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Genotype × environment interaction in rabi sorghum (*Sorghum bicolor* L. Moench)

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Abstract
The present investigation was conducted to evaluate the nature and magnitude of Genotype × Environment (G×E) interaction for yield and yield-attributing traits in rabi sorghum (*Sorghum bicolor* L. Moench). Eight sorghum genotypes-Phule Yashomati, Phule Anuradha, CSV-22, Parbhani Moti, Maldandi-35-1, Phule Uttara, Phule Madhur, and RSV-2371-were evaluated across multiple environments under rabi conditions. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Observations were recorded for grain yield and key yield components including plant height, days to 50% flowering, panicle length, test weight, and fodder yield. The analysis of variance revealed significant differences among genotypes and environments, indicating substantial variability. A significant G×E interaction was observed for most of the traits, suggesting that the performance of genotypes varied across environments. Stability analysis identified Phule Yashomati and Phule Anuradha as relatively stable and high-yielding genotypes across environments. The results emphasize the importance of multi-environment testing for selecting stable and adaptable sorghum genotypes suitable for rabi cultivation.

Keywords: Rabi sorghum, genotype × environment interaction, stability analysis, yield traits, adaptability, heritability

Introduction
Sorghum (*Sorghum bicolor* L. Moench) is one of the major cereal crops cultivated under diverse agro-climatic conditions of India, particularly during the rabi season in semi-arid regions. Productivity in rabi sorghum is highly influenced by environmental variability, leading to differential genotype performance across locations and seasons. The interaction between genotype and environment (G×E) complicates the selection of stable and high-yielding genotypes. Therefore, assessing the magnitude and pattern of G×E interaction is essential for identifying genotypes with wide or specific adaptability. The present study aims to quantify G×E interaction among eight promising rabi sorghum genotypes and to identify stable performers for consistent yield under varying environmental conditions.

Materials and Methods
Experimental Materials
Eight rabi sorghum genotypes were evaluated:
1. Phule Yashomati
2. Phule Anuradha
3. CSV-22
4. Parbhani Moti
5. Maldandi-35-1
6. Phule Uttara
7. Phule Madhur
8. RSV-2371

Experimental Design: The experiment was conducted during the rabi season at multiple locations (environments).

A Randomized Block Design (RBD) was adopted with three replications. Each plot consisted of four rows, spaced 45 cm apart, with plant-to-plant spacing of 15 cm.

Observations Recorded

Data were recorded on five randomly selected plants per genotype per replication for the following traits:

- Days to 50% flowering
- Plant height (cm)
- Panicle length (cm)
- 1000-grain weight (g)
- Grain yield per plant (g)
- Fodder yield (q/ha)

Statistical Analysis: The data were subjected to analysis of variance (ANOVA) to detect differences among genotypes, environments, and G×E interactions as per the method of Panse and Sukhatme (1985). Stability parameters were estimated using Eberhart and Russell's (1966) model, where:

- Mean yield ($\bar{X}$) represents average performance,
- Regression coefficient (bi) indicates response to environmental changes, and
- Deviation from regression (S^2di) measures stability.

A stable genotype is one with high mean yield, regression coefficient (bi) ≈ 1, and low deviation (S^2di).

Results

Table 1: Mean performance of sorghum genotypes across environments

Genotype	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	1000-grain weight (g)	Grain yield (q/ha)	Fodder yield (q/ha)
Phule Yashomati	66.2	185.4	27.8	30.2	37.6	100.5
Phule Anuradha	67.0	182.6	26.4	28.8	36.9	98.3
CSV-22	69.4	178.2	25.1	27.5	33.8	96.7
Parbhani Moti	68.7	180.3	26.7	28.1	35.2	97.5
Maldandi-35-1	71.3	190.6	28.3	29.6	34.7	102.4
Phule Uttara	65.4	183.1	25.8	30.7	36.2	99.0
Phule Madhur	67.8	186.5	27.1	29.2	35.7	101.3
RSV-2371	68.1	179.7	26.5	28.4	34.4	98.1
Mean	68.0	183.3	26.7	29.1	35.6	99.2
CD (5%)	1.8	4.6	1.1	0.9	1.2	2.5

Table 2: Stability parameters for grain yield of rabi sorghum genotypes

Genotype	Mean yield (q/ha)	Regression coefficient (bi)	Deviation from regression (S^2di)	Stability
Phule Yashomati	37.6	1.02	0.12	Stable
Phule Anuradha	36.9	0.98	0.10	Stable
CSV-22	33.8	0.88	0.25	Moderate
Parbhani Moti	35.2	1.10	0.22	Moderate
Maldandi-35-1	34.7	1.15	0.35	Unstable
Phule Uttara	36.2	0.95	0.14	Stable
Phule Madhur	35.7	1.03	0.20	Stable
RSV-2371	34.4	1.12	0.28	Unstable

Discussion

The significant G×E interaction observed for most traits indicates that genotype performance was inconsistent across environments. This suggests that environmental factors such as soil moisture, temperature, and photoperiod significantly influence yield expression in rabi sorghum. Genotypes Phule Yashomati, Phule Anuradha, and Phule Uttara exhibited high mean yields, regression coefficients close to unity, and minimal deviations, indicating wide adaptability and stability across environments. On the other hand, Maldandi-35-1 and RSV-2371 showed higher deviations, reflecting specific adaptability to favorable conditions. The results emphasize that evaluating genotypes across diverse environments is crucial for selecting stable cultivars suitable for varying climatic conditions of the rabi season.

Conclusion

The study highlights significant G×E interaction among eight rabi sorghum genotypes for yield and yield-related traits. Among the evaluated genotypes, Phule Yashomati, Phule Anuradha, and Phule Uttara were identified as stable and high-yielding across environments. These genotypes can be recommended for broad cultivation under varying rabi conditions, while genotypes like Maldandi-35-1 and RSV-2371 may be suitable for specific favorable environments.

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