Mobilizing Neglected and Underutilized Crops to Strengthen Food Security and Alleviate Poverty in India

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The M.S. Swaminathan Research Foundation, Chennai in collaboration with Bioversity International, Rome has been implementing a project on neglected and underutilized crops with the support of the International Fund for Agricultural Development, Rome. The neglected and underutilized crops chosen for this study included finger millet (*Eleusine coracana*), Italian or foxtail millet (*Setaria italica*) and little millet (*Panicum sumatrense*). Two locations where these crops have been traditionally under cultivation and intrinsically linked with food security, livelihood and cultural identity of local tribal communities, were chosen as target sites. These crops by virtue of their extremely high resilience to the harsh agro-climatic conditions, particularly in marginal soils, hilly terrain and under aberrant rainfall, are well adapted to offer a dependable level of food security to the poor. They are also valued for their better nutritious profile of the grains and high quality straw. The grains have high bio-available minerals, particularly calcium and iron, vitamins, dietary fibre, and other phyto-chemicals. Their unique physico-chemical composition renders them slow digestible and with low glycemic index, which is a valued nutraceutical property in food grains. The long shelf life of these grains is also an attribute preferred by the communities living in regions characterized by poor communication.

A unique aspect of this study was that major activities were carried out in farmer participatory mode with a location specific blend of traditional and scientific know how. Major activity components and their outcome in enhancing food and nutritional security and income generation of the communities discussed in the paper are participatory seed selection, shift from marginal to modern crop management, seed selection and quality seed production and sharing, promotion of local landraces, value addition of grain and value chain development to achieve enhanced income, particularly to farm women, multifaceted capacity building, strengthening of common property local infrastructure and creation of community institutions for building sustainability to the change. The paper also discusses the increasing relevance of these crop species in the context of advancing climate change.

Key Words: Food security, Underutilized crops, Millets, Value addition, Participatory variety selection, Gene-seed-grain bank, Self help groups, Landraces

Introduction

The agriculture of biodiversity rich India is known for cultivation of few hundreds of species where in the process over historic period had evolved variable wealth of genetic diversity in all these species. While about 7,000 plant species are found useful in agriculture, only about 150 species among them are largely used and less than 30 plant species meet about 90 per cent of world's food requirement. The more recent intensification of agricultural research, production and associated policy support at the national and global levels had been narrowing the species base with emphasis only on a few of them belonging to cereal and other crop groups, while many species are left out of priority. Such shrinking species content in the food basket is a matter of major concern (Prescott and Prescott, 1990; Frison *et al.,* 2006; Swaminathan 2005). On the food front, currently about 60% of calories and 50% proteins are derived only from three major cereals, rice, wheat and maize (FAO, 1995). This process has resulted in the marginalization of a large group of locally important crops, appreciated by communities because of their adaptability to marginal farming conditions, relevance to local food culture and diverse nutritional values and nutraceutical advantages. These crops belonging to categories such as cereals and pseudo cereals, legumes, vegetables, oilseeds, roots and tubers, aromatic and medicinal plants, fruits and nuts, have earned collective names such as 'neglected and underutilized' or 'forgotten','orphan', 'minor' crops (Padulosi *et al.,* 2004, 2008). Many of these species are relevant to the poor people in many parts of the world. As important component of local crop diversity, they exert significant influence on the cultural traditions and diversity and contribute to the self-identity, self-esteem and visibility of local communities (Thies, 2000; Williams and Haq, 2002). The extraordinary hardiness of many of these species and their ability to cope with adverse growing and climatic conditions offer great promise in the era of climate change (Bala Ravi *et al.,* 2006). In this context, they are the 'crops of the future'.

The production systems followed in the cultivation of these crops are usually very marginal, largely based on local landraces conserved by farmers, with least or no external inputs or often under default organic farming. Their continued neglect, in spite of their resilience and strength in providing a favourable harvest under very marginal production situations of arid, hilly and mountainous regions, is leading to the rapid loss of their competitiveness, genetic resources as well as the associated traditional knowledge on production, processing and utilization. Their decreasing cultivation is being confined to fragile agro-ecological regions, which are largely inhabited by tribal or other socio-economically poor farming communities trapped below the poverty line (Bala Ravi, 2004). These crops are predominantly grown as mixed or inter crop along with fodder yielding cereals like maize or sorghum, grain legumes like chick pea or pigeon pea, and oil seeds like mustard or niger. The lack of technology for processing their produce and hence the continued dependence on traditional processing methods of high drudgery is also eroding their competitiveness. These are the motivations behind the farmer participatory studies undertaken by M.S. Swaminathan Research Foundation in collaboration with Bioversity International with the support of the International Fund for Agricultural Development. The results and conclusions reported here are based on the efforts of such investigations carried out during 2007 and 2008 seasons and involving 654 farm families in Tamil Nadu and Orissa States.

Materials and Methods

Three minor millets, finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*) and foxtail millet (*Setaria itallica*) were targeted by the work, focusing on eleven villages in Kolli Hills (Namakkal District, Tamil Nadu) and Kundura (Koraput District, Orissa), areas where such crops used to be or continue to be grown as traditional food. The three major objectives of the study are: (1) Promote conservation of genetic diversity of underutilized and neglected crops by encouraging their cultivation, consumption and commercialization; (2) Enhance the food security and income generation potential of target species through better use of genetic diversity, improved agronomic practices and marketing; (3) Build and strengthen the capacity of women and men farmers through need based trainings and infra-structure support. The study was initiated with a bench mark survey of socio-economic-technological status of the community in the domains of project intervention. This was done with a structured questionnaire and using samples of 105 and 148 households in Kundura and Kolli Hills, respectively. All local landraces of target species were initially identified and taken to on-farm conservation under the community managed Village Gene-Seed-Grain Bank approach developed and advocated by the MSSRF (2001). While practicing such on-farm conservation of all local landraces, farmers in each village were encouraged in participatory variety selection from scientifically laid out replicated variety trials comprising all land races and locally appropriate improved varieties. Introduction of improved varieties enlarged the genetic diversity accessible to farmers.

Participatory variety selection (PVS) in finger millet was conducted by using 26 varieties, including five local landraces and remaining improved varieties. Three trials were conducted in three villages with each variety grown in 3 x 3 m sub-plots and each trail replicated twice. At different stages of crop growth variety performance including their response to major disease (blast) was systematically recorded (in 1-5 scale) by the project staff. At physiological maturity stage, each farmer was requested to identify the best three visually determined varieties (in order of preference) from each replication and at each village location. The selection involved actively 116 farmers, including 65 women farmers. Care was taken that the decision of one farmer on selection is not prejudicing that of another. Focus Group Discussions at the trial sites revealed that farmers selected varieties using attributes like maturity duration, grain and straw yield, grain size, colour, appearance, taste and disease resistance, in their own way. The ranks given by the farmers to varieties selected by them were compiled using a scoring pattern of 5 points for first superior variety, 3 points for second superior and 1 point for the third superior variety. This ranking was assessed with data on average plot yield and disease response to determine the final variety selection.

Improved agronomic intervention had the following components: (1) Use of quality seeds of participatory selected varieties, including traditional varieties; (2) Promotion of density regulated row planting instead of the traditional broadcasting with high seed rate; (3) Structured intercropping of millet and non-millet traditional crops instead of their broadcasting as multi-species seed mix; (4) Promotion of use of farmyard manure and fertilizer with option to the farmer to choose either or both; (5) normalization of plant density by

thinning/transplanting and promoting weeding, inter-cultivation and often with a top dress, and (promotion of homestead vermin-compost production to replace farmyard manure and fertilizer. Several farmer participatory demonstrations on the said improved method were conducted in all villages together with traditional method in equal area. Data on cost-benefit aspects of both methods were collected. Field days were organized at a few of these demonstrations to sensitize other farmers on the merit of the advocated production system. The number of such demonstrations in Kolli Hills and Kundura were 4 and 5, respectively in 2007, and 7 and 15, respectively in 2008. While the main crop was finger millet in both Kolli Hills and Kundura, the intercrops in Kolli Hills were pigeon pea, little millet, mustard, *Dolichos* and maize and in Kundura pigeon pea, maize, niger and and black gram. Family labour was accounted in calcu -lating the cost of production.

During the last 30 years or so, small millets, which were the principal crops in Kolli Hills were substantially replaced by tapioca (Finnis, 2007), as the latter offers more than double profit. The local farmers who prefer millets for consumption are retaining very little area under millets as well as about 21 landraces of four millet species. However, shrinking area of cultivation is a growing challenge to the conservation of local agrobiodiversity. On the other end, surveys indicated that local communities retained an interest in consuming these grains. Participatory demonstrations were thus organized to promote finger millet cultivation as an intercrop with tapioca using a shorter duration variety and taking advantage of the slow early growth of tapioca. Seven such participatory demonstrations were conducted during 2007 and 2008. Data on crop competition and economics of production were also collected.

Value addition of millet grains is another strategic approach followed to enhance economic competiveness of these crops. Intervention in this domain was designed as to leverage the specific nutritional and nutraceutical advantages of these grains (Hulse *et al.,* 1980; Swaminathan, 1995; Chetan and Malleshi, 2007). As the farming community knew only the traditional processing methods, which is tedious, and traditional cuisine from these grains, training programmes on commercially attractive products were organized together with the Rural Home Sciences Departments of the University of Agricultural Sciences, Bangalore and Dharwad. Selected women farmers of several self help groups (SHGs) and farmers' clubs (FCs) organized in the project villages were deputed to these Home Science Departments to receive extensive practical training on development of different value added products, both traditional and novel and maintaining product quality and hygiene. Market orientation to the production of locally appropriate products was promoted by providing infrastructure such as flour mill, grain de-hulling unit and other facilities for processing and product packaging and labeling and training at group level with focus on women farmers.

Results and Discussion

Bench Mark Survey

The benchmark survey revealed that no farmer was aware of either improved varieties of these millets or their improved cultivation. The traditional practices of broadcasting millets as pure or mixed crop using high seed rate and no plant density regulation or inter cultivation provided a very low yield, which on average was 317 kg/ha in Kundura and 857 kg/ha in Kolli Hills. These gains, on an average, contributed to 58% of the daily grain intake and 100 per cent of households cultivated and consumed millets in Kundura, while in Kolli Hills millets constituted only 7% of the food basket and 39% of the households cultivated and consumed these grains. Cultivation of millets contributed only 2.8% to the household income in Kolli Hills, and 14.6% in Kundura. Prior to this project intervention, none of the farm households in Kundura and Kolli Hills knew about post harvest processing, value added product development and commercialization potential of such products. Average annual household income in Kolli Hills was Rs. 17,407, while the same in Kundura was Rs. 3,861. The house hold income from millet cultivation was 4% of total income, while that in Kolli Hills was 3.2%. According to the poverty level defined by the Indian Planning Commission (GOI, 2007) these income levels, all the households in Kundura and 65.5% of those in Kolli Hills were below the poverty line.

Participatory Variety Selection (PVS)

The advantage of participatory crop variety selection is well established (Witcombe and Virk, 2001; Witcombe and Joshi, 1996). Participation of farmers in seed selection with their strong traditional knowledge and the skill adds to their involvement and ownership to the technology. The results of farmer participatory selection conducted under the present study are presented in Table 1. Farmers' ranking showed the highest preference to Indaf 9, a variety

with showy head and long fingers, which was followed by GPU 48, GPU 45, GPU 28, and Subhra (a rare white grain variety). Analysis of variance across location data showed significant differences in grain yield among varieties. The relationship between the ranking of varieties on the basis of average yield (as seen in Table 1), and farmer selection index was fairly good. Particularly among the top ten varieties. The CD value showed that the yield differences between these ten varieties were not significant and the top four were significantly superior to the best local variety Badomandia. The top five varieties, Subra and all local varieties were chosen for propagation and seed conservation through the Village Gene-Seed-Grain Bank. All these improved varieties were found to be fairly tolerant to blast disease.

Yield Enhancement

Productivity improvement was planned with use of quality seeds of farmer selected varieties and deployment of improved production technology. The farmer participatory productivity enhancement demonstrations with options left to farmers on choice of intercrops and fertilizer application clearly brought out the comparative advantage of the improved practices over the traditional ones. The results from 31 trials conducted across two seasons at 11 villages in Kundura and Kolli Hills, provided clear trend on the impact of quality seeds and improved practices in increasing productivity and income from millets and millet based intercropping systems. The millet yield in Kundura, on an average, was two to three-folds higher than the traditional practice (Fig. 1). Here, millet farming is usually done with family labour and its exchange. On reckoning this labour in cost of production, it was observed that traditional millet cultivation resulted in a loss to several farmers due to low yield. As estimated in the benchmark survey, the grain yields and income from traditional millet farming practices were higher in Kolli Hills in comparison with the same in Kundura. Therefore, the average gain achieved by PVS seeds and improved practices was comparatively lesser here. The yield increase

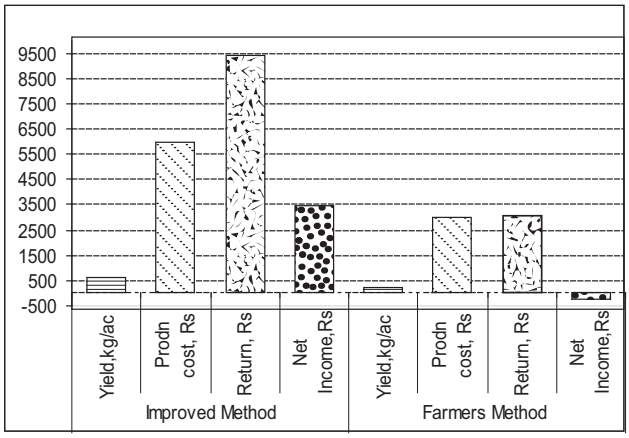

Fig. 1: Yield and income increase with improved method at Kundura

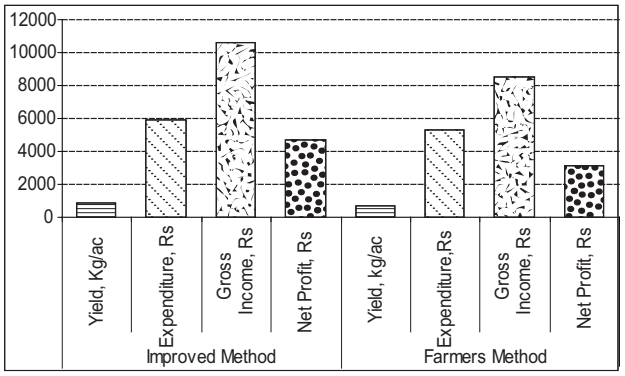

Fig. 2: Yield and income increase with improved method at Kolli hills

Table 1. Over all PVS score and grain yield of varieties studied at Kundura

Sl. No.	Variety	Av. yield (g/9m^2)	Farmers' ranking	Sl. No.	Variety	Av. yield (g/9m^2)	Farmers' ranking
1	GPU 28	2655.3	4	14	VL 149	1851.7	11
2	GPU 26	2644.3	10	15	Neelanchal	1790.5	14
3	PR 202	2514.8	9	16	RAU 8**	1780.5	15
4	GPU 45	2510.3	3	17	MR 33*	1763.5	17
5	GPU 48	2237.7	2	18	VR 708**	1692.5	6
6	L 5	2116.0	19	19	HR 91*	1685.8	23
7	Indaf 9*	2105.2	1	20	Badomandia	1677.5	25
8	PES 110**	2154.3	7	21	Birimandia*	1613.0	20
9	Indaf 5	2050.8	8	22	BM 91*	1577.8	13
10	Subhra	2031.0	5	23	Janhamandia**	1460.7	24
11	HR 374	1928.5	21	24	Dasahramandia*	1459.5	26
12	IE 3090	1855.5	18	25	Telugumandia	1396.2	16
13	OEB 10	1853.2	12	26	Dibyanshu**	1386.0	22
	Mean	1915.1			CD@5%	761.0	

Note: *, ** means varieties affected by leaf blast or leaf and finger blast, respectively.

from improved practices, however, was about 60% higher than that of traditional practices (Fig. 2). In terms of increased income due to improved practices, the gain was Rs. 7,536/ha in Kundura and Rs. 4,342/ha in Kolli Hills. When these millets were intercropped with the traditional intercrops either under improved or farmers' practices, the net income increased by 30% and 27%, respectively.

Finger Millet Intercrop in Tapioca

The purpose of this participatory trial was to demonstrate that a quick crop of finger millet could be raised from the very same land where tapioca is planted and thus the land could be profitably used to meet both food and cash needs of farm family. The short duration finger millet variety, GPU 48, matures in 90-95 days when tapioca plants reach the growth stage with 15-20 leaves and canopy width of about 40 cm, leaving sizeable inter-row space free. The growth of tapioca was monitored in both areas with intercropped and without intercrop. These results showed that finger millet intercropping with tapioca caused noticeable growth reduction to the latter, although this was compensated during rest of the growing period with no significant drop in tuber yield. The average finger millet grain yield achieved from four trails during 2008 was 1080 kg/ha, which fetched a net income of rupees 10,006/ha. The finger millet intercrop with tapioca in other words offered 50% more income than that from tapioca (Table 2). Wider application of this intercrop would mitigate the decline in millet production due to the conversion of millet grown land to tapioca and to generate additional income from same unit of land. This would also remove the threat of tapioca causing to the loss of local millet genetic diversity.

Value Addition

Enhanced capacity of the community members, particularly farm women organized under SHGs, was built through in-campus training in Home Science Colleges, village level training on good practices in product making, maintaining product quality, packaging, and marketing. SHGs were provided hand holding support by the project staff during initial period of product development and its standardization in quality, hygiene, packaging and marketing as well as building market linkages. Supply of small grain processing units functional at the project village level made a huge difference to the drudgery that these women were facing in processing these grains for domestic consumption. Financial resource for enterprise building was leveraged through creation of thrift fund by the SHGs and linkage with local banks, where the SHGs maintain their savings account.

SHGs in Kolli Hills identified millet-based malt, *chakkli* (*murukku*) and *laddu*, while those in Kundura selected malt and *nipputtu* (a sweetened ready to eat powder) for commercialization. The following example on the production and marketing of little millet malt is useful to highlight the underexploited potentials of minor millets. Little millet is the second best cereal grain suited to malting after barley [18]. This malt is a traditional weaning solid food for children from 6 month age onwards in view of its high digestibility and nourishment. Malting enhances the energy value of the grain, renders its protein, rich calcium, iron more bio-available and enlarges its vitamins such as niacin and folic acid (Malleshi and Desikachar, 1986). Little millet malt has blended components such as legume, which enhances the protein content and achieves better essential amino acid balance to the product. Thus, little millet malt is an excellent health food and beverage for all age groups. During 2007 and 2008, the SHGs at Kolli Hills and Kundura had produced and marketed more than one tone of finger millet malt.
The cost-benefit details of malt produced from 100 kg raw material and delivered at market end from both the locations are presented in Figure 3. While finger millet grain fetched Rs. 8-12 at the farm gate, depending on the location and time of sale, its value addition and marketing by farmers fetched them three-fold increase in income. In addition, value addition generated additional employment in the villages, value added the spare time

Table 2. Yield and income from pure and inter-cropped tapioca

Location	Tapioca (sole crop)			Tapioca with finger millet intercrop			
	Yield (kg/ha)	Cost of production (Rs.)	Net income/ ha (Rs.)	Yield (kg/ha)		Cost of production (Rs.)	Net income/ ha (Rs.)
	Tapioca			Finger. millet	Tapioca		
Village 1	9,518	12,825	19,725	1,215	8,910	16,033	29,020
Village 2	7,155	10,463	14,008	945	6,839	13,163	21,568
Mean	8,337	11,644	16,866	1,080	7,875	14,598	25,294

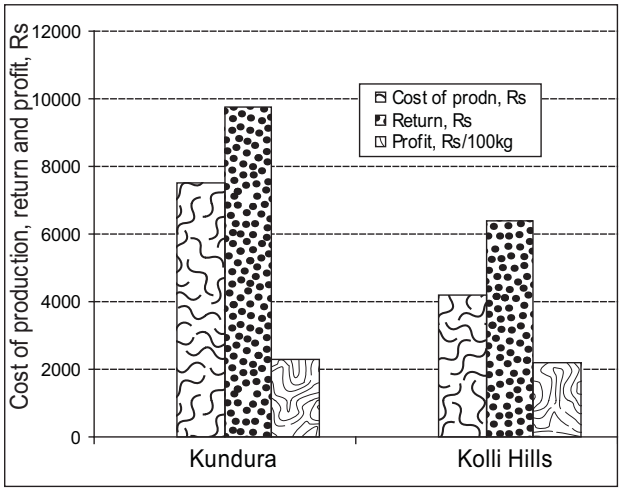

Fig. 3: Cost-benefit aspects of finger millet malt (costing of 100 kg raw material)

of the farm women and enhanced their social status and self-esteem.

A trademark was established for all millet products produced and commercialized from Kolli Hills and the malt is packaged in designer carton with international standards being followed for product labeling (Fig. 4). Introduction of similar pattern for the millet products developed and commercialized from Kundura is also under way.

This study demonstrates that the advantages offered by the underutilized and neglected crops, which enjoy high adaptive advantages under marginal agro-ecological and edaphic situations, in enhancing the food and nutritional security of local communities and enhancing their income. Importance of these crops in local food security and cultural diversity is well appreciated (Swaminathan, 2005; Thies 2000; Thrupp, 1998). Some of these crops are also amenable to be grown along with competing cash crops and thus supplement the local food production. The unique strength of certain underutilized and neglected crops in their rich and favourable nutritional composition, nutraceutical value and product development offers uncommon opportunities for income generation to the farmers, in particular the farm women. This study also showcases the over all impact of such interventions on these groups of crops to the socio-economics of the communities conserving and cultivating them, enhancing their food and nutritional security and strengthening of their traditional food culture. This study confirmed earlier work carried out in previous years also in India (Padulosi, 2003). These crops and their genetic resources, which are being threatened by their status of neglect, have promising potential in the era of climate change in view of their unique adaptive strength. Time has come to review and reassess the importance of these crops in the future agriculture of India and elsewhere in the world.

Fig. 4: Packed Finger millet malt

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