27 Floral Biology, Pollination, Genetics, Origin and Diversity in Little Millet (*Panicum sumatrense* L. Roth ex. Roem. and Schultz)

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Abstract

Little millet was domesticated in India 5000 years ago. Little millet is a domesticated variety of the weed *Panicum silopodium*. Little millet is a tetraploid ($2n = 4x = 36$) plant in the Poaceae family. The chromosomes of hybrids of *Panicum sumatrense* and *Psilopodium* pair fairly completely with only one quadrivalent, demonstrating the two species divergence. Little millet is divided into two races based on panicle morphology, nana and robusta, each with two subraces (laxa and erecta for nana and laxa and compacta for robusta). This crop's flowering is of the chasmogamous variety, in which pollination occurs earlier than flower opening. Each spikelet consists of two-minute flowers. The lower is sterile, while the top is fertile or bisexual but lacks rachilla extension. Due to this, the self-pollination has a significant advantage. Hybridization is thus a requirement for the creation of variety. Emasculation is required for crossing due to self-

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pollination and the lack of male sterility. In little millet crop, numerous emasculation and crossing procedures are used, including the touch method, hot water treatment, hand emasculation and the USSR method. However, the problem with these procedures is that it causes stigma harm, which diminishes the success rate of obtaining actual F1s. To alleviate all of the shortcomings of previous methods, the modified crossing 'SMUASB' method was recently employed. Cold water (5–8 °C) is sprayed on the panicle as a mechanical stimulator for the opening of florets in male and female panicles in this approach. Female panicle is gently rinsed in cold water for emasculation. This has no effect on stigma or its sensitivity. Before pollination, all fertilised florets and unopened immature florets are removed. As a result, the success rate in little millet using the SMUASB approach was increased, producing actual F1 with more space and fewer resources for F1 evaluation.

Keywords

Little millet · Floral biology · Origin · Diversity · Hybridization

27.1 Introduction

Little millet, also known as *sama*, is grown in India, Sri Lanka, Pakistan, Myanmar, and other Southeast Asian nations (Hiremath et al. 1990). It is significant to tribes in India's Eastern Ghat Mountains and is planted with other millets (Hiremath et al. 1990). Little millet is a coarse cereal that is consumed in the form of rice. It is a member of the Poaceae family and the Panicoideae subfamily. It is a self-pollinated crop with $2n = 4x = 36$ chromosomes. Little millet is a food and feed crop grown in India's tribal belts of Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, Odisha, and Andhra Pradesh. It is classified as a fast-growing grain with a short (60-day) to long (160-day) growing period that can survive both drought and water loading (Doggett 1989). It is also known as nutricereals or nutrimillets due to its nutritional excellence. The protein has a well-balanced amino acid profile and is high in methionine, cystine and lysine. Little millet can be produced in tropical and subtropical regions and is widely recognised for its drought tolerance. It is one of the least water-demanding crops and is suitable for delayed planting, rainfed conditions, drought tolerance, multiple and contingent cropping systems. Little millet contains a good level of iron and calcium when compared to other small millets and staple food crops like rice and wheat. Little Millet grains are as nutritious as or perhaps more so than some of the main cereals. Little millet is typically a disease-free crop; however, the incidence of grain smut (*Macalpinomyces sharmae*) can cause financial losses. Among insect pests, shoot flies are a common occurrence and are known to inflict financial losses; however, after receiving rainfall, shooflies become less common. Millets are typically renowned for their high nutritional value. The highest amount of crude fibre has been found in little millet. As a high source of minerals, vitamins, fat (4.79 g/100 g), protein (7.7%), and other nutrients, it must be taken into account as a necessary meal for dietary security (Hulse et al. 1980).

A domesticated variety of the weedy plant *Panicum psilopodium* is known as little millet (De Wet et al. 1983). *Panicum sumatrense* and *P. psilopodium* hybrids' nearly perfect chromosomal pairing and one quadrivalent suggest that the two species' original divergence may have been the result of a single reciprocal translocation (Hiremath et al. 1990). Due to the fertile, robust, and non-shattering spikelets of hybrid plants, gene introgression between the two species is frequently observed (Hiremath et al. 1990). Although specific dates are unknown, this capacity to hybridise and the variety of small millet crops grown across India suggest that little millet was independently domesticated multiple times (De Wet et al. 1983). In terms of fibre, fat, carbs, and protein, little millet is equivalent to other cereals. It is also high in phytochemicals such as phenolic acids, flavonoids, tannins, and phytate (Pradeep and Guha 2011). It can withstand dryness, pests, and salt, like many other little millets (Sivakumar et al. 2006; Bhaskaran and Panneerselvam 2013; Ajithkumar and Panneerselvam 2014).

27.2 Origin and History

Little millet (Panicum sumatrense Roth. Ex. Roem and Schultz) is one of the important small millets indigenous toIndian subcontinent and also has the presence of its wild ancestor Panicum psilopodium throughout India. Little millet was domesticated in the Eastern Ghats of India and became a staple food for tribal people there before spreading to Sri Lanka, Nepal, and Myanmar (Hiremath et al. 1990). There is no diversity and comparable wild species are not found outside of India, suggesting an Indian origin for this millet, which was also farmed or naturalised in nearby countries such as Sri Lanka and India. Little millet cultivation peaked at the Indus Valley Civilization of Harappa and Farman around 2600 BC, making up around 5% of the overall cereal assemblage. Earlier small millet was predominated grown in the Dang and Saurashtra region of Gujarat. In the Oriyo Timbo excavations in the Bhavnagar region of Gujarat state, ranging from 2000 to 1500 BC, 77% of the seeds were of millets, including little millet (https://milletmarvels.in).

A domesticated variety of the weedy plant *Panicum psilopodium* is known as little millet (De Wet et al. 1983). *Panicum sumatrense* and *P. psilopodium* hybrids' nearly perfect chromosomal pairing and one quadrivalent suggest that the two species' original divergence may have been the result of a single reciprocal translocation (Hiremath et al. 1990). Because hybrid plants are prolific, strong, and have non-shattering spikelets, it is typical for genes from the two species to interbreed (Hiremath et al. 1990). Although specific dates are unknown, its capacity to hybridise and the variety of small millet crops seen across India indicate that this plant was domesticated independently multiple times (De Wet et al. 1983).

Based on the morphology of the panicle, little millet is split into the nana and robusta races (Figs. 27.1 and 27.2). Compared to robusta, race nana grows earlier and produces less biomass (De Wet et al. 1983). Despite a short sampling area, diversity among locally cultivated landraces of small millet in a tribal region of the Indian Kolli hills was found to be high for all morphological features examined both within and between landraces (Arunachalam et al. 2005). A NBPGR collection of

Fig. 27.1 'Robusta' type Panicle of Little millet

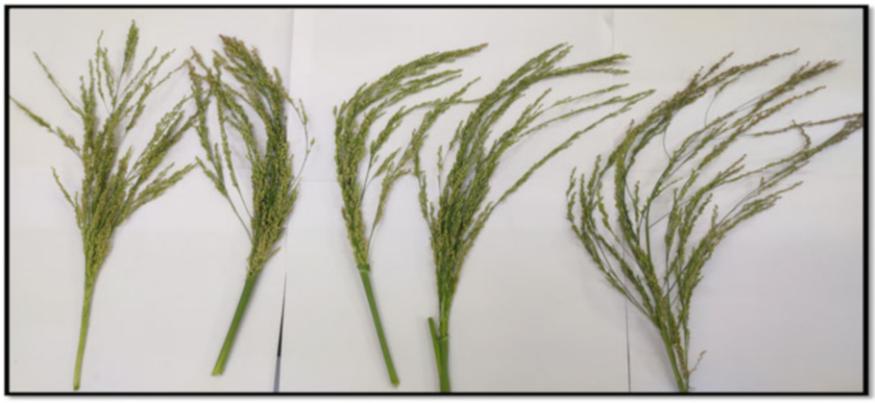
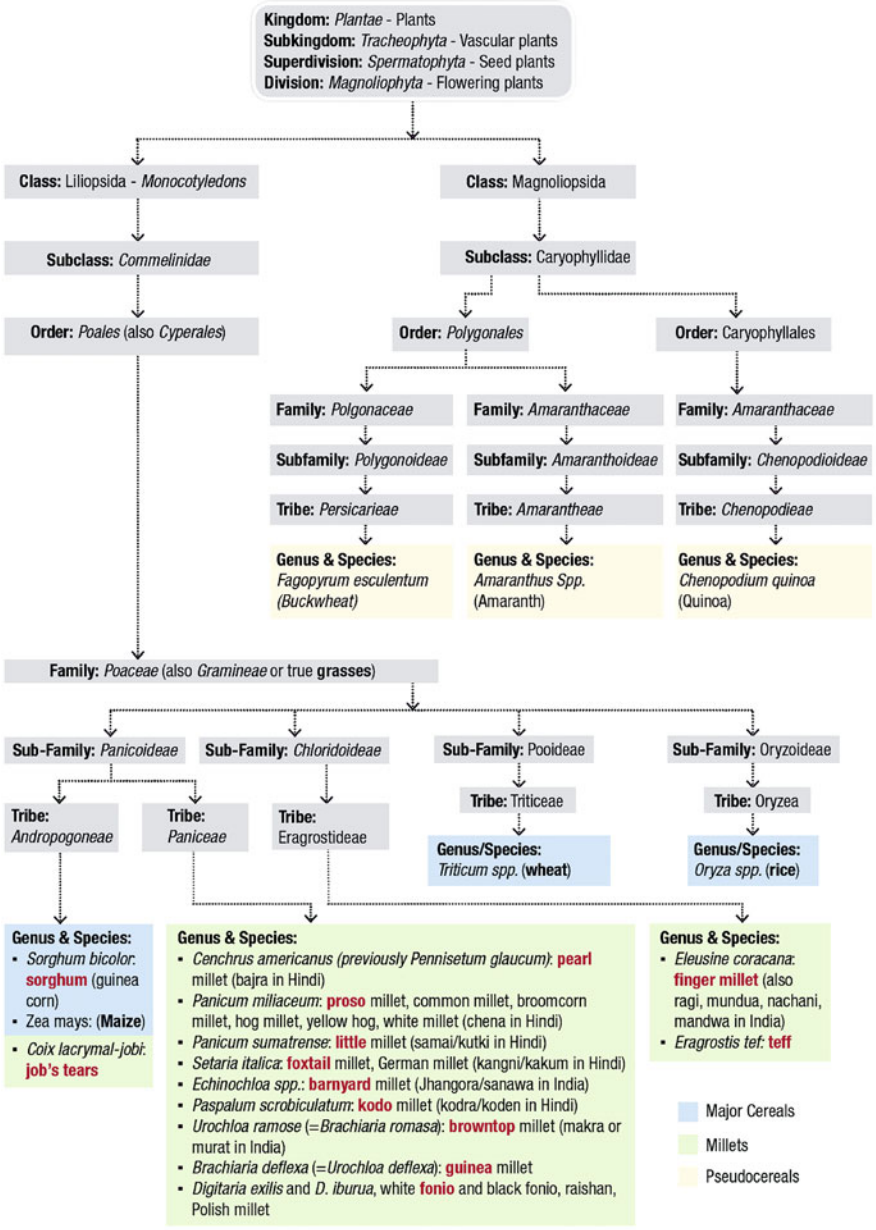


Fig. 27.2 'Nana' type Panicles of Little millet

10,409 landraces showed high diversity, heritability and genetic advancement in terms of yield and productive tillers, suggesting that the crop would be a strong candidate for varietal development (Nirmalakumari et al. 2010). For the majority of the variables analysed, a distinct collection of 460 accessions of small millet housed by ICRISAT showed genetic variation (Upadhyaya et al. 2014). It was determined that a core collection of 56 genotypes served as the seed bank's overall representation. With the help of mutational breeding, small millet populations have gained more heritable lodging resistance (Nirmalakumari et al. 2007).

Vetriventhan et al. (2020) provided the following taxonomical classification of tiny millets and other important cereals and millets, as well as pseudo-cereals. "Millet" is a frequent word for small-seeded grasses, sometimes known as dryland cereals. The grasses most commonly referred to as millets are: Major millet (pearl millet) and Minor/Small millets (finger millet, foxtail millet, proso millet, small millet, barnyard millet, kodo millet, browntop millet, fonio, teff and job's tears, and guinea millet) are the grasses that are most frequently referred to as millets.

Additionally, sorghum is occasionally referred to as major millet; in India, this is usually included in the classification of millets but is less common elsewhere.



Source: Nucleus, https://doi.org/10.1007/s13237-020-00322-3

27.3 Morphological, Cytogenetical and Genetic Diversity

Other names for the Indian cereal *P. sumatrense* include *miliare* and *attenuatum*. According to de Wet et al. (1983), *P. sumatrense* is the proper name for this native Indian cereal. The name was derived from a Sumatra specimen that was found. This plant is thought to have been brought to Indonesia by Indian immigrants and is thought to be grown on Tanimbar Island. It is difficult to understand the cytogenetics of panicum millets and their wild relatives. The basic chromosome number is $x = 9$, and evidence has been provided to support the theory that $x = 10$ is where this number first appeared. This genus frequently exhibits polyploidy, which can range from tetraploid to 12 ploidy levels (Chennaveeraiah and Hiremath 1990). The relationships between the genomes of these species are unknown. *P. psilopodium*, which is found all throughout India, is thought to be the ancestor of *Panicum sumatrense*. It thrives as a weed in the small millet farming in the Eastern Ghats of north Andhra Pradesh and creates fertile hybrids. *P. sumatrense* and *P. psilopodium*, two millet species that are grown for their morphology, can be identified from one another using a number of diagnostic traits. The hybrids had a strong reproductive capacity. In terms of non-shattering spikelets, the hybrids between *P. sumatrense* and *P. psilopodium* resembled *P. sumatrense* morphologically, and quantitative traits showed intermediate expression between the two parents. The purple glumes and stigma of the hybrids were similar to those of the male parent plant, *P. psilopodium*. The physical similarities, sympatric distribution, and creation of fertile hybrids are arguments in favour of *P. psilopodium* as the possible progenitor of *P. sumatrense*. For these two species, the genome designation is AABB. The meiotic behaviour seen in both taxa was completely normal. The parents showed regular 18 bivalents, and they are allo-tetraploid. The existence of regular 18 bivalents in the hybrids, along with the aforementioned characteristics, provide strong evidence that *P. sumatrense* may have evolved from the wild taxon *P. psilopodium* through selection and additional cultivation. The hybrid's presence of a single quadrivalent demonstrated the two species' genetic differentiation and divergence by a single reciprocal translocation (Gupta et al. 2010).

27.4 Floral Biology

The crop's floral biology is explained in detail (Fig. 27.3) by Clayton et al. in 2006. A panicle is the inflorescence. The panicle is rectangular, nodding, and about 5–40 cm long and 1–5 cm wide. The major panicle branches are 3–15 cm long and appressed. Scabrous panicle branches Spikelets are solitary, with fertile spikelets pedicelled. Fertile spikelets with one basal sterile floret and one fertile floret; no rachilla extension. Lemma II and its palea enclose the fertile flower, while lemma I and its palea enclose the staminate or sterile blossom (Sundararaj and Thulasidas 1976). Elliptical, dorsally compressed, and sharp spikelets characterise them. Spikelets are elliptic, dorsally compressed, and acute, measuring 2.5–3.5 mm in

Fig. 27.3 Little millet inflorescence and its parts. (**a**) Inflorescence; (**b**) Spikelet; (**c**) Side view of spikelet; (**d**) Opened spikelet; (**e**) Outer glume; (**f**) First lemma; (**g**) Sterile floret; (**h**) Fertile floret; (**i**) Upper glume; (**j**) Grain enclosed in lemma and palea; (**k**) Completely Open Flower

length and remaining on the plant. Glumes reach the apex of the florets and are narrower than the fertile lemma. Lower glume oval, 0.7–1.2 mm long and 0.25–0.33 mm long of spikelet, membranous with 1–3 veined keels. Lower glume lateral veins are either absent or obscured. Acute lower glume apex Upper glume is oval, membranous, and lacks keels; it has 11–15 veins. The upper glume apex is sharp. Palea barrens the basal sterile florets. Lower sterile floret lemma similar to upper glume, oval, 1 spikelet length, membranous; 9–13 veined; acute. Lower sterile floret palea 0.9 length of lemma, fertile lemma is oval, compressed dorsally, 2.2–2.5 mm long, indurate, dark brown, glossy, and lacks a keel. The margins of the lemma are involute, and the apex of the lemma is acute. Palea is involute and indurate. Three 1.5 mm long anthers 1.8–1.9 mm long caryopsis with attached pericarp.

27.5 Anthesis and Pollination

The second or third day after the panicle first appears the spikelets start to unfold. The panicle's blossoming develops from the top to the bottom. The majority of flowers bloom on the sixth or seventh day. A panicle takes around a fortnight to fully blossom (Sundararaj and Thulasidas 1976). Between 9.30 and 10.30 a.m., the anthesis takes place (Jayaraman et al. 1997). Self-pollination is the norm, and the

glumes only open for a brief period of time (Seetharam et al. 2003). The entire anthesis procedure takes around 2–5 min to complete.

27.6 Emasculation and Hybridization

Knowledge of the proper procedure for crossing and selfing in diverse crops allows the breeder to acquire the appropriate combination of traits. This requires ability and practice before the worker may expect the greatest outcomes. By recombining the alleles that contribute to yield components such as tiller number, primary branch number, secondary branch number, number of grains per panicle, and thousand-grain weight. Emasculation is the removal of stamens or anthers from a flower or the destruction of pollen grains without impacting the female reproductive organ in any manner. The goal of emasculation is to avoid self-fertilization in the female parent's flowers. Male plants in dioecious plants are removed, whereas male flowers in monoecious species are removed to avoid self-pollination. However, emasculation is required in bisexual blooms. Crossing is a procedure in which pollen from the desirable parent is sprinkled on the stigma of the seed parent because naturally self-pollinated crops are timid pollinators with very low movability to produce allogamy.

Crop enhancement effort in these crops has had some success so far. Some better cultivars have recently been created, although their yield potential is limited. Although there is substantial heterogeneity in the current germplasm collections, it has not been completely utilised. Hybridization and selection in the segregating population allow for the use of available variability to generate new improved cultivars. Hybridization is the interaction of people from different populations who differ in one or more heritable features (Harrison 1990). Hybridization can have immediate phenotypic repercussions due to hybrid vigour expression (Goulet et al. 2017). Hybridization is required for the efficient use of available germplasm, the development of breeding material, the introduction of novel genes, and the expansion of the genetic base. The generation of diversity in little millet is difficult due to challenges in artificial hybridization.

Understanding the characteristics that determine the duration of the flowering phase, pollination behaviour, and seed set is required for a successful hybridization programme in order to increase productivity and yield stability. The fundamental issue with all little millets is the difficulty in emasculation caused by the small size of the florets. The key factors linked to floral structure, diverse emasculation and crossing procedures, their downsides, and how to solve problems associated with old ways of crossing are summarised below.

27.7 Different Crossing Methods Used in Little Millet

1. Contact method/Approach method
2. Hand emasculation followed by pollination
3. Hot water treatment

4. USSR method
5. Modified crossing method (SMUASB method)

27.7.1 Contact Method/Approach Method

In this technique, the female parent that has been readied for pollination is planted next to the suitable male parent. The panicles of the sexes are loosely connected. The male parent should contain morphological markers so that it is easy to recognise real F1 after pollination and fertilisation have been finished and both have been separated (http://agritech.tnau.ac.in). Most self-pollinated crops use this form of crossing since it is the simplest. The likelihood of attaining real F1 is quite low. Only 2–3% of genuine F1 can be seen. To select real F1, a large plant population must be increased. For evaluation, more space and resources are required.

27.7.2 Hand Emasculation Followed by Pollination

This technique involved choosing flowers that will bloom the following day. The female reproductive organs were not in any way harmed by the removal of stamens or anthers. Pollination occurs the following morning after hand emasculation in the evening. Male flowers that would bloom that day are delivered to the emasculated female flower for pollination. Once tied, a butter paper bag is placed over them. Cross-pollination occurs naturally within 2–5 days. To determine the genuine hybrid, marker genes are used (http://agritech.tnau.ac.in). This is how self-pollinated crops have traditionally been produced. The main issue with this procedure was that the lemma and palea are extremely tight, making it impossible to open the flower before it goes through its regular anthesis without damaging it and preventing the development of seeds. The amount of time between the anthesis of the first flower on a panicle and the anthesis of the last floret on a panicle is another issue. Determining the appropriate time to emasculate before anthesis is therefore difficult (Jasovskij 1960). Nelson (1984), used a different method for selecting flowers for emasculation to address this issue. Using this technique, panicles were chosen around the place where the first florets open. The florets in the panicle started to open as the panicle was rubbed between the palms of the hands. To prevent the anthers from dehiscing before all of them were plucked, florets were sprayed with room-temperature water from an atomizer to keep them moist. The florets that hadn't been emasculated were removed once the florets finished opening and all of the opened florets had been closed. That comprised the top and bottom fertilised florets of the panicle as well as the immature florets at the bottom. The best time to emasculate was between 8 and 9 in the morning. At this time, the florets expanded at a rate that allowed effective emasculation conceivable. Emasculation was followed by fertilisation for 15 min. Male parents were rubbed and allowed to open for pollination. A glassine bag containing opened male florets was placed on top of the emasculated panicle. Five days were given to allow for crossing and moisture preservation. The benefit of this

approach is that the lemma and palea are permitted to open naturally, rather than being forced to do so. The drawback of this procedure is that, while emasculation, injury to the stigma prevents seed germination.

27.7.3 Hot Water Treatment

Many researchers have attempted to circumvent the issue of physically extracting the anthers from the florets by using the hot water treatment for emasculation (Keller 1952). This procedure involves choosing panicles that are expected to flower in the following 2–3 days and submerging them in hot water at 52 °C for 2 min. According to the percentage of hybrid seed set, this was the ideal temperature and timing (http://agritech.tnau.ac.in). According to Srivastava and Yadav (1972), emasculating little millet in hot water at 49 °C for 8–10 min or 50 °C for 5 min was successful. Similar to this, the male father that would open the next day is connected to the emasculated female parent and covered by a butter paper following emasculation using hot water for pollination. This method's limitations include the need for the appropriate equipment to maintain long time constant temperature. The stigma will be impacted by temperature, which could lead to a tiny amount of seeds being set (Primak and Jakovlev 1964)

27.7.4 USSR Method

This improved method of crossing was presented to alleviate the difficulty discovered in hand emasculation and hot water treatment in removing pollens (Seetharam et al. 2003). The induced opening of the flower (USSR method) has been effectively used in the creation and development of novel cultivars, as detailed below:

1. By gently stroking the panicle with the palm, florets are mechanically activated.
2. Florets open within 2–3 min, far earlier than usual flowering.
3. Dip in water that is room temperature to prevent another explosion.
4. With your forefingers, thrash the anthers from the opening florets.
5. Remove the unopened florets with scissors and keep the opened blossoms.

27.7.4.1 Pollination

The emasculated female spike was placed just below the male spike that was exuding pollen, and both spikes were then covered with a glassine bag to complete the pollination process. The female spike receives pollen from the male spike, which provides an excellent possibility for fertilisation. Throughout the daily anthesis periods, the spikes were jostled against one another for 2 days. The male spike was carefully removed on the third day of pollination, and the female spike was examined for any potential later-forming florets. Such florets frequently developed and produced seed when they weren't entirely removed, which could be mistaken for cross-fertilised seeds. The female spike was rebagged and kept until it was mature

enough to be harvested. The stigma may be damaged when the panicles are massaged to mechanically stimulate the florets to open, as well as when the anthers are removed from the florets with the forefingers in this way.

27.7.5 Modified Crossing Method (SMUASB Method)

This altered method of crossing was first used in little millet during kharif season at the Project Coordinating Unit on Small Millets at the University of Agricultural Sciences, GKVK, Bengaluru; it was given the designation SMUASB (Small millets, University of Agricultural Sciences, Bengaluru). Little millet has an extremely tight lemma and palea, making it impossible to attempt to open the floret before the typical anthesis without damaging the flower and preventing seed germination. Cold water is employed in the SMUASB method as a mechanical stimulator to encourage floret opening. Emasculation The Little millet flowers open from the top of the panicle to the bottom. For crossing, male and female parents are placed in different rows. The 8 to 9 a.m. is the ideal time to cross.

Details of emasculation are mentioned below

- The female plant's panicle must be chosen for emasculation so that the panicle's first floret has opened.
- Spraying cold water between 5 and 8 °C on the panicle. The florets are encouraged to open spontaneously 1 h earlier by this cold water spray than they would have otherwise.
- Emasculation is performed by dipping the panicle in cold water after all the florets have been opened, and all the anthers have been removed by washing the panicle in cold water.
- Unopened florets were eliminated. It has unfertilised florets at the top of the panicle and immature florets at the bottom.

Pollination

- The male parent is chosen in such a way that the first floret has opened.
- To open the florets and keep the anthers wet, male panicle is sprayed with cold water at 5–8 °C, the same as female panicle.
- It is knotted loosely around the female parent panicle immediately after the male florets open to facilitate proper oxygenation and pollination.
- The knotted panicles are then sprayed with water to keep the stigma and anthers moist.
- To avoid cross-pollination, male and female panicles are tied together and covered with butter cover.
- To prevent cross-pollination, male and female panicles are tied together and covered with butter cover. Because these crops are self-pollinated, only 3–5% cross-pollination may occur.
- Label the crossing panicle in the female parent for identification and seed collecting. The tag should include the cross combination and the date of crossing.

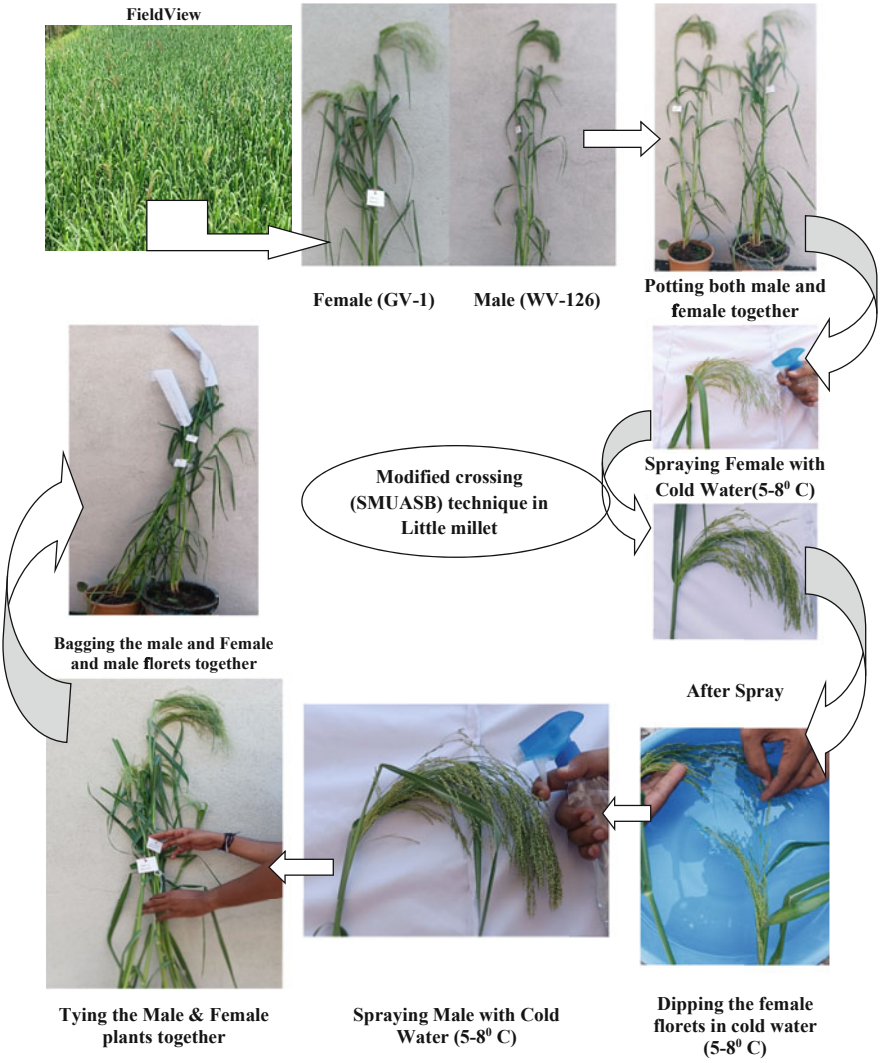


Fig. 27.4 Modified crossing (SMUASB) technique in little millet

In little millet, the SMUASB method is widely used for crossing Few crosses were attempted in Little millet using the SMUASB approach given in Fig. 27.4.

Female Parent: GV-1 (Nana flower type)
Male Parent: WV-126 (Robusta Flower type with Purple plant stem pigmentation-Gujarat local) and high-yielding genotype.

The primary limitation in this genotype is its long duration, which is incompatible with the cropping system. GV-1 is an early, tillering cultivar with high iron content. We crossed GV-1 with WV-126 to create a genotype that is short in duration, high in yield, and nutrient dense. WV-126 is utilised as a male parent and is purple in colour, whereas GV-1 is green in colour and is employed as a female parent. True F1s are distinguished by their purple coloration.

Success rate For crossing, three to four panicles were employed. Using the SMUASB procedure, panicles were emasculated and pollinated. Planting seed from the female parent allows for the identification of real F1s. Each panicle's seeds were collected and sown individually. Out of the 40 F1 plants that were planted in panicle 1, 20 plants were confirmed to be real F1s, indicating a 50% success rate. Similar results were obtained in panicles 2 and 3, with success rates of 55% and 56%, respectively. Using the SMUASB approach, small millet crossings experienced an average success rate of 40–50%.

Successful crosses in little millet are as below:

Sr. No.	Crosses	Objectives of the crossing programme
1.	GV-1 × WV 126	High yield and early to medium maturing, bold grain and lodging tolerant as well as shoot fly resistance
2.	GV-2 × WV 126	
3.	GNV-3 × WV 126	

Modified crossing (SMUASB) approach has the following advantages over other little millet crossing methods

The benefit of this SMUASB is that emasculation never results in stigma damage. In comparison to the other conventional approaches, this produces a larger seed set and a higher frequency of true F1's. It requires less effort and takes less time than manual emasculation. The removal of pollen from each and every floret during hand emasculation is time-consuming and technical skill is needed. Because the blossoms of these two crops are tiny, emasculation requires technical skill. In the modified crossing procedure, flowers open simply by being sprayed with cold water. It is a less difficult procedure because anthers are also easily removed by washing or dipping in water.

Emasculation and identifying real F1 requires less space and resources. For the contact approach, a significant number of seeds harvested from female plants must be examined for the presence of real F1s. The likelihood of acquiring actual F1s is lower. All unopened, immature, and previously pollinated florets are eliminated when using the modified approach. Only the florets with emasculated anthers are retained for pollination. As a result, the F1 plants that were collected from the female plant had less seeds. Therefore, fewer space and resources are

required for the examination and identification of actual F1s. In the modified crossing method, cold-water spray is utilised as a mechanical stimulator for opening the florets in place of hand messaging, as was done in the USSR approach, and hot water treatment for emasculation. The stigma is not harmed by this method. As a result, there is a higher success rate in getting actual F1s.

In little millet, the modified crossing (SMUASB) method of emasculation and crossing is a very beneficial method. This technique fixes the issues with the touch method, hand emasculation method, hot water emasculation method, and USSR way of crossing. Comparing this procedure to earlier ones, the success rate for obtaining actual F1s is higher. With this approach, less space and resources are needed to evaluate F1s. We attempted crosses in other small millets using the SMUASB approach. For little millets, the success rate was between 40% and 50%.

Constraints in Little millet hybridization and crossing techniques

- Small florets in this crop make it difficult to easily emasculate and hybridise it by hand.
- Knowledge of floral biology, a straightforward, practical hybridization technique, and an appropriate gene marker for identifying true F1 are necessary for artificial hybridization.
- The difficulty facing the breeders is to look for straightforward and efficient emasculation and pollination strategies in this crop, given the difficulties in creating artificial crosses.
- Despite the abundance of variability, artificial hybridization must be restored in order to combine the desirable traits from various accessions in genotypes, which necessitates the development of a quick and efficient process of pollination and emasculation. The best emasculation and pollination strategies can be planned with the aid of floral biology research.

27.7.5.1 Objectives for Little Millet Breeding and Improvement

When choosing the ideal donor parent, consideration should be given to the following targeted features in small millet: shoot fly resistance, non-lodging, days to maturity, and bold grain size (Nandini et al. 2019) in small millets improvement, yield and factors affecting yield are typically the most addressed features. As a result, selection for yield in and of itself has been the main driver of productivity improvement, but genotype-environment interactions greatly affect these features. To enhance yield, it is therefore crucial to evaluate yield stability across various conditions and look at physiological variables (such as harvest index, water use efficiency, etc.) linked to yield and adaptation. Depending on the location-specific requirements for soil, rainfall, temperature, humidity, day length, and cropping patterns, custom-made cultivars that fit into the different maturity groups—early, mid-late, and late—can be bred using the significant variation in maturity duration that germplasm collections exhibit. Medium- to long-duration types would be appropriate for places with a single cropping season and short-duration variations for double/intensive cropping regions (Haider 1997). The fundamental goal of

crossing is to broaden the genetic basis of the population for most efficient selection while also introducing variety and incorporating desired traits, such as high yield, pest and disease resistance and significant quality features, etc. into a single genotype.

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