Plant Archives **Vol. 25, Special Issue (ICTPAIRS-JAU, Junagadh) Jan. 2025 pp. 727-736**
e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives
Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.SP.ICTPAIRS-106

CHALLENGES OF THE LOW PRODUCTION AND WAYS FOR THE IMPROVEMENTS OF SMALL MILLETS IN GUJARAT AND INDIA

Harshal E. Patil*, G. D. Vadodariya and Sagar K. Jadav

AICRP-SM, Hill Millet Research Station, Navsari Agricultural University, Waghai, Gujarat, India.
*Corresponding author E-mail: harshalpatil@nau.in

ABSTRACT

Small millets have the potential to serve as an alternate/ supplement to major cereal staples because of their ability to be used/ cooked in similar ways, diverse adaptation to adverse conditions and nutritional qualities. Small millets can fit very well into multiple cropping systems both under irrigated and rainfed conditions. Their storability under normal storage conditions has made them 'famine reserves'. They can provide nutritious grains as well as valuable fodder in a short span of time. A very low number of germplasm and inadequate information on genetic diversity limits their effective utilization in crop improvement programs. Therefore, prioritizing germplasm collection is key to identifying trait specific resources, genes and alleles, which can be utilized in small millets breeding programs. So far, small millets varieties have been developed mainly through conventional breeding methods. The yield barrier in small millets can be broken by a male sterility system and exploiting heterosis, and genomics- assisted crop improvement, together with better crop management and mechanization. Genomics assisted breeding will facilitate the identification of novel alleles and genes with superior agronomic performance and resistance to biotic and abiotic stresses to accelerate small millets improvement. (Padulosi *et al.*, 2009) Biotechnology techniques such as tissue culture and genetic engineering reported in related crops could potentially support small millets improvement. The rapid development of sequencing technologies can generate millions of sequences reads at a low cost and in a short time irrespective of whether there is prior sequence information or not. Next generation sequencing techniques enable the molecular characterization of an entire set of small millets germplasm. These techniques could be used in crops such as little millet, kodo millet, and job's tears where genome decoding has not yet been done. Similarly, comparative genomics facilitates the exploration of orthologous genes of important traits in less studied crops with available genome sequence information from rice and foxtail millet. The emergence of genome editing techniques allows the modification of the genome of small millets to enhance production and stress tolerance. Similarly, comparative genomics facilitates the exploration of orthologous genes of important traits in less studied crops with available genome sequence information from rice and foxtail millet. In addition to conventional breeding and genomics-assisted improvement, a comprehensive and coordinated multidisciplinary collaboration across the agronomy, biomedical, food science and technology areas is required in order to shift the status of small millets out of 'minor and underutilized' crops' group. Additionally, public–private partnerships, public awareness, farmers' engagement across the countries who are interested in small millets research and promotion will be needed to incorporate small millets-based food products as an important source of nutrients in diets.

Given the changing climate scenario and prevailing hidden hunger, greater research and developmental focus on small millets and other traditionally important crops is the key to achieve food, feed and nutrition security.

***Key words*:** Challenges of the low production, small millets, Ways for the improvements, etc.

Introduction

Small millets are now world known "Nutricereals crop" being introduced in the highly nutritive crop during International Year of Millets-2023. Millets are able to grow successfully in diverse soils, rainfall and photoperiods. It can be cultivated from marginal land to mountainous

terrains. The adoptative quality of millets is combined with nutritional values creates opportunities and strengthen income generation through value addition to the marginal farmers. India is the largest producer of many kinds of millet, which are often referred to as coarse cereals. However, realizing the nutrient composition of these grains they are now considered as 'Nutri-cereals' (Nutritious grains). Small millets full of numerous grain crops which are named in locally *viz.*, finger millet (nagli), kodo millet (kodra), foxtail millet (kang), little millet (vari), barnyard millet (banti/badalo) and proso millet (cheeno). These crops are grown in tribal and hilly areas of India among all the millets, small millet is the staple food of the tribals. Small millets are very nutritious and even superior to rice and wheat in certain constituents.

Farmers for small millets cultivation using unfertile land with very low productivity also not applying fertilizers during crop growth means almost under organic condition, only. Promotion of value addition as an attractive and rewarding enterprise in hilly lands. Also, in recent era, high scope for the small millets for export due to high demands in outside countries to get more income and more profit to tribal hilly area. Hybridization is very difficult in case of small millets and success rate is 2 to 4 percent, only. The study of small millet to fit for dryland farming crop and withstand severe moisture stress under adjust to wide range of soil conditions. Thus, looking to the need of changing climatic conditions region specific objectives kept in mind to develop better cultivar. Also, different strategies would follow as per need of small millet crops in tribal areas of India. (De Wet *et al.*, 1983a & 1983b)

Small millets are important nutri-cereal crops cultivated by farmers in the adverse environmental conditions. These climate resilient crops are rich in nutrition and guaranteed remunerate crop of millions of poor hilly region farmers and their livelihood. India is one of the largest growers of minor millets in the world after Africa. In the recent past decades the area of cultivation of millets has declined due to their lower economic competitiveness with major cereals. Millets are able to grow successfully in diverse soils, rainfall and photo periods. It can be cultivated from marginal land to mountainous terrains. The adoptative quality of millets is combined with nutritional values creates opportunities and strengthen income generation through value addition to the marginal farmers. Small millets are known for their suitability to dry lands, hill and tribal agriculture. The resilience exhibited by this crop is helpful in their adaptation to different ecological situations and make it ideal crop for climate change and contingency planning. The millet grains are well known for their superior nutritional quality and can provide to effective nutritional security to human being. Small millets are known for its unique nutritional properties like high fiber content, rich source of dietary calcium, quality protein and important micronutrients *viz.*, Fe, P, Ca, Fe, Mn, Mg, *etc*. (Veena *et al.*, 2005)

Challenges and Prospects in Millet Sector in Gujarat and India

Millet sector has been facing numerous challenges pertaining to production, processing, value addition, marketing and consumption which have hindered the process of advocating millets as the staple foods through the world. The following are some of the key challenges identified in the processing and value addition of millets.

Challenges in millet production:

I. **Low productivity of millets:** Compared to wheat, rice and maize, millets have lower productivity in the country. This is attributed to their cultivation in marginal lands in rainfed farming and non-adoption of improved cultivars. The yield gap in millets is largely a reflection of farmers cultivation technologies that offer ample room for improvement. The country's average yield gap for *rabi* sorghum, *kharif* sorghum, bajra, ragi and small millets over 2009-2014 were 58%, 151%, 62%, 183% and 156%, respectively

II. **Resistance to pests and diseases:** Though millets have minimal pests and diseases, some pests and diseases often cause significant losses in sorghum (shoot fly, stem borer, grain mold), pearl millet (downy mildew and blast) and finger millet (blast). No productive cultivars with highly significant resistance to these pests and diseases are available and management options are mostly limited to agronomic and chemical methods.

III. **Area expansion in non-traditional areas:** Bringing the additional lands under millets cultivation is another important factor in increasing the production, especially the fallow and wastelands and the non-traditional areas are more sustainable without competing with the high remunerative crop.

IV. **End-product specific cultivars:** Geometrical and nutritional evaluation of several cultivars available in all the major millet growing areas and mapping them to the suitable end-use is essential for better end-product quality and scaling up the value addition by the giant processors.

V. **Seed hubs and breeder seed production:** There is a huge need for identifying various product-specific cultivars and establishing the seed hubs for breeding and producing such seeds so as to establish demand-driven production. The development of seed hubs that can deliver quality seed at high production levels is an important intervention. (Seetharam *et al.,* 2000)

Challenges in millet processing in Gujarat and India:

- The efficiency of current machinery is low with the recovery of 70-80% of grain and the remaining being the un-hulled and broken grains.
- One type of dehuller unit is not suitable for all the millets, as their morphological features differ mainly in size, shape and husk content and nature.
- Separation of husk and its collection is burdensome, which causes spillage all over the working station and sometimes mixes with the final hulled output.
- De-hulling efficiency of Millets is very much affected by Impeller speed. A provision to control the working speed of machines is to be incorporate
- Due to lack of gluten, gelatinization of starch through hydrothermal treatment, extrusion, etc., is being employed for the diversification of value addition but making some products like bread, buns, etc., with 100% millets is still a challenge.
- Lack of comprehensive data on the effect of various processing technologies on nutritional characteristics and a framework of best processing technologies for enhancing the availability of nutrients and decreasing the anti-nutritional contents.
- The measure of physiologically active bio compounds in altered foods compared to raw millets polyphenols and antioxidant capacity; Resistant starch, exploring medical benefits of anti-inflammatory properties of millets - Prebiotic and Probiotics of Millets. (Pradeep and Guha, 2011).

Challenges in Policy Advocacy

- **Changing consumer tastes and preferences:** Over the decades, consumer preferences have shifted to tastier and convenient foods either by demonstration effect of western culture or indigenous misconception that millets are poor man's foods.
- **Availability of other fine cereals at incentivized prices:** Fine cereals such as Rice and Wheat have been made available at incentivized prices through PDS, MDM, WCD and other public- funded feeding/nutritional programs
- **Inadequate support to research efforts for improving the millets cultivation:** While aligning more resources for the improvement of fine cereals, millets were not given adequate importance in research and development on improved varieties, productivity, diversification of processing technologies and marketing
- Lower profitability and lack of commercialization leading to millets being less remunerative crops due to lower yields coupled with declining prices due to vulnerable quality to environmental factors (*Kharif* Sorghum).
- Lack of processing machinery and diversification of processing technologies dedicated to millets (especially given the complexity of processing of small millets)

  Lack of MSP for Small Millets has slowed their area expansion and consequently the production and supply are hampered.
- Slow pace of outreach to promote millets through various institutions and governments have led to lack of awareness about the importance of millets. (Gupta *et al.,* 2010)

Regulatory Challenges

- Millet based products are not covered under standard foods and thus it will go through an approval process so that FSSAI should consider these innovative products and come out with standard.
- Quality standards and their certification is still a major drawback for export Millet based product claim should be part of the approved claim list of FSSAI so companies who are interested can use it in public relations.
- Lack of knowledge about export policies and understanding about the markets in different countries. (Seetharam *et al.,* 2000)

Major Initiatives by the Government to Promote Millets in Gujarat and India:

- In view of the nutritional value of the millets, the Government has notified millets as Nutri-cereals in April, 2018.

- The Government, under the Sub-Mission on National Food Security Mission (NFSM) Nutri-cereals, is creating awareness among farmers for Nutricereals (Millets) such as ragi, sorghum, bajra and small millets through demonstration and training.
- The Government is popularizing Nutri-cereals through Research and Development support. Support is also given to start-ups and entrepreneurs for developing recipes & value-added products that promote the consumption of millet. Eight bio-fortified varieties/hybrids of Bajra have been released for cultivation from 2018 to February 2022.
- To promote the shipment of Nutri-cereals, the Ministry of Commerce and Industry through its apex agricultural export promotion body, the Agricultural and Processed Food Products Export Development Authority (APEDA) has prepared a comprehensive strategy to promote Indian millets exports across the globe commencing December 2022.
- For the promotion of Indian Millets and its value-added products, the Centre has developed 30e-Catalogues on each of the targeted countries comprising information on various Indian Millets and the range of their value-added products available for export, list of active exporters, start-ups, FPOs and importer/retail chain/hyper markets, etc that to be circulated to the Indian Embassy abroad, importers, exporters, Start-ups and stakeholders.
- NITI Aayog signed a Statement of Intent (SoI) with United Nations World Food Program (WFP) on December 20, 2021. The partnership focuses on mainstreaming millets and supporting India in taking lead globally in knowledge exchange using the opportunity of 2023 as an International Year of Millets.
- Union Budget 2022-23 highlighted that support would be provided for post- harvest value addition, enhancing domestic consumption, and for branding millet products nationally and internationally.
- In a webinar, held on February 24, 2022, dealing with the positive impact of Union Budget 2022-23 on the agriculture sector, Prime Minister Narendra Modi called upon the corporate world to come forward in branding and promoting Indian millets.
- During the launch ceremony of the International Year of Nutri-cereals organized by the Food and Agriculture Organization of the United Nations (FAO) in Rome (Italy), Hon'ble Prime Minister Narendra Modi emphasized on making millets a food choice for the future. He also touched upon how climate change is affecting food availability. The Prime Minister remarked, "Millets are good for the consumer, cultivator and climate."
- A major initiative was taken by the Union Ministry of Agriculture and Farmers Welfare to promote millets in the country and the world by organizing a 'Special Millets Lunch' for MPs in the Parliament Courtyard on December 20, 2022. The luncheon served an elaborate curated millet buffet to highlight the diversity of Indian millet and the variety of millet cuisines, similar event was conducted at CM -House at Gandhinagar on Millets Food Festival during December, 2022.
- In order to promote the consumption of millets and in view of their health benefits, all offices of the Department of Food and Public Distribution (DFPD) have recently directed to introduce and promote millets in their canteens and in meetings.
- In order to enhance nutrition among children, the Central Government has requested State Governments/Union Territory Administrations to explore the possibility of introducing millets under the 'PM POSHAN' Scheme, preferably in the districts where eating millets is a culturally accepted food habit.
- By declaring 2023 as ''The International Year of Millets'' the UN General Assembly has set the tone for increasing the area of cultivation of millet across the world. India, which is the world's largest producer of millet, is taking wide- ranging steps to implement the benefits of this opportunity.

Problems/ Constraints of the Low Production and Productivity of Small Millets in India:

- Exploiting existing variability present in germplasm to be use in hybridization programme to derive new variations, this can support in breeding new cultivars with higher-yielding background.
- Small millets not only for grains but also for the fodder is prime need of the today for increasing the demand of cattle feed.
- Small millets are generally planted as rainfed crops and are severely impacted by drought due

to monsoon failure. Aside from drought, lodging is a serious issue in all small millets, owing to their soft stalks, crop management and climatic conditions.

- Small millets are well adapted to diverse climatic conditions and are less affected by major biotic and abiotic stresses. However, a few diseases *viz;* grain smut, head smut and leaf spot diseases in minor millets and insect pests like shoot fly are causing considerable yield loss, and therefore, breeding for cultivars resistant to diseases and a pest is important.
- Although lodging has not been directly estimated to cause a production loss in small millets, losses in big grains like rice and wheat have reached 50%. It happens when plants bend at maturity as a result of heavier panicles, softer stalks and weak anchorage roots.
- To reduce yield and quality losses, it is crucial to produce cultivars with increased lodging resistance because lodging is genotype-dependent and impacted by the environment.
- Grain shattering is a crucial quality for small millet. small millets experience significant yield losses as a result of grain shattering, hence developing small millets that are tolerant to or resistant to shattering will be essential to preventing yield losses caused by shattering.
- Developing machine harvestable cultivars, improving the nutritional value of grain and fodder to fetch high market value, developing cultivars suitable to make value-added products like rice, flour, vermicelli, flakes, hot and cold extruded snacks, noodles, and ready-to-cook mixtures, shade-tolerant genotypes for orchards and agro-forestry, quick growing genotypes for intercropping, and so on are special breeding traits to enhance the cultivation and consumption of small millets.
- Small millets have a great nutritional potential, but because of antinutrients including phytate, phenols, tannins, and enzyme inhibitors, as well as a significant number of protease and amylase inhibitors that reduce the digestion of millets grains, their usage is constrained. (Elangovan *et al.*, 2020)
- Small millets typically have higher levels of most grain nutrients than the major cereals, although germplasm varies widely in terms of both grain nutrients and antinutrients.
- Non-availability of improved quality seeds of sorghum, pearl millet, finger millet, foxtail millet, little millet, barnyard millet, brown top millet and kodo millet
- Farmers for small millets cultivation using unfertile land with very low productivity also not applying fertilizers during crop growth
- Lack of accepting improved cultivation practices in millets in tribal farmers like non transplanting seedlings in high rainfall zone in place of them throwing the seedlings, non-preparation of seed bed etc.
- Dissemination of improved cultivation practices in millets in tribal farmers
- Enhancing the accessibility of processing machinery to millet farmers
- Enhancing the awareness on goodness of millets for nutrition and health, besides sustainable agriculture
- Lack of transport facility and market facility in hilly areas where these crops get cultivating
- Non-adoption of timely tillage, sowing, weeding and inter-cultivation
- Lack of value addition chain development for millets- cultivation to consumption
- Strategic research interventions for positioning millets cultivation in hilly areas
- Promotion of value addition as an attractive and rewarding enterprise in hilly lands
- Promotion of Small millets as a 'Nutricereals' is slow among the consumers/peoples
- Lack of more millets production through mechanical method of harvest
- Lacking processing units small scale to large scale units
- Lack of market linkage and supply chains in value addition chain
- Lack of Nutricereals - Awareness programs in metropolitan cities
- Lacking millets for export due to high demands in outside countries to get more income and more profit to tribal hilly area
- Non adoption of improved varieties which are suitable for mechanization
- Expensive skilled labour and diversion to remunerative crops

- Lack of buyback system in minor millets (Seetharam *et al.*, 2000)

Reasons for Cultivation of Small Millets in Tribal Belt of India:

- Crops of antiquity-traditional cropping systems
- Gives high return under low cost of cultivation
- Suitable for dry lands and important in hill and tribal agriculture
- Food and fodder security of disadvantaged regions
- Require less water, mature early and adapt to different ecological conditions mostly high rainfall as well as drought.
- Ideal crops for climate change and contingency plantings
- Grow around the year and most suited to tribal belt
- Unique nutritional properties like high fiber, quality protein and mineral composition
- Nutritional security of disadvantaged groups
- Small millets are the better crop for value addition and high market demand

Major constraints faced in small millet cultivation under tribal belt of India which decreases the area under drastically under these crops: (Upadhyaya *et al.*, 2014)

- Traditional cultivation methods of small millets including improper planting techniques: As tribal farmers not using line sowing or transplanting method for small millets, in spite of that they simply drops or throws seedlings which not able to maintain plant population also more time is required to stand up the seedlings.
- Lack of awareness on improved technologies: Farmers having very less education and has very less adaptability of improved package of practices.
- Non-availability of inputs: Due to remote area and low monetary or expenditure capacity input availability is very less.
- Low price due to less market acceptance: As much of local produce is sold only in rural areas. The urban population has very less information about its usefulness.
- Lack of marketing facilities: Organized market is unavailable and APMC facilities are very less also farmers depend on only local markets.
- Lack of post-harvest and value-addition technologies: Non availability of post harvest and value addition leads to low price and losses occurred during storage is high.

Ways for the improvements of small millets growers in Gujarat and India:

- The area under small millets is declining over the years. To cope up with the increasing demand for these crops from the food processing sector and also to sustain the food and nutritional security of tribal, marginal and dry land farmers the productivity of these crops needs to be increased by developing high yielding varieties.
- To overcome the changes in climatic conditions, these crops needs to be further exploited taking in to consideration their plasticity to climate change.
- The mechanisms involved in biotic and abiotic stress tolerance in small millets at morphological and molecular level needs to be thoroughly understood for targeted breeding.
- Small millets crops are the best suited for the value addition and small-scale machines are the need of today's growers like little millet processing machines or finger millet papad etc.
- These crops, due to their low glycemic value and high mineral content are better suited for the changing food habits and dietary requirements in the current scenario. Hence, new varieties with superior nutritional qualities needs to be developed.
- New collection of land races of small millets for evaluation, documentation and conservation.
- Development of early maturing varieties of small millets suitable for sole as well as inter/mix cropping under rainfed situations across India with resistance to important biotic stresses. (Li *et al*., 2014)
- Crop like finger millet (Var. GN-8 due to early maturing>100 days) suited for the *Rabi* and late Rabi season or in summer season with very less attack of pest and diseases.
- Development of nutritionally superior varieties of kodo millet and little millet
- Development of low-cost production and protection technology for small millets.
- Identification of multiple disease / insect resistant sources

- Development of technologies to minimize / control kodo millet poisoning
- Transfer of viable technologies and its proper use to the farmers field through FLDs and other extension programmes.
- Implications in the implementation of OFT/ FLDs of newer technologies on tribal belt with biofortified varieties like 'GIRA' in finger millet. (As below)

Recently Released Biofortified Variety of Finger Millet

Finger Millet Var. CFMV-2 (GIRA) Biofortified Variety, National Release - 2020-21

Released by: Hill Millet Research Station, Nau, Vaghai Dangs

- High yielding as well as good fodder producing Finger millet variety.
- Found to be best performing in Gujarat, Andhra Pradesh, Chhattisgarh, Maharashtra and Odisha states of India.
- Medium maturity duration and synchronous maturity (119-121 days).
- Profuse tillered and non-lodging culture is highly suitable for rainfed cultivation.
- Bold grain size (2.94 g per 1000 seed weight) and non shattering habit.
- Plant type is erect and Reddish Brown grain colour with panicle is semi-compact.
- Better fertilizer responsive genotype.
- Found superior in respect to Ca, Fe, Zn and mineral matter (%) which showed the good and high nutritional value.
- Moderately resistant to leaf blast (%), foot rot (%), brown spot (G), grain mould (G), neck blast (%), finger blast (%) and banded blight (PDI).
- Moderately tolerant to stem borer (%), plants and panicles affected by shoot aphid (%).

Opportunities/ Scope / Benefits of Small Millets Growing In India Under Recent Era of Millets:

- Small millets are now world known "Nutricereals crop" being introduced in the highly nutritive crop during International Year of Millets-2023.
- Nutritional security of disadvantaged groups
- Gives high return under low cost of cultivation
- Best crop for the low fertile soils
- Small millets are the better crop for value addition
- Ideal crops for climate change and contingency plantings
- Best suitable crop for dry lands and important in hill and tribal agriculture
- Crops of antiquity-traditional cropping systems
- Food and fodder security of disadvantaged hilly regions
- Best suited for inter, intra as well as mixed cropping systems in hilly areas of India
- Require less water, mature early and adapt to different ecological conditions mostly high rainfall as well as drought.
- Unique nutritional properties like high fiber, Ca, Fe, Zn, Mg, quality protein and mineral composition.
- Very less suffers to biotic as well as abiotic stress during crop growth.
- Best suited for organic as well as natural farming concepts.
- Most of the small millets cultivated around the year, mostly from June to January.
- Best sustain under the diversified soil and climatic conditions.

Different strategies of small Millet Crop Improvement in Gujarat and India:

For the improvement in small millet crops for breeding objectives with targeted traits such as grain yield with better biotic and abiotic stress tolerance with green as well as dry fodder yield, improvement in quality traits, pest and disease resistance, Stem borer as well as shoot fly resistance, non-lodging, non-shattering, early to medium days to maturity, bold grain size with attractive grain colour, high harvest Index, short-duration varieties would be suitable for double/intensive cropping along with Medium-to long-duration varieties for single cropping season areas and sustain under adverse climatic conditions high rain, low rains (drought), also with salt tolerance, clod tolerance as well as thermo tolerance. Grain with better hulling capacity, good for value addition and making bakery products. Crop with less water use efficiency genotypes which are associated with yield and adaptation are essential to target yield increase, quick growing genotypes for inter-cropping and genotypes suitable for rice-fallows,

Table 1: List of small Millets Crops grown in India.

Sr. No.	Common Name	Vernacular Name	Scientific Names	Chromosome No.	Origin
1.	**Finger millet**	Ragi, Mandua, Nagli, Kapai, Madua, Nachani	***Eleusinecoracana L.***	2n=36(4x)	Ethiopia, African high lands
2.	**Foxtail millet**	Kang, Korra, Navane, Tenai, Rala	***Setariaitalica L.***	2n=18(2x)	Central Asia, India
3.	**Kodo millet**	Kodo, Varagu, Haraka, Arikalu	***Paspalum scrobiculatum L.***	2n=40(4x)	India
4.	**Little millet**	Kutki, Samai, Same, Samalu, Vari, Gundli.	***PanicumSumatrense L.***	2n=36(4x)	India
5.	**Proso millet**	Cheeno, Panivaragu, Variga, Baragu	***Panicummiliaceum L.***	2n=36(4x)	Central Asia, India
6.	**Barnyard millet**	Banti, Sawan, Madira, Kuduraivali,Oodalu	***Echinochloa frumentacea***	2n=54(6x)	India

Shade-tolerant genotypes for orchards and agro-forestry, search for sustainable genotypes under changing climates situations. Germplasm collections exhibit significant variation for various traits, including maturity duration that can be exploited to breed the cultivars that fit into the different maturity groups *viz;* early, mid-late and late, depending on the location-specific requirements of soil, rainfall, temperature, humidity, day-length and cropping patterns. (Jayaraman *et al.,* 1997).

The main objective of the hybridization is to create the variability and incorporate desirable traits such as high yielding, pest and disease resistance and important quality traits etc., in a single genotype and to widen the genetic base of the population for most effective selection but due to very less crossing ability in. (Nelson, 1984) Traditionally small millets were cultivated, integrated farming system was practiced in Gujarat which was sustainable, both in terms of human health and agriculture. Hence, search of genotypes which will be best suited for inert/ intra cropping systems with different crops in different ecological situations. Also, search of genotype which will be a best for drought tolerance and high-water use efficiency. In fact, the study of small millet to fit for dryland farming crop and withstand severe moisture stress under adjust to wide range of soil conditions. Thus, looking to the need of changing climatic conditions region specific objectives kept in mind to develop better cultivar. Also, different strategies would follow as per need of Small Millet crops. (Seetharam *et al.,* 2000 and 2003).

Strategies for improvements of small millets crop in India:

- As per climate change, there is need to evolve high yielding, pest and disease resistant and early maturing small millet varieties suitable for agro-climatic region of India as a high yielder for rainfed areas.
- Development and distribution of HYVs of small millets among the farmers.
- Improved agronomic practices and other technical assistance
- Creation of awareness about the nutritional benefits of the millets products among the consumers
- A value chain model is needed with emphasis on value addition and development of value-added products from millets.
- Major millets like jowar, bajra and ragi are only covered under the Minimum Support Scheme (MSP) of Government of India.
- Include minor millets as a major food to the old and child hood peoples
- Introduction of the millets products in the public distribution system
- Mid-day meal scheme will also create a substantial demand for these products and inclusion of nutricereals in the mid-day meal programme
- Improvement of export competitiveness of Indian Millets
- Promotion of Farmers Producers Organization (FPO)
- Creating farm gate processing and warehouse facilities
- Quality seed production and utilization in seed minikits
- Agronomically and physiologically efficient varieties for yield maximization
- High culm strength for mechanical harvest
- Bold seeded varieties for ease in processing

- Identification of drought tolerant genotypes
- Fertilizer responsive varieties
- Cropping system identification for high B:C ratio
- To develop the ideal plant type through combination of conventional and molecular biology in small millet crops.
- To develop new integrated crop management/ cultivation practices as per changing climatic conditions as well as best suited for organic agriculture.

Efforts needed under Nutricereal mission in India state for Small millets to enhance the Farmers income of tribal community are as below:

- Availability of quality Seed
- Dissemination of improved cultivation practices in millets
- Enhancing the accessibility of processing machinery to millet farmers
- Enhancing the awareness on goodness of millets for nutrition and health, besides sustainable agriculture
- Value addition chain development for millets-cultivation to consumption
- Strategic research interventions for positioning millets cultivation and value addition as an attractive and rewarding enterprise
- Promotion of small millets as a Nutricereals in social media
- More millets Production through mechanical method of harvest
- Processing units small scale to large scale at each district level
- Market linkage and Supply chains
- Nutricereals-Awareness programs in metropolitan cities
- Millets for export and more income. (Elangovan *et al.*, 2020)

Future Prospects of Small Millet Crop in Gujarat and India:

- Small millets have the potential to serve as an alternate/ supplement to major cereal staples because of their ability to be used/ cooked in similar ways, diverse adaptation to adverse conditions and nutritional qualities.
- Small millets can fit very well into multiple cropping systems both under irrigated and rainfed conditions.
- Their storability under normal storage conditions has made them 'famine reserves'. They can provide nutritious grains as well as valuable fodder in a short span of time.
- A very low number of germplasm and inadequate information on genetic diversity limits their effective utilization in crop improvement programs. Therefore, prioritizing germplasm collection is key to identifying trait specific resources, genes and alleles, which can be utilized in small millets breeding programs.
- So far, small millets varieties have been developed mainly through conventional breeding methods. The yield barrier in small millets can be broken by a male sterility system and exploiting heterosis, and genomics- assisted crop improvement, together with better crop management and mechanization.
- Genomics assisted breeding will facilitate the identification of novel alleles and genes with superior agronomic performance and resistance to biotic and abiotic stresses to accelerate small millets improvement. (Padulosi *et al.*, 2009)
- Biotechnology techniques such as tissue culture and genetic engineering reported in related crops could potentially support small millets improvement. The rapid development of sequencing technologies can generate millions of sequence reads at a low cost and in a short time irrespective of whether there is prior sequence information or not.
- Next generation sequencing techniques enable the molecular characterization of an entire set of small millets germplasm.
- These techniques could be used in crops such as little millet, kodo millet, and job's tears where genome decoding has not yet been done. Similarly, comparative genomics facilitates the exploration of orthologous genes of important traits in less studied crops with available genome sequence information from rice and foxtail millet.
- The emergence of genome editing techniques allows the modification of the genome of small millets to enhance production and stress tolerance.
- Similarly, comparative genomics facilitates the exploration of orthologous genes of important traits in less studied crops with available genome

sequence information from rice and foxtail millet.

- In addition to conventional breeding and genomics-assisted improvement, a comprehensive and coordinated multidisciplinary collaboration across the agronomy, biomedical, food science and technology areas is required in order to shift the status of small millets out of 'minor and underutilized' crops' group.
- Additionally, public–private partnerships, public awareness, farmers' engagement across the countries who are interested in small millets research and promotion will be needed to incorporate small millets-based food products as an important source of nutrients in diets.
- Given the changing climate scenario and prevailing hidden hunger, greater research and developmental focus on small millets and other traditionally important crops is the key to achieve food, feed and nutrition security

References

De Wet, J.M.J., Prasada Rao K.E. and Brink D.E. (1983a). Systematics and domestication of *Panicum sumatrense* (Graminae). J.d'agriculture Tradit. *Bot. appliquée*, **30**, 159-168.

De Wet, J.M.J., Rao K.E.P., Mengesha M.H. and Brink D.E. (1983b). Diversity in kodo millet, *Paspalum scrobiculatum*. *Econ. Bot*. **37**, 159-163.doi: 10.1007/ BF02858779.

Elangovan, M., Ganapathy K.N., Amasiddha B., Singode Avinash and Tonapi Vilas A. (Eds.) (2020). Online Refresher Course on Recent Advances in Millets Research, Compendium of Lecture Notes. Society for Millets Research, ICAR–Indian Institute of Millets Research (IIMR), Hyderabad 500030, 249.

Elangovan, M. and Tonapi Vilas A (2015). Genetic Resources Management in Sorghum and Millets. Indian Institute of Millets Research, Hyderabad. 471. ISBN: 81-89335-53-7.

Gupta, A., Maharaj V. and Gupta H.S. (2010). Genetic resources and varietal improvement of Small Millets for Indian Himalaya region. Biodiversity potentials of Himalaya, 305-316.

Jayaraman, N., Suresh S., Nirmala A. and Ganeshan N.M. (1997). Genetic enhancement and breeding strategies in Small Millets. In: National Seminar on SMALL Millets, 23-24, April, Coimbatore, Gujarat, 19-21 (Extended summaries).

Kalinova, J. and Moudry J. (2006). Content and quality of protein in proso millet (*Panicum miliaceum* L.) varieties. *Plant Foods Hum Nutr*.; **61(1)**, 45-49. doi:10.1007/ s11130-006-0013-9.

Li, L., Zhang Q. and Huang D. (2014). A review of imaging techniques for plant phenotyping. *Sensors*., **14**, 20078-20111.

Padulosi, S., Bhagmal Bala, Ravi S., Gowda J., Gowda K.T.K., Shanthakumar G., Yenagi N. and Dutta M. (2009). Food Security and Climate Change: Role of Plant Genetic Resources of Minor Millets. *J. Plant Genet Resource*, **22**, 1-16.

Pradeep, S.R. and Guha M. (2011). Effect of processing methods on the nutraceutical and antioxidant properties of little millet (*Panicum sumatrense*) extracts. *Food Chem*. **126**, 1643-1647. doi: 10.1016/j.foodchem.2010.12.047

Seetharam, A., Riley K.W. and Harinarayana G. (Eds). (2000). Small Millets in Global Agriculture (1st Edn), Oxford and IBH Publishing company, Delhi, India, 59-70.

Seetharam, A., Gowda J. and Halaswamy J.H. (2003). Small Millets. In: Chowdhury SK, Lal SK (Eds) Nucleus and breeder seed production manual, Indian Agriculture Research Institute, New Delhi, Gujarat, 54-67.

Upadhyaya, H.D., Dwivedi S.L., Singh S.K., Singh S., Vetriventhan M. and Sharma S. (2014). Forming core collections in barnyard, kodo, and little millets using morpho agronomic descriptors. *Crop Sci*. **54**, 1-10. doi: 10.2135/crop- sci2014.03.0221.

Veena, S., Bharati V.C., Rama K.N. and Shanthakumar G. (2005). Physico-Chemical and Nutritional Studies in Barnyard Millet. *Karnataka J Agric Sci*. **18**, 101-105.