Minor Millets in South Asia

Learnings from IFAD-NUS Project in India and Nepal

Bioversity International

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Bhag Mal, S. Padulosi and S. Bala Ravi, *editors*

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Foreword

The project, "Enhancing the Contributions of Nutritious but Neglected Crops to Food Security and to Incomes of the Rural Poor: Asia Component-Nutritious Millets" was part of a multi-country initiative on underutilized crops supported by the International Fund for Agricultural Development and globally coordinated by Bioversity International (formerly, the International Plant Genetic Resources Institute (IPGRI), Rome. The M.S. Swaminathan Research Foundation implemented and coordinated the South Asian component of this project. This book summarizes the major achievements made under this project during its first phase during 2002-2004.

I am extremely happy that this three-year project has made spectacular progress in promoting nutritious millets for enhancing the food and nutritional security of rural people, who largely depend on these crops. These crops also play an important role in contributing to livelihood security. The project leveraged approaches such as farmer participatory variety selection, improved agronomic practices and value chain development on grain. The significant achievements made on yield enhancement together with better cost-benefit ratio and increased income generation through value addition of grain and linking these products to the market. The contributions of this project in farmer participatory conservation of the genetic resources of these crops with increased participation of women farmers, replacing of traditional millet grain processing with automated simple village level machinery and empowering farm women and men with knowledge and skill on value addition and product development, have made notable impact in arresting the rapid erosion of these valuable genetic resources, promoting increased consumption of these nutritious grains at household level, reduction of drudgery of women in grain processing, and creating capacity to initiate group enterprises on grain value addition as well as income generation from off-farm activities. The value chain development has also generated substantial additional employment and income to the local people. The project has been successful in generating considerable awareness among farmers and other consumers on the nutritional importance of these grains, while it had addressed policy makers on the importance of these grains in regional and national food and nutritional security. I am confident that the results achieved under this project in India and Nepal will be consolidated by the donor agencies and food policy experts to achieve the Millennium Development Goal relating to the elimination of hunger and poverty. Above all, by establishing a strong linkage among conservation, cultivation, consumption and commercialization in these underutilized food crops, this project has established a successful model in creating an economic stake in conservation of local genetic resources.

The International Fund for Agricultural Development which provided funding support and Bioversity International which extended logistic and technical support deserve appreciation for their visionary policy initiative on promoting the neglected

crops and thus safeguarding the livelihood and nutrition security of many of the poorest of the poor in the constituent countries. These crops have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security. Above all, these less water requiring crops will become an additional blessing in the emerging era of climate change and associated adverse changes in precipitation and temperature.

I sincerely thank Dr. S. Appa Rao and Dr. S. Bala Ravi for their leadership as coordinators of the Asia component of this project. I also greatly appreciate the commendable efforts made by Drs. S. Bala Ravi, Stefano Padulosi and Bhag Mal for bringing out this publication, which provides the important learning from the Phase I of this project. I hope this publication will be widely read and used by policy makers and scientists engaged in building a sustainable nutrition security system.

Date: 20 November, 2010

Prof. M.S. Swaminathan
Chairman, M.S. Swaminathan
Research Foundation, Chennai, India

Foreword

I extend my congratulations to the authors and contributors of this publication that documents the results of the IFAD funded project "Enhancing the Contribution of Nutritious but Neglected Crops to Food Security and to Incomes of the Rural Poor: Asia Component-Nutritious Millets" that was implemented from 2002-2004. The project was coordinated at international level by Bioversity International (then known as IPGRI) and for South Asia by M.S. Swaminathan Research Foundation (MSSRF). This publication summarizes the successful implementation and results of the project in India and Nepal.

The results of the project highlight the importance looking at the entire value chain of millets from production to value addition and marketing. This is essential if we are to achieve a sustainable enhancement of the economic conditions of householders through reduction of drudgery, increased employment, as well as their improved food and nutrition security. The development of efficient processing technologies for the target crops and making them available to communities helped make these underutilized millets commercially more profitable to farmers and other value chain actors while at the same time boosting peoples' ability to diversify the portfolio of their locally made products. Development of capacities of farmers and their families on the different aspects of millet production, processing, utilization; marketing and allied subjects were another important activity of this project. Public awareness complemented these efforts to publicize the strategic nutritional value of these crops targeting both producers and the general public, including policy makers. This farm-to-fork approach involving interventions along the entire value chain of millets proved to be very successful in re-invigorating peoples' interest in underutilized and neglected crops such as those addressed by the project. Moreover, the inter-disciplinary, multi-stakeholder, gender and cultural sensitive participatory approach used in implementing the project helped in ensuring the success of the project.

This publication is an important resource for developing strategies and programmes that aim to tackle the difficult issues of poverty, food and nutrition security through mobilization and better use of existing and indigenous farm resources. Our hope is that the findings described in this publication will gain greater attention from decision makers to allow their scaling up and contribute to the greater sustainable conservation and use of minor millets and other similar crops.

The Asia-Pacific region is the centre of diversity of many important food crops, including those that are now considered neglected and underutilized. These indigenous fruit trees, cereals, and vegetables are historically the sources of food and nutrition of the people in the region but have recently become neglected and underutilized partly because of the strong policy focus towards a limited number of crops as the main components of food security. This bias has been aggravated

by constraints in the production, post production and product quality of these indigenous crops which the project has addressed in millets through its farm-to-fork approach.

Bioversity is very keen in moving forward this shift in paradigm that recognizes the broader contribution of agrobiodiversity on food security, nutrition and health, livelihood and adaptation to climate change. We will continue to work with our partners through the networks in the Asia-Pacific region to pursue this goal and continue research and development on the important neglected and underutilized crops in the region. Our attention will continue to focus on enhancing the capacities of stakeholders in the use of these nutritious crops across the region in order to bring them these sustainable changes and benefits.

Our hosting of the global facilitation office of the Crops for the Future (CFF) further strengthens our partnership in this area that we hope will result in greater recognition of the importance of neglected and underutilized crops.

Again, I thank IFAD for the generous support to this project and congratulate Bioversity colleagues, and the local and regional partners for their achievements.

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Preface

The small millets comprising six species, namely, finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*), Italian or foxtail millet (*Setaria italica*), barnyard millet (*Echinochloa crusgalli*), proso millet (*Panicum miliaceum*) and kodo millet (*Paspalum scrobiculatum*) are grown in about 2 million ha area in India, Among these, finger millet is the most important and occupies about 60% of the area and contributes 70 % of small millet production. These crops are hardy and quite resilient to varied agro-climatic adversities and play important role in marginal agriculture more common in hilly and semi-arid regions as important source of food grain as well as highly valued fodder. Many kinds of traditional foods and beverages are made from these grains in different regions and hence have important role in the local food culture. Nutritionally, they have high micronutrient content, particularly calcium and iron, high dietary fibre, higher amount of essential amino acids and low glycemic index and thus play an important role in the food and nutritional security of the poor.

However, their presence in the Indian food basket had been declining over the years primarily due to wheat and rice being available at subsidized rates. These species are neglected in research and development and are not receiving the policy support they need and rightly deserve. This neglect is also causing the marginalization of farmers who have been traditionally depending on these crops for their food security and income. However, there is an increasing recognition of their favourable nutrient composition and utility as health food, in the context of increasing life style diseases. Thus, apart from their traditional role as a staple for the poor in the marginal agricultural regions, they are gaining a new role as crops for healthy food and for the urban high income people. The IFAD supported project "Enhancing the Contribution of Nutritious but Neglected Crops to Food Security and to Incomes of the Rural Poor: Asia Component – Nutritious Millets" was a good attempt in this direction.

This publication contains valuable information on the outstanding contributions made under this project both in India and Nepal to advance the sustainable conservation and use of minor millets, including the characterization of their genetic resources, their participatory variety selection, the development of improved agronomic practices, seed production, value addition and product development, capacity building of stakeholder groups and public awareness. We believe that this publication will be very useful to all stakeholders engaged in promoting these crops, such as researchers, farmers and community members, entrepreneurs, students, planners and policy makers.

We are highly indebted to Prof. M.S. Swaminathan, Chairman, M.S. Swaminathan Research Foundation, Chennai, India and wish to record our sincere gratitude and deep appreciation to him for his kind guidance and personal attention for the successful implementation of the project. We are also grateful to Prof. P.C. Kesvan,

Executive Director, MSSRF, Chennai, Dr. S.A. Patil, Vice Chancellor, University of Agricultural Sciences (UAS), Dharwad, Dr. M.N. Sheelavantar, Vice Chancellor, University of Agricultural Sciences, Bangalore, Dr. A. Seetharam, Scientist Emeritus, All India Coordinated Small Millets Improvement Project, Bangalore and Dr. V. Prakash, Director and Dr. Narasimha, Head, Division of Grain Milling and Processing, Central Food Technology Research Institute, Mysore for their kind support and help in implementing the project in India. The support on value addition extended by the staff of the Divisions of Rural Home Sciences at UAS, Dharwad and Bangalore, also deserves special mention.

Mr. D.S. Pathic, Executive Director, Nepal Agricultural Research Council and his colleagues in the Crops and Horticultural Division took keen interest in the effective implementation of this project in Nepal. Dr. R.P. Sapkota, former Executive Director, Nepal Agricultural Research Council deserves special thanks for the initiative and leadership provided to the Nepal component of this project during initial period. Dr. Anil Subedi and Dr. Pratap K. Shreshtha, Exectuve Directors, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Nepal provided excellent support in implementing the project and deserve sincere thanks.

The enthusiastic support and hard work put in by many scientists, technicians, field staff, farm women and men at the project villages in India and Nepal was largely instrumental to the success achieved under the project and all of them deserve our special thanks and deep appreciation.

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Executive Summary

The project "Enhancing the Contribution of Neglected and Underutilized Species to Food Security, and to Incomes of the Rural Poor: Asia Component-Nutritious Millets" supported by the International Fund for Agricultural Development, coordinated at the international level by Bioversity International (formerly, IPGRI) and by the M.S. Swaminathan Research Foundation (MSSRF) at the South Asia level, was successfully implemented in India and Nepal during the period 2002-2004. MSSRF, Chennai, University of Agricultural Sciences (UAS), Bangalore and UAS, Dharwad were the partners of the Indian component of this project. The project component under MSSRF was implemented in three villages located at Kolli Hills (Tamil Nadu) and Jeypore (Orissa). The project activities performed under UAS, Bangalore were located at the Home Science College, Hebbal, and in 17 villages of the Kolar district (South Karnataka). The project component under UAS, Dharwad was located at the Rural Home Science College, Dharma, and in eight villages of Dharwad, Bellary and Haveri districts (Northern Karnataka). The Nepal Agricultural Research Council (NARC) and the Local Initiatives for Biodiversity Research and Development (LI-BIRD) were the partners of the Nepal component of the project. The project component under NARC was located at Kathmandu and two villages of Nuwakot district. The LI-BIRD project sites included two villages in the Kaski district.

The project embraced the work on three crop species of nutritious millets, finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*) and Italian or foxtail millet (*Setaria italica*), in India and finger millet alone in Nepal. The main objectives of the project were the productivity enhancement through farmer participatory identification and adoption of yield enhancing measures (such as high yield in traditional or improved varieties suited to each region and improved methods of cultivation), the promotion of household consumption of nutritious millets through increased production and redressing the drudgery associated with its traditional processing, and the income boosting from millet farming through increased production, value addition, product development and marketing. These activities were highly interconnected with on-farm and *ex situ* conservation of the traditional varieties of target crops, with capacity building of the value chain actors in the maintenance and production of quality seeds of selected varieties, strengthening traditional seed storage and sharing system, empowerment of women farmers with infrastructure and capacity building for drudgery-free processing, value addition and marketing, establishment of self help groups to build entrepreneurship for collective management of different aspects of millet production, processing and marketing and generating awareness among public, elected representatives and policy makers on the importance of these millets to the food baskets of the poor, and to their nutritional well being and income generation opportunities.

The participatory surveys on uses, constraints and opportunities undertaken by MSSRF in Kolli Hills (Tamil Nadu), which was a major millet growing area for

several years, showed that cultivation of these crops had been under increasing threat from tapioca, which was promoted as a cash crop by the local starch industry through a kind of contract farming. Farmers are encouraged to grow tapioca with advance monetary payments by the middlemen involved in the purchase of tapioca from farmers and its supply to the industry. On the contrary, no such marketing arrangement existed for millets. Some of the farmers allotted a small portion of their land for millet cultivation in view of the food value of these crops, which they had traditionally valued. Under the local cultivation practices being followed by farmers in Kolli Hills, no chemical fertilizers or other agricultural chemicals were used for millets resulting in their produce being organic which offered special marketing opportunities for millets.

The participatory surveys undertaken by UAS, Bangalore revealed that almost in all farm holdings in the project villages, the farmers were cultivating finger millet for grain as well as fodder which clearly showed its critical role as an important food crop in the region. Nearly 66% of farms were small and marginal; more than 60% farmers used farm-saved seeds for growing finger millet indicating the importance of seed recycling at the farm or village level; the pesticides usage in finger millet cultivation was negligible; finger millet fodder was highly valued and considered superior to other straw/stover, especially rice. Millet grains were largely used for home consumption and *mudde* was the most common daily form of consumption. Most farmers were not aware of the options available for diversified utilization. Both men and women actively participated in finger millet production. Women were mostly involved in weeding, harvesting, threshing and post-harvest grain cleaning, processing and utilization.

The participatory surveys undertaken in project villages by the UAS, Dharwad revealed that ethnic foods of millets being traditionally used were staple, convenient, health based snack items, fried foods and special foods. Boiling, steaming, fermentation, dry roasting, frying, malting and popping were the simple and less developed processing technologies adopted for different preparations. The results of the survey revealed that 50% of the consumers had the knowledge of use of millet as *roti, mudde, ambali,* and rice. Only a few consumers (5-25%) had the knowledge of diversified uses of millets. None of the consumers had the knowledge of availability of secondary processed products in local markets. Fifty per cent consumers had the knowledge about the significance of millets for medicinal purposes and their high nutritional value which was good for health.

In Nepal, resource mapping of finger millet growing project sites was done by NARC and the traditional knowledge was also documented. The current status of finger millet production and utilization in different project sites was addressed through case studies. There was a widespread public perception that finger millet is a low status food and consumed only by the poor and not preferred by those with better economic standard. A major use of this millet is as a raw material to ferment a locally produced alcohol, largely produced at household level and marketed by

women. Information was also gathered on beverage preparation, marketability of value added products, extent of foliar and panicle diseases affecting finger millet and the role of women in finger millet production. The participatory survey conducted by LI-BIRD revealed that preparation and selling of alcoholic beverages seemed profitable due to high positive gross margin from beverage production. The farmers could obtain Nepalese rupees (NR) 13.5 per kg net benefit by selling good quality alcohol at the rate of NR 18 per bottle.

This project facilitated the institutionalization of on-farm conservation with the establishment of village seed banks and promoting quality seed production and seed sharing among farmers. The on-farm conservation activities at field sites in Kolli Hills and Jeypore were carried out with a set of the seeds of all local varieties stored in the medium-term *ex situ* Community Gene Bank at MSSRF, Chennai. In Kolli Hills which was recorded having a large genetic diversity of nutritious millets, the farmers had been conserving about 21 landraces of these three millets for a long time. At Balia in Jeypore, five traditional varieties, three of finger millet and two of little millet, were conserved on-farm. The farmers in Kolar district maintained the diverse useful germplasm of finger millet suitable for higher grain yield production as well as value addition and product development. Farmers who were promoting organic farming also promoted local varieties which possessed some special characters and these were conserved and shared with other organic farmers and thus helped in conserving the precious finger millet germplasm on-farm. Some important local varieties/landraces were conserved on-farm in the project villages chosen by UAS, Dharwad. In Nepal, the important local varieties/landraces of finger millet were conserved on-farm by the farmers and many of these varieties are preferred by farmers for production in different villages.

The participatory variety selection in MSSRF was initiated with 7,000 accessions of these three crops accessed from the international germplasm collection available at the International Crops Research Institute for Semi-arid Tropics (ICRISAT), Patancheru and from other national institutions working on these crops. These accessions after two cycles of selection were brought down to 33 accessions at Jeypore and 25 accessions at Kolli Hills. As a result of further participatory selection in the final year of the project (2004), farmers identified two to three superior varieties in each of the three nutritious millet crops. In Italian millet, farmers preferred the traditional varieties, Bada Kangu in Jeypore and Senthinal in Kolli Hills. Two improved varieties of little millet were found most acceptable at both the locations. However, farmers wanted to retain the best local varieties, Kalakosla at Jeypore and Kattavetti Samai at Kolli Hills. In the case of finger millet, the improved variety chosen at Jeypore had 34% yield advantage over the best local variety Athangulia Mandia, while the best selected variety at Kolli Hills showed 52% yield superiority over the locally popular land race Sattaikevuru.

The participatory variety selection (PVS) under UAS, Bangalore and UAS, Dharwad followed a different approach with identifying a few improved varieties and farmers

growing them along with one locally popular farmers' variety. UAS, Bangalore included five improved varieties of finger millet and one farmers' variety. Thirty farmers in 15 villages deploying larger plot size were involved in the participatory selection. The results revealed that the varieties, L 5 and GPU 28 of finger millet selected by farmers under participatory variety trial became popular in the project villages, not only for their superiority in grain and fodder/straw yield, but also due to their relatively higher resistance to blast disease, which is more prevalent in the region and causes yield loss to the tune of about 15-20% depending upon the weather conditions. Thus, participatory variety selection led to achieving the yield enhancement to the tune of about 30-35% over the variety cultivated. The PVS under UAS, Dharwad was initiated in all the three crops with five varieties in each of the three crops. A total of 45 farmers, deploying larger plot size and located in 15 villages were involved in this selection process. PVS concluded in second year of the project identified varieties GPU 28 in finger millet, Sukshema in little millet and HMT 100-1 and Krishnadevaraya in Italian millet. Large scale farmer participatory demonstrations conducted during 2004 confirmed the yield superiority of these varieties to the tune of 31-35% over the local varieties.

In the participatory variety selection carried out in Nepal, NARC used four traditional and five improved varieties of finger millet. The data on varieties tested under participatory variety selection (PVS) revealed that there were no significant differences in the grain yield of different cultivars. However, the high grain yield was produced by improved varieties such as GE 5176, GPU 25, and Acc. 523-1 and local varieties such as Mudke, Mabire, and Dalle at different locations in different years. The LI-BIRD chose six PVS varieties including one local variety. The farmers identified and verified ACC.523-1 and GPU 25 varieties as the most promising among all PVS varieties to add varietal diversity in the area under millet cultivation. They preferred variety ACC. 523-1 due to its high grain and straw yield, early maturity, and bold grain, whereas GPU 25 was preferred due to its bigger ear head, bold grain and high grain yield.

The results from all the locations in Nepal and India suggested that farmers' preference on varieties chosen was more specific to regional conditions than the *per se* productivity of varieties. This exercise, apart from convincing farmers on the advantages of the varieties they selected through PVS, offered enriching experience to project staff on the selection nuances of farmers, who did not always place over emphasis on grain yield alone, but on a set of other traits important to their agricultural, agro-climatic and ethnic requirements. There were slightly different selection nuances between women and men farmers, the former giving consideration to grain colour and culinary aspects.

During 2004, more than 200 demonstrations in 35 villages were laid out in India and about a dozen in four villages in Nepal. These demonstrations were also used to popularize the selected variety and production technology through field days

and seed exchange involving more local farmers and to provide on-farm capacity building on production of quality seed.

Refinement in crop production management was an important approach used to enhance productivity of these millets. In India, these crops are more often grown as crop mixtures, while in Nepal they are largely grown as sole crops, although sometimes intercropped with legumes. Indian farmers largely grow them by broadcasting a seed mix comprising different species in different proportions. The species in these mixes and their relative proportions are location specific and intelligently chosen to suit the local agro-climatic conditions to meet the food and cash needs and to minimize the risks possible from climatic vagaries of marginal dryland farming. While farmers in most of the project villages sow the crop by broadcast method, those in Southern and Northern Karnataka grow these crops as intercrop planted in rows with variable row ratios for millets and non-millet crops. An important non-cereal component of crop mixture/intercrop is a legume, either pigeonpea (*Cajanus cajan*) or black gram (*Vigna mungo*). The marginal farmers rarely manure the crop either organically or chemically. The farmers in Kolli Hills and Jeypore used only organic manure, while the farmers in Karnataka applied low levels of chemical fertilizers. Chemical fertilization was far less frequent in Nepal. Similarly, inter-cultivation or weeding was uncommon in the crop sown by broadcast method, while this was practiced in row-planted crop. Thus, most of these traditional crop management practices resulted in productivity much lower than the actual potential. Therefore, apart from better variety and quality seed, there is a need to adopt improved production methods in order to have enhanced production for improved food security and income generation. These methods involve judicious location-specific choice and proportion of intercrop species, row planting and better agronomic management.

A farmer friendly and sustainable intercrop system has to have farmer chosen crop combination along with good management to ensure nutrient use efficiency, soil nutrient enrichment, also by promoting biological nitrogen fixation, reduced cost of production and enhanced net profit. Farmer participatory production refinement regime was determined jointly by farmers and project scientists for each region and this was tested with farmer-practiced (traditional) method. Such trials at Kolli Hills and Jeypore showed that with farmer selected varieties, yield gain was 23 - 33% and the relative increase in net return was 2.8 times higher. Similar trials showed income enhancement of 31- 46% in UAS, Bangalore and 21% in UAS, Dharwad. In terms of strengthening of food security arising from increased nutritious millet grain productivity contributed by improved agronomic practices, it was 39% in the case of finger millet, 37% in the case of little millet and 31% in the case of foxtail millet.

The yield from improved practice was consistently and significantly higher than that from the traditional practice of cultivation in all the three millet species. The finger millet variety GPU 48 performed superior to other varieties consistently across the demonstrations in Kolli Hills. The little millet varieties Kattavetti Samai

in Kolli Hills and OLM 203 in Jeypore performed well across the demonstrations. The yield data from these trials, apart from demonstrating the strength of improved agronomic practices in enhancing the yield also validated the precision achieved in the farmer participatory variety selection.

The results of participatory field testing undertaken by MSSRF, Chennai showed that some of the local varieties are as good as or more preferable to farmers than the improved varieties. For example, both in Jeypore and Kolli Hills, the local Italian millet cultivars were ranked first and their grain yield also justified such ranking. Similarly, in the case of little millet, farmers widely preferred both improved and traditional varieties (Kalakosla at Jeypore and Kattavetti Samai at Kolli Hills) and they did not show significant yield differences. In the case of finger millet, the improved variety chosen at Jeypore had 34% yield advantage over the best local variety Athangulia Mandia, while the top variety selected at Kolli Hills (GPU 48) had 52% higher yield over the best local landrace Sattaikevuru. Thus, participatory variety selection confirmed the agronomic superiority of the respective local varieties of Italian millet and little millet and led to the identification of varieties capable of giving significantly higher yield in finger millet and broadening the genetic base of all the three millets. This selection process also assisted farmers to identify rarely available white-grained variety of finger millet, which is highly preferred for making specific cuisines.

In Nepal, the comparative study on the performance of improved and local varieties under improved and local cultivation practices was undertaken by NARC at Pipaltar, Khanigaun and Kabre in 2004. The results revealed that local variety with improved practice produced the highest grain yield of 35.75 q/ha at Pipaltar and 27.67 q/ha at Khanigaun, while the improved variety with improved practice produced the highest grain yield of 17.72 q/ha at Kabre indicating thereby that the performance of varieties was location specific. This clearly established that the recommendation on varieties and production practices have to place more emphasis on location specificity.

The need for quality seed of the selected varieties emerged due to increased local demand. Quality seed and its local availability at affordable price have tactical significance in millet cultivation and yield in South Asia, largely due to the associated poor economic and agricultural resources. Poverty and food shortage rampant among the poor do occasionally force these farmers to consume the saved seed. Physical and genetic purity of seed is compromised because these crops are more often sown and harvested in mixtures. Hence, this project has given importance in capacity building on quality seed production and its safe storage in community managed seed-grain banks advocated by MSSRF. The results from MSSRF component of the project showed how seed bank had helped in making the quality seed available to larger number of farm holdings in a short time. A total of 78 farmer participatory field demonstrations on improved agronomic practices were conducted in 2004 in Kolli Hills and Jeypore to increase yield of millets and millet-based cropping

systems. These demonstrations used 346 kg of quality seeds of three millet crops, which were supplied free of cost to farmers. Additional 269 kg quality seed was also distributed among farmers as loan from local seed bank. The seed bank also sold some quantity of seeds to farmers. The seed production undertaken by UAS, Dharwad at the Agricultural Research Station, Hanumanamatti resulted in the production of 60 q of quality seed of Sukshema of little millet (32 q), HMT 100-1 of foxtail millet (20 q) and GPU 28 of finger millet (8 q) which was distributed to farmers in the project villages.

At the project sites under UAS, Bangalore, the cultivation of finger millet + pigeon pea in 8:2 ratio or finger millet + field bean (*Lablab purpureus*) in 8:1 ratio was found highly suitable and was recommended to realize higher monetary returns and better nutritional security. This type of intercropping was found highly successful and productive in the farmers' fields and hence received much importance and popularity with the farmers. The results also revealed that the farmer practice offered profit only under favourable growing conditions. Hence, the improved intercropping system under line sowing helped in realizing higher grain yields and economic returns, depending on the level of management provided by farmers. In addition, pigeonpea and field bean enriched the soil with biologically fixed nitrogen and increased solubilisation of fixed phosphorous. The results of the on-farm demonstrations conducted at the UAS, Bangalore showed that the farmers could increase the productivity of the crop by 30-35% with adoption of improved practices over farmers' practices in Karnataka. Thus, the farmers can realize an additional income of INR 5000-6200 ($ 110-135) per hectare by adopting practices advocated by the project through many participatory demonstrations.

While the studies by all partners at many project locations in India had convincingly proved the economic and ecological advantage of millet-based mixed/ intercrop system over their pure crop systems, the results of an exploratory study on mixed cropping conducted by LI-BIRD, Nepal revealed also that such a system was economically rewarding since there was no additional cost for mixed cropping except the cost of seed. The soil enriching properties of black gram used in the mixed crop was an additional advantage. The results of this study opened scope for further research in Western part of Nepal to standardize the mixed cropping system and to make the cultivation of finger millet crop more profitable.

More convincing results on the advantage of mixed cropping over sole crop were provided from central part of Nepal by NARC. Its study clearly brought out that sesame (*Sesamum indicum*) was a crop competing with finger millet when planted as sole crop. Sole crop of sesame gave in fact the highest gross return (NR 28,260) , while lowest return came from sole finger millet crop (NR 17,050). However, when finger millet was grown mixed with black gram, as practiced by farmers traditionally in certain villages, this mixed system gave the highest gross return (NR 26,697) and was also the second highest in gross return among the treatments indicating that this cropping system was economically more competitive. It also helped to enrich the

soil fertility. It was also observed that finger millet (*Macrotyloma uniflorum*) mixed with horsegram was more profitable as compared to millet mono crop.

For the millet-based cropping system, the demonstrations in farmers' fields conducted by the UAS, Dharwad, concluded that growing little millet, finger millet and foxtail millet along with pigeonpea in 4:2 row ratio, compared with other row proportions was more productive and profitable in Karnataka.

Another major intervention made by the project in all locations in India and Nepal was on post-harvest processing, value addition, market linkage aimed at reducing drudgery of women, promotion of household consumption of these nutritious grains and generation of income. This intervention in Nepal was also targeted to remove the social stigma on the grain and broaden its consumer base. Promotion of household consumption was to leverage the nutritional benefits of these grains to the community and to enhance their nutritional security. The project introduced micro-mills in the project villages in India, organized self help groups (SHGs) to manage these mills and built capability of these groups, particularly women, in processing, value addition, product development and marketing. Women SHG members from Kolli Hills and Jeypore were trained at the Rural Home Science Colleges of UAS, Bangalore and UAS, Dharwad on processing and value addition. They were also trained in marketing, packaging, quality standards, account keeping and entrepreneurship. This novel project approach had a great impact on the consumption of nutritious millets by the farm families, earning more income from value addition and additional employment generation and creating new urban markets for millets. According to the MSSRF experience in Jeypore and Kolli Hills, value addition of a ton of nutritious millet, on an average, offered income ranging from INR 1,050 - 19,250, depending on the product. It also generated additional employment, particularly for women, to the tune of 40-300 man-days per ton of grain. The removal of drudgery by innovating easy-to-operate village scale mechanical grain processing technology is recognized by this project as an important primary step to promote household consumption and building grain-based value chain.

Similar intervention under this project in Nepal was undertaken in 2004 with the supply of mini-mills to a few villages. Prior to that, LI-BIRD had been involving local traders and hoteliers in product development and promoting the demand for finger millet. They also had developed a number of locally valued products, although the benefits of this value addition were not accessible to farm families. Thus, an end-to-end project approach from production of millets to value addition and marketing is important for substantial enhancement of economic advantage to the farm family in terms of drudgery reduction, increased employment, food security and income generation.

Processing requirements of finger millet and other two millets are different. Finger millet, including its malt, is largely milled directly into flour and the products are made from sieved and whole flour. Little and Italian millets are largely consumed as rice and this requires de-husking and polishing. No village level machinery is

available for such quality polishing and hence trade on these millets and profit from processed rice are inaccessible to farmers. There is a need for designing efficient mini-hulling-cum-polishing machinery to benefit farmers growing little and Italian millets and such village-based processing facility has great potential to make a huge difference to farmers both on their household consumption and income generation capacity.

The food products were analyzed for protein and energy content and it was evident that small millet grains were nutritionally superior and were good source of quality protein, minerals, phytochemicals and vitamins. With appropriate processing and value added strategies, the millet grain can find a place in the preparation of several value added and health food products, which may result in high demand from large urban population and non-traditional users.

The studies at UAS, Dharwad revealed that small millets could easily be incorporated at 25% and 50% levels in wheat, rice and pulse recipes. Small millet products were highly acceptable among rural and urban population. The shelf life of a few small millet products was observed to be above two months at room temperature. In general, 50% incorporation of any small millet flour was found ideal for preparation of biscuits. The higher proportion of flour of finger millet and little millet resulted in harder texture of biscuits, while such blending with foxtail millet flour, the texture of biscuit remained soft. The mineral content of millet based biscuits/cookies was higher than refined wheat flour biscuits. The mineral content of biscuits prepared with blending millet flour at 25% ranged from 0.2 to 1.02% , and the maximum was found in finger millet based biscuits. The nutrient composition of biscuits prepared from different levels of blending with foxtail millet flour revealed that these provided fairly good amounts of nutrients, namely, protein, fat, carbohydrates, mineral, fibre, iron and calcium. Incorporation of 50% foxtail millet or malted finger millet flour to refined wheat flour for making muffins resulted the product turning more dense, compact and too dry to swallow. The overall acceptability level was lower as compared to standard muffins.

The consumer acceptability of various value added millet products ranged from 65-90%. The economic estimation indicated that value addition as health food can increase the profit of small millet growers by about four times. The results clearly revealed that there is a need to promote such value added products to meet the needs of the community through ready-to-eat convenient and nutritious breakfast food. The economic analysis of local beverage (*rakshi* and *jad*) production in Nepal undertaken by NARC in Pipaltar and Khanigaun indicated that the overall profit was very low, while the same study in Pokhara by LI-BIRD provided a favourable result. While beverage production from finger millet in Nepal is not legal, it is a widely followed traditional value addition process generating income to poor families.

The value added product development efforts by LI-BIRD were successful and resulted in the development of several new consumer preferred millet based products

such as bread, noodles, *namkin*, malt, and other bakery items like rolls, cookies and cakes. These products were promoted through a few bakery and hotel outlets by a kind of franchising after providing training and some financial assistance. Among these, Annapurna Bakery and Sital Agro-Products commercially produced and marketed cookies, bread, *namkin* and roasted millet malt that gained popularity in urban market of Pokhara, including local youth.

A project impact survey conducted on the trainees of self help groups (SHGs) in the operational area under Kolar district (Karnataka) in October, 2004 showed that production and marketing of finger millet malt and other selected value added products had become one of the major activities in these villages apart from other group activities such as dairying and vermi-composting. The survey also revealed that selected products of finger millet were finding their way to food market outlets in Kolar town and Bangalore city suggesting their demand profile among urbanities.

Training and skill development to farmers including members of SHGs, awareness generation on the nutritional value of these crops to farmers and general public and capacity building in different aspects of millet production, processing, utilization, marketing and allied aspects was another important activity of this project to strengthen its operational software. Nearly sixty trainings/workshops/exhibitions were organized by the Indian and Nepalese project partners under this project. A good number of them were on value addition and on nutritional importance. The training was imparted on various aspects such as participatory variety selection, quality seed production, improved millet production technologies, soil and water conservation, organic millet farming, vermi-compost production, product packaging and marketing, and account keeping, etc.

Awareness about the importance of finger millet and the improved technologies including high yielding varieties and better cultivation practices was brought about through organizing field demonstrations, farmers' fairs, and exhibitions. Demonstrations on processing, value addition and product development helped the farmers, men and women, communities, entrepreneurs and members of self help groups in understanding the important role finger millet and other small millets can play in enhancing income, nutritional security and sustaining the livelihood of poor people. Many TV programmes and All India Radio programmes in India and FM radio programmes in Nepal were organized to promote the awareness about the usefulness of finger millet and to reach out to the larger groups of finger millet farmers and consumers for enhancing production and consumption.

A documentary film on finger millet in *Kannada* (provincial language of Karnataka state) with a copy in English version was made. The film describes the crop, its traditional importance, varietal diversity, improved cultivation practices, nutritional importance, methods of value addition, enterprise building and some of the project activities. These documentary films proved to be a very useful tool in formal and informal training programmes and also for the transfer of technology through other agencies working in this area. These documentaries contributed to successful

dissemination of information on high yielding varieties, improved cultivation and production technology and also processing, value addition and product development for the benefit of the farmers, entrepreneurs and other users.

Apart from the awareness generation on the nutritional importance of these crops at farm family, village and city levels, this project made major efforts in India and Nepal to sensitize the policy makers on the critical importance of these crops in the food basket of the rural poor living in the arid and mountain regions, its primacy to the income generation of the poor farmers and the unique advantages of these crops offer as promising health foods. All the project partners fairly succeeded in taking this message to the senior policy makers of their region. This effort achieved a big milestone in the organization of an International Consultation on "the Role of Biodiversity in Achieving the Millennium Development Goal on Freedom from Hunger and Poverty" with the joint efforts of MSSRF, Bioversity International (formerly, IPGRI) and Global Facilitation Unit (GFU) at Chennai on 18-19 April, 2005. This consultation which was attended by Ministers and other senior policy makers from 25 countries highlighted the specific role of underutilized crops in addressing the regional Millennium Development Goal (MDG) on freedom from hunger and poverty. The recommendations emerged from this Consultation, termed as "Chennai Platform for Action on Agricultural Biodiversity and Elimination of Hunger and Poverty" have been widely appreciated and incorporated in the regional and global programmes and policies.

Introduction

Background

Global food security has been increasingly narrowing down to a handful of crops. Over 50% of the global requirement for proteins and calories are met by just three grains, maize, wheat and rice. Only 150 crops are commercialized on a significant global scale, while humankind over time, had used more than 7,000 edible species. The narrowing base of global food security is limiting livelihood options for the rural poor, particularly in marginal areas. Addressing their needs requires that we broaden the focus of research and development to include a much wider range of crop species, as one of the options. Many of these species occupy important niches, adapted to the high risk and fragile conditions where significant sections of the rural communities practice marginal farming. These crops have a comparative advantage in marginal lands where they have been selected to withstand stress conditions and contribute to sustainable production with low inputs at low cost of production. They also contribute to the diversity-richness as well as to the stability of agro-ecosystems. There are hardly any alternatives to these species for their strategic role in fragile ecosystems, such as found in arid and semi-arid lands, in mountains, steppes and tropical forests.

Ethnobotanic surveys indicate that hundreds of such species are still to be found in each country, representing an enormous wealth of agrobiodiversity with potential to contribute to improved incomes, food security and nutrition, combating hidden hunger caused by micronutrient (vitamin and mineral) deficiencies. However, these locally important species are frequently neglected by development workers, science and policies. Lack of attention has meant that their potential value is underexploited. This neglect places them in danger of continuing genetic erosion and, ultimately, disappearance, further restricting food security and livelihood options for the rural poor.

Sustainably improving rural livelihoods is a complex endeavour. Coping with greater competition for natural resources, urbanization and climate change will require a broader portfolio of crops to meet new environmental conditions and new markets. Some key resources to meet these challenges are already in the hands of the rural poor in the form of the wide range of neglected crop species that they use on a regular basis to meet household needs. Research to increase the value of these crops and make them more widely available would broaden the resource base and increase the livelihood options for rural communities.

Rationale

Neglected and underutilized species are considered ‘minor’ in terms of global trade and the research attention that they have received. They are often, however, far from minor in the lives of the rural poor. As well as playing significant, if not crucial roles in household food security and income generation, many are important in local food cultures. Such is the case for, to mention a few, taro, small millets and

buckwheat in Asia, fonio and bambara groundnut in Sub-Saharan Africa, or quinoa, oca and ulluco in the Andes. These genetic resources and associated cultural values are important assets of the rural poor that need to be safeguarded and promoted. They are also strategic for broadening the portfolio of crops and foods that can improve the livelihoods and food security of poor communities around the world, particularly in an era of climate change.

Because agricultural research has paid little attention to these species, there are major gaps in our knowledge and capacity to conserve and improve them. There is also a lack of knowledge about their agronomy and the improvement of their yield potential and quality. A little has been done to identify the most effective commercialization, processing, value addition, marketing and policy frameworks to promote their use and maximize their economic value. All of these factors represent, at various levels, the bottlenecks that need to be addressed for successful promotion of millets.

The international community has made clear calls for greater support for development of neglected and underutilized species in agriculture. This is an agreed priority of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (FAO, 1996), and its importance has been recognized by Agenda 21 and the Global Forum for Agricultural Research (GFAR). This was reaffirmed at the IFAD-supported Consultative Workshop on Enlarging the Basis of Food Security, organized by the CGIAR and the M.S. Swaminathan Research Foundation at Chennai, India, in February 1999. Whilst acknowledging the ongoing work of several CGIAR Centres, the Chennai meeting recognized that, despite the evident demand, research and development activities on neglected species have been sporadic and lacking in a coherent framework and strategy. Thus, the meeting called for greater attention to the area and recommended establishment of a platform to address work at the international level.

Within the mandate of Bioversity International (formerly, IPGRI), a special attention is dedicated to the promotion of neglected and underutilized species (NUS) and the project whose activities are herewith reported is part of Bioversity' s global efforts to enhance the potential contribution of these species in improving people's livelihoods around the world.

This international effort (the first of the UN dedicated solely to NUS) was successfully carried out from 2002-2004[1]. Composed of three regional components (South Asia, West Asia/North Africa, and Latin America), its framework was developed through several multi-stakeholders participatory workshops held in the course of 2001. The species selected during these consultations were the nutritious millets (focus of the project in India and Nepal), the Andean grains (focus in Bolivia, Ecuador and Peru) and medicinal and aromatic species (focus in Egypt and Yemen). The selection reflects the contribution of the species to sustainable agricultural systems, their potential for increased use, levels of threats of genetic erosion, and their local or regional importance for food security, nutrition and income generation in target areas.

1 A second phase approved by IFAD in 2007 (IFAD-NUS II) will be ending in December 2010.

The project was developed to also enhance the cooperation between farmers and researchers and create new synergies among them in order to better secure the genetic resource base of NUS, and improve the quality and availability of planting materials for local communities. The identification of the options for strengthening marketing and income generation for NUS along with a better networking of actors of the value chain were also key objectives. The project was designed around action-oriented research meant to produce (i) direct impact in project sites through enhanced use of the genetic resources and identification of specific investment opportunities, and (ii) global lessons that can be generalized to other species and regions. Public awareness was also emphasized in the design of the project in order to promote the nutritional values of NUS as well as their resilience traits, particularly helpful to address the challenges brought about by climate change.

Goal and objectives

The project's goal was to contribute to raising the incomes and strengthening the food security of small farmers and rural communities around the world through securing and exploiting the full potential of the genetic diversity contained in neglected and underutilized species. The project aimed to redress the neglect of valuable plant genetic resources of crops managed by the rural poor through development-oriented research and action in South Asia, West Asia and North Africa, and Latin America.

Its specific objectives included:

- Increasing the demand for and use of neglected and underutilized species through development and application of appropriate processing technologies, commercialization and marketing strategies
- Enhancing the genetic diversity, improving the quality, and increasing the availability of germplasm of the most promising species and varieties
- Securing the genetic resource base and expanding the distribution of specific crops through the development and application of integrated conservation strategies

Key programme activities

During the preparatory regional workshops, priority species were identified, along with problem analyses, project logframe, and specific activities and outputs expected to be delivered by each regional project component.

The crops selected for South Asia included finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*), Italian or foxtail millet (*Setaria italica*); all the three species to be addressed in India and only finger millet to be addressed in Nepal. The basis for identification of these species was that these were the staple crops for millions of the households and were highly nutritious and strategic source of food for the poor rural communities in India and Nepal.

On the basis of Bioversity's own research findings and the outcome of the stakeholder meetings, the project's activities were identified in order to address eight key problems affecting the use of NUS in participating countries, namely:

- Lack of the required genetic material of the target neglected and underutilized species
- Loss of germplasm and traditional knowledge
- Lack of knowledge of uses, constraints and opportunities for the target neglected and underutilized species
- Limited income generation
- Market commercialization and demand limitations
- Lack of research and development activities and weak national capacities
- Lack of links across conservation and production to consumption "*filières*"
- Inappropriate or inadequate policy and legal frameworks

The bulk of the genetic resources of neglected and underutilized species are largely in the hands of local communities. They constituted the primary biological assets of poor farmers and hence the work of this project was based on a participatory and bottom-up approach. Moreover, women are the primary managers and sources of knowledge for many NUS, making gender-sensitive approaches essential to the successful implementation of the project. The approaches that guided the formulation of the project activities comprised the following:

- Focusing on the local value, indigenous knowledge and uses of the crops, in order to link and promote cooperation among stakeholders
- Identifying and overcoming the socioeconomic and technical constraints to the conservation and use of the diversity
- Analyzing and enhancing the demand using market oriented strategies
- Empowering the rural poor to retain access to these resources as their value increases
- Mainstreaming gender-sensitive approaches to genetic resources management and use
- Establishing an operating framework for managing plant genetic resources that can provide a safety back-up for conservation and use

The major project activities included:

- Set up local germplasm supply systems among rural communities; initiate participatory improvement programmes to obtain clean planting materials and improved varieties.
- Assess distribution of species and genetic erosion threats; sample germplasm for *ex situ* maintenance and use; implement on- farm conservation through community-based actions; identify and collate traditional knowledge using participatory procedures based on informed consent (including e.g. recipes on uses).
- Undertake participatory surveys on uses, constraints and opportunities with communities and other levels of the "*filières*"; analyse the survey data for gender and other socially significant factors.

- Develop value adding strategies (through processing, marketing, commercialization, etc.); investigate and identify improved agronomic and production procedures.
- Strengthen operational links in the *"filières"* between seed supply system, processing and distribution stakeholders; develop improved low-cost processing techniques; analyze and identify market opportunities.
- Carry out short training courses for researchers; develop and undertake community-based participatory courses; characterize crops for agronomic, nutritional and market related traits; study formal and informal classification systems; investigate methods of maintaining and enhancing nutritional value; investigate new areas of crop production.
- Organize planning workshops for all stakeholders; establish and strengthen operational links between stakeholders.
- Identify inappropriate policy/legal elements; undertake public awareness actions among policy-makers; establish close partnerships with extension workers and others involved in agricultural development.

Expected outputs

Both organizational and technical outputs with local, national and global elements were expected from the project. The major organizational outputs expected were as follows:

- Networks established for provide participatory systems and procedures to support the improved production and use of the selected crops
- Operational alliances formed among selected network partners to implement actions that overcome production and marketing constraints (e.g. seed supply systems, processing groups, distribution cooperatives)
- Linkages established to existing rural and economic development projects where the neglected and underutilized crops could make contributions to incomes, nutritional well being and the resource base of rural communities
- Capacity of marketing associations and producer groups enhanced to use improved materials of neglected and underutilized crops and more stable demand
- Awareness raised among policy-makers of issues and options for improved policy and legal frameworks impacting on neglected and underutilized crops

The expected technical outputs were:

- Integrated conservation of selected crop genetic resources undertaken
- Information made available on crop materials - their distribution, variation and potential for improvement, and for contributing to nutritional well being and income enhancement

- Seed and other planting materials made available for use by local communities and strengthened local seed production systems
- Improved crop materials with enhanced competitiveness made available to rural communities through participatory variety selection and participatory plant breeding
- Information on major production and use constraints available throughout the producer to consumer chain
- Improved processing and marketing opportunities identified, leading to specific investment and income generation opportunities through greater demand for the selected crops and their products
- Enhanced national capacity to work with neglected and underutilized crops and to support rural community needs for these crops
- A secure resource base established for the selected crops for use in global development initiatives including deployment in marginal areas in other regions
- Knowledge of effective procedures gained to integrate neglected and underutilized crops into development actions, publications including technical guidelines, information on specific crops, their properties and nutritional value, and an overall synthesis
- Experience gained for linking plant genetic resources research with local institutions for managing crop resources

Promoting Nutritious Millets for Enhancing Income and Improved Nutrition: A Case Study from Tamil Nadu and Orissa

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1. Introduction

Small millets comprising six species are grown in India over ca 2 million ha, mostly in semi-arid, hilly and mountainous regions. India has the third largest area under small millets cultivation in the world. The six small millet species grown are finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*), Italian or foxtail millet (*Setaria italica*), barnyard millet (*Echinochloa crus-galli*), proso millet (*Panicum miliaceum*) and kodo millet (*Paspalum scrobiculatum*). Among these, finger millet occupies about 60% of the area and contributes 70% to the overall small millet production. These are hardy crops and quite resilient to a variety of agroclimatic adversities, such as poor soil fertility and limited rainfall. In view of their superior adaptability (compared for instance to rice), they play an important role in supporting marginal agriculture, such as that so commonly practiced in hilly and semi-arid regions of India. Among these crops, finger millet is the most important and widely grown in India, from the semi-arid plains to the foot hills of the Himalayas, up to an elevation of 3,500 m asl. These millets are the source of important food grain in their areas of cultivation, while their straw is highly valued as fodder. Many kinds of traditional foods and beverages are made with these species across the country and hence they play an important role in the local food culture. Nutritionally, they are characterized by a high micronutrient content, particularly with regard to calcium and iron, and high dietary fibre. Their grain protein is richer in sulphur-containing and other essential amino acids than all other major cereals. For this reason, Prof. M.S. Swaminathan, Chairman MSSRF, Chennai had suggested to call them more appropriately as "*nutritious millets*", rather than coarse grains. The nutraceutical value of these grains, by virtue of their high dietary fibre and low glycemic index, is receiving increasing attention. Their cheaper price, compared to that of rice and wheat makes them more accessible to the poor people and those living in economically backward mountainous and semi-arid regions of South Asia. Thus, they play an important role in the food and nutritional security of the poor.

However, their presence in the Indian food basket has been declining over the years. One reason for this decline is the increased availability of rice, wheat and maize (particularly rice and wheat under subsidized public distribution system). These grains are neglected in research and development. The lack of modern technologies for their effective processing and utilization is an important reason for their declining importance. There is a policy gap in all countries of the south Asian region with regard to the promotion of cultivation and consumption of these underutilized grains. All these elements have collectively contributed to the neglect and underutilization

of these millets leading to their increased marginalization, accelerated loss of their genetic diversity and traditional food culture associated with them. This neglect is also causing the marginalization of farmers who have been traditionally depending on these crops for their food security and income. Over the last few years, there is an increasing recognition of their favourable nutrient composition and benefits as healthy food. Thus, apart from their continued strategic role as staple for the poor in marginal agricultural regions, they are also assuming a new role as a health food for the urban high income people.

2. Objectives

The aim of this project was to enhance the contributions of three nutritious millets, namely, finger millet, little millet and Italian or foxtail millet to strengthen the food security and to enhance the income generation of the rural poor, with following major objectives:

- Enhancing the production and productivity through the use of better seeds and improved cultivation practices
- Strengthening local capability for production and supply of quality seed at the community level
- Introducing drudgery-free grain processing technology to assist women towards promotion of consumption of these grains and enhancing income by building value chain
- Creating awareness on the importance of millets for food and nutritional security

This chapter reports the outcome of the project activities in Tamil Nadu and Orissa States in the frame of the first phase of the IFAD-NUS project (2002-2004).

3. Project sites

The project placed emphasis on all the three millet species in India, while only finger millet was being researched in Nepal. In addition to the M.S. Swaminathan Research Foundation (MSSRF) which was also responsible for coordination of the project implementation in South Asia, the project partners in India were the Universities of Agricultural Sciences (UAS) at Bangalore and Dharwad and the Central Food Technology Research Institute, Mysore. The two project partners in Nepal were the National Agricultural Research Council (NARC), Kathmandu, and the NGO "Local Initiatives for Biodiversity Research and Development" (LI-BIRD), Pokhara, Nepal. The field-based project activities under the MSSRF

Fig. 1. Map of India and Nepal Indicating IFAD project sites in South Asia

were located at Kolli Hills in Namakkal district of Tamil Nadu and at Jeypore in Koraput district of Orissa. In Kolli Hills, the project was located in two villages, Padasolai and Sembuthuvalavu, while in Jeypore it was located in the Balia village. The project sites in India and Nepal are given in Fig. 1 and the staff involved in the implementation of the project is given in Annexure 1. This chapter reports the results of the project implemented in Kolli Hills and Jeypore.

4. Preliminary surveys on uses, constraints and opportunities

Initial surveys in Kolli Hills showed that millet farming has been under increasing threat from tapioca (*Manihot esculenta*), which is promoted by the local starch industry through a kind of contract farming. Farmers are encouraged to grow tapioca with advance monetary payments received from the middlemen involved in the purchase of tapioca from farmers and its supply to the industry. The produce from millets had no such marketing arrangements and this is a major bottleneck for their promotion. Moreover, tapioca occupied the field for ten months while millets left the field fallow for 5-6 months and the net income from former is higher than that from millets. However, some of the farmers allotted a small portion of their land for millet cultivation in view of the food value they attach to these crops.

The project worked to increase the production of millets through the following interventions: (i) increased allotment of area to these crops in farmsteads, (ii) improved productivity, and (iii) a new strategy of introducing millet as intercrop with tapioca. The tapioca-millet intercropping has the advantage of getting an additional grain crop while ensuring the cash income from tapioca. Increased millet production was expected to increase the availability of these grains for local consumption and also for marketing the surplus.

Under the local cultivation practices being followed by farmers in Kolli Hills, no chemical fertilizers or other agricultural chemicals are used for millets, although tapioca is cultivated by using fertilizers. Hence, the millet crops grown in certain areas, except those grown as intercrop with tapioca or grown in fields planted with tapioca in the recent past, are virtually organic and this offered special marketing opportunities. The farmers were, therefore, assisted by the MSSRF to secure organic certification from ECO-CERT, Germany. This helped to fetch a premium price to the organic grain, which partially contributed to gain competitiveness to millets vis-a-vis tapioca.

5. Germplasm conservation, evaluation, testing and utilization

5.1. On-farm community conservation of local landraces

Conservation of local germplasm and its enrichment with introduction of new genetic stocks were also important goals pursued by MSSRF under this project. These were carried out as part of on-farm conservation activities at the field sites of Kolli Hills and Jeypore. At the same time, samples of all local varieties

of millets from these locations were also stored in the medium-term *ex situ* Community Gene Bank at MSSRF, Chennai. In Kolli Hills, which hosts a large genetic diversity of nutritious millets, farmers have been conserving about 21 landraces of these three millets for a long time. At Balia, in Jeypore, five traditional varieties were conserved, three of finger millet and two of little millet. This project facilitated the institutionalization of on-farm conservation with the establishment of village seed banks and promoting quality seed production and seed sharing among farmers.

5.2. Participatory field testing and variety selection

The initial round of seed selection was conducted on about 6,000 entries of finger millet, little millet and Italian or foxtail millet, comprising germplasm accessions obtained from the International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru and improved varieties secured from the All India Coordinated Small Millet Improvement Project (AICSMIP), Bangalore and other national institutions. This evaluation was conducted in 2002 at Kolli Hills. Preliminary selections made by project scientists and farmers shortlisted 150 accessions. The selected accessions were further evaluated in farmers' fields under replicated statistically appropriate field design at Kolli Hills and Jeypore in 2003. More farmers, men and women, were involved in the variety selection during this second cycle. The second round of selection identified 25 varieties in Kolli Hills and 33 varieties in Jeypore (Table 1). These selections grown in replicated compact family block design during 2004 (Fig. 2) were further subjected to a third round of selection by farmers. The plot size used for each entry in each replication was 15 m^2. These trials received near to normal rainfall at Kolli Hills, while the heavy rains received at Jeypore exposed the finger millet varieties to high incidence of leaf, neck and finger blast (*Piricularia flourscens*). This condition offered an opportunity to select varieties for their tolerance to blast disease. Comparatively better tolerance was shown by the local variety, although this was only second best to GPU 28 in tolerance and the latter was not totally resistant to the disease. The local variety, by being late in maturity appeared to have escaped

Fig. 2. A view of participatory variety trial in Balia village

the incidence of finger and neck blast. The late maturing local variety was second best to GPU 48, which has medium maturity duration and the highest yield. Late maturing little millet varieties were also found to be, in general, well adapted to the local conditions. Similar was the case with Bada Kangu, another late maturing local Italian millet variety.

Table 1. Varieties of three millets subjected to participatory selection (2004)

Crop	Jeypore (Orissa)	Kolli Hills (Tamil Nadu)
	Name and number of varieties	**Name and number of varieties**
Finger millet	IE 812, IE 2089, IE 2791, IE 2863, IE 2991, IE 2999, IE 3001, IE 3089, IE 3091, IE3093, IE4685, GPU 48, Athangulia Mandia, Chariangulia Mandia, (14 Varieties)	IE2863, IE3023, IE3155, IE4885, MR1, VHC 3880, GPU 48, GPU 26, GPU 28 (9 Varieties)
Little millet	IMPR 23, IMPR 41, IMPR 393, IMPR 437, IMPR 462, IMPR 706, OLM 20, OLM 36, OLM 203, Kalakosla, Bija Suan, (11 Varieties)	IMPR706, IMPR393, IMPR41, IMPR988, IMPR921, IMPR984, Sukshema, Vellaperu Samai, Kattaveti Samai (9 Varieties)
Italian millet	ISE 45, ISE 809, ISE 914, ISE 1262, ISE 1269, ISE 1321,ISE 1359, Bada Kangu (8 Varieties)	ISE 38, ISE 23, ISE 3155, TNAU 173,ISE1269, ISE 832, Senthinai (7 Varieties)
Total	**33 (Germplasm-18; Improved-10; Traditional- 5)**	**25 (Germplasm-9; Improved-13; Traditional- 3)**

Participatory variety selection was made at the prime maturity stage of every variety (Fig. 3). Depending on the maturity differences among varieties, these selections were made on two or more days. Each farmer was asked to make independent selection of three varieties from each of the three crops, from each replication. They were also asked to rank these varieties from 1 to 3, in order of preference by tying tags numbered accordingly. After such selection by every farmer, the varieties carrying the tags and ranks were noted and these tags removed prior to selection by the next farmer. Such removal of tags was

Fig. 3. Varieties at maturity stage in PVS trial

made to prevent bias in the selection of farmers who followed the earlier selectors. This process was repeated for every farmer who participated in the selection. The final results of selection were arrived at by compiling varieties selected and their ranks across three replications. Participation of farmers in selection varied in Kolli Hills and Jeypore. While 7 farmers (all women) and 4 staff members participated in Kolli Hills, 20 farmers (10 men and 10 women) and three staff members participated in Jeypore. The three varieties selected by majority of farmers in each crop at Jeypore and Kolli Hills together with the ranking given to them on the basis of farmers' preference are listed in Table 2.

Table 2. Varieties selected by participatory method at Jeypore and Kolli Hills

Crop	Jeypore (Orissa)		Kolli Hills (Tamil Nadu)	
	Varieties	Ranking	Varieties	Ranking
Finger millet	GPU 48	First	IE 2863	First
	Athangulia Mandia (local)	Second	GPU 48	Second
	IE 3093	Third	VHC 3880, IE 3023	Third
Little millet	OLM 203	First	IMPR 393	First
	Kalakosla (local)	Second	Kattavetti Samai (local)	Second
	IMPR 393	Third	Sukshema	Third
Italian millet	Bada Kangu (local)	First	Senthinai (local)	First
	ISE 809	Second	ISE 38	Second
	ISE 1269	Third	TNAU 173	Third

Following the visual selection performed by farmers, the yield data of selected as well as other varieties in the trial were collected from each replication. The mean yield of most of the farmers' selections was found to corroborate, by and large, with the visual ranking made on these varieties. Apart from yield, farmers gave preference to maturity duration and grain colour. These results on the selected varieties are presented in Table 3. The differences among the varieties, which were ranked as first to third, were statistically significant only in the case of finger millet varieties in Jeypore. The yield of selected varieties of finger millet in Kolli Hills and the Italian and little millets at both locations did not show significant differences. While the Kolli Hill farmers preferred varieties with mid-early or medium maturity range, the Jeypore farmers preferred, in most cases, late maturing varieties. This has rationale in the rain fall pattern and distribution at these locations. Moreover, women farmers in Jeypore did not prefer early maturing varieties due to the high vulnerability of these varieties to bird damage.

These results showed that some of the local varieties were as good as or more preferable to farmers than the improved varieties. For example, both in Jeypore and

Kolli Hills, the local Italian millet cultivars were ranked first and their grain yield also justified such ranking. Similarly, in the case of little millet, farmers widely preferred both improved and traditional varieties (Kalakosla at Jeypore and Kattavetti Samai at Kolli Hills) and they did not show significant yield differences. In the case of finger millet, the improved variety chosen at Jeypore had 34% yield advantage over the best local variety, Athangulia Mandia, while the top variety selected at Kolli Hills (GPU 48) had 52% higher yield over the best local landrace, Sattaikevuru (Table 3). Thus, participatory variety selection confirmed the agronomic superiority of the respective local varieties of Italian and little millets and led to the identification of varieties capable of giving significantly higher yield in finger millet and broadening the genetic base of all the three millets. This selection process also assisted farmers to identify rarely available white-grained variety of finger millet, which is highly preferred for making specific cuisines.

Table 3. Important agronomic traits of farmer selected varieties

		Jeypore (Orissa)				Kolli Hills (Tamil Nadu)				
Rank	Variety selected	Days to flower	Grain yield (kg/ha)	Fodder yield, (kg/ha)	Grain colour	Variety selected	Days to flower	Grain yield (kg/ha)	Fodder yield, (kg/ha)	Grain colour
Italian millet										
1	Bada Kangu	88	1149	7472	Lt Y	Senthinai	61	833	4668	R
2	ISE 809	53	932	6639	Lt Y	ISE 38	61	775	4625	Y
3	ISE 1269	53	1051	5694	Lt Y	TNAU 173	61	907	4458	Y
Little millet										
1	OLM 203	99	1283	3037	Lt Y	IMPR 393	55	695	3375	Lt gr
2	Kalakosla	109	1144	3759	Br	Kattavetti Samai	113	715	3400	D.Gr
3	IMPR 393	71	950	2250	Lt gr	Sukshema	64	650	3293	Gr
Finger millet										
1	GPU 48	82	3262	8046	Lt Br	IE 2863	87	1205	4875	Lt Br
2	Athangulia Mandai	90	2429	6139	Red	GPU 48	64	1225	4093	Lt Br
3	IE 3093	86	1727	4694	Lt R	VHC 3880, IE 3023	57 87	793 763	3743 2968	Pl Br Pl Wh

R - Red; Y - Yellow; Lt Y - Light yellow, G - Grey; D. Gr - Dark grey; Lt Br - Light brown; Pl Br - Pale brown; Wh - White; Lt R - Light red.

5.3. Farmer participatory agronomic interventions

Small millets are more often grown either as mixed crop or intercrop with a group of other cereal and non-cereal crops, having variable maturity and plasticity to weather conditions. This kind of farming system under rain-fed, marginal farming situations reduces the possible risk from weather vagaries, while providing food grain, fodder and cash crops to communities. These crop combinations vary across

locations. For example, in Kolli Hills, in finger millet-led crop mixture, farmers chose other cereals like little and Italian millets, or maize, and non-cereal crops like pigeonpea and rapeseed mustard (Fig. 4). The intercrops preferred in Jeypore along with finger millet are little millet, sorghum, pigeonpea, black gram, and niger.

Fig. 4. Intercrop of finger millet with pigeonpea and mustard

Under traditional practice, seeds of some of these crops are mixed in variable proportions and broadcasted. It also uses a heavy seed rate as a safeguard against poor seed quality and uncertain soil moisture. Such seed rate under favourable soil moisture results in a very dense crop, which is normally not thinned out and leads to crowded plant population and poor yield. Traditional practice of cultivation also does not apply manure or fertilizers or any other intensive management practices. Under such situation, the crop offers poor to modest yield depending on weather. Seeds saved from such mixed crops also turn to be of inferior quality with considerable physical mixing, which adversely affects the yield potential.

Hence, major interventions on improved agronomic practices to enhance productivity of nutritious millets and income from their cultivation are (i) use of farmer preferred millet varieties, (ii) use of quality seed produced in participation with farmers, (iii) planting in rows instead of broadcast sowing (Fig. 5), (iv) use of scientifically recommended seed rate, (v) effective use of row ratios for millet-based intercrops, (vi) encouraging application of farm yard manure and/or fertilizers, on farmers' choice, (vii) thinning to regulate plant population, and (viii) inter-cultivation and need-based top dressing with fertilizers, Another intervention made in Kolli Hills in view of increasing replacement of nutritious millets with tapioca was promotion of both crops in the same land by inter cropping short duration millets with tapioca together with modified agronomy to get high yield from both crops.

Fig. 5. Farmers initiated row planting for millet cultivation

During 2004, a total of 78 farmer participatory field demonstrations on improved agronomic practices were

conducted in Kolli Hills and Jeypore to increase yield of millets and millet-based cropping systems. These demonstrations were laid out with all the three millets, either as pure crop or as intercrop, in accordance with farmers' choice. In the case of intercrop, the local choice of crop combinations with minor modifications in their row ratios was promoted. For example, finger millet-based intercrop normally followed in Kolli Hills used a crop mixture comprising 6 parts finger millet, 1 part each of little millet and Italian millet, half part rapeseed mustard and 2 parts pigeonpea. Following this planting ratio, an intercrop system was designed and successfully demonstrated during 2003 and 2004 crop seasons (Fig. 6). Most of these demonstrations, as much as the land area of each farmer permitted, had control planting where farmer followed the traditional practices along with traditional seeds. All demonstrations used quality seeds of farmer selected varieties of nutritious millets with other interventions mentioned above. The plot size of demonstrations varied from 20 cents (0.08 ha) to 50 cents (0.2 ha).

Fig. 6. Intercropping with finger millet in Kolli Hills

5.4. Quality seed production and management of village seed bank

In view of the extreme shortage of millet seeds and poor quality of seeds being used, production and supply of quality seeds were identified as an important project activity for increasing productivity. This activity involved training farm women and men on quality seed production including practical lessons on variety characteristics, rouging in each variety, and handling of seed during harvest, threshing, drying and storage. Farmers from 24 farm families belonging to three villages in Jeypore and Kolli Hills were covered in this training. Subsequent local production and supply of quality seeds of varieties identified by participatory selection were done by these farmers.

In 2004, seeds of some of the varieties identified in the farmer participatory variety selection during 2003, comprising 14 varieties of finger millet, three varieties of little millet and one variety of Italian millet were multiplied. These seeds were purified with rigorous rouging to maintain quality equivalent to the certified seed. This generated 359 kg seeds, comprising 329 kg of finger millet, 18 kg of little millet and 12 kg of Italian millet (Table 4). The village seed banks in Balia and in Kolli Hills had built a seed stock of 1,007 kg for all the three millet species during 2004. This included 377 kg seed produced during *kharif* (rainy) season and 359 kg seed produced during summer season (Table 4). These seeds from the community seed banks were availed by 144 farm families during 2003 and 2004. Some of the farmers returned the seed loaned during 2003. One local NGO, called Agragaamee also received free seed supply from the project for popularization of farmer selected varieties away from project villages.

Table 4. Seed produced and cycled through the village seed bank during 2003-04

Year	Crop	Seed loaned (kg)	Seed returned with interest (kg)	Total quantity of seed (kg)	No. of farm families availed the loan	Area planted (ha)	Varieties
2003	FM	181	90	271	49	12.15	Bhiravi, local varieties
2004 (*Kharif*)	FM	266	107	373	93	24.30	PVS varieties Including local varieties
	LM	3	1	4	2	0.20	PVS varieties
Seed produced 2004 (summer)	FM			329		0.26	14 PVS varieties
	LM			18			3 PVS varieties
	IM			12			1 local variety
Seed shared*		20				1.62	Few PVS varieties
	All	**470**	**198**	**1007**	**-**	**38.53**	**PVS varieties**

*Seed supplied to a local NGO named 'Agragaamee'
FM - Finger millet; LM - Little millet; IM - Italian millet

The 78 demonstrations used 346 kg of quality seeds of three millet crops, which were supplied free of cost to farmers. Additional 269 kg quality seed was also distributed among farmers as loan from local seed bank. The community seed banks also sold some quantity of seeds to farmers.

5.5. Yield enhancement from improved agronomic practices

Grain and fodder yield results from all the 78 demonstrations were quite encouraging. Majority of the demonstrations (68%) used intercrops (Fig. 6), while the rest were pure crops of each of the three millets. Out of these, 35 demonstrations were with finger millet as main crop (Fig. 7). The yield from improved practice was consistently and significantly higher than that from the traditional practice of cultivation. The increase in individual trials ranged from 11-77% with mean increase of 39.0%. The finger millet variety GPU 48 performed superior to other varieties consistently across the demonstrations.

In other 35 demonstrations, the principal nutritious millet crop was little millet. The grain yield from these demonstrations is plotted in Fig. 8. These results

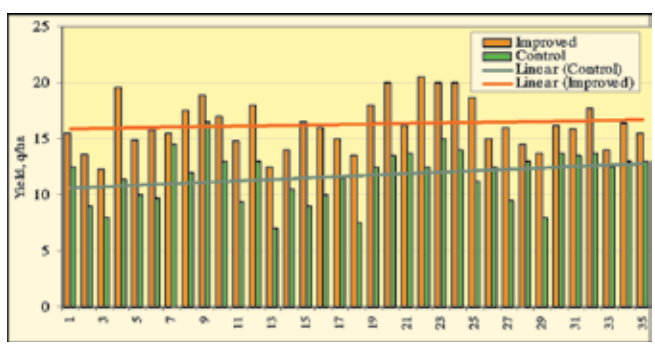

Fig. 7. Grain yield of finger millet in improved and control plots

showed consistent and significant increase in the yield from improved practices in comparison with yield from traditional practices. The increase in individual trials ranged from 7-83% with mean increase of 37.3%. The little millet varieties Kattavetti Samai in Kolli Hills and OLM 203 in Jeypore performed well across the demonstrations.

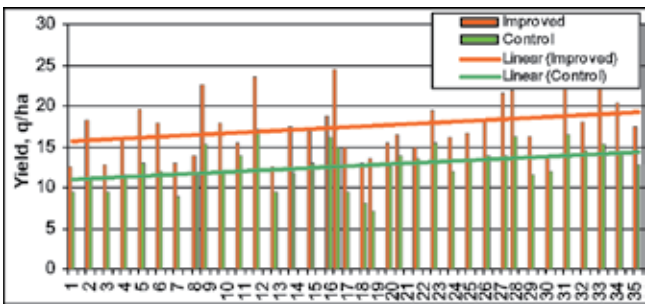

Fig. 8. Grain yield of little millet in improved and control plots

The results from 8 foxtail millet based demonstrations were in the similar lines with 29.6% average increase in improved practices. The yield data from these trials, apart from demonstrating the strength of improved agronomic practices in enhancing the yield also validated the precision achieved in the farmer participatory variety selection.

5.6. Increase in income generated from improved agronomy

Increase in productivity achieved over traditional practices (TP) which used local varieties (LV) by improved agronomic practices (IP) using farmer selected varieties (FSV) and their quality seeds resulted in either improved availability of nutritious millet grain for home consumption or marketable surplus. A comparison among demonstrations using pure crop of millet and millet-based intercrops showed that the intercrop systems invariably provided higher income, to the tune of 12 - 23%. Almost whole of the produce of all intercrops such as pigeonpea, mustard, black gram, niger, etc. offered cash income, while whole or good share of the millet grains was saved for home consumption. The marketable produce was sold almost immediately in the local market. Cost: benefit analysis of improved practices with farmer selected varieties of finger millet in pure and intercrop systems showed that the pure crop provided, on an average, 51% higher net income (Fig. 9), while the intercrop, on an average, offered 56.5% more income than the traditional practices with local varieties. In the case of intercrop systems, about 48% of the net income was contributed by the companion crops like pigeonpea, although this share widely varied, both due to the yield and cash value of crops used. In actual terms, the additional income generated, on an average, was INR 4,540/ha in the case of finger millet-based intercrop

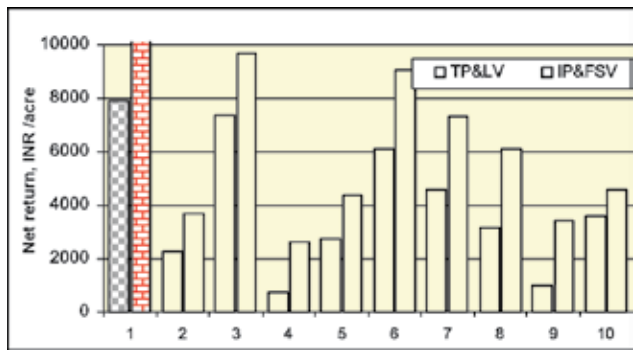

Fig. 9. Differences in net return from traditional and improved production practices-representative trials

and INR 2,733 in the case of pure finger millet crop. In the case of little millet and foxtail millet, the additional income generated from improved agronomic package of practices were 53% and 40.8%, respectively. In actual terms, the additional average net income generated by the improved practices in the little millet-based intercrop was INR 4,605/ha, while the same in the foxtail millet-based intercrop was INR 3,512/ha. In terms of strengthening of food security arising from increased nutritious millet grain productivity contributed by improved agronomic practices, it was 39% in the case of finger millet, 37% in the case of little millet and 31% in the case of foxtail millet (Fig. 10).

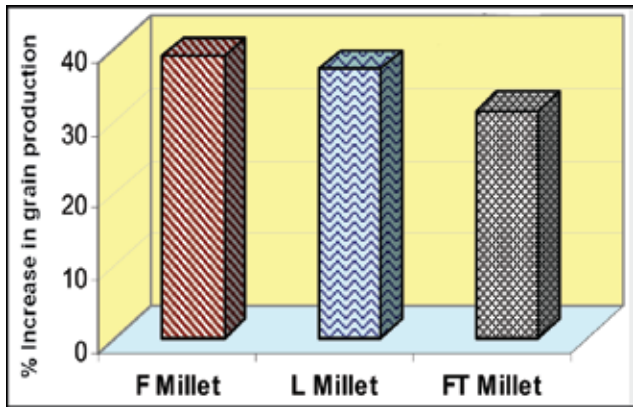

Fig. 10. Increased food security contributed by improved agronomy

6. Development of value chains of nutritious millets

6.1. Reduction of drudgery in processing nutritious millet grains

Nutritious millets are neglected in all respects including technology development for grain processing. There is no efficient technology for processing these grains at village level, despite India producing about 2 million tons of these grains. Such lack of technology has been forcing the dependence on traditional methods of grain processing, which are tedious, time consuming and cause of drudgery for women. This is another reason contributing to the decreasing popularity of these grains even among people who had been its traditional consumers. Small millet grains differ in their seed coat structure, particularly with respect to the abrasive force required to remove the seed coat. All except finger millet are covered by tight and hard seed coat, which require intense abrasive action for removal. While finger millet could be directly made to flour in a grinding mill, other grains are to be first dehulled and then polished to make them fit for consumption. The traditional practice of making flour from finger millet in villages is using stone grinder, which is operated by two women (Fig. 11). It requires manually rotating the grinding stone for long time

Fig. 11. Women grinding finger millet

Fig. 12. Dehulling of little millet with mortar and pestle

to make food grade flour. In the case of other millets, their dehulling by traditional method is of far higher drudgery to women. Dehusking is done by repeatedly beating the grain in mortar with pestle (Fig. 12). One has to work with pestle for almost an hour to process two kg of grain. The extent of drudgery demanded from such operation is well imaginable. All these tedious post-harvest operations are performed by the women. With the changing life styles, even in villages, women neither have time for such processing, nor do they have willingness to undertake this drudgery as a regular chore. This has discouraged the use of these millets in household consumption, particularly when there is access to alternative grains like rice, wheat or sorghum. Therefore, removal of this drudgery by innovating easy-to-operate village scale mechanical grain processing technology is recognized by this project as an important primary step to promote household consumption and building grain-based value chain.

6.2. Introduction of simple and easy-to-operate processing machines

In the absence of readily available technology, the project introduced a modified version of coffee grinder (Fig. 13) for helping women self help groups (SHG) in grinding finger millet and other grains. Although the throughput of this grinder was a mere 3 kg/hr, it was enthusiastically welcomed by the women as it offered a way out to their drudgery from stone grinding and they very effectively used this mechanical grinder to process finger millet for household use and production of certain value added products. The project could identify another small sized hammer mill that can be operated at village scale with low electricity rating. This mill was then introduced in Jeypore as a trial to assess its suitability to the needs of the village community (Fig. 14).

This mill operating on 2 HP single electrical phase motor had the throughput of 30 kg flour/hr. This proved to be a great success and created much enthusiasm among women in the project villages and adjoining villages. Women regularly accessed this mill for grinding finger millet on payment basis

Fig. 13. Initially introduced micro-mill for processing finger millet

for the service, which was provided by the SHG. For SHG, it generated income useful for managing and maintaining the mill. This totally eliminated the drudgery in processing the finger millet and opened new opportunity in value addition and building value chain.

Fig. 14. Power-operated small mill

6.3. Training women members of SHGs on value addition

Village women had the knowledge only on the use of millets for making traditional food items commonly used in their own region. For example, the villagers in Jeypore prepared a traditional gruel from millets. They also used finger millet to develop a local brew. They had no knowledge on any other products that could be made from millets. In Kolli Hills the local people make two traditional preparations from millets, called '*kali*' and '*roti*'. There, traditional recipes have low commercial potential due to their poor shelf life and lack of preference beyond the locality.

Therefore, the building of value chains for millets, apart from availability of processing machinery, required also capacity building of the communities, particularly women. They also needed to be educated on the commercial potential of the crop with value addition and development of novel products. Selected women members from SHGs at Kolli Hills and Jeypore were sent to Rural Home Science College of the University of Agricultural Sciences, Dharwad for a five day training course. The trainees included ten women and one man from Jeypore and nine women and one man from Kolli Hills. This comprehensive training included talks by experts on nutritional value of these grains, important products possible with value addition, and the importance of clean and hygienic conditions during the entire process of product preparation. The practical training on product making provided hands on experience to every trainee (Fig. 15). The trainees identified the products which they could successfully make and commercialize in their villages and got well trained on these products. The products on which more focus was given in the training were *chakli* (extrusion product deep fried to crisp

Fig. 15. Training of SHG members at Rural Home Science College, Dharwad

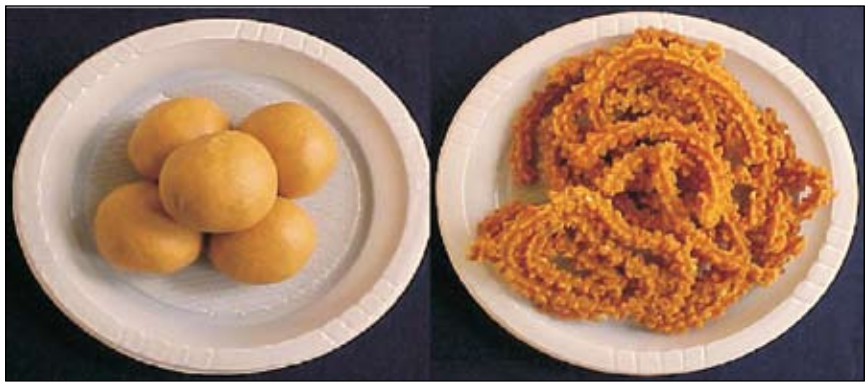

Fig. 16. Products given focus during training; *laddu* (left) and *chakli* (right)

finish), *laddu* (sweet ball, which is traditionally preferred) (Fig. 16) In addition, focus was also given for preparation of malt (useful as nutritious beverage to adults and easy to digest food to infants), *roti* (traditionally made half leavened bread) and *pakkodi* (deep fried snack item suitable for home use and saleable in local festivals). The training also provided certain tips on marketing. On completion of this training, the trainees were locally assisted to provide the same training to more women in their respective villages. This created team of interested women within each SHG, who were volunteering to venture commercial production of some of these products. They received assistance from the project during early stage both in the making and selling these products in the local market and venues of local festival.

These early efforts provided useful experience to the farm women in the production of products, their quality control and in assessing the demand as well as the acceptability of these products. This experience and exposure helped in the production of these products and gaining marketing skill. The regular commercial production was started in small scale with a strategy to slowly invest the working capital in production and also considering the short experience of these women in building regular market. Important products regularly made and marketed at Jeypore were *laddu, chakli* (also called *murukku)* and finger millet malt, while the products in Kolli Hills included finger millet flour and rice of little and Italian millets in addition to *laddu, chakli* and malt

Fig. 17. Finger millet malt, flour and little and Italian millet rice

(Fig. 17). Apart from these, the SHGs in each location prepared a few special products such as the products from flaked little millet in Jeypore and ready mixes like semolina in Kolli Hills. Among these, malt and rice of little and Italian millets were the fast moving products while *chakli* and *laddu* had the modest market.

6.4. Marketing

Marketing of value added products was done either directly by the members of the same SHG which produced the products or by another SHG which undertook specialized task in packaging and marketing the products. The members of SHG in Jeypore made production and marketing by themselves, while the two SHGs which produced products transferred the bulk unpacked material to the third SHG in the plane (proximal to the urban market) and the latter undertook the packaging, labeling and marketing. This arrangement improved the marketing efficiency and production turn over. Right from the beginning of commercial production, the SHGs in Kolli Hills and Jeypore marketed the different products under specific brand names (Figs. 17, 18). In short time, these SHGs learned the advantage of brand building and need for maintaining the product quality representing the brand.

Fig. 18. Packaging of Trupti Malt

A detailed cost:benefit analysis of value added product development was conducted both at Kolli Hills and Jeypore. The results of this study are presented in Table 5. These results showed that the highest net return was offered by the rice of little and Italian millets (data only from Kolli Hills) and the next highest return was from malt, *laddu* and *chakli*, while the lowest net return was from finger millet flour (Fig. 19).

An assessment of the market potential of these products showed that there is good demand for rice of little millet and Italian millet and malt. The low glycemic value

Table 5. Cost: benefit analysis of production and marketing of value added millet products

Cost: benefit particulars	*Laddu*	*Chakli*	Malt	LM Rice	IM Rice	FM Flour
Cost of production of 100 kg (INR)	4108	3401	4075	1300	1300	795
Total return from 100 kg (INR)	5625	4600	6000	2500	2500	900
Net return from 100 kg (INR)	1517	1199	1925	1200	1200	105
Profit as % of cost	37%	35%	47%	92%	92%	13%
Labour man days generated for production of one ton product	300	150	300	100	100	40

LM - Little millet; IM - Italian millet; FM - Finger millet

of the rice of these millets is getting wider recognition for being valued as important health food. Similarly, the malt is a nutritious beverage for people of all ages and in particular valuable as important weaning food. The cost:benefit study led to the conclusion that, on average, value addition of one ton of nutritious millet offered income ranging from INR 1,050 for finger millet flour to INR 19,250, for finger millet malt (Fig. 19). Moreover, value addition also generated additional employment, particularly for women, to the tune of 40 - 300 man-days from every ton of value added grain, depending on the products (Table 5).

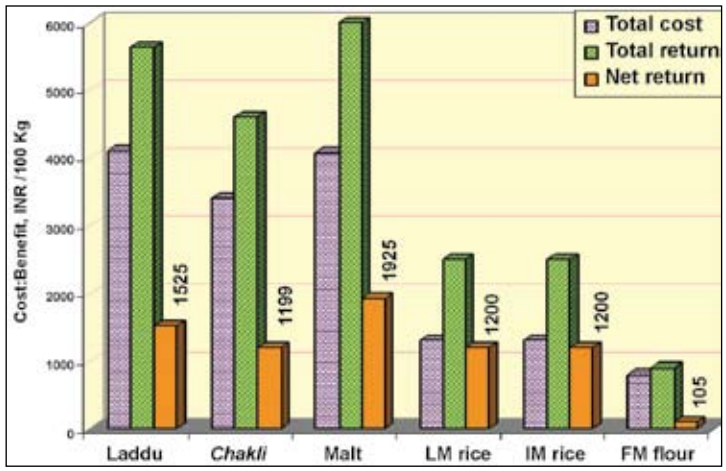

Fig. 19. Cost-benefit analysis of valu added millet products

6.5. Establishment and promotion of local entrepreneurs within the community

The experience gained in value addition, market demand driven product development, their commercial production with fairly consistent quality and its marketing encouraged the members of the SHGs and farm families to slowly bring out the entrepreneurial strength present in some of them. The project staff oversaw these changes and promoted the process with various specialized trainings on product development, quality management, product packaging, labeling, marketing, and management of accounts and finance. The slow change to increased confidence for up-scaling the processing to a semi-commercial venture and establishing a network of market outlets through regular production, delivery, consistency in product quality and product presentation (Fig. 17). Finger millet malt, and polished rice of little and Italian millet emerged as promising products with increasing demand from urban areas. At the end of this project phase, the scale of operation constrained with capital was low and the market reach of SHGs was limited. Although the production and marketing of promising products had expansion potential, the major constraints were finance as these SHG members belonged to poor farm families, need for more marketing expertise and the difficulty of these women to spare full time because of their responsibilities on attending household chores, participating in household and wage earning seasonal farm operations, and role in socio-cultural events such as community events, local festivals and periodic migration away from villages. Therefore, promotion of entrepreneurship among women within such community is not easy, though not impossible in the course of time. It may be possible to identify

few women and men who will be interested to spend more time and effort and taking value chain as a business. In such cases, it is quite possible that it may not essentially work on the SHG model as every member may not be able to put in reasonable time and effort for the commercial activity. An evolutionary approach to entrepreneurship may be a more practical option.

Suggestions have been made that linking farmers to private business parties who may undertake the business in value chain would help in building the value chain faster and thus benefiting the farmers growing millets. Such option, in fact, may make farmers as mere suppliers of raw material, and often such supply may have to be made at low prices decided by the buyer. While this may surely generate demand for grain, the economic benefit of value addition may elude the farmers. Possibly, such production by private parties may generate some additional unskilled employment opportunities to local farmers. Nevertheless, the gross benefit to farmers from such private commercial enterprise on value addition of these grains will be far less than the economic and employment benefit they could access from direct involvement in the commercial activity, although such option could be slow and very challenging to them.

6.6. Creating forward and backward linkages between market and technology

The SHGs of women were an important village institution used in building the linkage between market and technology. SHGs were established in project villages for organizing and managing village gene-seed-grain banks, for promoting millet cultivation, dissemination of improved production technologies, enhancing millet consumption (by facilitated access to drudgery-free processing), undertaking value addition and marketing. Members of these SHGs were the main beneficiaries of the increased income arising from high value realization of the value added products and also from the additional employment generated by the value addition. The outcome of farmer participatory demonstration of improved production practices showed that the increased income from higher grain yield achieved/acre is between INR 1,434 and INR 3,658. The gain from increased fodder productivity was not factored as fodder is not utilized in locations like Kolli Hills. Members of five SHGs apart from farm families of the villages were associated with project implementation. Out of these five SHGs, two were based in Padasolai and Chembuthuvalavu villages of Kolli Hills, while the fourth SHG was at Namakkal, and another two SHGs were in the Balia village in Jeypore. While four of these SHGs were organized and operating within the project villages, the one at Namakkal was outside project area and undertaking packaging and marketing of value added products. These SHGs established forward and backward linkages between millet production, processing and product marketing.

7. Capacity building and training

Capacity building of farmers in project villages was made through regular interaction with project staff and structured training to them on specific subject matter related

to different project activities. The village community was also favourably empowered with the introduction of infrastructure such as village seed-grain bank, mechanical grain processing facilities, etc.

7.1. Reduction of drudgery of farm women

Drudgery for women from the traditional method of nutritious millet grain processing was an important reason for its decreasing household consumption and lack of scope for value addition. Therefore, initial introduction of mini-mills followed by setting up of small mills in the villages made a huge difference to the women who enthusiastically came forward to process the grain for regular domestic consumption and join the project programme on value addition. These mills were installed in common space provided by one of the members of the SHG and its operation and maintenance were managed by the concerned SHG. The mill was regularly operated by one or two trained persons and a record on the operation was maintained. The service of the mill was extended to farm families outside project villages on charges fixed by the SHG. Thus, the services of the mill were accessible to many farm families in and outside project villages to promote consumption. Major impact of the mill in project villages was its facilitation to local SHGs in initiating value addition of the marketable surplus of the grain and commercialization of value added products instead of selling the grain to the middlemen. This contributed to substantial increase in the income of farm women. Thus, introduction of mill and training on value addition and associated capacity building to members of SHGs impacted on (i) elimination of processing drudgery to farm women, (ii) promotion of household consumption of nutritious millets by families in and outside project villages, (iii) opened opportunity for value addition of these grain for accruing additional income to the SHG members, (iv) generation of additional employment from value addition activities, and (v) enhanced social status and self-esteem of women.

7.2. Training and skill enhancement

Several training sessions were organized by the project staff in and outside project villages on many themes related to the project activities, apart from building awareness on several other topics also relevant to the communities. These trainings could be classified into three major categories. The first category included those trainings which were conducted in project villages on themes explained by project staff or resource person with interaction from the trainees. Examples are trainings on soil health management, vermi-compost production and use, nutritional quality of millets, etc. Trainings of the second category were those conducted in field with practical demonstration of the training thematic area with practical exercises given to trainees. Examples are training on quality seed production, row planting, participatory seed selection, etc. The third category of training was those conducted away from project villages, where the trainees were taken, put on board and trained by specialists. Examples are training on value addition given at the Rural Home

Science College, Dharwad (Fig. 20). All these trainings did substantially help in adding and sharpening the skill and knowledge of farmers and ensured their effective participation in project implementation and accruing greater benefits from the project both in the short and in the long term. Some of the training such as improved crop production methods, quality seed production, value addition, vermi-compost production, etc. took the farmers to totally new learning and changed practices with long term impact. Specialized training on processing and product development from nutritious millet grains made a major change on the outlook of those women who underwent the training and were subsequently assisted for setting up value addition unit. Training on marketing, account keeping, product quality management, product packaging and labeling, etc. generated a new capacity and self-confidence among women.

Fig. 20. Training to members of SHG at UAS, Bangalore

A list of trainings (not exhaustive), conducted at Kolli Hills and Jeypore is presented in Table 6. During the first two years of the project, 28 sessions of training extending for 40 days were organized, which were attended by 647 participants (209 men and 438 women).

Table 6. Details of trainings organized at Jeypore and Kolli Hills during 2003 & 2004

S. No.	Topic of training	Date	Training duration (days)	Participants	
	Jeypore (Orissa)			**Men**	**Women**
1	**2**	**3**	**4**	**5**	**6**
1	Training on improved method of cultivation	02 June, 2003	1	31	8
2	Participatory variety selection of little millet and Italian millet	08 Sept., 2003	1	16	23
3	Participatory variety selection of finger millet	18 Oct., 2003	1	25	19
4	Training on quality seed production of finger and little millet	20 Oct., 2003	1	26	28
5	Training and visit to OUAT Regional Res. Centre, Similipal and training on land and water management	27 May, 2003	1	6	4

Contd...

Table 6 (Contd.)

1	2	3	4	5	6
6	Training of SHG members from Kolli Hills and Balia at Rural Home Science College, Hebbal, Bangalore on finger millet processing and value addition	22 Oct., 2003	4	2	19
7	On-farm training on improved method of millet cultivation with intercrops in Balia village	17 June, 2004	2	9	12
8	Land preparation and manuring for planting millets in Balia village	2-3 June, 2004	2	11	6
9	Training on IPM and organic farming to barefoot village resource persons at MSSRF, Jeypore	24 July, 2004	1	2	6
10	Participatory variety selection of little millet and Italian millet in Balia village	27 Sept., 2004	1	10	10
11	Participatory variety selection of finger millet in Balia village	19 Oct. 2004	1	10	10
12	Micro-enterprise on production and marketing of vermi-compost by SHGs in Balia village	15-17 Dec., 2004	3	4	9
13	Quality seed production, processing and storage including grain in Balia village	26 Oct., 2004	1	12	18
14	Improved method of millet cultivation	02 July 2003	1	7	35
15	Storage and processing of grains of millets at Balia village	12 Jan., 2004	1	10	5
16	Minor millet processing, packaging and product hygiene, MSSRF, Jeypore	Feb., 2004	1	12	8
17	Exposure training to urban housewives on nutritional quality of minor millets and products at MSSRF, Jeypore	10 April, 2004	1	42	9
18	Training to members of SHG of Balia & Kolli Hills on millet value addition, product development & quality control at UAS, Dharwad	12-14 May, 2004	4	2	4
19	Training on millet based product development, packaging, marketing and account keeping at Balia village	5 Nov., 2004	1	2	18
	Kolli Hills (Tamil Nadu)				
20	Training on organic millet cultivation	17 Dec., 2003	1	0	28

Contd...

Table 6 (Contd.)

1	2	3	4	5	6
21	Processing, packaging and marketing of millets	12 Sept., 2003	1	2	6
22	Participatory variety selection	16 Sept 2003	1	10	37
23	Exposure visit to farm technology & variety diversity exhibition at TN Agrl University, Coimbatore	16-17 May, 2003	2	4	4
24	Hands-on trainers' training on minor millet value addition, product development and quality control at UAS, Dharwad	12-14 May, 2004	3	2	5
25	Exposure training on millet value addition at Namakkal	Dec., 2004	1	0	50
26	Improved method of inter-crop cultivation	13 July, 2004	1	0	19
27	Field training on inter-cropping of tapioca with little millet	17 July, 2004	1	5	30
28	Participatory variety selection	23 July, 2004	1	6	8
	Total		**40**	**209**	**438**

Each SHG also functioned as thrift group generating savings into a local bank account out of their monthly earning. This qualified them to receive bank loans, which became useful as an operational resource for value addition activities.

8. Awareness on nutritional benefits of minor millets

Awareness activities on the nutritional importance of millets and their strategic role in providing food and nutritional security in certain agro-climatic regions were widely organized under the project to reach out different stakeholders such as farmers, particularly farm women, urban housewives (Fig. 21), government officials engaged in rural development, school and

Fig. 21. Training of urban housewives on the nutritional value of millets and their value added products

college children and the public at large. Different methods such as talks on the eve of International Day of Biological Diversity, World Food Day, World Nutrition Day and World Diabetes Day in project villages and local schools and colleges, organizing exhibitions showcasing the posters on the nutritious millets and value added products, publishing popular articles on the crops and project activities, media exposure to major project events and showing documentary made on these millets were used for generating awareness on these crops.

8.1. Exhibitions and fairs

The project villages in Kolli Hills and Balia have usual annual festivals on the eve of '*Adi 18*' in Kolli Hills and '*Parab*' festival in Jeypore (Koraput). During these occasions, the members of SHGs of these locations together with project staff organized exhibition of nutritious millets. All value added products of millets were displayed at these exhibitions which lasted for three to five days and these occasions also offered opportunity for large sale of value added products (Figs. 22-24). This has helped in creating wider publicity for these products and increasing their demand. SHG members also made and sold certain ready-to-eat preparations such as millet *pakkodi, chakli, laddu*, etc. and beverage drinks such as finger millet malt, which attracted wider attention and demand. During these occasions, illustrated posters made in local language were prominently displayed to create awareness on the nutritional value and other importance of these grains. Exchange of seeds was also carried out at these exhibitions.

Fig. 22. Exhibition and marketing of millet products at a local festival in Jeypore

Fig. 23. Exhibition of millet value added products

Fig. 24. A group discussion with farmers in Balia village

Similar exhibitions and sale of nutritious millets and their value added products were also organized in the eve of national and international conferences organized at MSSRF, Chennai. Such exhibitions also facilitated the distribution of booklets, folders and brochures prepared on minor millets describing the nutritional and income generation advantages of minor millets, value addition opportunities for increasing profitability from these crops and traditional and novel recipes of millets.

Project scientists also delivered several awareness talks/lectures on the nutritional, food and health values of the minor millets and on their relative nutritional advantage over more common cereal grains.

8.2. Awareness among policy makers

The project staff during the course of project implementation had opportunities to brief the senior national policy makers on the project progress and the role the minor millets could play in providing local food security, particularly the poor farming and tribal communities. During an institutional event at MSSRF, Jeypore, the Chief Minister of the State of Orissa was briefed on the project and its benefits to the village community. They also explained the various value added products and the income generation opportunity being offered. The Chief Minister showed great interest and tasted some of products on display and sale at the venue (Fig. 25). In Kolli Hills, the work on small millets was explained to the district administration. The administration showed great interest in value addition and marketing of the products by the village women. In appreciation of these efforts, the Namakkal district administration allotted one room space in a Municipal Complex to the SHGs to support their marketing efforts.

Fig. 25. Chief Minister of Orissa visiting IFAD project exhibition and enjoying a finger millet "*laddu*" at MSSRF, Jeypore

An International Consultation on 'The Role of Biodiversity in Achieving Millennium Development Goal on Freedom from Hunger and Poverty' was organized at MSSRF on 18-19 April, 2005 in collaboration with Bioversity International (formerly, IPGRI) and the Global Facilitation Unit for Underutilized Crops (GFU, now Crops for the Future; www.cropsforthefuture.org/) and this was an important public policy intervention made as an offshoot from this project. This Consultation underscored the special role of underutilized crops in meeting the MDG goal on hunger and poverty. The conference was attended by representatives from IFAD, IDRC, SDC and large number of policy makers including ministers from 25 countries from Asia, Africa, Europe and North and South America,

eminent world experts on agricultural biodiversity, farmers' associations, NGOs, and media representatives. The details of the Consultation are brought out in a publication "Hunger and Poverty: The Role of Biodiversity" edited by Bala Ravi, *et al.* (2006). The major recommendations emerged from this Consultation were presented as "The Chennai Platform for Action" (Annexure II) and widely circulated in different UN languages in the UN Assembly, and also to major international organizations, governments, donor agencies and non-governmental groups and associations. The event, which received high local and international media attention was well covered also by the WREN media and Sci. Dev. Net.

8.3. Information on website

The important conclusions and outcome of the project were projected on the MSSRF website (www.mssrf.org). As mentioned above, this website also showed the outcome of the International Consultation on 'Agricultural biodiversity with special emphasis on underutilized crops". This information is available for download at www.bioversityinternational.org/nc/publications/publication/issue/agricultural_biodiversity_and_elimination_of_hunger_and_poverty.html.

9. Policies

Although small millets are important for the food security and income of poor farmers in certain agroclimatic regions, these crops have not received adequate attention of the policy makers for the purpose of investment on their research and development, mainstreaming these grains in developmental programmes, in public procurement and distribution system. Such neglect of small millets over a period of time is marginalizing them, leading to the loss of their genetic resources and loss of food culture and traditional knowledge associated with their use. These crops, however, are important to the present and future agriculture in view of their superior nutritional value and resilience to climate change. Therefore, there is need for a policy reversal to recognize their role in regional food and nutritional security and in adapting agriculture to changing climate. Such policy change needs to support promotional measures for their improvement, production, procurement and distribution through the public distribution system in India. Also for example, introduction of these grains in the special nutrition programmes such as Intensive Child Development Scheme (ICDS) and the school mid-day meal scheme, at least in regions where these grains are available in adequate quantity, may significantly impact on the cultivation and production of these crops, which in turn would help in the conservation of their genetic resources as well as the associated traditional knowledge.

10. Impact of the project

The project has been successful in creating measurable impact on following aspects:

- The project has been helpful in wider public realization on the superior nutritional value of small millet grains and increased recognition of their role in providing regional food security or at least better food security to the poor.
- The project has enhanced the community concern in conservation of landraces of these crops, strengthened the on-farm community conservation practices and broadened the genetic base by adopting improved millet varieties.
- The project facilitated in reduction of drudgery faced by farm women in processing these grains by traditional methods through introduction of simple and low cost processing machinery, which is managed by women groups.
- Intervention in grain processing enhanced the household consumption of these grains to accrue better health benefits.
- Mechanical processing opened new opportunities on value addition of these grains and commercialization of value added products leading to generation of additional employment and income to farm families.
- Organization of farm women to SHGs and their increased exposure for multi-skill development in technologies and income generation opportunities enhanced the confidence, social status and self-esteem of the women.
- The farmer participated variety selection, capacity to produce and use quality seeds and improved agronomic practices made significant increase in millet productivity and consequent enhanced food security as well as income.
- Mobilization of farm women under SHGs promoted dissemination of project tools, methods and approaches for larger benefit of the communities.
- The project under its auspices organized an international consultation on "the Role of Biodiversity in Achieving the Millennium Development Goal on Freedom from Hunger and Poverty" which created awareness among senior policy makers including ministers from several countries in Asia, Africa, Europe, North and South Americas.

11. Recommendations

During the implementation of this IFAD-supported project component and from its results, a number of recommendations emerged on mainstreaming the small millets in agricultural production and food chain systems either on local or regional basis. Some of these recommendations are listed below:

- The continued neglect of small millets is causing serious erosion of their genetic resources and there is a greater urgency for promoting their on-farm community conservation by creating an economic stake in conservation.
- Complementing with conservation, farmer participatory variety selection along with quality seed production and supply strategies need to be adopted and

promoted together with appropriate training and capacity building.

- Value chain building on millet grain by deploying low cost and village-friendly machinery offers great opportunity for eliminating the drudgery to rural and tribal women farmers and enhancing their income and need further concerted efforts.
- Training and capacity building with focus on cultural, nutritional and economic importance of small millets can substantially contribute to the improvement of family health, and enhancing the skill, social status, self-confidence and self-esteem of women from poor families.
- The strategic potential of small millets in improved human nutrition, well being and better adapting to climate change needs to be better understood and appreciated by policy makers.
- The potential of value chain development in enhancing the income of rural poor demonstrated by this study needs to be further explored for scaled up operation to cause widespread economic impact.
- The farmer participatory approaches demonstrated by this project to achieve significant productivity increase, improved food and income security needs to be replicated in larger scale.

12. Publications

Some of the research papers published based on the results of this project are listed below:

Appa Rao S., N.K. Rao, S. Padulosi, G.D. Sharma, B.S. Phogat and Padmaja Rao, S. 2002. Sustaining agricultural productivity and enhancing livelihoods of rural communities through promotion of neglected crops and their associated biodiversity in the semi-arid agro-ecosystems. In: Proceedings of the International Workshop on sustaining agricultural productivity and enhancing livelihoods through optimization of crop and associated biodiversity in Agro-ecosystems with particular focus on Semi-Arid ecosystems, 23-25 September 2002, ICRISAT, Patancheru.

Bala Ravi S. 2004. Neglected millets that save the poor, LEISA INDIA, March 2004 Vol. 6 (No 1): 34-36

Bala Ravi S. I, Hoeschle-Zeledon, M.S. Swaminathan, and E. Frison (eds). 2006. Hunger and Poverty: the Role of Biodiversity. Published by MSSRF-IPGRI-GFU, Chennai, 232p.

Hodgkin T., K. Atta-Krah, J. Thompson, D. Jarvis, C. Hoogendoorn and S. Padulosi. 2004. Managing Genetic Diversity in Agroecosystems: State of the Art and Implications for Ecoagriculture. Proceedings of the International Ecoagriculture Conference and Practitioners' Fair. 27 September - 1 October, 2004, Nairobi, Kenya.

S. Padulosi, A. Giuliani and J. Noun. 2003. Underutilized species: what are they? 2003. Proceedings of the In Went International Workshop on Underutilized Plant

Species and Poverty Alleviation, Leipzig, Germany, 6-8 May 2003. In Went, Germany.

Padulosi S., J.R. Noun, A. Giuliani F. Shuman W. Rojas, B. Ravi. 2003. Realizing the benefits in neglected and underutilized plant species through technology transfer and human resources development. In: Proceedings of the Norway/ UN Conference on Technology Transfer and Capacity Building (P.J. Schei, O.T. Sandlund and R. Strand, eds.). 23-27 June, 2003, Trondheim, Norway.

Padulosi S. and A. Giuliani. 2004. Enhancing the use of underutilized plant species: Strategies, approaches and experiences at IPGRI. In: Genetic Improvement of underutilized and neglected crops in low income food deficit countries through irradiation and related techniques. Proceedings of a final research coordination meeting organized by the joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and held in Pretoria, South Africa, 19-23 May, 2003. IAEA, Vienna 2004. ISBN 92-0-113604-8.

Padulosi S. and I. Hoeschle-Zeledon. 2004. Underutilized plant species: what are they? LEISA 20(1): 5-6.

Wren media, 2006. A major revamp for minor millets. Agriculturist On line, Reporting Agriculture for the 21st Century, Available at http://www.new-agri.co.uk/06-2/ develop.html#01

13. Acknowledgements

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14. Reference

Bala Ravi S., I. Hoeschle-Zeledon, M.S. Swaminathan and E. Frison (eds.). 2006. Hunger and Poverty: the Role of Agrobiodiversity. Published by MSSRF-IPGRI-GFU, Chennai, 232 p.

Enhancing Food Security and Income of the Rural Poor through Technological Support for Improved Cultivation of Finger Millet: A Case Study from Southern Karnataka

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1. Introduction

Finger millet (*ragi*) is an important crop in the states of Karnataka, Tamil Nadu, Orissa, Maharashtra, Uttarakhand, Jharkhand and Andhra Pradesh. The crop is cultivated on 1.6 million ha with production of about 2.1 million tons. India occupies more than 50% of the cultivated area in the world. The area under finger millet is gradually decreasing in the country but the production level is increasing due to increase in productivity. In India, more than 120 million people from across 10 States use finger millet as a main component of their diet. About 25 million farm families cultivate finger millet in the country. Finger millet is an excellent dryland crop characterized by good drought tolerance, quick rejuvenating capacity on alleviation of stress, ease of cultivation, low cost of cultivation and resistance to pests and many diseases. Although finger millet acreage is coming down, the overall production of the crop is showing increasing trend mainly due to the impact of research on the crop productivity, which has been rising particularly over the past 10 years.

Finger millet is grown for its grain and straw, predominantly in the southern parts of Karnataka. Being a hardy crop, with quick rejuvenation ability after prolonged dry spells; it is a preferred crop of dry lands especially by small and marginal farmers who cultivate with little inputs. The crop productivity is low besides showing large year-to-year variation. However, there is scope for yield enhancement through technology adoption. The grain yield realized at the Research Stations as well as in front line demonstrations have convincingly shown the potential available through improved technology package and the need for bringing awareness among small and marginal farmers on the need for adopting improved practices.

Finger millet is a nutritious grain with balanced protein, higher calcium, iron, minerals, phosphorus and dietary fibre content. There are ample opportunities for enhancing the utility range of grain for food use through value added products. The project addressed to the above issues holistically with the ultimate aim of improving the crop productivity and enhanced income of the finger millet growing farmers.

2. Objectives

The component of IFAD-NUS (Phase I) Project implemented at the University of Agricultural Sciences (UAS), Bangalore had the following major objectives:

- To enhance the productivity and production of finger millet
- To increase the income of finger millet growing farmers
- To create awareness on the opportunities for enhanced and diversified use through processing, value addition and product development

3. Centres/ agencies and project locations involved

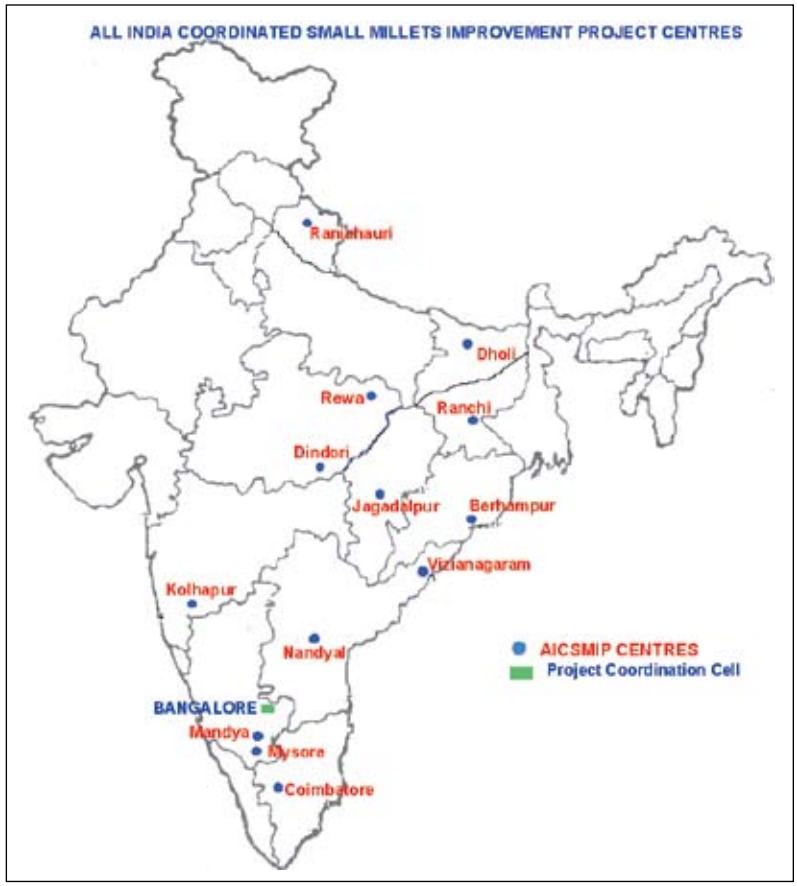

Fig. 1. Finger millet growing areas in India

The project was implemented by the All India Coordinated Small Millet Improvement Project (AICSMP) at the University of Agricultural Sciences (UAS), Bangalore under the coordination from the M.S. Swaminathan Research Foundation, Chennai. Other departments of the UAS involved were the Department of Home Science, Hebbal, and the Extension Education Unit. The State Department of Agriculture, Karnataka was also associated. The project was implemented at the selected villages in Chintamani, Kolar, Srinivaspura and Malur taluks (sub-divisions) of Kolar district which is a major finger millet growing region in the State. The activities on grain processing and value addition including development of products were carried out in the Department of Rural Home Science, Hebbal. The major millet growing regions in India, where the centres of All India Coordinated Small Millet Improvement Project are located are shown in Fig. 1. The two major districts where the project was implemented are depicted in Fig. 2 and the major finger millet growing areas in Kolar district are shown in Fig. 3.

Fig. 2. Map of Karnataka showing the two districts chosen for project implementation

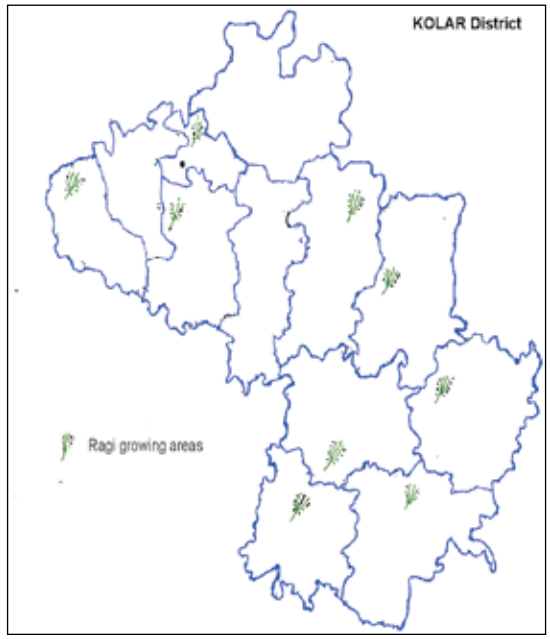

Fig. 3. Finger millet growing areas in Kolar district

4. Origin, geographic distribution, area of cultivation and productivity trends

Finger millet originated in Ethiopia and highlands of Africa. It reached India at least 3,000 years ago. Finger millet both in India and Africa is highly variable. Long history of cultivation in India accompanied with human selection has resulted in the generation of extensive variability giving India the status of secondary centre of diversity. Many wild species of finger millet exist in nature. However, *Eleusine coracana* and *E. africana* are much widely used species in genetic enhancement programmes. The cultivated *E. coracana* is a tetraploid (2n = 4x = 36) and has morphological similarity with both *E.indica* (L) Gaertn (2n = 18) and *E. africana* (2n = 36). The cytological evidences indicate that *E. indica* has contributed one of the genomes (AA) to the cultivated *E. coracana* (AABB). Both the tetraploids, *E. afticana* and *E. coracana,* are closely related and the gene flow occurring between them in nature suggests that *E. coracana* possibly originated from *E. africana* through selection (Channaveeraiah and Hiremath, 1974; Hilu and de Wet, 1976; Hilu, 1977).

Finger millet is the most important crop grown in many states of Southern, Central, Eastern, Western and Northern India from sea level in coastal Andhra Pradesh to 2,400 m altitude in the Himalayas. The area under finger millet has considerably reduced during the past three decades but there was significant improvement in production and

productivity. The major finger millet growing states are Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar Maharashtra and Uttar Pradesh. Karnataka State has the largest area of around one million hectares (50% of total area) followed by Orissa, Maharashtra, Tamil Nadu, Andhra Pradesh and Uttar Pradesh, each having 10-12% of the total area.

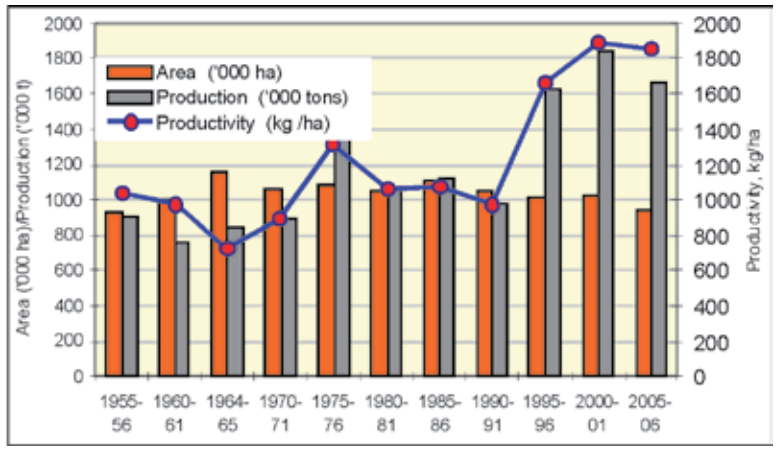

Fig. 4. Finger millets area and production trends in Karnataka

In Karnataka, finger millet is an important crop in the southern parts of the state which is predominantly red soil area. Finger millet crop is grown under rainfed conditions. The area, production and productivity trends are given in Fig. 4.

In Karnataka, over a period of 30 years, the cultivated area under finger millet has come down from 1.078 million ha in 1975-76 to 0.939 million ha in 2005-06. However, there was a steady increase in the production that was mainly attributed to the improved technological components as well as better crop management by the farmers. The average productivity increased from 10.32 q/ha in 1955 -56 to 18.58 q/ha in 2005-06.

5. Participatory survey on uses, constraints and opportunities with communities and other levels of value chain

The participatory surveys to know the status of finger millet production, consumption pattern, marketing avenues and economic benefits were undertaken in three taluks of Kolar district. The survey provided a clear insight on production to consumption chain in respect of finger millet in the prevailing socio-economic milieu. It also brought out important issues associated with this chain.

Almost in all farm holdings in the project villages, the farmers were cultivating finger millet for grain as well as fodder which clearly showed its critical role as an important crop in the region. Nearly 66% of farmers were small and marginal. Majority of farmers were aware of the improved varieties, production practices and use of organic and inorganic nutrients in enhancing production, although the impact of new technologies was less pronounced. However, more recently, a trend in crop diversification appeared to be slowly getting in, wherein finger millet based cropping system was giving way to horticultural or commercial crops. Nevertheless, there was significant increase in the productivity of finger millet and finger millet based

cropping system. Now at least 83% of the farmers were harvesting higher yields. This better harvest was also linked with partial adoption of improved production technology, including better variety and better agronomic practices. At least two-thirds of the farmers were aware of the availability of improved varieties and the advantage of growing them.

More than 60% farmers used farm saved seeds for growing finger millet indicating the importance of seed recycling at the farm or village level. Farmers were also aware of the importance of proper nutrition management utilizing both organic and inorganic sources of manure as well. The pesticides usage in finger millet cultivation was unheard of, indicating the absence of chemical contaminants in the finger millet production system. Finger millet fodder was highly valued and considered superior to other straw/stover, especially rice. Farmers did not find it difficult to market the surplus grain and straw.

Millet grains were largely for home consumption but in case of extra production, the surplus produce was marketed without any difficulty. The consumption of the grain was in one or more of the six major important traditional food forms, viz., *mudde* (dumpling), *roti* (unleavened bread), gruel, noodle, *dosa*, and *hurihittu*. Among these, *mudde* was the most commonly consumed item on daily basis. Most farmers were not aware of the options available for diversified utilization and showed interest to learn preparation of new products.

Both men and women actively participated in finger millet production by sharing work. Women were mostly involved in weeding, harvesting, threshing and post harvest grain cleaning, processing and utilization. Nearly 75% of the farmers were literate with varying levels of education. Majority of the farm families had at least one member with secondary or higher level education. Nearly two third of the farmers in the project villages were small and located in marginal areas. The trend observed indicated that finger millet is going to be cultivated in increasingly smaller area where intensive methods are likely to be deployed for meeting the domestic requirement.

6. Germplasm evaluation, selection and conservation

6.1 Current major holdings of target species

A total of 21, 226 accessions of different small millets are maintained at the National Genebank at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi for long-term conservation. The crop-wise details of these accessions are given in Table 1.

The Project Coordinating Unit of the All India Coordinated Small Millet Improvement Project (AICSMIP), University of Agricultural Sciences (UAS), Bangalore which has been recognized as National Active Germplasm Site for small millets is maintaining 12,296 accessions of different small millets. These include finger millet (6,770 accessions), foxtail millet (2,644 accessions), little millet (920 accessions), proso millet (928 accessions), barnyard millet (918 accessions), and *kodo* millet (116

Table 1. Status of small millets germplasm in the National Genebank at NBPGR, New Delhi

S. No.	Crop	Exotic accessions	Indigenous accessions	Total
1.	Finger millet	117	10217	10334
2	Foxtail millet	94	4379	4473
3	*Kodo* millet	03	2270	2273
4	Barnyard millet	28	1690	1718
5	Little millet	01	1410	1411
6	Proso millet	15	1002	1017
	Total	**258**	**209 68**	**21,226**

accessions). The AICSMIP was consulted in deciding the varieties to be used for different studies under the project.

6.2. Source and description of varieties used

High yielding released and pre-released varieties of finger millet available with the Coordinating Unit of AICSMIP were used in different studies conducted under the project. Most of these varieties were drought resistant and some of them were free from major diseases. The centres involved in the development of these varieties included the Project Coordinating Unit of AICSMIP of ICAR, GKVK Campus, Bangalore, Zonal Agricultural Research Station, Mandya of the UAS, Bangalore, and the Karnataka State Department of Agriculture, Bangalore. The studies were conducted in Kolar and Bangalore districts of Karnataka and the GKVK Campus of the University of Agricultural Sciences, Bangalore. The characteristic features of the selected varieties are given below:

L5: A long duration variety developed at the Agricultural Research Station (ARS), Nagenahalli, Mysore and released by the University of Agricultural Sciences (UAS), Bangalore during 1999; recommended for both rainfed and irrigated conditions; green with dark pink/purple nodal pigmentation; resistant to blast; grain yield about 35 -40 q/ha.

GPU 28: A medium duration variety; maturity in about 110-115 days; medium height; green plant type, highly blast resistant; grain yield about 35-45 q/ha; released in1998 for general cultivation in Karnataka state.

GPU 26: A short duration variety; maturity in 95-100 days; suitable for late planting in August; green medium thick stem; grains with light brown colour and smooth surface; grain yield about 30-40 q/ha; released in 2000 by UAS, Bangalore for cultivation in Karnataka state.

GPU 45: An early duration variety; maturity in about 95-100 days; suitable for late *kharif* (rainy season) planting, grain yield about 30-35 q/ha; released in 2001 at the national level for cultivation in the states of Madhya Pradesh, Gujarat, Karnataka, Maharashtra and Jharkhand.

GPU 48: A short duration variety; maturity in about 90-95 days; suitable for late planting in *kharif*, grain yield about 30-35 q/ha; released in 2006 for cultivation in Karnataka state.
Local Hulubelae: A farmer variety; maturity in about 115–120 days; thin stem; prone to lodging and highly susceptible to blast.

6.3. Participatory variety selection

In order to acquaint the farmers about the choice of finger millet varieties, 30 farmers were identified from 16 villages in three taluks of Kolar district, namely, Chinthamani, Kolar and Malur. Varieties suitable for these places were identified and seed multiplication of these varieties was taken up. The farmers were imparted training for enhancing their knowledge in improved cultivation practices for finger millet. The seeds of identified varieties along with other inputs were given to all the participating farmers during 2002 and 2003 cropping seasons and the farmers were asked to critically assess the performance of the varieties. Periodical visits by project scientists were made to observe the crop conditions during the growing season. The performance of varieties in terms of grain yield obtained in 2002 and 2003 and the straw yield obtained in 2003 is presented in Table 2.

Table 2. Performance of varieties in farmers' participatory variety trial

Varieties	Grain yield (q/ha)	Grain yield (q/ha)	straw yield (q/ha)	Mean grain yield (q/ha)
	2002*	2003**	2003**	
L 5	43.25	36.18	79.20	39.72
GPU 28	41.75	35.85	80.70	38.80
GPU 26	37.43	28.48	67.40	32.96
GPU 45	38.08	30.17	67.90	34.13
GPU 48	39.55	27.74	63.70	33.65
Local variety	29.00	22.00	51.20	25.50

* Grain yield in irrigated trials ** Grain yield in rainfed trials

The results revealed that the varieties, L 5 and GPU 28 of finger millet had superior yield performance and therefore were selected by farmers under participatory variety trial (Figs. 5, 6). These varieties were widely accepted in the project villages, not only for their superiority in grain and fodder/straw yield, but also due to their relatively higher resistance to blast disease, which is more prevalent in the region and causes yield loss to the tune of about 15-20% depending upon the weather conditions during the month of October. Thus, participatory variety selection led to achieving the yield enhancement to the tune of about 30-35% over the variety cultivated until then under comparable production management. Importance of variety input for

production enhancement was further demonstrated in the project villages through front line demonstrations (FLD).

The front line demonstrations (FLD), in real terms showed the technology potential to achieve an additional grain yield of 6.0-8.0 q/ha under appropriate production management conditions. In economic terms, it translated to gain of INR 3,000-4,000/ha by cultivating farmer selected improved varieties. This created much awareness on the economic advantages of growing farmer selected varieties, GPU 28 and L 5 and these varieties started spreading in the district with more than 35-40% of farmers growing these varieties. Wider adoption of these varieties in and around the project villages increased the demand of their seed. This led to capacity building efforts to train the farmers in production of quality seeds of these varieties. The selected farmers successfully produced the quality seed of these two varieties which was procured by the Karnataka State Seed Corporation. These two varieties of finger millet were also recommended for large scale cultivation in Kolar district of Karnataka State.

Fig. 5. GPU 28: A blast resistant and high yielding variety of finger millet

Fig. 6. A view of L5 variety of finger millet in farmer's field in Hadigere village

6.4. Farmers' contribution through on-farm conservation

During 1950s and 1960s, the farmers themselves used to preserve the best grains /seeds of important landraces such as Hulubelae, Giddaragi, Karikaddi, etc. for use as seed for raising the crop next year. They used to share the seed materials with their close relatives, and sometimes with others on cash and carry basis. The women used to play an important role in preserving the seed materials in earthen containers and conducting periodical monitoring of the seed materials for insect

pests attack. After the advent of high yielding varieties, this traditional method of on-farm conservation slowly weakened. However, in recent years the earlier traditional method is regaining its importance.

Several self help groups interested in promoting the products of finger millet were identified in Kolar district. They were found interested in promoting finger millet products not only in rural areas but also supplying them to urban population. Besides, some groups were also engaged in vermi-composting. Thus, the farmers maintained the diverse useful germplasm of finger millet suitable for higher grain yield production as well as value addition and product development. Farmers who were promoting organic farming also promoted local varieties which possessed some special characters and these were conserved and shared with other organic farmers and thus helped in on-farm conservation of precious finger millet germplasm.

7. Improved agronomic practices

7.1 Refinement of production system technologies

Finger millet is mainly grown as rainfed crop in India. It is mainly grown during *kharif* (June-July to October-November) and responds well to applied fertilizers, although the amount of nutrients required may be in smaller quantity. It is essential to supply the additional nutrients to meet the balanced requirement of nutrients of the crop. Line sowing, thinning and optimum spacing are very important for its successful cultivation. Controlling the weeds is very much required in order to enhance the fertilizer use efficiency. Intercropping of finger millet with legumes especially pigeonpea (*Cajanus cajan*) and field bean (*Lablab purpureus*) brings higher returns as well as nutritional security to finger millet farmers. Although a traditional practice of mixing seeds of many crops (legumes, oilseeds, food crops) and sowing these in a line after every 5-6 rows of finger millet (main crop), commonly called *Akkadi* system, is not considered suitable under high input management conditions but provides a very good insurance against the failure of the main crop under adverse weather conditions. Based on the research work carried out at the AICSMIP Centre Bangalore and Dryland Agriculture Project, Bangalore, the cultivation of finger millet + pigeonpea in 8:2 ratio or finger millet + field bean in 8:1 ratio has been recommended in order to realize higher returns as well as to achieve nutritional security. This type of intercropping was found highly successful and productive in the farmers' fields and hence received much importance and popularity with the farmers.

In many farming systems under rainfed agriculture, single crop farming is not preferred and invariably, the farming system involves intercropping or mixed cropping. Finger millet in Kolar district is largely grown as mixed or intercropped with pigeonpea, fodder sorghum, field bean, etc. Farmer participatory on-farm trials were laid out in all the three years of project period to test the efficacy of different farming systems, including relative proportion of each intercrop, such as (i) intercrop of pigeonpea and finger millet vs. farmers' practice of mixed cropping, (ii) line sowing the intercrops using seed drill vs broadcasting the mixed

seed lot, and (iii) chemical weed control vs. traditional manual weed control. About 30 farmers from 17 villages were involved in these participatory trials. The details of intercropping system followed in Kolar district during 2002-2004 are given in Table 3; while performance of improved farming system over traditional practice and the net returns and cost: benefit ratio are given in Table 4 and Table 5, respectively.

Intercropping of finger millet with field bean or pigeonpea (Fig. 7) was found to offer higher returns than the farmers' practice (Table 6). The results also revealed

Table 3. Farmers and villages involved and rainfall received in Kolar district in different years

Details	2002	2003	2004
No. of farmers involved	30	31	26
No. of villages included	17	15	8
Amount of rainfall (mm)	495.2	464.7	675.4

Table 4. Performance of improved farming system over traditional practice

Treatment	FMGEY * (kg/ha)		Mean	Increase over check (%)
	2003	2004		
Finger millet + pigeonpea (8:2)	4,615	4,276	4,446	35.38
Finger millet + field bean (8:1)	4,905	4,701	4,803	46.25
Sole crop of finger millet	-	3,761	3,761	31.12
Farmers' practice (check)	3,253	3,315	3,284	

*FMGEY = Finger millet grain equivalent yield

Table 5. Net returns and benefit:cost ratio of intercrop system

Cropping system	Net returns (INR/ha)			B:C ratio		
	2003	2004	Mean	2003	2004	Mean
Finger millet + field bean	26,184	11,436	18,810	2.1	1.12	1.61
Finger millet + pigeonpea	18,100	9,045	13,573	1.5	0.89	1.20
Pigeon pea (sole crop)	10,946	4,620	7,783	1.1	0.45	0.78

that the farmer practice offered profit only under favourable growing conditions. Hence, the improved intercropping system under line sowing helped in realizing higher grain yields and economic returns, depending on the level of management. In addition, pigeonpea and field bean enriched the soil with biologically fixed nitrogen and increased solubilization of fixed phosphorous.

The level of crop management by the farmers and also the adoption of improved technology were of low order. With the active participation of scientists in transfer of technology as well as in its adoption, the improvement in production management was of relatively higher order. Farmers commonly broadcast seeds by hand and

Fig. 7. Intercropping of finger millet with pigeonpea (letf) and field bean (right)

cover it with soil. This practice does not facilitate inter-cultivation during subsequent vegetative growth periods. Hence, line sowing of finger millet using seed drills/seed-cum- fertilizer drills was considered better as it facilitated effective inter-cultivation and efficient use of fertilizers. Line sowing vs. broadcasting was demonstrated to the farmers. Finger millet, being a small grain crop, takes longer period for germination and the coverage of land and therefore, the weeds take the upper hand and smother the crop.

In order to control the weeds effectively, the line sowing proved better in taking up repeated inter-cultivation. The other alternative considered important was the use of weedicides. Spraying 2, 4-D Na salt at 0.75 kg ai/ha 10-12 days after sowing of the crop or use of Isoproturon 75 WP 0.562 kg/ha within 3 days of sowing in 750 liters of water proved very good in controlling the weeds effectively. However, under rainfed conditions, the cultural and mechanical measures proved more useful than the use of herbicides.

The results of the frontline demonstrations clearly showed that farmers could increase the productivity of the crop by 30-35 % with adoption of improved practices over farmers' practices in Karnataka. Similar demonstrations conducted in other states also amply demonstrated that the increase in productivity will be much higher (50-55%) due to scientific interventions. The results of the on-farm demonstrations showed that the finger millet farmer in Karnataka State can realize an additional income of INR 4,950-6,100 ($ 110-135) per hectare by adopting scientific cultivation practices.

7.2. Harvest and post-harvest operations

Finger millet crop matures in about 95-125 days depending on the variety used, the crop season and the method of cultivation. At maturity, the stem turns to straw colour and the ears turn to brownish colour. Plants are cut to ground level using sickles, left in the field for drying for 3-5 days, tied in bundles, and either stacked in the field itself or transported to the threshing yard and stacked there.

The other method of harvesting is to cut and remove only the ears from the plants, dry them thoroughly and thresh by beating with sticks or tread using tractor or stone roller. No effective machineries are available for harvesting and threshing operations. With scarcity in availability of labourers in the villages, finger millet harvesting and threshing are indeed considered as drudgery, which might affect the acreage under the crop in coming years.

8. Value addition, product development and marketing

8.1. Nutritional composition of millets

Finger millet grain is highly nutritious with 7-8% protein, 1-2% fat and 2.7% minerals. It has a well balanced amino acid profile and is a good source of methionine, cystine and lysine. These amino acids are of special benefit to vegetarians who depend on plant foods for their protein requirements. Small millets are important due to their several nutritional and other useful characteristics which are given below:

- Their grains are small and store well for long periods ensuring regular food supply in years of crop failure and in the lean seasons.
- In view of small size, the millet grains often require less cooking time which could be an important factor for the women who is required to look after many farm related responsibilities in addition to cooking food.
- Many methods of using millets have been established as materials of traditional staple foods. There are also ways of processing millet grains into novel preparations as well. This can be a factor in increasing market demand for them. Millets are used as materials for making local beverages too. This application is closely related to the farm practices, dietary culture and agricultural rituals of rural communities.
- The excellent nutritional properties of small millets are contributed by high levels of minerals such as iron, calcium and zinc, dietary fibre, quality protein, nutraceuticals, etc. Finger millet is especially known for its excellent malting qualities which should make it an important ingredient for the preparation of several novel, and high value foods.
- These crops often have dual use and grown for grain and quality fodder/ straw and both are equally important in mixed dry farming systems.

These minor millets have small seeded grains and resemble paddy or rough rice in their morphological features. The grain has distinct husk, bran and endosperm tissues. Although, embryo is a distinct tissue, its proportion in the kernel is hardly 2%. The husk is non-edible and very coarse, whereas bran may be part of the edible component. However, it is separated to prepare milled millets for food uses. Normally, husk accounts to 15-20% of the kernel whereas the bran accounts to about 5%, and the endosperm to about 75% of the kernel. Most of these grains are oval shaped and their 1,000 kernel weight and volume range from 1.9-5.5 g and 1.3-3.8 ml, respectively. The seed coat and husk of foxtail millet, little millet and proso millet are generally of single entity with glossy appearance whereas *kodo* and

barnyard millet contain the seed coat with multiple layers. Normally the seed coat of *kodo* millet is of brick red color, while the seed coat of foxtail millet is of yellowish colour. The other millets have grayish coloured seed coat.

The small millets are comparable to major cereals such as rice, wheat, maize and sorghum with respect to their nutrient composition (Table 6). On the other hand, some of these millets contain considerably higher proportion of phytochemicals with neutraceutical properties. Generally, their protein content ranges from 7-12% and fat content varies from 3-5%.

The protein quality of these cereals is of fairly good biological value since they contain about 2.54 g of lysine/100 g protein, while other amino acids also in desirable proportion including leucine: isoleucine ratio. Some of the millets contain good amount of arginine, which is an important essential amino acid for growing children. Prolamins, albumins, globulins and glutelins are the important proteins of these millets and among these prolamins form the major constituent. The presence of proteinaceous enzyme inhibitors has been reported but they are heat labile and hence, their protein digestibility is not affected.

The millet carbohydrates comprising of free sugars, non-starchy polysaccharides and starch, form the major source of energy to the consumers. While the free sugars

Table 6. Nutrient composition of small millets and other cereals (per 100 g edible portion; 12 % moisture)

Food	Protein (g)	Fat (g)	Ash (g)	Crude fibre (g)	Carbohy-drate (g)	Energy (kcal)	Ca (mg)	Fe (mg)	Thiamin (mg)	Ribofl-avin (mg)	Niacin (mg)
Rice (brown)	7.9	2.7	1.3	1.0	76.0	362	33	1.8	0.41	0.04	4.3
Wheat	11.6	2.0	1.6	2.0	71.0	348	30	3.5	0.41	0.1	5.1
Maize	9.2	4.6	1.2	2.8	73.0	358	26	2.7	0.38	0.2	3.6
Sorghum	10.4	3.1	1.6	2.0	70.7	329	25	5.4	0.38	0.15	4.3
Pearl millet	11.8	4.8	2.2	2.3	67.0	363	42	11.0	0.38	0.21	2.8
Finger millet	7.7	1.5	2.6	3.6	72.6	336	350	3.9	0.42	0.19	1.1
Foxtail millet	11.2	4.0	3.3	6.7	63.2	351	31	2.8	0.59	0.11	3.2
Proso millet	12.5	3.5	3.1	5.2	63.8	354	8	2.9	0.41	0.28	4.5
Little millet	9.7	5.2	5.4	7.6	60.9	329	17	9.3	0.3	0.09	3.2
Barnyard millet	11.0	3.9	4.5	13.6	55.0	300	22	18.6	0.33	0.10	4.2
Kodo millet	9.8	3.6	3.3	5.2	66.6	353	35	1.7	0.15	0.09	2.0

*N × 6.25

Source: Hulse, *et al.,* 1980; United States National Research Council/National Academy of Sciences, 1982; USDA/HNIS, 1984

hardly account for 2-3% in the milled grains, the non- starchy polysaccharides account for 15-20% and the starch content varies from 60-75%. Among the free sugars, glucose, fructose and sucrose are prominent and the presence of flatulence causing oligosaccharides such as arabinose, stachyose and verbascose are generally absent. The non-starchy polysaccharides form the major part of dietary fibre, and comprise of cellulose, hemicelluloses and pectinaceous material. The presence of β glucans and lignin like material is generally negligible. Normally, the insoluble dietary fibre accounts for 90% of the total dietary fibre. Most of the dietary fibre is contributed from the aluerone layer and cell wall matter of the kernel. Similar to other cereals, the millet starch consists of amyloses and amylopectin, which are generally present in the ratio of 25:75. Although, most of the millets are considered as high amylose cereals, the malt flour is a good source of nutrients besides, serving as a source of amylases and hence termed as "Amylase Rich Food" (ARF). It can be mixed with powdered sugar, milk powder and flavouring agents such as cardamom to use as milk based beverage, which is popularly sold as '*ragi* malt' in Southern India. Since the malt flour contains hardly 3-5% protein, it can be blended with vegetable or animal protein source such as grain legumes, milk powder, egg powder, etc., to prepare supplementary nutritious food for children. Now-a-days, about 5% finger millet malt is invariably blended with the energy food to improve its texture. This food is produced in bulk and supplied to the weaning children. The process for preparation of weaning food based on malted millet (two parts) blended with malted green gram (one part) has been developed at the Central Food Technology Research Institute (CFTRI), Mysore and the food is popularly termed as 'malted weaning food' (MWF). Controlled child feeding trials on the MWF have shown its superior nutritional and textural qualities compared to several proprietary weaning foods. The food on reconstitution with water and heating to boiling forms nutrient dense slurry (low bulk) and under comparable consistency, the MWF contains twice the amount of nutrients than the roller dried weaning foods. The malt flour as a substitute to malt dextrin can be blended with milk and spray dried to prepare the infant food. Very little information is available on the structural features of the amylose and amylopectin but the limited information available indicates that the starch granules are compacted in the cell and major portion of the endosperm is of vitreous nature. The morphology of the granules differs from each other but most of the granules are of smaller size (3-10 μ) as compared to wheat.

These millets are also good source of micronutrients and B-group vitamins and contain polyphenols, carotenoids, tocopherols and tocotrienols which exhibit antioxidant properties. Some of them are known to contain β carotene also. Probably next to maize, foxtail millet is the richest source of β carotene and it is present in the form of its isomers.

8.2. Value addition and product development

Processing of finger millet and development of value added products received major emphasis during the implementation of the project. Finger millet flour is

easy to make since endosperm and seed coat are pulverized together and in such flour, the dietary fibres are also high. Finger millet offers many opportunities for value addition and diversified utilization of the grain. Malting is one of the age old practices and finger millet is highly suitable for malting. Finger millet malt has improved nutritional quality with enhanced digestive enzymes and is an ideal base to prepare weaning foods, infant foods, malted milk foods as well as health and medical foods. Grain is suitable for popping and develops fine aroma. Popped finger millet flour is useful to make many ready-to-eat products. The Department of Rural Home Science (DRHS), UAS, Bangalore has developed more than 30 different kinds of finger millet products suited to the taste of both urban and rural people.

The millet grains could be popped similar to what is being practiced for other cereals. However, it is essential to equilibrate them to 16-18% moisture level prior to subjecting to short time high temperature treatment to produce the popped material with higher expansion ratio. Normally, the volume of the expanded material varies from 5-9 ml/g. Generally, during popping, the husk gets detached from the popped grain and hence the popped millet grains become a ready-to-eat product. Since it contains almost all the bran of the millet, the popped material is a good source of dietary fibre also. Moreover, the material undergoes high temperature short time treatment; which makes it almost free from microbial contaminants. Probably due to the lower moisture level and inactivation of lipase during heat treatment and also due to the presence of antioxidants, the popped millet grains have good shelf-life. The popped grain is a pre-cooked food and may find usage as an adjunct in brewing and also because of the fluffy texture and cushioning nature, could be used as a packaging material. The popped millets could be blended with ready-to-eat grain legumes, oilseed, milk powder, sugar or jaggery and fortified with necessary vitamins and minerals to formulate nutritious food suitable for supplementary feeding programme.

The millet flour along with refined wheat flour can be used as composite flour for bakery products also. Malting of these millets does not offer economic advantages because of the low yield of malted grains, poor levels of amylolytic enzymes.

Parboiling or hydrothermal treatment seems to be highly promising because of the nutritional benefits, improved milling qualities and improved culinary characteristics. However, no concerted efforts seem to have been made to standardize the methodology of parboiling. Only recently, some efforts to this effect have been made at CFTRI, Mysore. Since the millets resemble rice in their morphological features, the husk provides protection to the grains during steaming and prevents burst opening. Normally, the grains can be soaked at ambient to higher temperature (80°C). Soaking the grain at higher temperature reduces the time of hydration to hardly a few hours. The grains soaked to their equilibrium moisture content (35%) can be steamed at atmospheric or at higher pressure to gelatinize the starch. The millets can also be parboiled adopting *shella* or dry heating methodology. The steamed grains can be dried in a conventional manner and milled in rice milling machinery

similar to parboiled rice and this will offer considerable advantages with respect to milling characteristics, namely, reduced breakage during milling and higher yield of healthy grains. Similar to rice, probably the parboiled millets may contain the better retention of vitamins especially the thiamine and also enhanced storage life.

Parboiled grains on cooking form less sticky food products and the cooked material can be utilized similar to rice along with other adjuncts or can be seasoned with spice and condiments to prepare *chitranna (*yellow coloured rice prepared by adding turmeric powder to white rice), tamarind rice and such other products. The parboiled millets can be processed to prepare a ready-to-eat product similar to expanded rice. However, by incipient germination and hydrothermal treatment, the expansion is 4-5 times. The expanded millets possess all the desirable characteristics for preparation of snacks and also adjuncts in specialty health products. Now-a -days, there is a growing demand for ready-to-eat high fibre products and hence the expanded millets will be of great commercial value.

The epidemiological evidences indicate that people on millet based diets suffer less from degenerative ailments such as heart disease, diabetes, hypertension, cancer, etc. Recent studies have shown hypoglycemic effect of small millets. They contain higher proportion of unavailable carbohydrate and release of sugar from millet food is slow. Small millets contain water soluble gum- ß-glucan and resistant starch which are useful in improving glucose metabolism. Food products, viz., foxtail millet biscuit, barnyard millet biscuit, foxtail millet sweets, barnyard millet sweets, barnyard millet fenugreek *pulao*, barnyard millet *idli* and barnyard millet-fenugreek *idli* were developed for diabetics. Some important value added products developed from finger millet and other small millets are shown in Figs. 8, 9.

Fig. 8. Finger millet based baked products

The food products were analyzed for protein and energy content and it was evident that small millet grains are nutritionally superior and are good source of quality protein, minerals, phytochemicals and vitamins. With appropriate processing and value added strategies, the millet grain can find a place in the preparation of several value added products to the liking of large urban population and nontraditional users.

8.3. Commercialization and marketing

Fig. 9. Products developed from millets

A project impact survey was conducted on the trainees of self help groups (SHGs) in the operational area under Kolar district in October, 2004. This survey showed that production and marketing of finger millet malt and other selected value added products had become one of the major activities in these villages apart from other group activities such as dairying and vermi-composting. The survey also revealed that selected products of finger millet were finding their way to food market outlets in Kolar and Bangalore cities suggesting their gaining popularity among urbanities.

Market price of finger millet had not been very encouraging since many decades which resulted in significant reduction in the acreage of this crop forcing many farmers not to cultivate finger millet for commercial purpose but rather to restrict its cultivation to meet their domestic requirements as well livestock demand. However, compared to other small millets, the market price of finger millet was fairly better. Finger millet was not included in the list of commodities for minimum support price by the Government of India and was also not included in public distribution system (PDS) in earlier years. Concerted efforts are now being made to get finger millet included in PDS in the Karnataka State.

9. Training and capacity building

Fig. 10. A view of trainee participants at Chintamani, Kolar

Capacity building on value addition and product development was an important activity undertaken under this project by the DRHS, UAS, Bangalore. The training was imparted to the officers of the State Department of Agriculture, *krishi vigyan kendras* (KVK's), non-governmental organizations (NGO's), self help groups (SHG's), urban

house wives and the farm families. This greatly helped them in developing diversified value added products. The DRHS served as a platform for providing the training and enhancing the knowledge of many SHG members associated with this project in India and Nepal. The scientists working under the project worked as resource persons for the training programmes to impart training on processing, value addition and product development of finger millet and other small millets.

Fig. 11. Participants in trainers' training programme at Tumkur

Several value added products were developed from finger millet grains with low investments and were demonstrated to the participants through various training programmes. With minimum additional expenditure, the farm women were able to prepare value added finger millet food items which were highly diversified and more attractive to youngsters in the family. Imparting of the training helped the officers to take up further training programmes in other parts of the finger millet growing areas.

A total of 153 participants belonging to different categories including NGOs, officers of State Department of Agriculture, members of self help groups and farm women from different places were provided training on processing, value addition and product development (Figs. 10, 11) organized at different centres (Table 7).

Table 7. Training programmes organized on value addition and product development

S. No.	Date of training programme	Place of training programme	No. of partici-pants	Category of participants
1.	27-28 June, 2002	UAS, Hebbal, Bangalore	23	NGOs, SHGs, farm women, officers of Agriculture Department
2	19 March, 2003	Chintamani, Kolar district	34	Farm women in project area
3.	13-14 May, 2003	Tumkur	40	Selected NGO's, SHG members, farm women, officers of Agril. Dept.
4.	12 July , 2003	Anekal, Bangalore	35	Farm women of Anekal taluk -Shivanahalli and nearby villages
5.	22-23 December, 2003	UAS, Hebbal, Bangalore	21	Selected NGO's, farm women, officials and SHG members.
	Total		**153**	

Practical demonstrations for the preparation of different value added products were also given to the participants during the training (Figs. 12, 13).

Fig. 12. Housewives in a value addition training

Fig. 13. A value addition training in Tumkur

10. Public awareness

10.1. Organizing demonstrations, exhibitions and fairs

Awareness about the importance of finger millet and the improved technologies including high yielding varieties and better cultivation practices was brought about through organizing field demonstrations, farmers' fairs, and exhibitions. Demonstrations on processing, value addition and product development helped the farmers, men and women, communities, entrepreneurs and members of self help groups in understanding the important role finger millet and other small millets can play in enhancing income, nutritional security and sustaining the livelihood of poor people.

10.2. Creating awareness through media

Many T.V. programmes and All India Radio programmes were organized to promote the awareness about the usefulness of finger millet and to reach out to the larger groups of finger millet farmers and consumers for enhancing production and consumption.

10.3. Documentary film on finger millet

A documentary film of 20 minute duration on finger millet, both in *Kannada* (provincial language of Karnataka state) and English languages was made. The film describes the crop, its traditional importance, varietal diversity, improved cultivation practices, nutritional importance, methods of value addition and enterprise building. This documentary film proved to be a very useful tool in formal and informal training programmes and also for the transfer of technology through other agencies working in this area. The documentary film successfully disseminated information on high yielding varieties, improved cultivation and production technology and also processing, value addition and product development for the benefit of the farmers, entrepreneurs and other users.

10.4. Establishing linkages with extension workers and others involved in agricultural development

During the implementation period of the project, a close interaction with agriculture and extension officers of the State Department of Agriculture, Government of Karnataka and other persons involved in agricultural development was maintained, which helped in wider transfer of technologies developed and tested under this project. This process was further assisted by the participation of NGOs and SHGs.

11. Policies

The government policies in many states discourage the cultivation of finger millet and other small millets. Providing rice to the people under the public distribution system (PDS) on subsidized rates encouraged the larger working population to consume rice as compared to small millets. In many states in India, this policy is being implemented and as a result, the consumption of finger millet has reduced drastically. Lack of support for appropriate machineries for improved cultivation was also considered as an impediment in the spread of these crops and appropriate policies are lacking in the state of Karnataka to provide support for developing efficient and low cost machineries for cultivation, value addition and product development.

12. Impact of the project

The project had been able to create awareness among the farmers, communities, entrepreneurs and other stakeholders about the importance and use of millets especially for enhancing income and also for better nutrition. Based on participatory field demonstrations, the millet farmers were highly convinced about the fact that better varieties and improved cultivation practices are opportunities for enhanced production food security and income generation. They were able to identify their own desired varieties of finger millet for achieving these goals. The value added products exhibited tremendous potential to be exploited and popularized among rural and urban consumers. The availability of small mills greatly helped in reduction of drudgery of farm women and thus resulted in women empowerment. The training on various aspects of production, processing, value addition and product development greatly helped the farmers in their skill enhancement which provided them greater confidence in venturing in to diversified product development and organized marketing in order to harness better profits from their produce.

13. Recommendations

- On-farm conservation of important landraces, improved varieties and wild relatives of millets needs to be given utmost attention in order to make use

of genetic diversity in developing better varieties and also to conserve the precious material for posterity and future use.

- Greater focus needs to be given to farmer participatory approaches in the selection and identification of better varieties and improved cultivation practices. This will greatly help in effective and larger adoption of improved technologies.
- The value added products exhibited tremendous potential to be exploited and popularized among rural and urban consumers. The efforts for value addition and development of diversified products need to be strengthened and scaled up through participatory mode of working which ensures effective backward and forward linkages for technology testing and assessing farmer acceptance of technologies.
- There is a great need for technology fine-tuning in a location-specific and farmer-friendly manner through the participatory process resulting in faster adoption and spread of technology.
- Skill enhancement programmes need to be strengthened in all aspects of production-consumption-marketing chain.
- There is also a great need to build linkages with the concerned departments, NGO's, and SHGs so as to have a win-win situation for enhancing farm income and reducing poverty.
- Appropriate marketing links needs to be established so as to enable the farmers and communities to get the maximum benefits from their produce.

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Food Security and Income Enhancement of Rural Poor through Improved Production Technology and Value Addition of Nutritious Small Millets: A Case Study from Northern Karnataka

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1. Introduction

The transformation of agriculture to more productive systems has often been accompanied by increased production in a fewer crop species. As a result, the area, production and diversity of traditional crops like small millets have declined. Yet, in many parts of the world, these crops play an important role in maintaining stable and sustainable forms of agriculture. Small millets are currently cultivated in areas where they produce a more dependable harvest compared to other food grain crops. This has been largely responsible for their continued existence and cultivation of some of the surviving entities of the underutilized crops. These crops provide staple grain to safeguard the food security of people involved in farming under adverse agro-ecological conditions. This apart, the small millets offer good nutrition for having relatively better composition with protective nutrients such as vitamins, minerals, dietary fibre, essential amino acids and phytochemicals. In view of this, these crops are now considered as nutritious grains. Therefore, it is important to enhance production and productivity of these crops to support food security and to alleviate hidden hunger.

The small millets occupy a large area in the State of Karnataka. Their cultivation over long period across varied agro-climatic situations in conjunction with selection pressure to improve them to suit to different growing conditions and consumption practices has resulted in vast diversification of genotypes in the State. With the modern agriculture placing more and more emphasis on high yielding crops and crop varieties for increasing production, productivity and profit, the cultivation of small millets is being abandoned. This is causing serious loss to the genetic resources of these crops. *In situ*/on-farm conservation of local varieties is a potential strategy to conserve these important genetic resources particularly through farmer participatory approaches. The local varieties/landraces continue to evolve in response to natural and human selection and the crop population retains adaptive potential for the future. The yield enhancement can also be done through appropriate crop improvement and better agronomic management. The high yielding varieties developed and tested at research stations do not always perform well under farmers' situations and hence the farmers continue to grow the local varieties of their preference (Joshi and Witcombe, 1996). In the present day crop improvement programmes, there are little opportunities to bring farmers and breeders closer for identification of varieties suitable for real farm situations (Sthapit *et al*., 1996). Although some technologies on yield enhancement of small millets are already available, adoption of these technologies is low due to lack

of awareness among millet growing farmers. However, appropriate crop varieties and better agronomic management can help in realizing the vast untapped potential of these crops and the frontline demonstrations deploying these technologies have proved to be effective in convincing the farmers on the importance and strength of improved technology for enhancing yields.

Among various inputs in crop production, seed takes a central position. Quality seeds of improved varieties along with other production inputs may enhance the productivity of small millets. The farmers are, largely using seeds saved from the crop they had grown during preceding season and currently there is no organized system in place for seed production and supply of improved varieties. The productivity of small millets is low because they are mainly cultivated on marginal soils by resource poor farmers. There is a need to make the traditional systems more productive and competitive on sustainable basis using modern concept of cropping system and nutrient management approach. Although small millets are nutritionally superior, the non-availability of refined and processed millets in ready-to-use form has restricted their use on a larger scale. Millet grains offer many opportunities for value addition and diversified utilization which may create income enhancement opportunities for the farmers. This project addressed some of these issues with a view to strengthen the role of small millets in food security and income generation.

2. Objectives

The studies were conducted at the University of Agricultural Sciences (UAS), Dharwad under the project funded by the International Fund for Agricultural Development (IFAD) with the following objectives:

- To identify the most suitable cultivars from a few national/state released varieties and promising varieties and popularize these through field demonstrations
- To strengthen local capability for production and supply of good quality seeds of varieties selected through farmer participatory selection
- To conserve on-farm the local varieties through community based action
- To refine the cultivation technologies and disseminate these to the farmers
- To develop value addition strategies (through processing, marketing, commercialization, etc.) and promote their sustainable utilization

3. Project areas/sites

The programme was implemented by the University of Agricultural Sciences, Dharwad under the coordination from the M.S. Swaminthan Research Foundation, Chennai. The project activities were located in Haveri and Bellary districts of Northern Karnataka and involved three small millet species at different sites during the project period. The details are given in Table 1.

Table 1. Project areas/sites for minor millet species (2002-2004)

Crop	Project areas/sites
Little millet	Jekinakatti, Savanur taluk; Haveri district Chandapur Tanda, Ranebennur taluk: Haveri district
	Harabagonda, Byadgi taluk; Haveri district
Foxtail millet	Metriki, Sandur taluk; Bellary district Balakundi, Bellary taluk, Bellary district
	Janakunte, Bellary taluk, Bellary district
Finger millet	Koda, Hirekerur taluk; Haveri district Bisalahalli, Ranebennur taluk; Haveri district

4. Geographic distribution of target species

Among rainfed crops, millets as a group figure prominently. India is the largest producer of many kinds of millets, which are often referred to as coarse cereals. Millets grown in India are sorghum, pearl millet and small millets which include finger millet (*ragi*), *kodo* millet, foxtail millet, little millet, proso millet and barnyard millet. Of the total area of 23-24 million ha under millets, small millets account for about 2.7 million ha and their cultivation extending from sea level in coastal Andhra Pradesh to 2,400 m asl in the hills of Uttarakhand and north-eastern states. These crops are grown in diverse soils, varying rainfall regimes and in areas widely differing in thermo and photo-periods. The resilience exhibited by these crops is helpful in their adaptation to different kinds of ecological niches and have made them important and indispensable for low rainfall, tribal and hill agriculture where crop substitution is difficult.

The major finger millet growing states are Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Maharashtra and Uttarakhand. Karnataka state has the largest area under finger millet. The cultivation of *kodo* millet, little millet and foxtail millet is predominant in Madhya Pradesh, Chhattisgarh, Orissa, Tamil Nadu, Jharkhand, Karnataka, Andhra Pradesh and Maharashtra. The state of Madhya Pradesh with around 1 million hectares accounts for the largest area under *kodo* millet and little millet. The barnyard millet and proso millet are largely grown in Uttarakhand, north-east region, north Bihar, western Uttar Pradesh and Maharashtra.

The mean annual planting area under small millets is around 2.7 million ha. Of this, nearly 1.6 million hectares is planted under finger millet with the annual production of 2.1 million tons with productivity of around 1,300 kg/ha. In contrast, the area under other small millets accounts for 1.1 million hectares with the production of 0.51 million tons and the productivity more less stagnating around 494 kg/ha.

Little millet, foxtail millet and finger millet are the most important food and fodder crops of Karnataka. These crops having a high level of regional/local adaption and grown on marginal lands still provides an assured harvest thus making them indispensable in specific ecosystems. Karnataka state alone accounts for 50% of the

area and 54% of total production of finger millet in the country. Finger millet is being grown widely in southern part of the state, while the little millet and foxtail millet are important for northern Karnataka.

5. Participatory surveys on uses, constraints and opportunities

5.1. Documentation of local and traditional knowledge on the use of small millets for consumption

Although many varieties have been released for cultivation, their adoption by farmers had been the minimal. In vast dryland areas where little millet, foxtail millet and finger millet were grown, the growing conditions were different from those that were prevailing on the research stations. As a result, there is a high probability that an improved variety performing well in research stations may not perform up to expectations in the farmers' fields. This situation has led the farmers not to have any preference for the new varieties and hence the farmers continued the cultivation of local/traditional cultivars having lower genetic potential. As a consequence, the grain yield productivity was low. This situation could be improved by providing varieties/cultivars selected by the farmers through participatory varietal selection and accepted by them for cultivation in these areas.

With a view to understand the farmers' perception and needs on varietal choice, a survey using participatory rural appraisal (PRA) techniques was undertaken during April- May, 2002. This was done by individual farmer survey using the proforma especially developed for this purpose. PRA helped in assessing the cropping system, economic status as well as the features of varieties that farmers were looking for. The results of PRA survey revealed: (i) the majority of the small millets growing farmers were looking for a variety possessing drought tolerance with higher grain and fodder yield and in finger millet, they also wanted resistance to blast, (ii) the farmers were growing traditional varieties with low yield potential and were not aware of high yielding varieties released at the state and national level, (iii) the life of rural people was strongly influenced by social conditions, and (iv) the division of work between men and women showed that they had different fields of experience and expertise and accordingly some traits were perceived more important by women, while others were considered more important by men resulting in different rankings for specific traits.

A household survey involving 100 families was undertaken in the villages of millet growing areas of Karnataka based on purposive sampling to gather information on traditional knowledge on the uses of millets for consumption, processing and existing milling technologies. Ethnic foods were standardized in the laboratory and evaluated for nutritional and sensory quality characters by thirty trained judges (Swaminathan, 1995) and were also analyzed for cost: benefit ratio of millet products. Consumer need based value added millet products were designed by modifying the basic traditional recipes of major food grains by application of simple indigenous processing technologies to emphasize, nutritional, functional and sensory qualities

(Swaminathan, 1995). Selected products were tried at pilot scale and evaluated by two hundred rural and urban consumers for acceptability. Standardized ethnic foods and value added products were promoted by organizing different types of awareness and adoption campaign programmes to different segments of the population and assessed the perception levels.

Millet growing villages of Haveri, Hubli and Dharwad taluks were surveyed for documentation of local foods, methods of their preparation and the associated traditional knowledge. Regular consumption of millet as staple food was found rare in rural communities of project villages and was confined only to millet growers and low income families (Yenagi, 2004). Rice from decorticated little millet and foxtail millet, *roti* and *mudde* from finger millet, were the most common staple foods consumed regularly. Sweet products like *hurakki holige*, *halubai* from finger millet, sweet cheese from foxtail millet (*ginna)*, fried products like *chakli*, *dosa, hurihittu* from finger millet were some of the traditional foods that have cultural significance (Fig. 1). Fermented beverages of millets and malt beverage of finger millet were also prepared occasionally. Preparation of a few selected millet products during the festivals was strictly followed by all rural communities and thus they preserved the traditional cultural significance of use of millets in their regular diet (Inamdar and Chimmad, 2004). Milk and milk products were commonly used for millet consumption. Rural consumers were more familiar with traditional products of millets only. Hal Navane, a unique cultivar of foxtail millet, is especially used for patients due

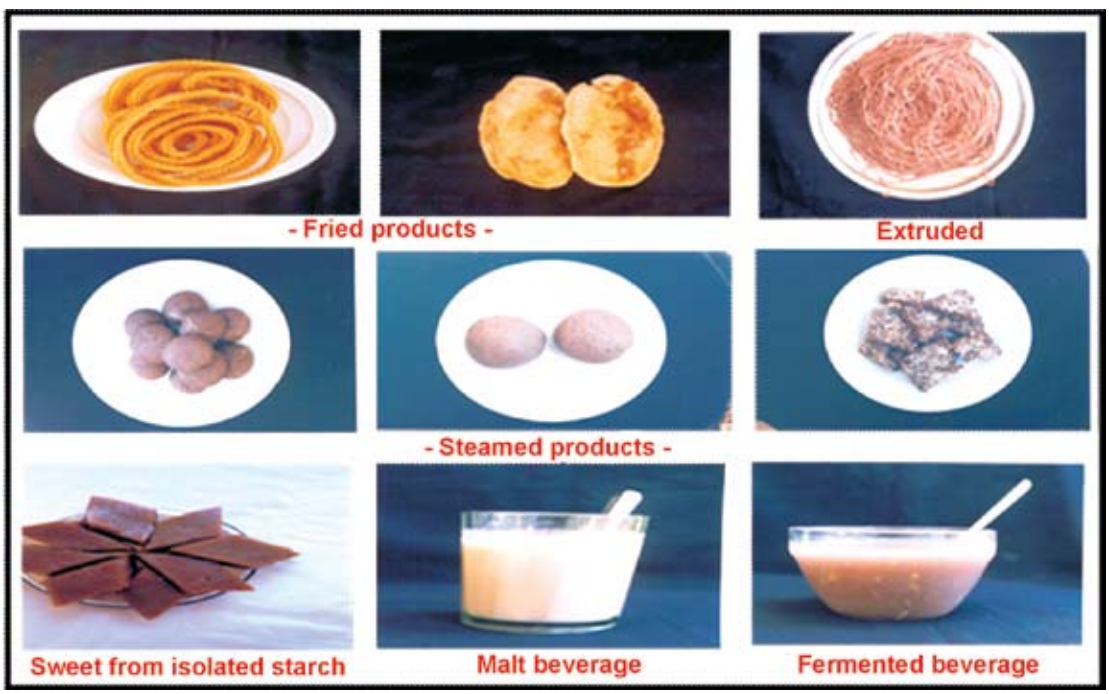

Fig. 1. Ethnic foods of minor millets (*ragi*, foxtail millet and little millet)

to its soft textural quality characters and better digestibility. Decorticated little millet has a special significance and is used as a food in the form of cooked rice or *uppuma* during *vrath* (fasting) in most of the states in India. Survey results also revealed that ethnic foods of millets were classified as staple, convenient, health based, snack items, fried foods and special foods. Boiling, steaming, fermentation, dry roasting, frying, malting and popping were the simple and less developed processing technologies adopted for different preparations. There is a need for developing advanced technologies for maintenance of quality for better marketing (Pattanayak, 1986).

5.2. Consumers' knowledge

The results of the survey revealed that 50% of the consumers had the knowledge of use of millet as *roti, mudde, ambali,* and rice. Only a few consumers (5-25%) had the knowledge of diversified uses of millets like *idli*, malt, juice, porridge and other health foods. None of the consumers had the knowledge of availability of secondary processed products like bakery products, extruded products *papad*, shendige and malt in local markets. Fifty per cent consumers had the knowledge about the significance of millets for medicinal purposes and their high nutritional value which was good for health. Only 15% consumers knew about their significance for high satiety value and their use in the management of diabetes (Table 2).

Table 2. Consumers' knowledge towards use of millets for home consumption (N=100)

	Food items	N (%)
A	***Availability of millet based products in local market***	
	Whole grain	40
	Primary processed products	
	Finger millet (*ragi*) flour	15
	Polished millets	20
	Secondary processed products (bakery, extruded, vermicelli)	Nil
B	***Food uses***	
	Staple food	
	Ragi mudde	50
	Foxtail millet and little millet rice	60
	Ragi roti	50
	Breakfast food	
	Savi idli	15
	Ragi dosa	*20*
	Health food and beverage	
	Ragi malt	*25*
	Ragi juice	10

Contd...

Contd...

	Food items	N (%)
	Ragi ambali	50
	Ragi porridge	5
	Other food items	
	Ragi kadabu	20
	Ragi papad	20
C	***Nutritional and therapeutic significance***	
	Medicinal value	50
	Diabetic food	15
	High satiety value	15
	Health food	50

6. Genetic resources, their evaluation, selection and conservation

6.1 Varieties used and their status

Based on the farmers' requirement from the basket of varieties available, five varieties in each crop were selected (Table 3) for testing with farmers from among those released for Karnataka State as well as those that were promising in the State trials and All India Coordinated Trials but were not adopted by the farmers.

Table 3. Varieties of minor millets selected for testing at farmers' fields

Crop	Variety	Status/special features
Little millet	Sukshema	Released for Northern Karnataka
	CO 2	Released for the whole country
	PRC 3	Released for the whole country
	OLM 20	Released for the whole country
	TNAU 98	Promising variety in coordinated trials
Foxtail millet	HMT 100-1	Promising variety in station trials
	RS 118	State released variety
	TNAU 173	Promising variety in station trials
	Krishnadevaraya	Released for the whole country
	Narashimharaya	Released for the whole country
Finger millet	GPU 26	Blast resistant, released for Karnataka
	GPU 28	Blast resistant, released for Karnataka
	MR 1	High grain yield
	L 5	High grain yield
	Indaf 9	High grain and fodder yield

6.2. Participatory variety selection

Farmer participatory varietal selection has been found to be very useful in crop improvement (Joshi and Witcombe, 1996). In the farmer managed participatory rural (FAMPAR) trials conducted in 2003, one improved variety along with the local variety was grown in an area of 0.4 ha by the individual farmers adopting the prevailing cultivation practices. Each variety was given to three farmers in the same village to serve as replications. Thus, five test entries were tested by 15 farmers in each village. Also, two farmers were given all the five varieties to test the comparative performance of all the five varieties. After sowing, regular visits of the scientists during the crop growth period were made to keep up the continuous interaction with the farmers. This enabled proper execution of the trials as well as for gathering farmers' perception on the material under testing.

The performance of the varieties in each FAMPAR trial in each village was judged visually as well as quantitatively by a select group of 20 farmers specially formed for this purpose, so that the final judgment and ranking of varieties were solely made by the farmers themselves. The group visited all the trial plots. Scientists, extension officers and key officials also accompanied the farmers' group. The input provided by the group was used for formulating a pre-harvest ranking of varieties along with local check, by assessing important characters, namely, crop duration, panicle type and size, disease resistance, drought tolerance, grain density and estimated yield potential. After the harvest, grain and fodder yield data were collected from all trial plots for a more critical comparison.

In FAMPAR little millet trial, the mean grain yield data (Table 4) indicated that the cultivar Sukshema was superior to other five entries in all the three locations. Variety Sukshema recorded the highest overall mean grain yield of10.30 q/ha with the yield increase of 73.69% over the local variety used as check. The next better performing variety was TNAU 98 which ranked second with an overall mean grain yield of 8.88 q/ha, accounting for an increase of 49.74% over the local variety. The varieties OLM 20, PRC 3 and CO 2 recorded 8.32 q/ha, 8.18 q/ha and 7.58 q/ha grain yield, registering an increase of 40.3%, 37.94%, and 27.82%, respectively.

Table 4. Performance of little millet varieties over three locations (2003)

S. No.	Varieties	Mean grain yield (q/ha)			Mean grain yield over locations (q/ha)	Increase over local check (%)
		Jekinakatti	Channapura Tanda	Harabagonda		
1	Sukshema	14.66	10.08	6.16	10.30	73.69
2	TNAU 98	12.46	9.16	5.03	8.88	49.74
3	OLM 20	12.56	8.25	4.16	8.32	40.30
4	PRC 3	12.56	8.00	4.00	8.18	37.94
5	Co 2	11.33	7.91	3.50	7.58	27.82
6	Local	8.59	5.44	3.76	5.93	-

In foxtail millet, the mean grain yield data (Table 5) indicated that HMT 100-1 was superior to all the other five entries over the locations. HMT 100-1 recorded an overall mean grain yield of 15.35 q/ha with an increase of 36.44% over the local variety. The next best performing variety was Krishnadevaraya which ranked second with an overall mean grain yield of 13.73 q/ha registering an increase of 22.04% over the local variety. The varieties TNAU 173, Narasimharaya and RS 118 recorded mean grain yield of 13.50 q/ha, 13.15 q/ha and 12.46 q/ha, registering an increase of 20.00%, 16.88%, and 10.75%, respectively.

Table 5. Performance of foxtail millet varieties over three locations (2003)

S. No.	Varieties	Mean grain yield (q/ha)			Mean grain yield over locations (q/ha)	Increase over local check (%)
		Halakundi	Metriki	Janakunte		
1	HMT 100-1	14.90	15.06	16.10	15.35	36.44
2	Krishnadevaraya	13.10	11.90	16.20	13.73	22.04
3	TNAU 173	14.00	13.40	13.10	13.50	20.00
4	Narasimharaya	12.50	12.65	14.30	13.15	16.88
5	RS 118	12.85	11.85	12.70	12.46	10.75
6	Local	11.14	11.12	11.50	11.25	-

In finger millet, among five cultivars tested, GPU 28 was significantly superior in mean grain yield over all the locations (Table 6). Variety GPU 28 recorded the highest mean grain yield (20.52 q/ha) registering an increase of 49.56% over the local variety. This was followed by L 5 with mean grain yield of 19.90 q/ha registering an increase of 45.04%. The varieties, GPU 26, MR 1, and Indaf 9 recorded the mean grain yield of 16.42 q/ha, 15.22 q/ha and 14.30 q/ha, with an increase of 19.67%, 10.93% and 4.22%, respectively.

Table 6. Performance of finger millet varieties over four locations (2003)

S. No.	Varieties	Mean grain yield (q/ha)				Mean grain yield over locations (q/ha)	Increase over local check (%)
		Haveri district		Bellary district			
		Koda	Bisanalli	Hirekolachi	Bedaladauku		
1	GPU 28	19.60	18.50	25.00	19.00	20.52	49.56
2	GPU 26	16.40	14.4	20.6	14.3	16.42	19.67
3	L 5	19.90	18.10	23.60	18.00	19.90	45.04
4	MR 1	13.80	13.10	20.50	13.50	15.22	10.93
5	Indaf 9	12.50	14.00	18.60	12.10	14.30	4.22
6	Local	13.00	11.80	18.30	11.80	13.72	-

6.3. Description of varieties selected

The participatory rural appraisal showed that the main considerations for the little millet growing farmers were grain and fodder yield. Based on grain yield, the cultivar Sukshema was found significantly superior to all other entries. This variety was preferred by the farmers because of early maturity (85 days), high tillering, non-lodging and drought tolerance. In foxtail millet, the farmers accepted HMT 100-1 which matured in 85 days and had moderate tillers, thin stems and healthy foliage even at harvest and was superior to TNAU 173 and Narashimharaya in grain yielding ability. In finger millet, the farmers selected GPU 28 due to its superiority for normal planting in the second fortnight of June to first fortnight of July. GPU 28 followed by L 5, GPU 26 and MR 1 were found superior for grain yield. Indaf 9 was not preferred by the farmers due to its low yield potential and susceptibility to blast.

Pre- and post-harvest focus group discussions (FGDs) considering some of the important characters, viz., crop duration, ear head type and size, disease resistance, drought tolerance and grain and fodder yield revealed that the cultivars Sukshema in little millet, HMT 100-1 in foxtail millet and GPU 28 in finger millet were found to be very near to the farmers' choice and requirements. The farmers of the test villages were satisfied with the performance of the varieties and were keen to plant more area under these varieties in the ensuing crop season.

6.4. Popularization of PVS varieties through field demonstrations

The spread of high yielding varieties had been limited in small millets. Hence, large scale field demonstrations were conducted to demonstrate the full potential of selected varieties identified through participatory varietal selection vis-a-vis local cultivars. The cluster of villages and areas were selected for conducting farmers managed participatory varietal (FAMPAR) trails during 2003 and 2004 on the basis of predominance of cultivation of different millet species. For example, in Haveri district, the demonstration trials were conducted for two species, namely, little millet and finger millet as these were popular millet species grown in large areas in the district, while in Bellary district, the field demonstrations were conducted only for foxtail millet being the most popular species covering larger area under cultivation. The details of demonstrations conducted during 2003 and 2004 in Haveri and Bellary districts are given in Table 7.

Table 7. Demonstrations conducted for different millets during 2003 and 2004

District	Crop	No. of demonstrations		Total
		2003	2004	
Haveri	Little millet	35	50	85
	Finger millet	35	9	44
Bellary	Foxtail millet	10	35	45
Total		**80**	**94**	**174**

For each demonstration, the farmers were given 4 kg seeds of improved variety and were asked to grow selected variety along with local variety in an area of 0.8 ha (0.4 ha each of improved variety and local variety) by adopting prevailing cultivation practices. Regular visits by the scientists during the crop growth period were made to have continuous interaction with the farmers. This enabled proper conduct of demonstrations as well as gathering of farmers' perceptions/views on the performance of improved varieties. The results of these demonstrations are given in Table 8.

Table 8. Performance of improved varieties of millets in field demonstrations

S. No.	Crop/Variety	Mean grain yield (q/ha)		Increase over local (%)	Mean fodder yield (q/ha)		Increase over local (%)
		Improved variety	Local variety		Improved variety	Local variety	
1	Little millet (Sukshema)	8.00	5.72	39.9	46.0	34.3	34.1
2	Finger millet (GPU 28)	11.74	7.21	62.8	36.1	24.5	47.3
3	Foxtail millet (HMT 100-1)	11.52	7.99	44.2	42.9	31.1	37.9

In little millet, the mean grain yield of improved variety (Sukshema) was 8.00 q/ha in comparison with 5.72 q/ha of local variety. The per cent increase in productivity of the improved variety over the local was 39.9%. The fodder yield recorded in variety Sukshema was 46.0 q/ha as against 34.3 q/ha in the local variety. The productivity of finger millet in large scale demonstrations registered an increase in grain yield to the extent of 62.8% with improved variety GPU 28 over the local variety, while the fodder yield of improved variety (36.1 q/ha) over the local variety (24.5 q/ha) showed an increase of 47.3%. Similarly, in foxtail millet, the mean grain and fodder yield of improved variety HMT 100-1 was 11.52 q/ha and 42.9 q/ha as compared to 7.99 q/ha and 31.1 q/ha, respectively of local variety registering an increase of 44.2% in grain yield and 37.9% in fodder yield.

The trend of grain yield performance of improved PVS varieties, namely, Sukshema of little millet, HMT 100-1 of Italian millet and GPU 28 of finger millet over their respective local varieties over the locations are given in Figs. 2, 3. A view of farmer participatory demonstration in the field is given in Fig. 4.

6.5. Creating local capability for production and supply of good quality seed

The superior varieties developed and released for large scale cultivation need to be maintained for their genetic and physical purity in order to exploit their full genetic potential. The improved varieties are prone to genetic deterioration as they have a very carefully built up genetic constellation/gene combination for higher productivity,

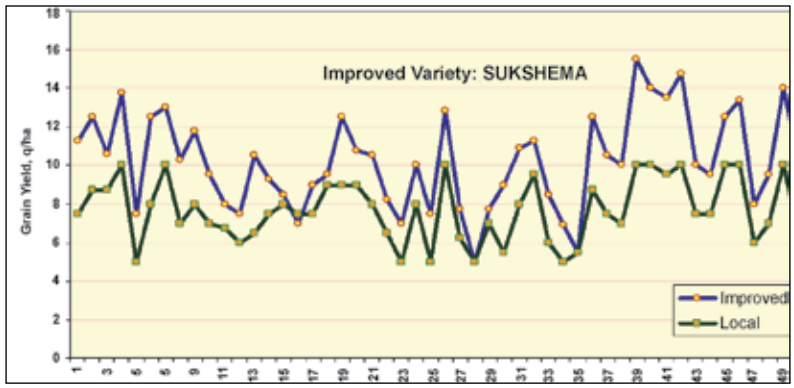

Fig. 2. Comparative performance of improved variety Sukshema over local variety in little millet in demonstrations conducted in 2004

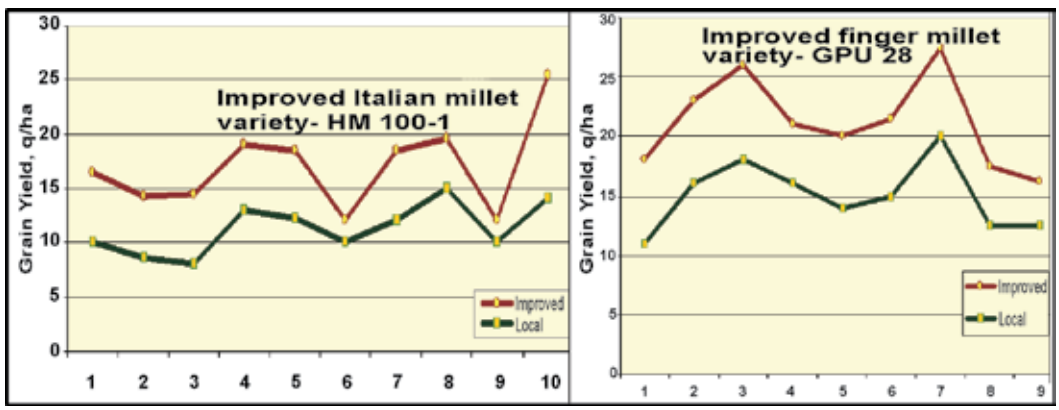

Fig. 3. Comparative performance of PVS varieties of Italian millet (HMT 100-1) and finger millet (GPU 28) over their local varieties (2004)

Fig. 4. Farmer participatory demonstration of Italian millet variety HMT 100-1

regional adaption and inbuilt genetic resistance for biotic and abiotic stresses. In a well managed crop improvement programme, maintenance of released variety becomes very important in order to prolong the consistency of performance. In this context, training was given to farmers for production and supply of good quality seeds. The farmers who were involved in conducting frontline/field demonstrations were given training for adopting proper procedure for maintaining the genetic architecture of the variety.

The seed production programme was taken up at the Agricultural Research Station, Hanumanamatti for production of quality seeds of little millet variety Sukshema, foxtail millet variety HMT 100-1 and finger millet variety GPU 28. The quantity of seed produced for these varieties for distribution to the farmers of the project village are given in Table 9.

Table 9. Quality seed production for selected PVS varieties

S. No.	Crop	Variety	Seed quantity (q)		
			(2003)	(2004)	Total
1	Little millet	Sukshema	10.0	22.0	32.0
2	Foxtail millet	HMT 100-1	10.0	10.0	20.0
3	Finger millet	GPU 28	4.0	4.0	8.0
	Total		**24.0**	**36.0**	**60.0**

6.6. Farmers' contribution through on - farm conservation

In situ/ on-farm maintenance of local varieties is a potential strategy for genetic conservation. By its very nature, on-farm conservation is dynamic because the varieties that the farmers maintain continue to evolve in response to natural and human selection and thus the crop population retains adaptive potential for the future. One notable example is the variety Halu Navane (sweet foxtail millet) which is conserved on-farm through cultivation by farmers in Hirekolochi village of Bellary district.

Under the project, the process of on-farm conservation started with a group meeting involving local farmers to educate them about the need and importance of conserving local landraces and to seek their cooperation in this process. An area of 1.0 hectare was selected in each village and the farmers were persuaded to grow all local cultivars. Project scientists documented the special features of the local cultivars by observation and through discussion with farmers and made regular visits during the crop growth period in order to keep continuous interaction with the farmers. These cultivars possessed the characteristic features of purple pigmentation, thin stem, small leaves, and 100-110 cm plant height. The maturity period varied from 90-95 days with low grain yield potential of 6-7 q/ha. Straw yield varied from 40-50 q/ha, which is a preferred trait of a good variety in the region due to the importance of fodder in this dry tract. The fodder quality of local varieties was better because of thin stem and more succulent leaves. For this reason, farmers took great care to

conserve these varieties by growing at least in small area of their land. The local varieties/landraces of little millet and foxtail millet conserved on-farm during the period 2003-2004 are given in Table 10.

Table 10. On-farm conservation of local varieties/landraces

Crop	Year	Project area location
Little millet	2003	Budapanahalli, Ranebennur taluk, Haveri district
	2004	Chikkalingadahalli and Kanapura, Haveri taluk, Haveri district
Foxtail millet	2003	Rajapura, Sandur taluk, Bellary district
	2004	Hirekolachi, Huvinahdagali taluk, Bellary district

Special features of the local cultivars were documented by interviewing the farmers. These cultivars were observed to possess thin stems, small leaves, plant height of 90-100 cm, maturity period of 90-95 days, low grain yield potential of 5-6 q/ha and the straw used as precious fodder for livestock.

7. Agronomic practices for refinement of cultivation technology

7.1. Enhancing production through improved cropping systems

A study was conducted in farmers' fields by 11 farmers in four selected villages in Haveri and Dharwad districts to study the response of different small millets to different cropping systems. The treatment details in respect of little millet, finger millet and foxtail millet are as follows:

A. Little millet:

T_1 Little millet + pigeonpea in 4:2 row ratio

T_2 Little millet + pigeonpea in 5:1 row ratio

T_3 Little millet (sole crop) – horsegram sequence

B. Finger millet:

T_1 Finger millet + pigeonpea in 4:2 row ratio

T_2 Finger millet + pigeonpea in 5:1 row ratio

T_3 Finger millet (sole crop) – horsegram sequence

C. Foxtail millet:

T_1 Foxtail millet + pigeonpea in 4:2 row ratio

T_2 Foxtail millet + pigeonpea in 5:1 row ratio

The results of the response of little millet to intercropping (Table 11) indicated that intercropping of little millet with pigeonpea in 4:2 row ratio recorded the highest net returns (INR 11,899/ha) and benefit: cost ratio of INR 3.75 per rupee

Table 11. Response of little millet to cropping systems (mean over farmers and locations)

Treatments	Grain yield (q/ha)					Gross return (INR/ha)	Net return (INR/ha)	B:C ratio (INR/rupee invested)
	Narendra	Tirumala-koppa	Agadi	Palikoppa	Mean			
T1. Little millet + pigeonpea in 4:2 row ratio	12.6+5.2	8.7+5.9	8.6+4.8	8.0+6.2	9.5+5.5	16,224	11,899	3.75
T2. Little millet + pigeonpea in 5:1 row ratio	14.1+3.1	9.8+3.5	9.5+2.9	9.2+3.2	10.7+3.1	13,554	9,329	3.20
T3. Little millet – horsegram sequence	17.2+3.5	12.0-4.3	12.0-3.1	11.0-3.8	13.1-3.6	13,957	9,982	3.51

Market rates:
Little millet (grain) – INR 725/q; Pigeonpea (grain) - INR 1,425/q; Horsegram (grain) – INR 775/q
Fodder/straw (for all the three species) – INR 50/q

Fig. 5. Intercropping of little millet with pigeonpea

invested compared to either intercropping of little millet with pigeonpea in 5:1 row ratio or sequence cropping of little millet followed by horsegram. A field view of intercropping of little millet with pigeonpea is given in Fig. 5.

The response of finger millet to cropping systems was studied by 11 farmers in two villages and the results (Table 12) revealed that intercropping of finger millet with pigeonpea in 4:2 row ratio recorded the highest gross return (INR 14, 008/ha), net return (INR 9,883/ha) and benefit: cost ratio (3.40) followed by finger millet – horsegram sequence and the lowest return in finger millet + pigeonpea in 5:1 row ratio system. The response of foxtail millet to cropping system studied by 11 farmers in three villages (Table 13) indicated that intercropping of foxtail millet with pigeonpea in 4:2 row ratio was more profitable than the farmers' practice of 5:1 row ratio. Intercropping in 4:2 row ratio recorded the highest net return of INR 11,305/ha and benefit: cost ratio of INR 3.24/rupee invested.

Table 12. Response of finger millet to cropping systems (mean over farmers and locations)

Treatments	Grain yield (q/ha)			Gross return (INR/ha)	Net return (INR/ha)	B:C ratio (INR/rupee invested)
	Anur	Aralikatti	Mean			
T1 Finger millet + pigeonpea in 4:2 row ratio	9.35+4.75	9.18+5.49	9.26+5.12	14,008	9,883	3.40
T2 Finger millet + pigeonpea in 5:1 row ratio	10.50+4.12	10.15-4.18	10.32+4.15	9,847	5,747	2.40
T3 Finger millet – horsegram (sequence)	12.40+5.20	12.83+5.18	12.61+15.19	10,929	7,079	2.84

Market rates:
Finger millet (grain)-INR 425/q; Pigeonpea (grain) - INR 1,425/q; Horsegram (grain) - INR 775/q; Fodder/straw - INR 50/q

Table 13. Response of foxtail millet to cropping systems (mean over farmers and locations)

Treatments	Grain yield (q/ha)				Gross return (INR/ha)	Net return (INR/ha)	B:C ratio (INR/rupee invested)
	Halyal	Chebbi	Belur	Mean			
T1 Foxtail millet + pigeonpea in 4:2 row ratio	18.1+7.5	14.2+5.0	10.4+8.7	14.2+7.0	16,355	11,305	3.24
T2 Foxtail millet + pigeonpea in 5:1 row ratio	20.0+4.5	15.0+3.1	12.5+5.9	15.8+4.5	13,182	8,282	2.69

Market rates:
Grain; Foxtail millet – INR 400/q; Pigeonpea - INR 1,425/q; Fodder/straw: Foxtail millet - INR200/t; Pigeonpea - INR 50/q

Based on these demonstration trials on farmers' fields, it was concluded that among the cropping systems, growing little millet, finger millet and foxtail millet along with pigeonpea in 4:2 row ratio was found more productive and profitable.

8. Processing, value addition, product development and marketing

India is one of the world's largest producers of agricultural and food products. Three quarters of the population live in rural areas and largely depend on subsistence agriculture for survival. Today, the consumer is looking for food with three basic characteristics, (i) convenience in preparation, (ii) cultural acceptance, and (iii) high quality. There is an increasing concern over the need for restructuring and rejuvenation of the agro-food chain in order to improve efficiency and employment opportunities (Yenagi *et al*., 1998). A study was undertaken on three important small millet crops, viz., finger millet (*ragi*), foxtail millet and little millet to explore the inherent technological opportunities for better utilization of resources in designing

value added products and suitable technologies for promotion of millet based ethnic food through cottage industries.

8.1. Assessment of existing millet processing units in project villages

Decortication (dehulling) of millet by hand pounding was still in practice in rural communities. It is laborious and time consuming and hence majority of women were not following this method. Local flour mills were being used for dehusking and polishing and it was again hand pounded at home for better refinement of grains. Polished grain yield was only 50% as broken grains and flour yield was more in local flour mills. Commercially cone type decortication units, resembling rice/*dhal* polishers are in existence since 1950 in Kolhapur, Pune and Nasik districts in Maharashtra State. Nasik has the maximum processing units for millets, especially for little millet and proso millet. Cost of each unit is around INR 22 lakhs ($ 50,000) and the capacity of each unit is 100 quintals/day. Several institutions, viz., Central Food Technology Research Institute (CFTRI), Mysore, Millet Research Centre, Uttarakhand, Central Institute of Agricultural Engineering (CIAE), Bhopal, and University of Agricultural Sciences (UAS), Bangalore, also attempted to design small units for processing of millets but these efforts were not much successful due to the machines not being efficient and cost effective. Finger millet grains were commercially processed for manufacture of malt, *hurihittu*, bakery products, pasta products and frymes. Milling technologies developed by CFTRI, Mysore and UAS, Bangalore were being used for processing of finger millet commercially in many places in Southern Karnataka but these were not yet popularized in project villages of UAS, Dharwad (Fig. 6).

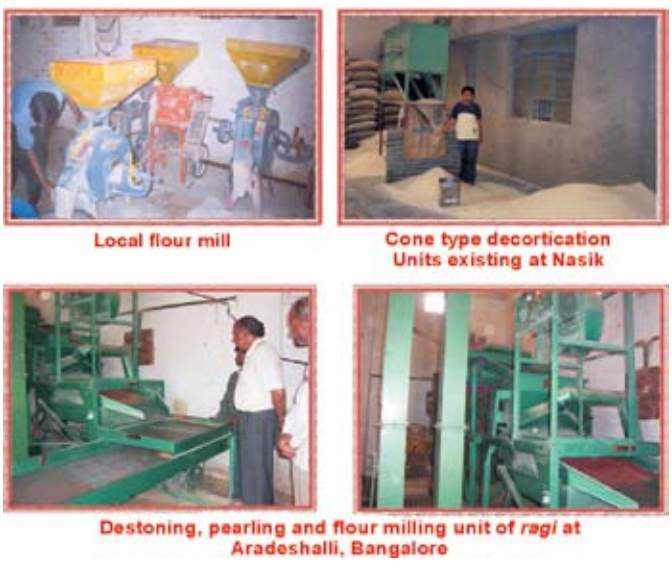

Fig. 6. Existing processing units of finger millet, foxtail millet and little millet

8.2. Marketing strategies of small millets

The whole grains and decorticated grains of little millet and foxtail millet were sold in the markets in towns and on weekly market days in the villages for regular consumption by the farmers. Little millet grains grown in Hubli, Dharwad, Haveri

and Savanur taluks were collected by local people and sold to whole sale merchants in Hubli, Dharwad, and Haveri. Further, the grain was transported to Maharashtra for value addition, where millet grains were polished several times and sold in local markets of Maharashtra, Karnataka and also in some states in Northern India. Decorticated or whole grains were also being exported to other countries for use as 'bird feed'. The survey results of retail shops revealed that millet grains were not available in all retail shops as was usually the case with other staple cereals. Decorticated millets were very costly as compared to rice and the price variation was very high (Table 14).

Table 14. Availability of millets and their products in retail shops or home consumption (N=27)

S. No.	Items	Shops		No. of products	Price (INR/kg)
		No.	%		
1	Finger millet	16	59.0	1	6 - 8
2	Finger millet in polythene cover	3	11.0	1	12
3	Finger millet flour	5	18.5	1	10 - 12
4	Finger millet flour in pack	7	25.9	1	13 - 14
5	Finger millet malt (R.K. Vita brand)	2	7.4	1	112.5
6	Polished foxtail millet	9	33.3	1	12 - 13
7	Polished little millet	1	3.7	1	24
8	Rice	27	100.0	5-6	10 - 20
9	Wheat	27	100.0	2-3	9 - 12
10	Sorghum	27	100.0	2	7
11	Broken rice	4	14.8	1	10 - 12

N - No. of families surveyed

8.3. Development of consumer need based value added products of small millets

8.3.1. Value addition to traditional foods

Traditional millet based recipes and processing techniques used for preparation of these recipes were gathered from books and other literature and also by conducting cooking competitions, to know the significance of traditional products for different qualities, value addition and commercialization. Millet based products were prepared by substituting rice, wheat and pulse with small millets in different proportions and were evaluated for quality characters for better acceptability among rural and urban community (Fig. 7).

The small millets possess certain significant inherent quality characteristics for product development. For example, all millet products were observed to have

excellent taste, excellent crispy texture of foxtail millet was found suitable for making biscuits and cookies and also in fried products (Yenagi *et al.,* 2004). Soft non-sticky textural quality of starch was observed in finger millet *halwa.* Light and puffy quality characters of little millet were observed in fermented products like *idli* and *dosa.* Small millets can easily be incorporated at 25, 50 and 100% levels in wheat, rice and pulse recipes (Tables 15, 16). Small millet products were highly acceptable among rural and urban population. Storability of a few small millet products was observed to be above two months at room temperature (Table 17).

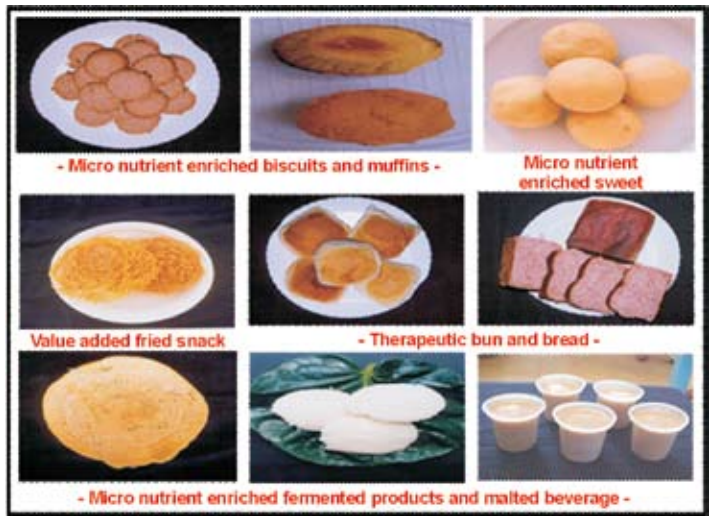

Fig. 7. Standardized and organoleptically accepted ethnic foods and value added products of minor millets for cottage industries

Table 15. Quality characters of *idli* prepared with incorporation of small millets in different proportions

Proportion (Rice: Millet)	Weight of one *idli* (g)	Descriptive organoleptic quality characters			
		Colour	Texture	Taste	Heaviness
1. Rice					
100:0	35	White	Very soft	Good	Light
2. Little millet					
75:25	34	White	Slightly hard	Good	Fairly light
50:50	34	White	Soft	Good	Light
25:75	34	Slightly dull white	Soft	Good	Light
0:100*	31	Slightly dull white	Very soft	Good	Very light
3. Foxtail millet					
75:25	38	Light yellow	Slightly hard	Good	Fairly heavy
50:50*	35	Light yellow	Soft	Good	Fairly light
25:75	34	Yellow	Soft	Bitter taste	Light
0: 100	34	Yellow	Very soft	Bitter taste	Very light

*Consumer accepted millet based *idli*: little millet – 100% and foxtail millet – 50% incorporation

Table 16. Quality characters of *chakli* prepared with incorporation of small millets in different proportions (100g)

Proportion * Rice: Millet: BG: BLG	Water uptake (ml)	Wt. of dough (g)	Oil absorption (ml)	No. of *chakli*	Wt. of *chakli* (g)	Volume (20 g *chakli*) (cc)	Texture
5: 0:1:1	40.00	100	32	7	80	158	Slightly hard
0:5 (N):1:1	45.00	100	32	8	90	166	Very crisp
0:5 (S):1:1	35.00	90	35	6	85	162	Slightly crisp
2.5:2.5(N):1:1	43.75	100	40	8	90	160	Very crisp
2.5:2.5(S):1:1	47.5	100	30	7	90	152	Moderately crisp
0:5 (S):0:2	40.00	90	30	6	75	164	Slightly hard
0:5 (N):0:2	46.25	100	25	8	90	162	Fairly crisp
0:5 (S):2:0	40.00	100	25	7	85	166	Slightly hard
0:5 (N):2:0	45.00	110	15	8	92	156	Very crisp

*BG: Bengal gram, BLG: Black gram, S: *Same* (little millet), N: *Navane* (foxtail millet)

Table 17. Storability of standard and value added millet products

S. No.	Product	Storability/keeping quality (days)	
		Room temperature	Refrigerator
1	Finger millet malt	90	180
2	*Besan laddu*	90	*
3	Fried products	60	*
4	Biscuits	75	*
5	Muffins	3	7
6	Bread	2	7
7	Finger millet *halwa*	3	10
8	Finger millet *ambli*	2	10
9	*Hurakki holige*	30	*
10	Polished rice	90	*

*Not kept in refrigerator

8.3.2. Millets in bakery industry

Bakery is one of the largest sectors in food industry. There is an increase in consumption of bread and bakery products and it is gaining popularity in the urban communities due to their emphasis on speed of service. The American Heart Association, and The Dietary Guidelines for American and Healthy People 2010, recommended that consumers should choose at least six servings per day. But, only 1-3% of U.S. population is meeting the USDA Food Guide Pyramid recommendations. There is a need to take a look at the foods people in India are eating from cereals to breads and consider what can be done to encourage whole grain consumption.

At the same time, there is also a need to develop appropriately processed whole grain products that meet consumers' needs and tastes. For a baker, adding whole grains and adding fibres can pose challenges for the baking process. Nutritious millets can play an important role in the development of healthy bakery products with enriched grains.

A study was conducted with the aim of enriching the nutritional quality of biscuits with value addition through the use of small millets. The finger millet, foxtail millet and little millet flours were incorporated at the rate of 25, 50, 75 and 100% in refined wheat flour for preparing the biscuits. The data on weight and diameter of cookies/biscuits (Table 18) revealed that in general, the weight of biscuits prepared with incorporation of millets, particularly in lower proportions, was lesser as compared to that prepared with *maida* (fine wheat flour), while the size of biscuits was comparatively larger indicating thereby a better quality of biscuits. The foxtail millet flour was incorporated at appropriate proportions in four types of biscuits, namely, *nankhatai*, melting movements, peanut and chilli biscuits as per the standardized specification and the biscuits were prepared as per the prescribed method of preparation (Table 19) and these biscuits were assessed for functional and sensory qualities (Yenagi and Masur, 2004a).

Table 18. Quality characters of biscuits prepared with incorporation of small millet flour in different proportions

S. No.	Proportion *Maida* (fine wheat flour): millet flour	Weight of cookies/biscuits (g)*	Diameter of the cookies/biscuits (cm)
1	*Maida* 100:0	230	3.46
	Finger millet		
2	75:25	220	3.93
3	50:50	230	3.78
4	25:75	250	3.81
5	0:100	270	3.56
	Foxtail millet		
6	75:25	230	3.75
7	50:50	230	3.70
8	25:75	240	3.77
9	0:100	260	3.80
	Little millet		
10	75:25	230	3.95
11	50:50	240	3.16
12	25:75	240	3.03
13	0:100	245	3.05

*Weight of cookies prepared from 100 g flour

Table 19. Raw materials and method of preparation of different types of biscuits

Raw materials	Quantity required	Raw materials	Quantity required	Method of preparation
1	2	3	4	5
Nankhatai biscuits				
Foxtail millet flour	100 g	Cardamom powder	A pinch	Cream *vanaspati* (vegetable oil) and sugar till light and fluffy; add *soda* (baking powder), nutmeg, cardamom, curd and mix well; sieve millet flour and *maida* (fine wheat flour); add sieved flour to the above cream and make stiff dough; divide the dough into small equal portions; round them and place on greased baking trays one inch apart; bake at 275°F for about 15 minutes.
Maida (fine wheat flour)	100 g	*Soda* (baking powder)	¼ tea spoon	
Vegetable oil (*Vanaspati*)	120 g	Ammonium bicarbonate	¼ tea spoon	
Sugar powder	100 g	Curd	2 table spoons	
Nutmeg powder	A pinch			
Melting movements (Coconut biscuits)				
Foxtail millet flour	75 g	Egg	½	Cream *vanaspati* and sugar light and fluffy; beat the egg with vanilla and add to the creamed mixture; sieve the flour and baking powder twice; add the flour to the above mixture and make soft and smooth dough; divide the dough into small equal portions; round them and place them in the greased baking tray one inch apart; bake at 300° F for about 10 minutes.
Maida	75 g	Vanilla	A few drops	
Baking powder	¼ tea spoon	Cornflakes or coconut powder	50 g	
Vanaspati	120 g			
Sugar	90 g			
Peanut biscuits				
Foxtail millet flour	125 g	Peanuts	50 g	Cream fat and sugar; beat egg with vanilla; add beaten egg to the cream; sieve millet and *maida* flour; add the flour into the above creamed mixture; knead into a smooth dough; add milk if required; roll the dough into 1/4 inch thickness and cut with fancy biscuit cutter; arrange them in greased baking tray; bake at 300°F for about 10 minutes.

Contd...

Table 19 (Contd.)

1	2	3	4	5
Maida	125 g	Egg	½	
Vanaspati	150 g	Vanilla	A few drops	
Sugar	100 g	Milk	As needed	
Nutmeg powder	A pinch			
Chilli biscuits				
Foxtail millet flour	75 g	Green chillies	As needed	Sieve the *maida* with baking powder and salt twice: rub in fat and then add sugar; mix the chilly mixture and curd; knead it to soft dough; roll the dough into a thin sheet 1/2 inch thick and cut it with a biscuit cutter; place it on a baking tray little apart; bake at 300°F for 15 minutes.
Maida	75 g			
Vanaspati	75 g	Coriander leaves	A few	
Sugar	5 g	Ginger	Small quantity	
Baking powder	¼ g	Curd	2 table spoons	
Curry	15 g	Salt	A pinch	

The colour, texture and surface appearance of the biscuits prepared with incorporation of different millets showed a wide variation (Table 20). The whole grain finger millet flour biscuits had astringent taste but showed very good spreading quality and breaking strength and had soft and crunchy texture and smooth surface appearance. Foxtail millet biscuits were very tasty, possessed good spreading quality with soft and crunchy texture and smooth or light cracks surface appearance. In general, 50% incorporation of any small millet flour was found ideal for preparation of biscuits. The higher proportion of millet flour resulted in harder texture of biscuits in case of finger millet and little millet, while the texture was soft in case of foxtail millet. The mineral content of millet based biscuits/ cookies was higher than refined flour biscuits. The mineral content of millet biscuits with incorporation of millet flour at 25% ranged from 0.2-1.02%, and the maximum was found in finger millet based biscuits (Table 20). The nutrient composition of different types of foxtail millet biscuits, namely, "peanut", "melting movements", "*nankhatai*' and "chilli" biscuits (Table 21) revealed that these provided fairly good amounts of nutrients, namely, protein, fat, carbohydrates, mineral, fibre, iron and calcium.

Table 20. Quality characters of biscuits prepared with incorporation of small millet flour in different proportions

S. No.	Proportion *Maida* (fine wheat flour) : Millet flour	Descriptive quality characters			Total mineral content (%)
		Colour	Texture	Surface appearance	
1	100:0	White	Slightly hard	Cracks	0.85
Finger millet					
2	75:25	Light brown	Soft and crunchy	Smooth	1.02
3	50:50	Light brown	Soft and crunchy	Cracks	
4	25:75	Moderately brown	Semi hard	Cracks	
5	0:100	Brown	Very hard	Cracks	
Foxtail millet					
6	75:25	Slightly creamish	Soft and crunchy	Little cracks	0.98
7	50:50	Slightly creamish	Soft and crunchy	Cracks	
8	25:75	Creamish	Too soft	Cracks	
9	0:100	Creamish	Too soft	Cracks	
Little millet					
10	75:25	White	Soft and floury	Cracks	0.20
11	50:50	White	Soft floury	Little cracks	
12	25:75	White	Moderately soft	Little cracks	
13	0:100	White	Very hard	Smooth	

Table 21. Nutrient composition of foxtail millet based biscuits

S. No.	Nutrients	Peanut biscuits	Melting movements biscuits	*Nankhatai* biscuits	Chilli biscuits
1	Calories	494	497	484	479
2	Protein (g)	8.06	5.80	5.38	9.37
3	Fat (g)	30.54	31.84	28.08	30.81
4	Carbohydrate (g)	46.82	46.37	52.24	41.12
5	Mineral (g)	0.88	0.65	0.69	0.93
6	Iron (mg)	1.52	1.25	1.23	1.58
7	Fibre (g)	1.98	1.52	1.78	2.42
8	Calcium (mg)	23.75	13.40	22.0	26.92

"Melting movements" biscuits prepared from foxtail millet at 50% incorporation level scored the highest overall acceptability followed by that for "peanut", "*nankhatai*" and "chilli" biscuits (Fig. 8).

The zinc content was higher in "peanut" and "melting movements" biscuits. Thus, small millet biscuits have great potential to enter bakery industry as value added products ((Yenagi and Masur, 2005). The effect of addition of foxtail millet flour and malted finger millet flour on the quality of muffins as per standardized specification

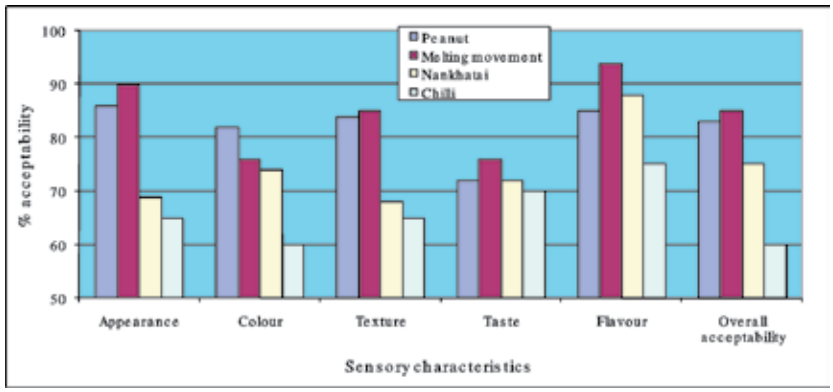

Fig. 8. Sensory characteristics of biscuits made from wheat flour and foxtail millet flour blends

was studied for functional, nutritional and sensory qualities. Incorporation of 50% foxtail millet or malted finger millet flour to refined flour adversely affected the quality of muffins (Yenagi and Masur, 2004b). Millet muffins were more dense, compact and too dry to swallow (Table 22). The overall acceptability level was 50-60% as compared to standard muffins (Figs. 9, 10).

Modification of the standard recipe with increase in fat to the extent of 25% improved the physical and sensory quality characteristics of millet muffins. Sensory quality scores of finger millet muffins were on par with standard muffins and these were highly acceptable for taste and texture. One hundred grams of millet muffins

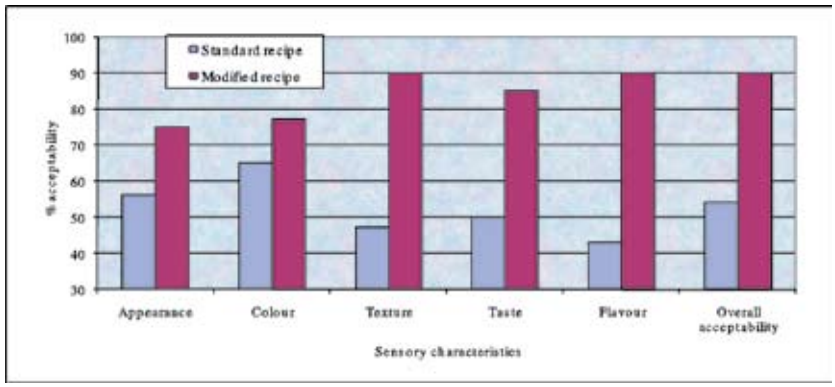

Fig. 9. Sensory characteristics of muffins made from wheat flour and finger millet flour blends

provided good amount of protein, fat, calories and mineral contents (Table 23). Finger millet muffins also contributed good amount of calcium. The results clearly revealed that there is a need to promote such value added products to meet the needs of the community through ready-to-eat convenient and nutritious breakfast food.

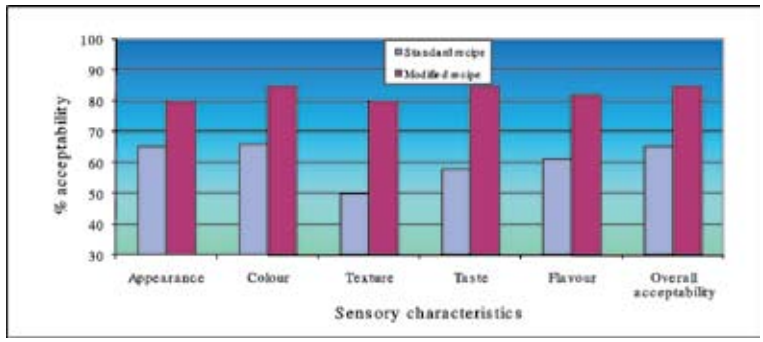

Fig. 10. Sensory characteristics of muffins made from wheat flour and foxtail millet flour blends

Table 22. Descriptive qualities of muffins prepared by incorporation of small millet flour (50%) to refined flour

S. No.	Flour used for muffin	Muffins prepared by standard recipe (with refined wheat flour)		Muffins prepared by modified recipe (with incorporation of millet flour)	
		Weight of single muffin (g)	Muffin qualities	Weight of single muffin (g)	Muffin qualities
1	Standard (Refined wheat flour)	28.50	Light, well puffed, golden brown, soft crust with good luster, and good taste		--
2	Foxtail millet	26.30	More dense, less puffed, hard, more compact, difficult to swallow but very tasty	30.0	Light, yellow in colour with good luster, fairly light, slightly sticky in the mouth, fairly puffed but very tasty
3	Finger millet	27.50	More dense, less puffed, hard, more compact grains, very dry, difficult to swallow, poor appearance but good taste	31.0	Light, well puffed with light coffee colour, and good taste

Table 23. Nutrient composition of finger millet muffins

S. No.	Constituents	Quantity
1	Calories (k cal)	395
2	Protein (g)	5.30
3	Fat (g)	19.50
4	Carbohydrate (g)	50.00
5	Mineral (g)	0.84
6	Iron (mg)	2.00
7	Fibre (g)	0.54
8	Calcium (mg)	75.89

8.3.3. Consumer acceptability

A study on consumer acceptability level of a large number of value added small millet products was undertaken. The results revealed that the acceptability level was moderate to high and the per cent acceptability ranged from 65-90 (Table 24).

Table 24. Level of consumer acceptability of value added small millet products

S. No.	Value added products	No. of products developed	Level of incorporation of millets (%)	Significance of value addition	Acceptability level (%)
1	Staple food (rice of different types)	20	100	Micronutrient enriched	70.0
2	Fermented foods	10	50	Probiotic food	70.0
3	Fried products	10	50	Adds variety	90.0
4	Special sweets	2	50	Adds variety	80.0
5	Convenience foods*	7	100	Adds variety	90.0
6	Bakery products	10	25-50	Therapeutic value	70.0
7	Health foods and therapeutic foods	4	25-50	Better nutrition	65.0

* The food that is designed to save consumers' time and reduce wastage from spoilage. It includes ready-to-eat and ready-to-drink products.

8.3.4. Economic benefits

The viable indigenous and value added millet based technologies (Table 25) revealed that the benefit: cost ratio of these products ranged from 1: 1.2 to 1: 2.0. Diabetes is one of the World's leading health problems and according to World Health Organization (WHO), 57 million of Indians will be diabetic by 2025 (Sarah *et al.*, 2004). Small millets will play an important role in combating this problem due to their inherent characteristics of slow release of carbohydrates. Nutritionally and functionally superior crops such as small millets with high nutraceutical properties are suitable in development and production of value added health food. The economic estimation indicated that value addition as health claim can increase the profit of small millet growers by about four times.

9. Training and capacity building

The millet products developed were promoted by organizing several training programmes for different segments of the population and the impact of use of these products was assessed by testing the knowledge of trainee participants before and after the training (Fig. 11). Training on production of quality seeds of PVS varieties (Fig. 12) was organized along with field demonstrations in a few villages of Haveri and Bellary districts. One month training on baking with special emphasis on millet-based products was given to 15 trainees. Refresher training was imparted to ten bakers from the baking industry. On-campus and off-campus trainings were organized for self entrepreneurs and urban women on millet nutritional quality and

Table 25. Viable indigenous and value added millet based food processing technologies

	Value added products	Cost (INR)	Significance	Marketing strategy	B:C ratio
A. Indigenous/traditional products					
1	*Ragi ambali* (fermented beverage)	4/cup	Probiotic food; ideal food for summer	Hotels, restaurants, canteens, religious temples	1:2.0
2	*Ragi halwa*	70/kg	Special sweet for specific occasions; adds variety (good texture)	Hotels, restaurants, canteens, religious temples	1:1.5
3	Decorticated grains	20/kg	Nutritious, high satiety value, rich in complex carbohydrates and micronutrients	Hospitals, retail shops, hotels, restaurants, theaters	1:2.0
4	*Hurakki holige*	60/kg	Adds variety	Retail shops, schools, institutions	1:1.25
5	*Ragi hurihittu*	50/kg	Instant food, rich in phytochemicals and micronutrients	Hospitals, schools, colleges	1:1.5
6	*Ragi* malt	8/100g	Nutritious and easily absorbable	Hotels, retail shops	1:1.5
7	*Ragi papad* and fryums		Adds variety (crispy, better taste)	Retail shops, restaurants, theaters	1:1.2
B. Value added products					
1	Popped supplementary food	10/100g	Reduces protein calorie malnutrition among children; good for old people	Schools, hospitals, retail shops	1:1.2
2	Nutritious *ragi* malt	10/100g	Health food for infants, children, pregnant mothers and old people, geriatric food	Schools, hospitals, retail shops	1:1.2
3	Nutri enriched *besan laddu* (nutri-enriched)	70/kg	Supplementary food for school children; adds variety (good taste)	Schools, retail shops, religious temples	1:1.5
4	Millet based fried snacks	50/kg	Ready-to-eat products; adds variety	Schools, retail shops, hotels	1:1.25
5	Millet cookies	60/kg	Micronutrient rich, supplementary food for children	Schools, hostels, bakeries	1:2.0
6	Millet muffins	10/100 g	Ideal whole breakfast food	Schools, hostels, bakeries	1:2.0
7	Millet based bread	10/loaf	Therapeutic food for diabetic, heart and cancer patients being fibre and micronutrient enriched food	Hospitals, bakeries, institutions	1:2.0

value addition. In addition, a large number of training programmes were organized by the Department of Food Science and Nutrition at Dharwad, Hubli, Haveri and Hangal taluks.These training programmes included one day and three days programmes and covered diverse topics such as (i) participatory demonstration of use of small millet grains in bakery industry, (ii) participatory demonstration on millet snacks for self entrepreneurship, (iii) participatory demonstration on millet based therapeutic food for home industry, (iv) millet based infant and supplementary foods for small scale industry, and (v) participatory demonstration on use of small millets in regular recipes. In all, 33 training programmes were organized which benefitted 810 participants. The details of these training programmes are given in Table 26.

Fig. 11. Women participating in product development training

Fig. 12. Farmers participating in quality seed production training at Bellary

Table 26. Training programmes organized

S. No.	Training programme	Place	No. of trainings	No. of beneficiaries	Type of beneficiaries
1	Value addition and product development	Department of Food Science and Nutrition, UAS, Dharwad	6	125	Women entrepreneurs from millet growing areas and also from project sites in Jeypore and Kolli Hills
2	Participatory demonstration on use of millets in bakery products, therapeutic food, supplementary food for infants and regular recipes	Rural and urban places in Dharwad, Hubli, Haveri and Hangal taluks	15	560	Rural women including adolescent girls, self entrepreneurs, college students, members of Mahila Mandal (Women Group)
3	Refresher training on baking of millet based products	Department of Food Science and Nutrition, UAS, Dharwad	2	25	Bakers from bakery industries in Dharwad
4	Production of quality seeds of PVS varieties	Field sites in Bellary and Haveri districts			Farmers from the project sites
5	Nutritional quality and value addition	Department of Food Science and Nutrition, UAS, Dharwad	10	100	Self entrepreneurs and urban women
	Total		**33**	**810**	

10. Public awareness

The use of millet based value added products was promoted through several awareness campaigns and programmes. These included exhibitions, school children projects, on-campus and off-campus lectures, development of education materials and cooking competitions. A total of 44 exhibitions including Food Exhibition at *Pragati Maidan*, New Delhi, Food Expo in Bangalore, agricultural fair in Dharwad and several other exhibitions at other places were organized and more than hundred thousands of people attended these events and were directly exposed to the products and results of the project.The beneficiaries included farm men and women, entrepreneurs, agriculture officers, school children, college students and teachers, NGO representatives, members of women organizations, and local people from nearby towns. A total of 35 lectures were organized benefitting 1,185 persons and 5 cooking completions were organized in Dharwad city and project villages in which 125 ladies participated. In addition, a folder on nutritional significance and method of preparation of finger millet malt and recipe books on finger millet, foxtail millet and little millet were prepared and widely distributed to users. The details of the awareness programmes organized are given in Table 27.

Table 27. Promotion of nutritious minor millets through awareness campaigns

S. No.	Type of activities	Place	No. of activities	Total no. of beneficiaries	Type of beneficiaries
1	2	3	4	5	6
1	Exhibitions	Dept. of Food Science and Nutrition (FSN)/ Directorate of Extension/ Agriculture Technology and Information Centre UAS, Dharwad	25	750	Special invitees, key officers and staff, UAS Dharwad; Assistant Agriculture Officers, NGO representatives, students and self entrepreneurs
		Krishi Mela (Agriculture fair) UAS, Dharwad during 2002 and 2004 (each for 3 days)	2	55,000	Farm men and women of different villages of North Karnataka, special invitees, school children, college students, staff of different organizations and local people from Hubli, Dharwad and also nearby towns
		Food Exhibition at *Pragati Maidan*, New Delhi, and Food Expo at Bangalore	2	50,000	Local people of Delhi and Bangalore, respectively; and people from other places
2	Trainings	Off campus training at millet growing areas of Dharwad, Hubli, Haveri and Hanagal Taluks; Educational Institutions and Hospitals in North Karnataka (Organized in collaboration with All India Coordinated Small Millet Improvement Project, Dept. of Food Science and Nutrition, Peri -Urban and CIDA project of UAS, Dharwad and State Dept. of Agriculture in different districts of Karnataka	15	600	*Mahila Mandal* members, women entrepreneurs, Assistant Agriculture Officers, adolescent girls, farm men and women
3	School projects	Schools in Dharwad city and in rural areas of Dharwad district	4	40	High school children and school teachers

Contd...

Table 27 (Contd.)

1	2	3	4	5	6
4.	Lectures				
	a) On-Campus	Dept. of Food Science and Nutrition, College of Rural Home Science, UAS, Dharwad, Directorate of Extension, CIDA project of Dept. of Marketing, UAS, Dharwad	10	325	Assistant Agriculture Officers, scientists from different places, students, trainees from different organizations
	b) Off-Campus	Both rural and urban places of Dharwad, Hubli, Haveri and Hanagal Taluks	25	860	*Mahila Mandal* members, Assistant Agriculture Officers farm men and women, retired people from Hubli and Dharwad, members of Rotary Club, Dharwad
5	Development of educational materials	Finger millet, foxtail millet and little millet based 'recipe book', in local language	1	1500 copies	Distributed to College Principals, school teachers, trainees, and special invitees from different institutions
		Folder on nutritional significance and method of preparation of finger millet malt in local language	1	2000 copies	
6	Cooking competitions	Dharwad city and project villages	5	125	*Mahila Mandal* members, rural house wives and adolescent girls

11. Impact of the project

The implementation this project has created a good impact on the farming communities, entrepreneurs and other users to a great extent and enhanced awareness about the importance and use of different millet species for better nutrition, health and income generation. The impacts created by different training programmes and awareness campaigns organized for the participants and women self entrepreneurs are as follows:

11.1. Impact on trainees

- Majority of trainees were not aware about the value addition of small millets and its usefulness in the preparation of traditional products of standard quality. The training created the needed awareness and they were convinced to include millets in their regular diet.

- Only 50% trainees knew that small millets have medicinal value and are good for health but the training provided an opportunity to all of them to know about the usefulness of small millets for better nutrition and health.
- The trainees felt that promotion of millet based products, viz., snacks, health foods and bakery products have great potential for cottage industry at local national markets.
- Trainees perceived that value added products of millets were viable technologies for income generation to rural community.

11.2. Impact on women self entrepreneurial activities

- The women entrepreneurs from Orissa and Hulkoti started generating income from the sale of value added millet based *besan laddu* and *chakli.*
- Trainees from Mugad village started entrepreneurial activity through selling of polished grains of small millets to the Diabetic Centers in Dharwad.
- Trainees from Hulkoti and Bakery Centre, UAS, Dharwad started generating income from bakery products.
- The staff of the canteen at University of Agricultural Sciences (UAS), Dharwad who received training under the project started selling millet based products on consumer demand

11.3. Impact of awareness campaign

The awareness campaigns improved the market structure with respect to availability of grains of small millets in retail shops, other than in weekly *mandis* (markets) and majority of persons suffering from diabetes, cardiovascular diseases and obesity started increasingly accepting millet grains as healthy staple food in the management of these diseases.

12. Recommendations

- The ethnic foods were highly acceptable for their taste and texture and there is a need to explore these qualities for value addition and designing processing equipments at cottage industries for better exploitation of their market potential. About fifty Indian traditional recipes of major cereals, viz., wheat, rice and pulses, prepared by replacing 25-100% with small millet grains were found highly acceptable.
- Promotion of indigenous and value added products through different communication and awareness programmes enhanced the consumers' knowledge and readiness to incorporate small millet foods in the daily diet.
- Development of diversified value added products and their efficient utilization must receive a greater attention towards economic benefits and these aspects need to be promoted. There is a need to promote value added products to meet the needs of the community through ready-to-eat convenient and nutritious breakfast food.

- Nutritionally and functionally superior millets with nutraceutical properties are highly suitable in the development of therapeutic foods to cope up with the problem of metabolic disorders that are emerging increasingly in the urban population. In the age of nutritional awareness and health consciousness, promotion of health foods at national and international levels may open up new avenues for the wide spread utilization of minor millets and create a sense of security in the needy and ailing populace and hence concerted research and development efforts on these nutritious millets need to be undertaken in order to exploit their full potential.
- The prevailing traditions and culture had preserved the significance of small millets by preparing compulsorily their recipes on festivals and other special occasions. Ethnic foods have excellent taste, crispy texture, light and fluffy characters, superior textural quality of cooked starch and blends well with milk and milk products and are highly acceptable for taste and texture by both rural and urban consumers. Thus, there is a great need for documenting information on ethnic foods and their utilization.
- There is a need to make the traditional systems more productive and competitive on sustainable basis using modern concept of cropping system and nutrient management approach. This aspect needs to be paid greater attention in the national research and development agenda in order to develop improved cultivation technology for enhance grain production.
- There is a need to take a look at the foods people in India are eating from cereals to breads and consider what can be done to encourage whole grain consumption. At the same time, there is also a need to develop appropriately processed whole grain products that meet consumers' needs and tastes

13. Publications

Based on the work done under the project, the following scientific papers and educational materials were brought out:

13.1. Scientific papers

1. Yenagi N.B. 2004. Value adding strategies for conservation and sustainable use of indigenous minor millets. Presented at First National Convention on "Science and Tradition of Food-India's Heritage of 5,000 Years, organized by Academy of Sanskrit Research Melkote, India, and CFTRI, Mysore. 25–27 July, 2004. P. 80
2. Yenagi N.B. 2004. Ragi malt. Krishik Bhandhu (Kannada language), September 2004, P. 31.
3. Yenagi N.B. 2004. Importance of millets and their use in daily consumption. Krishik Bhandhu (Kannada language), December 2004, Pp. 45-46.
4. Yenagi N.B. and Shakuntala Masur. 2004. Development of micronutrient

enriched millet based breakfast muffins. Scientific programme, abstracts of talks and abstracts of posters, Nutrition Society of India, Annual Meeting, 5-6 November, 2004. P. 119.
5. Yenagi N.B. and Shakuntala Masur. 2004. Effect of incorporation of millet four on nutritional, functional and sensory qualities of biscuit. Scientific programme abstracts of talks and abstracts of poster, Nutrition Society of India, Annual Meeting, 5-6 November, 2004. P. 120.
6. Yenagi N.B., Usha Malgi, G.S. Shanthkumar and S.A. Patil. 2004. Promotion of value added minor millet products to enhance the contribution to food security and incomes of the rural poor. Scientific programme, abstracts of talks and abstracts of posters, Nutrition Society of India, Annual Meeting, 5-6 November, 2004. P. 74.
7. Yenagi N.B. and Shakuntala Masur. 2005. Effect of incorporation of millet flour on nutritional, functional and sensory qualities of biscuits, Wheat Update IV (1): 38-41.

13.2. Educational materials

1. Yenagi N.B. 2002. Ragi, foxtail and little millet based recipe book (Kannada language). University of Agricultural Sciences, Dharwad. 18 p.
2. Yenagi N.B. 2002. Ragi, foxtail and little millet based recipe book (Kannada language). Second Edition. University of Agricultural Sciences, Dharwad. 56 p.
3. Nirmala Yenagi and G. Shanthakumar. 2004. Training course manual on popularization of value added products of neglected and nutritious millets (Kannada language). 22 p.
4. Nirmala Yenagi. 2004. Manual on farmers' training programme on value addition to millets (Kannada language). 24 p.
5. Nirmala Yenagi and Shakuntala Masur. 2004. Training course manual on millets in bakery industries (Kannada language). 10 p.
6. Folder on nutritional significance and method of preparation of ragi malt (Kannada language). University of Agricultural Sciences, Dharwad. 1 p.
7. Folder on nutritional and processing significance of millet (Kannada language). University of Agricultural Sciences, Dharwad. 1 p.

14. Acknowledgements

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Yenagi N.B., U. Malgi, G.S. Shanthkumar and S.A. Patil. 2004. Promotion of value added minor millet products to enhance the contribution to food security and incomes of the rural poor. Scientific programme, abstracts of talks and abstracts of posters, Nutrition Society of India, Annual meeting 5-6 November, 2004. Page No. 74.

Yenagi N.B. and S. Masur. 2004a. Effect of incorporation of millet flour on nutritional, functional and sensory qualities of biscuit. Scientific programme abstracts of talks and abstracts of poster, Nutrition Society of India, Annual meet, 5-6 November, 2004. Page No. 120.

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Yenagi N.B. and S. Masur. 2005. Effect of incorporation of millet flour on nutritional, functional and sensory qualities of biscuits, Wheat Update IV (1): 38-41.

Food Security and Income Generation of Rural People through the Cultivation of Finger Millet in Nepal

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1. Introduction

Finger millet (*Eleusine coracana*) is the fourth cereal crop in Nepal in terms of acreage and production after rice, maize and wheat (ABPSD, 2004) and is one of the most important mandate crops of Hill Crops Research Programme (HCRP, 2003). It is a cheap and widely accessible source of food for the poor people dwelling in remote hilly regions of the country and a good income generation crop for the extremely poor farmers. It occupied 7.73% area and contributed 3.66% of the total cereal production of the country during 2003-04. The crop is relayed with maize under mid-hill environment of eastern and central parts of the country, while it is grown under mono-culture in western region possibly due to the differences in rainfall pattern and irrigation facilities. The grain is mainly consumed in the form of porridge and bread but a major part of the produce is utilized for preparing the beverages. Consumption of the grain is considered good for the people suffering from blood pressure, heart diseases, and type II diabetes and is also useful for the development of bone and teeth in children. Although the crop plays a vital role in food security and also in nutritional security, being a rich source of calcium (Ca) and iron (Fe), it is still considered as a low status food in the society in Nepal. In order to address some of these issues and mobilize greater benefits to the Nepalese resource poor farmers, a project "Enhancing the Contribution of Neglected and Underutilized Species to Food Security and to Incomes of the Rural Poor" supported by the International Fund for Agricultural Development (IFAD) was successfully implemented during the period 2002-2004.

2. Objectives

The project had the following main objectives:

- To utilize the potential of finger millet genetic resources through development oriented research, which contributes to enhance the income and strengthen the food security of small farmers
- To change peoples' perception of the crop through the development of novel value added products of millets and thus contribute to its wider acceptance by the society
- To raise awareness among the people about the importance and diverse uses of the crop, including the industrial applications such as the production of alcohol for licensed use and production of new types of beverages of non-alcoholic nature

3. Geographic distribution and trends in area, production and productivity

3.1. Distribution of finger millet in Nepal

Finger millet is reported to be cultivated in 259,130 ha in Nepal and producing 282,860 tons of grain with the productivity of 10.92 q/ha (ABPSD, 2004). It is evident from Fig. 1 and Fig. 2 that the western development region has the maximum area under finger millet cultivation. Fig. 3 shows that the crop is grown in the maximum area (76.0%) under mid-hill environment of the country.

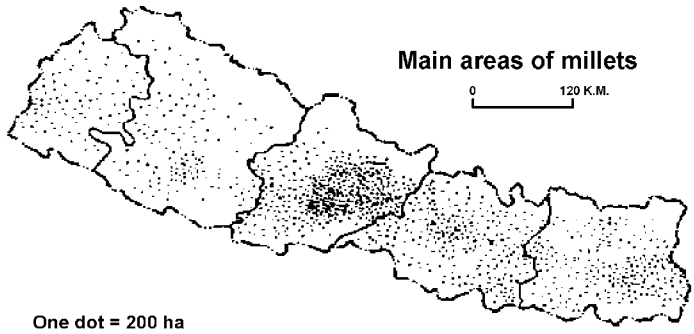
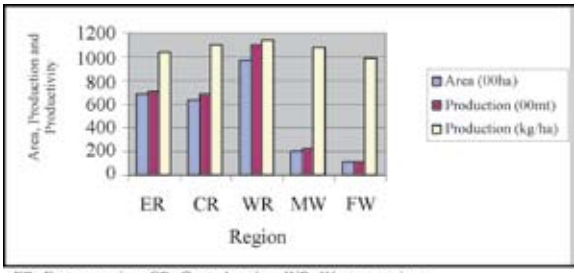


Fig. 1. Distribution of finger millet in Nepal



ER: Eastern region; CR: Central region; WR: Western region; MW: Mid-wester region; FW: Far-western region

Fig. 2. Region-wise area, production and productivity in Nepal (2002-03)

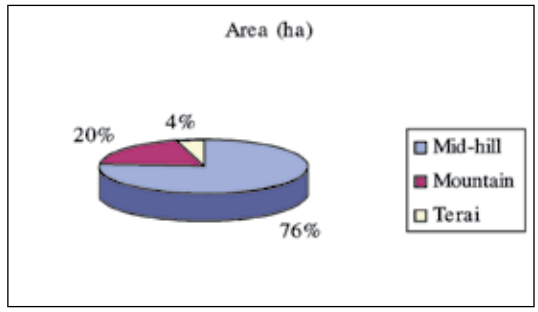


Fig. 3. Finger millet cultivation in different physiographic regions of Nepal (2002-03)

3.2. Trends in area, production and productivity of finger millet

The trends in area, production and productivity of finger millet since 1998-99 are depicted in Fig. 4. The data revealed no significant change in the area, production and productivity of finger millet during the period 1998-99 to 2002-03.

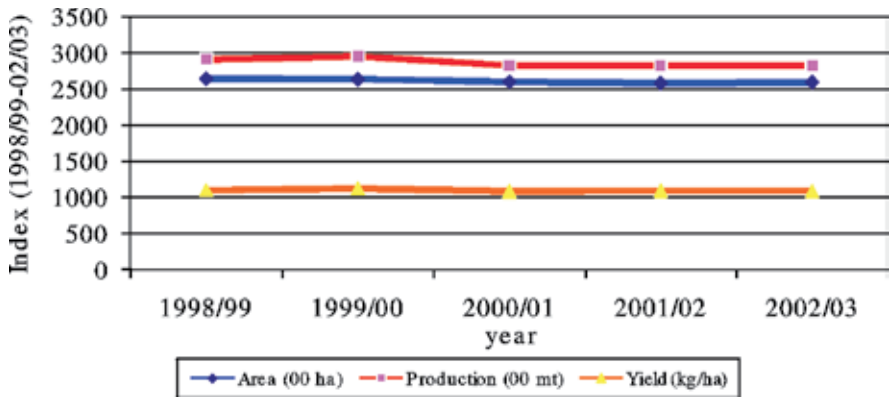


Fig. 4. Trends in finger millet area, production and productivity from 1998-99 to 2002-03

4. Project sites and agencies involved

4.1. Project sites

The project was implemented by the Nepal Agricultural Research Council (NARC) in collaboration with the NGO "Local Initiatives for Biodiversity Research and Development" (LI-BIRD), Pokhara. NARC implemented the project activities at three sites:

- Tallo Pipaltar Village Development Committee (VDC), Nuwakot district
- Khanigaun Village Development Committee, Nuwakot district
- Kabre Village Development Committee, Dolakha district

4.2. Agencies involved in implementing the project

The following agencies/communities were involved in implementing the project at target sites:

- Hill Crops Research Programme (HCRP), Kabre, Dolakha under Nepal Agricultural Research Council (NARC)
- Local Initiatives for Biodiversity Research and Development (LI-BIRD), Pokhara
- Agriculture Development Office (ADO) under Department of Agriculture and Cooperatives
- Department of Food Technology and Quality Control under His Majesty's Government of Nepal
- UN supported Micro-enterprise Development Project (MEDEP)
- Cooperative farmers
- Micro-entrepreneurs
- Bakery producers
- Various Disciplinary Divisions under NARC:
  - Division of Engineering
  - Division of Botany

- Division of Soil Science
- Division of Outreach Research
- Post Harvest Technology Unit

5. Socioeconomic studies and documentation of traditional knowledge

5.1. Resource mapping of finger millet growing project sites

Based on the discussions held among the HCRP/LI-BIRD scientists involved in finger millet research, geographic information services (GIS) personnel and soil scientists, a strategy was developed regarding the type of information to be collected and the working methodology to be adopted by the project in Nepal. The available maps related to project sites were collected. The Village Development Committee (VDC) maps with ward boundary were the basic requirements for mapping the resources available in the wards. Digital maps of the respective project sites were also collected. A group of knowledgeable farmers from each project site was visited, informed about the purpose of the project, provided with the maps of the ward of the respective sites and requested to indicate the distribution of their crops on the maps. All of these maps prepared in consultation with farmers were then converted into digital maps with GIS software. All the information was also put in a common database. The details of resource mapping of Khanigaun VDC and Pipaltar, Bidur Municipality are given below:

5.1.1. Khanigaun Village Development Committee

Land use: Forest, agriculture and pasture were the main land uses in the site (Fig. 5). About 50-60% of the total area was under forest in both wards of the VDC. Agricultural area was further grouped into two main groups; a) *khet* (lowland) and b) *bari* (upland). Most of the area was under *bari* land (upland) ranging from 70-90% of the total area. A limited area was under *khet* (lowland) concentrated mainly near the riverbanks.

Soil: The soils were shallow to deep, somewhat excessively drained to well drained. Black and red soils were common in both wards. In the eastern side of both wards, the soils were black and the rest were red soils. Soils were sandy loam to silt loam ranging within steep to very steep slopes. Soil reaction was slightly acidic. Most of the soils were of poor quality in grazed grasslands and forest lands.

Agriculture: In lowland area, rice (*Oryza sativa)*, wheat (*Triticum aestivum*), and potato (*Solanum tuberosum*) were the main crops and rice-wheat and rice-potato were the major cropping systems. In upland area, maize (*Zea mays*) finger millet (*Eleusine coracana*) and sesame (*Sesamum indicum*) were the main crops with maize-millet, and maize-sesame as the major cropping systems. The varieties of finger millet, namely, Mudke, Paheli, Bhursi and Chaure were common in both wards. The variety Mudke was more common in black soil, while Bhursi was common in red soil. The grain yield of finger millet varied from 17.6-22.7 q/ha in red soil and 25.2-30.2 q/ha in black soil. The cropping patterns used in both soils were as follows:

Bari land (Upland)

Red soil	Maize - sesame
Black soil	Maize - finger millet

Khet land (Lowland)

Red soil	Rice - wheat
Black soil	Rice - potato

Ethnicity: In both wards, *Magar* had its dominance over other ethnic groups. More than two third of the total ethnic community was *Magar* followed by *Ghale, Chhetri, Brahmin* and other lower castes. Being dominated by the *Matwali* ethnic group in which the alcohol was permitted in their culture in the study area, more than 80% of the total finger millet was consumed for making alcoholic products for home consumption and selling purpose and only 20% was used for consumption as food. Finger millet was used for food only during winter season (*Mangsir-Magh*; November-February).

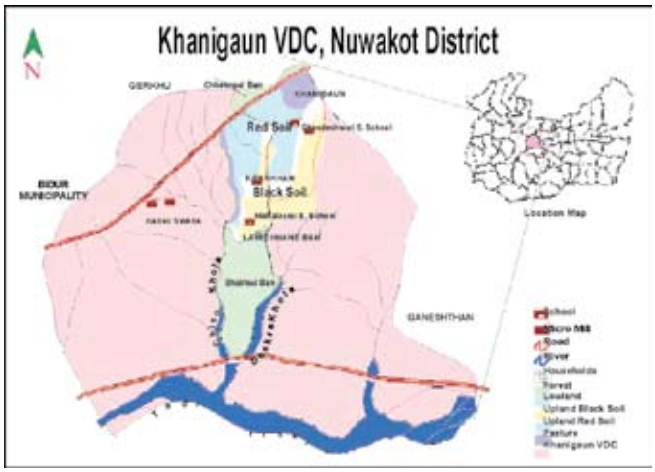


Fig. 5. Resource map of Khanigaun, Nuwakot

5.1.2. Pipaltar, Bidur Municipality

Land use: Forest and agriculture were the main land uses in the site (Fig. 6). Most of the agricultural land was under *bari* land (upland). *Khet* land (lowland) was mainly along the river basin of Trishuli and Tadi River in western and southern parts of the Ward No.7. Most of the area in this site was a somewhat flat terrain.

Soil: As in Khanigaun VDC, the soils were mostly black and red. The road to Kathmandu passing almost through the middle divided the Ward 7 into two distinct soil groups, black soil on the west side of the road and red soil on the east side of the road. The red soils were somewhat light textured (sandy and silt loam) and were drier than black soils which were clayey in nature and held more soil water. The soils were deep, well drained and slightly acidic.

Agriculture: Rice, wheat and *tori* (ridge gourd, smooth gourd) were commonly grown in *khet* land. Maize, millet, black gram, soybean and sesame were the major crops of *bari* land. The finger millet varieties in the ward were the same in different soil types. Rice-wheat, rice-*tori* were the common cropping systems in lowland, while maize-finger millet, maize-pulse and maize-sesame were common in the upland. Sesame was grown only in red soils.

Ethnicity: The ethnic groups in Tallo Pipaltar (west of Kathmandu road) were *Kumal*, *Majhi* and *Newar* belonging to *Matwali* ethnicity, while in Pipaltar, it was a mixed ethnic community comprising of *Brahmin, Kumal* and others. The preferences of these ethnic communities were clearly reflected on crops and their consumption pattern. The ethnic group in Tallo Pipaltar preferred finger millet for making alcoholic products, while ethnic group in Pipaltar preferred sesame which was a cash crop.

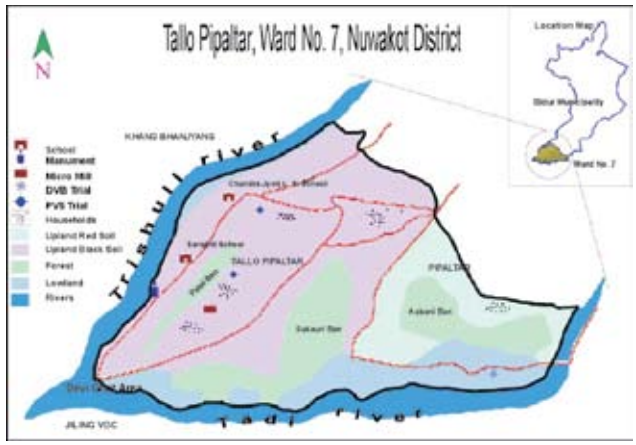


Fig. 6. Resource map of Pipaltar, Nuwakot

5.2. Finger millet production and utilization

5.2.1. A case study of Pipaltar

A case study of Pipaltar VDC in Nuwakot district was undertaken in order to study the finger millet production and utilization aspects. A total of 80 households were settled in cluster pattern in Pipaltar of Bidur municipality of which 46 households (40%) were included in the study. The samples were taken in the same proportion from two different ethnic groups. Structured questionnaire was used to undertake the household survey and a simple open checklist was used for focus group discussions (FGDs).

Demography, socioeconomic and cultural information

In the surveyed households, the population was 343 of which males and females were 174 and 169, respectively. The average family size of *Newar* was 6.6 persons/family, while in *Kumal*, the family size was 7.7 persons/family. It was dominated by *Matawali* ethnicity (80%) and *Brahmin* and *Chhetri* communities were in minority. The average land holding size was 0.64 ha/family.

Contribution of finger millet towards food availability

Almost all the persons interviewed mentioned that the finger millet was inferior quality food. Mudke, Chaure, Ghurasi and Seto Kodo were the commonly grown varieties in the site among which Mudke and Chaure were more popular. About 70% of the people were growing Mudke, while 46% cultivated Chaure (Table 1). According to the data gathered, 41% households were having sufficient food for more than 12 months (Table 2).

Table 1. Grain yield of existing finger millet cultivars

Cultivars	Grain yield by ethnicity (q/ha)		Mean grain yield (q/ha)	Growers (%)
	Newar	*Kumal*		
Mudke	32.06	32.20	32.13	70
Chaure	25.20	30.52	29.26	46
Seto Kodo	-	28.00	28.00	2
Mean	**28.63**	**30.24**	**29.80**	**-**

Source: Field Survey 2003 and 2004

Table 2. Food sufficiency amongst the households

Duration (months)	HHs (No.)	HHs (%)
<3	1	2.2
3-6	5	11
6-9	9	19
9-12	12	26
>12	19	41
Total	**46**	**100**

The survey results indicated that finger millet occupied the third position in terms of contribution (22%) towards total food availability from the food security point of view (Table 3).

Table 3. Contribution of different crops towards food availability in Pipaltar

Food crops	Total production (q)	Contribution (%)
Rice	180.48	28
Maize	301.34	46
Finger millet	140.61	22
Wheat	34.12	4
Total	**656.55**	**100**

Source: Field Survey 2003 and 2004

Land preparation and fertilizer application

Land preparation for finger millet cultivation is difficult when transplanted as a relay crop under maize-finger millet systems but in sequential cropping after maize harvest, it is comparatively easier. The survey indicated that the farmers did not use animal power in land preparation even in maize-finger millet systems. The land preparation was completely done by using human labour. No basal application of manure and fertilizer was done. Top dressing of 65 kg N (141 kg urea)/ha after 3-4 weeks of transplanting was adopted by all the farmers.

Harvesting and post harvest operations

Finger millet crop is ready to be harvested when its ear heads turn brown. The farmers indicated that the ear heads were picked with sickle and stacked in threshing floor or in bamboo *bhakari* for about one month which made threshing easy. During winter, the ear heads were spread on the threshing floor (*khala*) and threshed with a wooden stick. The threshing was mostly done by men, while winnowing was completely done by the women. Storing of finger millet seemed to be easier and more effective than any other food grain because no insect pests were noticed in the storage bins. However, because high moisture content in the grain might damage the seeds during storage, care needs to be taken for choosing the right harvesting time. More than 50% of the farmers reported that the grain was mostly stored in sacks or *bhakari*. Generally, milling was handled by women although, in rare cases, was also done by men. *Ankle*, *janto* (*chakki*) and diesel/electric flour mills were the prevailing milling equipments in the site. *Janto* and *ankle* milled flour was said to be tastier and of longer shelf life than the flour prepared with diesel or electric mills.

Utilization of main product and byproducts

Both the ethnic groups, *Kumal* and *Newar*, used 66% of the millet grain for local beverage production, 28% for food recipes (*dhindo*, *roti*) and the rest for seed and animal feed (6%). Millet byproducts were the good source of animal feed during lean period. Millet straw was highly preferred by the animals either in green state at harvest or after drying. It fetched high market price when sold in early spring season.

Medicinal and cultural value

Consumption of finger millet was reported to be good for the people suffering from heart attack, blood pressure and type II diabetes. Its flour was also used in the treatment of allergic conditions, measles, *ghamaura* (skin disease) and bone fracture. The ethnic group *Kumal* offered the millet recipes to God as an indispensable item during the religious worship in the month of *Magha* (15 January-14 February).

Marketing

The market was very close to the site for buying inputs and selling outputs. Forty one per cent of farmers sold 5-35% of their produce to middle men in the local market at cheaper rate immediately after threshing. According to the survey, this was needed in order to respond to urgent cash need by farmers for meeting their household necessities. This way, they were not in a position to wait for price rises, even though they were aware that the price of millet usually goes high in the rainy season (June-July). In general, the millet grain price was observed to have been decreasing over the years due to lower food value as well as low consumption of local beverage in the local market in the district and also not being used as food or as feed for the livestock.

Cost: benefit analysis

Economic analysis of finger millet cultivation showed a cost: benefit ratio of 1:1.08. Pipaltar is a dry plain area and therefore, the farmers were enforced to grow finger millet because of no other profitable alternatives.

Need of suitable alternatives

Pipaltar is a dry plain area without irrigation facility and for such agro-ecological conditions, no suitable agricultural alternative other than millets had been identified so far. A need was felt to launch nutritional awareness programme through the curriculum for secondary school children. Finger millet is a high labour demanding crop of which 77% is contributed by women farmers. It should be noted that women represent the largest providers of labour within the household and hence, an urgent need was felt to carry out research to reduce the drudgery of women farmers in finger millet cultivation, processing as well as food preparations.

5.2.2. A case study of Khanigaun

A case study was conducted in Khanigaun VDC, Nuwakot district. A total of 170 households were settled in scattered pattern in Khanigaun village of which 44 households (25%) were taken as a representative sample. The sample households were taken in the same proportion from the two ethnic groups. Structured questionnaire was used to run the household survey and a simple open check list was used for focus group discussions (FGDs). A total of thirty farmers participated in the group discussion among which 40% were women. During the discussions, both male and female farmers participated equally.

Socioeconomic and cultural information

Khanigaun area was inhabitated by mixed ethnic groups. Out of total population, 80% were *Matawali* and the rest were *Brahmin* and *Chhetri*. The total population of the sample village was 289 of which 147 were female and 142 were male. The average family size was 6.5 persons per family. Family size of *Brahmin* and *Chhetri* communities was bigger (6.67/family) than *Matawali* community (6.54/ family). Out of total population of Khanigaun, 160 people were economically better. The age and sex- wise population distribution of survey site is presented in Fig 7.

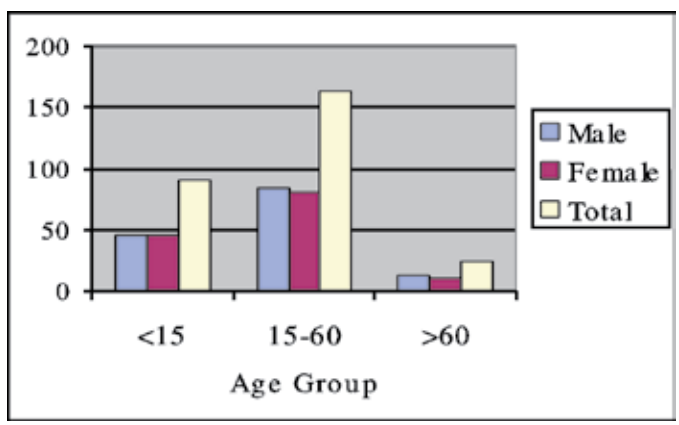


Fig 7. Population distribution of the sample area of Khanigaun based on age and sex

Food sharing, situation and habit

The study indicated that the contribution of finger millet towards food security among the cereals was 30% (Fig. 8). Almost all the persons interviewed mentioned that the finger millet was low quality food. Consumption of finger millet as a food was gradually decreasing, although being largely utilized in preparing local beverages. The rich families did not consume finger millet since long back and the situation seemed to still hold today. Although, the entire mid hill areas of Nepal has food deficit, the situation in Khanigaun VDC was different as 30% people had surplus food and 5% had food available for less than six months (Fig. 9).

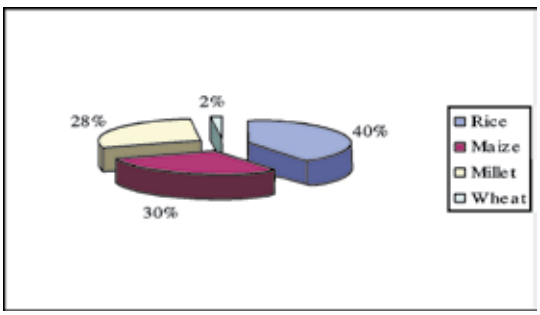


Fig. 8. Contribution of finger millet as staple food as compared to cereals

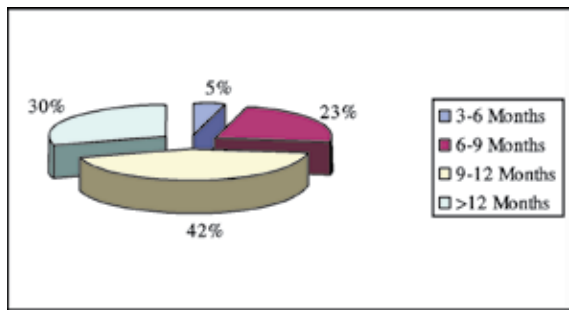


Fig. 9. Per cent of population with various food sufficiency months in Khanigaun

Utilization of main product and byproducts

The high cast people like *Brahmin* and *Chhetri* used about 50% of finger millet grain as animal feed, and the rest of the people used it for food (38%) and beverage production, while people of *Matawali* ethnicity used 60% of production for preparation of local beverage and the rest for other uses such as *dhindo*, *roti* and animal feed (15%). Finger millet, soybean and black gram seeds were crushed and made into a paste for applying on cracked/fractured bones.

Labour supply systems

Family members were the main source of labour and either they do the farm work themselves or exchange labour among the farm families as per the existing practice which is popularly known as "*Parma*" In totality, 79% of labour force was contributed by women in finger millet cultivation.

Marketing

The survey indicated that 30% of the farmers sold their produce in small quantity (5-15%) in the local market at cheaper rate immediately after threshing. This was due to the fact that they needed money quickly to meet their urgent household requirements.

Economic analysis

The cost of cultivation of finger millet was high in Khanigaun because animal power was not used in finger millet cultivation. Human power was more expensive than the animal power. Economic analysis of finger millet cultivation showed that the cost: benefit ratio was 1:1.08 (Table 4).

Table 4. Economic analysis of finger millet cultivation (INR/ha)

Activities	Quantity	Rate (NR)	Total (NR)
Labor input (No.) Male	62	70	4340
Female	225	35	7910
Material inputs (kg/ha)			
Seeds	7.5	35	225
Urea	118	15	1770
Cost of cultivation			14245
Gross production (kg/ha)	1936	8	15488
Net profit			1243
Cost: benefit ratio			**1:1.08**

Source: Field Survey, 2003

Crops and varieties

Rice, maize, finger millet and wheat were the main food grain crops grown in Khanigaun. The most popular varieties of finger millet were Mudke, Chaure, Dalle, Paheli and Bhursi among which Dalle was more popular and grown by 55% of the farmers.

Seed maintenance and management systems

As per the existing practice, the experienced women farmers were assigned the job of selecting the healthy ear heads (*Biu balyaune*) as a source of seed for the following year planting. The head should be true to the type, well matured, big, and free from diseases. Harvested heads were stored after drying otherwise the quality of the seeds might deteriorate. Dried heads are stored as such in the sacs or in bamboo *bhakari*. Threshed seeds were stored in the earthen pots (*gagro, ghayampo*)/*kothari*. This was the age old traditional practice of seed storage for maintaining seed purity and viability.

Gender involvement

For one hectare of millet cultivation, about 361 labour days were required of which 292 (77%) were contributed by women. Usually, the tasks requiring physically hard work (such as land preparation), were performed by men and the lighter jobs performed by women. In spite of the high labour contribution by women, there was disparity in relation to men for labour exchange. In general, two woman labour days

were considered equivalent to one man labour day even for the same work assuming that man does double the work as compared to the women. The wages were also fixed on the same basis and whether in cash or kind, the females always used to get only 50% of that was paid to males for the same working days. This represents obviously a sign of high disparity between men and women, further underscoring the unfair treatment that women still receive as far as their agricultural work is concerned.

Major constraints

Finger millet was used only in traditional recipes like *roti*, porridge (*dhindo*), *khole* and local beverage. It was considered as a non-prestigious food because the rich people never liked it and made a proverb "*Kucharle kuanna khayo, Ku kathale dhapaidena kumanchhe*" meaning thereby "bad man hits the bad bird (with a bad wood) which eats bad grain (finger millet)". This obviously shows a very low status and dignity of the people consuming this grain. Preparation of the local alcoholic beverage is not legal in Nepal but the local culture has contributed to the acceptance of this practice by the society in many regions.

5.3. Survey on local beverage preparation in Nuwakot district

Based on the discussions in a group meeting held at Nepal Agricultural Research Institute (NARI), Khumaltar, a survey methodology was finalized and a questionnaire for the survey of cost: benefit analysis of local beverage production was developed. A purposive method of sampling was applied for the survey in view of the professional processors being small in number, and the beverage being consumed by all the *Matawalese* and other large number of non-*Matawali* communities. Twenty five percent of the total households were taken as a sample representing medium to poor families from the professionally alcohol selling group. Besides this, rest of the information was collected from rich families who prepared alcohol and *jad* (local beverage in a thick liquid form) for home consumption and not for sale.

Local beverage production and quality

Finger millet was considered as a beverage crop rather than food crop in *Matawali* group in Nuwakot district. The farmers expressed that the quality of finger millet beverage was always superior to that of other grains like maize, wheat and rice. Farmers also believed that millet beverage was good for health if consumed in little quantity regularly as a medicine. *Jad* was prepared throughout the year for home consumption and used as a part of daily food in all the *Matawali* community.

Use of landraces in local beverage

During the survey interactions, the farmers reported that the varieties/landraces having sweet taste when used for *roti* and *dhindo* were also found good for beverage production.

Gender involvement in local beverage processing and marketing

More than 90% of the local beverage preparation activities were performed by women. However, pearling was done by both the sexes. The male folk were involved in relatively hard work like collection of firewood. Most of the local beverage preparation activities were performed by using family labour or their close relatives.

Production, consumption and marketing of local beverages

Jad was normally used for home consumption as well as for the farm labour twice a day in both the sites and it was popular among *Matawali* ethnic group. Non-*Matawali* groups also hired the *Matawali* labour for preparing *jad* because it was necessary to offer part of *khaja* (snacks) to the farm labour. *Rakshi* was another type of local beverage, usually prepared for the festivals, weddings and local cultural ceremonies such as *Bratamanda*, *Kulayan Puja*, *Dashain, Tihar, Maghesakranti, Baishakhi Purnima, Jamare Aushi and Mangshire Purnima*. Among the local beverages, only *rakshi* was commonly sold in the local market at cheaper rate ranging from Nepalese rupees (NR) 19-31/litre in Khanigaun and Pipaltar where the market was about 5-7 km away from the site of production.

Contribution of local beverage in household economy

Preparation of local beverage was one of the cash generating off-farm activity within farming household of the *Matawali* ethnic group and thus contributed significantly towards household economy.

Socio-cultural and medicinal value of local beverage

Besides the social and cultural value, 3 *pane rakshi* was used as a medicine for protecting human health against different diseases like rheumatism and diarrhoea. Massage with *rakshi* was reported to give good relief from rheumatic pain.

Economical analysis of local beverage

Economic analysis of local beverages (*rakshi* and *jad*) in Pipaltar and Khanigaun indicated that the overall profit was very low. The cost: benefit ratio in Pipaltar was 1: 1.1 to 1:1.6 whereas in Khanigaun, it was 1: 1.06 to 1:1.53 with the same investment because of price variation of products.

Constraints in local beverage production

The major constraint in alcohol preparation from any grain was the ban imposed by His Majesty's Government of Nepal. Apart from this, there were some socio-economic problems like non-availability of fire wood, costly utensils for alcohol preparation, low price of *rakshi* and limited market in both the sites. Although beverage production was not profitable, it kept the family labour busy rather than

sitting idle. Therefore, an urgent need was felt to explore the new ways of millet consumption in the locality itself or to legalize the quality beverage production from millet in the locality for export to urban areas.

5.4. Market related study of value added products based on finger millet

A key informant survey was conducted in 2004 at the study site in Bidur municipality of Nuwakot district. The information was collected from both the untrained entrepreneurs as well as from the entrepreneurs trained during 2003. A total of five entrepreneurs and one promoter were interviewed using two different sets of structured questionnaires prepared by a group of expert scientists. The results of the survey revealed the following important facts:

- There was a lack of awareness in consumers about finger millet nutrient composition and its usefulness to the people particularly the diabetic patients, pregnant women and growing young children.
- The image of finger millet in the mind of people was of low status food.
- The consumers were not willing to pay the price for finger millet products as high as that for wheat products.
- Baking was difficult due to specific properties of finger millet flour.
- The farmers expressed the need for a suitable provision for assured selling of the value added products.
- There was a need for publicity about the nutritional importance and income generation through millet based products by organizing workshops, trainings, demonstration activities, print media, electronic media like radio, television and website, etc.
- There was a good scope to promote the use of millet based biscuits if enough awareness could be created through appropriate publicity.

5.5. Role of women in finger millet cultivation

The survey conducted in the project site showed 77% labour used in finger millet cultivation was constituted by women. Their work included uprooting seedling, transplanting, threshing and cleaning the grain. They did not take hard work like carrying the compost and ploughing the field. Pearling of the crop was done by both the sexes. Variety selection for cultivation, fixation of selling price and marketing were done with the participation of both sexes. Cooking the harvested crop was done by women More than 90% of the locally beverage preparation activities were performed by women. Selling of locally made liquor and fixing of its price were done by women. The establishment of a micro-mill in each project site reduced the drudgery of female farmers for making the millet flour. Development of threshing machine and modification of pearling machine by the Engineering Division of NARC also proved to be very helpful to the female farmers.

6. Genetic resources, evaluation and selection

6.1. Finger millet genotypes and their characteristics

A total of 257 genotypes including varieties/accessions/landraces of finger millet were assembled from different sources including international organizations and were evaluated in different experiments at Hill Crops Research Programme Kabre, Pipaltar, and Khanigaun during 2002-04.These varieties/landraces showed a wide range of variation for different traits, namely, grain yield, plant height, maturity duration, head type, disease incidence and phenotypic acceptance. Some of them were *in situ* collections. Two genotypes, viz. Acc. 523-1 and GPU 25 were selected and proposed for release as new finger millet varieties for the purpose of general cultivation under foot-hills and mid- hills. Some landraces such as Mabire, Paheli, Mudke, Seto Jhyape, Chamre and Chaure were selected for use in the yield experiments. A few of them including released variety Kabre Kodo 1 might be recommended for cultivation under farmers' conditions and could be used in hybridization programme to develop new finger millet varieties. The above mentioned genotypes are still under cultivation in the project sites and performing well.

6.2. Varietal evaluation

Fourteen finger millet genotypes acquired from the international organizations were evaluated to identify the sources of resistance to blast and *Cercospora* leaf spot disease under field conditions at Hill Crops Research Programme (HCRP), Kabre and

Table 5. Evaluation of finger millet genotypes for disease resistance

S. No.	Genotypes	Blast disease score (0-9 scale)				CLS score (0-9 scale)	
		Kabre		Malepatan		Kabre	Malepatan
		FB	NB	FB	NB		
1	Acc.6389	4	5	-	-	5	9
2	Acc.6554	1	0	1	0	8	4
3	Acc.6436	1	1	0	1	7	9
4	Acc.6489	1	5	-	-	3	3
5	Acc.6355	2	5	-	-	8	6
6	Acc.6575	1	1	1	1	4	4
7	Acc.6426	0	0	2	1	2	2
8	Acc.6529	2	0	0	2	2	1
9	Acc.6602	1	2	0	0	5	1
10	Acc.6571	1	2	1	2	6	7
11	Acc.6552	1	0	0	0	5	6
12	Acc.6416	1	2	1	2	5	5
13	Acc.6456	1	3	2	1	5	3
14	Acc.6373	1	5	1	1	7	6

FB-Finger blast; NB-Neck blast; CLS-*Cercospora* leaf spot

Agricultural Research Station (ARS), Malepatan. It was observed that millet cultivars such as Acc.6554, Acc.6436, Acc.6575 and Acc.6552 showed fairly high resistance to blast (Table 5), while they exhibited moderate to high susceptibility to *Cercospora* leaf spot (CLS). Three finger millet genotypes, namely, Acc.6489, Acc.6426 and Acc. 6529 were found moderately resistant to CLS. It was noted that the genotypes resistant to finger blast were different than those resistant to *Cercospora* leaf spot indicating thereby a very low possibility of getting the material possessing multi-disease resistance.

6.3. Testing of finger millet landraces by the local community

A total of 18 local landraces of finger millet collected from Kaski and Nuwakot sites including Kabre Kodo 1 as a standard check were tested at Pipaltar, while 17 local landraces were tested at Khanigaun site of Nuwakot district in the growing

Table 6. Performance of finger millet landraces evaluated in diversity block at Pipaltar, Nuwakot (2003).

S. No.	Name of cultivars	Days to 50% flowering	Days to 75% maturity	Plant height (cm)	Plant stand /m^2	No. of fingers /head	Grain yield (q/ha)
1	Seto Jhyape	90.0	128.0	112.0	100	6	11.44
2	Seto Kodo	90.0	128.0	92.0	72	7	14.96
3	Kalo Jhyape	82.0	120.0	76.0	86	6	15.84
4	Seto Dalle	85.0	123.0	107.0	74	8	15.40
5	Kukurkane	85.0	123.0	100.0	58	7	17.60
6	Dalle Kodo	86.0	124.0	96.0	62	8	18.04
7	Mudke Kodo 1	85.0	123.0	104.0	88	7	16.72
8	Paheli Kodo	91.0	129.0	101.0	64	8	24.20
9	Paheli Mudke	91.0	129.0	105.0	82	7	16.72
10	Chamre Kodo	85.0	123.0	102.0	80	7	18.04
11	Kabre Kodo 1	83.0	121.0	95.0	76	6	16.94
12	Jalbire Kodo	91.0	129.0	110.0	82	8	18.92
13	Mudke Kodo 2	78.0	116.0	110.0	100	8	20.24
14	Chaure Kodo	85.0	123.0	104.0	88	7	19.80
15	Mudke Kodo 3	91.0	126.0	98.0	106	7	22.00
16	Chittwane Local	85.0	123.0	100.0	102	8	18.48
17	Kalo Dalle	88.0	126.0	107.0	96	7	18.04
18	Local Check	87.0	125.0	114.0	96	9	17.82
	Mean	86.5	124.3	101.8	84	7	17.84
	Maximum	91.0	129.0	114.0	106	9	24.20
	Minimum	78.0	116.0	76.0	58	6	11.44
	SD	3.6	3.5	8.8	14.4	0.8	278.26

seasons of 2003 and 2004. Each genotype was planted in 2 rows, each of 2 m length, following the farmers' management practices.

Among these genotypes, Paheli Kodo produced the highest grain yield (24.20 q/ha) followed by Mudke Kodo 3 (22.00 q/ha) at Pipaltar (Table 6), while Seto Jhyape was the highest yielder (43.50 q/ha) followed by Paheli Mudke (37.40 q/ha) and Kalo Jhyape (36.90 q/ha) at Khanigaun in 2003 (Table 7). The variety Paheli Mudke produced the highest grain yield of 26.25 q/ha followed by Chitwane (23.75 q/ha) and Chamre Kodo (23.75 q/ha) at Khanigaun (Table 8), Seto Jhyape produced the highest grain yield (24.00 q/ha) followed by Chaure (21.00 q/ha) and Mudke (21.00 q/ha) at Pipaltar, while Kabre Kodo 1 was the highest grain yielder (30.00 q/ha) followed by Seto Jhaype (28.33 q/ha) at Kabre. These varieties should be promoted for wider use. The incidence of *Cercospora* leaf spot

Table 7. Performance of finger millet landraces evaluated in diversity block at Khanigaun, Nuwakot (2003)

S. No.	Name of cultivars	Plant vigour	No. of fingers/ head	Head type	Plant height (cm)	Days to maturity	Grain yield (q/ha)
1	Seto Jhyape	3	5	Open	100	Late	43.50
2	Seto Kodo	2	6	Open	120	Medium	35.20
3	Kalo Jhyape	2	7	Open	136	Medium	36.90
4	Seto Dalle	4	7	Open	145	Late	26.80
5	Kukurkane	4	7	Open	119	Late	31.20
6	Dalle Kodo	4	8	Close	120	Medium	26.40
7	Mudke Kodo 1	4	9	Close	121	Medium	34.30
8	Paheli Kodo	3	8	Open	109	Medium	29.70
9	Paheli Mudke	2	6	Open	113	Early	37.40
10	Chamre/Chaure	3	7	Open	125	Early	29.70
11	Jalbire Kodo	1	9	Open	126	Early	24.20
12	Mudke Kodo 2	3	6	Close	108	Early	29.70
13	Chaure Kodo	4	7	Close	116	Medium	8.80
14	Mudke Kodo 3	3	8	Close	110	Medium	15.80
15	Seto Kodo	3	8	Close	126	Medium	9.90
16	Mabire Dalle	2	7	Close	91	Early	22.00
17	Kabre Kodo-1 (Check)	1	7	Open	138	Medium	30.80
	Maximum		9		145		43.50
	Minimum		5		91		8.80
	Mean		7		119		27.70

Plant vigour: 1. Excellent, 2. Good, 3. Fair, 4. Poor; Plant height: Dwarf <100 cm, Medium 100-110 cm and Tall >110 cm; Maturity: Early <115 days, Medium 116-130 days, and Late >130 days.

(CLS) was observed at Kabre which indicated that the disease does not appear at lower altitudes and therefore finger millet cultivars susceptible to CLS might be recommended for lower altitudes. The severity of finger blast was observed very low at all the locations.

Table 8. Comparative performance of finger millet landraces evaluated in diversity block at Pipaltar, Khanigaun and Kabre (2004)

S. No.	Genotypes	Pipaltar			Khanigaun			Kabre			
		Grain yield (q/ha)	FB (0-9)	Maturity status	Grain yield (q/ha)	FB (0-9)	Maturity (Days)	Grain yield (q/ha)	FB (0-9)	CLS (0-9)	Maturity (Days)
1	Seto Kodo	10.00	1	ML	20.00	0	145	11.67	1	6	180
2	Seto Dalle	16.00	1	ML	22.50	2	144	16.67	1	3	175
3	Kalo Dalle	13.00	2	L	-	-	-	20.00	1	2	172
4	Kalo Jhyape	20.00	1	L	15.0	2	136	26.67	1	4	173
5	Mudke Kodo	21.00	1	ML	21.25	1	136	23.33	1	4	170
6	Paheli Kodo	13.00	1	ML	15.00	1	135	13.33	1	3	172
7	Chamre Kodo	12.00	1	ML	23.75	1	136	20.00	1	2	181
8	Paheli Mudke	10.00	1	ML	26.25	1	143	21.67	1	3	181
9	Kukurkane	13.00	1	L	12.25	0	142	15.00	1	1	151
10	Chaure Kodo	21.00	1	M	22.50	1	145	20.00	1	2	180
11	Chitwane	20.00	1	M	23.75	0	150	18.33	1	2	150
12	Jalbire	19.00	1	M	21.25	1	148	16.67	1	1	151
13	Seto Jhyape	24.00	1	L	20.00	1	146	28.33	1	1	148
14	Kabre Kado	12.00	1	M	18.75	1	142	30.00	1	4	145
15	Paheli	6.00	1	M	17.50	1	139	17.50	1	4	151
16	Dalle	6.00	1	M	16.25	1	138	23.33	1	3	181
17	Farmers' local	13.00	1	M	20.00	1	138	21.66	1	2	151

FB-Finger blast; CLS-*Cercospora* leaf spot; L-Late; M-Medium; ML-Medium late

6.4. Participatory variety selection

Six millet cultivars including the check were evaluated in a randomized complete block design (RCBD) at Pipaltar and Khanigaun of Nuwakot district and Kabre of Dolakha district in which same genotypes were included at Khanigaun and Kabre, while two genotypes were different in the set of varieties tested at Pipaltar in 2003 and 2004. The plot size was 9 m^2 with the inter-row spacing of 10 cm and inter-plant spacing of 10 cm. The chemical fertilizers were applied at the rate of 45:30:30 NPK kg/ha. The seed rate used was 10 kg/ha and the observations on grain yield and yield contributing characters were recorded. The evaluation of millet genotypes was done with the participation of farmers for preference ranking for the important

characters and the number of farmers involved for each character was the same. Statistical analysis was done using statistical tool for data analysis (MSTATC) and Duncan's multiple range test (DMRT).

The data on varieties tested under participatory variety selection (PVS) revealed that there were no significant differences in the grain yield of different cultivars (Tables 9-13). However, the highest grain yield was produced by GE 5176 at Pipaltar in 2003, Local Mudke at Pipaltar in 2004, Mabire Dall Local at Khanigaun in 2003, Acc.523-1 at Khanigaun in 2004 and Acc.523-1 at Kabre in 2004.

Table 9. Performance of finger millet genotypes evaluated in PVS at Pipaltar (2003)

S. No.	Genotypes	Days to 50% flowering	Days to 75% maturity	Plant height (cm)	Plant stand/m²	Fingers/ head	Grain yield (q/ha)
1	Kabre Kodo 1	95	130	100.6	72	6	16.67
2	GPU 25	91	126	101.2	71	6	16.25
3	GE 5176	95	130	124.0	78	7	17.08
4	GE 122	94	130	124.0	79	6	15.42
5	Acc.523-1	100	134	113.9	78	7	14.58
6	Mudke Kodo	101	134	104.5	96	9	16.25
	Mean	96.0	130.7	111.4	79.0	6.8	16.04
	CV%	1.21	0.66	20.0	10.03	16.38	4.5
	F test	**	**	NS	NS	NS	NS

Table 10. Performance of finger millet genotypes evaluated in PVS at Pipaltar (2004)

S. No.	Genotypes	Grain yield (q/ha)	Days to 75% maturity	Plant stand /m²	Inflorescences or heads/m²	Plant height (cm)	Fingers /head
1	Kabre Kodo 1	26.50	130	91	91	124	5.9
2	GPU 25	27.83	130	101	101	96	6.4
3	GE 5176	25.56	133	98	101	106	6.5
4	GE 122	22.56	126	99	100	114	5.6
5	Acc. 523-1	23.28	128	99	99	111	6.0
6	Local Mudke	28.28	126	101	102	114	7.4
	Mean	25.67	128.8	98.2	99.0	110.8	6.3
	F- Test	NS	**	NS	NS	**	NS
	CV	18.34	1.99	12.63	11.6	5.95	11.8
	LSD 0.05%	709	3.85	18.6	17.28	9.9	1.1

Based on the preference ranking with the participation of farmers of both sexes, several varieties were selected on the basis of their performance for different characters

Table 11. Performance of finger millet genotypes evaluated in PVS at Khanigaun (2003)

S. No.	Genotype	Head type	Inflorescences or heads/m^2	Plant height (cm)	Fingers/ head	Days to maturity	Grain yield (q/ha)
1	Okhale 1	Open	90	109	6.6	125	22.10
2	GPU 25	Semi- fist	86	100	6.8	115	17.20
3	GE 5176	Open	156	109	6.6	141	19.70
4	GE 122	Fist	105	110	7.4	143	18.10
5	Acc.523-1	Open	102	107	7.5	138	25.70
6	Mabire Dall Local	Open	120	105	7.6	146	30.50
	Maximum		156	110	7.6	146	30.50
	Minimum		86	100	6.6	115	17.20
	Mean		109.8	106.7	7.1	134.7	22.22

Table 12. Performance of finger millet genotypes evaluated in PVS at Khanigaun (2004)

S. No.	Genotypes	Grain yield (q/ha)	Days to 75% maturity	Plant stand /m^2	Inflorescences or heads/m^2	Plant height (cm)	Fingers /head
1	Okhale 1	26.17	147	91	95	118	6.6
2	GPU 25	29.79	142	91	94	105	6.2
3	GE 5176	20.73	140	101	105	106	6.2
4	GE 122	29.29	145	95	98	116	6.0
5	Acc. 523-1	31.31	149	94	97	117	6.4
6	Local	27.03	149	93	101	111	6.2
	Mean	27.39	145.3	94.2	98.3	112.2	6.3
	F- Test	NS	**	NS	NS	NS	NS
	CV	25.78	2.1	14.4	16.4	9.9	9.67
	LSD 0.05%	1064	4.6	20.5	24.3	16.7	0.924

Table 13. Performance of finger millet genotypes evaluated in PVS at Kabre (2004)

S. No.	Genotypes	Grain yield (q/ha)	Days to 75% maturity	Plant stand /m^2	Inflorescences or heads/m^2	Plant height (cm)	Fingers /head
1	Okhale 1	11.94	148	124	140	81	5.4
2	GPU 25	17.78	143	125	134	70	4.4
3	GE 5176	22.44	138	112	123	78	5.5
4	GE 122	17.89	149	130	140	83	5.0
5	Acc. 523-1	22.83	147	128	135	77	4.8
6	Local	17.67	147	127	138	78	5.3
	Mean	18.42	145.3	124.3	135.0	77.8	5.1
	F- Test	NS	NS	NS	NS	NS	NS
	CV	22.55	3.8	11.01	19.41	14.17	12.9
	LSD 0.05%	672	8.4	20.6	39.5	16.7	1.0

(Tables 14-16). However, GE 5176 was selected as an early maturing genotype at Pipaltar, while Acc.523-1 and GPU 25 were selected based on grain yield and other characters for the purpose of recommendation as new finger millet varieties. The experiment indicated that the excellent local cultivars should also be considered for cultivation and their use by farmers be promoted.

Table 14. Preference ranking of finger millet genotypes evaluated in PVS at Khanigaun (2004)

Characters	Okhale1	GPU 25	GE 5176	GE 122	Acc.523-1	Local
Grain yield	8	10	11	11	6	4
Days to maturity	7	5	4	7	12	12
Plant height	9	3	4	5	8	9
Diseases	6	9	9	9	3	3
Overall acceptability	5	10	9	14	6	4

Table 15. Preference ranking of finger millet genotypes evaluated in PVS at Pipaltar (2004)

Characters	Kabre1	GPU 25	GE 5177	GE 122	Acc. 523-1	Local
Grain yield	13	10	13	18	14	6
Days to maturity	12	13	18	14	9	6
Plant height	10	4	9	9	6	7
Overall acceptability	11	10	17	17	16	4

Table 16. Preference ranking of finger millet genotypes evaluated in PVS at Kabre (2004)

Characters	Okhale 1	GPU 25	GE 5176	GE 122	Acc.523-1	Local
Grain yield	12	6	7	8	6	9
Days to maturity	11	7	8	9	8	7
Plant height	7	8	6	9	6	6
Overall acceptability	6	9	10	16	7	8

6.5. Setting- up local seed supply system

Considering the importance of quality seeds for enhancing grain yield, the seed production of improved varieties/landraces was undertaken at Khanigaun and Pipaltar in 2003 and 2004. Each variety was grown in 250 m^2 area. Seeds of the selected varieties/genotypes, the required amount of chemical fertilizers based on recommended doses and the technical inputs were provided to the farmers under the project, while other management inputs were used by farmers themselves as per their practices. The estimation of grain yield was done by taking stratified randomized crop cutting sampling from one square meter quadrant replicated four times at full maturity stage. Each sample was dried, threshed and weighed and then grain yield was calculated at 12% moisture content in the seeds.

Seed production of six genotypes, viz., Okhale 1, GPU 25, Seto Kodo, Mudke (Kaski), Mudke (Nuwakot) and Paheli Kodo undertaken at Khanigaun in 2003 indicated that local landrace Mudke from Nuwakot showed better performance (Table 17) than other genotypes in seed production plot. Three finger millet genotypes, viz., Kabre Kodo 1, GPU 25 and Local Mudke identified under the participatory variety selection (PVS) programme were put under seed production activity at Pipaltar site in 2003. The data revealed that the grain yield potential of GPU 25 was very high (3.3 tons/ha) as compared to other varieties such as Kabre Kodo 1 and Local Mudke but this variety had longer grain filling period, slightly shorter plant height and was susceptible to foliar diseases.

In 2004, the seed production was undertaken at Khanigaun, Pipaltar and Kabre locations. The results (Table 18) indicated that the maximum amount of seed (138 kg/500 m^2) was produced by Chitwane at Pipaltar, while the lowest yield was obtained from GPU 25 at Kabre location. However, GPU 25 was preferred by the farmers due to its desirable characters like earliness, higher number of grains/head and short plant height.

Table 17. Seed production of finger millet varieties at Khaniguan and Pipaltar (2003)

Khanigaun			Pipaltar		
Variety/ landrace	Area (m^2)	Seed yield (kg)	Variety/ landrace	Area (m^2)	Seed yield (kg)
Okhale 1	250	79.7	Kabre Kodo 1	250	60.0
GPU 25	250	88.0	GPU 25	250	82.5
Seto Kodo	250	71.5	Local Mudke	250	63.3
Mudke from Kaski	250	85.2	-	-	-
Mudke from Nuwakot	250	93.3	-	-	-
Paheli Kodo	250	79.7	-	-	-

Table 18. Seed production of finger millet varieties at Pipaltar, Khanigaun and Kabre (2004)

Khanigaun			Pipaltar			Kabre		
Genotype	Area (m^2)	Seed yield (kg)	Genotype	Area (m^2)	Seed yield (kg)	Genotype	Area (m^2)	Seed yield (kg)
Mabire	500	112	Chitwane	500	138	Kabre-1	500	94
White seeded	500	98	GPU 25	500	134	GPU-25	500	88

6.6. On- farm conservation through community based actions

Local landraces like Chitwane and Dalle local were popularly grown and conserved by the community at Pipaltar site. At the Khanigaun site, local landraces, viz., Mabire and Dalle were popular and hence were conserved until improved high yielding varieties become available to replace these landraces. Besides, a few farmers were

growing white grained local finger millet landraces. Though white grained finger millet (Samadhi Kodo) fetches high price, it was not common in the community due to lower yield in comparison to other landraces. In fact, this landrace was observed to be endangered and thus was included in the seed production programme for its conservation through utilization. The food made out of white grained finger millet was considered socially prestigious and hence named as Samdhi Kodo .

7. Improved agronomic practices

Finger millet relayed with maize is a predominant cropping system in the upland of the mid-hills (Shakya, 2002), while in lower river basin, it is mostly cultivated as mono-crop. It is grown under completely rainfed production system under residual fertility condition. Very few farmers apply urea as top dressing in finger millet on the road side locations whereas in the remote areas, the hill farmers do not apply chemical fertilizers and apply only compost/farm yard manure (FYM). Following experiments were designed and conducted in the project site to raise the productivity of the crop, viz: (i) study on the comparative economy of finger millet based production systems under rainfed condition at Tallo Pipaltar in Nuwakot district, (ii) density-cum-fertilizer study in finger millet, (iii) studies on method of nitrogen application and crop density on finger millet yield under maize-millet system, and (iv) comparative study on performance of improved and local varieties under improved and local cultivation practices. The outcome from these studies is reported in the following sections:

7.1. Finger millet based production systems under rainfed conditions

A comparative study on economy of finger millet based production system under rainfed conditions was undertaken at Tallo Pipaltar in Nuwakot district. Local landraces of finger millet (Chaure), black gram (Kalo), horsegram and sesame were used in this experiment. The experiment was conducted considering finger millet as main summer crop and sesame as the competitive crop of finger millet in the rainfed production system. Farmers' practice of mixing black gram and/or horsegram with finger millet was considered in designing the experiment to study the comparative economy. The experiment was laid out in randomized complete block design (RCBD) with four replications and the plot size for each treatment was 3 m x 2 m. About 35-40 days old finger millet seedlings were transplanted in each plot. Before transplanting, the seed of all legumes were broadcasted as per farmers' need or according to local practice. It was considered that residual compost applied to maize was also utilized by finger millet crop. Chemical fertilizers were applied at the rate of 40:30:20: N, P, K kg /ha for all treatments. All the phosphorous and potash and 50% of nitrogen was applied at the time of land preparation, while 50% nitrogen was top dressed after 35 days of transplanting. In case of sole legumes, all the chemical fertilizers were applied at the time of planting. MSTATC programme was used for data analysis.

The data (Table 19) revealed that among the sole crops, sesame gave the highest gross return (NR 28,260) and finger millet the lowest (NR 17, 050). However, in case of mixed cropping, finger millet mixed with black gram gave the highest gross return (NR 26,697) and was also the second highest in gross return among the treatments indicating that farmers' practice of mixing finger millet with black gram not only helped to maintain the soil fertility but also was economical than mono crop of finger millet. Besides, finger millet mixed with horsegram was better than mono crop.

Table 19. Grain yield and gross income in different production systems at Pipaltar (2003)

S. No.	Treatment	Grain yield of finger millet (q/ha)	Grain yield of legume (q/ha)	Selling price / kg (NR)	Gross income (NR)	Total gross income (NR)
1	Finger millet	15.50	–	11.00	17,050.00	17,050.00
2	Black gram	–	7.20	35.00	25,200.00	25,200.00
3	Horsegram	–	7.38	25.00	18,450.00	18,450.00
4	Sesame	–	9.42	30.00	28,260.00	28,260.00
5	Finger millet + black gram	11.67	3.96	–	12,837.00 +13,860.00	26,697.00
6	Finger millet + horse gram	10.38	3.96	–	11,418 .00 +9,900.00	21,318.00
7	Finger millet + sesame	10.54	–	–	11,594.00 +12,510.00	24,140.00

These results appeared quite interesting and were of paramount significance for long-term fertility maintenance of the soil to sustain the production in subsistence farming system by the rural poor. However, such practice needs extensive dissemination and scaling-up among stakeholders under similar environment. Though mono cropping of sesame gave the highest gross return among all the treatments, mixed cropping of finger millet and black gram should be encouraged and further disseminated due to the socio-cultural importance of these crops. However, more detailed and critical studies are needed for further verification of these findings from socio-cultural and economic viewpoints.

7.2. Plant density-cum-fertilizer study on finger millet

This experiment was conducted in the summer season of 2002 at Khumaltar (1,350 m asl). The soil samples taken from the experimental plots were analyzed for texture, organic matter, pH, and NPK. The soil texture was silt loam with low organic matter and nitrogen but high phosphorus and potash. Soil reaction was acidic with 4.0 pH. Forty days old finger millet seedlings of var. Kabre Kodo 1 were transplanted under mono-culture. All the compost was applied in the soil one week before transplanting and chemical fertilizer was applied at the time of planting, 50% nitrogen in treatment

3 and 7 was top dressed after 40 days of transplanting. The experiment was laid out in randomized complete block design (RCBD) with three replications and the plot size for each treatment was 3.0 m × 3.0 m with two plant density regimes of 10 cm × 10 cm and 20 cm × 20 cm. Urea, di-ammonium phosphate (DAP), single super phosphate, and muriate of potash were used as chemical fertilizers. The data was analyzed using MSTATC. The treatment details are given in Table 20.

Table 20. Details of treatments for plant density and fertilizer application

Treatments	Density (cm)	FYM (t/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
T 1	10 × 10	0	0	30	30
T 2	10 × 10	15	0	30	30
T 3	10 × 10	0	30	30	30
T 4	10 × 10	7.5	15	30	30
T 5	20 × 20	0	0	30	30
T 6	20 × 20	15	0	30	30
T 7	20 × 20	0	30	30	30
T 8	20 × 20	7.5	15	30	30

The results of the trial conducted at Khumaltar in 2002 (Table 21) revealed significant differences between the treatments with respect to grain yield, straw yield, number of bearing heads/m^2, plant height and number of plants /m^2. However, the treatment differences for fingers/head were non–significant. Both the grain yield (23.84 q/ha) and straw yield (104.82 q/ha) were the highest in treatment 2 with the application of 15 t/

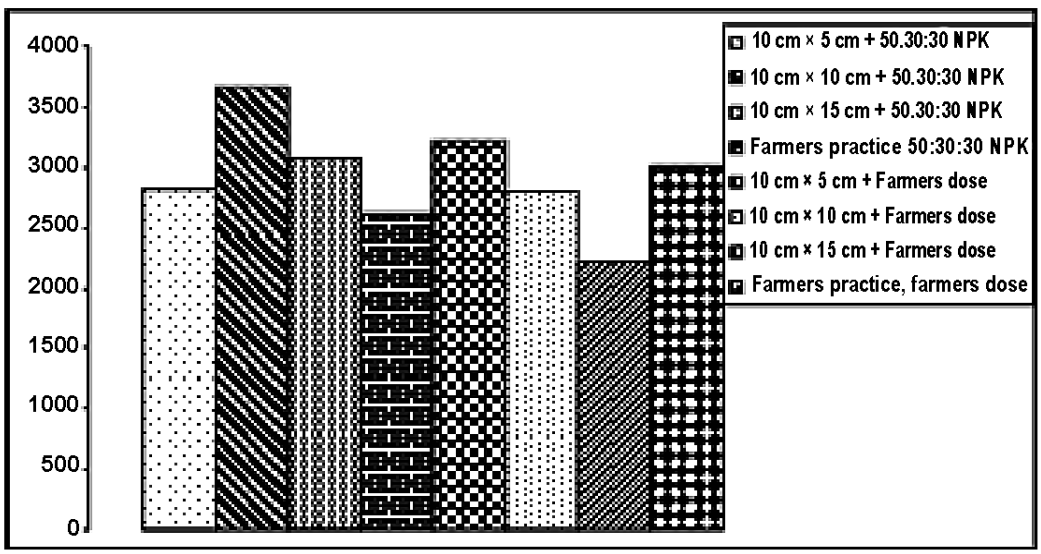


Fig. 10. Grain yield performance of finger millet under plant density and fertilizer trial at Kabre (2004)

Table 21. Grain yield and other traits of finger millet in plant density-cum- fertilizer trial at Khumaltar (2002)

Treatment	Plant stand/m²	Bearing heads/m²	No. of fingers/ head	Plant height (cm)	Grain yield (q/ha)	Straw yield (q/ha)
T 1	91.7	100	5	77	22.91	87.78
T 2	88.7	95	6	84	23.84	104.82
T 3	91.3	91	6	83	22.73	101.85
T 4	87.0	91	6	79	22.46	92.59
T 5	30.3	45	5	63	11.25	37.04
T 6	30.0	53	6	68	13.10	48.52
T 7	30.7	54	6	70	13.74	48.89
T 8	30.7	52	6	69	14.54	51.11
Mean	60.1	72.6	5.7	74.1	18.07	71.57
CV%	12.13	17.14	7.4	3.8	12.72	11.37
F test	**	**	NS	**	**	**
LSD 0.05%	7.8	13.34	0.43	3.0	246.4	873

ha farm yard manure (FYM), 30 kg P_2O_5/ha and 30 kg K_2O/ha indicating that balanced nutrient from organic and inorganic fertilizers was more important in finger millet. The results of plant density and fertilizer trial conducted at Kabre in 2004 revealed (Fig. 10) that 10 cm × 10 cm spacing with the application of NPK fertilizers at 50:30:30 kg/ha rate proved to be the best combination for attaining the highest grain yield and therefore, such combination might be recommended for general cultivation.

7.3. Effect of plant density and method of nitrogen application on performance of finger millet under maize-millet system

The experiment was conducted under maize-finger millet relay cropping system at Khumaltar in summer 2003. The soil of the experimental plot was acidic (pH 5.0) and the texture was clay loam with lower level of organic matter (OM). Total nitrogen, phosphorus (P_2O_5) and potash (K_2O) were found to be low, medium and high, respectively. Rampur composite variety of maize was planted with 120:60:40 N; P_2O_5: K_2O kg/ha two months before finger millet transplanting. Finger millet variety Kabre Kodo 1 was transplanted at 10 cm × 10 cm, 10 cm × 15 cm, and 10 cm × 20 cm distances in the standing crop of maize. Nitrogen for finger millet was applied at 30 kg/ha rate as follows: (i) all nitrogen 30 days after transplanting and (ii) 50% nitrogen after 30 days of transplanting and remaining 50% after 10 days of first application. The sources of fertilizers were urea, di-ammonium phosphate and muriate of potash. Plot size was 12.0 m².The experiment was conducted in a randomized complete block design with three replications and six treatments (Table 22). The data were analyzed using MSTATC (Computer based statistical software package).

Table 22. Details of spacing and method of nitrogen application

Treatment	Spacing	First top dressing after 30 days of transplanting	Second top dressing after 10 days of first application
T1	10 cm × 10 cm	30 kg N /ha	-
T2	10 cm × 15 cm	30 kg N /ha	-
T3	10 cm × 20 cm	30 kg N /ha	-
T4	10 cm × 10 cm	15 kg N /ha	15 kg N /ha
T5	10 cm × 15 cm	15 kg N/ha	15 kg N/ha
T6	10 cm × 20 cm	15 kg N/ha	15 kg N/ha

The treatment differences were found significant for plant population/ m^2, number of bearing heads /m^2, grain yield and straw yield of finger millet (Table 23). However, data revealed that method of fertilizer application had no effect on plant population and bearing heads. Thus, the significant differences for these traits were due to spacing treatments, which is obvious. Grain yield was the highest (12.00 q/ha) in treatment No. 4 i.e. with split application of nitrogen under highest plant population but data revealed that the effect was due to density rather than method of fertilizer application (T 4 and T 1). Though, single dose of nitrogen produced significantly higher yield than split application (T 2 and T 5) under the same plant population (10 cm x 15 cm spacing), however, data did not coincide with other treatments. Thus, even within very reasonable coefficient of variation and significant yield differences among treatments, data were not conclusive even though results were interesting. Straw yield was also the highest (43.25 q/ha) in treatment No. 4. The straw yield trend resembled more or less with that of grain yield.

Table 23. Performance of finger millet as affected by methods of fertilizer application and plant density in maize-millet system at Khumaltar (2003)

Treatment	Plants/m^2	Bearing heads*/m^2	No. of fingers/ head	Plant height (cm)	Grain yield (q/ha)	Straw yield (q/ha)
T 1	68	82	5	50	11.14	35.31
T 2	52	62	5	49	11.07	42.19
T 3	48	58	5	53	10.18	31.45
T 4	60	88	5	49	12.00	43.25
T 5	51	64	5	45	7.63	24.56
T 6	46	53	5	47	9.93	31.47
Mean	53.5	67.8	5.0	48.8	10.335	34.71
CV	16.67	13.05	11.88	7.5	6.69	16.93
F test	*	**	NS	NS	**	*
LSD .o5%	16.13	16.13	1.03	6.66	125.7	1068.7

* Significant at 5 % level; ** Significant at 1 % level; NS – Non-significant

7.4. Comparative study on performance of improved and local varieties under improved and local cultivation practices

The comparative study on the performance of improved and local varieties under improved and local cultivation practices was undertaken at Pipaltar, Khanigaun and Kabre in 2004.The results (Fig. 11) revealed that local variety with improved practices produced the highest grain yield of 35.75 q/ha at Pipaltar and 27.67 q/ha at Khanigaun, while the improved variety with improved practice produced the highest grain yield of 17.72 q/ha at Kabre indicating thereby that the performance of varieties was location specific. These results clearly established that recommendations for enhancing the use of finger millet should always be location specific, using genotypes which have best performed in the target site along with practices that have been also tested out in the same place.

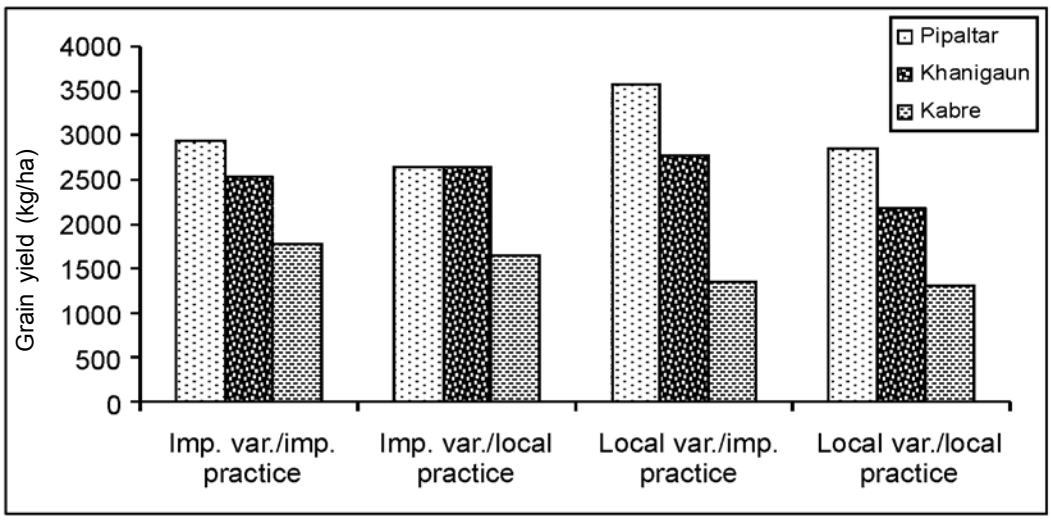


Fig. 11. Performance of finger millet under improved and local cultivation practices

7.5. Harvest and post-harvest operations

The use of threshing machine developed by the Division of Engineering, NARC, Nepal proved to be much better. Winnowing was done both by using blowing machine like fan operating manually and also by local method. The finger millet flour was prepared at low cost in the micro-mill provided under the IFAD-NUS Project to the community. To some extent, dehusking was also done by using pearling machine modified by the Division of Engineering. It was expressed by the farmers during interaction that finger millet flour milled in *janto* and *ankle* was tastier and could be kept for longer time as compared to that made with micro-mill. The use of micro-mills was found advantageous due to saving of time, ease of preparation of different recipes, reduction in drudgery of women, and commercialization.

8. Processing, value addition and product development

8.1. Nutrition

Four varieties of finger millet, namely, Kabre Kodo 1, Okhale Kodo 1, Dalle Kodo and a promising genotype GE 5016 were subjected to chemical analysis. Nutrition and other quality parameters, such as density, moisture, total ash, crude fibre, protein, calcium, phosphorus and iron were determined according to S. Rangana's

Table 24. Nutritional characteristics of finger millet genotypes

Genotypes	Density (g/ml)	Moisture (%)	Protein (%)	Total ash (%)	Acid insoluble ash (%)	Fat (%)	Crude fibre (%)	Calcium (mg/ 100g)	Phos-phorus (mg/ 100g)	Iron (mg/ 100g)
Kabre Kodo 1	1.48	13.94	7.64	2.2	0.221	1.41	1.82	390.30	330.19	4.68
Okhale Kodo 1	1.38	14.25	7.35	2.25	0.211	1.34	1.79	386.48	286.19	4.64
Dalle Kodo	1.38	13.50	7.32	2.17	0.197	1.32	1.74	396.81	314.76	3.66
GE 5016	1.26	14.67	7.03	2.19	0.211	1.38	1.64	379.33	257.82	4.26

Table 25. Nutritional composition of finger millet as compared to other cereal grains

S. No.	Characteristics	Per 100 g			
		Finger millet	Maize	Wheat	Rice
1	Water (g)	13.10	12.00	12.20	13.70
2	Protein (g)	7.30	9.20	12.10	6.80
3	Fat (g)	1.30	3.90	1.70	0.50
4	Carbohydrate (g)	72.00	73.70	69.40	78.20
5	Fibre (g)	3.60	1.60	1.90	0.20
6	Minerals (g)	2.70	1.20	2.70	0.60
7	Calcium (mg)	344.00	20.00	48.00	10.00
8	Phosphorous (mg)	283.00	256.00	355.00	160.00
9	Iron (mg)	6.40	2.40	11.50	3.10
10	Thiamin (mg)	0.42	0.38	0.49	0.06
11	Calories	328.00	355.00	341.00	345.00
12	Carotene (mg)	42.00	90.00	29.00	-

method (Bhandari and Upreti, 2003). The chemical characteristics of these genotypes (Bhandari and Upreti, 2003; Shakya, 2003) are given in Table 24, 25. The data revealed that finger millet is the excellent source of calcium and phosphorus which ranged from 397-389 mg and 330-258 mg per 100 g, respectively. Iron content in the grain was found to be comparatively low.

8.2. Value addition and product development

The traditional recipes of finger millet for preparing staple foods include bread, thick and thin porridge and *powa* (characterized by a very good smell and taste). However, such recipes are preferred by indigenous people and not usually appreciated by upper class society members. In order to increase the popularity of finger millet, the project focused for the development of more attractive and modern types of products. Various types of recipes such as bread, cake, *ainthi*, *namkin*, *bhatura*, puff, doughnut, biscuits, cookies and noodles were developed. Other preparations like weaning, snacks and staples such as *halwa, lito*, malt-*satu*, pancake, etc. were also developed. Flour of different grains like maize and wheat was mixed with finger millet flour and in some recipes, flour of pulses was also added as a source of protein and to make the dishes tasty.

The varieties of finger millet with light coloured grains are reported to have more thiamin and protein as compared to dark coloured varieties (Bhandari and Upreti, 2003). The recipes from white grain are served to the guests as a symbol of respect. Presently, the bakery products like bread, *namkin* and biscuit might become popular in the society with publicity on these products. With value addition, there is a high scope of product diversification, enhancing employment and entrepreneurship and initiating supplementary/ weaning food programmes. The important finger millet based recipes and bakery products are depicted in Figs. 12, 13.

Fig. 12. Finger millet based recipes

Fig. 13. Finger millet based bakery products

8.3. Constraints experienced in value addition of finger millet

There were several problems and constraints which hindered the popularization and spread of value added products which need to be properly addressed in order to promote the use of finger millet with success. These included:

- The perception by people that finger millet is a low status food.
- People were not aware of the nutritional importance and potential of the crop.
- There was lack of public interest in value added millet products.
- The consumers did not like to pay high price of millet products as done for wheat products.
- The bakery producers and noodle producing industries were afraid of losing the market of popular products.
- There was no appropriate mechanism in place to popularize millet products through print, media and other communication channels as well as through display of millet based products in fairs and exhibitions.
- There was lack of training to millet growers and entrepreneurs for value addition and product development.
- There was no provision of assured marketing.
- There was no provision of financial support to small industries and entrepreneurs for the production of diversified recipes based on finger millet.

9. Cost: benefit analysis and marketing

9.1. Cost: benefit analysis

The cost of cultivation of finger millet was high in Pipaltar because the entire finger millet cultivation activities were carried out using human labour. The investment cost, gross income, net benefit and cost: benefit ratio is given in the Table 26. The economic analysis of existing finger millet cultivation in Pipaltar showed that the cost: benefit ratio was 1:1.13.

The cost of cultivation of finger millet was high in Khanigaun because the entire activities were undertaken by human labour and no animal power was used in finger millet cultivation. The total investment, gross income, net benefit and cost: benefit ratio is given in the Table 27. The economic analysis of finger millet cultivation showed that the cost: benefit ratio was 1:1.08. The cost: benefit analysis of finger millet production from seed production at Khanigaun, Pipaltar and Kabre (Table 28) indicated that the highest net income of NR 8,680/ha was received from finger millet seed production at Kabre.

9.2. Economical analysis of local beverage production

The economic analysis of local beverage (*rakshi* and *jad*) production in Pipaltar and Khanigaun indicated that the overall profit was very low. The cost: benefit ratio in Pipaltar was 1: 1.1 to 1:1.6 whereas in Khanigaun, the cost: benefit ratio was 1: 1.06

Table 26. Economic analysis of finger millet cultivation at Pipaltar

Activities	Quantity	Rate (NR)	Total (NR)
Labor input (No.) Male	60	120	7,200
Female	180	60	10,800
Sub-total			**18,000**
Material inputs (kg/ha)			
Seeds	7.5	35	225
Urea	120	15	1,800
DAP	43	23	1,035
Sub-total			**3,060**
Total cost of production			21,060
Gross production (kg/ha)	2,980	8	23,840
Net profit			2,780
Cost: benefit ratio			**1:1.13**

Source: Field Survey, 2003

Table 27. Economic analysis of finger millet cultivation at Khanigaun

Activities	Quantity	Rate (NR)	Total (NR)
Labor input (No.) Male	62	70	4,340
Female	225	35	7,910
Material inputs (kg/ha)			
Seeds	7.5	35	225
Urea	118	15	1,770
Cost of cultivation			14,245
Gross production (kg/ha)	1,936	8	15,488
Net profit			1,243
Cost :benefit ratio			**1:1.08**

Source: Field Survey, 2003

Table 28. Cost:benefit analysis of seed production in finger millet

Location	Area (m^2)	Total income (NR)	Total cost (NR)	Net income (NR)	Net income (NR/ha)
1 Khanigaun	500.0	1,070	743.5	326.5	6,530
2 Pipaltar	500.0	791.0	833.0	138.0	2,760
3 Kabre	500.0	1,215.0	781.0	434.0	8,680

to 1:1.53 with the same investment because of price variation of products. Slightly better quality of *rakshi* (6-8 *pane*) was prepared in Pipaltar and was sold at 50% higher price than that of Khanigaun. The increased number of changing water led to the production of inferior quality and increased quantity of beverage. Therefore, the farmers of Khanigaun could sell *rakshi* at lower price than Pipaltar (Table 29, 30). More volume of *rakshi* was received from increased number of water change and vice versa.

9.3. Marketing

The market approach followed by the farmers included (i) selling finger millet grain in the local market, (ii) traders coming to the village to buy the grain, (iii) farmer to farmer selling of grain, (iv) selling of millet based recipes in the bakery shop of district headquarters, (v) marketing of millet based products in the bakery shops in Kathmandu, and vi) selling of home-made liquor in the local market and at home. It was observed that 41% of farmers sold 5-35% of the produce to middle men in the local market at cheaper rate immediately after threshing. Usually, the price

Table 29. Economical analysis of finger millet *rakshi* (local beverage) at Pipaltar, Nuwakot (2004)

S. No.	Inputs	1st time preparation (*salta*)			2nd time preparation (*balta*)			3rd time preparation (*balta*)			Remarks
		Unit	Unit cost (NR)	Total cost (NR)	Unit	Unit cost (NR)	Total cost (NR)	Unit	Unit cost (NR)	Total Cost (NR)	
1	**Material inputs**										Additional ingredient like *mana*, beaten rice, and jaggary yielded 25% and 10% more *rakshi* in second and third processing respectively.
	Finger millet (kg)	32	10	320	0	0	0	0	0	0	
	Marcha (yeast) pieces	10	4	40	10	4	40	10	4	40	
	Fire wood (kg)	150	1.75	262.5	120	1.75	262.5	120	1.75	262.5	
	Mana (kg)	0	0	0	7.5	30	225	11	30	330	
	Beaten rice (kg)	0	0	0	5	16	80	7.5	16	120	
	Jaggery (kg)	0	0	0	12.5	26	325	19	26	494	
	Utensil hiring cost for *rakshi* (litre)	4.16	31	129	4.16	31	129	4.16	31	129	
2	**Labour inputs**										
	Male		60	60	1	60	60	1	60	60	
	Female	1	40	80	2	40	80	2	40	80	
	Total cost	2		891			1226.5			1440	
3	**Local beverage (*rakshi*) production** (litre)	46.8	31	1450	58.5	31	1813.5	51.48	31	1596	
	Cost: benefit ratio			**1:1.6**			**1:1.61**			**1:1.1**	

Table 30. Economical analysis of finger millet *rakshi* (local beverage) at Khanigaun, Nuwakot (2004)

S. No.	Inputs	1st time preparation			2nd time preparation			3rd time preparation			Remarks
		Unit	Unit cost (NR)	Total cost (NR)	Unit	Unit cost (NR)	Total cost (NR)	Unit	Unit cost (NR)	Total cost (NR)	
1	**Material inputs**										Additional ingredients like *mana*, beaten rice, and jaggery yielded 25% and 10% more *rakshi* in second and third processing, respectively.
	Finger millet (kg)	32	10	320	0	0	0	0	0	0	
	Marcha (yeast) pieces	10	2	20	10	2	20	10	2	20	
	Fire wood (kg)	150	1.5	225	120	1.5	180	120	1.5	180	
	Mana (kg)	5	30	150	7.5	30	225	10	30	300	
	Beaten rice (kg)	0	0	0	5	18	90	7.5	18	133	
	Jaggery (kg)	0	0	0	10	26	260	15	26	390	
	Utensil hiring cost for *rakshi* (litre)	2.6	20	52	2.6	20	52	2.6	20	52	
2	**Labour inputs**										
	Male	1	80	80	1	80	80	1	80	80	
	Female	2	40	80	2	40	80	2	40	80	
	Total cost			927			977			1236	
3	**Local beverage (*rakshi*) production** (litre)	49.4	20	988	75	20	1500	80	20	1600	
	Cost: benefit ratio			**1:1.06**			**1:1.53**			**1:1.29**	

was higher in rainy season than at harvest time and it was not possible for them to wait until the price rise in the market. In general, the millet grain price had been decreasing over the years due to lower food value as well as low consumption of local beverage in the local market because of political situation.

A market study of finger millet products after one year of training was conducted in Bidur municipality of Nuwakot district. Most of bakery producers were inspired to incorporate finger millet flour in their bakery products such as noodles, *namkin*, cookies and biscuits but they produced very small quantity of millet based recipes. During the interaction with bakery producers, they expressed several types of

problems and suggested strategies for better promotion of millet based products in the market including the following: (i) the product should be good and with longer shelf life, ii) provision of assured selling of the products, (iii) promoting sale of products by creating greater awareness through workshops, trainings and other demonstration activities explaining the nutritional and other advantages of millets, (iv) providing some financial support as an incentive to bakery producers and small industries, and (v) arrangement of loan through Agriculture Development Bank or any other financial institution for initial investment.

10. Capacity building and training

10.1. Training and skill enhancement

The implementation of the project benefitted a large number of people belonging to different stakeholder groups. The major beneficiaries included the farmers, entrepreneurs, bakery producers, people engaged in small industries, extension workers, researchers, students, and the persons from government and non-government organizations. Several short duration training programmes were organized by the HCRP at Trishuli, Nuwakot district during 21-25 October, 2003 and 10-11 September, 2004 in order to enhance the skill of farmers and entrepreneurs in the field of improved cultivation practices and value addition and product development. Value addition and development of finger millet based products, their commercialization and market promotion activities were undertaken for which the necessary training was provided to the farmers and entrepreneurs.

Several approaches were used for capacity building and education of people engaged in finger millet production and utilization. A few need based equipments were provided to Food Research Unit at Nepal Agricultural Research Council (NARC) and also the lap top and digital camera were provided to facilitate the research work.

10.2. Establishing micro-mills

One micro-mill each at Pipaltar and Khanigaun sites of Nuwakot district was established and handed over to the farmers' group to reduce the drudgery of women farmers in making the millet flour (Fig. 14). Thus, the farmers of that area were benefited by milling finger millet flour at reasonable price and the person of the community getting an

Fig. 14. Micro-mill established at Pipaltar

opportunity of job and the source of income. The farmers of that community showed their interest to increase the milling capacity of the machine. A micro-mill was also established at Kabre site of Dolakha district. An improved version of the pearling machine developed by Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora was established at Kabre (Fig. 15) to dehusk millet grain and improve quality and to reduce the drudgery of women farmers.

Fig. 15. Millet pearling machine at Kabre (left) and modified pearling machine (right)

11. Public awareness

The awareness about the importance of finger millet, its genetic diversity and use was raised through a number of means, including the dissemination of prints and electronic media, exhibitions, display of improved varieties and value added millet based products through seminars/workshops as well school programmes and participation of researchers of NARC in several workshops, meetings and symposia/ conferences. The major awareness activities undertaken are given below:

- Finger millet seeds, plants along with ear heads, and their photographs were displayed in the exhibitions organized from time to time at Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur.
- Seed samples of different varieties and promising lines of finger millet were displayed on the occasion of NARC Foundation Day organized on 8 May, 2003.
- Finger millet seeds and finger millet based products were displayed at the time of the seminars held at NARC, NARI Hall, Khumaltar, Lalitpur on 12

December, 2003 and NARC Hall, Singh Durbar Plaza, Kathmandu on 28 January, 2004.

- Finger millet seeds and finger millet based products were displayed in the micro-entrepreneurs' fair at Blue Star Hotel in Kathmandu organized by Micro-enterprise Development Project (MEDEP) from 20-22 May, 2004.
- Display of finger millet based products was done in the exhibition at the time of seminar organized by Women in Science and Technology (WIST) in Kathmandu from 28 February- 2 March, 2003.
- Finger millet varieties and promising millet based products were displayed in the local fairs at Trishuli, Nuwakot and Charikot, Dolakha organized by a Trade Union for a period of three days.
- Publicity of finger millet based products was done through school programme at Pipaltar, Trishuli and Khanigaun during the training programmes. Products were evaluated by the students and teachers. Publicity was also done through local leaders and the persons in higher positions.
- Exhibition of finger millet varieties and millet based products was organized on First International Mountain Day (11 December, 2003) which was inaugurated by His Royal Highness Crown Prince Paras of Nepal.
- Publicity through press and media: i) broadcasts about finger millet products were made through Nepal TV under the Agriculture Programme on 23 October, 8 November, 2003 and 22 May, 2004, ii) through Radio Nepal and FM Radio, and iii) through Newspapers.
- Publicity of millet varieties, cultivation practices and finger millet based products was also done through the website (http://www.hcrp.org.np) developed and upgraded by HCRP, Kabre.

12. Policies

In spite of the importance of underutilized crops in Nepal, adequate emphasis has not been given to research, extension and market promotional activities on these crops. Finger millet and other minor millets are considered as a low status food in Nepal and the people consuming these grains are looked down as very poor. Although the people are aware to some extent about the high nutritional value of finger millet but its consumption is not common. At present, there are no appropriate policies of His Majesty's Government of Nepal to enhance the status of this crop that it deserves in terms of research, development and extension. The IFAD-NUS project has amply demonstrated the possibility of enhancing income of the rural poor through the enhanced use of finger millet and millet based products. There is a great need to create wider awareness at all levels including the consumers, researchers, planners and policy makers to promote the use of this crop in Nepal. There are tremendous opportunities for making use of finger

millet in ensuring food security including nutritional security, enhancing income and employment, value addition and diverse product development and better utilization of poor marginal lands by growing finger millet. Finger millet is a crop of subsistence farming system and an income generating crop for women farmers especially through local beverage production in the hilly regions and hence it needs to be given a fair treatment by getting included in the national research and development agenda in Nepal.

13. Impact of the project

The project has been successful in creating awareness among the people in Nepal about the importance and usefulness of finger millet towards the nutrition aspects and health benefits. Also the stigma of its low status food was reduced to some extent and the farmers as well as consumers were convinced about the important role it can play in reducing the risk due to heart diseases and type II diabetes. It has further demonstrated the possibility of enhancing income through the development and sale of diversified finger millet based products. The training and skill enhancement of the farmers and entrepreneurs convinced them to venture in to value addition and product development activities aimed at income generation. The farmers were also got motivated to grow important landraces and high yielding improved varieties and adopt better cultivation practices to enhance production and consequently the income.

14. Recommendations

Based on the experiences and lessons learnt from the implementation of this project, the following major recommendations emerged:

- Greater emphasis needs to be given to enhance productivity of finger millet through the use of better varieties and improved cultivation practices.
- Concerted efforts need to be made to strengthen research capabilities in product development and build capacity through the provision of need based equipments and training.
- More efforts need to be made to explore possibilities and encourage micro-entrepreneurs to produce millet based products in potential millet growing areas.
- Popularization of appropriate machines, tools and equipments for the efficient cultivation as well as processing, value addition and product development needs to be given due emphasis.
- Efforts should be made to standardize the methods for preparation of non-alcoholic drinks. Also, assistance should be provided to the local people for the preparation of good quality alcohol within the legal frameworks.
- Establishing links with markets in order to promote the value added products is extremely important and needs to be given greater thrust.

- Concerted efforts should be made to sensitize the consumers through print, electronic media (FM Radio, TV), exhibitions, fairs and festivals, school/ college programmes, extension, training, seminars/workshops for creating mass awareness about the importance of millets for health and nutrition.

15. Publications

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Promoting Neglected and Underutilized Species in Nepal: A Case of Finger Millet

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1. Introduction

Underutilized crops are usually considered important in relation to their end use and are usually grouped into cereals, beverage, oil, spices, fruit and vegetable categories (Williams and Haq, 2002). In fact, such uses are variable from place to place. Underutilized crops are found in numerous agricultural ecosystems and often adapted to marginal farming systems. These minor crops have received little attention, yet almost all of these neglected species are essential to local people as food and a source of income. Research and development in general are lacking in underutilized crops. In recent decades, a number of scientific and economic interests have emerged with focus on lesser known cultivated species.

Finger millet (*Eleusine coracana*) occupies almost 9% of the total cultivated area in Nepal and about 75% of this lies in mid-hills. Although this is the fourth most important food crop in terms of area coverage in Nepal (Upreti and Bimb, 2002), finger millet is one of the neglected crops of this country. The crop is important in subsistence based farming systems due to its several important features (Box 1). Farmers grow finger millet in marginal land with low external inputs. Hence, finger millet is a part of daily diets of poorer people living in marginal areas. Among cereals, finger millet is rich in iron, calcium, and zinc, but in spite of these advantageous nutritional properties, it is considered a low status food by people of Nepal. Recent trends indicate that production and consumption of finger millet is further decreasing in the country. This chapter reports the results of efforts made by LI-BIRD to increase productivity and consumption of finger millet in Nepal through the project, "Enhancing the Contribution of Nutritious but Neglected

Box 1. Key features of neglected and underutilized crop: finger millet

- *Important source of food for poor people in Nepal*
- *Suitable for growing on marginal (low fertile) and dry soils (rainfed)*
- *Low infestation of crop pests and diseases*
- *Associated with poor or marginal farming households with larger area planted*
- *Utilized largely in the form of traditional foods*
- *Found in wild forms and if domesticated, package of scientific cultivation practices not properly developed*
- *Very low profile in national research and development priority*

Crops to Food Security and to Incomes of the Rural Poor: Asia component- Nutritious Millets."

This Project was a part of a global project funded by the International Fund for Agricultural Development (IFAD) through Bioversity International (formerly, International Plant Genetic Resource Institute -IPGRI). In Nepal, it was jointly implemented by the Nepal Agricultural Research Council (NARC) through the Hill Crops Research Programme (HCRP) and Local Initiatives for Biodiversity, Research and Development (LI-BIRD). The project was highly multi-disciplinary and implemented through the participation of many stakeholders. It addressed issues across the entire chain from cultivation to use including processing, value addition and marketing of ultimate products. It aimed at establishing avenues for enhanced processing and value addition by the poor, explore and identify market opportunities and undertake public awareness actions at different levels besides increasing the productivity through adoption of appropriate production technology and germplasm enhancement/varietal improvement.

2. Goal and objectives

The project goal was to contribute to increased income and strengthen the food security of small farmers and rural communities through exploiting the genetic diversity contained in neglected and underutilized species through the enhanced value addition, marketing and public awareness. Following were the specific objectives set out for the project:

- To increase production and productivity of landraces and varieties through participatory crop improvement/germplasm selection
- To enhance consumption of millets through value addition and public awareness actions among consumers to policy makers
- To document local knowledge and gather socioeconomic data on finger millet production, processing and utilization

3. Project sites

LI-BIRD implemented its activities in two sites of Kaski district, namely, Kalabang village (Pumdibhumdi Village Development Committee -VDC) and Ralmare village (Lekhnath Municipality) (Figs. 1-3). Kalabang village (1,300 m asl) represented mid-hills, growing conditions, whereas Ralmare village (900 m asl) represented those of the foothills. Both are peri-urban village sites near Pokhara city. Kalabang village is linked by a rural road and inhabited mostly by *Gurung* ethnic group (75%), whereas Ralmare village is two hours walking distance from fair season road and is characterized by a majority of *Brahmin/Chettri* communities (80%). Finger millet is the second most important crop (after rice in Ralmare and after maize in Kalabang) in these areas and contributes substantially to their household food security. The details of the project sites are given in Table 1.

The project activities were implemented in close collaboration with the District Agricultural Development Office, farmers' groups and private entrepreneurs (latter engaged specifically in value addition work). The list of collaborators involved in the project is given in Table 2.

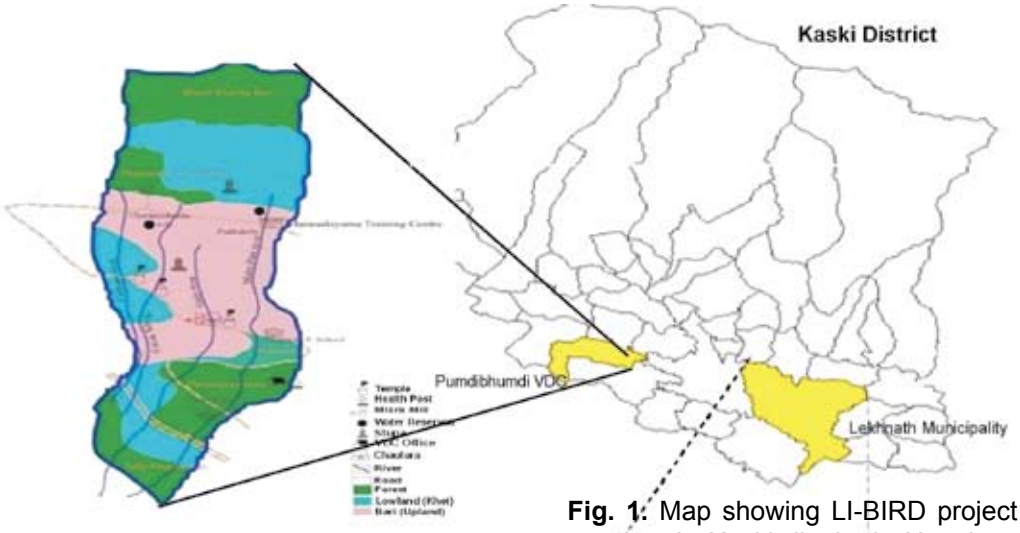

Fig. 1. Map showing LI-BIRD project sites in Kaski district in Nepal

Fig. 2. Resource map of Kalabang village, Pumdibhumdi VDC-6, Kaski

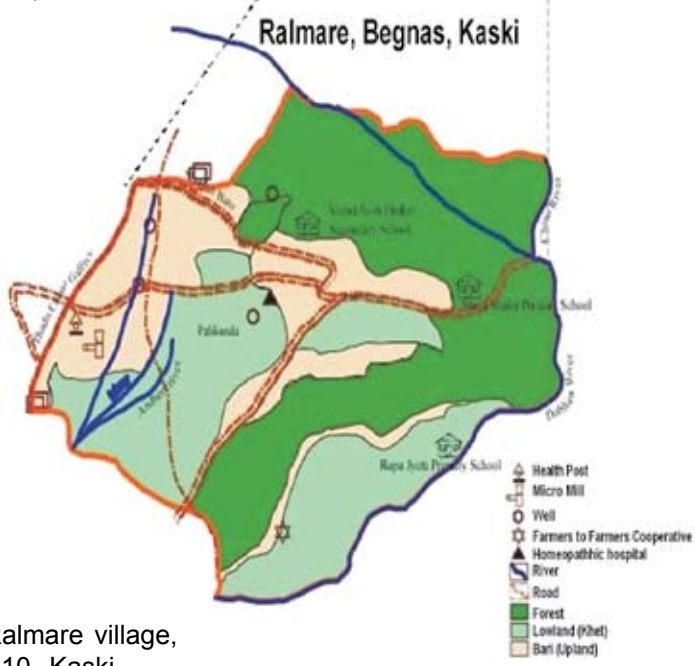

Fig. 3. Resource map of Ralmare village, Lekhnath Municipality-10, Kaski

Table 1. Details of selected sites for IFAD-NUS finger millet project in Kaski district, Nepal

Characteristics	Selected sites in Kaski district	
	Kalabang	Ralmare
I	2	3
1 Agro-ecological settings		
Ward No.	6	10
VDC/Municipality	Pumdibhumdi VDC	Lekhnath municipality
District	Kaski	Kaski
Altitude (m asl)	1300	900-1000
Aspect	South	South
No. of households	180	230
Distance from all season road	30 minutes	2 hours
Distance from fair season road	15 minutes	2 hours
Distance from local market	1 hour	2 hours
2 Land type (% land)		
Khet land	60	60
Bari land	40	40
3 Ethnic composition (%HH)		
Brahmin/Chhetri	15	80
Gurung/Magar	75	5
KDS	10	10
Others	-	5
4 Important crops	Maize, finger millet, rice, wheat and potato	Rice, finger millet, maize and upland rice
5 Cereal crops	Maize , finger millet, rice and wheat	Rice, finger millet, maize, upland rice
6 Vegetable crops	Potato, rayo, radish, chayote and cucurbits	Potato, soybean, black gram, cowpea, and onion
7 Varietal diversity of finger millet	Dalle, Ashare, Ashoje, Mansire and Seto Kodo	Ghape, Dalle, Shamdhi Kodo, Dudhe, Batule Kodo, Kukurkane
Landraces grown (%)	100	100
Major landraces grown	Kalo Dalle, Rato Dale and Seto Kodo	Jhyape, Dalle, Shamdhi Kodo
Improved varieties grown (%)	0	0

Contd...

Table 1 (Contd.)

1	2	3
8 Cropping pattern		
Khet	Rice-fallow-fallow (75%) Rice-*tori*/wheat/potato-maize (25%)	Rice-fallow (100)
Bari	Maize+*kodo*-potato/*tori*-wheat (75%) Maize-*tori*-fallow (25%)	Maize-finger millet-*tori*/wheat/potato (80%) Maize-finger millet-fallow (20%)
9 Finger millet production practices		
Mono crop (%)	10	100
Relay crop (%)	90	0
Seeding time	April- May(*Baisakh-Jestha*)	July (15th of *Ashar*-15th of *Shrawan*)
Transplanting time	June-July (*Jestha-Shrawan*)	August (*Bhadara*)
Harvesting time	Sept.-Nov. (*Ashoj-Mangsir*)	Oct.-Nov. (*Kartik- Mangsir*)
10 Fertilizer use (HH % age)		
Compost	100% in maize crop	100% in maize crop
Chemical	0	0
11 Use of finger millet (%)		
Food (*dhindo, roti*)	20	50
Liquor	40	15
Sale	5	25
Others (cattle feed, etc.)	35	10 (5% exchange with wheat)
12 Trend of finger millet area under cultivation	Constant	Decreasing
13. Local organizations involved	Marga Joyoti Bikash Samuha, Environmental Protection Community Organization Community Forestry Group	Development and Environment Club, Begnas Ralmare Women Community Development Committee

4. Geographic distribution and production trends

Finger millet ranks fourth in importance after rice, maize and wheat in Nepal. It is the third important crop for the hilly regions of this country. A survey conducted in 1991 showed that 90% of the households in the mid-hills of Nepal were dependent on finger millet. The area and production of finger millet in different development regions during 1998-99 to 2001-02 are given in Table 3.

Table 2. Collaborators involved in the project activities

Type of organizations	Collaborators	Locations
Community based farmers' groups and organizations	Marga Joyoti POWER Women Group (52 HHs)	Pumdibhumdi VDC-6, Kalabang village, Kaski
	Ralmare Community Development Group (17 HHs)	Lekhnath Municipality-10, Ralmare village, Kaski
Private entrepreneurs for product diversification	Sital Agro- Products	Sitaladevi, Pokhara
	Annapurna Bakery Udyog	Nayabazar, Pokhara
	Madhav's Café	Chippledhunda, Pokhara
	Taja Pouroti Udyog	Zerokilometer, Pokhara
	Kundhar Khaja Udyog	Kundhar, Pokhara
Other research and development organizations	Hill Crops Research Programme	Nepal Agriculture Research Council (NARC), Kathmandu
	District Agriculture Development Office, Kaski	Birauta, Pokhara
	Home Science Department, Prithivi Narayan Campus, Tribhuvan University	Bagar, Pokhara

Table 3. Area and production trend of finger millet in Nepal

	Area (ha)				Production (tons)			
Dev. Region	**1998-99**	**1999-2000**	**2000-01**	**2001-02**	**1998-99**	**1999-2000**	**2000-01**	**2001-02**
Eastern Dev. Region	72938	70489	68741	68306	79189	76407	74509	70179
Central Dev. Region	66242	68866	63795	63126	76707	79330	71365	73083
Western Dev. Region	91156	87581	95610	93560	98403	98490	103096	104046
Mid western Dev. Region	21135	22900	21084	21127	23497	-	23331	23242
Far western Dev. Region	12479	13614	10658	12001	13574	15456	10551	12020
Total	**263950**	**363450**	**259888**	**258120**	**291370**	**269925**	**282852**	**282570**

Source: Central Bureau of Statistics (CBS), 2003

The finger millet species cultivated in Nepal is *Eleusine coracana,* whereas *E. indica* and *E. africana* can be found in the wild. Finger millet is the most preferred crop for making alcoholic beverages like *jandh, tumba, chjhang* and *rakshi*. These alcoholic beverages have cultural and religious importance in different ethnic communities. Recent agricultural statistics indicate that production and consumption of finger millet is decreasing in the country. The major reasons behind this trend in Nepal are believed to be the lack of awareness about its nutritional value and the lack of

easy-to-make products and recipes among consumers. The other reasons reported among farmers include the labour intensive production requirements, the low social status image attached to its food and the fact that more competitive crops are entering the market niche occupied so far by finger millet thanks to more efficient cultivation and value addition technology still missing for finger millet.

The most neglected aspect of finger millet research so far has been crop utilization, particularly with regard to the development of efficient and remunerative enterprises for delivering products to be sold directly in the market or to agro-industries (Sthapit *et al*., 1993). In this context, market based value addition activities were initiated under the project in partnership with private entrepreneurs. Development and diversification of millet food recipes contributed to increase local consumption. This in turn provided incentives to local producers on one hand and strengthened on-farm conservation together with food and nutritional security on the other. Thus, value addition through product diversification was found to be very effective to increase consumption of finger millet in rural and urban areas and provide good income incentives to the farmers for promoting the cultivation of this nutritious crop in a sustainable way.

5. Participatory surveys on uses, constraints and opportunities

The socioeconomic studies such as cost: benefit analysis of millet grain and beverage production, gender involvement in crop production and utilization, and marketing of millet and millet based products, were carried out through community-based work involving participatory rural appraisal (PRA), focus group discussions (FGD), key informant survey and field documentation.

5.1. Cost: benefit analysis of finger millet production

The cost of finger millet production was recorded from three farmers involved in seed production at Ralmare. Initially, it was recorded on per *Hall*[1] basis (1 *Hall*[1] = 2.3 *ropani*) for easiness which was then converted to hectare units. Similarly, the current farm gate price of millet grain and the straw in the Ralmare village was used to calculate the total income. The cost: benefit analysis showed that there was negative gross margin in cultivation of millet (Table 4). According to the farmers, the crop was not profitable in the region because of labour intensive production practices and lack of high yielding varieties under subsistence farming systems.

Although the cost: benefit analysis indicated that millet cultivation was not profitable, farmers were wisely utilizing their *bari*[2] land and at the same time the

[1]*Hall* is the local unit of the area ploughed by a pair of bullocks in a day which is equivalent to 2.3 *ropani* (1 *ropani*=500 m^2) in the hills in Nepal.
[2]*Bari* land is the unbonded upland suitable for growing finger millet crop

Table 4. Cost: benefit analysis (per ha) of finger millet production in Kaski in 2004

Items/activities	Unit	No.	Unit price (NR)	Total/ha (NR)
A. Cost of production				
Seedbed preparation	MD (Female)	10	75	750
Seed cost	*Pathi*	10	40	400
Farmyard manure	*Doko*	85	20	1,700
Labour for composting and fertilizer application	MD	10	75	750
Fertilizer (urea) for nursery	Kg	5	22	110
Land preparation for transplanting	Bullock (*Hall*)	8	300	2,400
Land preparation for transplanting	MD (male)	16	150	2,400
Seedling uprooting	MD (Female)	16	75	1,200
Transplanting	MD (Female)	60	75	4,500
Weeding	MD (Female)	40	75	3,000
Harvesting, threshing, cleaning , drying and storage	MD (Female)	40	75	3,000
Straw cutting	MD (Female)	25	75	1,875
Khaja[3] to workers	MD	225	12	2,700
Total cost (A)				**24,785**
B. Income				
Grain yield	*Muri*[4]	25	800	20,000
Straw yield	*Bhari*[5]	60	50	3,000
Total Income (B)				**23,000**
Gross margin B-A (NR)				**-1785**

Source: Field Documentation, 2004
* MD=Man Days

surplus family labour without compromising the alternative cost. This is because they do not have options to grow crops other than finger millet in these marginal lands. In real sense, there is a benefit to grow finger millet if the farmers have the option to utilize own family labour for its cultivation.

5.2 Cost: benefit of beverage production from finger millet

A key informant survey was undertaken with the people at Kalabang village involved in preparing alcoholic beverage from finger millet for home consumption. The results of the survey were validated through focus group discussions (FGD)

[3]*Khaja* means some kind of snacks provided to the workers during the work time
[4]*Muri* is a local unit of measurement. For finger millet, one *muri* is equivalent to 63 kg.
[5]*Bhari* is also a local unit of measuring straw as a by-product. One *bhari* is approx. 25 kg.

in the same village. The cost: benefit ratio was calculated on per *Bahan*[6] basis. The survey revealed that preparation and selling of alcoholic beverages seemed profitable (Table 5). The farmers could obtain net benefit of NR 13.5 per kg by selling good quality alcohol at the rate of NR 18 per bottle, which is a very attractive income for Nepalese small entrepreneurs.

Table 5. Cost: benefit analysis of beverage production at household level in Kalabang (per *Bahan*)

Particulars	Quantity	Unit cost (NR)	Total cost (NR)
Cost of preparation			
Millet grain	10 kg	12	120
Marcha[7] (cake)	25 (No.)	1	25
Firewood	1 *Bhari*	50	50
Water	200 lit.	0	0
Depreciation cost of utensils	Lump sum		10
Human labour (women)	1 MD	70	70
A. Total Cost			**275**
Income			
Alcohol 5 *pane*[8] (good quality)	20 bottles	18	360
By-product (*kat*)	5 kg	10	50
B. Total Income			**410**
Net profit (B-A)			**135**
Net profit (NR) per kg millet from alcohol preparation			**13.5**

Source: Key Informant Survey, 2004

5.3 Gender involvement in crop production and utilization

A household survey was conducted in the project villages with the aim to identify the role of male and female farmers in finger millet crop production, utilization and gender-based benefit sharing. The survey revealed that women superseded men in all the activities i.e. crop production, sale as well as access and control over the income obtained from millet irrespective of the sites and the communities (Table 6). In the *Gurung* community, males had very little role as compared to those in the *Brahmin* and *Chettri* communities except beverage production. The *Gurung* was a dominant ethnic community at Kalabang followed by disadvantaged groups whereas *Brahmin* and *Chettri* were the major ethnic groups at Ralmare.

[6]*Bahan* is the quantity used in preparing alcoholic beverage at a time that equals to 10 kg millet grain
[7]*Marcha* is a kind of cake and used as a catalyst in preparing alcohol at houshold level
[8]*Pane* indicates the quality of alcohol

Table 6. Gender involvement in crop production and utilization in Kaski (%)

Activities	Kalabang			Ralmare		
	Male	Female	Both	Male	Female	Both
Field selection	13.7	68.6	17.6	8	48	44
Variety selection	9.8	84.3	5.9	4	60	36
Millet cultivation	7.7	92.3	0	10	44	46
Millet sale	11.1	88.9	0	5.3	47.4	47.4
Price determination	7.7	88.5	3.8	5.1	38.5	56.4
Recipe preparation (food items)	3.9	96.1	0	4.1	63.3	32.7
Alcoholic beverage production	4.0	92.0	4.0	0	100.0	0

Source: Field Survey, 2003

5.4 Marketing of millet and millet based products

A market study on the supply of finger millet and its products in urban and peri-urban areas of Pokhara was also successfully carried out. Data related to the work of four entrepreneurs involved in production and marketing of finger millet and value added products, were included in the study. Sital Agro-Products was involved in the supply of millet grain and its flour and other entrepreneurs such as Annapurna Pouroti, Taja Pouroti and Kundhar Khaja Udyog were involved in production and marketing of value added products in Pokhara.

The initiatives on value addition and market promotion increased the demand and consequently the sales of finger millet (grain and flour) by Sital Agro-Products more than 3-folds in the market of Pokhara during the period 2002-04 (Fig. 4). This was due to the increased awareness among health conscious groups (diabetics and intellectuals) and to the development of diversified products targeted to different category of people, both activities carried out through the IFAD-NUS project.

Similarly, the sale trend of millet products sold by the entrepreneurs slowly increased and diversified over time (Fig. 5) and as a result, millet products became

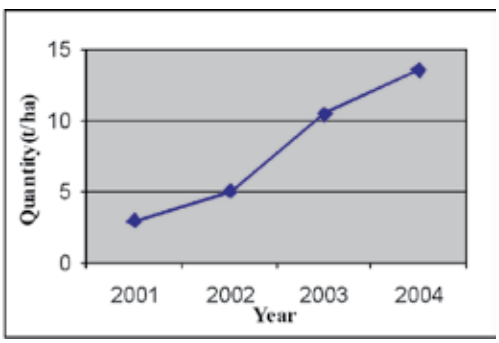

Fig. 4. Trend in sale of finger millet by Sital Agro-Products

Fig. 5. Trend in finger millet products marketing by entrepreneurs in Pokhara

more popular among the consumers in Pokhara. The consumers of finger millet included intellectuals, diabetics, young people and members of the *Thakali* community. The health conscious group preferred malt, bread, rolls and *knophe* whereas young people demanded cookies more than other products. Similarly, *knophe* was the product especially targeted to *Thakali* community due to its name derived from the language used by this community. However, the marketing demand of such products was less as expected because of the high cost and hence the market linkage was not sustainable indicating the need for further research on developing low cost technologies to produce diverse food products.

6. Genetic resources, evaluation and selection

6.1 Materials used and source of accessions

LI-BIRD received twelve promising lines, namely, GPU 25, GE 18, GE 122, GE 356, GE 357, GE 1024, GE 5001, GE 5016, GE 5176, Acc. 523-1, Acc. 2827-1, Dalle 1 and a released variety Okhale 1 from Hill Crops Research Programme, National Agricultural Research Council (NARC), Kathmandu in the first year of project implementation. At the same time, locally available landraces were collected from areas in and around project villages with the aim to test these in project sites. In total, eight different landraces were collected from both locations and the adjoining villages of Kaski site in 2003. Among them, two were rare types and six were commonly existing types. These local landraces were provided to Hill Crops Research Programme for *ex situ* conservation in the genebank as well as for future crop improvement programme.

6.2 Varietal evaluation

Diversity block was used as an entry point to test and screen promising lines and varieties in the project villages. In the first year (2002), farmers preferred lines and varieties including the local variety to include in participatory variety selection (PVS) (Table 7). The major criteria for selection were higher production potential in terms of grain and straw yield as well as boldness of grain. Farmers preferred those varieties that produced not only high grain yield but also higher straw yield to feed their livestock. The promising lines and varieties selected in 2002 were GPU 25, ACC.523-1, GE 5016, GE 122 and Okhale1. Popular local landraces Kallo Dale and Kallo Jhyape of project villages also performed better in Kaski district. These results reaffirmed the importance of finger millet as a livelihood asset of the poor in view of its multiple benefits (both for food and feed) and validating its role in sustainable agro-ecosystem practices.

The collected landraces from both LI-BIRD and NARC were also evaluated along with a released variety Okhale 1 used as check in farmers managed diversity blocks across project sites in 2003 (Table 8). The farmers selected Kalo Jhyape, Seto Dalle, Kalo Dalle and Chitwane among the landraces. However, out of 15 landraces, three landraces, namely, Seto Jhyape, Seto Kodo and Kalo Jhyape were already popular farmers' varieties in Kaski.

Table 7. Performance of finger millet genotypes in diversity block in 2002

S. No.	Genotype	Days to 75% maturity	No. of fingers/ head	Plant height (cm)	Grain yield (q/ha)	Farmers' observation	Decision
1	GE 356	136.5	7.55	77.45	19.4	Low yield	Rejected
2	GPU 25	143.5	7.70	73.75	29.0	Bold grain	Selected
3	Dalle	142.0	7.45	73.70	12.9	Low yield	Rejected
4	GE 18	131.5	6.45	74.85	13.7	Low yield	Rejected
5	GE 5001	136.0	5.65	58.40	22.1	Severe disease	Rejected
6	GE 357	137.0	7.35	78.40	14.5	Low yield	Rejected
7	GE 5016	144.5	8.05	86.30	24.9	Bold grain	Selected
8	GE 1024	142.5	6.75	90.30	25.1	Severe disease	Rejected
9	ACC.523-1	144.0	6.75	99.65	28.4	-	Selected
10	ACC.2827-1	139.5	6.15	76.55	15.0	Medium yield	Rejected
11	Okhale 1	139.0	7.60	97.45	23.9	-	Selected
12	GE 122	139.0	7.05	91.75	21.5	-	Selected
13	GE 5176	133.5	6.35	81.00	26.2	very early, severe disease	Rejected
14	Popular local	145.5	7.10	80.90	31.6	-	Selected
	Average ± SD	139.57 ±4.3	6.99 ±0.68	81.46 ±10.88	22.2 ±0.59		

6.3 Participatory variety selection

Participatory variety selection (PVS) is a farmer-participatory approach for identifying improved crop cultivars or varieties. It is a rapid and cost-effective process of identifying farmer-preferred cultivars. In 2003, six varieties/genotypes (Okhale, GPU 25, GE 0122, GE 5176, GE 5016 and ACC.523-1) identified from on-farm evaluation in 2002, were distributed to many farmers to compare their performance over farmers' local variety. Average performance of PVS varieties for quantitative traits like maturity, plant height and grain yield were recorded from farmers' fields. Farmers ranked PVS varieties from their own perspectives in each site. The performance of PVS varieties is given in Table 9.

Similarly, four promising varieties (Okhale 1, GPU 25, ACC.523-1 and GE 5016) were tested in 64 farmers' fields under PVS in 2004 for further testing and scaling-up in and around project villages. The PVS activity was implemented in collaboration with two women farmers' groups, namely, Marga Joyoti POWER Women Group and Community Development Women Group at Kalabang and Ralmare sites, respectively. Each farmer was given one variety to compare with the local variety. The performance

Table 8. Performance of local landraces of finger millet in diversity block (2003)

S. No.	Landrace	Maturity (days)	Plant height. (cm)	Grain yield (q/ha)	Disease score		Overall acceptance *	Head type
					CLS (1-9)	Blast (1-9)		
1	Seto Jhyape	133.0	80.0	23.2	3.5	3.0	4.5	0pen
2	Seto Kodo	128.0	69.5	15.8	5.0	4.0	6.0	Close
3	Kalo Jhyape	129.0	93.4	24.4	4.0	3.0	3.5	Open
4	Seto Dalle	126.5	89.7	23.1	3.5	2.5	3.5	Close
5	Kukurkane	129.0	85.7	21.3	5.0	4.0	5.0	Incurved
6	Kalo Dalle	128.0	79.0	20.1	3.5	3.5	4.0	Close
7	Mudke Kodo	126.5	80.5	20.9	4.5	3.5	5.5	Close
8	Panheli Kodo	126.0	96.4	24.8	4.5	3.5	5.5	Incurved
9	Panheli Mudke	132.5	77.1	20.2	4.0	3.0	4.5	Close
10	Chamre Kodo	126.5	89.3	26.7	4.0	3.5	4.5	Incurved
11	Okhale	120.5	104.2	32.0	3.0	3.0	4.0	Incurved
12	Jalbire Kodo	130.0	82.8	26.8	4.0	4.0	5.0	Open
13	Chaure Kodo	120.0	82.8	28.6	4.5	4.5	5.5	Incurved
14	Chitwane	121.0	68.0	30.2	3.5	3.5	4.0	Close
15	Popular local	138.0	97.0	24.0	3.0	3.0	3.0	Open/close
	Mean ±SD	127.63 ±4.84	85.03 ±10.13	24.1 ±0.43	3.97 ±0.64	3.43 ±0.53	4.53 ±0.88	
	Maximum	138.0	104.2	32.0	5.0	4.5	6.0	
	Minimum	120.0	68.0	15.8	3.0	2.5	3.0	

CLS: *Cercospora* leaf spot
*Lower number means better performance and acceptability

Table 9. Performance of PVS varieties over farmers' local in Kaski (2003)

S. No.	Varieties	Maturity (days)	Plant height (cm)	Grain yield (q/ha)	Remarks
1	Okhale	117	110.35	27.8	Selected
2	GPU 25	127	86.70	33.7	Selected
3	GE 122	115	94.55	23.4	Rejected
4	GE 5016	132	103.40	29.3	Selected
5	GE 5176	116	89.60	16.9	Rejected
6	ACC.523-1	129	100.35	26.8	Selected
7	Farmers' local (Check)	127	96.10	28.5	

of PVS varieties over farmers' local variety under farmers' management conditions was compared. Data and information were collected through field observations and

focus group discussions (FGDs). The performance of these varieties with regard to incidence of diseases and other important agronomic traits was assessed during stakeholders' visits arranged by experts from LI-BIRD, HCRP and District Agricultural Development Officers in Kaski during the maturity stage of the crop (Fig. 6). Household surveys were also carried out to obtain farmers' perception on maturity, plant height, disease infestation and grain yield after crop harvest. Besides their own local variety, the farmers preferred PVS varieties GPU 25 and ACC.523 (Table 10).

Fig. 6. Stakeholders' field monitoring at Kalabang village

The farmers' response on PVS varieties is given in Fig. 7. The farmers identified and verified ACC.523-1 and GPU 25 varieties as promising among all PVS varieties and appreciated their value in adding varietal diversity to the area under millet cultivation. They preferred variety ACC. 523-1 due to its high grain and straw yield, early maturity, and bold grain whereas GPU 25 was preferred in view of its bigger ear head, bold grain and high grain yield. ACC. 523-1 was found promising for mid-hills (1,000-1,500 m asl) whereas GPU 25 performed better in lower hills (<1,000 m asl). As regards seed production, 57.1% and 36.4% farmers saved the seed of ACC.523-1 and GPU 25, respectively in 2004. Seed production of farmer

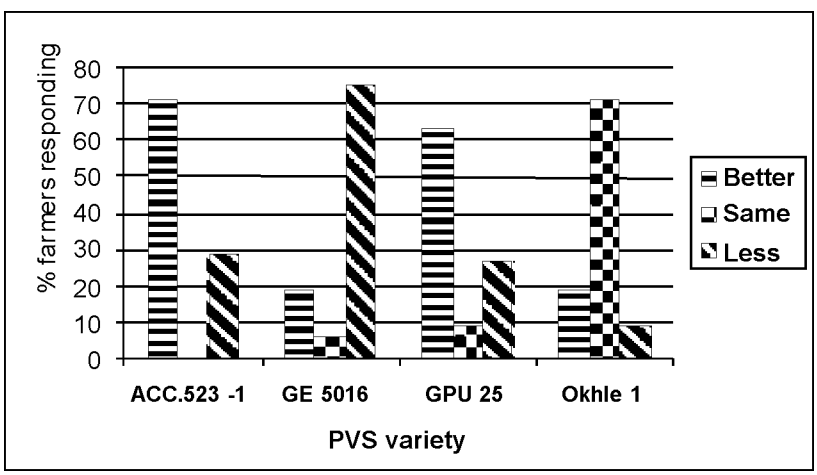

Fig. 7. Farmers' response on PVS varieties in 2004

Table 10. Farmers' responses (numbers) on the performance of PVS varieties in project villages in 2004

Characters	Varieties	Better	Worse
Plant height	ACC.523-1	4 (57.1)	0
	GE 5016	5 (31.2)	0
	GPU 25	2 (18.2)	1 (9.1)
	Okhale 1	12 (57.1)	1 (4.8)
Disease/ pests incidence	ACC.523-1	1 (14.2)	3 (42.9)
	GE 5016	3 (18.7)	6 (37.5)
	GPU 25	1 (10)	3 (30)
	Okhale1	0	10 (50)
Maturity	ACC.523-1	6 (85.7)	0
	GE 5016	6 (37.4)	5 (31.3)
	GPU 25	4 ((36.4)	2 (18.2)
	Okhale 1	14 (70)	2 (10)
Head size	ACC.523-1	5 (71.4)	2 (28.6)
	GE 5016	6 (37.5)	9 (56.2)
	GPU 25	7 (63.6)	3 (27.3)
	Okhale 1	9 (42.9)	2 (9.5)
Grain size	ACC.523-1	4 (57.1)	2 (28.6)
	GE 5016	14 (87.5)	0
	GPU 25	10 (90.9)	1 (9.1)
	Okhale 1	10 ((50)	2 (10)
Grain yield	ACC.523-1	5 (71.4)	2 (28.6)
	GE 5016	4 (25)	9 (56.3)
	GPU 25	6 (54.5)	3 (27.3)
	Okhale 1	2 (9.5)	7 (33.3)

Figures in the parentheses indicate percentage respondents

preferred varieties and landraces was also carried out to make easy access of quality seed to the farmers in and around the project villages by organizing farmers in groups. They produced and supplied 370 kg seed of selected varieties/genotypes during 2004.

These two varieties were also disseminated and tested through PVS and informal research and development (IRD) activities in collaboration with District Agricultural Development Offices (DADOs) of Kaski, Syanjya and Myagdi districts in 79 farmers' fields in 2004. The response from the surveys carried out by DADOs revealed that farmers preferred the varieties GPU 25 and ACC.523-1. Also, all the participating farmers saved the seed of these varieties for the following year planting. The household survey also revealed that 45 non-participating farmers demanded the seed of GPU

25 from the participating farmers in Kaski district. This clearly indicated possible spread of PVS varieties within the district through farmer to farmer network. In Syanjya district, majority of farmers (60%) responded that Okhale 1 produced lower yield as compared to the local landraces.

The adaptability of the local landraces was found to be much site specific because almost all local genotypes collected from locations other than Kaski performed poorly in diversity block under farmers' inputs and management conditions. This strongly supported the on-farm conservation and promotion of locally adapted landraces. However, some of the landraces such as Kalo Jhyape in Kaski district and Chitwane in Nuwakot district performed equally better across sites in diversity blocks and were also preferred by the farmers.

6.4 Setting-up local seed supply system

Seed production of farmer preferred varieties and landraces identified through participatory variety selection (PVS) in 2002 and 2003, namely, GPU 25, ACC.523-1, Kalo Dalle and Samdhi Kodo, was initiated in both project villages. Standard seed production procedures (selection and rouging) were carried out in approximately 1 *ropani* (500 m^2) area for each variety. In 2004, the project produced 135 kg seed of four selected varieties (Table 11). The project also saved 72 kg seed for distribution to farmers through the network of DADOs of this region in 2005 season for further popularization.

Table 11. Seed production of farmers' preferred varieties in 2004

Variety	Seed produced (kg)			Seed saved (kg)
	Kalabang site	Ralmare site	Total	
GPU 25	-	45	45	20
ACC. 523-1	40	-	40	20
Kalo Dalle	30	-	30	22
Samdhi Kodo	-	20	20	10
Total	**70**	**65**	**135**	**72**

6.5 Farmers' contribution towards on-farm conservation and landrace enhancement

Since the crop genetic resources are eroding very fast, the project duly emphasized on the need for conservation of finger millet germplasm through various approaches. Eight landraces including the two rare landraces, Urso and Kukurkane, were collected and sent to national programme for *ex situ* conservation in the genebank. The farming communities also maintained diversity blocks of different varieties to provide seeds in the villages. Another important aspect of genetic resource conservation was the landrace enhancement meant to increase production and productivity. Every year, farmers' groups in each site established diversity blocks (plot size 4 m^2 each) with

the aim to evaluate local landraces and improved varieties on-farm under farmers' input and management practices. This also served as demonstration block as well as seed source to farmers from where they could obtain seed of their preferred landraces for planting next year.

After two years of project implementation, farmers' groups with the support from LI-BIRD initiated grass-root breeding in finger millet in collaboration with NARC/Hill Crops Research Programme. The project strategically selected one landrace for each of the two project villages (Kalabang and Ralmare) based on the information obtained from survey, group discussions and other sources. Four square principles of varietal dynamics based on average area and number of households growing the landraces were used to select landraces for enhancement work. The popular landrace, Kalo Dalle, grown in larger area by many households (55.7%) due to its unique characteristics (i.e. tolerant to hailstone) was selected for Kalabang. In Ralmare, the rare landrace, Samdhi Kodo with unique trait of whitish grain, though grown in smaller area by few households (4%), was selected. The main objective of such germplasm enhancement was to purify farmers' landraces to supply quality seed that also helped for its long-term conservation. These landraces are being conserved on-farm by a number of households in the project villages (Table 12).

Table 12. On- farm conservation of finger millet landraces in project sites in Kaski

Landraces	No. of HHs growing finger millet (%)		Average area/HH (m^2)		Salient characteristics
	Kalabang	Ralmare	Kalabang	Ralmare	
Kalo Dalle	55.7	17.5	1,340	970	Tolerant to shattering, high grain yield, late variety
Seto Dalle	34.2	7.2	597	1,016	Shattering prone, medium in maturity
KaloJhyape	1.4	43.2	250	1,297	Shattering prone, early maturity
Seto Jhyape	2.8	20.6	598	1,185	Good taste, early maturity
Dudhe Dalle	-	5.1	-	-	High grain yield, late maturity
Samdho Kodo	-	-	-	649	Whitish grain, low grain yield, preferred for *roti* and *powa*
Kukurkane	-	2	-	-	Less tasty, small grains, high grain yield

Source: Field Survey, 2003

The activities on collecting diversity from farmers' fields, and participatory selection focusing on preferred quality traits (grain yield, grain size and disease resistance) were undertaken in 2004. The farmers' groups were involved in further selection and evaluation of these materials. Farmers' groups of Ralmare provided 133 collected accessions of Samdhi Kodo (white millet) along with all

information to the national programme for continuity of work after the phasing out of this project.

7. Improved agronomic practices

7.1. Improved nutrient management

A comparative study on recommended doses of fertilizers vs. farmers' practice was conducted on finger millet at both the project villages in a plot size of 4 m^2 each. Three promising varieties (GPU 25, Okhale 1 and ACC. 523-1) and four landraces (Seto Kodo, Kalo Jhyape, Kalo Dalle and Khalse at Kalabang and Seto Jhyape at Ralmare) were included in each trial. NARC/HCRP recommended doses of nitrogen, phosphorus and potassium (50:30:0 kg/ha, respectively) were applied in finger millet crop. Generally, the farmers of project villages cultivated finger millet without applying chemical fertilizers but using farm yard manure (FYM) as organic fertilizer instead.

The results of the trial (Table 13) were not much encouraging because the increment in grain yield with recommended doses of fertilizers was very low (1.5-11.5%). Variety Kalo Dalle yielded low under recommended doses because of severe lodging at Kalabang site. Generally, it was observed that tall varieties (Okhale 1, Khalse, Kalo Dalle, Kalo Jhyape and ACC.523-1) suffered with lodging in the plots where recommended doses of fertilizers were applied at Kalabang. The team during monitoring also noticed that the soil at Kalabang was more fertile as compared to that at Ralmare village.

Table 13. Effect of fertilizers on grain yield of improved varieties and landraces of finger millet (2004)

Varieties	Grain yield (q/ha)						Yield increase (%)
	Farmers practice			Recommended fertilizers			
	Kalabang	Ralmare	Mean	Kalabang	Ramare	Mean	
Okhale 1	28.8	35.0	31.9	36.8	30.0	33.4	4.7
Local†	25.0	30.6	30.3	37.5	35.0	33.8	11.5
Kalo Jhyape	24.4	38.8	31.6	30.0	34.8	32.4	2.5
GPU 025	31.2	32.4	32.3	32.5	38.0	35.3	9.3
ACC 523-1	34.7	34.0	34.4	40.6	34.4	37.5	9.0
Kalo Dalle	37.5	37,5	37.5	30.0	39.2	34.6	-7.7*
Seto Jhyape	21.3	30.6	25.9	20.0	32.5	26.3	1.5

† Local variety: Khalse at Kalabang village and Samdhi Kodo at Ralmare village
* Reduction in grain yield due to lodging at Kalabang

7.2. Sole and mixed cropping system

Many farmers in Ralmare village of Begnas practice mixed cropping of finger millet with black gram. Therefore, a simple on-farm study on gross returns from mixed

cropping was conducted in 2003 at Ralmare site to see the comparative advantages from mixed and sole cropping of finger millet under farmers' management and input conditions. It was an exploratory study placed in four farmers' fields. The plot size was 6 m^2 (3 m x 2 m) for each treatment and the sowing was done on the same day as per farmers' practice. The crop was harvested separately and grain yield was recorded. This was then converted to monetary value as per the local price. The results of this exploratory study revealed that mixed cropping was economically rewarding since there was no additional cost for mixed cropping except seed (Table 14). The soil enriching property of black gram was an additional advantage. The results of this study opened scope for further research to standardize the mixed cropping system in future to make the cultivation of finger millet crop more profitable.

Table 14. Average grain yield and income from sole and mixed cropping of finger millet (2003)

S. No.	Treatment	Grain yield (q/ha)	Income (NR)	Gross income (NR)
1	Finger millet (sole)	20.3	24,360	24,360
2	Finger millet+	19.9	23,880	35,320
	black gram	2.6	11,440	
3	Black gram (sole)	7.9	34,760	34,760

Market price: Finger millet- NR 12.0/kg; Black gram- NR 44.0/kg
NR: Nepalese rupee

8. Value addition, product development and market promotion

There are several ways to add values such as through plant breeding including participatory plant breeding (PPB), sensitizing community and consumers (awareness on nutritive and medicinal value of traditional foods), creating market based value adding measures like improved processing, product diversification and policy incentives (Rijal *et al*., 2001). The experience of the earlier project on *in situ* conservation was capitalized for value addition through creating awareness and product diversification to increase consumption. In this project, LI-BIRD at Kaski site gave more thrust on creating awareness, product development, diversification and skill enhancement and dissemination through trainings and orientations.

8.1. Establishment of small pilot processing units at community level

The project has supported community groups to establish a micro-mill in each site (Fig. 8). A letter of agreement (LoA) was signed with these groups separately to establish and run the micro-mills so that they will manage and provide services to farmers at a reasonable cost and help to increase millet consumption in and nearby project villages. The women groups, namely, Marga Joyoti POWER Group of Kalabang and Community Development Group of Ralmare were given the responsibility for operating these micro-mills. The project provided practical orientations to the members of these groups for operation and record keeping and also suggested

them to establish a maintenance fund. These community groups were able to successfully run these mills and therefore provided good services to the members of the community at cheaper price. However, after the project support was over, it was reported that these micro-mills were not functioning well. Since these were smaller capacity mills, it was not possible to generate enough income even to support their maintenance and operation and hence was not cost effective. The results thus indicated the need for providing bigger mills to establish community processing units to meet the needs of the communities at Kaski site.

Fig. 8. Community operated micro-mill used in villages

In addition, a farmers' group of Kalabang village started millet grain collection and marketing. They used their own micro-mill and marketed the grain in 1 kg packets under the brand name 'POWER' in Pokhara city. Initially, these groups experienced some difficulties in running the mills effectively due to lack of technical knowhow for operation and maintenance of the micro-mill. But, after receiving practical training on mill operation in each site, they gained full confidence in the milling operations as well as on how to carry out minor repairs and maintenance of the equipment.

8.2. Development of value added products

In the past, there was no research on market based production and development in finger millet. It was primarily due to the fact that finger millet food was considered as low status food in Nepalese society. Hence, none of the entrepreneurs was interested to produce millet recipes targeting the consumers. Through the concerted efforts under the project, few entrepreneurs were identified who were innovative and interested to work in partnership for developing millet based products targeting particularly young consumers in Pokhara area. This process-led approach passed through many steps (Fig. 9).

The product development efforts were successful and resulted in the development of several new consumer preferred millet based products (Fig. 10) such as bread, noodles, *namkin*, malt, and other bakery items like rolls, cookies, cakes. Among these, Annapurna Bakery and Sital Agro-Products commercially produced and promoted cookies, bread, *namkin* and roasted millet malt that gained popularity in urban

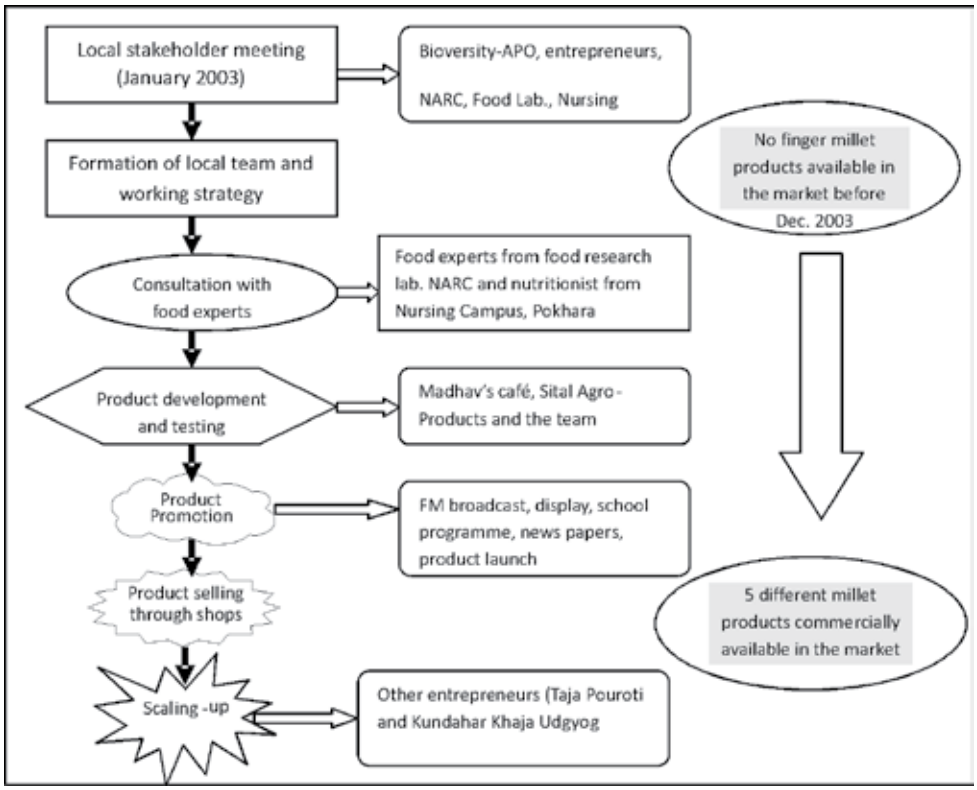

Fig. 9. Various steps of market based value addition in finger millet and its promotion in Pokhara, Nepal (Source: Bhandari *et al.*, 2004)

Fig. 10. Diversified millet products

market of Pokhara. But, after the project support was over, only three entrepreneurs continued to be involved and hence the scale of production did not increase as expected. Similarly, all the value added products developed and tested during project period were not sustainable in the market simply due to higher production costs and low consumer preferences. However, a few products like cookies, millet based malt and *namkin* were comparatively better accepted in urban markets, while rural recipes such as *selroti*[8], *namkin*, *halwa*, pancake, and *malpuwa*[9] gained popularity in rural areas around Kaski.

[8]*Selroti* is a kind of traditional food prepared from rice flour during religious ceremonies and festivals
[9]*Malpuwa* is a food item prepared from wheat flour and used for breakfast

9. Training and skill enhancement

The series of interactions and surveys revealed that one of the major reasons for decreasing millet consumption in the rural villages was the non availability of easy-to-make product recipes suitable for household preparations. In view of this, training programmes were organized under the project for developing millet based food recipes aiming at easy household preparations such as *selroti, halwa, namkin, malpuwa,* pancake porridge and soup. In total, 50 people including entrepreneurs, rural farmers, urban housewives and home science students were trained as resource persons (Fig. 11). These included 32 rural women who were trained as resource persons for skill transfer and creating awareness among villagers. Different food recipes were documented in Nepali vernacular language during the course of training and published as a booklet and also a video was produced with the financial support from another LI-BIRD project.

Similarly, five private entrepreneurs were trained to produce millet based bakery products targeting urban consumers. The project also involved students of the Home Science Department of Pokhara University and some interested urban women housewives, all trained as resource persons to disseminate further product diversification methods among user groups (Fig. 12).

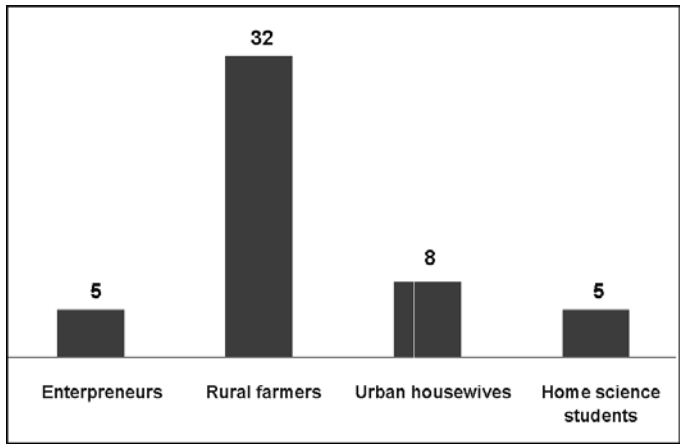

Fig. 11. Training to resource persons during 2002-04

10. Public awareness

The awareness and education activities such as diversity fairs, food fairs and festivals, FM radio broadcast, folk song competitions, etc. are important ways to create interest amongst the consumers for using local products (Pantha, 2002). Under this project, various activities targeting different categories of people were organized in order to raise awareness on the nutritional importance of finger millet as well as its value added products for promoting its wider consumption (Fig. 13). These included print materials, electronic media, fairs and festivals, workshops, folk song competitions, diversity fairs and school programmes. Besides, millet products were also linked with café, cooperative shops, supermarkets and schools for promotion.

Fig. 12. Product diversification training at Pokhara Tourism Training Centre

The listeners' survey and their correspondents had proved electronic media particularly FM radio a powerful tool in creating mass awareness among people living in rural as well as peri-urban areas. It greatly impacted in changing consumers' perception positively towards using millet foods in these areas.

Printed materials are the foundation of information dissemination contributing to increase public awareness. In view of this, two posters and three leaflets were developed under the project for display and distribution to the public. This created enormous awareness to the people particularly in urban and peri-urban areas on importance of finger millet for better health and nutrition and its value added products. As a result, the market demand of finger millet flour and grain in the urban markets of Pokhara was increased by more than 3 fold during 2002-04.

The experiences gained under the project clearly established that the school awareness programme was a good approach to reach to the young generations for creating awareness effectively (Box 2).

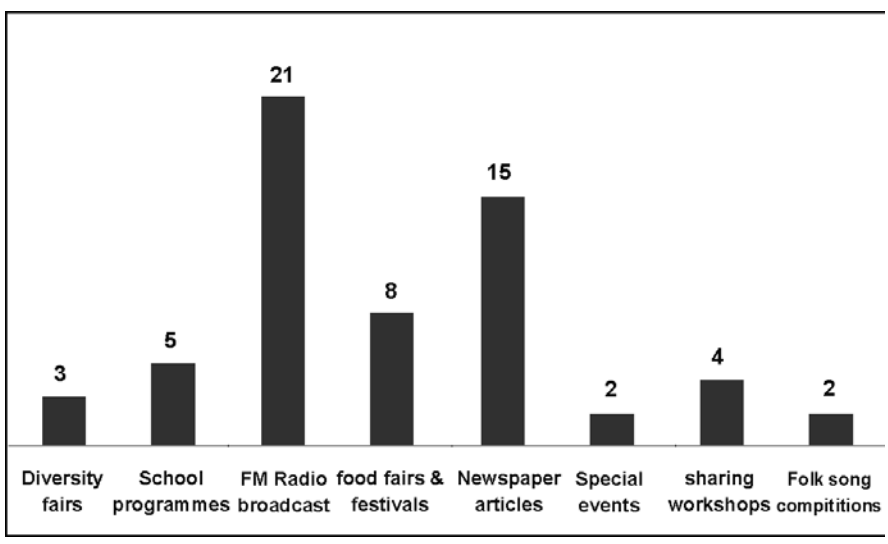

Fig. 13. Different categories of awareness programmes conducted and their frequencies during 2002-04

Box 2. Reaction of students participating in school programme

"The interaction programme is good, educative and informative. Initially, we used to think that millet food is not tasty but now we are clear that millet is really a tasty and healthy food "

"The millet products have better taste and the programme raised awareness about their importance to us. Now, we will of course, use millet products and will share this information with friends".

SOS school students, Pokhara

The students of Tarakunja Boarding School in Pokhara were encouraged to form a "Biodiversity Conservation Forum" and to organize many awareness activities for the conservation of biodiversity and promotion of local foods and culture. Similarly, fairs and festivals were used as good platforms for mass awareness that helped in promoting the traditional foods. Participation in these fairs helped greatly for refining the products, and accessing the markets before initiating commercial production. These proved to be the best fora to reach directly to the urban people for creating awareness through display, distribution, sale of products and dissemination of related information and getting feedback directly from them. The food fairs created ample awareness among the participants as perceived by themselves to think positively about millet foods.

Three national workshops were organized under the project which duly highlighted the project activities among scientists, extension workers, academicians and administrators in the country (Fig. 14).

The stakeholders were also invited on various occasions to attend/participate in project activities such as field monitoring, trainings, workshops/seminars and product launching functions. This proved to be very effective in creating awareness and changing the perception of policy makers towards the millet crop. The stakeholders' workshop finally recommended scaling up of such activities on a wider scale to promote the cultivation and use of finger millet in Nepal.

LI-BIRD also placed important project information on its website; www.libird.org which briefly covers project title, collaborators, project sites and major activities and outcomes.

Fig. 14. Stakeholders' sharing workshop at Pokhara

11. Policies

In Nepal, finger millet is considered as a food for the poor and thus no systematic efforts were made with respect to the conservation and promotion of this crop. Despite the importance of finger millet in the food and nutritional security of rural poor especially the disadvantaged ethnic groups, it was not given adequate emphasis in the research, extension and market promotion activities (Joshi and Thakur, 2002). The national policy mainly focused on improving food and nutritional security of the people by emphasizing on major crops and the commodities. The minor crops were conserved by the farming communities particularly for their specific use values. The results of the project clearly demonstrated the importance of finger millet to produce a wide range of economically viable diversified value added products and therefore the government should develop appropriate policy and legislation measures aimed at facilitating and encouraging the production, marketing and the use of neglected and underutilized crops such as finger millet, which are so important for improving the food security and nutrition of the people in the country.

12. Impact of the project

The project has created awareness about the importance of finger millet and its varietal diversity which has resulted in collecting and conservation of landraces and improved varieties of finger millet in the national genebank. As a result of the efforts under the project, market demand of finger millet grain and finger millet based products significantly increased. Training and skill enhancement for processing, value addition and product development encouraged the people for product diversification and enhanced use. The participants who received training on value addition and product development are now using their skills in developing value added products of finger millet. Many other farmers and community groups in rural and peri-urban areas also started capitalizing on their skills for diversified uses of millets on various occasions. Three trainees also initiated commercial production of finger millet products in Pokhara, mainly the malt, *namkin* and other bakery products. The project has been able to change farmers' wrong perception about finger millet as a low status food with low social dignity. The public awareness activities conducted under the project helped people to think differently and changed their perception about finger millet foods. Now, they have understood about the nutritional importance of finger millet and its benefits. In addition, rural people have gained skills on developing diverse millet products suitable for rural preparations through well organized trainings. Even after the completion of the project, rural people had been advocating its importance by organizing rural food fairs on various occasions. The women groups are generating small income by selling millet based diverse products. It has greatly helped in increasing millet consumption in the villages. Also, through public awareness efforts, finger millet is no more considered as a low status crop and the people now do not hesitate to offer millet foods even to the guests. The

project had also been able to attract attention of policy makers and planners to pay greater attention for research and development of finger millet in Nepal.

13. Constraints

Although significant efforts were made towards on-farm testing and screening of genotypes and the farmers tested the exotic genotypes and several landraces collected from Kaski and Nuwakot sites in Nepal but the landraces showed a high location-specific adaptation and most of exotic genotypes, though high grain yielders were not preferred due to being poor in other traits mainly low straw yield which is equally important for farmers since livestock is an integral part of Nepalese farming systems. Hence, availability of good germplasm was still one of the constraints to select and scale up for increasing finger millet production and productivity.

The farmer participatory landrace enhancement programme accomplished good results but could not be continued as there was no in-built mechanism to support this programme after the project period was over and therefore the selected material was handed over to the national programme for conservation and further use in future.

The market based value addition and its promotion through various public awareness activities targeting to consumers was also one of the important components under the project. Through training and skill enhancement activities, some private entrepreneurs were convinced and were involved in value addition activity through product development and its marketing. They also had some expectations from the project to support them mainly on product development technology and awareness since the value added products were being linked to the markets. However, fund limitation and also short duration of the project did not allow continuing support to these entrepreneurs.

14. Lessons learnt and recommendations

Although, this was a small project, it proved very effective in piloting value addition in finger millet crop for the first time in Nepal. A lot of interest was generated among the participating farmers, communities and entrepreneurs. This opportunity needs to be capitalized and the activities to be scaled up for creating a wider impact. Thus, a strong need was felt to provide further support for such initiatives by the national and international organizations and donor agencies. The national workshop organized at the end of project identified some lessons learnt from this project and suggested a few important recommendations.

14.1. Lessons learnt

- The participatory variety selection (PVS) can successfully identify farmers' preferred varieties and landraces and is quick in dissemination of these to farmers.
- Diversity block approach is a good method for the on-farm characterization

and identification of genotypes through PVS as well as study of disease reaction of local and improved finger millet cultivars.

- Landrace enhancement is a bettor option for increasing production and productivity of finger millet landraces in niche specific environments.
- Uniformity in grain quality and assured supply of raw materials is an essential perquisite to attract entrepreneurs and industries for commercial production of millet products.
- Trained personnel especially micro entrepreneurs need to be motivated for value addition, product development and marketing.
- Sensitization/public awareness can effectively play an important role for changing people's perception about finger millet and its foods that help increase millet consumption in rural and urban areas.

14.2. Recommendations

- The national programme should focus on developing demand based finger millet varieties and their dissemination.
- Disease resistant varieties should be used in breeding programme aimed at developing high yielding and widely adapted varieties.
- Scaling-up of farmers identified landraces and genotypes should be taken up through the national research and extension system.
- There is a need to strengthen research capabilities in product development and build capacity by providing necessary equipments and enhancing knowledge through training programmes. The farmers' groups or cooperatives should be revitalized and/or established for production and supply of good quality seed.
- Sincere efforts need to be made to explore possibilities and encourage micro-entrepreneurs to produce millet based products in potential millet growing areas.
- Concerted efforts should be made to sensitize the consumers through print, electronic media (FM Radio, TV), exhibitions, fairs and festivals, school/ college programmes, extension, training, seminars/workshops for creating mass awareness about the importance of millets for health and nutrition.

15. Publications

Based on the work done under IFAD-NUS project, the following publications were brought out:

Bhandari B., S. Gyawali, K.R. Chowin and R.P. Upreti. 2003. Farmers' production practice and finger millet diversity block in Kaski district. Proceedings of NUS-Finger Millet Project Workshop. NARC/LI-BIRD. 12 December, 2002.

Bhandari B., S. Gyawali, D.K. Rijal, B.R. Sthapit and P. Shrestha. 2004. Value addition and market promotion in finger millet crop: LI-BIRD's experiences.

Paper presented in 28th National Summer Crop Workshop. NARI, Khumaltar, Kathmandu. 28-30 June, 2004.

16. Acknowledgements

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Annexure I

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Annexure II

UN Millennium Development Goals - Five years later: Agricultural Biodiversity and Elimination of Hunger and Poverty

The Chennai Platform for Action

1. From the earliest days of domestication of plants for human use about 12,000 years ago, agricultural biodiversity has played a pivotal role in sustaining and strengthening food, nutrition, health and livelihood security all over the world. In spite of enormous progress made in enhancing crop productivity through Mendelian and more recently molecular breeding, more than 800 million children, women and men go to bed every day under-nourished. The majority of them are in South Asia and Sub-Saharan Africa, areas of the globe that are rich in endemic agricultural biodiversity. Reducing hunger and poverty by half by the year 2015 is the first of the UN Millennium Development Goals (MDGs), which represent a Global Common Minimum Programme for universal human security and well being. An assessment made five years after the adoption of the MDGs indicates that progress in reducing hunger and poverty is inadequate. It is in this context that the conclusions of an International Consultation on the role of agricultural biodiversity in achieving a sustainable end to hunger and poverty, recently held at Chennai, India, assume significance.
2. Endemic hunger caused by protein-energy malnutrition, hidden hunger caused by deficiencies of iron, iodine, zinc, Vitamin A and other micro-nutrients in the diet, and transient hunger caused by drought, floods, and other natural disasters can be overcome through an integrated strategy for the conservation and sustainable and equitable use of agricultural biodiversity. Even during the titanic tsunami of December 26, 2004, land races of rice were found in coastal Tamil Nadu, India, which could survive seawater inundation. Many life-saving crops like tubers and legumes were cultivated in the past and we urgently need to rekindle such dying wisdom and take steps to save vanishing crops, which can help to heal the wounds inflicted by natural or man-made calamities. Women, in particular, are holders of such traditional knowledge and the critical role of women in the conservation and sustainable management of agricultural biodiversity needs to be strengthened and revitalized. Tropical fruits, beta-carotene rich sweet potato and other vegetable crops can help to fight Vitamin-A deficiency in children. In other words, agricultural biodiversity provides uncommon opportunities for developing decentralized and locale-specific community food security systems involving field gene banks, seed banks and grain banks developed and managed by

local women and men. This approach will further help to enlarge the food security basket by including nutrition-rich but under-utilized crops. This is the most sustainable and affordable pathway to achieving the MDG in relation to elimination of hunger and poverty.

3. Agricultural biodiversity offers the crucial raw material for improving in perpetuity the productivity and quality of crops, livestock and fish. Goals such as "health for all" and "fish for all" can be achieved only by conserving medicinal plants and genetic diversity in fish. Agricultural biodiversity also offers opportunities, especially to the landless poor, for entrepreneurial initiatives, which will generate employment and income from a range of value-added foods, medicines, nutraceuticals, bio-fuel and other products. Such opportunities are of particular value, since today the inadequate income and purchasing power are the major causes of food insecurity at household level. The potential of agricultural biodiversity for coping with climate change is not well appreciated. In short, the "flagship role" played by agricultural biodiversity in overcoming hunger in an environmentally, economically and socially sustainable manner is yet to be widely realized and integrated with national and global strategies for achieving the MDGs. Better nutrition is also vital for fighting pandemics like HIV/AIDS and tuberculosis, since a drug-based approach alone will not lead to the desired results. The health foods of tomorrow will be mostly the under-utilized crops of today.
4. Agricultural biodiversity and cultural diversity have feedback relationships. Local farming systems provide the feedstock for poems, songs, dance and drama. Community-led food security systems based on the conservation, cultivation and consumption of local foods thus help to preserve cultural and ethnic diversity in crop and culinary preferences. Thus, agricultural biodiversity confers multiple benefits — ecological, economic, nutritional and cultural.
5. Taking cognizance of these unique strengths of agricultural biodiversity, the participants[1] at the International Consultation held on 18-19 April 2005 adopted the following **Chennai Platform for Action for a Hunger and Poverty Free World**. The Platform for Action is designed to assist national governments and international agencies to achieve as soon as possible the UN MDG relating to halving hunger and poverty by 2015 which therefore should:

[1]About a hundred experts and policy makers with varied backgrounds from 25 countries took part in an International Consultation at the M.S. Swaminathan Research Foundation in Chennai, India, on 18 and 19 April 2005. Our task was to consider how agricultural biodiversity can help the world to achieve the Millennium Development Goals, and in particular the goal of freedom from hunger and poverty. This was jointly organised by M.S. Swaminathan Research Foundation, International Plant Genetic Resources Institute and Global Facility for Underutilized Crops in cooperation with Swiss Agency for Development and Cooperation, Canadian International Development Agency, International Fund for Agricultural Development, Ford Foundation and Syngenta Foundation for Sustainable Agriculture.

i. Recognize that incorporation of agricultural biodiversity conservation and sustainable use in national development plans, such as Poverty Reduction Strategies, along with the creation of cross-sectoral linkages and coherence among concerned Ministries at national level, is important for the delivery of this Millennium Development Goal.
ii. Agree to incorporate agricultural biodiversity in the implementation of existing global policy tools, such as Food-Based Dietary Guidelines and the WHO/FAO Global Strategy for Diet, Physical Activity and Health.
iii. Introduce legislative measures to use land and other natural production resources to enhance the ability of all to make use of agricultural biodiversity and its associated traditional knowledge for promoting off farm employment and income generation in harmony with traditional rights, cultural identity, ecosystem integrity and gender equity.
iv. Strengthen the multilateral system of exchange provisions of the FAO International Treaty on Plant Genetic Resources for Food and Agriculture to expand its coverage of plant species important to food security and income generation for the poor, while ensuring fair and equitable benefit sharing of commercial gains accrued from accessed genetic resources, and work towards a similar treaty on multilateral exchange of animal genetic resources relevant to food and agriculture.
v. Recognize and reward the invaluable contributions of rural and indigenous people, particularly women, in the conservation and enhancement of agricultural biodiversity and confer social prestige and economic benefit to its primary conservers.
vi. Promote local markets and facilitate access to international markets for the products of agricultural biodiversity, especially traditional and functional foods, ensuring equity and fairness amongst all participants.
vii. Advocate and strengthen national nutrition literacy through participatory knowledge management involving all societal segments, particularly women and young people, and train agricultural extension workers and health and nutrition professionals in the importance of dietary diversity and evidence-based beneficial effects of traditional foods to re-establish the relevance of regional agricultural biodiversity in fighting hunger and poverty.
viii. Ensure that food and nutrition support safety net programmes, especially food aid and school feeding programmes as well as food banks, are fostering greater dietary diversity by broadening the food basket with more indigenous crops as part of National Nutritional Policy.
ix. Restructure research and development priorities to enhance productivity, profitability and value chain development of a wider range of agricultural biodiversity, including hitherto neglected species, thereby generating an economic stake in their conservation.

x. Bring in change in mind-set to prevent the perennial loss of vanishing crops and dying wisdom through international initiatives to change the public image of under-utilized and orphan crops by steps such as re-designating "coarse cereals", where appropriate, as "nutritious cereals", and classifying a wide range of leafy vegetables, tubers, grain legumes and tropical fruits as "health foods". Saving plants for saving lives and livelihoods should become everybody's business, thereby leading to a global "agricultural biodiversity for human security" movement.

The global struggle against poverty and hunger cannot be won now or in the long run without increased international collaboration in the conservation and sustainable and equitable use of agricultural biodiversity. International commitment is imperative for actions on some of the recommendations listed above, while national initiatives can act upon others. We urge all to employ those approaches and practices that are most relevant in their individual situation and to put in place their own detailed plans to make better use of agricultural biodiversity to achieve the Millennium Development Goal on hunger and poverty. The fact that, five years after the adoption of the MDGs, most developing nations are unable to make proportionate progress in the elimination of hunger and poverty indicates that a "business as usual" approach will not help us to achieve the goal of a hunger-free world. Equally concerning is the human population growth rate, which continues to exceed the growth rate in food production, aggravating the poverty-induced endemic hunger. Where hunger rules, peace cannot prevail. Hence, the time has come to embrace the idea of a decentralized and community-managed sustainable nutrition security system based on expanded agricultural biodiversity.

Acronyms

ABD	:	Agriculture Botany Division
ABPSD	:	Agri-Buisiness Promotion and Statistical Division
ADO	:	Agriculture Development Office
AICSMIP	:	All India Coordinated Small Millet Improvement Project
AIDS	:	Acquired Immune Deficiency Syndrome
APO	:	Asia, Pacific and Oceania
ARF	:	Amylase Rich Food
ARS	:	Agricultural Research Station
asl	:	Above Sea Level
CBS	:	Central Bureau of Statistics
CFF	:	Crops for Future
CFTRI	:	Central Food Technology Research Institute
CGIAR	:	Consultative Group on International Agricultural Research
CIAE	:	Central Institute of Agricultural Engineering
CIDA	:	Canadian International Development Agency
CLS	:	Cercospora Leaf Spot
DADO	:	District Agricultural Development Office
DAP	:	Di-Ammonium Phosphate
DMRT	:	Duncan's Multiple Range Test
DOA	:	Department of Agriculture
DRHS	:	Department of Rural Home Science
FAMPAR	:	Farmer Managed Participatory Rural
FAO	:	Food and Agriculture Organization of the United Nations
FB	:	Finger Blast
FGD	:	Focus Group Discussion
FLD	:	Front Line Demonstration
FM	:	Finger Millet
FMGEY	:	Finger Millet Grain Equivalent Yield
FSN	:	Food Science and Nutrition
FSV	:	Farmer Selected Varieties
FYM	:	Farm Yard Manure
GFAR	:	Global Forum for Agricultural Research
GFU	:	Global Facilitation Unit for Underutilized Crops
GIS	:	Geographic Information Service
GKVK	:	Gandhi Krishi Vignana Kendra
HCRP	:	Hill Crops Research Programme

HH : House Holds
HIV : Human Immunodeficiency Virus
HNIS : Human Nutrition Information Service
HP : Horse Power
IAEA : International Atomic Energy Agency
ICAR : Indian Council of Agricultural Research
ICDS : Intensive Child Development Scheme
ICRISAT : International Crop Research Institute for Semi-Arid Tropics
ICUC : International Centre on Underutilized Crops
IDRC : International Development Research Centre
IFAD : International Fund for Agricultural Development
IM : Italian Millet
INR : Indian Rupee
IP : Improved Practice
IPGRI : International Plant Genetic Resources Institute
IPM : Integrated Pest Management
IRD : Informal Research and Development
ISBN : International Standard Book Number
KDS : Kami (blacksmith), Dami (tailor), Sarki (Shoemaker)
KVK : Krishi Vigyan Kendra
LEISA : Low External Input and Sustainable Agriculture
LI-BIRD : Local Initiatives for Biodiversity Research and Development
LM : Little Millet
LoA : Letter of Agreement
LV : Local Varieties
MD : Man Days
MDG : Millennium Development Goal
MEDEP : Micro-enterprise Development Project
MSSRF : M.S. Swaminathan Research Foundation
MWF : Malted Weaning Food
NARC : Nepal Agricultural Research Council
NARI : Nepal Agricultural Research Institute
NB : Neck Blast
NGO : Non - Governmental Organization
NR : Nepalese Rupee
NUS : Neglected and Underutilized Species
OM : Organic Matter
ORD : Outreach Research Division
OUAT : Orissa University of Agriculture and Technology

PDS : Public Distribution System
PPB : Participatory Plant Breeding
PRA : Participatory Rural Appraisal
PVS : Participatory Variety Selection
RCBD : Randomized Complete Block Design
SDC : Swish Agency for Development and Cooperation
SHG : Self Help Group
TP : Traditional Practice
UAS : University of Agricultural Sciences
UN : United Nations
US : United States
USA : United States of America
USDA : United State Department of Agriculture
VDC : Village Development Committee
VPKAS : Vivekananda Parvatiya Krishi Anusandhan Sansthan
WHO : World Health Organization
WIST : Women in Science and Technology

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