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RESEARCH PAPER

Elucidation of Yield Potential in Proso millet under Rainfed Cultivation in North Eastern Agro-Climatic Zone of Tamil Nadu, India

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ABSTRACT

The research aimed to analyze the impact of climatic conditions on proso millet performance under rainfed conditions over three *Kharif* seasons from 2020 to 2022. Rainfall increased from 459.7 mm in 2020 to 663.4 mm in 2022, with August being the wettest month. Temperature data showed maximum temperatures ranged from 33.4°C to 37.2°C, and minimum temperatures varied between 24.6°C and 28.1°C. Growth metrics demonstrated significant improvements: plant height increased from 15.41 cm at 15 days after sowing to 115.3 cm at harvest, alongside increases in branches, root length, leaf area index and crop growth rate. Yield parameters remained stable, with productive tillers ranging from 3 to 5, total dry matter between 55.4 and 57.3 g/plant, panicle length from 33.8 to 34.2 cm, grain yield from 7.2 to 7.8 g/plant, straw yield from 23.4 to 25.6 g/plant, and a harvest index of 0.31 to 0.34. These results highlight the beneficial effects of increased rainfall and stable temperatures on proso millet growth and yield, emphasizing the importance of sufficient water availability and favorable climatic conditions for optimal crop performance during the *Kharif* season.

HIGHLIGHTS

- Proso millet is one of the most important nutri-cereal small millets cultivated under rainfed condition in worldwide.
- Weather parameters viz., rainfall and temperature (maximum and minimum) play a major role for the production of proso millet in rainfed condition.

Keywords: Proso millet, Leaf area index, Crop growth rate, Rainfall, Temperature

Proso millet, scientifically known as Panicum miliaceum, is also referred to by various common names such as broomcorn millet, common millet, hog millet, Kashfi millet, red millet, and white millet. This crop is widely grown in countries including China, India, Nepal, Russia, Ukraine, Belarus, the Middle East, Turkey, Romania, and the United States, covering approximately half a million acres annually (Elangovan *et al*. 2023). It is highly valued for its high-quality proteins, ranging from

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11.5% to 13%, and can reach up to 17% (Abiyaremye *et al*. 2017). Additionally, it is rich in essential minerals and vitamins, including potassium, iron, and manganese (Kumar *et al*. 2020).

Proso millet is notable for its short growing cycle of 65-70 days and low water requirements, making it efficient in producing grain per unit of moisture compared to other grains. It belongs to the grass subfamily Panicoideae and plays a crucial role in avoiding summer fallow and facilitating continuous crop rotation. The plant has a superficial root system and is highly resistant to drought (Gyulai *et al*. 2006 and Gyulai, 2014), making it suitable for regions with limited water availability and extended dry periods. It thrives best in light to medium-heavy soil, and due to its flat shallow root system, soil compaction should be avoided (Mathanghi *et al*. 2020). Moreover, proso millet does not tolerate waterlogged conditions. Given the crop's significance and rising demand, a study was conducted to evaluate its growth and yield performance under rainfed conditions, adhering to all standard operating procedures.

MATERIALS AND METHODS

Description of the study area

The field experiment was conducted during *Kharif* seasons from 2020 to 2022 at research farm of the Centre of Excellence in Millets, Tamil Nadu Agricultural University, Athiyandal, Tiruvannamalai district, situated North Eastern Agro-climatic zone of Tamil Nadu (Fig. 1). The elevation of this Site is 163.36 meters above sea level and lies at 12°07′ N latitude and longitude 78°99′ E. The soil of experimental field was sandy clay loam in texture, low in organic carbon, available nitrogen, medium in available phosphorus and high in available potassium.

Description of climatic conditions

The major challenges faced during the study period was rainfall and the variability in rainfall patterns between years could significantly impact crop performance and results. It was addressed by analyzed long term rainfall patterns. The following quantity of rainfall were received during the

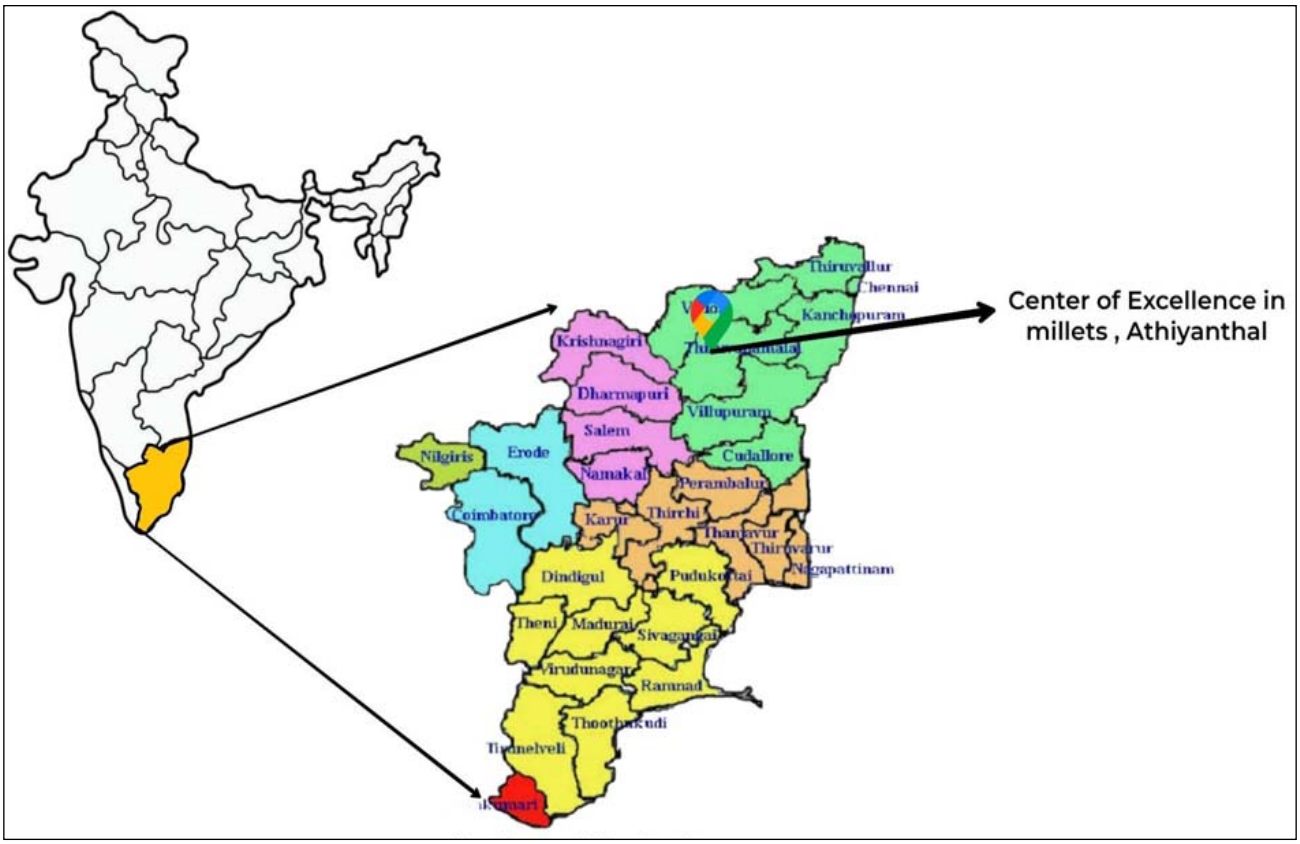

Fig. 1: Location of field experiment site

cropping period ranges from 500 to 1000 mm (Fig. 2).

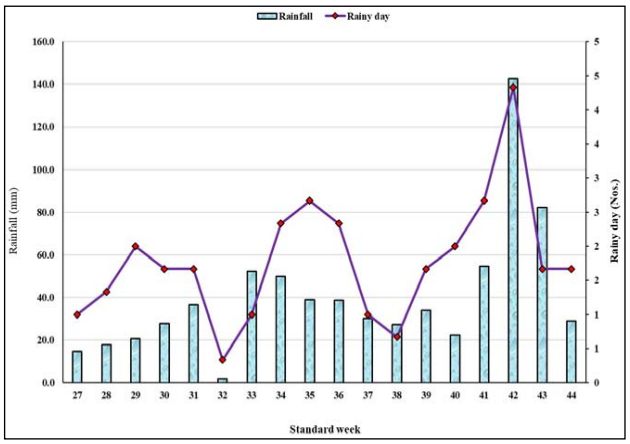

Fig. 2: Average rainfall and rainy days (3 years) during the cropping period

The geneal climatic condition of the expeimental location had maximum temperature of 36°C and minimum temperature of 18°C with the relative humidity of 67-86 %. The meteorological data on various parameters as observed during the period of experimentation are presented in Table 1.

Crop raising and data recording

The experimental field was thoroughly ploughed with cultivator and rotavator up to get a fine tilth. For basal application 12.5t /ha of FYM was applied. The variety ATL 1 was used for this study. The general character of the variety has profuse tillering, strong culm with non-lodging and bold grains with golden yellow colour. Prosomillet 10 kg seed was taken and treated with 50 ml of Azospirillum liquid biofertilizer. The crops were sown in the line sowing method with the adoption of a row-to-row distance of 25 centimeters and a plant-to-plant distance of 10 centimeters. Proso millet is a short-duration crop and requires relatively less amount of nutrients compared to other cereals. The general fertilizer recommendations under rainfed conditions 44 kg Nitrogen, 22 kg P_2O_5 and 22 kg K_2O per hectare have been adopted. Applied an whole amount of phosphorus, half of the nitrogen and potash as a basal dose at the time of sowing. The remaining half of nitrogen and potassium were applied at the time of first weeding. Generally Proso millet doesn't require any irrigation because it is sowed during *Kharif* season. Weeding is mainly done to get a higher yield and to minimize the loss of soil moisture and nutrient during the rainy season. It was done on 15 -20 DAS with a hand hoe. These are all the operating procedures followed in this study. In this study, multi stage-cum simple random sampling was adopted for selecting the typical sample in order to attain the objective of the research. The growth and yield parameters like plant height (cm), number of tillers, leaf area index, crop growth rate were recorded at different stages of the crop. The total plant was uprooted to study the root length and biomass of the plant. The crops were harvested at physiological maturity or at 65-70 DAS and yield attributing characters were also recorded and estimated the yield in grams per plant.

RESULTS AND DISCUSSION

Effect of rainfall on proso millet growth and yield

The rainfall data (Table 1) for the *Kharif* season from 2020 to 2022 shows notable variations in precipitation across the months. In June, rainfall increased significantly from 110.9 mm in 2020 to 238.3 mm in 2022, with the number of rainy days also rising from 6 to 9. This suggests that 2022 provided better water availability early in the season. July saw a substantial increase in rainfall from 38.7 mm in 2020 to 101.4 mm in 2021 but decreased slightly to 95.8 mm in 2022, indicating some variability in water availability during a crucial growth period.

Table 1: Rainfall data during the cropping period

Months of *Kharif* season	2020		2021		2022	
	Rainfall (mm)	Rainy days (No.)	Rainfall (mm)	Rainy days (No.)	Rainfall (mm)	Rainy days (No.)
June	110.9	6	79.8	7	238.3	9
July	38.7	5	101.4	7	95.8	7
August	115.8	7	181.3	6	259.9	12
September	194.3	11	183.5	6	69.4	3

August consistently recorded the highest rainfall each year, with a marked increase to 259.9 mm in 2022 from 115.8 mm in 2020 and 181.3 mm in 2021. This higher rainfall in August is particularly beneficial for crop growth during the peak season. Conversely, September experienced a significant drop in rainfall in 2022, down to 69.4 mm from 194.3 mm in 2020 and 183.5 mm in 2021, which could negatively impact late-season crop development due to reduced water availability. Overall, the data highlights that while early and mid-season rainfall improved in 2022, the substantial reduction in September rainfall may pose challenges for the late growth stages, underscoring the importance of balanced rainfall throughout the entire *Kharif* season for optimal crop performance. Janus *et al*. 2011 indicated that the shortage of rainfall affected the plant height and restricted the leaf area and yield depents on the amount of rainfall received during the crop growth period. The proso millet generally requires 400 – 450 mm of rainfall throught the cropping period in 2022 the amount of rainfall was high bu providing well drainage facility to the crop will not affect the crop growth and yield.

Effect of temperature on growth and yield of proso millet

The temperature data (Table 2) for the *Kharif* season from 2020 to 2022 shows distinct trends. In June, maximum temperatures increased from 34.2°C in 2020 to 37.2°C in 2022, indicating warmer conditions, while minimum temperatures ranged from 25.9°C to 27.2°C. July saw a slight decrease in maximum temperatures from 36.2°C to 34.7°C in 2022, with minimum temperatures varying from 25.8°C to 27.6°C. August experienced a cooler trend with maximum temperatures dropping from 36.0°C to 34.0°C and minimum temperatures from 26.3°C to 25.2°C. September also cooled down, with maximum temperatures decreasing from 35.6°C to 33.4°C and minimum temperatures from 28.0°C to 24.6°C. Overall, while June and July were warmer in 2022. Plant growth and development rates are influenced by the ambient temperature, with each species thriving within a distinct temperature range that includes minimum, maximum, and optimal levels, eventhough proso millet was a drought tolerant crop which performs well in the cooler temperatures in August and September (Jerry Hatfield and John Pruger, 2015).

Effect of season on growth of proso millet

The crop growth data across different stages reveals significant development (Table 3). At the seedling stage (15 DAS), plant height was 15.41 cm, with a root length of 2.36 cm, LAI of 1.54, and CGR of 2.22 mg/m²/day. By the vegetative stage (30 DAS), plant height increased to 43.20 cm, with root length rising to 12.1 cm, LAI to 1.89, and CGR to 6.85 mg/m²/day. During the flowering stage (45 DAS), plant height further grew to 109.5 cm, with 2.0 branches, root length of 16.7 cm, LAI of 2.35, and CGR of 27.08 mg/m²/day. At harvesting stage (70 DAS), plant height reached 115.3 cm, with 5.4 branches,

Table 2: Temperature data during the cropping period

Months of *Kharif* season	2020		2021		2022	
	Temp. Max.	Temp. Min.	Temp. Max.	Temp. Min.	Temp. Max.	Temp. Min.
June	34.2	25.9	35.0	28.1	37.2	27.2
July	36.2	26.9	35.0	27.6	34.7	25.8
August	36.0	26.3	35.0	27.4	34.0	25.2
September	35.6	28.0	36.0	27.3	33.4	24.6

Table 3: Growth parameters of proso millet under varied climatic condition (mean of three seasons)

Stage of the crop	Plant height (cm)	Number of branches (No.)	Root length (cm)	LAI	CGR (mg/m²/day)
Seedling stage (15 DAS)	15.41	—	2.36	1.54	2.22
Vegetative stage (30 DAS)	43.20	—	12.1	1.89	6.85
Flowering stage (45 DAS)	109.5	2.0	16.7	2.35	27.08
Harvesting stage (70 DAS)	115.3	5.4	16.9	3.14	29.43

root length of 16.9 cm, LAI of 3.14, and CGR of 29.43 mg/m²/day. These metrics demonstrate robust growth and development, with significant increases in plant height, root length, LAI, and CGR as the crop progresses through its stages. Shivali Amit Wagle and Harikrishnan, 2021 confirmed the above result by the climate influences the huge effect on crop production.

Effect of season on yield parameters and yield of proso millet

The yield parameters (Table 4) for the crop show that productive tillers ranged from 3 to 5 per plant. Total dry matter production varied between 55.4 g and 57.3 g per plant. Panicle length was between 33.8 cm and 34.2 cm, while the 1000 grain weight ranged from 5.0 g to 5.8 g. Grain yield was recorded from 7.2 g to 7.8 g per plant, and straw yield ranged from 23.4 g to 25.6 g per plant. The harvest index varied between 0.31 and 0.34. These metrics reflect a stable and productive crop performance, with consistent yields and biomass conversion efficiency. This study and result was confirmed by Venkata Shashank Konduri *et al.* (2020).

Table 4: Yield parameters and yield of proso millet under varied climatic condition (mean of three seasons)

Yield parameters	Range
Productive tillers (Nos.)	3- 5
Total dry matter production (g/plant)	55.4 – 57.3
Panicle length (cm)	33.8 - 34.2
1000 grain weight (g)	5 – 5.8
Grain yield (g/plant)	7.2 – 7.8
Straw yield (g/plant)	23.4 - 25.6
Harvest index	0.31 – 0.34

CONCLUSION

From 2020 to 2022, total rainfall increased from 459.7 mm to 663.4 mm, with August consistently being the wettest month, crucial for crop growth. Maximum temperatures ranged from 33.4°C to 37.2°C, and minimum temperatures from 24.6°C to 28.1°C, providing stable conditions conducive to crop development. Plant height grew from 15.41 cm at the seedling stage to 115.3 cm at harvest, with significant increases in branches, root length, LAI, and CGR, indicating robust vegetative growth. Yield parameters remained consistent: productive tillers (3-5), total dry matter (55.4-57.3 g/plant), panicle length (33.8-34.2 cm), grain yield (7.2-7.8 g/plant), straw yield (23.4-25.6 g/plant), and a harvest index of 0.31-0.34. These findings highlight the positive impact of increased rainfall and stable temperatures on crop growth and yield, underscoring the importance of adequate water availability and stable climatic conditions for maximizing crop performance during the *Kharif* season.

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