

Barnyard millet:

Recent advances and improved technologies

B Amasiddha*, M Elangovan, A V Umakanth, K N Ganapathy, K Venkatesh, R Swarna, C Deepika and S Srividhya

ICAR-Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana 500 030

Barnyard millet (Echinochloa frumentacea), due to its remarkable ability to withstand erratic rainfall and varying weather conditions has been classified as one of the drought stress hardy crop. It is largely cultivated in harsh and fragile environments, with minimal use of agricultural inputs. Barnyard millet with rich nutritional profile is one of the best choices for patients with dietary based health defects like diabetic, heart related diseases and celiac diseases. Presently, crop improvement programmes in barnyard millet are targeting recombination breeding, use of molecular markers, tagging genes/QTLs for nutritional qualities, biotic and abiotic stresses, improving/modifying the crossing techniques, mutation breeding to enhance the diversity etc. However, the whole genome sequencing in Indian barnyard millet is necessary to understand its adaptability and dissecting the phenotypic characters at genotypic level and utilizing the information in improving the yield contributing traits to break the stagnated yield levels.

Keywords: Barnyard millet, Germplasm, Recombination, Sequencing, Varieties

BARNYARD millet is becoming one of the most important minor millet in the world specifically in India because of its multiple uses like food, feed and fodder. It is scientifically named as *Echinochloa* sp. which contains two major species *Echinochloa esculenta* (Japanese barnyard millet) and *Echinochloa frumentacea* (Indian barnyard millet) cultivated for human consumption and livestock feed. Globally, India is the biggest producer of barnyard millet, both in terms of area (0.146 m ha) and production (0.147 mt) with average productivity of 1034 kg/ha during the last 3 years (IIMR 2018). It is less susceptible to biotic and abiotic stresses and mainly cultivated in marginal lands in fragile soils. Barnyard millet is a good source of protein, carbohydrates, fibre and most notable micronutrients like iron and zinc, and vitamins. Despite of its agronomic and nutritional benefits, this crop has remained as underutilized orphan crop. Recently, after the establishment of ICAR-Indian Institute of Millets Research (IIMR) and collaborative works with ICAR-National Bureau of Plant Genetic Resource (NBPGR), New Delhi and International Crops Research Institute for Semi-arid Tropics (ICRISAT), Patancheru, Hyderabad the progress has been achieved in the areas like characterization of large number of germplasm

resources, identification of trait specific accessions, discoveries of genes/QTLs, transcriptome analysis studies, genome sequencing (Japanese barnyard millet) etc. In this article we are highlighting the recent advances in genetic and genomic resources development, and improved technologies in barnyard millet.

Recent advances in barnyard millet improvement

Echinochloa sp. belongs to the family Poaceae, sub-family Panicoideae, in which 35 related species are identified for their *taxa* and phylogenetic relationships through morphological, biochemical and molecular markers. Globally, 8000 germplasm accessions were conserved at different centres, viz. Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), India; Indian Institute of Millets Research (IIMR), India; National Institute of Agro-biological Sciences (NIAS), Japan and Consultative Group on International Agricultural Research like International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), India. Core collection comprising of 89 accessions was established from the main set of 736 germplasm lines representing the entire diversity based on phenotypic and genotypic characterization. Three potential and trait specific genetic stocks (easy dehulling, glumeless mutant

and grain smut disease resistant) were registered with national Gene Banks (NGB) to protect from IPRs and also to facilitate the breeders to use in crop improvement programmes. In India more than 20 improved varieties were released for cultivation in different parts. Breeding methods followed in barnyard millet were mainly pureline selection and pedigree method. Most of the developed varieties were based on selections from germplasm accessions, viz. K1 released from Tamil Nadu and PRJ 1 from exotic collections released from VPKAS Almora. Recently crop improvement programmes are concentrating on recombination breeding followed by pedigree method. Presently DHBM 93-3 and VL 207 are used as national checks in AICRP on small millet system which were developed based on pedigree method of breeding. The use of chemical hybridizing agents (CHAs) for inducing male sterility was tried at ICAR-IIMR, Hyderabad in which treatment of alcohol at 15% concentration and Ethrel at 1500 ppm was found best for inducing male sterility up to 40% and 75% respectively. Contact methods crossing and hand emasculation, and pollinations were improved to get more number of hybrid seeds than selfed seeds in barnyard millet at ICAR-IIMR, Hyderabad (IIMR, Annual Report-2021). With the improved methods of crossing and identified trait specific accessions as donor parents, the improvement programme in barnyard millet has reached faster rate.

Various scientists used molecular markers to understand the phenotype at genotypic level. The scientist's team from China has released the whole genome sequence of the weedy species *E. crus-galli* (Japanese barnyard millet) and reported that the total genome length is 1.27 Gb representing 90% of the predicted genome size. However, in Indian barnyard millet, very limited attempts have been made to discover the genomic structure and associated downstream processes due to its genome complexity and lack of research funding on this orphan crop. The genome sequence information of Indian barnyard millet has yet to be sequenced for better understanding and to bring quick improvements in the development of improved cultivars. Whole genome sequencing and publishing in the peer reviewed journals will position India at the international levels in the scientific achievements in agriculture field.

Improved technologies in barnyard millet

With the advancement of technologies and bringing recombination breeding efforts to combine two parents has brought high yielding cultivars in barnyard millet. Five improved varieties and their yielding ability with state in which they are under cultivation are given as:

1. VL 207: Medium maturing variety

Year of release: 2008

Production condition: Rainfed/kharif

Recommended states: All states except Gujarat and Tamil Nadu

Salient features:

- Medium maturing (85–100 days)
- Narrow leaf with erect growth habit

- Presence of culm branching
- Green plant pigmentation at flowering
- Leaf lamina pigmented with purple colour
- Compact and pyramidal type of inflorescence
- Purple glume pigmentation at seed maturation stage



VL 207 (Barnyard millet)

2. CO2: Medium maturing variety

Year of release: 2008

Production condition: Rainfed/kharif

Recommended states: Tamil Nadu

Salient features:

- Medium maturing (95–100 days)
- Narrow leaves with erect growth habit
- Cylindrical and purple coloured inflorescence
- Absence of culm branching
- Compact panicle type



CO2 (Barnyard millet)

3. DHBM93-3: Medium maturing variety

Year of release: 2016

Production condition: Rainfed/kharif

Recommended states: All states except Uttarakhand and Himachal Pradesh

Salient features:

- Higher grain yield (24.0 q/ha)
- Higher fodder yield (5.5–6.5 t/ha)
- Compact earhead
- Sturdy tillers with lodging resistance
- Pale green leaf colour
- Tolerance to shoot fly
- Resistant to head smut and grain smut



DHBM-93-3 (Barnyard millet)

4. MDU1: Medium maturing variety

Year of release: 2018

Production condition: Rainfed/kharif

Recommended states: Tamil Nadu

Salient features:

- Medium maturing (100–105 days)
- Broad leaf with erect growth habit
- Presence of culm branching
- Green plant pigmentation at flowering
- Compact and pyramidal type of inflorescence



MDU1 (Barnyard millet)

5. DHBM23-3: Medium maturing variety

Year of release: 2019

Production condition: Rainfed/kharif

Recommended states: Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu

Salient features:

- Higher grain yield (32.0 q/ha)
- Higher fodder yield (6–7 t/ha)
- Semi-compact earhead
- Panicles are glume pigmented at seed maturation stage
- Thin and more tiller bearing variety
- Tolerance to shoot fly
- Resistant to head smut, grain smut



DHBM-23-3 (Barnyard millet)

SUMMARY

Despite its agronomical and nutritional values, and health benefits, barnyard millet has remained as an underutilized crop and very less attention was given for its improvement. This crop has become orphan crop because of lack of funding from agencies and research organizations. Whole genome sequencing of crops adds an advantage of understanding the plant at its genetic and molecular level, and identification of genes and molecular markers strengthens and fastens the breeding programmes. Specifically sequencing of Indian barnyard millet species (*Echinochloa frumentacea*) is of prime importance to know the genetic architecture and compare with Japanese barnyard millet species and to identify the genes/QTLs responsible for high grain and biomass yield. However, the recent advances in recombination breeding with improved crossing techniques and identified trait specific parental lines has given more scope to break the stagnated yield levels.

*Corresponding author's e-mail: amasiddha@millets.res.in

FEW FACTS

All manufacturers claim their own cooking oil is the best! Canola oil, olive oil, sunflower oil, butter, margarine, and virgin coconut oil all have their supporters. But the fact is that all liquid oils are about the same. They all provide about 120 calories per tablespoon. Unless you drink your cooking oil, or deep-fry every day, your choice of cooking oil doesn't make a huge difference. It's good that we pay attention to our oil. But the fact is, the major source of oil in our diets isn't home cooking – it's packaged foods and fast-food meals! If we're concerned about GMO (Genetically Modified Cooking Oils), it's likely that corn, soy, and canola oils are genetically-modified. There're non-GMO, organic kinds of these oils available. So check the label. Choose sunflower oil or canola oil if you wish to fry foods, as these oils have a higher smoke point. It is best not to fry with extra-virgin olive oil, as its smoke point is only about 190°C/375°F.