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Climate-Smart Millet for Sustainable Food Security under Climate Change

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SUMMARY

Millets are emerging as climate-smart grains that can help safeguard India's agriculture against rising temperatures, erratic rainfall, and frequent droughts. With their efficient C4 photosynthetic system, short growing duration, low water needs, and strong tolerance to heat and poor soils, millets thrive where major crops often fail. They require minimal inputs, have a low carbon footprint and are naturally resistant to pests, making them ideal for sustainable farming. Rich in nutrients and easy to grow even in rainfed areas, millets offer a powerful solution for ensuring food and nutrition security in a changing climate.

INTRODUCTION

"Climate change, global warming" are the most chanting words nowadays, among the environmentalists and scientific community. Climate change is the change in the weather parameters *viz*. temperature, rainfall-amount and distribution, wind velocity, *etc*., in a manner that is not favourable to both plant and animals on earth. Climate change has deleterious effect on both human welfare and agriculture production. Researchers are looking for novel ways to combat the adverse climatic effect on agriculture sector, which has to feed the whole world. India is the 4th largest agricultural sector in the world with more than 140 million hectares of farm land and dependents, more than 54% of the country's population. India's production of food grains has been increasing every year and India is among the top producers of several crops such as wheat, rice, pulses, sugarcane and cotton. It is the highest producer of milk and second highest producer of fruits and vegetables. As per the Global Economy 2019 report, India's agricultural sector contributed to 15.96% of the country's GDP. The economic survey 2019-20 reveals that the agriculture and its allied sectors grew up by 2.88% from 2014-15 to 2018-19. Gross value added by agriculture, forest and fishing was estimated at Rs. 19.48 lakh crore (US$ 276.37 billion) in financial year 2019-20. Although agricultural production has increased over the years, 62% of the agriculture in India is still monsoon dependant and hence Indian agriculture continues to fundamentally depend on weather. Clearly, climate change and weather directly impacts agriculture since changes in temperature, precipitation, and carbon dioxide concentration affect the agricultural production. The rainfed is the most common feature in world of agriculture, but it produces about 70% of the world's staple food. In the world 55 % of rice, 91 % of coarse grains, 90 % pulses, 85 % oilseeds and 65% cotton are grown as rainfed". Millets and other coarse grains can be grown with annual rainfall less than 350 mm, but other cereal crops can't grow under minimum water and climate variability. Millets are considered highly nutrition-rich and climate-resilient coarse grain cereals and it can enhance income as well as improve food and nutrition security. Millets require 70 % less water than rice and half of that required by wheat and also it requires almost 40 % less energy in processing. Millets are the best and they are figure out for situations like climate change, water scarcity, and drought conditions and also can provide sustainable food security with high nutritive value. India has the highest area under millets cultivation with a production of 10.91mt, highest among top ten countries.

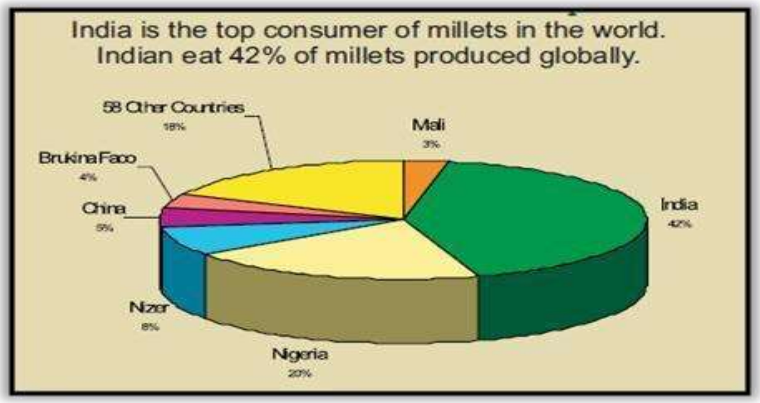

Fig. 1. Global millet consumption pattern

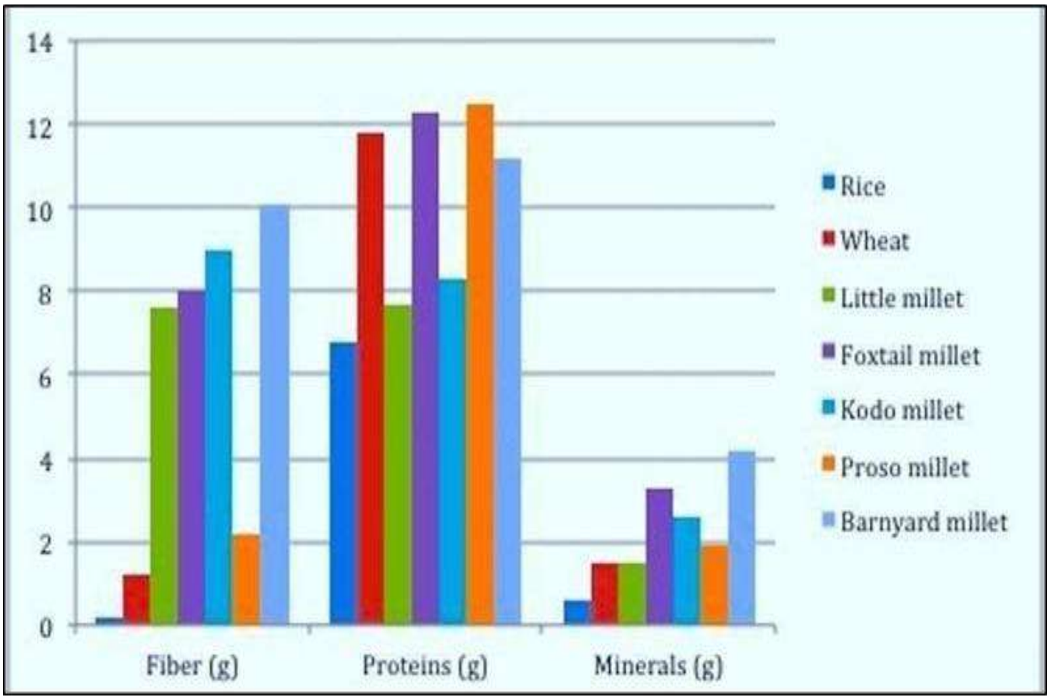

Fig. 2. Nutrition content of different Crops

Why Millets Are Climate Resilient:

1. **Drought Tolerance**: Sorghum and millets have C_4 type of photosynthetic pathway. This C_4 photosynthetic pathway allows sorghum and millets to be more efficient in water use, radiation use, and nutrient use, thus allowing them to survive in harsh climatic conditions (drought, high temperatures and nitrogen stress). The C_4 plants have a specialized leaf anatomy called Kranz anatomy. This is characterized by the presence of chloroplasts in mesophyll cells and vascular bundle sheath cells, both of which take part in photosynthesis. The primary function of this Kranz anatomy is to enrich carbon dioxide around Rubisco, thus reducing photorespiration.
2. **Heat Resistance**: Millets are also resistant to extreme heat, making them well-suited for growing in hot and arid regions. The plants have a high tolerance for high temperatures, allowing them to continue growing and producing a good yield even during hot spells. Millets' heat-resilient cellular structures result from robust adaptations like stable cell membranes, which prevent damage at high temperatures, and heat-shock proteins (HSPs), which protect and repair heat-damaged proteins. They have a strong antioxidant defence system that neutralizes harmful reactive oxygen species (ROS) generated during heat stress. Additionally, their metabolic enzymes and chloroplast structures remain functional under high heat, ensuring sustained energy production and photosynthesis. These combined features enable millets to tolerate extreme heat and thrive in challenging environments.
3. **Short Growing Seasons**: Short duration (crop duration varies from 75- 110 days) of the millets has the greater advantage in growing them as catch crops (efficient utilization of resources) and best suited under water scarce conditions (escapes seasonal drought by maturing early). Millets have high water productivity as compared to other crops (finger millet-13.4, sorghum-9.0, pearl millet-8.0 and rice-3.0 kg ha^{-1}). These characters make them highly tolerant to aberrant weather. They have remarkable rejuvenation capacity due to their tillering habit and recover very fast once the moisture stress conditions are alleviated.
4. **Adaptability**: Millets are adapted to a wide range of ecological conditions often growing on skeletal soils that are less than 15 cm deep. It does not demand rich soils or inputs for their survival and growth. Hence, for the vast dry land area, they are a boon.
5. **Carbon Footprint**: Millet production has a significantly lower carbon footprint compared to water-intensive crops like rice and wheat. Millets require less water, fewer chemical inputs, and thrive in marginal soils, reducing greenhouse gas emissions from irrigation and fertilizer use. Their resilience to harsh climates and minimal agricultural demands make them an environmentally sustainable choice for farming.
6. **Pest and diseases**: These millets are grown under traditional methods and no millet attracts any pest. They can be termed pest-free crops. A majority of them are not affected by storage pests either. Therefore, their need for pesticides is close to nil. Thus, they are a great boon to the agricultural environment.

CONCLUSION

Millets stand out as one of the most reliable solutions to the growing challenges of climate change, especially for a country like India where agriculture depends heavily on rainfall. Their ability to withstand drought, heat, and poor soil conditions, combined with low input requirements and high nutritional value, makes them ideal crops for a sustainable future. Promoting millet cultivation can enhance farmers' resilience, reduce environmental pressure, and strengthen national food and nutrition security. As the climate continues to change, millets offer a resilient, eco-friendly, and health-promoting pathway toward a more secure and sustainable agricultural system.

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