Plant Archives Vol. 26, No. 1, 2026 pp. 625-632 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.1.086

KNM 6965 – A HIGH YIELDING EARLY DURATION LONG SLENDER RICE (*ORYZA SATIVA* L.) VARIETY SUITABLE FOR THE STATES OF CHHATTISGARH AND MAHARASHTRA IN INDIA

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(Date of Receiving-05-12-2025; Date of Revision-27-01-2026; Date of Acceptance-17-02-2026)

ABSTRACT

The present investigation was conducted from 2014 to 2020 at the Agricultural Research Station, Kunaram, Telangana, India with the objective of developing short duration (120-125 days), high-yielding, blast resistant, and early maturing rice genotypes without compromising quality through pedigree method breeding. Among the evaluated rice genotypes, the long slender, short duration promising genotype KNM 6965 consistently demonstrated superior performance in terms of yield, disease reaction, and quality under irrigated conditions across a series of research station level evaluations**.** Subsequently, KNM 6965 was nominated, and evaluated during 2019–2021 under the All India Coordinated Research Project (AICRP) on Rice trials**,** and based on its superior and consistent performance across test locations in Chhattisgarh and Maharashtra, it was released in 2022 by the Central Varietal Release Committee (CVRC) as Telangana Rice 7**,** recommended for cultivation in these states**.** Across three years of multilocation testing, KNM 6965 recorded a weighted mean yield of 4922 kg ha^{-1}, showing a 17.86% yield advantage over the national check with moderate resistance to leaf blast and grain discoloration. It possessed long slender, translucent grains with intermediate amylose content (21.82%) and head rice recovery of 66.9%, indicating good milling and cooking quality. It had semi dwarf plant type with moderate tillering, erect flag leaf, semi-compact and exerted semi-erect attitude of branching panicle. Telangana Rice 7 (KNM 6965) is suitable for cultivation under *kharif* season conditions in Chhattisgarh and Maharashtra, combining high yield potential, moderate disease resistance, and superior grain quality**.**

***Key words*: Amylose, Blast, Early duration, KNM 6965, Yield.

Introduction

Rice (*Oryza sativa* L.) is a vital global crop, with over 90% of its production and consumption occurring in Asia. To keep pace with rising demand and support a growing population, rice production must increase by 25% by 2030 (Alam *et al.*, 2024). On the other hand, rice is cultivated on about 50 million hectares with a production of 145 million tons in India (Anonymous, 2024). Despite significant progress in recent years with the adoption of high-yielding varieties, increasing productivity remains essential to bring down the cost of cultivation. Rice grain quality, like yield, has become a key priority for producers, millers, and consumers, as it plays a crucial role in securing premium prices in the market (Barrett *et al.*, 2022; Lin *et al.*, 2024). Rice farming is facing mounting threats from climate variability, environmental challenges, and the increasing unpredictability of weather patterns. Overall, Indian rice production declined by an average of -3.93%

Table 1: Summarized grain yield (kg/ha) data of coordinated varietal trials. Adoptability Zone: For the states proposed to release- Chhattisgarh and Maharashtra.

	Year of testing	No of trials / Locations	Proposed Variety IET 28343	National Check CO 51	Zonal Check	Local check
Mean grain yield (kg ha^{-1})	1st year 2019	5	4757	3746	3621	4703
	2nd year 2020	8	4684	4345	3346	4204
	3rd year 2021	9	5226	4265	4217	4303
	Weighted Mean		4922	4176	3765	4358
% Increase over checks and qualifying varieties	1st year 2019			26.99	31.37	1.15
	2nd year 2020			7.81	39.98	11.42
	3rd year 2021			22.52	23.93	21.45
	Weighted Mean			17.86	30.74	12.95
Frequency in the top three ranks (pooled for three years)			5/22	3/22	0/22	0/22

Note: The mean yield data given in the table pertains to the states proposed.
Weighted mean: [(4757×5)+(4684×8)+(5226×9)]/ [5+8+9]=4922

annually between 1998 and 2019, due to the impact of climatic variability (Gupta *et al*., 2025). The adoption of early-maturing rice varieties has the potential to substantially enhance mean yields while simultaneously mitigating exposure to climatic variability, production uncertainty, and downside yield risks (Hori *et al*., 2016; Zhou *et al*., 2021; Sreedhar *et al*., 2022). By optimizing the utilization of available temperature and soil moisture throughout the crop growth cycle, these varieties strengthen the adaptive capacity and resilience of rice based farming systems to climate change. Moreover, their cultivation is associated with a potential reduction in greenhouse gas emissions, thereby contributing to more sustainable production pathways (Hasan, 2014). Collectively, these benefits suggest that early-maturing varieties can also improve the economic returns and net farm incomes of rice producers (Liang *et al*., 2024). Rice blast stands out as one of the most harmful diseases hindering rice output, and continues to affect rice production, leading to global rice yield losses of about 10%–30% annually (Mandal *et al*., 2023). The most economically and effective approach to control this disease is to create rice cultivars with broad-spectrum resistance against it (Khush *et al*., 1989; Deng *et al*., 2017; Kalia *et al*., 2019; Agbowuro *et al*., 2020). In India, blast is rated as the most important disease of rice in terms of spread, severity of damage, and yield loss, following the introduction of semi-dwarf and high-yielding varieties during the Green Revolution (Khush *et al*., 1978). Rice Grain Discoloration (RGD) has emerged as a significant constraint in rice production in recent years. The disorder is widely prevalent across Asia, Africa, and Latin America, where it contributes to considerable reductions in both grain quality and overall yield (Raghu, 2020). RGD is attributed to a complex interplay of both biotic and abiotic factors. Alterations in cropping practice, the adoption of high-yielding varieties, favorable agro-climatic conditions, and the intensified use of fertilizers have all been identified as major contributors influencing its incidence and severity (Yadahalli and Konnur, 2018). While abiotic conditions, including elevated temperatures, irregular or insufficient rainfall, unexpected hailstorms, and high humidity levels during the post-flowering stage contribute to the RGD, biotic factors are considered to play a more dominant role in its occurrence. According to Chhabra and Vij (2019), more than 59 fungal genera and 99 species have been linked to the disease. Among them, the most frequently reported and predominant fungal genera include *Bipolaris*, *Curvularia*, *Pyricularia*, *Fusarium*, *Phoma*, *Drechslera*, *Helminthosporium*, *Rhizopus*, *Penicillium*, *Aspergillus*, *Alternaria*, *Nigrospora*, *Chaetomium*, and *Tilletia* species (Mancini *et al*., 2016). Keeping this in view, a focused breeding programme was initiated with the objective of developing high yielding, blast resistant, and early maturing rice genotypes possessing superior grain quality suitable for diverse agro-ecological regions of India.

Materials and Methods

The study was conducted at the Agricultural Research Station, Kunaram, Telangana, over a span of seven years, from 2014 to 2020. The farm is geographically situated at 18.6°N Latitude, 79°E Longitude and an elevation of 231m AMSL. The soil is silty loam with pH 7.43 and EC 0.26 dS m^{-1}. The breeding at Agricultural Research Station, Kunaram, focused on combining various traits desired by farmers, including high yield, blast and grain discoloration resistance, earliness, and quality (Sreedhar *et al*., 2022). In this connection, the pedigree method of

Table 2: Agronomic performance of the entry, IET 28343, in coordinated NMT of Early (TP) under transplanted conditions.

N levels Kg ha^{-1}	Yield (t/ha) IET 28343	Check varieties Yield (t/ha)			For N level	
		Check -1 NC (CO-51)	Check -2 ZC(PR-124)	Check -3 LC	CD (at 5%)	CV (%)
Location: Coimbatore						
75 kg ha^{-1}	4.89	4.84	3.94	-	0.10	1.84
150 kg ha^{-1}	6.57*	6.45	5.32	-		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-34.35					
F2: 150 kg ha^{-1}						
Location: Dhangain						
75 kg ha^{-1}	3.19	2.36	2.60	2.66	0.30	8.51
150 kg ha^{-1}	4.65*	3.33	3.93	3.46		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-45.76					
F2: 150 kg ha^{-1}						
Location: Faizabad						
75 kg ha^{-1}	4.23*	2.93	3.09	2.15	0.20	5.83
150 kg ha^{-1}	4.50	4.44	3.80	3.01		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-6.38					
F2: 150 kg ha^{-1}						
Location: Ghaghraghat						
75 kg ha^{-1}	4.10*	2.97	2.99	2.31	0.04	1.19
150 kg ha^{-1}	4.73*	4.37	3.84	3.0		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-15.36					
F2: 150 kg ha^{-1}						
Location: Jagdalpur						
75 kg ha^{-1}	2.93	4.14	6.59	3.63	NS	18.38
150 kg ha^{-1}	2.30	5.87	5.95	4.14		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	+21.5					
F2: 150 kg ha^{-1}						
Location: Karjat						
75 kg ha^{-1}	3.46'	2.67	2.91	3.56	0.4	10.91
150 kg ha^{-1}	4.47	3.57	4.0	4.67		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-29.19					
F2: 150 kg ha^{-1}						
Location: Mandya						
75 kg ha^{-1}	3.55	3.91	3.57	-	NS	7.77
150 kg ha^{-1}	4.73	4.23	3.89	-		
Percent gain or loss under other doses						
F1: 75 kg/ha	-33.23					
F2: 150 kg/ha						
Location: Maruteru						
75 kg ha^{-1}	4.04	3.55	5.13	-	0.72	14.46
150 kg ha^{-1}	5.26	4.56	5.69	-		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-30.19					
F2: 150 kg ha^{-1}						

***Continue* ...2**

Location: Ranchi						
75 kg ha^{-1}	4.33	3.91	4.67	3.15	0.19	4.53
150 kg ha^{-1}	5.01	4.47	5.16	3.43		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-15.7					
F2: 150 kg ha^{-1}						
Location: Rewa						
75 kg ha^{-1}	4.77	4.20	4.70	5.27	0.07	1.72
150 kg ha^{-1}	5.37	5.47	5.13	6.23		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-12.57					
F2: 150 kg ha^{-1}						
Location: Sabour						
75 kg ha^{-1}	4.28	4.19	4.85	4.24	0.15	3.39
150 kg ha^{-1}	4.78	4.46	5.37	4.66		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-11.68					
F2: 150 kg ha^{-1}						
Location: Vadgaon						
75 kg ha^{-1}	3.19	3.12	3.56	3.13	0.26	6.19
150 kg ha^{-1}	4.86	4.71	5.14	4.52		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-52.35					
F2: 150 kg ha^{-1}						
Location: Varanasi						
75 kg ha^{-1}	3.25	2.6	3.9	3.8	0.23	6.43
150 kg ha^{-1}	4.65	3.6	5.2	4.94		
Percent gain or loss under other doses						
F1: 75 kg ha^{-1}	-43.07					
F2: 150 kg ha^{-1}						
* Significant at 5% level over all checks (National, Zonal and Local) based on CD values						

breeding was followed to develop a variety with the required objective by selecting two parents, i.e., MTU 1010 and KNM 118. The female parent, MTU 1010, is noted for its high yielding potential with long slender grains, earliness, and tolerance to pests and diseases developed at the Regional Agricultural Research Station (RARS), Maruteru. KNM 118 is a long slender variety with good marketability and is selected for its earliness and resistance to leaf blast and moderately resistant to neck blast, developed at the Agricultural Research Station, Kunaram, and used as a male parent. These two parents were crossed and raised the F_1 and crossed plants, which were confirmed, based on the characters at the Agricultural Research Station, Kunaram, during the rainy season of 2015. The seeds of F_2 were evaluated with approximately 6,000 population in the summer of 2015-16. Pedigree method of breeding was followed in the F_3 and F_4 populations by selecting single plants for the characters, such as long slender grain, semi dwarf, long panicle, with a good number of grains. This process was continued up to F_5 till these lines attained uniformity in height, panicle length, grain type, along blast resistance. The breeding line with Index No. KNM 6965 resulted from the bulk harvest of an F_5 family in summer, 2017-18, and it was subsequently evaluated in the yield trials from 2017-18 to 2019-20 at the Agricultural Research Station, Kunaram. It was nominated and tested in AICRP (Irrigated Early-Transplanted) trials, i.e., IVT-E-TP (2019), AVT-1-E-TP (2020) and AVT-2-E-TP (2021).

Results and Discussion

The short-duration (115-120 days) entry, IET 28343 (KNM 6965) was nominated and tested in AICRP on Rice (Irrigated Early-Transplanted) trials, i.e., IVT-E-TP (2019), AVT-1-E-TP (2020) and AVT-2-E-TP (2021) during *kharif* seasons and yielded+17.86%,+30.74% and +12.95%, higher than national, zonal and local checks respectively on overall mean and found suitable for irrigated wet lands in the states of irrigated areas of Chhattisgarh and Maharashtra. In the overall performance, KNM 6965 recorded a mean productivity of 4922 kg ha^{-1} in three years of all the trials over the 22 locations (Table 1).

During the *kharif* season of 2021, agronomy field experiments were conducted at Coimbatore, Dhangain, Faizabad, Ghaghraghat, Jagdalpur, Karjat, Mandya, Maruteru, Ranchi, Rewa, Sabour, Vadgaon and Varanasi to know the response of rice cultures with different levels of nitrogen (75% and 150% N ha^{-1} of the recommended dose) in transplanted rice. The grain yield of this rice culture with different nitrogen levels was found to be significant in most of the locations. The rice entry IET 28343 in agronomy nutrient management trial exhibited marked responsiveness to nitrogen fertilization across diverse locations, with grain yield consistently increasing from 75 kg N ha^{-1} (50% RDN) to 150 kg N ha^{-1} (100% RDN) in most environments. At the higher nitrogen level, IET 28343 recorded significantly superior yields over all checks at Coimbatore (6.57 t ha^{-1}), Dhangain (4.65 t ha^{-1}) and Ghaghraghat (4.73 t ha^{-1}), compared to 4.89, 3.19 and 4.10 t ha^{-1}, respectively at 75 kg N ha^{-1}. At the lower nitrogen dose, the entry also showed significant superiority at Faizabad (4.23 t ha^{-1}) and Ghaghraghat (4.10 t ha^{-1}). Overall, yield enhancement due to increased nitrogen ranged from marginal increases (4.23 to 4.50 t ha^{-1} at Faizabad) to substantial gains (3.19 to 4.65 t ha^{-1} at Dhangain). These results indicate that IET 28343 possesses high yield potential under improved fertility conditions and exhibits moderate stability across varying environments. In a similar experiment to the above, an increase in grain yield with every 100kg of N ha^{-1} from 100kg to 300kg ha^{-1} was significant, and a significant interaction effect on grain yield was observed due to method of crop establishment, varieties, and nitrogen levels (Rajesh *et al*., 2015; Ramulu *et al*., 2020). In both the System of Rice Intensification (SRI) and the Conventional Transplanting System (CTS), higher fertilizers resulted in better growth, yield, and yield attributes; moreover, the optimum fertilizer dose was 100% RDF (Rafi *et al*., 2024). Among the different nitrogen levels, 125% RDN (recommended dose of nitrogen) recorded the highest grain, straw and biological yield and harvest index; however, it was at par with 100% RDN treatment during both the years of experimentation. Among the different nitrogen levels, 125% RDN (recommended dose of nitrogen) recorded the highest grain, straw and biological yield and harvest index; however, it was at par with 100% RDN treatment during both the years 2021 and 2022 of experimentation (Mir *et al*., 2025). The yield of rice plants under high nitrogen (315 kg ha^{-1}**)** conditions was significantly higher than that of plants under medium (270 kg ha^{-1}) and low nitrogen (180 kg ha^{-1}) conditions (Zhang *et al*., 2024) (Table 2).

Table 3: Distinguishing morphological characters of Rice variety, KNM 6965 (Telangana Rice 6).

Habit	:	Semi dwarf plant type with medium tillering green foliage.
Coleoptile colour	:	Colourless
Plant Height	:	101-110 cm
Leaf: Intensity of green colour	:	Medium
Basal leaf: Sheath colour	:	Green
Leaf: Anthocyanin pigment	:	Absent
Leaf Blade	:	Medium, green and non-pigmented
Flag leaf	:	Erect and non-pigmented
Junction, Auricle, Ligule, Septum	:	Anthocyanin pigment absent
Internode thickness	:	6-7 mm
Ear bearing tillers/m^2	:	260-315
Awns	:	Awn less
Panicle	:	Semi-compact and semi-erect attitude of branching
Exertion	:	Well exerted
Panicle length	:	26-28 cm
Number of grains/Panicle		140-160
Lemma, Palea	:	Straw colour
Apiculus	:	Straw colour
Husk colour	:	Straw colour
Rice colour	:	Translucent, white colour
Abdominal white	:	Absent
L/B ratio	:	3.11
1000 grains weight (g)	:	27-28
Rice grade	:	Translucent long slender grain
Maturity (Days to 50% flowering)	:	85-90 days (*Kharif*)
Days to maturity (Seed to seed)	:	115-120 days (*Kharif*)

The proposed promising high yielding rice genotype, KNM 6965, was a long slender, non-shattering, and relatively short duration variety, with a total growth duration of about 115-120 days, with high yield potential (4922 kg ha^{-1}). It had tolerance to blast and grain discoloration with better adaptability and good quality. It had been released through the Central Varietal Release Committee under the name of Telangana Vari 6 for Maharashtra and Chhattisgarh during the year 2022 as an alternate variety to existing long slender varieties. It was suitable for the *Kharif* season. This was a semi dwarf rice variety with moderate tillering, erect flag leaf,

Table 4: Data on the quality characteristics.

Designation	Year	HR	MR	HRR(%)	KL(mm)	KB(mm)	L/B Ratio	ASV	AC (%)	GC (mm)	Grain Chalk
Proposed variety IET 28343	2020	79.6	70.1	63.2	6.41	2.07	3.09	3	21.35	69.0	VOC
	2021	79.9	72.4	70.6	6.61	2.11	3.13	3	22.29	68.0	A
	Mean	79.8	71.3	66.9	6.51	2.09	3.11	3	21.82	68.5	VOC
National check	2020	77.8	68.3	63.1	5.32	1.93	2.75	4	25.60	50.0	VOC
	2021	78.6	71.4	70.8	5.65	2.01	2.81	4	25.22	45.0	VOC
	Mean	78.2	69.9	67.0	5.48	1.97	2.78	4	25.41	47.5	VOC
Zonal check	2020	79.5	68.3	56.8	6.17	2.03	3.03	4	23.81	67.0	VOC
	2021	81	74.1	73	5.55	1.99	2.78	4	23.29	64.0	A
	Mean	80.3	71.2	64.9	5.86	2.01	2.91	4	23.55	65.5	VOC

HR (%): Hulling Recovery (%); MR (%): Milling Recovery (%); HRR (%): Head rice recovery (%);
KL (mm): Kernel length (mm), KB (mm): Kernel breadth (mm); L/B ratio: Length and breadth ratio;
ASV: Alkali spreading value; AC: Amylose content; GC: Gel consistency; VOC: Very occasionally present

all plant parts green, semi-compact, well-exerted, semi-erect attitude of branching panicle, and straw-colored awn with fewer grains per culture. It had around 260 to 315 ears bearing tillers m$^{2-1,}$ and the height was in the range from 100 to 105cm with strong culms having the internodal thickness of 6-7mm. The panicle length ranged from 26 to 28cm with 140 to 160 no. of grains per panicle. The panicle was with a semi-compact, semi-erect attitude of branching in nature, showing full exertion without any awns and sterility. The kernels were with a 1000 grain weight of 27 to 28g without any abdominal white resembling MTU 1010 (Table 3). The variety KNM 6965 (IET 28343) possessed translucent, long slender grains with 6.51 mm kernel length, 2.09 mm kernel breadth and L/B ratio of 3.11. Further, the variety recorded a milling recovery of 71.3% and a head rice recovery of 66.9%, accompanied by translucent kernels. Such characteristics are highly desirable from a millers' perspective, as they contribute significantly to market value. In addition, it exhibited a hulling recovery of 79.8%, indicating superior grain processing quality. It was similar to the findings of Oko *et al*., (2012) and Robin *et al*., (2019), who reported a significant positive association of head rice recovery with milling outturn. In parallel with enhancing paddy yield, improving the milling quality of rice is essential in ensuring food security by mitigating the impact of significant losses during the postharvest processing of rice grains. From an industrial standpoint, maximizing the milling recovery of whole grain polished rice is crucial in fetching higher revenues to rice farmers (Butardo and Sreenivasulu, 2019). The amylose content of rice starch ranges from 0 to 35%. According to the amylose content, rice starch can be classified as waxy (<2%), very low (5–12%), low (12–20%), intermediate (20–25%), and high (>25%) amylose starch (Wani *et al.*, 2012; Pal *et al.*, 2015). It exhibited an intermediate amylose content (21.82%), which is considered desirable from a consumer perspective, as this range is typically associated with favorable cooking and eating qualities. Additionally, the genotype recorded an intermediate alkali spreading value (3.0) and a gel consistency of 68.50 mm, further indicating its suitability for good cooking quality (Table 4). It exhibited moderate resistance to leaf blast and grain discoloration in pathology screening experiments of NSN-2 (2019), and NSN-1 (2020 and 2021) (Table 5).

Table 5: Summary of the reaction to major diseases of the entries.

Diseases	YT	NOL	PE	Check varieties					NDR	MTU	CO	US
				IR 64	HR 12	RP bio226	TN 1	Vikramarya				
				R(Blast)	S(Blast)	R(BLB)	S(BB, RTD)	R(RTD)				
Leaf blast	2019	17	4.2	5.4	7.9	5.9	6.8	5.9	4.6	-	3.9	4.4
	2020	20	5.8	5.6	8.0	6.7	7.3	6.7	5.5	4.9	5.2	4.6
	2021	28	5.2	4.6	7.6	5.9	6.2	6.2	4.8	5.2	4.2	4.0
	Mean	65	5.1	5.2	7.8	6.2	6.8	6.3	5.0	5.0	4.4	4.3
Grain discoloration	2019	1	3.0	-	-	-	-	-	-	-	5.0	5.0
	2020	3	6.0	5.0	6.0	5.0	7.0	5.0	5.0	7.0	6.0	4.0
	2021	3	5.7	4.3	5.0	5.7	5.7	5.0	4.3	5.0	5.0	5.0
	Mean	7	4.9	4.6	5.5	5.3	6.3	5.0	4.6	6.0	5.3	4.7

Source: Screening Nurseries (NSN-2) for 2019, (NSN-1), 2020 and 2021;
YT: Year of Testing; PE: Proposed Entry IET 28343; NOL: Number of locations; NDR: NDR 359(NC);
MTU: MTU 1010(RC); CO: CO 51(NC); US: US 314(HC)

Conclusion

The variety IET 28343 (KNM 6965) is an early-duration, long slender rice genotype identified and released for cultivation in the states of Chhattisgarh and Maharashtra during the *kharif* season under intensive irrigated ecosystems. It exhibited excellent adaptability and suitability to the prevailing agro-climatic conditions of these regions, coupled with high yield potential**,** earliness (120–125 days)**,** and moderate resistance to blast and grain discoloration**.** Additionally, the variety possesses a non-shattering habit and superior grain quality**,** making it a promising alternative to the existing check varieties in the irrigated *kharif* ecosystem.

Author's Contribution

The authors sincerely thank Rice breeding, Agricultural Research Station, Kunaram, Peddapalli, Telangana State-505174, where the work has been done and also the Associate Director of Research, Regional Agricultural Research Station, Jagtial, for providing the support.

Declaration

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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