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Effect of environmental conditions on pearl millet in Western Rajasthan

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Abstract
Pearl millet (*Pennisetum glaucum*) is a staple crop in Western Rajasthan, where it serves as a primary source of food and fodder. Due to its resilience to harsh climatic conditions, pearl millet is extensively cultivated in this arid and semi-arid region. However, environmental factors such as temperature, rainfall, soil quality, and wind patterns significantly impact its productivity. This review examines the effects of these environmental conditions on pearl millet growth and yield, emphasizing adaptive strategies for sustainable cultivation in Western Rajasthan. Environmental conditions in Western Rajasthan pose challenges for pearl millet cultivation, but adaptive strategies and improved agronomic practices can enhance resilience and productivity. Research on climate-resilient varieties and sustainable soil and water management techniques is crucial for ensuring long-term agricultural sustainability in this region.

Keywords: Environmental conditions, pearl millet, Western Rajasthan

Introduction
Pearl millet was recognized as a main source of energy for livestock and is fed at critical times, such as during lactation, illness, and for weight gain. Farmers felt that grass is more useful to fill the animals' stomachs and would therefore come before crop stover as a feed. Farmers preferred Deda over Kona because it has more biomass. The area under both sorghum and pearl millet has declined, while maize and wheat has increased. The productive improvements among dairy animals can be made through proper management, feeding, handling, etc., which may influence the expression of productive characters as per their heritability nature. Before identifying the animals for breeding and production purposes, screening of animals shall be performed on the basis of physical traits (Singh *et al*., 2013, Singh and Sharma, 2013a, Singh *et al*., 2012, Singh and Sharma, 2014, Singh *et al*., 2013b, Singh *et al*., 2014a, Singh *et al*., 2014b, Singh *et al*., 2014c, Singh *et al*., 2014d, Singh *et al*., 2014e, Singh *et al*., 2014f, Singh *et al*., 2014g) [2, 3, 1, 4, 5-12]. Reproductive management of an animal is governed through a number of parameters, *viz*. age at first conception, age at first calving, first gestation length, etc. However, this study is limited to studying the reproductive management in terms of the age of the animal at first calving (Singh *et al*., 2014h) [13], Pearl millet is a key part of local livelihoods and culture in the study areas. In the perception of farmers, millet has many different functions. The introduced millet varieties scored higher than the local landraces for all of these attributes (Singh and Sharma, 2015, Singh and Sharma, 2015a) [14, 15]. Pearl millet is more tolerant to high temperatures than any other cereal. The best temperature for the germination of pearl millet seed is from 23 to 32°C. The optimum rainfall requirement of pearl millet ranges between 500-800 mm and it can also be successfully grown in areas that receive less than 500 mm of annual rainfall. The ability of the crop to grow in dry environments is due to a number of physiological and morphological characteristics,

i) Rapid and deep root penetration (root depths of 3.6 m have been recorded);
ii) Fast growth and development; and
iii) High tillering capacity. It is valued for both its grain and stover.

Its stover is an important component of livestock ration during the dry period of the year. In view of pearl millet's importance in the *kharif* season in terms of area and production, and the scope for expanding its area in summer due to significant higher yields, this paper looks (Singh and Sharma, 2015b, Singh and Sharma, 2016, Singh and Sharma, 2016a, Singh and Sharma, 2016b, Singh *et al*. 2017) [16, 17, 18, 19, 20]. Animals reared in intensive production systems consume a considerable amount of protein and other nitrogen-containing substances in their diets (Singh *et al*. 2017a) [21]. Small ruminants have a large impact on the economy and food supply of people in subtropical and tropical countries. This benefit is often not shown in national statistics because of informal trading and slaughtering (Singh and Sharma, 2017b, Singh *et al*. 2017c, Singh and Sharma, 2017d, Singh *et al*. 2018, Singh, G. 2019) [22, 23, 24, 25, 26]. India is endowed with a significant share of the world's livestock population, growing steadily and continuously. Buffalo are predominantly animals of poor countries with a very high density of livestock and human population and with poor feed resources. In tropical and subtropical regions, dairy cattle usually depend exclusively on native or introduced pastures as their only source of nutrients, and in particular, during critical periods of the year, such as the winter or dry season, the animals cannot fulfill their nutrient requirements because forage is either scarce or of low quality (Singh, G., 2019a and Singh *et al*. 2025b) [27, 38]. Milk-secreting tissues and various ducts throughout the udder can be damaged by bacterial toxins, and sometimes permanent damage to the udder occurs. Severe acute cases can be fatal, but even in cows that recover; there may be consequences for the rest of the lactation and subsequent lactations (Singh and Singh, 2020) [28]. Livestock has become an integral part of all interventions aimed at reducing rural poverty and enhancing food and nutrition security. The dairy livestock owners who raise cattle and buffaloes are yet ignorant of scientific management practices (Singh and Somvanshi, 2020a, Singh, G., 2024) [29, 30].

Fig: Spikes of pearl-millet

Man, animal, and nature are in a symbiotic relationship for their survival and sustenance. The balance maintained among the three for several millennia has been disturbed by the overexploitation of natural resources to meet the demands of the increasing population of men and animals (Singh *et al*., 2024a, Singh *et al*. 2024b and Singh *et al*. 2025a, Singh *et al*. 2024c, Singh *et al*. 2024d) [31, 32, 37, 33, 34]. The productive improvements among dairy animals can be made through proper management, feeding, handling, etc., which may influence the expression of productive characters as per their heritability nature (Singh *et al*. 2024e) [35]. The production and use of animal products in the use of human diet is receiving tremendous attention. (Singh *et al*. 2025 and Singh *et al*. 2025c) [36, 39]. at area and production trends of pearl millet in India and northwestern India. Bajra is one of the important kharif cereals grown extensively in arid and semi-arid regions of the state. The area under the crop sometimes exceeds 50 lac ha during the monsoon season. The hybrid RHB 154 has been developed for low rainfall (below 400 mm) areas of the Country (A1 Zone). Unique sick-plot sites for cereal cyst nematode, dry root rot and termite are available at this station for development of resistant varieties and technologies for maximization of crop production and productivity under problematic areas of the State. The State of Rajasthan has 10 agro-climatic zones as per the concept of National Agricultural Research Project of Indian Council of Agricultural Research. About 28 percent land area of the zone has problematic soils due to salinity and sodicity. On an average the zone receives 500-600 mm rainfall, mainly during rainy season the above agronomic practices are profitable both in summer and *kharif* crop. However, in case of summer pearl millet, higher fertilizer doses (NPK 90:40:0), two weedings instead of one at 25 DAS and 40 DAS and five to six irrigations recorded higher profitability.

Impact of environmental conditions

1. Temperature

- Pearl millet thrives in temperatures between 25–35°C, but excessive heat (>40°C) during flowering and grain filling can reduce yield.
- High night temperatures can negatively affect grain setting and quality.
- Genetic improvement for heat tolerance is essential for stabilizing yield.

2. Rainfall

- The crop is predominantly rainfed, with annual rainfall ranging between 100–400 mm.
- Erratic and insufficient rainfall leads to moisture stress, stunted growth, and poor grain development.
- Conservation practices like mulching and rainwater harvesting help mitigate drought effects.

3. Soil quality

- Western Rajasthan has sandy soils with low organic matter and nutrient content.

- Soil salinity and alkalinity pose additional challenges for pearl millet growth.
- Integrated soil fertility management, including organic amendments and balanced fertilization, can enhance productivity.

4. Wind patterns

- Strong winds cause sandstorms, leading to lodging and mechanical damage to crops.
- Wind erosion also results in soil degradation and loss of nutrients.
- Agroforestry and windbreaks can help reduce wind-induced damage.

Adaptive strategies for sustainable cultivation

- **Drought-resistant varieties:** Breeding programs focus on developing cultivars with improved water-use efficiency.
- **Water management techniques:** Adoption of drip irrigation and conservation tillage enhances water availability.
- **Soil enrichment practices:** Application of biofertilizers, compost, and green manures improve soil health.
- **Climate-smart agricultural practices:** Use of early-maturing varieties and crop rotation aids in risk reduction.

Conclusion

Environmental conditions in Western Rajasthan pose challenges for pearl millet cultivation, but adaptive strategies and improved agronomic practices can enhance resilience and productivity. Research on climate-resilient varieties and sustainable soil and water management techniques is crucial for ensuring long-term agricultural sustainability in this region.

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