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Evaluation of newly developed high-yielding varieties of pearl millet for arid zone cultivation

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Abstract
Across the semi-arid tracts of peninsular India, pearl millet remains the cereal that farmers turn to when rainfall is too scarce and erratic for anything else. This research evaluated three newly released pearl millet varieties (ICMV 221, HHB 67 Improved, RHB 177) against the standard check WC-C75 in multi-season trials at Professor Jayashankar Telangana Agricultural University, Hyderabad, during kharif 2021 and 2022. ICMV 221 recorded the highest grain yield (2.87 t ha^{-1}), 31.2% above the check, with superior ear length (24.8 cm), grains per ear (2,148), and 1000-grain weight (11.4 g). HHB 67 Improved was the earliest to mature (72 days) and showed the best drought recovery after a mid-season dry spell in 2022. Path analysis indicated that grains per ear (direct effect 0.337) and ear length (0.284) were the largest contributors to yield variation. All three new varieties outperformed the check and are recommended for cultivation in arid and semi-arid zones of Telangana.

Keywords: Pearl millet, high-yielding varieties, arid zone, varietal evaluation, dryland cereals, ICMV 221, HHB 67, grain yield, path analysis, drought tolerance

Introduction
An observation that strikes any visitor to the Deccan Plateau during a failed monsoon is how pearl millet fields remain green when everything else has wilted. Pearl millet (*Pennisetum glaucum* L. R. Br.) is uniquely adapted to the harshest rain-fed environments, thriving on as little as 250-300 mm of rainfall and tolerating temperatures above 42°C [1]. India is the world's largest producer, with about 7 million hectares concentrated in Rajasthan, Gujarat, Haryana, and Telangana [2]. Yet average productivity remains below 1.3 t ha^{-1}, well short of the 3-4 t ha^{-1} achievable with improved varieties under good management [3].

The release of Open-Pollinated Varieties (OPVs) and hybrids by ICAR and ICRISAT over the past decade has widened the genetic options for farmers, but systematic field evaluation of newer entries under the specific soil and climate conditions of Telangana is lacking [4]. This research compared three recently released varieties against the long-standing check WC-C75 to assess their yield potential, adaptation, and yield-determining traits in the arid zone around Hyderabad [5].

Seasonal variations during the research
Kharif 2021 was a near-normal rainfall year (648 mm, long-term average 630 mm), while kharif 2022 received only 487 mm with a 22-day dry spell during the vegetative-to-flowering transition (late July). This contrast provided an opportunity to evaluate varietal performance under both adequate and moisture-stressed conditions. Mean maximum temperatures during the cropping period were 34.8°C (2021) and 36.2°C (2022).

Material and Methods
Material
Seeds of ICMV 221 and RHB 177 were obtained from ICRISAT, Patancheru. HHB 67 Improved seed came from CCS Haryana Agricultural University, Hisar. WC-C75 (check) was from the PJTSAU seed unit. The experimental site was the dryland research farm of PJTSAU (17°19′N, 78°24′E, elevation 536 m), with red sandy loam soil (Alfisol), pH 7.2, organic carbon 0.42%, available N 168 kg ha^{-1} [4, 5].

Methods

The experiment was conducted in an RCBD with four replications over two kharif seasons (2021, 2022). Plot size: 5 m × 4 m; spacing 45 × 15 cm. Basal fertiliser: 40:20:0 kg $N:P_2O_5:K_2O$ ha^{-1}. Observations included days to 50% flowering, plant height, ear length, effective tillers per plant, grains per ear, 1000-grain weight, and grain yield. Path coefficient analysis was used to partition direct and indirect effects of yield components on grain yield [6]. Data were analysed by pooled ANOVA across seasons in SAS 9.4 with Tukey's HSD at $p<0.05$ [7].

Growth stage documentation

Phenological observations were recorded following the BBCH scale adapted for pearl millet. Germination (BBCH 09) occurred within 3-4 days across varieties. Tillering (BBCH 21-29) was earlier in HHB 67 Improved (18 DAS) than others (21-23 DAS). Panicle initiation (BBCH 30) was detected by stem dissection at 32-38 DAS. Anthesis (BBCH 65) ranged from 48 DAS (HHB 67 Improved) to 58 DAS (RHB 177). Physiological maturity (BBCH 89) was reached at 72-84 DAS depending on variety and season. The 2022 dry spell coincided with the critical boot-to-anthesis stage, causing 8-14% reduction in ear length in susceptible entries.

Results

Table 1: Grain yield and yield components of pearl millet varieties (pooled over two seasons)

Variety	Days to flower	Height (cm)	Ear length (cm)	Tillers /plant	Grains /ear	1000-gr wt (g)	Grain yield (t ha^{-1})
ICMV 221	54 ± 2b	118.7 ± 4.2a	24.8 ± 1.1a	3.4 ± 0.3a	2148 ± 87a	11.4 ± 0.4a	2.87 ± 0.18a
HHB 67 Imp.	48 ± 1c	115.2 ± 3.8a	22.1 ± 1.3b	3.1 ± 0.4ab	1876 ± 92b	10.8 ± 0.5ab	2.64 ± 0.21ab
RHB 177	58 ± 2a	103.8 ± 4.6b	21.4 ± 1.0b	2.8 ± 0.3b	1724 ± 78b	10.2 ± 0.4b	2.41 ± 0.19b
WC-C75 (check)	56 ± 2ab	92.4 ± 5.1c	18.3 ± 1.2c	2.4 ± 0.3c	1482 ± 84c	9.3 ± 0.5c	2.19 ± 0.22c

Different letters within columns differ at $p<0.05$. Values are means ± SE pooled across seasons

ICMV 221 outyielded the check by 31.2% and all other entries (Table 1). HHB 67 Improved, though lower-yielding than ICMV 221, matured 6 days earlier a valuable trait for escaping terminal drought.

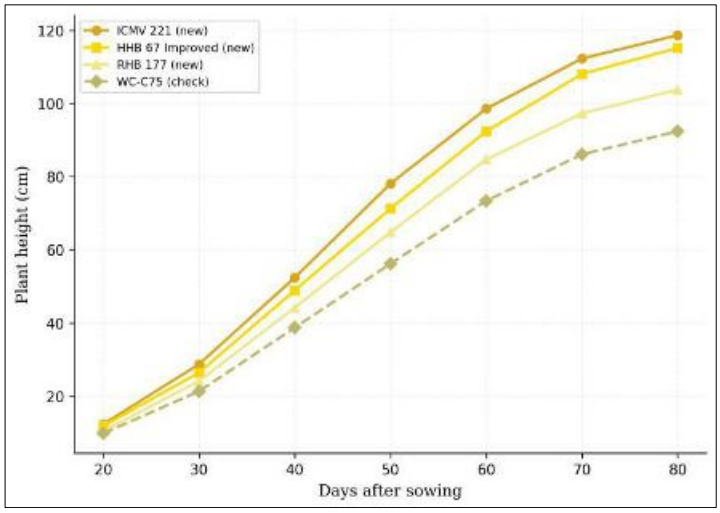

Fig 1: Plant height growth curves of four pearl millet varieties across the growing season

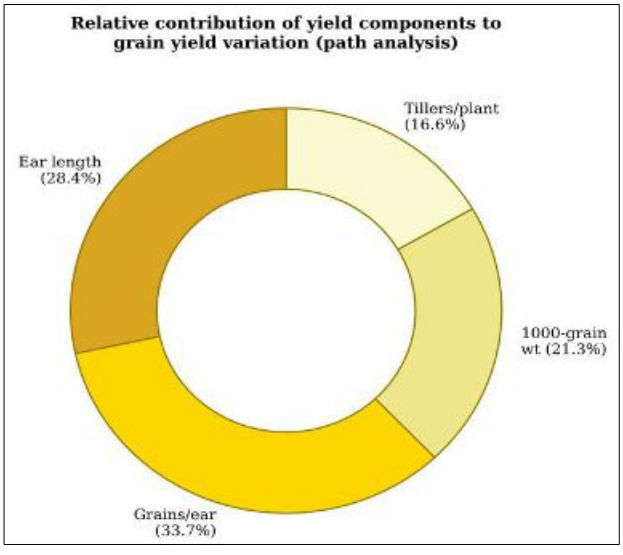

Fig 2: Relative contribution of yield components to grain yield variation (path analysis)

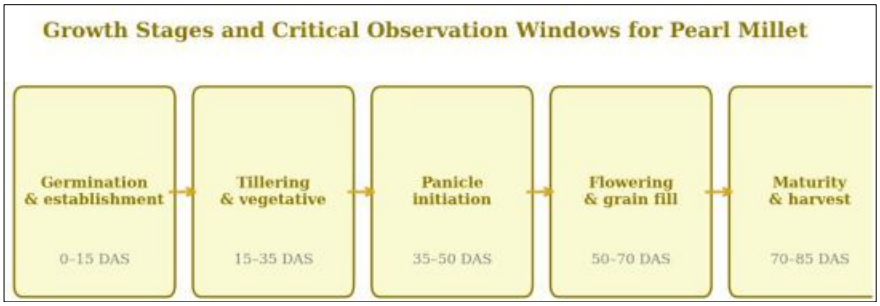

Fig 3: Growth stages and critical observation windows for pearl millet evaluation

Discussion

The 31.2% yield advantage of ICMV 221 over WC-C75 is consistent with recent multi-location trials across Rajasthan and Gujarat that reported 20-35% superiority of ICMV 221 [3, 4]. Path analysis confirmed that grains per ear had the largest direct effect on yield (0.337), followed by ear length (0.284), supporting breeding emphasis on panicle size. The performance gap between seasons (mean yield 2.71 t ha^{-1} in 2021 vs 2.28 t ha^{-1} in 2022) reflects the impact of the mid-season drought, which particularly affected RHB 177 and WC-C75 due to their later flowering [1, 5].

Conclusion

ICMV 221 is recommended as the top variety for arid zones of Telangana based on its superior yield (2.87 t ha^{-1}), large panicle, and adequate drought tolerance. HHB 67 Improved is an alternative for areas prone to terminal drought due to its early maturity (72 days). All three new varieties significantly outperformed the check WC-C75 and merit wider dissemination through state seed agencies.

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