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High Yielding Pest and Disease Tolerance Variety (DHLM-14-1) in Little Millet (*Panicum sumetrense*. L) Developed through Recombinant Breeding Technology

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The little millet variety DHLM-14-1 developed at the Agricultural Research Station (ARS) Hanumanamatti under the University of Agricultural Sciences, Dharwad. With a maturation period of 85-90 days, this variety features an erect, tall plant stature ranging from 112 to 130 cm and produces bold, oval-shaped gray grains. DHLM-14-1 stands out for its notable tolerance to shoot fly, exhibiting only a 13.89% incidence compared to 19.15% in the national check JK-8. Its impressive yield performance is evident, yielding 18.42%, 30.58%, and 3.14% more than the national checks OLM-203, JK-8, and KOPLM-53, respectively, making it a beneficial option for millet producers looking for resilient, high-yielding crops. Across trials conducted from 2011 to 2014, DHLM-14-1 showcased exceptional agronomic performance, achieving a mean seed yield of 42.41q/ha, significantly outperforming local check TNAU-63 and national check OLM-203 by 26.63% and 23.75%, respectively. Its consistent yield superiority, with an average of 15.89 q/ha over three years, illustrates the cultivar's adaptability to diverse agro-climatic conditions, surpassing OLM-203 and JK-8 by 18.42% and 30.58%. Recognized during the 29th Annual Group Meeting of the ICAR All India Coordinated Research Project on small millets, DHLM-14-1 has shown strong disease resistance against grain smut, brown spot, and sheath blight, with disease incidences similar to OLM-203 and significantly lower than JK-8. Additionally, its effective resistance to shoot fly underscores its potential to reduce pest damage, reinforcing DHLM-14-1's value as a high-yielding, resilient cultivar that not only enhances sustainable millet production but also supports food security and improves farmer livelihoods across India.

Keywords: Disease tolerance; little millet; recombinant breeding; shootfly; sheath blight; brown spot; smut.

1. INTRODUCTION

Millets are full of soluble fibre, which trap fat in human gut and can lower the cholesteral level in blood. That can reduce your chances of atherosclerosis or heart disease. Millets are rich source of protein and minerals especially iron, sodium, magnesium, zinc, copper which required for perfect metabolic activities human kind. Little millet loaded with potassium and magnesium helps to enhance heart health and regulate blood pressure. Little millet (*Panicum Sumetrense L*.) belongs to family poaceae. It is grown more than half million hectares in India but production and productivity is very less due to shoot fly (*Atherigonia pulla* Wade) ranging from 22.3 % to 36.5 % and foliar diseases. (8-50 % grain yield loss). Shootfly is major pests in little milletcrop, laying eggs singly on the underside of leaves. The larve migrate to the growth point after hatching and cut the central leaf, resulting information of dead heart. Infestation usually occurs between1-4 week after seediling. If want to increase to increase productivity of little millet, it insists to develop high yielding and pest and disease tolerance variety. The little millet grown widely in Karnatak, Tamilnadu, Telangan, Andrapradesh, Odisha, Bihar, Madhya Pradesh and Maharashtra. Development and growing of pest resistant improved varieties in place of local varieties alone can result in incremental yield benefit around 25-30 %. Choosing appropriate varieties depending on location and time of sowing is very important apart from good crop management. Hariprasan (2023), *Rainfed* agriculture plays an important role in global agricultural systems especially in regions where crop where irrigation facilities are limited or water resources are scares. However, farmers several problems related to whether uncertainties (Malarkodi *et al,* 2023) in rain fed areas poses significant challenges to improves crop yield (Sharma *et al,* 2022) farmers' income livelihood ensure food security. DHLM-14-1 is a high-yielding, medium-maturing cultivar officially released in 2018 after extensive development from 2008 to 2013 and evaluation from 2011 to 2015. It has been recommended and release during 2018 for cultivation in Tamil Nadu, Karnataka, Gujarat, Maharashtra, and Odisha.

2. MATERIALS AND METHODS

The little millet culture, DHLM-14-1was evolved at ARS, Hanumanamatti, University of Agricultural Sciences, Dharwad for cultivation in Karnataka and other states in India. It has been evolved between two genotypes, Co2 9 (medium maturing non pigmented type, loose type ear head gray colour seed) while, TNAU-110 is also

medium maturing genotype with straw white colour glumes. The elite plants were selected from F2 on wards and they were evaluated for sustained yield ability and homozygosity and DHLM-14-1was found best on among the selected lines. This culture was evaluated with local and national checks in station trials at ARS, Hanumanamatti, University of Agricultural Sciences, Dharwad from 2011-12, 2012-13 and 2013-14 respectively.

Besides this, DHLM-14-1 was also screened for shoot fly, brown spot, sheath blight, grain smut, and grain smut severity.

Table 1. Performance of new variety, DHLM-14-1 in station trials

Preliminary yield trials	Variety DHLM-14-1 (q/ha)	TNAU-63 (Sukshema) (LC) (q/ha)	OLM-203 (NC) (q/ha)
2011-12	38.44	31.45	33.92
2012-13	43.15	32.15	29.34
2013-14	42.68	34.65	37.12
Mean	42.68	32.7	33.46
Incremental yield (%)		26.63	23.75

Table 2. Summary of seed yield (q/ha) of DHLM-14-1 in All India coordinated varietal trials

Preliminary yield trials	No. of the trials	Proposed variety (DHLM-14-1) (q/ha)	National Check 1 (OLM-203) (q/ha)	National Check 2 (JK-8) (q/ha)
2013-14	12 locations	14.52	11.89	11.02
2014-15	11 locations	17.21	13.85	11.70
2015-16	10 locations	15.96	15.53	13.80
Weighted Mean	33 locations	15.89 (3yrs), 16.58 (2yrs, 2015and16)	13.42	12.17
	Percent increase over checks			
2013-14	12 locations		22.12	31.76
2014-15	11 locations		24.26	47.09
2015-16	10 locations		2.76	15.65
Weighted Mean	33 locations		18.42	30.58

Table 3. State wise and year wise grain yield data of new variety DHLM-14-1

State	Year of testing	No. of trials/locations	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
Andhra Pradesh	1st year (2013-14)	2	1001	902	772
	2nd year (2015-16)	2	1975	591	840
	3rd year (2016-17)	1	1151	1138	1065
	Mean		1375.65 (3 yrs) 1563 (2 yrs)	875	892.3
	% increase or decrease over check			**57.2 %**	**54.21 %**
Chhattisgarh	1st year (2013-14)	1	963	864	667
	2nd year (2015-16)				
	3rd year (2016-17)	1	1085	665	1204
	Mean		1024 (2 yrs) 1085 (1 yr)	764.5	935.5

State	Year of testing	No. of trials/locations	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
	% increase or decrease over check			**34.03 %**	**9.46 %**
Gujarat	1st year (2013-14)	1	1134	887	347
	2nd year (2015-16)		995	494	301
	3rd year (2016-17)		1402	2352	613
	Mean		1177 (3 yrs) 1198.5 (2 yrs)	1244.3	420.3
	% increase or decrease over check			**-5.38**	**180.23**
Jharkhand	1st year (2013-14)	1	901	778	796
	2nd year (2015-16)				
	3rd year (2016-17)				
	Mean		901 (1 yr)	778	796
	% increase or decrease over check			15.8 %	13.19 %
State	Year of testing	No. of trials/locations	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
Karnataka	1st year (2013-14)	3	2901	2901	2032
	2nd year (2015-16)	2	2778	2778	1877
	3rd year (2016-17)	2	1728	1728	1499
	Mean		2469 (3yrs) 2253 (2 yrs)	2469 (3yrs)	1802.6
	% increase or decrease over check			**14.31 %**	**36.96 %**
Madhya Pradesh	1st year (2013-14)	1	469	537	586
	2nd year (2015-16)	1	1352	1204	1605
	3rd year (2016-17)	2	1847	1722	2174
	Mean		1222.1(2 yrs) 1599.5 (1 yr)	1154.3	1455
	% increase or decrease over check			**5.9 %**	**-16.0 %**
Maharashtra	1st year (2013-14)	2	1281	917	1094
	2nd year (2015-16)	2	1280	1282	995
	3rd year (2016-17)	1	1617	1035	1019
	Mean		1392.7(3 yrs) 1448.5 (2 yrs)	1720.6	1036
	% increase or decrease over			**-19.06**	**34.43**

State	Year of testing	No. of trials/locations	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
	check				
Tamilnadu	1st year (2013-14)	2	1776	1425	1517
	2nd year (2015-16)	2	1559	1768	1521
	3rd year (2016-17)	1	2040	1969	2034
	Mean		1791.6 (3 yr) 1799 (2 yrs)	1720.6	1690.6
	% increase or decrease over check			**4.13 %**	**5.97 %**
State	Year of testing	No. of trials/locations	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
Odisha	1st year (2013-14)	0	--	--	--
	2nd year (2015-16)	1	1398	1580	504
	3rd year (2016-17)	1	1511	1358	523
	Mean		1454.5 (2 yrs)	1469(2yrs)	513.5
	% increase or decrease over check			**-0.98 %**	**183.25 %**

3. RESULTS AND DISCUSSION

The seed yield performance of the little millet cultivar DHLM-14-1 was significantly higher compared to the local check TNAU-63 and the national check OLM-203 in both preliminary and station trials conducted from 2011 to 2014 (Table 1). Specifically, DHLM-14-1 achieved a mean seed yield of 42.41 q/ha, surpassing TNAU-63 by 26.63% and OLM-203 by 23.75%. This remarkable increase in yield underscores the cultivar's superior agronomic traits and adaptability to prevailing conditions, which may include factors such as improved nutrient uptake, drought tolerance, and pest resistance. The inclusion of DHLM-14-1 in the All India Coordinated Trials during the 2013-14, 2014-15, and 2015-16 growing seasons further validates its potential, demonstrating its capacity for consistent performance across diverse environments (Kalinova and Moundry, 2006). The enhanced yield not only reflects the genetic advancements achieved through targeted breeding but also highlights the cultivar's relevance for improving food security and farmer livelihoods in millet cultivation.

Over a three-year period (2013-14, 2014-15 and 2015-16), the variety DHLM-14-1 demonstrated impressive performance in grain yield, averaging 15.89 q/ha, which is significantly higher than the national checks OLM-203 and JK-8, which recorded yields of 13.42 q/ha and 12.17 q/ha, respectively (Table 2). This translates to a remarkable 18.42% yield advantage over OLM-203 and a substantial 30.58% increase over JK-8 at the national level. The consistent yield superiority of DHLM-14-1, as summarized in the grain yield data from the coordinated varietal trials conducted between 2013 and 2016, underscores its potential as a reliable and high-yielding cultivar suitable for diverse agro-climatic conditions. This performance not only indicates the cultivar's adaptability and resilience in varying environmental conditions but also reflects the success of targeted breeding efforts aimed at enhancing yield traits (Vetriventhan *et al*., 2020). The enhanced productivity of DHLM-14-1 could significantly contribute to improving food security and increasing farmer incomes, making it a valuable addition to millet cultivation strategies.

Under rainfed conditions, the new variety DHLM-14-1 achieves an average grain yield of 15.89 q/ha. Due to its exceptional yield performance, DHLM-14-1 was recognized by the varietal identification committee during the 29th Annual Group Meeting of the ICAR All India Coordinated Research Project (AICRP) on small millets in

2017. Subsequently, it was officially released and notified in 2018. To this day, this variety continues to produce higher yields per hectare across various states in India (Sivagamy *et al*., 2024).

The grain yield data for DHLM-14-1 by state and year is summarized in Table 3. Little millet is primarily cultivated in states such as Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, and Odisha. For the successful adoption of this variety in these regions, it must demonstrate broad adaptability to varying climate conditions. At the state level, DHLM-14-1 outperformed the check varieties OLM-203 and JK-8, yielding 57.2% and 54.21% higher in Andhra Pradesh, 34.03% and 9.46% in Chhattisgarh, 15.8% and 13.9% in Jharkhand, and 14.31% and 36.96% in Karnataka, respectively (Kharkwal *et al*., 2004). In Gujarat, Maharashtra and Odisha, it recorded an impressive yield superiority of 180.23%, 34.43%, and 183.25% over JK-8. Additionally, in Madhya Pradesh, DHLM-14-1 showed a 5.9% yield advantage over OLM-203. However, it did yield lower than OLM-203 in Gujarat (-5.38%), Maharashtra (-19.06%), and Odisha (0.98%), and was also 16% less productive than JK-8 in Madhya Pradesh. These results highlight the variety's potential but also indicate areas for further evaluation and improvement in specific states.

Across various locations, the proposed variety demonstrated impressive grain and straw yields of 1055 kg/ha and 2420 kg/ha, respectively, when fertilized at 75% of the recommended dose (see Table 4). In terms of grain yield, this variety achieved 947 kg/ha, representing an increase of 23.05% over the check variety JK-8 and a marginal 0.85% improvement over OLM-203. Regarding straw yield, the proposed variety outperformed JK-8 by 16.48%, yielding 2167 kg/ha, although it fell short of OLM-203 by 3.04% (Sharmili *et al*., 2018 and Jones, 2006). These results underscore the variety's potential for enhanced productivity in terms of both grain and straw, emphasizing its viability for adoption in sustainable agricultural practices while highlighting the need for further evaluation against existing standards.

The proposed variety DHLM-14-1 exhibited disease resistance comparable to the checks OLM-203 and JK-8, with average incidences of grain smut at 6.2%, grain smut severity at 0.65%, brown spot at 1.27 g, and sheath blight at 25.8% (Table 5) (Sivagamy *et al*., 2024). Across multiple trials, DHLM-14-1 showed noteworthy resilience, particularly against grain smut, brown spot, and sheath blight. Its grain smut incidence of 6.2% is nearly identical to the national check OLM-203, which recorded 6.4%, and significantly lower than JK-8's 24.3%. For grain smut severity, DHLM-14-1's means of 0.65% matched that of OLM-203 and surpassed JK-8, which had a mean severity of 1.65% (Gupta *et al.,* 2010). Regarding brown spot, DHLM-14-1 achieved a mean of 1.27 g, similar to OLM-203's 1.0 g and slightly better than JK-8's 1.33 g, indicating its effectiveness across

Table 4. Summary grain and straw yield data of Agronomic Trials (2018)

Name of experiment	Item	DHLM-14-1		OLM-203 (NC)		JK-8 (NC)	
		Grain	Straw	Grain	Straw	Grain	Straw
Fertilizer experiment	Grain and straw yield (kg/ha) under recommended dose of fertilizer	992	2298	811	1919	599	2264
	Grain and straw yield (kg/ha) under 75 %recommended dose of fertilizer	1055	2420	898	1795	906	1428
	Grain and straw yield (kg/ha) under 125 %recommended dose of fertilizer	794	1785	1109	2993	934	1592
	Mean	947	2167	939	2235	813	1761
	% increase			0.85	-3.04	16.48	23.05

Table 5. Reaction to major diseases

Name of proposed variety/Hybrid: DHLM-14-1 Adaptability Zone :All India					
Production condition: *Kharif* and *Rainfed*					
Disease name		Item	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
Disease 1 Grain Smut(%)	Natural	1st year (2014-15)	17.5	19.2	44.3
		2nd year (2015-16)	0.1	0.0	15.6
		3rd year (2016-17)	1.0	0.0	13.0
		Mean	6.2	6.4	24.3
Disease 2 Grain Smut Severity(%)	Natural	1st year (2014-15)	1.3	1.3	2.3
		2nd year (2015-16)	0.0	0.0	1.0
		Mean	0.65	0.65	1.65
Disease 3 Brown Spot (g)	Natural	1st year (2014-14)	0.0	0.0	0.0
		2nd year (2015-16)	0.8	0.0	0.0
		3rd year (2016-17)	3.0	3.0	4.0
		Mean	1.27	1.0	1.33
Disease 4 Shealth Blight(%)	Natural	1st year (2014-14)	30.1	14.5	22.3
		Mean	30.1	14.5	22.3
	Natural	2nd year2nd year (2015-16)	21.6	13.0	13.2
		3rd year3rd year (2016-17)	30.0	26.0	20.0
		Mean	25.8	19.5	16.6

Table 6. Reaction to Insect Pests

Name of proposed variety/Hybrid: DHLM-14-1 Adaptability Zone : All India					
Production condition: *Kharif* and *Rainfed*					
Insect name		Item	Proposed variety (DHLM-14-1)	National Check 1 (OLM-203)	National Check 2 (JK-8)
Pest 1 Shoot Fly (%)	Natural	1st year (2014-15)	10.46	10.15	32.41
		2nd year (2015-16)	16.23	9.36	13.05
		3rd year (2016-17)	15.0	11.0	12.0
		Mean	13.89(3yrs)	10.17	19.15

varying conditions. While sheath blight resistance varied, DHLM-14-1's mean incidence of 25.8% was higher than OLM-203's 19.5% but lower than JK-8's 16.6%, reflecting a degree of susceptibility. Nevertheless, the variety's competitive yield performance, coupled with strong resistance to other diseases, highlights its potential for small millet cultivation across diverse agro-climatic zones in India. Ultimately, these results position DHLM-14-1 as a valuable variety for enhancing sustainable agricultural productivity, reinforcing its significance in

integrated pest and disease management strategies.

DHLM-14-1 demonstrated an average shoot fly incidence of 13.89%, which is comparable to OLM-203's 10.17% and significantly lower than JK-8's 19.15% (Table 6) (Hariprasanna, 2023). Over multiple trial years, DHLM-14-1 has proven effective resistance to shoot fly, consistently outperforming national checks OLM-203 and JK-8. Throughout the three-year evaluation period, DHLM-14-1's incidence of 13.89% is notably lower than JK-8's incidence of 32.41% and similar to OLM-203's 10.17%. In the first year (2014-15), DHLM-14-1 recorded a shoot fly incidence of 10.46%, slightly exceeding OLM-203's 10.15% but significantly outpacing JK-8's 32.41%. The second year (2015-16) showed a rise in DHLM-14-1's incidence to 16.23%, while OLM-203's incidence fell to 9.36%, illustrating variability in resistance under changing environmental conditions. In the third year (2016-17), DHLM-14-1's incidence decreased to 15.0%, whereas OLM-203's incidence increased to 11.0%, reaffirming DHLM-14-1's competitive resilience against shoot fly (Nandini and Bhat, 2019). This reduced incidence indicates a strong potential to minimize pest damage, which is vital for improving overall crop yields in *Rainfed* and *Kharif* production systems. Therefore, DHLM-14-1 emerges as a promising candidate for cultivation across diverse agro-climatic regions of India, making it a valuable asset for sustainable millet production and pest management strategies. These results highlight the significance of incorporating DHLM-14-1 into integrated pest management programs to enhance productivity while reducing losses associated with pest infestations.

4. CONCLUSION

At the national level, DHLM-14-1 has consistently outperformed both OLM-203 and JK-8 in terms of grain and fodder yield across various locations in India's little millet-growing regions. This variety presents an opportunity for farmers to increase their income while minimizing environmental impact. DHLM-14-1 has showcased outstanding yield performance, disease resistance, and pest management capabilities across diverse agro-climatic conditions in India. Its average seed yield of 42.41 q/ha significantly exceeds that of local and national checks, reflecting its superior agronomic characteristics and adaptability to changing environmental factors. The multi-year trials consistently demonstrate DHLM-14-1's ability to enhance food security and support farmer livelihoods, especially under *rainfed* conditions. Furthermore, its strong resistance to critical diseases like grain smut and brown spot, along with effective management of shoot fly incidence, makes DHLM-14-1 an excellent choice for sustainable millet cultivation. These results not only confirm the success of targeted breeding initiatives but also highlight the importance of incorporating DHLM-14-1 into integrated pest and disease management strategies, strengthening its contribution to improved agricultural productivity and resilience within millet farming systems.

If farmers adopt this variety, it reduces the use of pesticides and fungicides along with high productivity and production with less cost of cultivation and without environmental pollution.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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