiata*) and urdbean (*Vigna mungo*) (RPPS-03) Dr. R.D.J.V. Prasada Rao, NBPGR, Hyderabad	80.29463	16.55413	23.40940
57.	Upgradation and evaluation of mini dal mill (RPPS-04) Dr. R.R. Lal, IIPR, Kanpur	60.01500	10.57800	8.78466
58.	Low cost technology for safe storage of pulses (RPPS-05) Dr. S.D. Deshpande, CIAE, Bhopal	53.47000	10.33950	9.01575
59.	Improvement of components of agrotechnologies for management of intercrops (RPPS-06) Dr. G.B. Gaikwad, MPKV, Rahuri	158.18000	23.40750	28.46644
60.	Development of bio-intensive IPM modules in chickpea against Helicoverpa armigera, wilt and dry root rot (RPPS-07) Dr. R. Ahmed, IIPR, Kanpur	105.68100	16.35300	19.50717

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
61.	Development of bio-intensive IPM modules against pest complex, wilt and phytophthora blight in pigeonpea intercropping systems (RPPS-08) Dr. R.G. Chaudhary, IIPR, Kanpur	77.70500	13.19700	11.97917
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) Dr. G.R. Maruthi Sankar, CRIDA, Hyderabad	31.99985	—	0.70382
63.	Evaluation and improvement of Indigenious methods of moisture conservation and runoff management (RPPS-10) Dr. K.D. Sharma, CRIDA, Hyderabad	162.32500	40.06900	30.20221
64.	Integrated nutrient management in major pulse based cropping systems and identification of the most productive and remunerative systems (RPPS-11) Dr. A.K. Biswas, IISS, Bhopal	72.23500	12.26650	13.49263
65.	Utilisation of by-products of pulses, oilseeds along with coarse cereal grains for intensive goat production (RPPS-12) Dr. T.K. Dutta, CIRG, Mathura	123.29450	18.32650	25.92649
	Total	**1046.32218**	**180.62838**	**195.54079**

Cotton based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	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) Dr. O. Challa, NBSS & LUP, Nagpur	36.87450	—	9.71545
67.	Optimising nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system (RCPS-02) Dr. Jagvir Singh, CICR, Nagpur	123.61250	32.32500	20.09393
68.	Assessment of gossypol content in cotton germplasm (RCPS-03) Dr. Mukta Chakrabarty, CICR, Nagpur	24.47200	4.11400	5.15377
69.	Delineating the efficient productive zones for cotton production system using GIS based crop models (RCPS-04) Dr. K.V. Rao, CRIDA, Hyderabad	60.61050	11.28225	13.96674
70.	Rain water conservation, harvesting and recycling/recharging techniques for enhanced productivity of cotton based cropping system (RCPS-05) Dr. D.S. Sonkusale, ZARS, Yeotmal	115.01000	12.79100	24.02348
71.	Improving cotton productivity in salt affected soils through identification of species/genotypes and farmers participation (RCPS-06) Dr. S.G. Patel, College of Agril., Dharwad	78.38600	13.45200	15.37335

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
72.	Promotion of productive high quality G.*arboreum* cotton to meet the needs of marginal cultivators of rainfed ecosystem vis-à-vis textile industry (RCPS-07) Dr. L.A. Deshpande, MAU, Parbhani	99.39500	21.62700	17.89455
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) Dr. B.M. Khadi, UAS, Dharwad	141.41650	37.66800	31.79430
74.	Collection and characterization of Indigenous cotton germplasm of north eastern region (RCPS-09) Dr. Ashutosh Roy, RARS, AAU, Diphu	24.67045	4.79500	4.59168
75.	Development of *Bt* transgenic diploid cotton against bollworm (RCPS-10) Dr. S.B. Nandeswar, CICR, Nagpur	19.88770	5.29800	4.71599
76.	Impact of tillage, land treatment and organic residue; management on soil health, drainage and crop productivity of rainfed cotton based system (RCPS-11) Dr. R.S. Chaudhary, IISS, Bhopal	93.42100	31.21550	16.12214
	Total	**817.75615**	**174.56775**	**163.44538**

Nutritious Cereals based production system

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
77.	Processing of millets for value addition and development of health foods (RNPS-01) Dr. Salil Sehgal, CCSHAU, Hisar	102.84750	21.58350	21.92486
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) Dr. B.R.M. Rao, NRSA, Hyderabad	149.59100	36.05050	36.88928
79.	Developing live fencing systems for soil and water conservation, crop diversification and sustaining productivity in rainfed regions (RNPS-03) Dr. Prasidhi Rai, NRCAF, Jhansi	189.24050	33.15000	29.59053
80.	Strengthening of research on integrated management of blast of fingermillet (Eleusine coracana Gaertn) (RNPS-04) Dr. T.B. Anil Kumar, UAS, Bangalore	82.56597	13.61634	28.91156
81.	Refining small millets based cropping systems for augmenting supply of legumes (Grain/Vegetables) (RNPS-05) Dr. T.K. Krishna Gowda, UAS, Bangalore	89.53600	15.64650	14.60996

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
82.	Development of national data base on rainfed sorghum, pearlmillet and fingermillet for research, planning and policy making (RNPS-06) Dr. B. Dayakar Rao, NRCS, Hyderabad	34.29000	2.50000	11.74645
83.	A Critical Analysis of changing scenario of *kharif* sorghum growing areas (RNPS-07) Dr. B. Dayakar Rao, NRCS, Hyderabad	54.90150	10.94100	7.76791
84.	Evaluation/Improvement of dual types of sorghum and make available indigenous cultivars liked by farmers (RNPS-08) Dr. M.S. Desai, GAU, Surat	115.86750	17.74500	26.22292
85.	Develop agri-horiculture and agroforestry systems in *kharif* sorghum area decreasing regions for overall sustainablility of the production systesm (RNPS-09) Dr. N.N. Reddy, CRIDA, Hyderabad	113.76550	22.80300	23.05890
86.	Management strategies for improving *rabi* sorghum productivity (RNPS-10) Dr. M.S. Raut, NRCS, Hyderabad	143.68600	26.18850	30.86553
87.	Improving productivity of rainfed maize based cropping system with rain water management on watershed (micro) basis (RNPS-11) Dr. B.L. Gaur, MPUAT, Udaipur	127.39550	28.49250	21.53542
88.	Studies on development of silvopasture system for improving livestock productivity in rainfed regions (RNPS-12) Dr. M.M. Roy, IGFRI, Jhansi	150.89250	23.36050	33.20383
89.	Forecasting and management of diseases and insects in sorghum in cropping system perspectives (RNPS-13) Dr. N.D. Das, CRIDA, Hyderabad	25.87150	—	7.81039
90.	On-farm research for enhancing productivity of pearlmillet in Vertisols of semi-arid tropics (RNPS-14) Dr. B.N. Chavan, MAU, Aurangabad	87.88500	22.32500	19.81868
91.	On-farm research for enhancing productivity for pearlmillet in arid regions of India (RNPS-15) Dr. Makhan Lal, RAU, ARS, Jodhpur	72.28650	18.51550	17.49091
92.	Utilisation of nutritious cereals and byproducts of oilseed based cropping systems for poultry production (RNPS-16) Dr. A.B. Mandal, CARI, Izatnagar	148.20400	23.91900	29.43323
93.	Improving the utilization of coarse cereal crop residues by strategic supplementation for livestock feeding (RNPS-17) Dr. K.T. Sampath, NIANP, Bangalore	134.27800	17.46850	21.45789
94.	Resource characterisation and socio-economic constraint analysis of productivity in the maize based crop production system (RNPS-18) Dr. P.C. Kanthaliya, MPUAT, Udaipur	83.63600	—	17.13910

Sl. No.	Project title with code	Budget allocation Total	Budget allocation 2002-2003	Utilization*
95.	Rain water management on watershed (micro) basis in sub-montane region (RNPS-19) Dr. R.P. Yadav, CSWCRTI, Chandigarh	164.86850	23.45360	33.20071
96.	Improvement of roti making quality and shelf life of grain sorghum (RNPS-20) Dr. G.K. Garg, GBPUAT, Pantnagar	151.65000	15.63600	22.25594
97.	Improving productivity and profitability of rainfed fruit based production system based cropping system in low productive environments (RNPS-21) Dr. B. Prasanna Kumar, IIHR, Bangalore	166.53600	24.81425	34.95551
98.	Improving the productivity and profitability of vegetable crops under rainfed agro ecosystems (RNPS-22) Dr. M. Prabhakar, IIHR, Bangalore	145.66200	18.34750	33.85965
99.	Total grain quality management of *kharif* sorghum (RNPS-23) Dr. S. Audilaxmi, NRCS, Hyderabad	199.72750	43.94850	60.14057
100.	Developing sorghum as an efficient biomass and bio-energy crop and providing value addition to the rain damaged *kharif* grain for creating industrial demand (RNPS-24) Dr. C.V. Ratnavati, NRCS, Hyderabad	188.83100	34.56450	57.68745
101.	Identifying systems for carbon sequestration and increased productivity in semi-arid tropical environments (RNPS-25) Dr. S.P. Wani, ICRISAT, Hyderabad	179.38250	31.70700	48.85577
102.	Developing sustainable alternate land use systems for industrial biomass production from drylands (RNPS-26) Dr. J.V.N.S. Prasad, CRIDA, Hyderabad	19.97000	3.25600	9.32648
103.	Efficient clonal propogation of high value horticultural and forest species for dryland agriculture (RNPS-27) Dr. G.M. Reddy, G.M. Reddy Research Foundation, Hyderabad	71.12985	18.62375	15.76412
	Total	**3194.49782**	**548.65644**	**715.52355**

* Utilization is based on SoE and includes the carryover budget from 2001-02 also.

Annexure III

On-farm Trials Conducted, Number of Farmers and Area Covered under Production System Research

Production system	No.of on-farm projects	Area covered (ha)	No.of on-farm trails	No.of villages
Rainfed Rice	27	826	3517	1834
Oilseeds	10	387	654	418
Pulses	8	150	349	171
Cotton	07	253	794	209
Nutritious Cereals	16	1068	1033	501
Total	**68**	**2684**	**6347**	**3133**

Annexure IV

List of Technologies from PSR Projects under Assessment/to be Assessed Through TAR- IVLP

Sl. No.	Name of the technology	Relevant in the areas of
	Rainfed Rice Based Production System	
1.	Sequence cropping of vegetables and oilseeds in rice fallows	Chhattisgarh, M.P., Orissa
2.	Intercropping of upland rice + pigeonpea (5:2)	Uplands in Chhattisgarh, Jharkhand and Orissa
3.	Pigeonpea + groundnut intercropping system (2:6)	Uplands in Chhattisgarh, Jharkhand and Orissa
4.	Rain water harvesting and recycling through *dabris*	Chhattisgarh, Orissa and Jharkhand
5.	Utilisation of excess rain water in medium and low lands for second crop and fish culture	Orissa and Jharkhand uplans
6.	Mango + upland rice agri-horticultural system	Uplands of Koraput district
7.	Mango + ginger/turmeric agri-horticultural system	Uplands of Koraput and Phulbani district
8.	Rice-fish-duck farming system	Tribal areas of Jharkhand
9.	Rice-fish-pig-farming system	Tribal districts of West Bengal
10.	Improved upland rice varieties for aberrant weather	Orissa, Chhattisgarh and Jharkhand
11.	Integrated nutrient management with incorporation of legume intercrop in rainfed rice	Orissa and Jharkhand
12.	Management of parasitic diseases (nematodes and trematodes) in buffaloes	Orissa, Chhattisgarh and Jharkhand
13.	Improved methods of upland vegetable cultivation (ginger/turmeric/onion) with emphasis on nursery technologies	Orissa and Jharkhand
14.	Use of bullock drawn puddler 99 for improved yield of rainfed rice in low lands	Orissa, Chhattisgarh and Jharkhand
15.	Integrated weed management in upland rice	Chhattisgarh and Jharkhand
16.	Integrated pest management in rainfed rice	Assam, Manipur, Orissa and West Bengal

Sl. No.	Name of the technology	Relevant in the areas of
17.	Water management technique for increasing cropping intensity through utilization of abandoned village ponds	Bhadrak and Balasore district of Orissa
18.	Improved *biasi* method of cultivation	Chhattisgarh
19.	Storage of paddy in RCC ring bin	Assam, Manipur and Orissa
20.	Improved method of drying paddy through rack drying	Orissa, Assam and Manipur
21.	Inter row crop seeder for rice and green manure crop	Orissa and Assam
22.	Sprouted rice seeder	Orissa and Chhattisgarh
	Oilseeds Based Production System	
23.	Cultivation of non spiny varieties of safflower	Maharashtra and Karnataka
24.	Use of safflower (multicrop) harvester	Karnataka and Maharashtra
25.	Improved technology for storing soybean seeds to increase viability	Madhya Pradesh and Maharashtra
26.	Improved technology for production of eri silkworm	Assam and Manipur
27.	Feeding of livestock with sunflower head based complete feed	Maharashtra, Karnataka and A.P.
28.	IPM modules for sunflower, safflower, mustard and groundnut	Relevant states growing these crops
29.	INM in oilseed based cropping systems	M.P and Maharashtra
30.	*In situ* moisture conservation technology in castor and groundnut	A.P and Maharashtra
31.	Production technology for castor, groundnut, safflower and linseed for saline and sodic soils	A.P, Maharashtra, Gujarat and U.P.
32.	Integrated management of groundnut stem necrosis	Anantapur and Kurnool districts of A.P.
	Pulses Based Production System	
33.	Liquid rhizobium inoculant for pulses	Relevant states growing chickpea, pigeonpea and soybean
34.	Non pesticidal control of soil nematodes	U.P.
35.	Management of MYMV in mung bean and urd bean	A.P, Tamil Nadu and U.P.
36.	Use of improved mini dal mill	All relevant states growing pigeonpea, chickpea and lentil
37.	Pitfall trap for monitoring and control of pulse beetle	All states
38.	Integrated crop management technology for pigeonpea based intercropping systems	Maharashtra, M.P and A.P.
39.	Bio-intensive IPM modules for pigeonpea and chickpea	All relevant states

Sl. No.	Name of the technology	Relevant in the areas of
	Cotton Based Production System	
40.	Rain water management in cotton on toposequences in a watershed	Maharashtra, Karnataka and A.P.
41.	Cultivation of quality *arboreum* varieties of MDL 2463, DLSA-17 and PA-402	A.P, Karnataka and Maharashtra
42.	Land treatments for moisture conservation and INM in cotton based cropping system	Maharashtra, Tamil Nadu, A.P and M.P.
	Nutritious Cereals Based Production System	
43.	Popularisation of value added health foods from pearlmillet and fingermillet	Karnataka, Haryana and Maharashtra
44.	Establishment and management of live fences around the crop fields	Maharashtra, A.P and U.P.
45.	Integrated management of blast disease in fingermillet	Karnataka and Tamil Nadu
46.	Fingermillet based intercropping systems with legumes for improved returns	A.P, Karnataka and Tamil Nadu
47.	Cultivation of dual purpose sorghum variety CSV-15	All relevant states
48.	Improved production technology for *rabi* sorghum	Maharashtra and Karnataka
49.	Rain water management technology in maize based cropping system	Rajasthan and Gujarat
50.	Establishment of improved silvi pasture systems for small ruminants	U.P, Gujarat and A.P.
51.	Moisture conservation and nutrient management technology for pearlmillet	All relevant states
52.	Feeding of poultry with substitute rations to reduce the cost of production	U.P and A.P.
53.	Improved coarse cereal residue based feeds for livestock	All relevant states
54.	Management technologies for mango based agri-horticultural systems	Gujarat and Karnataka
55.	Technology of physiological harvesting and grain drying in *kharif* sorghum	A.P and Maharashtra
56.	Cultivation of high yielding sweet sorghum genotypes	A.P, Karnataka, Maharashtra and Tamil Nadu
57.	Preparation of value added products like syrup, jaggery and cake from sweet sorghum	All relevant states

Annexure V

Meetings of the Scientific Advisory Panel
(From April 2002 to March 2003)

Sl.No. of the Meeting	Dates	Major Agenda
30	April 5 and 19, 2002	Annual progress review and consideration of special project on “Farming Systems Research”
31	July 12-13, 2002	Project-wise review, discussion on peer review reports and guidelines on HRD for scientists
—	August 16, 2002	Special SAP Meeting for discussion on drought situation during *kharif* 2002
32	November 25-26, 2002	Discussion on peer review reports and format for preparation of final reports
33	March 28, 2003	To finalise annual workshops schedule and discussion on extension proposal of projects

Annexure VI

Details of the Peer Reviews of PSR Projects

Dates	Type of Review	Projects reviewed	Location	Review team
19-20 April, 2002	Desk review	ROPS-14	CRIDA, Hyderabad	Dr.R.K.Gupta Dr.B.R.Hegde Dr.P.K.Joshi
7-8 May, 2002	Desk review	ROPS-17	NRCG, Junagadh	Dr.P.S.Reddy Dr.D.M.Hegde Dr.M.S.Basu
26-30 August, 2002	Field visit and presentation	24 sub projects in rainfed rice based production system	Ranchi, Darisai and Dumka in Jharkhand and Barrackpore in West Bengal	Dr.J.S.Kanwar Dr.I.C.Mahapatra Dr.S.K.Mohanty Dr.U.Prasada Rao Dr.H.P.Singh Dr.B.N.Singh
24 - 28 September, 2002	Field visit and presentation	19 sub projects in rainfed rice based production system	Titabar and Jorhat in Assam	Dr.J.S.Kanwar Dr.R.P.Singh Dr.U.Prasada Rao Dr.S.K.Mohanty Dr.S.R.Singh
3-6 October, 2002	Field visit	16 sub projects in rainfed rice based production system	In 9 target districts of Orissa	Dr.I.C.Mahapatra Dr.B.N.Singh Dr.S.Pathak Dr.J.K.Roy Dr.S.K.Mohanty Dr.S.R.Singh
7-10 October, 2002	Field visit and presentation	18 sub projects in nutritious cereals and oilseeds based production system	Kolar, Tumkur and Bangalore districts of Karnataka	Dr.J.S.Kanwar Dr.B.R.Hegde Dr.U.Prasada Rao Dr.V.Veerabhadraiah Dr.D.M.Hegde Dr.Sreenath Dixit
16-21 October, 2002	Field visit and presentation	22 sub projects in nutritious cereals, oilseeds, pulse and cotton based production system	CIRCOT, Mumbai and NRCG, Junagadh, Rajkot and Khed Brahma in Gujarat	Dr.P.S.Reddy Dr.D.M.Hegde Dr.B.Venkateswarlu Dr.K.D.Sharma

Dates	Type of Review	Projects reviewed	Location	Review team
3-6 December, 2002	Field visit and farmers interaction	2 sub projects in cotton based production system	Adilabad district of A.P. and Nanded in M.P.	Dr.N.G.P.Rao Dr.C.P.Ghonsikar Dr.M.H.Rao Dr.S.S.Balloli
27-28 December, 2002	Presentation and desk review	2 sub projects in rainfed rice and nutritious cereals based production systems dealing with remote sensing application	NBSSLUP, Regional Station, Kolkata	Dr.J.S.Kanwar Dr.N.N.Goswami Dr.R.K.Gupta Dr.D.P.Singh Dr.B.Venkateswarlu
7-8 February, 2003	Field visit and desk review	Sub project RPPS-10 of pulse based production system	CRIDA, Hyderabad	Dr.B.K.James Dr.U.Prasada Rao Dr.B.Venkateswarlu
16-17 February, 2003	Presentation and desk review	Special review of *rabi* sorghum work under NATP	College of Agriculture, MPKV, Pune	Dr.J.S.Kanwar Dr.N.G.P.Rao Dr.H.P.Singh Dr.B.Venkateswarlu

Annexure VII

Members of Scientific Advisory Panel (SAP) and Facilitators (as on 31.3.2003)

Dr.J.S.Kanwar, DDG (Emeritus), ICRISAT	Chairman
Dr.N.G.P.Rao, Ex-Chairman, ASRB and Ex-Vice Chancellor, MAU, Parbhani	Member
Dr.I.C.Mahapatra, Former Vice Chancellor, OUAT, Bhubaneswar	Member
Dr.B.K.Soni, Ex-DDG (ICAR)	Member
Dr.N.N.Goswami, Dean & Jt.Director (Retd.), IARI and Former Vice Chancellor, CSAUAT, Kanpur	Member
Dr.S.Bislaiah, Former Vice Chancellor, UAS, Bangalore and Chairman, Karnataka State Agril. Price Commission	Member
Dr.S.N.Puri, Hon'ble Vice Chancellor, MPKV, Rahuri	Member
Dr.P.S.Reddy, Ex Director, DOR, Hyderabad	Member
Dr.P.Das, Director, Regional Plant Resource Centre, Bhubaneswar	Member
Dr.R.K.Gupta, Director of Research, JNKVV, Jabalpur	Member
Dr.H.P.Singh, Director, CRIDA and AED (RF)	Member
Dr.D.P.Singh, National Coordinator (NATP)	Member
Nominee of Financial Advisor (DARE)	Vacant
Dr.B.Venkateswarlu, Principal Production System Scientist	Member Secretary

Facilitators for Different Production Systems

Dr.D.M.Hegde, Director, DOR, Hyderabad	Facilitator (Oilseeds)
Dr.Masood Ali, Director, IIPR, Kanpur	Facilitator (Pulses)
Dr.S.K.Banerjee, Principal Scientist, CICR, Nagpur	Facilitator (Cotton)
Dr.Devraj Panda, Principal Scientist, CRRI, Cuttack	Facilitator (Rice)
Dr.S.Indira, Principal Scientist, NRC Sorghum, Hyderabad	Facilitator (Nutritious Cereals)

Annexure VIII

Staff of Agro Ecosystem Directorate
(As on March, 2003)

Sl. No.	Name	Designation
1.	Dr.H.P.Singh	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
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 R.V.V.S.G.K. Raju	Technical Officer **
9.	Sri P.Chandrashekar	Technical Officer
10.	Smt. Hemlatha Kapil	Technical Assistant**
11.	Smt. M.A.Rekha	Junior Stenographer **
12.	Sri P.Nagabhushan Sharma	Stenographer **
13.	Sri K.R.Srinivas Rao	Assistant
	Contractual Staff	
14.	Dr.G.Ramesh	Research Associate
15.	Smt.Swathy Mohanty	Senior Research Fellow
16.	Sri V.Srinivas	Senior Research Fellow
17.	Sri M.D.Mazharulla	Stenographer-II
18.	Sri V.Krishna Murthy	Stenographer-II
19.	Sri Suresh Kanth Shukla	Assistant
20.	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 IX

Budget of AED at a Glance for 2002-03

(Rs. in lakhs)

Items	Remitted by PIU to AED	Released by AED during year	Expenditure incurred based on SoE
PSR	1610.00*	777.59	2179.65
IVLP	0.00	31.19	147.21
O&M	80.00	0.00	79.51
Total	1690.00	808.78	2406.37

* Refund to PIU – 300.00