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New Climate Resilience Rice Varieties for Coping with Climate Change HomThadokKham 17 (HTDK 17)

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Abstract: Rainfed rice cultivation dominates in Laos, covering an estimated 88% of the total area. This reliance on rainwater renders all production and planting activities vulnerable to unpredictable natural disasters, such as floods and droughts, that can strike at any point during the growing season. Such events can devastate rice production, leading to losses of up to 20% of the total domestic output. Moreover, climate change has further exacerbated challenges faced by rainfed rice farming in Lao PDR. To address these issues, a research project aimed at developing rice varieties adapted to changing environmental conditions was initiated in 1993. The project employed a hybridization approach, utilizing TDK8 (a high-yielding variety with broad environmental adaptability) and RGD10033-77-MAS-22 (a aromatic variety tolerant to flooding, drought and blast disease). In 2019, a promising aromatic line, RGD13300-88-1-1-MAS-5-MAS-TDK-1-B, emerged from the research efforts. This line exhibits tolerance to flooding for 14 to 20 days and demonstrates good resistance to leaf blight and neck blast. Throughout 2021, production tests were conducted in four provinces: Luangnamtha, Vientiane Capital, Savannakhet, and Champasak. The new variety, named HTDK17, delivered superior yields compared to both parental lines and local varieties, achieving an average of 3,974 kg/ha, representing a 3% increase. HTDK17 exhibits a maturity date of 130 to 135 days and is insensitive to photoperiod. To facilitate the dissemination of this new variety to farmers, seed of this variety has produced 11,000 kg of seed during the dry season of 2022-2023. This seed was distributed to 1,100 farmers acroses the four aforementioned provinces.

Keywords: Climate Change, Submergence Tolerance, Production Loss, Aromatic Rice Variety, Flood Torelance, Drought Tolerance

1. Introduction

Rice production faces numerous challenges, particularly in the 21st century, where climate change has become increasingly volatile. Rising global temperatures (1.32°C to 2.01°C) and erratic rainfall patterns, including increased floods, droughts, and storms, significantly impact crop yields, including rice. In Laos, annual rice production fluctuates due to these climate factors. Floods, for example, have devastated rice cultivation in various years, affecting 70,000 hectares in 1991 and 90,000 hectares in 2018 [29, 30]. In 2019, Savannakhet province experienced the worst flood in 48 years, and in 2020, the province faced both early-season droughts and late-season floods. Developing and utilizing climate-resilient rice varieties, particularly those resistant to flooding, is a crucial and environmentally friendly approach to mitigating these challenges. Several flood-resistant varieties have been developed, including IR64, Savarna, Sambhamahsuri, BR11, CR1009, [17]. In Laos, several new climate resilience rice varieties were developed such XBF2, XBF4, HTDK15 and HTDK16 [12, 13, 23, 24].

Climate conditions also influence the emergence and spread of insect-borne diseases, introducing new pathogens [30]. Leaf blight, a major concern, can significantly reduce rice yields [8]. Reports indicate yield losses of 10% to 30%, with potential for complete devastation under ideal conditions [1]. In ASEAN countries, studies suggest losses ranging from 30% to 50% [2, 32]. Researchers have identified genes responsible for leaf blight resistance on chromosomes 1 and 11 (QTL1 and QTL11, respectively). This knowledge has been utilized in breeding programs in Thailand and Laos, leading to the development of leaf blight-resistant varieties such as KDML105, RD6, and TDK1 [10, 19, 29].

In Laos, glutinous rice with aromatic qualities is preferred by consumers. These aromatic varieties command a premium price compared to non-aromatic varieties and are highly sought after in both domestic and foreign markets. 2-acetyl-1-pyrroline (2AP) is identified as the primary compound responsible for the desirable aroma [3, 14, 25, 26, 35]. While many traditional Laos varieties are aromatic, they often suffer from limitations like low yield, seasonality, and inconsistent quality across different regions. One example is the small chicken rice variety, which thrives in Xieng Khouang and Hua Phan provinces.

To address these challenges, the Rice Research Center, in collaboration with the Rice Gene Discovery Unit. This new variety offers high yield, flood tolerance, resistance to bacterial leaf blight, blast and photoperiod insensitivity, allowing for cultivation in both wet and dry seasons. This research exemplifies the ongoing efforts to develop new rice varieties capable of adapting to changing climatic conditions. By prioritizing flood resistance, leaf blight resistance, stem rot resistance, and photoperiod insensitivity, researchers aim to ensure sustainable and resilient rice production in Laos.

2. Materials and Methods

Parental lines used for developing new varieties.

The TDK 8 variety is a high-yielding, non-photoperiod glutinous rice variety developed by the Agricultural Research Center in 1996 through the breeding of RD10 and TDK1 [21]. It is a medium-height plant with good lodging resistance and matures in 130-135 days. The RGD10033-77-MAS-22 line is a fragrant, photoperiod glutinous rice variety resistant to bacterial leaf blight. It was bred from a cross of TDK303/IR85264//RGD07529 and flowers in early October [16].

Population development and selection

Hybridization was conducted in 2013. A hybrid was developed between the commercial rice variety TDK8 and the fragrant rice RGD10033-77-MAS-22. TDK8 was used as the female parent, while RGD10033-77-MAS-22 was used as the male parent to develop the F1 population. Selection was performed in the F2 generation to select lines that were photoinsensitive and possessed the aroma gene. From F3 to F6, selection was based on both phenotype and genotype through molecular-assisted selection (MAS). Analysis revealed that ThadoKham17 harbors three genes from the donor line. These genes include a fragrance gene on chromosome 8, a blast resistance gene on chromosome 11, and the submergence tolerance gene (Sub1) located on chromosome 9 (Table 1).

Promising lines were evaluated for grain yield and adaptability across four locations: the Rice and Cash Crop Research Center in Vientiane Capital, the Luangnamtha Research Center in Luangnamtha Province, the Thasano Agriculture Research Center in Savanakhet province, and the Phongnam Research Center in Champasak province. The line with the highest grain yield and best adaptation across all locations was selected and released as a new climate-resilient rice variety.

Table 1. *Results from DNA size differences between HTDK17 and the parent.*

Marker	gene	character	Chromosome	Female	Male	HTDK17
Fragrance marker	*bad 2*	Fragrance	8	400 bp	392 bp	392 bp
RM212	*QBL 1*	Blast resistance gene	1	~140 bp	~130 bp	~130 bp
RM319	*QBL 1*	Blast resistance gene	1	~140 bp	~130 bp	~130 bp
RM224	*Pikm-2*	Blast resistance gene	11	155 bp	140 bp	155 bp
RM144	*Pikm-2*	Blast resistance gene	11	~200 bp	240 bp	200 bp
R10783 indel	*Sub1*	flood resistant	9	350 bp	330 bp	330 bp

3. Result and Discussion

Yield and yield component

HTDK17 stands out as a promising new rice variety demonstrating exceptional yield and desirable characteristics. Across four diverse provinces and four locations, under both wet and dry season conditions, HTDK17 consistently outperformed local popular varieties, achieving a remarkable 4,299 kg/ha higher mean grain yield (Table2). This impressive increase translates to significant potential for boosting rice production and contributing to food security and economic development. HTDK17's success is attributed not only to its high yield but also to its superior yield components. Compared to the commercial variety TDK8, HTDK17 boasts a higher number of grains per panicle, greater percentage of filled grains, and heavier 1,000-grain weight (Table 3). This synergistic combination underpins the overall high grain yield, showcasing HTDK17's exceptional productivity potential. Furthermore, HTDK17 possesses a long-slender grain shape similar to TDK8 (Table 4). This characteristic caters to consumer preferences and facilitates market acceptance, ensuring that HTDK17's high yield is coupled with desirable grain quality. Overall, HTDK17 emerges as a game-changer in rice cultivation. Its combined attributes of high yield, superior yield components, and desirable grain shape make it a highly promising variety with significant potential to revolutionize rice production and improve food security. Extensive research and development efforts are now crucial to fully unlock its potential and facilitate widespread adoption by farmers.

Table 2. *Mean grain yield of HTDK 17 accros 4 provinces.*

Varieties	Luang Namtha (LNT)		Vientiane Capital (VCT)		Savannakhet (SVK)		Champasack (CPS)		Mean
	DS	WS	DS	WS	DS	WS	DS	WS	
HTDK17	3,495	3,290	5,407	5,017	3,971	3,758	5,078	4,379	4,299
local *	3,105	3,057	4,838	4,577	3,894	3,427	4,590	4,038	3,941

* Note: Ta Khet for LNT, TDK8 for VCT, TSN8 for SVK and PNG4 for CPS

Table 3. *Yield components of the seed HTDK17 compare to TDK 8.*

items	HTDK17	TDK8
The number of tiller per hill	10	10
Total grain number per panicle	130	125
% full grain	120	110
Weight 1.000 grain weight (g)	29,3	25.4

Table 4. *Rice husks And Enter the camera of the variety H TDK 17 compared to TDK 8.*

No	character	HTDK17	TDK 8
I.	Paddy rice		
1	Color of the seeds	straw color	Dark brown
2	Tablet size		
2.1	length (mm)	10, 18	10,51
2.2	Width (mm)	2, 42	2,59
2.3	thickness (mm)	1.80	2,08
2.4	Proportion (Length/Width)	4, 20	4,05
2.5	The shape of rice grains	Long-slender	Long-slender
II.	Milled rice		
1	The color of the seeds	White	White
2	Grain size		
2.1	length (mm)	7,24	6, 94
2.2	Width (mm)	2,10	2,21
2.3	thickness (mm)	1, 70	1,7 9
2.4	Proportion (Length/Width)	3,44	3,14
2.5	Shape	Long - slender	Long - slender

Milling and Eating quality

Beyond its impressive yield and desirable grain shape, HTDK17 offers a unique and delightful eating experience. Freshly cooked, the rice exudes a captivating aroma. Upon taking a bite, one encounters unparalleled softness, a textural pleasure that lingers even after leaving the rice untouched for an hour (Table 5). This remarkable characteristic mirrors that of the beloved TDK8 variety, ensuring a familiar and enjoyable experience for consumers. HTDK17 boasts a total milling quality of 75.6%, exceeding that of TDK8 by a significant margin. This translates to a higher percentage of whole, unbroken grains after milling, enhancing the visual appeal and marketability of the rice. Furthermore, the head rice percentage, which refers to the proportion of whole grains in the milled rice, reaches 42.8% during the dry season and 48.5% in the wet season, demonstrating remarkable consistency across different weather conditions (Table 6). This high head rice percentage ensures minimal breakage and loss during processing, maximizing the economic value of HTDK17. In essence, HTDK17 caters to both the culinary and economic needs of consumers. Its delightful aroma, soft texture, and high milling quality combine to create a truly exceptional rice experience. The consistent head rice percentage across seasons further strengthens its economic viability, making it an attractive proposition for farmers and consumers alike.

Table 5. *Quality of freezing And The eating of the variety HTDK 17, compared to TDK8.*

items	HTDK 17	TDK 8
Softness	Soft	Soft
Fragrance	fragrant	Not fragrant
Softness after 1 pleasant 1 hour	Soft	Soft

Note: For HTDK17 and TDK8 goes from cold to warm overnight, not sticky

Table 6. *Milling quality of HTDK17 compare with TDK8.*

items	H TDK 17	TDK 8
dry season Year 2021		
% Brown rice	75.6	73.2
% white rice	67.6	63.2
% Head rice	42.8	42.0
% bran	8.0	10.0
Rainy season Year 2021		
% Brown rice	76.8	76.0
% white rice	65.6	65.2
% Head rice	48.5	48.4
% bran	11.2	10.8

4. Conclusion and Recommendation

New aromatic sticky rice varieties with superior yield potential and resistance to blast disease are found growing wild in the country. These varieties are also tolerant to flooding, lodging resistant, medium-height, resistant to shattering, mature at medium-season, widely adaptable, suitable for harvesting machinery, and have soft eating quality and aroma. Reports of resistance to the blast disease isolate have been documented in Thailand and Laos [5, 15, 22], the Philippines [5], Cambodia [7], Vietnam [18]. While over 100 genes are known to confer resistance to blast disease, only 24 have been successfully cloned [34]. In Laos, 14 genes have been identified for resistance to the local blast isolate [22]. Notably, rice varieties harboring the qBL11 gene (Pikm-2) exhibit strong resistance to a wide range of blast disease strains [16]. This gene, along with Pi37, has been successfully utilized in breeding programs throughout Thailand to develop resistant rice varieties, including: RD6 [28, 33, 38], KDML105 [20], and IR77955-24-75-284 [9]. Molecular markers have been developed specifically for submergence resistance gene (Sub1) and fragrance (badh2), enabling accurate and precise selection for these traits. Successful breeding efforts incorporating these markers have been reported across Thailand [11, 36] and Laos [4, 16]. Rice cultivars with the Sub1 gene can withstand flooding for 10-20 days, depending on the specific water conditions [6].

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Conflicts of Interest

The authors declare no conflicts of interest.

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