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Research Article

Uttar Sona: A medium-slender grain rice variety suitable for cultivation during *Boro*-season

Bidhan Roy[1*], Vikash Kumar[2] and B. K. Das[2]

[1]Department of Seed Science and Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar 736165, West Bengal, India
[2]Mutation Breeding Research Group, NABTD, BARC, Trombay, Mumbai, India
***E-Mail:** bcroy10@yahoo.com

Abstract
Uttar Sona has been developed from the cross between MTU 7029 × Gontra Bidhan-1. It was tested under All India Coordinated Rice Improvement Project (AICRIP) in IVT-*Boro* during 2013-14 and 2014-15. It out yielded national, regional, local and hybrid checks with a yield advantage of 18.57, 29.03, 16.36 and 6.63 per cent, respectively. Overall rank of Uttar Sona during the first year of testing was third in IVT *Boro* 2013-14 and it ranked sixth during the second year of testing in IVT-Boro 2014-15. The entry has also tested under IVT-E-TP during 2013. It ranked first in IVT-E-TP 2013.Uttar Sona already has been adopted by the farmers of Unishbisha G.P. (Mathabhanga-II block), Patlakhawa G.P. (Cooch Behar-II block), Bamunhat G.P. (Dinhata-II block) and Chotosalbari G.P. (Sitalkuchi block) of Cooch Behar district. It showed field resistance to major pest and diseases.

Key words
Uttar Sona, rice variety, medium slender, *Boro*-season, West Bengal

INTRODUCTION

Rice is being grown in three seasons, namely *Aus* (February-March to April-May), *Aman* (May-June to October-November) and *Boro* (mid-November to mid-June) in the West Bengal region of India. Area under *Aus* season is diminishing gradually and only few varieties, namely, Seshaphal, Bittietc are available for cultivation. The main season for rice in West Bengal is *Aman* followed by *Boro* (irrigated). The percentage shares of these three categories of rice are 4.92, 68.65 and 26.43 with respect to area and 3.84, 62.69 and 33.47 in respect of production, respectively. The average productivity of *Aus, Aman* and *Boro* was 2009, 2309 and 3259 kg/ha, respectively and the state average of rice productivity was 2573 kg/ha (Samanta and Mallik, 2004; Anonymous, 2009). Thus, *Boro*-rice has considerable contribution in the total rice production in West Bengal.

Increasing the yield potential and decreasing the yield-gap of rice crops has been one of the critical challenges to the agricultural research scientists of the state. They have put-forth their valuable efforts in enhancing the yield potential of rice in the state to around 5 tons/ha (in term of rough rice). However, rice yield is stagnating over the last decade. To increase the productivity and the total production of rice efforts need to be taken to develop varieties with high productivity (> 5 t/ha), desirable grain type (preferably medium slender), increased nutritional quality (high Fe and Zn content), tolerant to biotic (major insect pests and diseases) and abiotic (particularly, low temperature during *Boro*-season, drought at reproductive stage during *Aman* season, and submergence/flood at the vegetative stage during *Aman*) stresses.

In general, rice breeders, as well as breeders for other crops, tend to cross high-performing parents and select from segregating generations to develop the

new commercial varieties. This strategy is based on the concept that major yield contributing traits in self-pollinated crops are controlled by additive genetic effects. In addition, both high-performing parents present a higher probability of generating superior segregants. To create a rice population for selection, it is important to choose parental materials with high levels of genetic differences for the traits under consideration.Hence, two diverse parents- MTU 7029 and Gontra Bidhan-1 were chosen for crossing to develop a mid-early variety with slender grain and tolerant to most of the biotic and abiotic stresses prevailing in the Tarai Zone and suitable for cultivation during the *Boro*-season.

MATERIALS AND METHOD

A cross was made between MTU 7029 (popular variety, 145 days duration, semi-dwarf rice variety with short bold grain, and high yield potential in low input areas and resistant to BLB) and Gontra Bidhan-1 (it is photoperiod insensitive, medium duration, can be grown in both the *Boro* and *Kharif* seasons, semi-dwarf, tolerant to sheath blight, sheath rot and moderately resistant to BPH having high yield potential) during 2009. A promising breeding line designated as Uttar Sona was developed through pedigree selection.

Initially for two consecutive *Boro*-seasons, Uttar Sona was tested under at University Research Farm, UBKV, Pundibari as observational trial. On satisfactory performance in the observational trials, the entry was sent for testing under All India Coordinated Rice Improvement Project with four checks, namely Goutam as regional check, IR 64 as national check, Rajlakshmi as hybrid check and Nabin as local check at UBKV, Pundibari). The entry was tested in eight locations in six states (Assam, Bihar, Odisha, Tripura, Uttar Pradesh and West Bengal) during the *Boro*-season over consecutive two years under AICRP (AICRIP Progress Report 2014, 2015). Based on the better performance in two years of trials by AICRIP, the entry was further tested under multi-location trial in West Bengal (**Table 5**). The variety was also tested under adaptive trial in the farmers' field.

DNA was isolated using standard CTAB method from rice leaves (Xu*et al*., 2005). Twenty SSRs (**Table 3**) located across all the 12 chromosomes of rice were selected for DNA fingerprinting. This study was conducted at Mutation Breeding Research Group, NABTD, BARC, Trombay, Mumbai. The SSRs were scored using the actual allele size using QIAxcl Advanced Fully Automated Capillary Electrophoresis system.

Table 1. Grain yield of Uttar Sona (IET 24171) in IVT-*Boro* 2013-14 in different states (kg/ha)

IET No.	Assam		Tripura		West Bengal		Bihar		Odisha		Uttar Pradesh		Mean		Yield advantage over checks (%)
	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	
24170	4905	4	8008	6	3813	-	3667	-	4209	-	5933	-	4907	-	-
Uttar Sona	**4959**	**3**	**7969**	**7**	**5429**	**1**	**4667**	**5**	**5139**	**7**	**7533**	**9**	**5760**	**3**	**-**
24172	4714	6	6433	-	4526	8	4917	1	6082	2	7933	5	5480	4	-
24173	4699	7	9428	1	5101	2	4667	5	7382	1	8200	2	6159	1	-
24174	3910	-	8031	5	3700	-	4583	6	4760	-	8265	1	5107	8	-
24175	4435	-	7119	9	5051	3	3500	-	4966	-	6100	-	5087	-	-
24176	4616	8	7236	8	3553	-	4167	8	-	-	5300	-	4720	-	-
24177	4998	3	6083	-	4735	7	4000	-	-	-	6533	-	5225	7	-
24178	3677	-	3547	-	4859	4	3417	-	-	-	7000	-	4434	-	-
23494	5889	1	8664	3	4262	-	4250	7	5195	6	8133	3	5818	2	-
23499	4187	-	6192	-	4754	5	4750	3	5513	5	7733	8	5258	6	-
23496	4471	-	8197	4	4043	-	4000	-	5136	8	6333	-	5087	-	-
23498	4148	-	2514	-	4278	9	4000	-	4979	9	7867	6	4526	-	-
Gautam (RC)	4056	-	2928	-	4750	6	4750	3	4287	-	6133	-	4464	-	29.03
IR 64 (NC)	4556	9	6978	-	4227	-	3250	-	3272	-	7800	7	4858	-	18.57
LC	4099	-	6883	-	3923	-	3667	-	6007	3	7000	-	4950	-	16.36
Rajalakshmi	4794	5	8781	2	3639	-	4000	-	5569	4	8000	4	5402	5	06.63
Ex. Mean	**4536**	**-**	**6764**	**-**	**4314**	**-**	**4132**	**-**	**5178**	**-**	**7165**	**-**	**5132**	**-**	**-**

NC: National check, **RC:** Regional check

Source: ICAR-Indian Institute of Rice Research, 2015, Progress Report 2014, Vol. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500 003, Telangana State, India, p. 1.343.

RESULTS AND DISCUSSION

Uttar Sona out yielded national, regional, local and hybrid checks with a yield advantage of 18.57, 29.03, 16.36 and 6.63 per cent, respectively and it ranked first in West Bengal based on grain yield (kg/ha) in IVT *Boro* 2013-14 (DRR, 2014; **Table 1**). Across other states it ranked third. It was significantly superior to regional and local checks at Karimganj (4th, 5194 kg/ha), Varanasi (9th, 7533 kg/ha) and Pundibari (1st, 5333 kg/ha). It was also significantly superior to national and local checks at Chinsurah (3rd, 5524 kg/ha). Uttar Sona was superior to regional check at Arundhatinaga (7th, 7969 kg/ha) national check at Pusa (5th, 4667 kg/ha) and CRRI (7th, 5139 kg/ha). State wise it ranked first in West Bengal (5429 kg/ha), 3rd in Assam (4959 kg/ha) and 7th in Tripura (7969 kg/ha) with 8.83, 14.20 and 14.28 per cent yield advantage over the respective best check. It also out yielded the hybrid check by 49.18 per cent in West Bengal.

The performance of Uttar Sona during Boro 2014-15 (ICAR-IIRR, 2016) is given in **Table 2**. In respect of mean grain yield, it ranked third in West Bengal and stood sixth based on overall mean (5017 kg/ha). It ranked first in Tripura (6035 kg/ha) and 4th in Bihar (4255 kg/ha). However Uttar Sona was not promoted for the third year of testing due to its lower value of overall mean yield.

As per the ICAR-IIRR report (ICAR-IIRR, 2014), Uttar Sona was significantly superior to all the three checks (**Table 3**) during *Kharif*-2013 in IVT-E-TP trial at Kaul (5600 kg/ha, 5th), Varanasi (7650 kg/ha, 2nd), Sakoli (3768 kg/ha), Warangal (9013 kg/ha, 1st), Aduthurai (4575 kg/ha, 8th) and Kurumbapet (6500 kg/ha). Against regional and local check it showed a superior yield at Ludhiana (6012 kg/ha, 6th). This entry performed well over the best check at Punjab (6th, 18.84%), Haryana (5th, 31.76%), Uttar Pradesh (1st, 37.84%), West Bengal (1st, 13.28%), Bihar (9th, 10.37%), Madhya Pradesh (10.14 %), Maharashtra (7th, 7.03%), Gujarat (5.87%), Andhra Pradesh (30.15%), Tamil Nadu (7.19%), Kerala (6.20%) and Puducherry (10.64%). In the region 4 and 5 it out yielded best checks with a yield advantage of 6.96 and 12.19 per cent, respectively. Uttar Sona ranked first during *Kharif* 2013 based on overall average yield (5364 kg/ha) under IVT-E-TP. It out yielded national, regional and local checks viz., 8.60, 47.96 and 14.36 per cent, respectively, on over all mean basis. Based on the overall performance in IVT-E-TP trial, it was promoted to AVT1-E-TP, however due unavailability of seeds during the next *Kharif* season, the trial was not continued.

Multi-locational trials were conducted at RRS-Chinsurah (RRI, 2018), RRS-Pundibari and RRS-Majhian during *Boro* 2016-17. Uttar Sona performed well as compared to local checks in all the location under multi-location trials in West Bengal (**Table 4**). Yield increase over local checks Khitish and Nabinby 13.42 and 14.62 per cent, respectively.

Table 2. Grain yield of Uttar Sona (IET 24171) in IVT-Boro 2014-15 in different states (kg/ha)

IET No.	Assam		Bihar		Odisha		Tripura		Uttar Pradesh		West Bengal		Mean		Yield advantage over checks (%)
	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	
24173	4684	3	3056	7	3528	-	4891	-	8000	1	9300	1	5353	3	-
Uttar Sona	4093	6	3611	4	3858	8	6035	1	5223	-	9130	3	**5017**	**6**	**-**
Gautam (RC)	2566	-	3889	3	4378	7	5524	7	5807	-	8395	4	4461	8	12.46
24172	3818	7	3472	5	4909	4	5280	8	6700	6	9295	2	5139	5	-
24177	3181	-	1667	-	2441	-	4550	-	5267	-	3895	-	3420	-	-
23494	4797	2	5417	2	6436	2	5597	5	7600	3	5895	-	5667	1	-
IR 64 (NC)	3421	8	2361		3505	-	5645	4	4600	-	6430	8	4100	-	22.36
24897	3213	-	3889	3	3533	-	4453	-	6033	8	6165	-	4214	-	-
24898	5037	1	5694	1	4618	6	5572	6	7667	2	6595	7	5657	2	-
LC	4373	4	3056	7	5391	3	5986	3	7267	4	5300	-	5015	7	-
24899	3376	-	1250		4668	5	4891	-	6833	5	6995	5	4346	-	-
Rajalakshmi	4144	5	3889	3	6653	1	6010	2	6600	7	6800	6	5298	4	05.30
24900	3642	-	3194	6	2997	-	4502	-	4633	-	5000	-	3906	-	-
Ex. Mean	3873	-	3419		4378	-	5303	-	6325	-	6861	-	4738	-	-

NC: National check, **RC:** Regional check

Source: ICAR-Indian Institute of Rice Research, 2016, Progress Report 2015, Vol. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500 003, Telangana State, India, p. 1.180.

Table 3. Grain yield of Uttar Sona in IVT-E-TP during *Kharif*, 2013

Regions	States	Locations S. No.	Locations	Uttar Sona		National Check		Regional Check	
				Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank
Region-II	Uttarakhand	1	Pantnagar	1668	-	3590	#$	2352	-
	Punjab	2	Ludhiana	6012	6 #$	5059	$	4367	-
	Hariyana	3	Kaul	5600	5 *#$	4250	$	3850	-
	Mean of Region-II	-	-	4427	#$	4300	#$	3523	-
Region-III	Odisha	4	CRRI, Cuttack	3400	-	4315	8	3685	-
		5	Jeypore	4697	#	6212	4 #$	1939	-
	Mean	-	-	4048	#	5264	1 #$	2812	-
	Bihar	6	Patna	5571	9 #	5048	#	2381	
	West Bengal	7	Chinchurah	5923	1 #	5229	-	4412	-
	Uttar Pradesh	8	Varanashi	7650	1*#$	5550	$	5250	-
	Madhya Pradesh	9	Waraseoni	3395	#	2573	#	1325	-
		10	Rewa	3653	#	3826	#	1931	-
		-	Mean	3524	#	3200	#	1628	-
	Mean of Region-III	-	-	4898	2 #$	4679	6 #$	2989	-
Region-IV	Maharashtra	11	Karjat	5811	4 $	5192	-	5636	-
		12	Sakoli	3768	*#$	3110	#	2153	-
		13	Vadagon	4874	-	5202	6	4722	-
		14	Mean	4818	7 *#$	4501	#	4170	-
	Gujarat	15	Vyra	5165	#	4664	#	2655	-
		16	Dabhoi	4216	#	4118	#	2745	-
		-	Mean	4690	#	4391	#	2700	-
	Mean of Region-IV	-	-	4767	#$	4457	#	3582	-
Region-V	Andhra Pradesh	17	Marutheru	3699	7 #	3742	5 #	1205	-
		18	Warangle	9013	1 *#$	6025	4 #	4391	-
		-	Mean	6356	1 *#$	4883	4 #	2798	-
	Tamil Nadu	19	Coimbatore	8529	1 #	7813	-	6622	-
		20	Ambasamudram	5875	-	6625	#	5688	-
		21	Adudurai	4575	8 *#$	3268	#	1471	-
		-	Mean	6326	6 #	5902	#	4593	-
	Kerala	22	Moncompu	2989	#	1618	-	1592	-
		23	Pattambi	4942	#	4365	-	3968	-
		-	Mean	4942	#	4365	-	3968	-
	Karnataka	24	Mandya	7276	8	6793	-	5672	-
		25	Brahmavar	4175	2 #	3687	4	2925	-
		26	Gangavati	8102	#	7716	#	4784	-
		-	Mean	6518	8 #	6065	#	4461	-
	PY	27	KYP	6500	*#$	5500	#	4500	-
	Mean of Region-V	-	-	6269	1 *#$	5553	#	4123	-
	Overall Mean			5364	1 *#$	4939	#$	3625	-

***:** Superior to NC; **#:** Superior to RC; **$:** Superior to LC

Source:

Directorate of Rice Research, 2014, Progress Report, 2013, Vol.1, Varietal Improvement All India Coordinated Rice Improvement Programme (ICAR) Directorate of Rice Research, Rajendranagar, Hyderabad – 500 030, AP, India. p. viii. & p. 1.96.

Table 4. Performance of the proposed entry Uttar Sona in respect of its grain yield under multilocation trials in West Bengal during *Boro* 2016-17

S.No.	Breeding lines	Locations			Mean yield (t/ha)	Yield increas over check (%)
		RRS, Chinchurah Yield (t/ha)	RRS, Pundibari Yield (t/ha)	RRS, Majhian Yield (t/ha)		
1.	Uttar Sona	5.10	5.38	5.76	5.41	-
2.	Local Check					
i.	Khitish	4.30	-	5.23	4.77	13.42
ii.	Nabin	-	4.72	-	4.72	14.62

Sources:
Technical Programme of Rice- Boro 2016-17, Rice Research Station, Chinchurah, Hoogly
Annual Report on Rice Research, 2016-17, UBKV, Pundibari, Cooch Behar 736165, West Bengal, UBKV, Pundibari, Cooch Behar

Table 5. Yield of Uttar Sona at farmers' field during *Boro* and *Kharif* seasons (kg/ha)

Seasons	Designation	F1	F2	F3	F4	Mean	% increase over check
Boro 2014-15	Uttar Sona	7483	8350	6331	7225	7347.25	66.24
	MTU 1010	4537	4701	4328	4113	4419.75	-
Boro 2015-16	UBKVR-1	7530	7386	7490	7050	7364.00	63.58
	MTU 1010	4627	4510	4308	4562	4501.75	-
Kharif 2015	UBKVR-1	6530	6601	6475	7015	6655.25	63.58
	MTU 1010	4100	3660	3975	4088	3955.75	-
Kharif 2016	UBKVR-1	6425	6600	6533	6820	6594.50	80.29
	MTU 1010	3865	3590	3766	3410	3657.75	-

F1: Shri Bharat Barman, Village- Kharikabari, Unishbisha G.P., Ghoskadanga, Mathabhnga-II, Cooch Behar dist.; **F2:**Manick Barman, Jayantir Hat, Mathabhnga-II, Cooch Behar dist.; **F3:** Shri BenzaminOraon, Village- Singhimari (Tribalpara), Patlakhawa G.P., Cooch Behar-II, Cooch Behar dist.; **F4:** Shri Ramkrishna Barman, Village- Petlanepra, ChhotoSalbari G.P., Sitalkuchi, Cooch Behar dist.

The yield performance in large scale demonstrations in farmers' fields were given in **Table 5**. The trials were conducted at four farmers' field during *Kharif* 2014 and 2015 as well as during *Boro* 2014-15 and 2015-16. Uttar Sona showed more than 60 per cent yield advantage over local check for all the test seasons in *Boro* and *Kharif*.

The results (**Table 6**) revealed that the Uttar Sona recorded the highest grain yield of 6.90 t/ha under 160 : 80 : 80 kg/ha of NPK and it was statistically at par with 120 : 60 : 60 kg/ha of NPK (6.80 t/ha). Hence, the nutrient dose of 120 : 60 : 60 kg/ha of NPK may be recommended for Uttar Sona for achieving higher productivity during the *Boro* season in West Bengal. Similar fertilizer dose (130 : 65 : 65 kg/ha of NPK) also has been recommended by Adhikari*et al*. (2011) for *Boro* rice.

The results showed that the disease infection was below the threshold level for all the genotypes tested at RRS, Pundibari, UBKV and Cooch Behar of West Bengal during *Boro* 2013-14, *Boro* 2014-15 and *Boro* 2016-17. The proposed entry, UIttar Sona showed no infection in respect of panicle blast, sheath rot, bacterial leaf blight, and sheath blight, but it showed a very low infection (score '1') in respect of leaf blast and brown spot indicating resistant to leaf blast and brown spot. Blast is major disease in northern part of West Bengal (Adhikari*et al*., 2011). Thus, Uttar Sona may be promising in West Bengal as it showed field resistance against blast.

The result showed that the proposed entry, IET 24171 was found to have a very low incidence of stem borer (0.09-0.10%) indicating its reaction in-between highly resistant to resistant. The said entry did not show any incidence of brown plant hopper, white back plant hopper, gal midge, leaf folder and white maggot during *Boro* 2013-14 and 2014-15. But it showed a very low incidence of leaf folder (0.37% Damaged Leaf) during *Boro* 2016-17.

Uttar Sona attained 50% flowering during *Khrif*-season at 90th day after sowing. However it attained 50% flowering during *Boro*-season at 133rd day after sowing (**Table 7**). As per the guideline of PPV & FRA, Uttar Sona categorized as medium duration rice (PPV & FRA, 2007). The average plant height of Uttar Sona was 105.0 cm and it fall under short (91-110 cm) category (PPV & FRA, 207). It showed an average of 304 panicles/m^2 with a test weight of 21.15 g.

Table 6. Performance of Uttar Sona grown under different levels of NPK during Boro, 2016-17

Genotypes/ Fertilizer dose	Yield (t/ha)					
	T1	T2	T3	T4	T5	Mean
UBKVR-15	7.20	7.20	6.00	5.50	3.40	**5.86**
UBKVR-15A	3.60	5.10	4.60	3.40	2.20	**3.78**
UBKVR-36	6.00	6.30	5.50	4.00	3.10	4.98
UBKVR-46	6.10	6.20	4.60	4.00	3.00	**4.78**
Uttar Sona	6.90	6.80	5.00	4.20	4.00	5.38
Nobin	6.60	6.38	4.50	3.30	2.80	**4.72**
Mean	6.07	6.33	5.03	4.07	3.08	
	T		V		VT	
C.D. (5%)	0.6025		0.2460		0.2695	

Source: Annual Report on Rice Research, 2016-17, UBKV, Pundibari, Cooch Behar 736165, West Bengal

Table 7.Yield attributing and grain quality characters of Uttar Sona in different trials

Characters	IVT-E-TP 2013	IVT-Boro 2013-14	IVT-Boro 2014-15	Tested at BARC	Mean
Yield attributing characters					
Days to 50% flowering	90.00	133.00	134.00	-	-
Plant height (cm)	112.00	100.00	103.05	-	105.00
Number of panicles per m^2	328.00	305.00	303.00	-	304.00
Grain quality characters					
Hulling (%)	-	-	75.00	-	75.00
Milling (%)	-	-	66.90	-	66.90
Head rice recovery (%)	-	-	53.20	61.80	57.50
Kernel length (mm)	-	-	5.47	-	5.47
Kernel breadth (mm)	-	-	2.05	-	2.05
L/B ratio	-	-	2.66	-	2.66
Grain type	-	-	-	-	Medium slender
Grain chalk	-	-	Very occasionally present	-	Very occasionally present
Alkali spreading value	-	-	4.00	-	4.00
Amylose content (%)	-	-	-	21.02	21.02
Gel consistency	-	-	53.00	-	53.00
Test weight (g)	-	-	-	-	21.15

Sources:

1. ICAR-Indian Institute of Rice Research, 2015, Progress Report 2014, Vil. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500 003, Telangana State, India, p. 1.341-1.344.
2. ICAR-Indian Institute of Rice Research, 2016, Progress Report 2015, Vil. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500 003, Telangana State, India, p. 1.182.
3. Directorate of Rice Research, 2014, Progress Report, 2013, Vol.1, Varietal Improvement All India Coordinated Rice Improvement Programme (ICAR) Directorate of Rice Research, Rajendranagar, Hyderabad – 500 030, AP, India. p. viii. & pp. 1.95, 1.119, 1.122, 1.125.

Fig. 1. Pictorial depiction of different features of Uttar Sona (IET 24171). A) Standing crop at famers' field (Shri Bharat Barman, Kharikabari, Unishbisha G.P., Mathabhanga-II, Cooch Behar district); B) Farmers' participatory varietal selection at Patlakhawa G.P. (Cooch Behar-II, Cooch Behar district, West Bengal)- farmers selected Uttar Sona along with other four varieties as best performing varieties; C) Un-dehusked rice of Uttar Sona; D) Dehusked rice of Uttar Sona; E) Length of un-dehusked rice Uttar Sona; F) Length of dehusked rice of Uttar Sona [length: 5.47 cm, breadth: 2.05 mm, L:B ratio- 2.66, gain type- medium slender].

Grains of Uttar Sona are medium slender (**Table 7; Fig. 1**). It bears excellent cooking qualities. Other quality characters hulling (%), milling (%) and head rice recovery were 75.00, 66.90 and 57.50 per cent, respectively. Amylose content was 24.64 per cent with medium gel consistency (53.00) indicating separable and soft cooked rice as preferred in India. Amylose content is an important rice grain quality parameter in respect of consumer preference. In India, consumers prefer medium (20-25%) amylose content in the endosperm and this is an important parameter for promotion of rice entries during All India Rice Improvement Project (Anonymous, 2017). Starch content (amylose) of rice is very important factors in grain yield, processing and palatability.

Coleoptile of Uttar Sona is colourless (**Table 8**). It bears white coloured split type of ligule. It shows medium tillering ability. Stem length of this variety is very short (excluding panicle length). It has semi-erect culm and droopy panicle, bright straw coloured lemma and palea and well exerted panicle. Other morphological and qualitative characters of Uttar Sona based on the "Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on Rice (*Oryzasativa*L.)" of PPV&FRA (2007) are given in **Table 8**.

Among 20 SSR markers, all markers were found to be highly polymorphic (**Table 9, Fig. 2**). Twelve markers had unique alleles present which can be used to distinguish

Table 8. Morphological and qualitative characters of Uttar Sona based on the PPV&FRA (2007)

S. No.	Characters	Classification
1.	Coleoptiles: Colour	Colourless
2.	Basal leaf: sheath colour	Green
3.	Leaf: Intensity of green colour	Dark
4.	Leaf: Anthocyanin colouration	Absent
5.	Leaf sheath: anthocyanin colouration	Absent
6.	Leaf: Pubescence of blade surface	Medium
7.	Leaf: Auricle	Present
8.	Leaf: Anthocynin colouration of auricle	Colourless
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.	Leaf: Length of blade	Medium
15.	Leaf: Width of blade	Medium
16.	Culm: attitude	Semi-erect
17.	Flag leaf: Attitude of blade (early observation)	Semi-erect
18.	Lemma: Anthocyanin colouration of keel	Absent
19.	Lemma: Anthocyanin colouration of area below apex	Absent
20.	Lemma: Anthocyanin colouration of apex	Absent
21.	Spikelet: Colour of stigma	White
22.	Stem: Length (excluding panicle length)	Very short (105.00 cm)
23.	Stem: Thickness	Medium
24.	Stem: Anthocyanin colouration of nodes	Absent
25.	Stem: Anthocyanin colouration of internodes	Absent
26.	Panicle: Length of main axis	Medium
27.	Panicle: Curvature of main axis	Dropping
28.	Panicle: Number per plant	Medium
29.	Spikelet: Colour of tip of lemma	Yellowish
30.	Lemma and Palea: Colour	Straw
31.	Panicle: Awns	Absent
32.	Panicle: Exertion	Well exerted
33.	Sterile lemma: Colour	Straw
34.	Decorticated grain: Aroma	Absent

Table 9. DNA fingerprinting of proposed variety, Uttar Sona with standard varieties (allele size in bp)

S. No.	Markers	IR64	MTU1010	Annada	GB-1	Uttar Sona	UBKVR 15
1.	RM 495	148	148	148	148	160	148
2.	RM 455	141	130	129	128	129	126
3.	RM 29	195	191	193	191	191	195
4.	RM 433	281	270	291	299	266	287
5.	RM 7434	125	123	123	125	119	121
6.	RM585	255	250	174	173	229	177
7.	RM3562	155	153	145	156	148	156
8.	RM 552	176	178	177	178	186	175
9.	RM 418	288	288	315	298	291	296
10.	RM 205	136	133	129	128	133	133
11.	RM 452	213	177	178	170	180	205
12.	RM 124	-	158	154	157	164	188
13.	RM 507	-	136	126	128	127	120
14.	RM 133	237	246	237	235	239	237
15.	RM 162	216	214	215	213	214	214
16.	RM 125	121	121	121	122	122	123
17.	RM 284	141	141	141	142	142	142
18.	RM 316	202	202	201	201	200	201
19.	RM 215	128	126	113	113	-	112
20.	RM 277	126	120	122	121	120	122

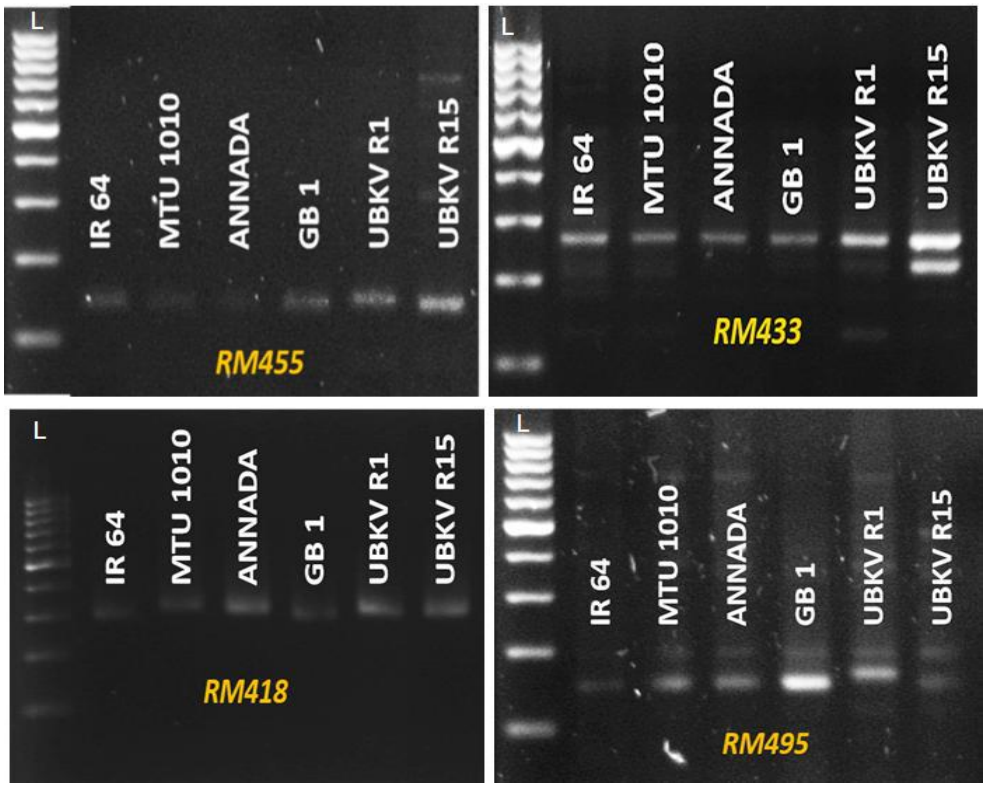

Fig. 2. DNA profile of six rice genotypes with primers RM455, RM433, RM418 and RM495; L= 100 bp molecular weight size standard.

it from rest of the other genotypes tested in combination with other SSR markers studied. These markers were RM495, RM433, RM7434, RM585, RM3562, RM552, RM418, RM452, RM124, RM507, RM133 and RM316.

Based on the performance of the entry in West Bengal (AICRIP trials, multi-locational yield trial in West Bengal and adaptive trials at the farmers' field) the variety was recommended by the 'State Variety Release Committee [Ref. 706(75)-Res, dated 10.10.2018, Directorate of Agriculture, West Bengal]' and forwarded by 'State Seed Sub Committee of Crop Standards Notification and Release of Varieties for Agricultural Crops' for release in West Bengal for cultivation of this variety during both the *Boro* and *Kharif* seasons. Subsequently the variety was notified by the 'Central Variety Release Committee (F. No. 3-71/2019-SD.IV, dated 05.09.2019, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Government of India)' for cultivation of this variety in West Bengal.

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