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Millets for diversification and risk mitigation

in rainfed agriculture

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Millets are small-seeded cereal crops grown for millennia, especially in Asia and Africa. These grains are gluten-free, nutrient-rich, and serve as a staple food and fodder in rainfed agricultural systems. Their nutritional versatility makes them a mainstay in many traditional diets. Additionally, millets are well-adapted to changing climates, maintaining productivity and resilience against various environmental stresses. Millets' short growing season, deep roots, and tolerance to hot temperatures and drought conditions make them climate resilient ready crops. Their ability to thrive in harsh environments ensures they remain a reliable food source, even as climate change brings more unpredictability to our agricultural systems.

Keywords: Crop diversification, Millets, Rainfed agriculture

MILLETS are small-seeded cereal crops grown for millennia, especially in Asia and Africa. Globally, millets are cultivated in over 125 countries with an area of 74 million ha. Looking into their utility as nutritious crops, Government of India declared millets as *'Nutri-cereals'*. In 2023, the world celebrated the International Year of Millets, highlighting the significant potential of millets to diversify food systems and strengthen global food security. Nutri-cereals include group of diverse cereal crops of *Poaceae* family, viz., sorghum, pearl millet, finger millet, foxtail millet, barnyard millet, proso millet, little millet and kodo millet. They thrive in diverse climates, including dry, semi-arid, and sub-humid regions.

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Major millets grown in India

India, Sudan, Niger, Nigeria, and Mali are the leading millet growing countries in the world accounting for 47% of the global area. India, USA, Nigeria, China, and Ethiopia are the leading millet producing countries contributing 53% to global millet production. India stands as the world's foremost producer of millets. Rajasthan, Maharashtra, Karnataka, Uttar Pradesh and Madhya Pradesh are the leading millet growing states with 83% of the total area.

Millets play a crucial role in rainfed agriculture globally. They hold substantial economic importance in rainfed agriculture due to their climate resilience, economic stability, nutritional value, low input costs, crop diversity and growing market demand. For farmers in drought-prone and marginal areas, millets represent a reliable source of income, helping to diversify their revenue streams and mitigate financial risks. With the rise of millet-based value chains and supportive government policies, millets offer significant potential for increasing farmers' incomes and contributing to rural economic development.

Diversification in rainfed agriculture

Millets contribute to crop diversification in rainfed areas, aiding in mitigating risks from unpredictable weather and soil conditions. The major ways in which the millets can support in diversification are described.

Crop diversification: In rainfed areas, farmers typically grow coarse grains like maize, sorghum, and pearl millet, as well as oilseeds such as castor and groundnut, along with pulses and cotton. Adding millets to this mix offers benefits like short growing season and stress adaptability. Both public and private sectors are developing new varieties of millets, tailored to specific locations and with enhanced resistance to biotic and abiotic stress. The improved millet varieties can boost both profitability and productivity for major and minor millets.

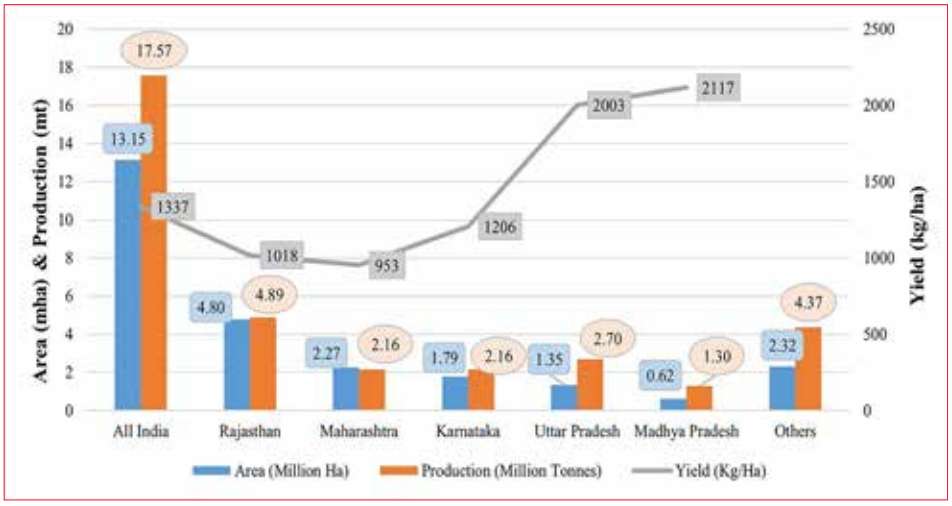
Successful millet-based mixed cropping systems

- ***Millet-Legume***: A common combination is sorghum/ pearl millet/finger millet with cowpea, green gram, chickpea, or pigeon pea. This mix benefits from the nitrogen-fixing ability of legumes, enhancing soil fertility and yield potential for both crops.
- ***Millet-Pulses***: Foxtail millet or proso millet can be grown alongside pulses like lentils or black gram, which not only provide protein-rich food but also contribute to soil health.
- ***Millet-root crop***: Barnyard millet or finger millet can be intercropped with sweet potato or cassava. This system works well as these crops use different soil layers, minimizing competition for resources.

Soil health management: Millets serve as an effective tool in soil health management, especially in rainfed agriculture, where maintaining soil quality is essential for long-term productivity. Through their deep roots, organic matter contribution, erosion control, and compatibility with low-input systems, millets not only thrive in challenging conditions but also help regenerate and sustain soil health for future agricultural cycles.

Intercropping: Millets, as part of an intercropping systems, contribute to sustainable farming by optimizing resource-use, enhancing soil health, reducing pest pressure, and increasing overall system resilience. Their adaptability and low input requirements make them ideal crops for inclusion in resource-constrained rainfed agricultural systems. Inter cropping with millets is not only environmentally sustainable but also beneficial for farmers in terms of food security, income diversification, and climate resilience.

Crop rotation: Pulses-millet crop rotation can significantly enhance soil health and crop productivity through soil enrichment (pulses fix nitrogen in the soil, boosting fertility when followed by millets, they benefit from this enriched soil), pest and disease management (rotation disrupts pest and disease cycles, reducing infestations without heavy chemical use), resource efficiency (millets and pulses have different water and nutrient needs, optimizing resource-use and minimizing soil depletion) and yield stability (rotation ensures better yields by maintaining soil structure and health over time).



Area, production and productivity of millets of major millets growing states in India for 2023-24 (*Source*: DA&FW, GoI)

Specific millets for marginal lands and problematic soils

- ***Pearl millet***: Grows well in sandy and low-fertility soils. Tolerates drought and saline soils and ideal for dryland regions with poor irrigation facilities.
- ***Sorghum***: Grows in a wide range of soil types, including infertile and marginal soils, tolerates drought and waterlogging and ideal for dryland regions.
- ***Finger millet***: Adaptable to acidic soils and thrives in hilly, eroded lands. Tolerates poor soil fertility and drought conditions and performs well in rainfed and upland areas.
- ***Foxtail millet***: Grows in a wide range of soil types, including infertile and marginal soils. Fast-growing, making it suitable for short growing seasons and degraded lands.
- ***Kodo millet***: Tolerant to saline and alkaline soils. Well-suited for drought-prone regions with low-input agricultural systems.
- ***Proso millet***: Performs well in saline soils and dry, sandy areas. Short growing season makes it suitable for marginal lands with limited water availability.
- ***Barnyard millet***: Grows in poor, waterlogged soils and withstands drought conditions. It can be cultivated in areas with heavy soil erosion and poor drainage.

Cultivation in marginal lands and problematic soils: Millets are highly suitable for cultivation on marginal lands and problematic soils due to their adaptability, resilience, and low input requirements. These lands, which are often characterized by poor fertility, water scarcity, and other challenges, can benefit significantly from millet cultivation. There are varieties in millets which suit various problematic soils such as sodic or saline soils, which is a key feature in dryland areas. Further development of both major and minor millet varieties can help in distribution of millets to these soils. Marginal soils which have low fertility and difficulty in access to resources due to various geographical and social factors, with few management practices can be adopted for millet cultivation which will also create a better livelihood for people living in these areas.

Millets as source of fodder: Millets are the major cereals of dryland crops in arid and semi-arid regions and form an important source of stover for the livestock of these regions. They serve as an excellent source of fodder under rainfed agriculture where water availability is limited. These crops are highly resilient to drought and can thrive in challenging environments, making them a reliable option for livestock feed when other forages may be scarce. The leaves and stem of millet provide nutritious fodder, rich in essential nutrients like fibre, protein, and minerals, which support healthy livestock growth and productivity. Additionally, after grain harvest, the remaining biomass can be used as silage or dry fodder, ensuring minimal waste, and maximizing the crop's utility in sustainable farming systems.

Crop management practices: Transplanting millets like finger millet can be advantageous, particularly when direct sowing fails or when early sowing of the next crop is required, or the previous crop has been harvested late. This ensures uniform crop establishment and better plant health. Additionally, millets can be intercropped with commercial crops. Their narrow leaves reduce shading on the main crop and enhance light absorption, optimizing the use of above- and below-ground resources and reducing pollution.

Post-harvest processing: Millet-based food products are increasingly available in the market. In dryland areas with uncertain rainfall or seasonal moisture, harvested millets can be processed into various food items catering to local and non-local preferences. This not only generates off-season income but also promotes innovative millet products, either alone or combined with other grains, offering tastes like conventional foods. Such initiatives can enhance dietary balance and leverage traditional millet-based culinary knowledge.

***Institutional support*:** There is a need for developing high-yielding millet varieties that can withstand monsoon variability, temperature fluctuations, low soil fertility, pests, and diseases. Research on grain and fodder requirements, quick stress recovery, and other traits should be a priority for both government and private sectors. Ensuring timely availability of seeds for these developed varieties is crucial for successful crop sowing. Additionally, raising awareness through extension activities about the benefits of including millets in farming and diets is essential. Enhanced market facilities can boost the sales of harvested millets, preventing post-harvest losses.

Some millet-based food products

Risk mitigation through millets in rainfed agriculture

Growing millets in rainfed conditions is a strategic approach for mitigating risks like drought, soil fertility and uneven weather patterns which were mostly faced by farmers. Following are the benefits of growing millets, particularly in rainfed agriculture.

Drought resilience: Millets are well adapted to the dry environment conditions and wide range of soil types. Following are the major adaptations, which makes them resistant to drought.

- *Deeper root systems*: Millets develop extensive root systems that can reach the deeper layers of the soil to absorb moisture even if there is a condition of low rainfall and enable them to survive during the prolonged dry spells.
- *Water-use efficiency (WUE):* Higher WUE indicates higher biomass with less quantity of water. Millets need around 350-500 mm of water, which is less than the other fine grains, as their physiological adaptations allow them to absorb more moisture during their critical growth periods.
- *Drought escape mechanism:* Most of the millets have shorter life cycle which is 80-100 days after sowing. So, they complete their growth period before water becomes critically low. The leaves of the millets are narrow, with dense cell wall, possess natural waxy coating to reduce the transpiration and helping them to retain water during the dry spells. When the condition in the soil is not suited for the germination, millets show dormancy which allow them to remain in the soil until the soil conditions improve.
- *Physiological adaptations:* Millets have C_4 photosynthetic pathway which is highly beneficial especially in case of dry area. In this pathway, there is negligible photorespiration (reduced up to 80%) and suppression in oxygenation of ribulose 1,5-bisphosphate (RuBP) which, increases the concentration of CO_2 around the ribulose-1,5-bisphosphate carboxylase/ oxygenase (RuBisCO) present in bundle sheath and increases its activity. In C_4 plants, under warm temperatures and elevated CO_2 levels, the performance of RuBisCO improves with plants showing better photosynthetic activity. This leads to improved water and nutrient-use efficiency when compared to the conventional cereal crop which possess C_3 pathway.

Reduced crop failure risk: By including the millets to diversify the crop, farmers can reduce their dependence on a single crop. If the primary crop of the farmer fails due to a pest infestation, diseases or adverse weather conditions, millets can provide a best alternative source of income.

Adaptability to climate variability: Millets have a shorter life cycle than rice and wheat, which helps to reduce stress. Plants with low stature, small leaf area, thicker cell walls, and deep root systems are more resistant to stress. Also, a shorter cycle means reduced exposure to prolonged dry spells. Millets benefit from the C_4 photosynthetic feature, which helps them survive even under low CO_2 concentration (8-10 ppm). Millets have the potential to adapt to shifting climates, making them a promising next-generation crop.

Lower inputs and market diversification: Millets often require less inputs like fertilizers and pesticides, when compared to other food grain crops. This reduces the dependency on costly inputs which has less financial risk. Also, at present, most people are choosing millets in their day-to-day diet as they are nutritionally rich and possess other major health benefits. So, with consumer demand, millets offer new opportunities in the market. By diversifying into millets, farmers can emerge their crop into new markets to reduce financial risk associated with the traditional crops like rice and wheat.

Promote biodiversity: Millets enhances the biodiversity in the agricultural systems, promoting a healthier ecosystem. Different millets support diverse habitats for insects, birds, and other wildlife, contributing to a more balanced ecosystem. A diversified ecosystem reduces the diseases and pests naturally, further reducing risks associated with crop production, particularly in rainfed agriculture.

Government schemes to promote millets

To promote millets, the GoI is putting in place a multi-stakeholder strategy that includes tactics to boost the value chain, boost production and consumption as a prime agenda during/after the *International Year of Millets 2023*. This Production-Linked Incentive Scheme for Millet Based Products (PLISMBP) encourages the use of millets in ready-to-cook or ready-to-eat products. The scheme has an outlay of ₹ 1,000 crores and aims to have a minimum of 15% millet content in approved food products. Sub-Mission on Nutri-Cereals (Millets) under NFSM scheme provides incentives to farmers for crop production and protection technologies, and for the distribution of certified seeds.

SUMMARY

Millets, belonging to the *Poaceae* family, are ideal crops for rainfed agriculture and for climate change conditions, outperforming traditional cereals like rice and wheat. They are extensively grown in diverse soil and climatic conditions. They excel in rainfed areas due to their drought tolerance and pest resistance. Economically, millets are minimal maintenance compared to conventional crops, reducing risks under unpredictable rainfall. They thrive in low rainfall and elevated temperatures, thanks to their unique physiological traits. Even if grain production is low, millets can serve as fodder for livestock. With rising awareness of their dietary benefits, demand for millets is increasing, making them a valuable choice for rainfed farming where conventional crops are riskier.

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