National Seminar on Recent Advances of Varietal Improvement in Small Millets

ABSTRACTS

Madurai Symposium 2013

September 12, 2013

Under the aegis of the

Revalorising Small Millets in Rainfed Regions of South Asia (RESMISA) Project

Organized by

DHAN Foundation
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Foreign Affairs, Trade and Development Canada / Affaires étrangères, Commerce et Développement Canada

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M.P. Vasimalai
Executive Director

MESSAGE

I am immensely happy that a National Seminar on "Recent advances of varietal improvement in small millets" is being organized as part of Madurai Symposium by RESMISA partners. Small millets being nutritious and climate resilient crops, it is important to stop decline in their area cultivated and take efforts to make them viable and attractive to farmers. This effort becomes very important since the National Food Security Bill includes small millets in the public distribution system. Varietal improvement and dissemination of improved varieties can play important role in improving the productivity of small millets. This year theme of Madurai Symposium being 'Governance for Development', it is apt to look at the various participatory approaches in varietal improvement in the seminar. I hope the deliberations in this seminar will throw light on the recent advances of varietal improvement in small millets and the critical areas in need of further research. I also hope that the deliberations will help the participants to gain insights for advancing varietal improvement and promotion of small millets. I wish the seminar a great success.

M.P. Vasimalai

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Welcome

Dear Participants,

On behalf of DHAN Foundation and other partners of Revalorising Small Millets in Rainfed Regions of South Asia project (RESMISA) we welcome all of you to the National Seminar on "Recent Advances of Varietal Improvement in Small Millets" organized on September 12, 2013, as part of Madurai Symposium in the heritage city of Madurai. RESMISA, an action research project, aims to increase production and consumption of nutritious small millets and associated pulse and oil seed crops in rainfed regions of India, Nepal and Sri Lanka. This three and half years project is anchored by DHAN Foundation and Canadian Mennonite University. The project is implemented in South Asia by DHAN Foundation in India, LI-BIRD in Nepal and Arthacharya Foundation in Sri Lanka. There are six third party organisations namely Tamil Nadu Agriculture University (TNAU), All India Coordinated Small Millets Improvement Project (AICSMIP) of Indian Council of Agriculture Research, WASSAN, University of Guelph, University of Manitoba and McGill University. This project is undertaken with the financial support of the International Development Research Centre (IDRC), www.idrc.ca, and the Government of Canada, provided through Foreign Affairs, Trade and Development Canada (DFATD),

The seminar aims to pool relevant knowledge on the recent advances of varietal improvement in small millets across India and to identify the areas for further research. There are three sub-themes namely, 1) Varietal improvement of small millets, 2) Participatory varietal improvement in small millets and 3) Innovative ways for dissemination of improved varieties at community level. We have received around 25 abstracts from various stakeholders and they were grouped under different thematic areas for easy reference.

We see this seminar as a great opportunity to learn from other actors and share our research work undertaken for the last two years on varietal improvement of small millets. We also see this seminar as a platform for mutual learning across research institutions and practitioners and for discussing core issues related to the theme. We expect that the rich deliberations of this seminar will help RESMISA project and other stakeholders involved in enhancing production of small millets across the country, by offering valuable insights and actionable suggestions.

We thank the Organising committee of Madurai Symposium for giving an opportunity to organize this seminar as part of their mega event and we thank IDRC and DFATD for providing financial assistance.

On behalf of organizers of this seminar, we welcome each and every one of the participants to take active part in this seminar to make it a great success.

Best Regards,

M. Karthikeyan & C.S.P. Patil,
Conveners, DHAN Foundation.

Contents

Genetic Improvement in Small Millets during Pre and Post Crop Coordinated Project era

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After decades of neglect, small millets are figuring in the Agricultural Development Agendas in some states. Millets are increasingly viewed as nutritive grains and hence the recent surge of interest in these crops. Further, the large population in the country is compelling to increase production of all crops, whether major or minor and grown on small or large area. Crop improvement research in India has been in progress since the beginning of the 20th century. But, the launching of coordinated crop improvement programs during late 1950s and 60s has contributed significantly by away of developing new superior varieties in all important crops. The release of these varieties for general cultivation has helped in 5 fold increase in grain production from 50 million to 250 million tons in the country. It is generally seen that this increase has largely come from two major crops -rice and wheat- and less from dry land crops such as millets and more so small millets, which receive meager attention in terms of inputs; water and technology back up.

Before the launching coordinated project, the small millets improvement was confined to fewer states such as Tamil Nadu, Andhra Pradesh, Karnataka and Uttar Pradesh. The emphasis was on varietal improvement through selection of better types from local cultivars. In Tamil Nadu, Millet Research Station was established in 1923 under the erstwhile Madras Presidency and the work later extended to Anakapalle (A.P.) and Hagari (Karnataka). Finger millet work in Karnataka dates back to 1900 and in Uttar Pradesh to 1944.

The first finger millet variety released in the country was H 22 as early as 1918 in Karnataka. The other finger millet varieties released were Co 6 (1935); R 0870, ES13, K1, ES11 (1939); Hagari1 (1941), Co1, Co2, Co3, Co4 (1942), VZM 1, VZM 2 (1958) and T36 B (1949).Similarly, many varieties were released in other small millets also. This included little millet variety Co 1 (1954); foxtail millet varieties Co1, Co2, Co 3 (1943), H1, H2 (1948), T 4 (1949); kodo millet varieties

PLR 1(1942, T 2 (1949), Co 1 (1953), proso millet variety Co 1 (1954) and barnyard millet varieties T 46, T25 (1949).

With the launching of All India Coordinated Small millets Improvement Project (AICSMIP) in 1986, the crop improvement research has been getting focused attention for developing varieties suitable to different regions. As many as 151 varieties (67 in finger millet, 20 each in foxtail and kodo millet, 14 in little millet, 16 in proso millet and 17 in barnyard millet) have been released for cultivation in different states. But, lack of efforts on seed production and distribution front has deprived farmers of the benefits accruing from growing them. The harnessing of yield advantages from these improved varieties is the need of the hour in order to make small millets cultivation competitive and economically viable.

The germplasm availability has vastly improved with the launching of AICSMIP. More than 15,000 accessions of various small millets are conserved with good data base. Several superior genetic stocks are identified in each of these crops. The careful deployment of desirable germplasm in breeding research can bring in immense benefits in improving grain and straw yield, grain quality and composition, pest and disease résistance, drought tolerance and as well meeting the emerging needs in future.

The rate of genetic advancement being made now barring finger millet is slow in all small millets. The realizable genetic potential is much lower compared to other dry land crops. As a result, these crops are lagging behind and getting more and more marginalized year after year. This trend needs to be reversed and breeders should intensify efforts to improve productivity along with resilience to adjust to adverse climates which is unique to small millets.

Theme 1

Varietal Improvement of Small Millets

Isolation and Characterization of Finger millet (Eleusine coracana L.) bZIP Transcription Factor

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Finger millet (*Eleusine coracana* L.) is an allotetraploid with a basic chromosome number of 9 and genome composition AABB ($2n = 4x = 36$). This crop is adapted to a wide range of environments and can withstand significant levels of drought, heat stress and salinity. It is relatively resistant to water logging and has few serious diseases. The crop has ability to grow under marginal environments and rainfed conditions. It recognized as nutri-cereal and climate resilient crop. Abiotic stresses (Drought, Heat, Salt, and Cold) are major threats to the crop regarding growth and productivity. Among these abiotic stresses, heat stress is one of the major factors that affect the plant growth and productivity to a greater extent. To understand the underlying mechanism of heat stress tolerance and to identify genes involved in it, suppressive subtractive hybridization has been performed for heat stressed tissues of finger millet seedlings and identified a novel *bZIP* transcription factor gene. In plants transcription factors of *bZIP* family are regulators of abiotic and biotic stress responses. Genetic, molecular and biochemical analyses indicate that *bZIP* transcription factors regulate important plant processes such as organ and tissue differentiation, cell elongation, nitrogen/carbon balance control, pathogen defense, energy metabolism, unfolded protein response, hormone and sugar signaling, light response, osmotic control and seed storage protein gene regulation. The expression of *bZIP* transcription factor encoding gene has been analysed by qRT-PCR. In order to obtain full length sequence of this gene 5'RACE (Rapid amplification of cDNA ends) was performed and the fragments obtained after 5'RACE was cloned in pGEMT-Easy vector. Sequencing result showed that the clones contain two alleles, with respect to the genome composition (AABB).The difference between two alleles is 17 amino acids at protein level and the major domains present in each allele are BRLZ and transmembrane domains. The sequences of two alleles are submitted to the NCBI and the accession numbers are KF245640 and KF245641. The full length *bZIP* transcription factor was cloned in binary vector pCAMBIA2300 and mobilized in to *Agrobacterium* strain EHA105 for tobacco transformation to characterize it for stress tolerance.

Identification of Resistant Sources for Blast Disease in Finger Millet (Eleusine coracana Gaertn.)

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Finger millet (*Eleusine coracana* Gaertn.) locally known as *Ragi, Chodi, Tydalu, Mandua, Nagli, Kapai* and *Marwa*, occupies a special position in the hill agriculture of Andhra Pradesh occupying the largest area next only to Rice. Although, Finger millet is known to cope up with abiotic and biotic stresses, however, under vulnerable conditions some of the diseases cause enormous losses and can damage entire crop. Of the several fungal diseases that affect finger millet crop, blast incited by *Pyricularia grisea* (Cke.) sacc. is the most devastating and economically important disease of finger millet growing areas of Andhra Pradesh. The average loss due to finger millet blast has been reported to be around 28% and has been reported as high as 80-90% in endemic areas. Limited information is available on resistant genotypes / cultivars / varieties and management of this disease for this region. The present investigations were undertaken to identify sources of resistance and contain blast disease of finger millet.

During 2010 and 2011, 31 entries in initial varietal trial and 16 varieties in advanced varietal trial (short and medium duration) were evaluated. Among them OEB-526 has showed nil incidence of leaf, neck and finger blast. Among 21 entries in advanced varietal trial (long duration) VR-958, BR-1, NRV-2, GPU-72 have showed nil incidence of leaf, neck and finger blast.

In NSN (National screening nursery) of finger millet, among 145 entries screened against blast GE-5176, -5181, -4966 showed nil incidence of finger blast as compared to susceptible check VR-708 (89.48%).

In pre- released and released varieties of finger millet among 16 entries were screened, GPU-28 has showed nil incidence of leaf blast, 1.43% of neck blast and 3.11% of finger blast as compared to the susceptible check VR-708 where the incidence of leaf blast was grade-4, neck blast-78.69% and finger blast-84.59%.

The results indicated that entries *viz*., OEB-526,VR-958, BR-1, NRV-2, GPU-72, GE-5176, -5181, -4966 and GPU-28 found resistant against all three forms of blast disease *viz*., leaf, neck and finger blast in finger millet and which can be employed in breeding programme for development of blast resistant material.

Genetic Enhancement of Finger Millet in Karnataka – An overview

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In Karnataka finger millet is grown in an area of 7.50 lakh ha, which is 49% of total national area and also ranks no.1 in production of finger millet, area is largely confined to Zone-4, 5, 6 and 7,where finger millet is a major food crop. The crop improvement work on finger millet has been carried out in 5 phases at Zonal Agricultural Research Station, V C Farm, Mandya (UAS, Bangalore). Under phase I, (1931-1951), 11 varieties were released which had a yield potential ranging from 285-512 kg/ha, which were mostly developed from indigenous collections. In phase II (1951-1964), Dr.Leslie C. Colman, an eminent Canadian scientist and 1st Director of Agriculture and Head of Agricultural Research Station, VC Farm, Mandya, made pure line selections, which had an yield potential of 900-2700 kg/ha. Phase-III (1964-1986) witnessed a revolution in finger millet varietal development due to the introduction of Indo-African crosses of finger millet by late Dr. C.H. Lakshmanaiah, who has been regarded as ''Ragi Brahma". His pioneering work resulted in release of 16 verities designated as 'INDAF' series. The yield levels of these verities ranged from 3000-4500 kg/ha. During phase-IV (1986-2000) the yield potential has further improved ranging from 4500-5000 kg/ha and the varieties released were resistant to Blast disease. During phase -V (2000-2012) upon establishment of AICSMIP, emphasis was laid on developing productive lines with elite background through hybridization to improve high grain and straw yield suitable for Kharif as well as Rabi season(where ever irrigation is available). The yield levels shot up, subsequently, ranging from 5000-5500 kg/ha. Further, the research efforts are underway, to develop medium and short duration varieties with high grain yield, resistant to blast disease and to address the challenges like drought, saline and alkaline soils, cold season and hilly areas, mechanical harvesting and value addition of finger millet.

Superior Popping Varieties in Finger Millet (Elusine coracana)

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Finger millet is one of the major food crops of southern Karnataka and also serving as pediatric foods with rich in calcium and iron. Though it is rich in nutrient composition, their availability to the human body is limited due to presence of phytates, phenols, tannins and enzyme inhibitors. Such effect can be reduced through processing techniques like popping, roasting, malting and fermentation. Popping is one of the age old practices that are commonly followed in rural household especially in preparation of pediatric foods. Identification of varieties with superior popping quality would be highly useful for food industry. Therefore, eighty six released varieties of finger millet were evaluated for popping. Popping was done using iron frying pan by adjusting grain moisture content to 19%. Initial grain moisture content found to be a non-constraint in determining the popping percentage. Significant varietal differences were observed for popping ranging from 18.6% (Pichakaddi ragi) to 88.2% (CO-10) with a mean of 54.2%. The varieties with high popping percentage (> 70%) are CO-10, Indaf-3, and Karikaddi ragi, PR-202, GN-4, ES-11, PRM-2, GPU-66, Indaf-9, Purna, RAU-3, Hullubele, BM-1, CO-12 and Indaf-8.

Isolation and Functional Characterization of *EcDREB* Gene from Finger Millet

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The Poaceae include an estimated 8000 species belonging to some 600 genera, which serve humans in many ways. But their use as cereal and feed for livestock makes them essential for human survival. Out of these, minor cereals are not only important in terms of world food production, but also essential as food crops in their respective agro ecosystems. Finger millet (*Eleusine coracana* L.) is one of the minor millet, which is originally native to the Ethiopian highlands and was introduced into India approximately 4000 years ago. It is the most important small millet in the tropics (12% of global millet area) and is cultivated in more than 25 countries in Africa (eastern and southern) and Asia (from Near East to Far East), predominantly as a staple food grain. Finger millet is a self-pollinated diploid (4x, 2n=36) C4 grass with a high photosynthetic efficiency. It is one among the few resilient crops that can adapt well to future climate change conditions, particularly the increasing drought, soil salinity and high temperatures. Heat stress adversely affects the growth, development, and production of plants. To understand the molecular basis of heat stress response and novel heat responsive genes, the finger millet variety MR1 was used to identify the genes differentially expressed in heat treated seedlings by subtractive suppression hybridization method. On the basis of high expression under heat stress a novel gene *EcDREB* was identified. The Dehydration-Responsive Element Binding Protein (DREB) genes are transcription factors that contribute to drought and heat stress tolerance by activating transcription through the cis-element dehydration-responsive element (DRE) in response to these stress stimuli. In order to obtain full length sequence 5' RACE (Rapid Amplification of cDNA Ends) was performed. The expression patterns of EcDREB have been analyzed via real time PCR. The gene is responsive to stress conditions of high temperature, dehydration, and osmotic stress. Full length *EcDREB* was cloned in binary vector pBI-121. The construct was mobilized into *Agrobacterium tumefaciens* and positive clones were confirmed by PCR analysis. The construct is ready for plant transformation.

Evaluation of Finger Millet (*Eleusine coracana* L.) Genotypes for Heat and Drought Stress

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Finger millet (Eleusine coracana L.) commonly known as Ragi, is an allotetraploid with genome AABB (2n = 4x = 36). It is an important food crop cultivated widely in India and other Asian countries, and also in many parts of Africa. It is rich in protein (~6-13%) and calcium (~0.3-0.4%). It also has nutritional qualities superior to that of rice and wheat. The finger millet genotypes constitute a rich source of biodiversity for environmental stress tolerant genes. Plants are adapted to respond to diverse environmental stress conditions, activating specific molecular and physiological changes in order to minimize damage. Heat and drought stress are major abiotic constraints which limits the crop production worldwide. In order to identify the genotypes which are tolerant to heat and drought stress, two sets of 10 genotypes each were analyzed for heat and drought stress separately. For heat stress, seeds of 10 finger millet genotypes GE-600, PES-110, GE-4683, GE-3510, KOPN-330, KJNS-52, INDAF-8, GN-5, GE-314 and PR-202 were grown at room temperature for 12 days and further transferred to 42ºC for 7 days with similar light and humidity conditions, and again shifted to room temperature. The results of this study have shown that PES-110, GE-600, GE-4683, GE-3510, KOPN-330 varieties recovered to a great extent compared with KJNS-52, INDAF-8, GN-5, GE-314 and PR-202 varieties. In order to identify drought tolerant genotypes, another set of 10 finger millet genotypes INDAF-5, GE-1294, GE-600, GE-3015, GE-1303, GE-4597, GE-1193, GE-2628, GE-4976 and GE-4810 were grown on solid MS medium aseptically for 12 days. Further seedlings were transferred to liquid MS medium without sucrose, with 30% PEG and 2M Mannitol separately. Medium without PEG and Mannitol was used as control. Growth parameters i.e., shoot length, root length and fresh weights were measured. The results of this study showed that INDAF-5, GE-4976, GE-1193, GE-4597, GE-600 genotypes performed better compared with GE-4810, GE-1303, GE-3015, GE-2628 and GE-1294. Using this characterization two contrasting genotypes for heat and drought stress have been identified for further molecular study.

Performance of Finger Millet (*Eleusine coracana* L.) Genotypes for Grain Yield

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The stable Genotype x Environment interaction was studied in ten promising genotypes of finger millet along with four checks during Kharif 2010 at six locations viz. Zonal Agril. Research Station, Kolhapur (E1), ARS Karad (E2), ARS Vadgaon Maval (E3), ARS Radhanagari (E4), ZARS Igatapuri (E5) and KVK Nandurbar (E6) in Maharashtra. Significant differences were observed for genotypes, environments and G x E interactions. On the basis of means of six locations, the genotype Phule Nachani (25.30 Kg/ha), KOPN 942 (21.57 Kg/ha) and IGPFM 08-49 (21.08 Kg/ha) recorded the higher grain yields over the highest yielding check GPU 28 (21.02 Kg/ha) followed by PR 202 (20.36 Kg/ha). The stability of genotype was measured as per Eberhart and Russell's model. Most of the environments showed low interactions. The genotype Phule Nachani had low interaction and hence it is stable for the grain yield. Among the genotypes, Phule Nachani had high mean value and positive interactions. Based on these results, it can be concluded that the genotype Phule Nachani was stable for grain yield and it is therefore recommended for cultivation in all environments of sub montane zone and ghat zone during *Kharif* season. The genotype KOPN 235 was named as "Phule Nachani" and released for cultivation in Maharashtra state in 2011.

PPR 2885 – A High Yielding Finger Millet Cultivar Suitable for Cultivation in Andhra Pradesh, Karnataka, Bihar and Gujarat States

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Finger millet (*Eleusine coracana* (L.) Gaertn) is an important cereal crop amongst the small millets and third in its importance among millets, in the country in area and production after sorghum and pearl millet. It is a staple food crop for drought prone areas of the world and it is considered to be an important crop for food and nutritional security. Finger millet is highly nutritious as its grains contain 65-75% carbohydrates, 5-8% protein, 15 -20% dietary fiber and 2.5-3.5% minerals. Generally lower yields in finger millet are due to lack of high yielding varieties and not adoption of improved cultural practices by the farmers.

A high yielding ragi variety tolerant to heat and drought situation is very important keeping in view of changing climatic situation. With this objective, a new and high yielding finger millet variety PPR 2885 was developed at Agricultural research station, Perumallapalle, to promote finger millet cultivation in different agroclimatic zones of Andhra Pradesh. It has been evolved through hybridization between PPR 2709 (high yielding and blast tolerant genotype) x Kalyani (a high yielding medium duration variety with drought and blast tolerance) followed by pedigree selection method.

This variety has performed well in Andhra Pradesh, Karnataka, Bihar and Gujarat states in co-ordinated yield trials with distinct yield superiority over checks. The yield increase over checks varied from 8 to 38 per cent in co-ordinated trials of the above states. This is a medium duration variety, having unique characteristics like semi dwarf plant height and sturdy culm with semi compact ear heads having many lengthy top curved fingers. This variety is highly tolerant to blast. It is also tolerant to drought, as it is having higher water use efficiency. It’s grain nutritive quality is also good in terms of calcium and free amino acids.

Improved Economic Status of Finger Millet Growing Farmers of Karnataka

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In rainfed regions of Karnataka, research activities are in progress to increase production and consumption of nutritious small millets and associated pulse crops. They are focused on over coming existing constraints related to production, distribution and consumption of small millets. An improved finger millet variety, MR-6 has been bred by using parents AW1 (African white) X ROH-2 (Shakthi) at AICSMIP, ZARS, V.C.Farm, Mandya. It has higher grain and straw yields suitable for Kharif and late Kharif under protective irrigation. It is resistant to finger and neck blast disease. It has higher calcium content. Hence, suitable for value addition. It was introduced in the predominant finger millet growing areas in three districts Viz., Mandya, Mysore and Chamarajanagar to enhance the economic returns of the finger millet growing farmers over a period of five years from 2005 to 2010.Over 10 ha of area under each districts was selected to introduce the new finger millet variety which recorded the highest grain yield compared to old varieties like Indaf-8, HR-911 and PR-202.The grain yield of improved variety was 4076 kg/ha when compared to old varieties (2483 kg/ha) which is an improvement of 61%. Similarly, the fodder yield obtained by the new variety was 6.42 t/ha when compared to farmers variety (4.06 t/ha), which accounts for 61.14% improvement. The net returns obtained by adopting a new variety was found to be Rs.37084/ha and the net increase was found to be Rs.14489/ha when compared to old variety (Rs.22674/ha).The study clearly indicates that, the adoption of new technology had improved the economic status of the finger millet growing farmers of the region.

Varietal Development in Finger Millet with Special Reference to White Ragi

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Finger millet (*Eleusine coracana* Gaertn.) commonly known as 'Ragi' is one of the important food crops and largely grown in Southern States of India. In Karnataka, finger millet occupies an area of 1.02 million hectare with a production of 1.875 million tonnes, accounting for 53.95 per cent area and 44.94 per cent production, and its cultivation is concentrated mostly in the districts of Bangalore, Kolar, Tumkur, Chitradurga, Hassan, Mysore, Mandya and Chamarajanagar. It is the cheapest and preferred food crop of economically suppressed but physical hard working people. It is appreciated by the people, because it can digest slowly thereby furnish energy for hard work throughout the day. The higher fibre content of finger millet helps in many ways as it prevents constipation, high cholesterol formation and intestinal cancer. Hence, diabetics are advised to consume finger millet and other small millet instead of rice. At Zonal Agricultural Research Station, V.C.Farm, Mandya, white finger millet variety, KMR-340 has been developed and tested its superiority across different agro-climatic zones. KMR-340 was developed through hybridization of WRT-14 X GE2124 during 2008. In station trials, this variety was recorded average yield of 48.00 kg/ha compared to check variety KMR-301(40.55 kg/ha) over three years. It is a long duration variety(120 days) with plant height of 100-110 cms , moderate tillering ability, long fingers with top incurved and more number of fingers, suitable for Kharif season. This has been found promising across six agro-climatic zones with mean average yield of 32.78 kg/ha and it has recorded highest grain yield of 50.48 kg/ha in Zone-III. Further, it has recorded high protein content (9.80g) compared to other finger millet varieties (8.10g) and resistance to neck (0.68 %) and finger blast (0.24 %) diseases. White finger millet can be further exploited for value addition for preparation of various products suitable for all sections of the society.

Effect of Age of Seedlings on Incidence of Brown Spot of Finger Millet Incited by *Helminthosporium nodulosum* in Different Cultivars

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An experiment was conducted to evaluate the effect of age of seedlings on incidence of brown spot in finger millet. Sixteen best entries selected across the nation were tested under field conditions in randomized block design with three replications. The pathogen was isolated and characterized for the cultural and morphological characteristics. The cultures were deposited in Indian type culture collection, IARI, New Delhi with number 6149 and Herbarium *Cryptogamae Indiae Orientalis* (HCIO) with number 46,921. The results also indicated that the crop which is devoid of proper nutrient management practices is prone to this disease.

During 2010 and 2011, sixteen entries were evaluated. Among them GPU-48, VR-708, PES-110, PR-202 entries showed the lowest incidence (1 Grade - less than 1%) of Brown spot with 3095 kg/ha yield. During maturity stage high incidence of brown spot was recorded in all entries as compared to pre-flowering stage. However, the highest grain yield (3333.7kg/ha) was recorded in VR-900.

During 2011 and 2012, sixteen entries were evaluated. Among them VR-958, GPU-28, VL-347, VR-929, KMR-107, VR-708 entries showed the lowest incidence (0 Grade) of brown spot. During maturity stage high incidence of brown spot was recorded in all entries as compared to pre-flowering stage. However, the highest incidence (4 Grade) was recorded in RAU-8.

The results showed that the entries *viz*., VR-958, GPU-28, VL-347, VR-929, KMR-107, VR-708 were found resistant against Brown spot disease.

Genetic Variability for Yield and Yield Related Traits in Finger millet Genotypes [Eleusine coracana (L.) Gaertn]

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The present study aims to reveal the existence of genetic variability and importance of some quantitative traits in the 305 finger millet genotypes. The objectives were to assess the variability, heritability, and genetic advance for yield and 12 yield component characters. Highly significant and wide ranges of variability were noticed among the genotypes for all the characters studied. Phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the characters studied. High values for phenotypic and genotypic coefficients were recorded for single plant grain yield and flag leaf blade length, indicating that more variability is present in the genotypes for these characters. All the characters recorded high heritability in the present study, which indicated that these characters were relatively less influenced by environmental factors and phenotypic selection would be effective for the improvement of these characters. High estimates of variability together with high heritability and high genetic advance were observed for flag leaf sheath width, flag leaf blade width and thousand grain weight, indicating these characters were governed by additive genes and selection would be effective for improvement of such characters. Since significant variability was observed among the finger millet genotypes, it could be used for genetic improvement through selection and hybridization.

Assessment of Promising Genotypes of Little Millet (*Panicum miliare* L.) for Grain Yield

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The local landraces of little millet collected from different parts of Maharashtra state were evaluated during Kharif 2009 and 2010. Among them nine promising genotypes were evaluated in the station trial during Kharif 2011. The local genotype KOPLM 83 (13.35 kg/ha) recorded highest grain yield followed by KOPLM 20 (11.58 kg/ha) and KOPLM 53 (10.52 kg/ha). All these nine promising genotypes of little millet again evaluated at 4 different agro-climatic zones of Maharashtra state during Kharif 2012 along with one check. These were evaluated at four locations viz. Zonal Agril. Research Station, Kolhapur (E1), ARS Karad (E2), ARS Vadgaon Maval (E3) and ARS Radhanagari (E4). Significant differences were observed for genotypes, environments and G x E interactions. On the basis of means of four locations, the genotype KOPLM 83 (13.96 kg/ha) followed by KOPLM 53 (12.77 kg/ha), KOPLM 47 (12.37 kg/ha) and KOPLM 41 (11.69 kg/ha) recorded the higher grain yield over the check OLM 203 (9.96 kg/ha). The stability of genotype was measured as per Eberhart and Russell's model. The local genotype KOPLM 83 found to be more stable at all these environments for grain yield and showed low interactions. The genotype KOPLM 83 having more ear length (21.5 cm) and tillers (5.5) resulted in higher grain yield. These characters need to be considered in selection of superior genotypes in little millet.

Relation of Yield and Yield Contributing Characters in Proso Millet Genotypes (*Panicum miliaceum* L.)

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The relation of yield and yield contributing characters in proso millet was studied. The correlation and path coefficient analysis recorded for nine characters in thirty-nine proso millet (*Panicum miliaceum* L.) genotypes during Kharif 2011 at Kolhapur. In this study, genotypic correlations were higher than the corresponding phenotypic correlation for all nine characters except for protein content. Grain yield per plant exhibited significant and positive correlation with days to 50% flowering (0.2475), productive tillers per plant (0.7518), plant height (0.7656), ear head length (0.7901), 1000 grain weight (0.7901) and harvest index (0.8053) indicating dependency of yield on these characters. Path analysis revealed that harvest index had the highest direct effect (0.3383) towards grain yield indicating true and perfect relationship between them suggesting direct selection based on this character would help in selecting the high yielding genotypes in proso millet. Along with harvest index, ear head length (0.3204), 1000 grain weight (0.2471) and productive tillers per plant (0.1756) were good indicators of grain yield in proso millet and can be used for making direct selection.

Status and Management of Kodo Millet Diseases in Madhya Pradesh

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Among the cultivated small millets, kodo millet (*Paspalum scrobiculatum* L.) ranks 3rd in area after finger millet and little millet. The crop is grown by people of poor socio-economic group using no or less cash inputs in wastelands. Few diseases like head smut caused by *Sorosporium paspali-thunbergii* (*Sporisorium paspali-thunbergii*), banded leaf and sheath blight caused by *Rhizoctonia solani* and one phanerogamic partial root parasite, *Striga* species, limit the production considerably under favourable conditions. Besides, problem of Kodo poisoning was also reported from few places. To see the status of diseases in farmers' fields, a roving survey was carried out in six districts namely Rewa, Satna, Sidhi, Singrauli, Shahdol and Umaria of Madhya Pradesh during 2009 and 2010. Incidences of head smut ranging from 0.0 to 7.0% and *Striga* sp. ranging from 0.0 to 14.5% were recorded. Out of 428 land races, fourteen, namely RPS 539, 575, 581, 583, 590, 804, 818, 820, 830, 859, 886, 898, 910 and 977 were found moderately resistant to head smut under artificial inoculations. Forty eight land races were resistant to banded leaf and sheath blight disease. Among the evaluated genotypes, fifteen viz. TNAU 95, DPS 54, BK 13, RK 971, BK 21, DPS 36, RPS 517, RPS 531, RPS 541, RPS 606, RPS 687, RPS 697, RPS 744, RPS 745, and TNAU 141 were resistant to *Striga* species. Seed treatment with Carboxin or Carbendazim @ 2 g kg^{-1} seed was found very effective in controlling head smut incidence. The incidence of *Striga* species can be minimized effectively by the application of nitrogenous fertilizer. Seed treatment with Validamycin @ 2 ml kg^{-1} seed was found effective and economical with highest B : C ratio of 3.2 for the management of banded leaf and sheath blight disease and enhancing grain yield (14.4%). The next effective treatments were seed treatment with Hexaconazole, Propiconazole @ 2 g kg^{-1} seed.

GGE Biplot Analysis to Evaluate Genotype, Environment and their Interactions in Foxtail Millet Multi-location Data

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Foxtail millet [*Setaria italica* (L.) Beauv] is a very important crop in the arid and semi-arid tropics of India and South East Asia. In the process of release of new cultivars using multi-location data major emphasis is being given on the superiority of the new cultivars over the ruling cultivars, while very less importance is being given on the genotype x environment interaction (GEI). In the present study, performance of four Indian varieties over 7 locations across the rainy seasons of 2010 and 2011 was investigated using GGE biplot analysis. Location attributed higher proportion of the variation in the data (52.6-86.9%), while genotype contributed only 4.2-22.4% of total variation. Genotype x location interaction contributed 8.2-35.6% of total variation. We could identify superior hybrids for grain yield and fodder yield using biplot graphical approach effectively. Majority of the testing locations were highly correlated. 'Which-won where' study partitioned the testing locations into three mega-environments: first with seven locations with SiA 3156 as the winning genotype; second mega environment encompassed three locations with SiA 3155 as the winning genotype, and last mega-environment represented by only one location with SiA 3121 as the winning genotype. This clearly indicates that though the testing is being conducted in many locations, similar conclusions can be drawn from one or two representatives of each mega-environment. We did not observe any correlation of these mega-environments to their geographical locations. Existence of extensive crossover GEI clearly suggests that efforts are necessary to identify location-specific genotypes over multi-year and -location data for release of varieties rather than focusing on overall performance of the entries.

Effect of Different Locations on Grain Yield and Protein Content in Foxtail Millet (*Setaria italica*)

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Foxtail millet is one of the world's oldest cultivated crop that thrives well in semi-arid areas. It is a well known fact that, the grain yields and protein content are inversely or poorly related in several crop species. However such studies in foxtail millet are essential to achieve higher grain yield in addition to protein content to bring down the dependency on pulses for protein. The objective of this study was to identify the superior accessions in grain protein and to study association between grain protein content and grain yield with GXE interactions. To understand this we conducted experiments at Bangalore (GKVK), Nandyal and Coimbatore during Kharif 2012 having 200 accessions, 21 released varieties and 3 national checks namely, SiA 326, SiA 3085 and PS-4. In Bangalore, Nandyal and Coimbatore, the values of grain yield (g pl^{-1}) were 12.25, 14.18 and 10.54, respectively, and were found to be significantly different from each other. Whereas, the protein content (%) recorded for each location were 11.2, 11.3 and 11.2, respectively, with no significant differences, suggesting that locations do not have effect on protein content in foxtail millet. At all locations, negative non-significant correlation was observed between protein content and grain yield. However there are certain accessions which have both higher protein and grain yield viz., ISe-1026, GS-430, ISe-1454, ISe-1808, ISe-1610, GS-140, GS-1017, Srilakshmi, GS-140 and GS-515. These accessions can be utilised in future breeding programmes aimed at protein improvement in foxtail millet.

Characterization of finger millet varieties based on morphological traits

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The enactment of Plant Varieties Protection and Farmers Right Act (PPV and FRA, 2001) by the Government of India is aimed at providing protection to varieties and germplasm in different crops. To consider under this act, the variety must meet DUS (Distinctness, Uniformity and Stability) and VCU (Value for Cultivation and Use) standards. In order to maintain genuineness and quality of seed, careful evaluation is needed at every stage of its seed production. The crop varieties could be identified or distinguished to a reasonable degree of accuracy on the basis of clear and consistent differences in one or more essential descriptive characters.

The Project Coordinating Unit has been entrusted with development of guidelines for DUS characterization released varieties of finger millet at two locations *viz.*, Bangalore and Vizianagaram. The qualitative traits viz. plant pigmentation, ear shape, finger branching, seed colour and quantitative traits like number of fingers on main ear, finger length, plant height and days to maturity were considered as DUS traits.

Out of 52 varieties, 39 are non-pigmented, while 13 entries exhibited pigmentation on all plant parts. Similarly 40 varieties possessed semi compact ear shape whereas 7 and 5 varieties exhibited while it was absent in 40 varieties. Seed colour also varied among the varieties, 2 were brown, 38 were copper brown, 3 were white and 9 were light brown types. By using these traits, it may not be possible to discriminate all the varieties. But it is useful for grouping the varieties.

The number of fingers on main ear varied from 7 to 15. It was low (<7) in 8, medium (8-10) in 30 and high (>11) in 14 varieties. Finger length varied from 3.4 cm (VL 315) to 12.60 cm (GM 3) while it was long (>7.5cm) in 7, medium (5.1 - 7.5 cm) in 22 and short (<5 cm) in 23 varieties. The highest plant height was recorded in MR 6 (111.0 cm) and lowest (<65 cm) in VL 315 (57.0 cm), medium in 39 (66-90cm) and highest (>91 cm) in 12 varieties. Based on duration, 10 entries were grouped into early (95.0 days), 38 into medium (96-100 days) and 4 into late (>110 days). The quantitative DUS traits may help in differentiating the varieties within the group. However, these traits need to be confirmed over seasons across locations. Further, application of molecular markers may aid in clearly distinguishing morphologically similar varieties.

Theme 2

Participatory Varietal Improvement in Small Millets

Enhancing On-farm Varietal Diversity in Small Millets through Participatory Varietal Selection-A Case Study in Finger Millet and Little Millet

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Small millets are gaining importance in recent days, both at national and international levels, in spite of being neglected crops during the green revolution era. Among them, finger millet and little millet are being cultivated extensively in many states; mainly because finger millet is consumed as staple food even now by a large section of population, while there is great demand in the market for little millet, though surveys indicate drastic reduction of its consumption in the traditionally growing areas. The impact of varietal improvement, however, is not much realised in all the areas of their cultivation due to various reasons. Hence the present study was initiated to preserve and also to enhance the varietal diversity of finger millet and little millet crops so as to sustain the interests of the local farming communities in cultivating these crops. The study has been initiated in four project sites, Anchetty, Bero, Jawadhu Hills and Semiliguda which are located in different agro-climatic regions. Finger millet occupies considerable area in all the four sites, while little millet is a major crop in Jawadhu Hills and it is second important small millet crop at Semiliguda. The study attempted to understand the existing varietal status of both crops in the project sites by adopting different tools. Maximum varietal diversity of finger millet was noticed in Semiliguda site and for little millet in Jawadhu Hills. Only at Anchetty the improved varieties were most popular and in other sites only traditional varieties were being grown.

The approach followed for identifying suitable varieties in each crop was participatory varietal selection; where in as many as163 varietal trials of finger millet and 93 varietal trials of little millet were conducted on farmers' fields during 2011 and 2012. Both quantitative and farmers' preference analyses were carried out, based on which 2 to 3 most preferred varieties were selected during 2011 and additional 1 to 3 during 2012, in each of the sites. The selected varieties of 2011 were retested along with the farmers' varieties on their fields (baby trials), 145 for finger millet and 35 for little millet, during 2012; and in majority of the cases the test varieties performed better than the check varieties. It was really encouraging to realise that within a short period of 3 years it was possible to identify a minimum of 4 most suitable farmer preferred varieties of finger millet in each project site and 4 varieties of little millet, 3 for Jawadhu Hills and 1 for Semiliguda. Some of the traditional varieties were found to be equally good (or even better, under specific situations) as those of improved ones. The study also recognises the effectiveness of PVS to meet the requirements of diverse situations of rainfed areas.

Enhancing On-farm Varietal Diversity in Small Millets through Participatory Varietal Selection-A Case Study in Barnyard Millet and Kodo Millet

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Barnyard millet (*Echinochloa colona* (L.) Link) and Kodo millet (*Paspalum scrobiculatum* L.) are the two major grain crops in India, which are being cultivated extensively at present in some states. The area under these crops, however, has declined considerably in the traditionally growing regions of the country during last 2 to 3 decades. The modern technologies to improve their productivity have also failed to reach the target areas due to many bottlenecks in technology transfer and adoption mechanisms. Therefore, the present study was initiated in one of the project sites (Peraiyur in Tamil Nadu) of RESMISA, a multi-pronged project on small millets, to enhance varietal diversity within the two crops mentioned above. Considering the diverse nature of localities, especially due to unpredictable rainfall pattern and soil types within the site, participatory varietal selection (PVS) was found to be appropriate approach in identifying the suitable high yielding varieties among the available promising traditional and improved varieties in both the crops.

In an effort to understand the existing status of varietal diversity in the two crops, the study indicated that none of the improved varieties of barnyard or kodo millets were known to the local farmers. One of the traditional varieties of barnyard millet, *Sadai kuduravali* was found to be the most popular, covering large area in the region. Similarly, *Siru varagu,* a local variety of kodo millet is being cultivated by most of the farmers in the site. Otherwise, the presence of other local varieties, not more than 3 to 4 in each crop, is very much limited in the site. Some of the old traditional varieties, such as *Pullu kudaravali* of barnyard and *Karu varagu* of kodo millet, appear to be almost extinct.

A set of promising varieties, about 20 in barnyard millet and 10 in kodo millet, comprising both traditional as well as improved ones were evaluated in unreplicated trials on the farmers' fields during 2011 and 2012. Scientific procedures of both quantitative and farmers' preference analyses were followed while identifying the most suitable varieties of each crop for the site. A group of 14 farmers participated in preference analysis in each crop, half of them being women farmers. Their preference scores were based upon desirable traits like drought tolerance, short duration, non lodging, bold grains, besides high grain and fodder yield. The results of the study indicated that four varieties of barnyard millet, namely, CO-2*, M, Arupukottai* and *M1*, and three varieties of kodo millet, *Siru varagu, Uppu varagu* and TNAU-111, are found to be the most preferred varieties for the region. Out of these CO-2 and TNAU-111 are improved varieties, while others are traditional varieties. Some of the traditional varieties showed higher yielding ability in the trials and need seed purification to protect their identities. Promotion of all the preferred varieties has been initiated in the site; and it is hoped that there will be at least 3 to 4 varieties on most of the farmers' fields in coming years.

Selection of Trait Specific Finger Millet Genotypes Involving Farmers' Participation

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The success of development of a new crop variety depends on the rate and extent of adoption by the target farmers. Finger millet (*Eleusine coracana* L. Gaertn.) is a stable food crop with inherent hardy nature and quality nutritional grain in majority of drought prone areas in several East African and South Asian countries in the world. Based on this premise, an investigation was carried out in the Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore during 2012-2013 to develop high yielding and nutritionally rich finger millet genotypes adapted to local conditions and accepted by farmers and consumers at large using farmers' knowledge and breeders' scientific approach. Participatory selection was applied to select trait specific and diversified finger millet genotypes that possess farmer-preferred plant and grain traits. Totally 25 genotypes that included of 20 local and 5 standard varieties were evaluated by farmers on community plots managed by them at several sites in different agro ecological areas. Selection was based primarily on agronomic traits such as days to maturity, plant height, number of productive tillers, number of fingers per earhead, finger length and grain yield per plant. In addition to yield traits, farmers were asked to rate their preference on earhead type, seed size, seed colour and lodging resistance. A total of 49 finger millet growing farmers participated in the evaluation programme. The farmers critically observed the entries in the participatory varietal selection trials and scored the varieties based on their preferences. They had showed their interest towards compact panicles, bold seeds, pest and disease free genotypes and non-lodging characteristics. The results of the present study showed that farmers' characterization of several accessions combined with statistical, nutritional, and genetic analyses performed by the breeders had allowed selection of finger millet genotypes that fulfilled the concern of both the scientists and farmers with the ultimate goal of product and profit.

Development of ML 365, a high Yielding, Disease Resistant, Drought Tolerant Finger Millet (*Eleusine coracana* Gaertn.) Variety by Integration of Marker Assisted and Conventional Selection

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Farmer participatory breeding by including farmers from six districts of Southern Karnataka resulted in identifying ML 365 Ragi variety that was released in 2008 by UAS, Bangalore. The variety was developed by involving farmers in selection of the parents for crossing and further selection at various levels and generations by growing in farmers' field in majority of the trials. SSR Markers were developed for finger millet generating genomic libraries. RIL populations were developed segregating for drought and blast resistance. Root parameters were the main focus for drought contributing traits including yield under stress and both leaf and neck blast resistance was considered for blast disease parameters. Mapping population of 381 RI lines were developed using SSD method and genotyped and phenotyped. Parents of the mapping population IE 1012 (resistant for blast and drought) x Indaf 5 (susceptible) revealed, 46 % polymorphism for RAPDs, 38% for newly developed SSRs developed between the parents. Resistant gene analogs also were tested and found useful for identifying resistance. The polymorphic primers were screened using RIL mapping population and regions mapped for drought, blast and yield parameters and duration. Six elite lines identified by the farmers as superior plants were identified by us with consensus and were validated and tested on large scale evaluation in farmers' field. Mother baby trials were carried out in SIX mother trials at different finger millet growing areas of Karnataka. Elite genotypes ML 31, ML 197, ML 322, ML 365, ML 426, ML181 and ML 553 with existing popular variety GPU 28 was used as check. ML 31, ML181, ML 322 and ML 365 were most preferred by farmers. They had higher grain yield, good fodder quality, low dusting character and good ball

(*mudde*) making quality. They were also superior calcium and iron content marginally. These lines were resistant to neck and finger blast. The average yield was 15-18 percent higher than the check. The three lines were tested in state varietal trials for three years in Wet season. Among these promising genotypes ML 365 with long roots, neck blast resistance and drought tolerance was released in 2008 for cultivation to farmers by UAS, Bangalore. QTL for these characters have been identified and mapped on rice chromosome. ML 365 is popular among the finger millet growing farmers of South Karnataka and entered the seed chain.

Theme 3

Innovative Ways for Dissemination of Improved Varieties at Community Level

Oral Presentation

Seed Entrepreneurship Development among the Farmers under the Seed Village Concept

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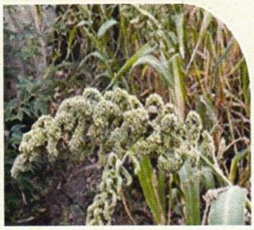
‘Seed Village concept’ is the term given to a practice wherein a group of likeminded (in their profession) farmers brought together into a ‘Self Help Group’ are trained to work together in their effort to produce seeds of crops of their choice and cater to the needs of their own and that of fellow farmers, in appropriate time and at an affordable cost. The main feature of this programme are - seed is available at the door steps of the farmers at appropriate time, seed is available at an affordable cost (lesser than the market price) due to decreased overheads, increased confidence among the secondary seed producers about the quality of the product because of known source of seed production, producer and consumer are mutually benefited (Win-a-Win situation), and facilitates fast spread of new cultivars and region specific varieties that are not covered by the seed agencies.

In an effort to induce seed production as an enterprise in the minds of the selected farmers, all the necessary infrastructure facilities, machinery and training are provided to them. Ultimately, trained self help groups in a district are clustered into a federation and trained to carry out the activity on their own.

About Rainfed Farming Development Program



The 'Rainfed Farming Development' theme, initiated by DHAN Foundation in 2002, graduated into an emerging program in 2008-09. The Rainfed Farming Development Program (RFDP) works with the shared vision of "making rainfed farming as a viable livelihood" and with specific goals of Food security, Income security and Ecological security. The broad strategy of RFDP is "enhancing viability of rainfed farming livelihoods through integrated and critical demand based interventions, depending on the context". As on July 2013, RFDP was working in fourteen locations in 6 states with 15647member farmers across different agro-ecological conditions. RFDP has been implementing various projects like NWDPRA, CAIM, IWMP and RESMISA in collaboration with agriculture department, marketing department and agricultural universities.

About RESMISA Project

The action research project 'Revalorising Small millets in Rainfed Regions of South Asia (RESMISA)' aims to increase production and consumption of nutritious small millets and associated pulse and oil seed crops in rainfed regions of India, Nepal and Sri Lanka. It pursues a multi-pronged research strategy related to conservation, productivity enhancement, value addition, post-harvest processing, promotion and policy action to raise the profile of small millets. The project has selected six research sites in backward and tribal dominated pockets of Tamil Nadu, Andhra Pradesh, Odisha and Jharkhand states of India and one site each in Sri Lanka and Nepal. The project is anchored by DHAN Foundation and Canadian Mennonite University. The other Indian partners are Tamil Nadu Agriculture University, All India Coordinated Small Millets Improvement Project of ICAR and WASSAN. This project is supported by Canadian International Food Security Research Fund (CIFSRF) promoted by International Development Research Centre (IDRC), www.idrc.ca, and the Government of Canada, provided through Foreign Affairs, Trade and Development Canada (DFATD).