

Uttar Sugandhi: High yield potential aromatic rice developed through pure line selection

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ABSTRACT

Uttar Sugandhi was developed through pure line selection from Kalonunia. The variety was released by state variety release committee for cultivation in West Bengal. It showed 16.15% yield advantage over Kalonunia in West Bengal, and it had 96.98% and 112.09% yield advantage against national check (Badshabhog) and regional check (Kalanamak) respectively in Maharashtra. It also showed 52.86% yield advantage over regional check (Kalanamak) in Odisha. Apart from yield advantage, it bears many desirable grain characters: the milling, hulling and head rice recovery are 81.85%, 70.8% and 67.0% respectively; it has medium slender kernel, 22.25% amylose content, 63.50 mm gel consistency and 14.83 g test weight. It has strong grain aroma. DNA finger printing was done along with the check varieties to characterize the variety at molecular level.

Keywords: Aromatic rice, high yield potential, medium slender, Uttar Sugandhi,

INTRODUCTION

In terms of worldwide food grain production, rice (*Oryza sativa* L.) is ranked second only to wheat as a key food crop and it is farmed everywhere. The USDA predicts that worldwide rice production will reach 513.5 million tonnes in 2023-2024, still the greatest amount ever. West Bengal is known as the 'bowl of rice', containing around 450 rice landraces (Deb, 2005; Chatterjee *et al.*, 2008). Rice is grown here on more than 65 percent of the agricultural land (Adhikari *et al.*, 2012) in three separate seasons: Aus (autumn rice), Aman (winter rice), and Boro (summer rice). West Bengal's rice landraces and cultivars are

known for their distinct scent, taste and resistance to disease.

Indian aromatic rice in general and 'Basmati' in particular has dominated the domestic and international market for aroma. More than 100 compounds have been identified (Buttery *et al.*, 1988; Grimm *et al.*, 2001) for aroma of rice. Among those, 2-acetyl-1 pyrroline (Buttery *et al.*, 1983; Niu *et al.*, 2008) is the principal aroma compound in all the aromatic rice cultivars. Aromatic rice is an important commodity worldwide and command premium price over non-scented varieties. The Indian subcontinent has the *Natural Gift* of basmati and much other non-

Basmati aromatic rice. In addition to Basmati, many local landraces are grown traditionally, which excel in aroma, grain quality and cooking quality. Most of these genotypes are having short bold to medium bold grain. However, most of the non-Basmati aromatic rice has poor yield potential. Exploration of collected germplasm can be used to identify new sources of genes that can be used to breed improved varieties (Atta *et al.*, 2023). With the objective of yield increment of the non-Basmati aromatic rice, pure line selection was followed to develop Uttar Sugandhi.

MATERIALS AND METHODS

Material

Uttar Sugandhi (IET 24616) was developed through pure line selection from Kalonunia. Kalonunia is a popular aromatic landrace of Cooch Behar, Jalpaiguri, Alipurduar districts and northern part of Uttar Dinajpur district of West Bengal. Kalonunia has been registered under Geographical Indication, bearing the Registration No: 743. It is highly photoperiod-sensitive, tall, lodging susceptible and long duration, and grown during *Kharif* season. Kalonunia has low yield potential ranging from 1.5 to 2.0 t/ha.

Uttar Sugandhi is also highly photoperiod-sensitive, long duration and lodging susceptible. However, it has high yield potential as compared to Kalonunia and distinct from Kalonunia by some DUS characters. Uttar Sugandhi has been assigned national identity number IC 633329 by National Bureau of Plant Genetics Resources, New Delhi.

Yield trials

Initially for two consecutive *Kharif* (May to November) seasons (2012 and 2013), the variety was tested at University Research Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. On satisfactory performance in the Station Yield Trials, the variety was sent for testing under

All India Coordinated Rice Improvement Project. It was tested for two consecutive *Kharif* seasons under Initial Varietal Trial-Aromatic Short Grain (IVT-ASG, 2014) and Advanced Varietal Trial-1-Aromatic Short Grain (AVT-1-ASG, 2015) with three checks, namely Badshabhog (National Check), Kalanamak (Regional Check) and Kalonunia (Local Check). Based on the better performance in two years of trials in All India Coordinated Rice Improvement Project (AICRIP), the variety was further tested under multi-location trial in West Bengal. The variety was also tested under adaptive trial in the farmers' field.

Grain yield and yield attributing data were obtained from AICRP trials (AICRIP, 2014 & 2015). Trials were also conducted in two locations of northern part of West Bengal, namely Regional Research Sub Station (Terai Zone), UBKV, Kharibari, Darjeeling district and University Research Farm, UBKV, Pundibari, Cooch Behar district.

DNA finger printing

DNA was isolated using standard CTAB method from rice leaves (Xu *et al.*, 2005). Thirty-two SSR markers were used for the DNA finger printing of KNS-2-1 and KNS-3-1 (Uttar Sugandhi) with standard varieties, namely Gobindabhog and Kalonunia. This study was conducted at Department of Biochemistry, Uttar Banga Krishi Viswavidyalaya.

RESULTS AND DISCUSSION

Performance of Uttar Sugandhi under AICRIP trials

The results (Table 1) revealed that the variety, Uttar Sugandhi (IET 24616) recorded higher grain yield of 2215 and 4147 kg/ha in West Bengal and Odisha respectively accounting to about 16.15% increase in yield over the local check variety Kalonunia (1907 kg/ha) in West Bengal and 52.86% increase in yield over regional check variety Kalanamak (2713

kg/ha) under the Coordinated Trial, IVT-ASG conducted during *Kharif*, 2014 (AICRIP, 2014). The variety also recorded higher grain yield of 4507 and 2952 kg/ha in Maharashtra and Uttar Pradesh respectively accounting to about 96.98 and 12.70% increase in yield over the national check variety Badshabhog (2288 and 2619 kg/ha respectively). However, Uttar Sugandhi showed mean grain yield of 3455.25 kg/ha while yield estimation was done over four locations in the Coordinated Trial, IVT-ASG conducted during *Kharif*, 2014 (AICRIP, 2014).

Performance of Uttar Sugandhi under yield trials in West Bengal

The yield trial was also conducted in two different locations in northern part of West Bengal. The results (Table 2) revealed that Uttar Sugandhi recorded maximum yield at Kharibari (5083 kg/ha). Its mean grain yield over two locations was 4492 kg/ha accounting to about 52.57% more over local check variety Kalonunia (1907.00 kg/ha) under trials conducted in northern part of West Bengal during *Kharif*, 2018.

Yield Attributing Characters

It could be revealed through Table 3 that Uttar Sugandhi showed plant height of 141.5 cm, days to 50% flowering of 120.5 days and number of panicle per m² of 256.5 while average was done over two years. All these characters of Uttar Sugandhi were comparable to that of Badshabhog.

Quality Parameters

The milling, hulling and head rice recovery of Uttar Sugandhi were recorded as 81.85%, 70.8% and 67.0% (Table 4) respectively, while average was done over two years. Based on kernel length, breadth and L:B ratio, Uttar Sugandhi showed its grains as medium slender. Chalkiness of the Uttar Sugandhi was absent, alkali spreading value was 5.0, amylose content was 22.25%, gel consistency

was 63.50 mm and test weight was 14.83 g. Amylose content is an important rice grain quality parameter in respect of consumer preference. In India, consumers prefer medium amylose content (20- 25%) in the endosperm and this is an important parameter for promotion of rice entries in All India Rice Improvement Project (Anonymous, 2017; Roy et al., 2020; Roy et al., 2021). Starch content (amylose) of rice is very important factors in grain yield, processing and palatability. Uttar Sugandhi possesses strong aroma.

Some Distinctiveness, Uniformity and Satiability (DUS) Characters of Uttar Sugandhi

The DUS characterization was done following the guidelines as outlined by PPV&FRA (2007) for rice. The detail of the DUS characterization of Uttar Sugandhi has been presented in Table 5. The main desirable grain features of this variety are medium slender (Fig. 1D&F), strong aromatic and having medium range of amylose (22.50%). Grain awns are small and distributed only in the upper part of the panicle (Fig. 1C&E). It possesses some undesirable features also plants are tall (116 cm excluding panicle; Fig. 1A&B), lodging susceptible and highly photoperiod sensitive. However, this variety has remarkable higher yield potentiality as compared to Kalonunia.

DNA fingerprinting

Total 32 SSR markers were used for the DNA fingerprinting of KNS-2-1 and KNS-3-1 with standard varieties, namely *Gobindabhog* and *Kalonunia* (Table 6; Fig. 2). Out of which, 12 markers (37.5%) were found polymorphic and 20 markers were monomorphic (62.5%). Out of 12 polymorphic markers, 5 markers (RM114, RM1, RM6250, RM165 and RM294) showed size based allelic polymorphism; whereas, remaining 7 markers (RM16655, RM10022, RM23, RM288, RM172, RM159, RM38) showed

polymorphism based on presence and absence of alleles.

CONCLUSION

Uttar Sugandhiis aromatic rice developed through pure line selection from Kalonunia. It had been released by state variety release committee for cultivation in West Bengal. It is highly photoperiod-sensitive and can be cultivated only during *Khari* season. It had 16.15% yield advantage over Kalonunia in West Bengal, and it had 96.98% and 112.09% yield advantage against national check (Badshabhog) and regional check (Kalanamak) respectively, in Maharashtra. It also showed 52.86% yield advantage over regional check (Kalanamak) in Odisha. Apart from yield advantage, it bears many desirable grain characters: the milling, hulling and head rice recovery is 81.85%, 70.8% and 67.0%, respectively; it has medium slender kernel, 22.25% amylose content. It has strong grain aroma. DNA finger printing was done along with the check varieties to characterize the variety at molecular level.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Performance of Uttar Sugandhi (IET 24616) in respect of grain yield under the AICRIP trials (IVT-ASG) conducted during *Kharif*, 2014

The Test Entry of Rice and Check Varieties	West Bengal		Maharashtra		Uttar Pradesh		Odisha		Mean grain yield over four locations (kg/ha)
	Yield (kg/ha)	% increase in yield in IET 24616 over checks	Yield (kg/ha)	% increase in yield in IET 24616 over checks	Yield (kg/ha)	% increase in yield in IET 24616 over checks	Yield (kg/ha)	% increase in yield in IET 24616 over checks	
<i>Uttar Sugandhi</i>	2215	-	4507	-	2952	-	4147	-	3455.25
<i>Badshabhog</i> (NC)	2205	0.45	2288	96.98	2619	12.70	4561	-	-
<i>Kalanamak</i> (RC)	2158	2.64	2125	112.09	2944	0.27	2713	52.86	-
<i>Kalonunia</i>	1907	16.15	-	-	-	-	-	-	-

NC: National Check, RC: Regional check

Table 2: Performance of Uttar Sugandhi in respect of its grain yield in West Bengal during *Kharif*, 2018

Rice Genotypes	Yield (Kg/ha)		Mean yield	Yield advantage over Kalonunia
	RRSS, Kharibari	RRS, Pundibari		
UBKVR-111	6750	5934	6342	-
UBKVR-124	7250	6220	6735	-
UBKVRA-1	3833	3096	3465	-
Uttar Sugandhi	5083	3901	4492	52.57
Nabin (LC)	-	4368	4368	-
Kalonunia (LC)	-	1907	1907	-

Source: Annual Report- Institutional Rice Project, 2018-19, Directorate of Research, UBKV, Pundibari, Cooch Behar 736165, West Bengal. p. 6.

Table 3: Plant height, Days to 50% flowering & No. of Panicles/m² of the test entry, Uttar Sugandhi under Coordinated Varietal Trials (*Kharif*, 2014 & 2015)

Characters	<i>Kharif</i> , 2014		<i>Kharif</i> , 2015		Mean of Uttar Sugandhi
	Uttar Sugandhi	Badshabhog	Uttar Sugandhi	Badshabhog	
Plant height (cm)	149	150	134	135	141.5
Days to 50% flowering	118	115	123	114	120.5
No. of Panicles/m ²	277	261	236	254	256.5

Table 4 Quality characteristics of the proposed entry, Uttar Sugandhi in Coordinated Varietal Trials (IVT-ASG Kharif, 2014 and AVT-ASG Kharif, 2015).

Characters	IET 24616	Shohini (NC)	Badshabhog	CR Sugandhdhan907	Dubraj (QC)
Hulling (%)	81.85		78.25	78.3	78.1
Milling (%)	70.8		69.1	66.9	63.5
Head Rice Recovery (%)	67.0		65.1	62.6	56.0
Kernel Length (mm)	5.04		3.77	5.26	5.27
Kernel Breadth(mm)	1.87		1.94	1.97	2.23
Length and Breadth Ratio	2.69		1.94	2.67	2.36
Grain type	MS	SS	SB	MS	SB
Grain Chalkiness	A	VOC	VOC	A	VOC
Alkali Spreading Value	5.0		4.5	4.0	4.0
Amylose Content (%)	22.25		20.87	25.75	26.04
Gel Consistency (mm)	63.5		51	23	43
Aroma	Strong	Mild	Strong	Mild Scent	Mild
Test weight	14.83 g	-	-	-	-

SB: Short bold; **MS:** Medium slender; **SS:** Short Slender; **VOC:** Very Occasionally Chalkiness; **A:** Absent; **NC:** National Check; **QC:** Quality check

Table 5: Some morphological and qualitative characters of test entry, Uttar Sugandhi based on the “Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability (DUS) on Rice (*Oryza sativa* L.)” of PPV & FRA (2007)

Sl. No.	Characters	Classification
1.	Coleoptiles: Colour	Colourless
2.	Basal leaf: sheath colour	Green
3.	Leaf: Intensity of green colour	Medium
4.	Leaf: Anthocyanin colouration	Absent
5.	Leaf sheath: anthocyanin colouration	Absent
6.	Leaf: Pubescence of blade surface	Strong
7.	Leaf: Auricle	Present
8.	Leaf: Anthocyanin colouration of auricle	Absent
9.	Leaf: Collar	Present
10.	Leaf: Anthocyanin colouration of collar	Absent
11.	Leaf: Ligule	Present
12.	Leaf: Shape of ligule	Split
13.	Leaf: Colour of ligule	White
14.	Culm: attitude	Semi-erect
15.	Time of heading (days to 50% flowering)	Late (120 days, when sown in third week of June)
16.	Days to Maturity*	Late (150 days, when sown in third week of June)
17.	Flag leaf: Attitude of blade (early observation)	Drooping
18.	Male sterility	Absent
19.	Lemma: Anthocyanin colouration of keel	Absent

20.	Lemma: Anthocyanin colouration of area below apex	Weak
21.	Lemma: Anthocyanin colouration of apex	Medium
22.	Spikelet: Colour of stigma	White
23.	Stem: Length (excluding panicle length)	Medium (116 cm)
24.	Stem: Thickness	Medium (0.5 cm)
25.	Stem: Anthocyanin colouration of nodes	Absent
26.	Stem: Anthocyanin colouration of internodes	Absent
27.	Panicle: Length of main axis	Medium (25 cm)
28.	Panicle: Curvature of main axis	Deflex
29.	Panicle: Number per plant	Medium (17/panicle)
30.	Spikelet: Colour of tip of lemma	Purple
31.	Lemma and Palea: Colour	Purple spots/furrows on straw
32.	Panicle: Awns	Present
33.	Panicle: Exertion	Well exerted
34.	Sterile lemma: Colour	Strew
35.	Decorticated grain: Colour	White
36.	Decorticated grain: Length	Medium (5.04 cm)
37.	Decorticated grain: Width	Medium(1.87 cm)
38.	Decorticated grain: Shape	Medium slender
39.	Endosperm: content of amylose	Medium (22.50%)
40.	Decorticated grain: Aroma	Present (Strong)



Fig. 1: Some important characters of Uttar Sugandhi. A) Field view; B) Panicle; C) undehusked grains; D) Dehusked grains; E) Undehusked grains length and breadth on graph paper; F) Dehusked grains length and breadth on graph paper.

Table 6: DNA fingerprinting pattern and amplifications of bands/alleles of proposed variety, KNS-3-1 (Uttar Sugandhi) and KNS-2-1 with standard varieties *Gobindabhog* and *Kalonunia*

Sl. No.	Primers	Expected size (bp)	Observed alleles	Varieties			
				<i>Gobindabhog</i>	<i>Kalonunia</i>	KNS-2-1	<i>Uttar Sugandhi (KNS-3-1)</i>
1.	RM114-a	200	2	0	1	1	1
	RM114-b			1	1	0	0
2.	RM108	80	1	1	1	1	1
3.	RM16655	200	1	0	1	1	1
4.	RM10022	200	1	0	1	1	1
5.	RM23	150	1	1	0	1	0
6.	RM327	200	1	1	1	1	1
7.	RM3872	150	1	0	0	0	0
8.	RM288	170	1	0	0	1	1
9.	RM1-a	100-120	2	0	1	0	0
	RM1-b			0	0	1	1
10.	RM256	65	0	0	0	0	0
11.	RM6250-a	180	2	1	0	1	0
	RM6250-b			0	1	0	0
12.	RM172	180	1	0	0	1	1
13.	RM159	150	1	1	1	0	1
14.	RM165-a	200-300	4	1	1	0	0
	RM165-b			1	1	1	1
	RM165-c			1	1	1	1
	RM165-d			1	1	1	1
15.	RM250	200	1	1	1	1	1
16.	RM23835	200	1	1	1	1	1
17.	RM321	200	1	1	1	1	1
18.	RM314	170	1	1	1	1	1
19.	RM291	200	1	1	1	1	1
20.	RM342	180	1	1	1	1	1
21.	RM7376	200	1	1	1	1	1
22.	RM460	300	1	1	1	1	1
23.	RM434	185	1	1	1	1	1
24.	RM3134	185	1	1	1	1	1
25.	RM332	180	1	1	1	1	1
26.	RM469	85	1	1	1	1	1
27.	RM285	150-200	0	0	0	0	0
28.	RM169	200	1	1	1	1	1
29.	RM195	300	1	1	1	1	1
30.	RM311	300	0	0	0	0	0
31.	RM38	900	1	1	1	0	1
32.	RM294-a	180-200	3	1	1	1	1
	RM294-b			0	1	0	0
	RM294-c			1	1	1	1

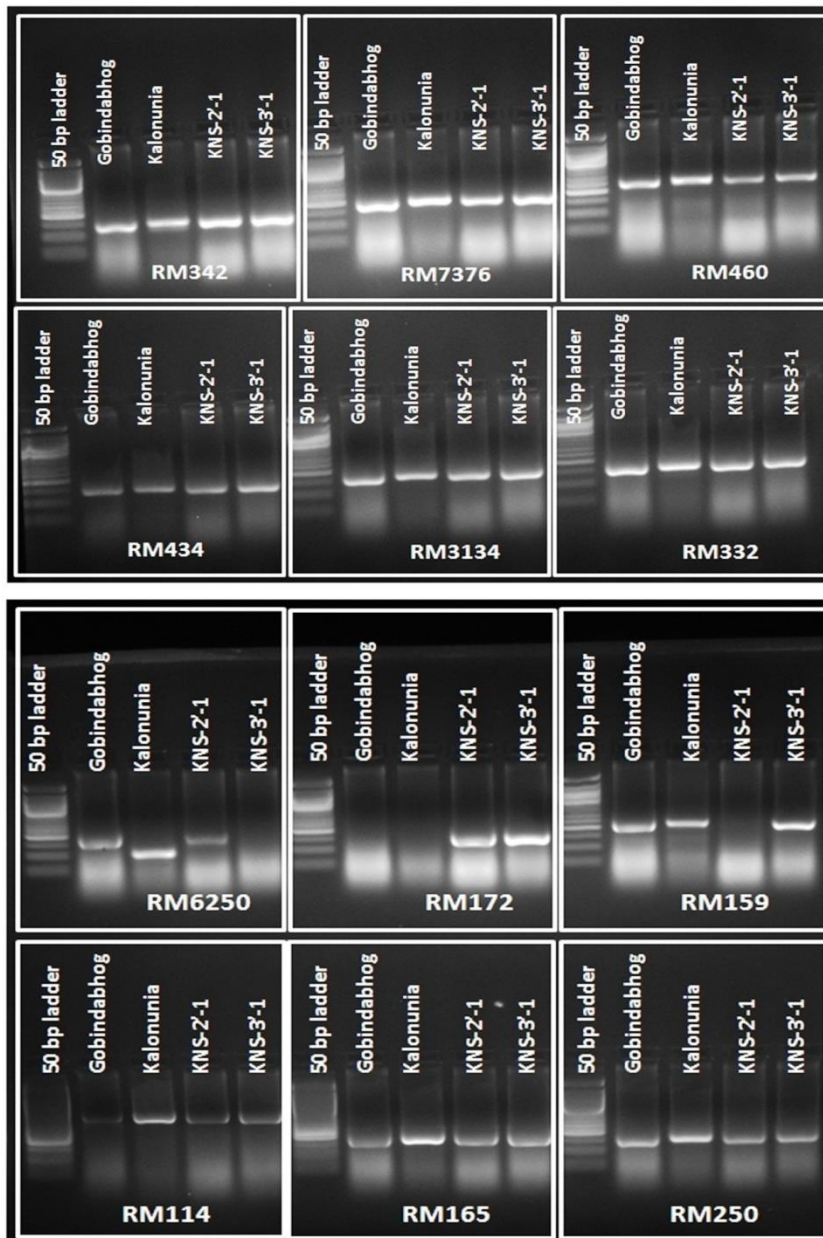


Fig. 2: DNA profile of *Gobindobhog*, *Kalonunia*, KNS-2-1 and KNS-3-1 (Uttar Sugandhi) with primers RM 342, RM 7376, RM 460, RM 434, RM 3134, RM 332, RM 6250, RM 172, RM 159, RM 114, RM 165 and RM 250; L= 50 bp ladder.