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Agronomic Management in Little Millet (*Panicum sumatrense* L.) for Enhancement of Productivity and Sustainability

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ABSTRACT

During recent time small millets have been re-evaluated as nutri-cereals. The grains of small millets are used as nutritious food and straw as palatable forage for livestock. Moreover, these crops enrich agro-diversity, check erosion in arid regions, sequester carbon and assure food and nutritional security to smallholders in drylands. But productivity of small millets is less compared to other cereals. Like other small millets, little millet (*Panicum sumatrens* L.) is also rich in nutrients, possesses other qualities and as a short duration crop it fits to different cropping systems. Sufficient research work has not been carried out on agronomic management targeting higher productivity. An initiative has been taken to gather information from available literature on improved agronomic management of little millet and presented in the article. Further, the article highlighted the future scope of research on the crop.

Keywords: Little millet; agronomic management; productivity; sustainability

Millets are small seeded coarse cereals; belong to the family *Poaceae*, widely cultivated in the world, mainly in Eurasia and Africa in arid and tropical regions. Minor millets were important food crops of the past and presently claimed as the future foods considering ill effects of global warming and climate change pronounced more prominently in fragile ecological conditions. These can be adapted to a wide range of temperature, moisture-regime and input condition and can be a potential option for providing food and feed to millions of smallholders of drylands and the domestic animals. Moreover, as C_4 plant, millets sequester carbon, thereby adding to CO_2 reduction opportunities, contribute to improved agro-biodiversity by their diversity and allow mutually beneficial intercropping with other vital crops (Brahmachari *et al*. 2018). Among different millets, sorghum (*Sorghum bicolor* L.) and pearl millet (*Pennisetum typhoides* L.) are considered as major millet, while small millets are finger millet or *ragi* (*Eleusine coracana* L. Gaertn), barnyard millet (*Echinochloa frumentacea* L.), foxtail of Italian millet (*Setaria italica* L.), *kodo* millet (*Paspalum scrobiculatum* L.), little millet (*Panicum sumatrens* L.), proso millet (*Panicum miliaceum* L.), brown-top millet (*Brachiaria ramosa* L. Stapf; *Panicum ramosum* L.), tef (*Eragrotistef*), fonio [*Digitariaexilis* (white fonio) and *D. iburua* (black fonio)] and Job's tears (*Coixlacryma-jobi*).. The acreage of small millets in India is around 7.0 lakh ha with productivity of 633 kg ha^{-1} (Anbukkani *et al*. 2017). The small millets cultivation is mainly confined in the drylands as rainfed crop. In addition to ecological and agronomic benefits, millets can offer other advantages, particularly in nutritional and livelihood security of smallholders in drylans. Small millets are also considered as 'miracle crops', because these have multifaceted use. Consideration of small millets in cropping system can provide numerous benefits, which include: use of grain as food and value added food products, straw as forage, enrichment of agro-diversity, checking of erosion in arid regions, higher C

sequestration and assurance of food and nutritional security to smallholders (Fig. 1).

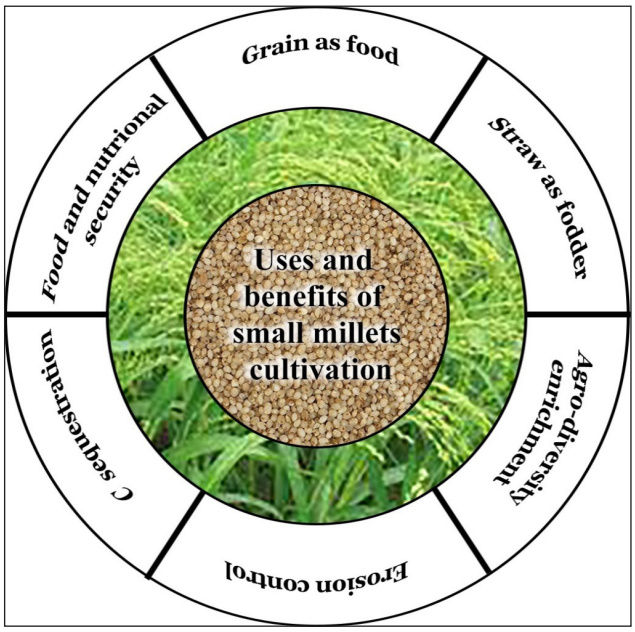

Fig. 1: Uses and benefits of small millet cultivation

The millets have always been considered as less important and the farming of millets is downgraded to the poor soils and fragile ecological conditions, unable to realize the potential of improved varieties. Even today, millets share to seven per cent of food basket, providing to the food and nutritional security of the underprivileged people. Since the 1970s millet has been gaining popularity in developed countries as a nutritious and delicious whole grain. Besides, these are gluten free and so perfect to sensitive and health conscious people. Among different small millets, finger millet occupies about 80 percent of area and production in India, however, the cultivation of other small millets is restricted in few states in India.

Little millet

The origin of little millet is not well documented and considered as Indian origin. The crop has a name in all vernacular languages of India. This millet was cultivated or naturalized in India and Sri Lanka, and cultivated in neighbouring countries and no diversity and related wild species are found outside India, suggestive of Indian origin. In the archaeological excavations of Gujarat dating to 2000-1500 BC presence of little millet seeds was evidenced (Venkatesh Bhat *et al*. 2018). The cultivation of little millet is mainly observed in the states of Karnataka, Madhya Pradesh, Andhra Pradesh, Odisha, Tamil Nadu, Gujarat, Chattisgarh and Maharashtra. Like other small millets, little millet is also rich in nutrients.

Nutritional insecurity is a major threat to the world's population that is highly dependent on cereals-based diet, deficient in micronutrients. In addition to ecological and agronomic benefits, millets can offer other advantages, particularly in nutritional security of smallholders. Millets are nutritionally superior to other cereals and considered as 'nutri-cereals' during present days. Each 100 g little millet grain contains 65.5 g carbohydrate, 10.1 g protein, 3.89 g fat, 346 Kcal energy, 7.7 g dietary fibre, 16.1 mg calcium, 130 mg phosphorus, 91 mg magnesium, 1.8 mg zinc, 1.2 mg iron, 0.26 mg thiamin, 0.05 mg riboflavin, 1.3 mg niacin and 362µg folic acid (Venkatesh Bhat *et al*. 2018).

Millets started receiving with attention with the launching of All India Coordinated Millets Improvement Project (AICMIP) in 1969 and All India Coordinated Small Millets Improvement Project (AICSMIP) was established in the year 1986. The research on small millets has been focused towards development of high yielding varieties and improved crop management for enhancement of productivity. However, sufficient research work has not been carried out for production improvement of little millet for different agro-climatic regions. Hence an initiative has been taken up in this article to bring together the agronomic management practices on the basis of available literature for enhancement of productivity.

Improved varieties of and uniform stand establishment

Little millet covers a marginal area in India, however, the crop is highly tolerant to moisture stress and drought and to some extent water logging and these qualities offer ample scope of adoption of the crop in diverse situations. Like other small millets, little millet is mainly cultivated as rainfed crop in drylands in poor soils where poor stand may be a constraint limiting yield potential. Uniform stand is obtained by sowing quality seeds of improved varieties in a well tilled bed during right season at proper spacing. Following the list of varieties of little millet cultivated in Indian states.

Table 1: State-wise recommended varieties of little millet (adopted from Chapke *et al*. 2018)

State	Varieties
Andhra Pradesh	OLM 203, JK 8, BL-6, DHLM-36-3
Chattisgarh	JK 8, BL 6, JK-137, BL-4, JK 36, DHLM-36-3
Gujarat	GNV 3, Gujarat GV 2, GV 1, OLM 203, JK 8, BL-6, DHLM-36-3, DHLM14-1
Karnataka	OLM 203, JK 8, BL-6, DHLM-36-3, DHLM-14-1
Madhya Pradesh	JK-4, JK 8, JK 36, JK-137, BL-6, DHLM-36-3
Maharashtra	Phule Ekadashi, JK 8, OLM- 203, BL-6, DHLM-36-3, DHLM-14-1
Orissa	OLM- 203, OLM -208, OLM-217, BL-6, DHLM-36-3, DHLM-14-1
Tamil Nadu	Paiyur 2, TNAU 63, CO 2, CO 3,C0-4,K1, OLM -203, OLM -20, BL-6, DHLM-36-3, DHLM-14-1

Moreover, there are some experimental results on varieties evaluated in different states. The little millet culture WV-125 is a pure line selection from the germplasm accession which recorded an overall increase of 8.77 per cent in grain yield (2864 kg/ha) over the local check variety GV-2 (2633 kg/ha) and 43.92 per cent increase over the national check variety CO-2 (1990 kg/ha) and WV-125 little millet culture has been released as a new variety GNV-3 (Gujarat Navsari Vari-3) for cultivation during *kharif* as rainfed in Hilly region of Gujarat (Patil *et al*. 2016). The test variety BL 150 was significantly superior to national check JK 8 (227.63% increase) and OLM 203 (168.63%) at Jagdalpur, Chattisgarh as reported by AICRPSM (2017). Experiments carried out in different part of the country indicated the performance of little millet varieties. A field experiment conducted during *kharif* 2016 at Kolhapur Maharashtra recorded growth and yield attributing characters and grain and straw yields of the variety Phule Ekadashi were superior to OLM 203 (Raundal and Patil, 2017). Though there was no difference in N, P and K content of grain and straw of these two little millet varieties, uptake of these nutrients were differed significantly and Phule Ekadashi removed more nutrients than OLM 203. Also the benefit-cost ratio of Phule Ekadashi was more (Patil and Raundal, 2018).

Little millet is mainly cultivated during *kharif* season. In Odisha, the crop is sown during middle of June and in Tamil Nadu in June, however, in Madhya Pradesh and Karnataka the seeding period is from end June to first week of July. Cultivation of little millet is also observed during *rabi* season in Tamil Nadu and sowing time starts from September to October. Resource poor farmers of drylands sow the crop by broadcasting method that requires 12 kg seed ha^{-1}, however, line sowing should be preferred with a row spacing of 22.5 cm and plant to plant spacing of 8-10 cm at a depth of 3-4 cm. Seed requirement for line sowing is 8 kg ha^{-1}. Prior to sowing seeds may be treated with fungicides like Captan or Ceresan at the rate of 3 g $kg^{-1}$of seed to avoid seedling mortality due to infection of fungal diseases and thus to assure uniform stand.

Nutrient management

Nutrient management is essential for achieving potential yield of crops. Though little millet is a less demanding crop, the improved varieties develop respond well to added nutrients because it is grown mainly in poor soils. Research experiments conducted on nutrient management showed the response to added nutrients by little millet (Bhomte *et al*. 2016). Chapke *et al*. (2018) suggested that application of 5 t farmyard manure (FYM) ha^{-1} about a month before sowing is beneficial. Generally In Bihar and Odisha 20:10:00 and in Tamil Nadu 40:20:00 kg ha^{-1} of N:P_2O_5:K_2O are recommended, but in Andhra Pradesh and other states a fertilizer dose of 20:20:00 kg ha^{-1} of N:P_2O_5:K_2O are applied. Further, seed inoculation with Agrobacterium radiobacter and *Aspergillus awamori* improves seed yield. A study conducted at Kolhapur, Maharashtra clearly mentioned that the fertilizer level 150 per cent recommended dose of fertilizer recorded significantly highest grain and straw yields (Raundal and Patil, 2017) and more N, P and K uptake by the crop (Patil and Raundal, 2018). A field experiment was conducted at Shivamogga, Karnataka in acidic sandy loam soils indicated that the application of 30 kg N and 20 kg P_2O_5 with or without 10 kg K_2O performed better for achieving growth and yield components and grain and straw yields (Divyashree *et al*. 2018b). Further, N, P, K and protein content of grain and uptake of N, P and K was more with the application of 30 kg N, 20 kg P_2O_5 and 10 kg K_2O than other levels of fertilizers tested (Divyashree *et al*. 2018a).

Integrated nutrient management (INM) is a scientific approach to supply nutrients to the crops for soil health improvement and agricultural sustainability. A field experiment conducted at Rewa, Madhya Pradesh revealed that the integrated application of FYM @ 7.5 t ha^{-1}, N40:P20:K10, calcium carbonate, zinc sulphate, and borax increased yield attributing characters, grain yield with higher B:C ratio (Prihar *et al.* 2010). Sandhya Rani *et al.* (2017) reported that highest grain and straw yields were recorded in the treatment 100% RDF + neem cake @ 1 t ha^{-1}, however it was on par with the application of 75% RDF + neem cake @ 1 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @5 kg ha^{-1}, 100% RDF + vermicompost @ 2 t ha^{-1}, 75 % RDF + vermicompost @ 2 t ha^{-1} + *Azospirillum*@ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} and 100% RDF + FYM @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}. Integrated nutrient management also influenced uptake of macro and micro nutrients. The uptake of macronutrients (N, P and K) was found to be the highest in the treatment 100% RDF + neem cake @ 1 t ha^{-1} and micronutrients (Zn and Fe) in the treatment 100% RDF + vermicompost @ 2 t ha^{-1}. The residual effect of nutrient management on soil fertility status was also studied in the experiment and integration of organic manures, biofertilizers and chemical nutrients showed superiority over application of only chemical fertilizers. There was no significant impact of INM on soil pH, but organic carbon content was seen the highest in treatments 75% RDF + vermicompost @ 2 t ha^{-1} + *Azospirillum* 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}. The treatments 100% RDF + neem cake @ 1 t ha^{-1} showed the highest availability of N,100% RDF + vermicompost @ 2 t ha^{-1} showed the highest available P_2O_5 and 100% RDF + vermicompost showed the highest available K_2O. The available Zn and Fe in the soil were found highest in the treatment 100% RDF + neemcake @ 1 t ha^{-1}, but available Cu and Mn were highest 100% RDF + vermicompost @ 2 t ha^{-1} which was probably due to mineralization of soil organic matter. In another study, conducted at south Gujarat showed that little millet performed well with 75% RDN through chemical fertilizer + 25% RDN through vermicompost in terms of growth and productivity of the crop where recommended dose of fertilizer was 40:20:00 kg N:P_2O_5:K_2O ha^{-1} (Thesiya *et al*. 2019). The studies clearly showed beneficial impact of INM for sustaining productivity of little millet in drylands.

Weed management

The weeds found in little millet field may be classified into two groups, namely, grassy weeds and broadleaved weeds. Among grassy weeds *Echinochloa colonum, Enhinochloa crus-gulli, Dactyloctenium aegypticum, Elusine indica, Setaria glauca, Cynodon dactylon, Phragmites karka, Sorghum halepanse* are commonly observed. The harmful sedge *Cyperus rotundus* is also abundant in little millet field. The broadleaved weeds like *Celosia argentia, Commelina benghalensis, Phylanthus niruri, Solanum nigrum* and *Amaranthus viridis* are also common. In general, twice inter-cultivation and one hand weeding in line sown crop and two hand weeding in broadcost crop are useful for effective weed control. Moreover, post-emergence application of 2, 4-D sodium salt (80%) @ 1.0 kg a.i./ ha at 20-25 days after sowing (DAS) is effective for controlling broadleaved weeds. Isoproturon @ 1.0 kg a.i. /ha as pre-emergence spray is also effective in weeds control (Chapke *et al.* 2018). But AICRPSM (2017) suggested that pre-emergence application of Isoproturon @ 0.5 kg a.i / ha along with one inter-cultivation at 40-45 DAS was a better weed management practice for getting higher productivity of little millet.

Water Management

Little millet is basically a rainfed *kharif* crop for drylands. But intermittent gap between rainy spells may occur and lifesaving irrigation can be given if water is available. But where it is grown in *rabi* season, crop should be irrigated. Chapke *et al*. (2018) suggested providing two irrigations, at 25-30 and 45-50 DAS.

Cropping System

Little millet is cultivated as rainfed crop is dry areas and as it is short duration crop there may be scope of growing second crop if little millet is planted by June. Results of multi-location experiments clearly mentioned that safflower or cowpea can be grown as sequence crop after little millet (AICRPSM, 2017). Moreover, sequential cropping of little millet and niger or lentil or gaur can also be taken into consideration. In south Bihar conditions, little millet is followed by niger (Chapke *et al.* 2018).

Under dryland conditions, intercropping system can be considered as a suitable option for giving protection against crop failure due to aberrant weather conditions and to utilize available resources efficiently (Maitra *et al*. 2019). However, little millet based intercropping is very common in different states in India. In alfisols of Karnataka, little millet + pigeonpea intercropping (4:2) expressed highest little millet equivalent yield (LMEY). Relay intercropping of little millet + horsegram recorded more LMEY than pure stand of little millet alone. The intercropping combination of soybean + little millet (4:2) registered higher land equivalent ratio (LER) and benefit cost (B:C) ratio (Manjunath and Salakinkop (2017). Sharmili and Parasuraman (2018) reported that little millet + pigeonpea with 6:1 row ratio recorded greater LMEY in Tiruvannamalai district of Tamil Nadu during *kharif* season. Intercropping combination of groundnut and little millet (6:1) assured better resource use efficiency as LER and more B:C ratio (Shwethanjali *et al.* 2018). In Odisha intercropping of little millet + black gram (2:1) and in Madhya Pradesh little millet + sesame / soybean / pigeon pea (2:1) are considered beneficial. Shalini*ei al*. (2019) opined that intercropping little millet and pigeon pea at either 6:1 or 6:2 is beneficial.

Future Scope of Research

The research evidences and literary sources clearly indicate that enough research has not been carried out on little millet. Considering the present demand and importance of the crop, research work should be carried out in the following directions.

- Varietal improvement and evaluation of promising varieties of little millet for different agro-climatic regions;
- Research on time of sowing, spacing and plant population for assuring optimum stand;
- Efficient nutrient management trials like soil test crop response and site specific nutrient management for target productivity;
- Studies on response to different micro-nutrient and management;
- Contingency measures and need-based agronomic management with manipulation of planting geometry, plant population and nutrient management under aberrant situation;
- Water management studies for *rabi* crop;
- Intensive study on cropping system and intercropping targeting production sustainability of drylands.

CONCLUSION

Productivity of little millet can be increased through adoption of improved agronomic management practices. Cultivation of improved varieties, adoption of proper sowing time and spacing assure uniform stand. The improved varieties respond well to added nutrients and nutrient management should be done judiciously. Weed management is essential for enhancement of productivity of little millet. Cropping system and intercropping system can help in achieving more yield and return. Further, there is enough scope for research on little millet like nutrient management trials like soil test crop response and site specific nutrient management for target productivity, micro-nutrient management, contingency crop management and intensive study in intercropping combinations and proportions for sustaining productivity.

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