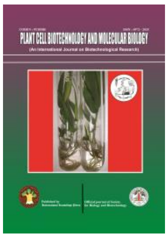

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LMV-513: Breeding Innovations for Pest and Disease Resilience in Little Millet (*Panicum sumatrense* L.)

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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 breeding innovations for LMV-513 in little millet (*Panicum sumatrense* L.) focus on enhancing resilience to pests and diseases, crucial for stable yields and reducing dependency on chemical inputs. This resilient variety supports sustainable agriculture by maintaining crop health in adverse conditions, aligning with the goals of ecological and resource-efficient farming practices. Little millet

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is developed and evaluated between 2013 and 2021, the shoot fly-resistant little millet variety LMV-513 was evaluated from 2013 to 2014 and officially released and notified in 2021, proving to be a high-yielding and medium-maturing cultivar. This variety, created at the MARS, University of Agricultural Sciences, Dharwad, is specifically recommended for cultivation in Karnataka, maturing in 85-90 days and exhibiting an erect plant type with a height of 123-130 cm. Its grains are bold, oval-shaped, and gray in color. Similarly, DHLM-28-4/LMV-513 demonstrated impressive performance, with grain and fodder yields of 17.14 q/ha and 6.5 t/ha, respectively, while maintaining a tolerance to shoot fly at 19.42%. This variety recorded grain yields that surpassed the national checks OLM-203 and JK-8 by 9.59% and 11.21%, respectively. The study emphasizes the superior yield potential and adaptability of both DHLM-36-3 and DHLM-28-4/LMV-513 across diverse agro-climatic conditions in India. Specifically, DHLM-36-3 achieved an impressive mean seed yield of 37.99 q/ha, exceeding local and national checks by 21.56% and 15.75%, respectively. Meanwhile, DHLM-28-4/LMV-513 consistently outperformed the national check OLM-203 by 11.95%. Both varieties demonstrated strong resistance to key diseases and pests, including grain smut, brown spot, leaf blight, and shoot fly, making them reliable choices for farmers. Additionally, DHLM-28-4/LMV-513 exhibited enhanced nutritional qualities, particularly in zinc, iron, calcium, and protein content. Its favorable morphological traits, such as early maturity and robust growth characteristics, further bolster its appeal. DNA fingerprinting analysis revealed significant genetic diversity among the evaluated varieties, enhancing their suitability for marker-assisted selection in breeding programs. Overall, these findings highlight the vital contributions of these cultivars to sustainable agricultural practices, food security, and public health, positioning DHLM-28-4/LMV-513 as a promising candidate for wider adoption in millet cultivation.

Keywords: LMV-513; shoot fly-resistant; DNA fingerprinting; millet cultivation.

1. INTRODUCTION

Now days people suffering from different disorders viz., obesity, Diabetic, blood pressure and other stomach related problems. Millets giving best solution to these problems andrainfed agriculture plays an important role in global agricultural systems especiallyin regions where irrigation facilities are limited or where water resources are scarce. However, farmers face several problems related to whether uncertainties (Malarkodi et al 2023). 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 et al*.,* [1] in rain fed areas poses significant challenges to improves crop yield (Sharma et al 2022) farmers' income livelihood ensure food security. Little millet (*Panicum sumetrense* L.) belongs to family poaceae. Grains of little millet are good source of protein (8.8 %), carbo hydrates (67.0 g/100 g), fat (4.79%) and other minerals and vitamins. It is highly tolerance to heat and drought. The little millet has major bottle necks are shootfly and foliar diseases. To overcome these problems, need to develop resistant high yielding little millet variety. The little millet grown widely in Andra Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu, Gujarat and Jharkhand in India.

2. MATERIALS AND METHODS

The little millet culture, LMV-513 was evolved at MARS, University of Agricultural Sciences, Dharwad for cultivation in Karnataka and other states in India. It has been evolved between two genotypes, Co2 (medium maturing non pigmented type, loose type ear head gray colour seed) while, Paiyur-2 is also medium maturing genotype with straw colour glumes. The elite plants were selected from F_2 on wards and they were evaluated for sustained yield ability and Homozygosity and DHLM-28-4/ LMV-513 was found best on among the selected lines. This culture was evaluated with local and national checks in station trials at MARS, University of Agricultural Sciences, Dharwad from 2013-14, 2014-15 and 2015-16, respectively.

Besides this, LMV-513 (DHLM-28-4) was also screened for shoot fly, brown spot, sheath blight, grain smut, and grain smut severity.

3. RESULTS AND DISCUSSION

In the trials conducted over multiple years, the little millet cultivar LMV-513 demonstrated superior yield performance compared to both local and national checks. The mean seed yield of LMV-513 was recorded at 37.99 q/ha, which is 21.56% higher than the local check TNAU-63 (31.25 q/ha) and 15.75% above the national check OLM-203 (32.82 q/ha). This increased yield suggests that LMV-513 is a promising cultivar with significant potential for enhanced productivity in little millet cultivation. Furthermore, DHLM-28-4/LMV-513 underwent rigorous testing in initial varietal trials (IVT) during 2016-17 and in advanced varietal trials (AVT) in 2017-18 and 2018-19 as part of the All India Coordinated Trials [2]. The consistent testing results highlight DHLM-28-4/LMV-513's stable performance across different agro-climatic conditions, supporting its suitability for broader cultivation. These results provide strong justification for the adoption of DHLM-36-3 and DHLM-28-4/LMV-513 in agricultural practices aimed at increasing millet productivity, which aligns well with sustainable and resilient crop improvement strategies.

The variety DHLM-28-4/LMV-513 consistently outperformed the national checks OLM-203 and BL-6 in coordinated varietal trials across multiple locations from 2016 to 2019. Over three years, DHLM-28-4/LMV-513 recorded an average grain yield of 17.14 q/ha, which is 11.95% higher than OLM-203 (15.31 q/ha) and 7.25% above BL-6 (15.98 q/ha). This consistent yield advantage of DHLM-28-4/LMV-513 across different environments underscores its stability and adaptability, making it a resilient choice for farmers aiming for higher productivity. The increased yield further suggests that DHLM-28-4/LMV-513 could contribute positively to food security efforts in millet production, especially in regions prone to yield fluctuations due to climate variability [3]. This performance data justifies the consideration of DHLM-28-4/LMV-513 as a promising cultivar for wider adoption at the national level, as it not only meets but exceeds the yield levels of established national checks, making it a valuable addition to sustainable millet farming practices.

The variety LMV-513, yielding an average of 15.89 q/ha under rainfed conditions, was recognized for its superior yield performance by the Varietal Identification Committee at the 30th Annual Group Meeting of ICAR-AICRP on Small Millets held on March 7-8, 2019, and subsequently released and notified in 2022. Its consistent productivity across states, along with DHLM-28-4/LMV-513's performance as a high-yielding cultivar in various regions, highlights their adaptability and resilience, making both varieties valuable options for increasing millet production in diverse Indian agro-climatic conditions [4]. This recognition underscores the varieties' roles in enhancing sustainable agricultural practices, especially in rainfed areas where yield stability is essential [5].

The state-wise and year-wise grain yield data for DHLM-28-4/LMV-513, detailed in Table 3, highlights its performance across key little millet-producing states such as Andhra Pradesh, Gujarat, Jharkhand, Maharashtra, Madhya Pradesh, and Tamil Nadu. For a variety to succeed in these regions, it must demonstrate adaptability to diverse and changing climatic conditions. DHLM-28-4/LMV-513 has shown notable yield increases compared to national checks, with gains of 25.04% and 4.43% in Andhra Pradesh, 6.87% and 67.81% in Gujarat, 30.13% and 17.45% in Jharkhand, 12.52% and 19.98% in Maharashtra, and 22.66% and 18.82% in Madhya Pradesh, relative to OLM-203 and BL-6, respectively [6]. In Tamil Nadu, it also outperformed BL-6 by 8.02%. This data underscores DHLM-28-4/LMV-513's robust adaptability and resilience, supporting its potential to enhance yields consistently across diverse agro-ecological zones and address the challenges posed by climate variability [7].

In the fertilizer experiment, DHLM-28-4/LMV-513 demonstrated varied performance relative to national checks OLM-203 and BL-6 across different fertilizer doses (Table 4). At 50% of the recommended dose, DHLM-28-4/LMV-513 yielded 797 kg/ha of grain and 2330 kg/ha of straw, lower than OLM-203 (1041 kg/ha grain, 3305 kg/ha straw) but comparable to BL-6 (873 kg/ha grain, 1995 kg/ha straw). At 100% fertilizer, yields increased to 910 kg/ha grain and 2395 kg/ha straw, while at 125%, DHLM-28-4/LMV-513 achieved its highest yield of 1150 kg/ha grain and 3018 kg/ha straw. This yield nearly matched OLM-203 (1342 kg/ha grain, 4031 kg/ha straw) and exceeded BL-6 (1142 kg/ha grain, 2576 kg/ha straw). Overall, DHLM-28-4/LMV-513 recorded an 18.77% higher grain yield than BL-6 across all fertilizer levels, although straw yield was lower than both checks (43.96% lower than OLM-203 and 28.90% lower than BL-6) [8]. These results indicate DHLM-28-4/LMV-513's grain yield advantage, especially at 125% of the recommended fertilizer dose (yielding 1150 kg/ha grain and 3018 kg/ha straw), making it particularly suitable for regions prioritizing grain production. The variety's responsiveness up to 125% fertilizer suggests its potential for optimized grain productivity with increased inputs across diverse locations [9].

Table 1. Performance of new variety, LMV-513 in station trials

Preliminary yield trials	Variety LMV-513 (q/ha)	TNAU-63 (Sukshema) (q/ha)	OLM-203 (NC) (q/ha)
1st year	34.25	30.14	32.66
2nd year	39.41	28.98	31.56
3rd year	40.32	34.65	34.24
Mean	**37.99**	**31.25**	**32.82**
Incremental yield (%)		**21.56**	**15.75**

Table 2. Summary of seed yield (q/ha) of LMV-513 in All India coordinated varietal trials

Preliminary yield trials	No. of the trials	Proposed variety (DHLM-28-4/ LMV-513) (q/ha)	National Check 1 (OLM-203) (q/ha)	National Check 2 (BL-6) (q/ha)
1st year	10 locations	17.98	15.53	16.94
2nd year	12 locations	15.99	15.03	14.19
3rd year	12 locations	17.60	15.42	16.98
Weighted Mean	34 locations	17.14	15.31	15.98
	Percent increase over checks			
1st year	10 locations		15.77	6.72
2nd year	12 locations		6.38	12.68
3rd year	12 locations		14.13	3.65
Weighted Mean	34 locations		11.95	7.25

The disease resistance performance of the proposed variety DHLM-28-4/LMV-513 was evaluated under natural infection conditions for grain smut, brown spot, and leaf blight across three years. For grain smut incidence, DHLM-28-4/LMV-513, along with the national checks OLM-203 and JK-8, recorded a mean of 0.0% across the evaluated years (2016-17 and 2017-18), indicating strong resistance to this disease in all varieties (Table 5). In terms of brown spot, DHLM-28-4/LMV-513 exhibited an average disease score of 3.0, comparable to OLM-203 (2.56) and lower than JK-8 (3.0). This suggests a similar level of tolerance to brown spot as OLM-203 but with a slightly improved performance over JK-8, particularly important in regions prone to brown spot outbreaks. For leaf blight, DHLM-28-4/LMV-513 had a mean score of 2.33, which is lower than the national checks OLM-203 (3.0) and JK-8 (3.33) over the three-year evaluation. This reduced severity score for leaf blight suggests that DHLM-28-4/LMV-513 has a comparatively higher tolerance, which could support enhanced productivity in disease-affected zones [10,11]. The lower susceptibility to leaf blight provides justification for recommending DHLM-28-4/LMV-513 as a resilient choice in *Kharif* and rainfed conditions, aligning with the increasing focus on disease-resistant cultivars in sustainable agricultural practices [12]. The adaptability of DHLM-28-4/LMV-513 across all-India zones under varying rainfed and disease conditions reinforces its potential as a robust cultivar for widespread cultivation.

The proposed variety DHLM-28-4/LMV-513 was evaluated for resistance to shoot fly infestations over three years (2016-17, 2017-18, and 2018-19) under natural conditions (Table 6). In the first year, it recorded a shoot fly incidence of 12.0%, comparable to the national checks OLM-203 (11.0%) and JK-8 (12.0%), indicating competitive early-season pest resistance. In the second year, DHLM-28-4/LMV-513 showed a slight increase in incidence to 11.72%, while OLM-203 and JK-8 experienced higher infestations of 19.47% and 12.44%, respectively, showcasing a significant 40% advantage over OLM-203. In the third year, infestations rose across all varieties, with DHLM-28-4/LMV-513 displaying a mean incidence of 34.54%, slightly lower than OLM-203 (31.84%) and higher than JK-8 (37.76%). Overall, DHLM-28-4/LMV-513 had an average infestation rate of 19.42%, lower than OLM-203 (20.71%) and comparable to JK-8 (20.74%) [13]. These findings suggest that DHLM-28-4/LMV-513 demonstrates good resistance to shoot fly, particularly in the second year when pest pressures were moderate, contributing to improved yield stability and productivity in Kharif and rainfed conditions [14]. Thus, its consistent performance against shoot fly supports its recommendation for cultivation across various regions in India, highlighting the significance of developing pest-resistant varieties in sustainable agricultural systems [1].

3.1 Quality Parameters

The proposed variety DHLM-28-4/LMV-513 was evaluated for quality characteristics, revealing its superior nutritional profile compared to national checks OLM-203 and JK-8, specifically in key parameters such as zinc (Zn), iron (Fe), calcium (Ca), and protein content (Table 7). DHLM-28-4/LMV-513 contained 28.7 mg/kg of zinc, higher than JK-8 (23.5 mg/kg) but slightly lower than OLM-203 (29.6 mg/kg), suggesting competitive zinc levels that are essential for human health [15]. It also showed a significant iron content of 35.98 mg/kg, outperforming both OLM-203 (34.7 mg/kg) and JK-8 (30.09 mg/kg), making it beneficial for addressing iron deficiency in populations reliant on staple crops. Additionally, DHLM-28-4/LMV-513 had a remarkable calcium concentration of 102.5 mg/kg, significantly higher than OLM-203 (25.9 mg/kg) and JK-8 (17.3 mg/kg), which is crucial for bone health and overall dietary intake. With a protein content of 12.51%, it exceeded both checks (OLM-203 at 8.81% and JK-8 at 9.61%), enhancing its overall quality and attractiveness to consumers [16]. Overall, DHLM-28-4/LMV-513 exhibits superior nutritional qualities, particularly in iron, calcium, and protein, supporting its recommendation for cultivation across diverse regions to contribute positively to food security and public health [17].

Table 3. State wise and year wise grain yield data of new variety LMV-513

State	Year of testing	No. of trials/locations	Proposed variety (LMV-513)	National Check 2 (OLM-203)	National Check 1 (BL-2)
Andhra Pradesh	1st year (2016-17)	1	10.38	11.38	13.96
	2nd year (2017-18)	3	10.88	6.52	11.11
	3rd year (2018-19)	3	14.60	12.83	11.95
	Mean		**17.36**	**13.88**	**16.62**
	% increase or decrease over check			**25.04**	**4.43**
Gujarat	1st year	1	3379	2352	1487
	2nd year	1	2526	2685	1396
	3rd year	1	1526	1916	1546
	Mean		**2477**	**2317.6**	**1476**
	% increase or decrease over check			**6.87**	**67.81**
Jarkhand	1st year	-	-	-	-
	2nd year	1	309	216	216
	3rd year	1	438	358	420
	Mean		**373.5**	**287**	**318**
	% increase or decrease over check			**30.13**	**17.45**
Maharashtra	1st year	1	1611	1037	1444
	2nd year	2	1034	1294	1150
	3rd year	1	1630	1093	969
	Mean		**1327.25**	**1179.5**	**1178.25**
	% increase or decrease over check			**12.52**	**19.98**
Madhyapradesh	1st year	2	19.92	17.22	22.63
	2nd year	1	23.82	18..08	13.17
	3rd year	2	13.52	10.71	14.58
	Mean		**19.08**	**14.78.8**	**16.06**
	% increase or decrease over check			**22.66**	**18.82**
Tamil nadu	1st year	1	1897	**1969**	**1722**
	2nd year	1	2599	**2202**	**2183**
	3rd year	1	2937	**3393**	**2976**
	Mean		**2477.6**	**2521.3**	**2293.6**
	% increase or decrease over check			**-1.73**	**8.02**

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

Name of experiment	Item	DHLM-28-4/ LMV-513		OLM-203 (NC)		BL-6 (NC)	
		Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Fertilizer experiment	Grain and straw yield (kg/ha) under recommended dose of fertilizer F_1 (50 %)	797	2330	1041	3305	873	1995
	Grain and straw yield (kg/ha) under 100 %recommended dose of fertilizer	910	2395	1215	3604	1007	2243
	Grain and straw yield (kg/ha) under 125 %recommended dose of fertilizer	1150	3018	1342	4031	1142	2576
Mean		**952.3**	**2581**	**1199**	**3446**	**1007**	**2271**
% increase				**18.77**	**-43.96**	**37.18**	**28.90**

Table 5. Reaction to major diseases

Name of proposed variety/Hybrid:DHLM-28-4/ LMV-513 **Adaptability Zone :All India**					
Production condition : Kharif and rainfed					
Disease name		**Item**	**Proposed variety (LMV-513)**	**National Check 1 (OLM-203)**	**National Check 2 (JK-8)**
Disease 1 Grain smut (%)	Natural	1st year (2016-17)	0.0	0.0	0.0
		2nd year (2017-18)	0.0	0.0	0.0
		3rd year (2018-19)	-	-	-
	Mean		**0.0**	**0.0**	**0.0**
Disease 2 Grain smut severity (%)	Natural	1st year (2016-17)	-	-	-
		2nd year (2017-18)	-	-	-
		3rd year (2018-19)	-	-	-
	Mean		**-**	**-**	**-**
Disease 3 Brown Spot (G)	Natural	1st year (2016-17)	3.0	3.0	4.0
		2nd year (2017-18)	3.0	3.0	4.0
		3rd year (2018-19)	3.0	1.67	1.0
	Mean		**3.0**	**2.56**	**3.0**
Disease 4 Leaf	Natural	1st year (2016-17)	**-**	**-**	-

Name of proposed variety/Hybrid:DHLM-28-4/ LMV-513 Adaptability Zone :All India				
Blight(g)	2nd year (2017-18)	**-**	**-**	-
	3rd year (2018-19)	2.33	3.0	3.33
Mean		**2.33**	**3.0**	**3.33**

Table 6. Reaction to Insect Pests

Name of proposed variety/Hybrid:DHLM-28-4/ LMV-513 Adaptability Zone: All India					
Production condition: Kharif and rainfed					
Pest 1 Shoot Fly (%)	Natural	1st year (2016-17)	12.0	11.0	12.0
		2nd year (2017-18)	11.72	19.47	12.44
		3rd year (2018-19)	34.54	31.84	37.76
		Mean	**19.42**	**20.71**	**20.74**

Table 7. Data on Quality Characteristics

Quality Characteristic.	**Item**	**Proposed Variety LMV 513**	**National Check OLM-203**	**National Check 2 JK-8**
Parameter -1	Zn (mg/kg)	28.7	23.5	29.6
Parameter -2	Fe (mg/kg)	35.98	30.09	34.7
Parameter -3	Ca (mg/kg)	102.5	17.3	25.9
Parameter -4	Protein (%)	12.51	9.61	8.81

Table 8. Descriptors of the LMV 513

Sl. No.	**Characters**	**Description**
1	Plant pigment	Absent
2	Plant height (cm)	126.66
3	Days to 50 % flowering (days)	63
4	No. of leaves	59
5	Colour of the leaves	Green
6	Leaf length (cm)	27
7	Leaf width (cm)	01
8	Midrib colour	Green
9	Glumes colour	Straw
10	Glumes covering	Complete
11	Threshing	Free
12	Seed size	Bold
13	Test weight (g)	2.76
14	Seed colour	Light black
15	Seed shape	Oval
16	Biotic stress	Tolerant to shoot fly

The proposed variety DHLM-28-4/LMV-513 exhibits a range of notable morphological and agronomic characteristics that underscore its potential for successful cultivation (Table 8). With a height of 126.66 cm and an early flowering period of 63 days, this variety demonstrates robust growth and early maturity, making it advantageous for regions with shorter growing seasons. It possesses 59 green leaves measuring 27 cm in length and 1 cm in width, which enhance its photosynthetic capacity, essential for biomass and yield. The glumes are straw-colored and provide complete seed coverage, facilitating ease of harvesting, while the variety's free threshing characteristics minimize post-harvest losses. DHLM-28-4/LMV-513 produces bold seeds with a test weight of 2.76 g, and the light black seed color and oval shape are appealing traits for market acceptance [18,19]. Importantly, it exhibits tolerance to shoot fly, a significant pest threat, which helps maintain yield stability and reduces the reliance on chemical pest control, promoting sustainable agricultural practices [20]. Overall, the comprehensive evaluation suggests that DHLM-28-4/LMV-513 is a promising variety with favorable traits, making it suitable for diverse environments and contributing positively to millet.

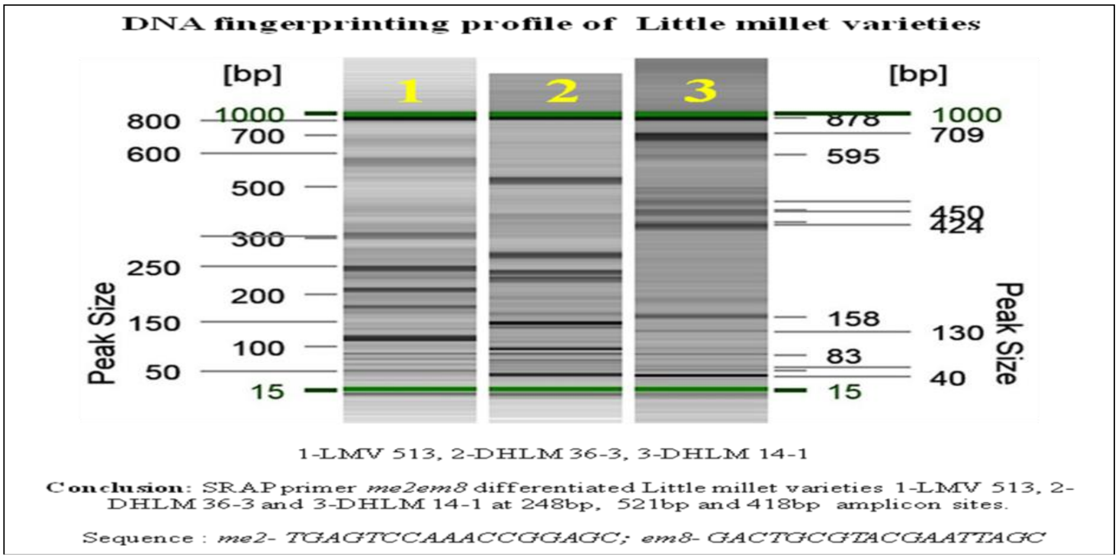

Fig. 1. DNA Fingerprinting

The DNA fingerprinting profile of little millet varieties, generated using SRAP (Sequence Related Amplified Polymorphism) primer combinations me2 and em8, reveals distinct banding patterns for the three evaluated varieties: LMV 513, DHLM 36-3, and DHLM 14-1, differentiated by their respective amplicon sizes. Each variety exhibits unique banding patterns, highlighting genetic diversity among them, with specific bands at 248 bp, 521 bp, and 418 bp in DHLM 36-3 and DHLM 14-1 that serve as distinct genetic markers for identification and breeding. The varying peak sizes, particularly the higher peaks in LMV 513 (up to 1000 bp), suggest a broader genetic background that may enhance adaptability and resilience to environmental conditions [21]. Furthermore, the unique profiles indicate potential for marker-assisted selection in breeding programs focused on improving traits like yield and disease resistance. Overall, the findings underscore the importance of molecular profiling in understanding genetic diversity, supporting conservation efforts, and developing high-yielding, resilient varieties that contribute to sustainable agricultural practices and food security [22].

4. CONCLUSION

At the national level, across various locations and over the years, the variety DHLM-28-4/LMV-513 has consistently outperformed the checks OLM-203 and BL-6 in both grain and fodder yield in regions where little millet is cultivated in India. Furthermore, this variety exhibits strong resistance to several key diseases, including shoot fly, grain smut (with a score of 0.0 G), brown spot (3.0 G), and leaf blight, making it a reliable choice for farmers. By adopting DHLM-28-4/LMV-513, farmers can increase their income while promoting environmentally friendly practices. DHLM-28-4/LMV-513 stands out as an exceptional variety for millet cultivation, offering a compelling blend of agronomic performance and quality traits that cater to diverse agricultural settings in India. Its high potential for grain yield, enhanced nutritional profile—rich in zinc, iron, calcium, and protein—and robust resistance to biotic stresses position it as a vital resource for boosting agricultural productivity and addressing public health challenges. The variety's advantageous morphological characteristics, quick maturity, and solid performance under varying fertilizer regimes further affirm its compatibility with *rainfed* and *kharif* farming systems. Moreover, the use of SRAP markers in DNA fingerprinting reveals significant genetic diversity among little millet varieties, paving the way for marker-assisted selection in breeding programs aimed at enhancing resilience and yield stability. Overall, these insights highlight the significant contributions of DHLM-28-4/LMV-513 to food security and sustainable agricultural practices, reinforcing its importance in millet breeding initiatives.

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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