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Millets: Recent Advancement in Crop Improvement

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The millets are essential for nutritional security due to the high number of amino acids. Most importantly, millets stand out from other cereal crops due to their low to zero gluten content and glycemic index. Millets are a storehouse of most of the nutrients required for the normal functioning of the human body. These crops are rich in micronutrients and minerals, four to five times more than others. Small seeded cereal grasses: coarse grains: Nutri cereals/ valuable food grains. Staple crops of the poorest people in the semi-arid tropics of Asia and Africa. Millets are grown in dry lands and important in hill and tribal agriculture -food security of disadvantaged regions; Nutritional security. Require less water, mature early and cultivated in scarcity conditions - Grown under low rainfall (200-600 mm) areas. Highly Resilient in adapting to different ecological conditions; ideal crops for climate change and contingency plantings. Last standing crop in drought. Being C_4 plants these are more environment friendly with high water use efficiency and low input requirement, but equally responsive to high input management. Unique nutritional properties – high fiber, quality protein & mineral composition, being called as "Nutri-cereals"

Ways for Improvements of Small Millets (Patil *et al.*,2023)

- High yielding varieties.
- Further exploited taking in to consideration their plasticity to climate change.
- Biotic and abiotic stress tolerance in small millets at morphological and molecular level needs to be thoroughly understood for targeted breeding.
- New varieties with superior nutritional qualities need 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.
- 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.
- 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
- Best suited for the value addition and small-scale business
- Transfer of viable technologies and its proper use to the farmer's field through FLDs and other extension programmes. OFT in tribal belt with bio fortified varieties like 'GIRA' in finger millet.

Small Millets Breeding Target Traits (Patil *et al.*,2023)

- Targeted traits in SM for improvement in yield, fodder and quality traits, focus should be given to
  - Shoot fly / Stem borer resistance
  - Non-lodging,
  - Days to maturity
  - Bold grain size
  - Physiological traits Harvest index, water use efficiency, etc.
- Germplasm collections exhibit significant variation for various traits, especially. Maturity duration depending on the location-specific requirements of soil, rainfall, temperature, day-length and cropping patterns. *Short-duration varieties would be suitable for double/intensive cropping regions and*

medium-to long-duration varieties for single cropping season areas.

- By *recombining the alleles contributing for yield components* like, tiller number, number of branches, number of panicles and thousand grain weight.
- Therefore, selection for yield per se has been the major basis for improving productivity, but genotype × environment interactions highly influence these traits. Therefore, assessing yield stability across multiple environments.

Modified crossing method (SM-UAS-B method) (Patil *et al.*,2023).

At Project Coordinating unit on Small Millets, University of Agricultural Sciences, GKVK, Bengaluru, introduced this modified method of crossing in Proso millet and Little millet during 2014-15, hence named this method as SMUASB (Small millets, University of Agricultural Sciences, Bengaluru).

To overcome the problem found in hand emasculation and hot water treatment, to remove pollens, this modified method of crossing was proposed (Seetharam *et al.*, 1986).

- In Little millet, lemma and palea are very tight and any attempt to open the floret prior to normal anthesis results in damage to the flower and no seed set.
- In SM-UAS-B method, cold water - mechanical stimulator for opening of florets. 5-8^{0}C is sprayed on the panicle.
- Male and female parents are planted in the alternate rows for crossing.
- Best time for crossing is 6 AM to 8 AM.

Details of emasculation

- For emasculation, female plant panicle has to be selected in such a way that, first floret has opened on the panicle.
- Emasculation in flower opening starts from top to bottom of the panicle.
- Cold water of 5-8^{0}C is sprayed on the panicle. This cold-water spray stimulates the florets to open naturally, one hour earlier than naturally opened.
- When all the florets were opened, all the anthers were removed by washing the panicle in cold water.
- Florets which are not opened were removed. Immature florets at the bottom and previously fertilized florets at the top of the panicle.

Key points before initiating the crossing

- 1. Florets are mechanically stimulated by gently massaging the panicle by hand.
- 2. Florets open within 2-3 minutes well before normal flowering.
- 3. To avoid another bursting, dip in water at ambient temperature.
- 4. Thrash anthers from opened florets with fore fingers.
- 5. Clip off the unopened florets and retain the opened flowers.

Pollination and Crossing (Patil *et al.*,2023)

- Male parent selected ...first floret has opened
- Cold water sparyed to 5-8^{0}C on male panicle to open the florets & anthers wet.
- Immediately tied loosely around male & female parent panicle in such a way to allow proper aeration and pollination.
- Sprayed on tied panicles to keep stigma and anthers in wet condition
- Tied male and female panicles are covered with butter paper
- Tag the crossed panicle date & Name of the parents

Tips

- Pollen from the male spike showers down on the female spike affording good opportunity for fertilization.
- Spikes shaken together for 2 days during the daily anthesis periods.
- On third day, the male spike was carefully removed and the female one was checked for any floret that may have developed later?

- Failure to remove such florets completely, often allowed them to develop and produce seed, which may be confused with the cross-fertilized ones.

Constraints in Hybridization/Problems occur during Crossing in small millets

- Highly Self-Pollinated Crop
- Very Small flower structure (> 0.5 cm)
- Emasculation is not physical but done by hot or cold water, only means cannot predict for perfect male removal.
- Choice of male parent should must be a marker character based otherwise difficult to identify real F_1 and F_2
- Timing for hybridization is mostly very early in morning hours 5.0 to 6.0 am
- Immature flower to fertilization & matured grain formation is 25-30 days process.
- Flower is cleistogamous nature
- Quality is a Polygenic trait, that's difficult for improvement without crossing
- Complex ploidy level in small millet crop
- Require higher technical skill in crossing
- Higher cost to for lab testing in true to type hybrid, otherwise marker trait is highly needed to identify true hybrid
- The molecular marker technique for confirmation of hybridity is also required for identification of true hybrid.
- Hybridization is very difficult in small millets and success rate is 2 to 3 percent only.

Table 1: List of Notified Varieties from Hill Millet Research Station, NAU, Waghai

Sr.No.	Crop	Variety	Year of release	Notification No.
1.	Finger Millet (Nagli)	Guj. Nagli -1 (Red)	1976	--
		Guj. Nagli -2 (Brown)	1882	--
		Guj. Nagli -3 (Red)	1990	--
		Guj. Nagli-4 (Red)	2006	--
		Guj. Nagli-5 (White)	2009	22/11/2016 (S.O.3540 E)
		Guj. Nav. Nagli-6 (Brown)	2014	22/11/2016 (S.O.3540 E)
		Guj. Nav. Nagli-7 (White)	2016	25/8/2018 (S.O. 2805 E)
		Guj. Nagli-8 (Red)	2018	2948/3220/2019 (SO 33004/99)
		GFMV-2 (Gira) Biofortified	2020	456/500/2021 (SO 224901E)
		CFMV-3 (Ekvijay)	2021	8/2022 (SO 232406 E)
2.	Little Millet (Vari)	Guj. Vari-1	1978	--
		Guj. Vari-2	2006	22/11/2016 (S.O. 3540 E)
		Guj. Navsari Vari-3	2016	27/3/2018 (S. O. 1379 E)
		Guj. Navsari Vari-4 (Ambika)	2022	89 th Meeting Proced. 04/12/2022
3.	Baryard Millet (Banti)	Guj. Banti-1	1984	--
4.	Kodo Millet (Kodo)	Guj. Kodra-1	1976Recent	--
		Guj. Anand Kodra-2 (CKMV-3)	1993	3-81/2021 SO-4
		Guj. Anand Kodra-3	2016	8/2022 (SO 232406 E)
		CKMV-4	2021	3-82/2021 SO-4

(Patil *et al.*, 2023)

Conclusion

Millets are highly nutritious or a storehouse of nutrients, with diversifying uses in human food, animal feed-fodder, pharmaceutical use and commercial starch production. Utilization of Millets for Alternative Uses of Millets are traditionally used for preparation of fermented foods and beverages.

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