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GUJARAT AEROBIC RICE 201 (GAR 201/ANAND AKSHAT), A HIGH YIELDING VARIETY WITH EARLY MATURITY AND LONG BOLD GRAIN RELEASED FOR AEROBIC RICE CULTIVATION IN GUJARAT INDIA

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ABSTRACT

Aerobic rice is a paddy crop grown in well-drained, non-puddled and non-saturated soils without ponded water. Main driving force behind aerobic rice is economic water use. Aerobic rice varieties have the ability to maintain rapid growth in soils with moisture content at or below field capacity, and can produce yields of 4-6 t/ha with a moderate application of fertilizers under such soil water conditions. Therefore, there is an urgent need to evolve high yielding and early maturing variety suitable for aerobic rice cultivation in Gujarat and hence, such a variety Gujarat Aerobic Rice 201 (GAR 201/ Anand Akshat) was developed from the cross between a high yielding bold grain variety Ratna and early maturing elite line NWGR-2010 through pedigree method of breeding from 2005-2013 at Main Rice Research Station, Anand Agricultural University, Nawagam. In the state co-ordinated aerobic rice varietal trials were conducted at different six locations of the state during 2019-2022, it was recorded 29.3, 22.3 and 13.4% higher grain yield over the check varieties NAUR 1, GR 8 and GNR 3, respectively. In All India Coordinated trials, over all locations in 2017, it has 8.4, 12.3, and 16.1% higher yield than the Zonal, Local and National checks, respectively in Zone-III, while in 2018 it has better performed over Zonal and Local check varieties in Zone-III. Due to having early maturity, long bold grains, less prone to pests and diseases, better grain qualities and popped rice recovery, this variety was released for aerobic rice cultivation in 54th State Varietal Release Committee meeting in 2023.

***Keywords*:** Rice, Aerobic rice, Direct seeded rice

Introduction

Rice (*Oryza sativa* L.) is one of the major cereal crops feeding over more than half of the world's population (Chandra *et al*., 2022). 'Rice is life' as it encompasses entire scope of life, including as a source of livelihood. In India rice crop is cultivated in 45.77 million hectare producing 124.37 million tons rice with productivity of 2717 kg/ha (Anon., 2023a). Rice is being cultivated both in *kharif* and *rabi* seasons as one of the most important crops in Gujarat. During the year 2021-22, rice crop was grown in Gujarat in an area of about 9.0 lakh hectares producing 21.0 lakh tons of rice with productivity of 2355 kg/ha (Anon., 2023b).

Rice is cultivated in 22 million hectares under irrigated ecology which accounts about half of the total area under rice production in India. In Gujarat more than half of the cultivated area is under irrigated ecology. In view of climate change, limiting water and human resources, aerobic rice is the need of the hour for substantial and stabilized crop returns. The concept of aerobic rice hold promise for farmers in water-short in irrigated rice environment where, water availability at the farm level is too low or where water is too expensive to grow flooded lowland rice. Aerobic rice technology is better remedy for future climate change under drought condition with lesser greenhouse gas (GHG) emission. Selection of good aerobic rice variety with desired physiological attributes along with good cultural practices and weed free environment would give better performance (Lal *et al*., 2014). Hence, the Main Rice Research Station, Anand Agricultural University, Nawagam has initiated the systematic efforts to evolve a superior early maturing aerobic rice

variety which is to be suitable for the direct seeded condition under irrigated ecosystem.

Materials and Methods

Development of GAR 201 by Pedigree Method

The Main Rice Research Station, Anand Agricultural University, Nawagam had developed a genotype NWGR-13031, from the cross of Ratna / NWGR-2010 using pedigree method of breeding during 2005 to 2012 (Rao *et al*., 2020). Superior segregants from the cross were selected in F_2 generation and single plant selection was practiced till F_8 generation. Progenies were evaluated in F_9 generation for yield and other traits, yield trial was conducted in F_{10} generation and promising line designated as NWGR-13031(Figure-1) and this was later release as Gujarat Anand Rice 201 (GAR 201/ Anand Akshat) for aerobic rice cultivation in Gujarat.

Experimental sites

The identified genotype NWGR-13031 was evaluated for yield and yield attributing traits along with other promising entries including check varieties, NAUR 1, GNR 3 and GNR 8. Its performance was evaluated in multi-location trials from 2015 to 2019 under irrigated transplanted condition. Due to having long bold grain type and semi-erect plant type the genotypes was further tested under the aerobic rice trials to evaluate its performance under direct seeded condition in irrigated rice ecosystem of Gujarat. During 2019 to 2022 the genotype was tested for 10 different tests under PET-Aerobic, SSVT-Aerobic and LSVT-Aerobic trials at four different locations *viz*., Derol, Thasara, Vyara and Navsari of the Gujarat. During the period the genotype NWGR-13031 was evaluated under the screening trials for pests and diseases at Nawagam and Navsari locations.

Before evaluating the genotype NWGR-13031 in Gujarat this genotype was nominated to evaluate under aerobic rice trials of AICRIP during 2017 to test across the locations of India with the designation as IET-27208. Where, it was tested under IVT-Aerobic trial at 11 different locations of Zone-II, Zone-III, Zone-V, Zone-VI and Zone-VII. Due to its better performance in Zone-III it was further tested in AVT-I-Aerobic (AICRIP) trial during *kharif*-2018 at six different locations of the Zone-III and achieved 8.1% higher yield over the zonal check.

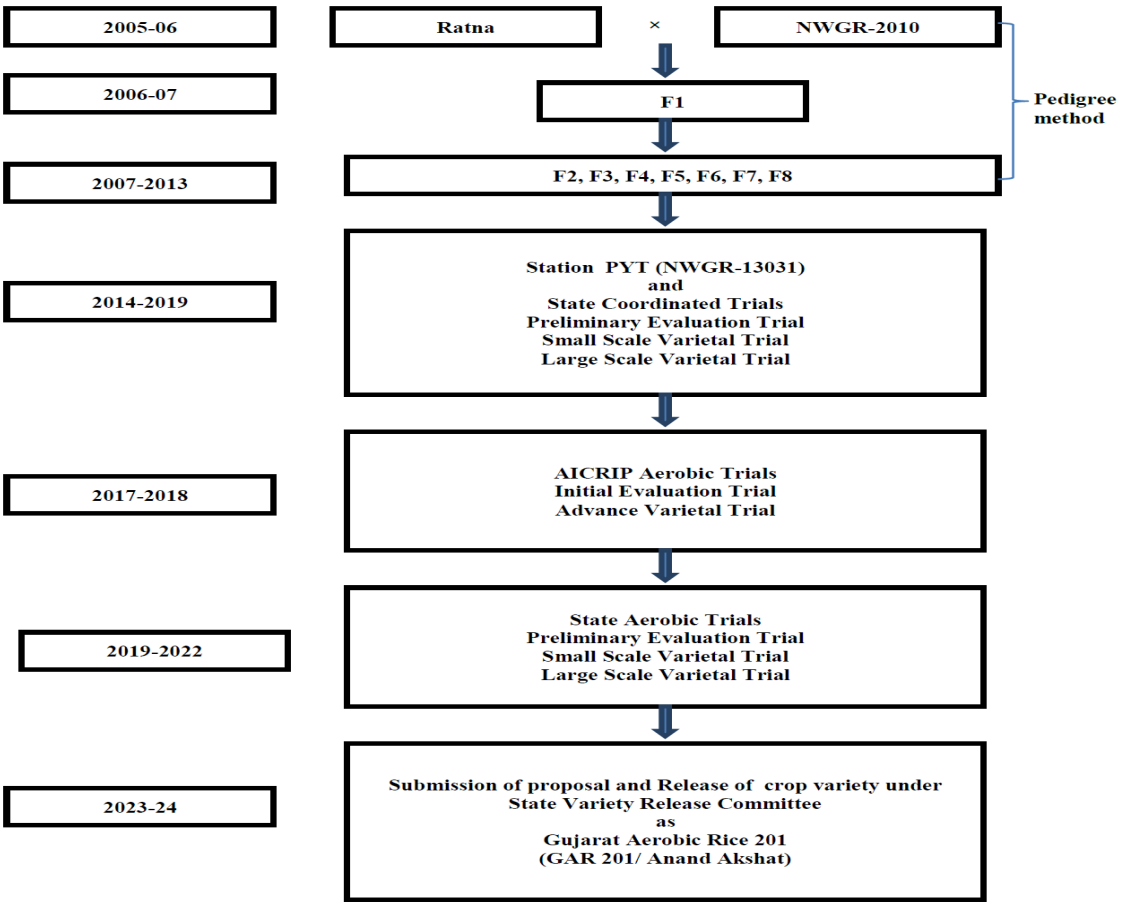

Fig. 1 : Flow chart details in the development of GAR 201 (Anand Akshat)

Observations Recorded and statistical analysis

Under state level trials the experiment was laid out in a Randomized Block Design (RBD) with three replications. The Genotypes were grown in five meters apart with three meters width by maintaining 30 cm ×10 cm plant spacing of individual genotype and all the recommended cultural practices for aerobic rice was applied. The data pertaining to grain yield and different yield contributing traits *viz*., days to fifty percent flowering, days to maturity, plant height (cm), panicle length (cm), number of grains per panicle, number of productive tillers per plant, number of panicles per m^2 and 1000 grain weight (g) were analyzed as per the procedure of randomized block design given by Panse and Sukhatme (1978) for individual environments. Furthermore, the grain type related characters *viz*., grain length and breadth (mm), kernel length and breadth (mm), and LB ratio and the quality characters *viz*., head rice, hulling %, milling %, amylose content, alkali spreading value were studied. The head rice (HR) recovery was determined according to the methods of Khush *et al.* (1979). Amylose content was determined by auto analyzer and manual modified method of Juliano (1971). The popped rice recovery was measured by steaming of paddy for 10 min at 0 kg/cm^2 as per Villareal and Juliano (1987) followed by shade air drying under fan for 16 hours. The paddy grains were then subjected to popping machine with thermostat maintained at 300°C for 60 seconds and then popping recovery was measured in percent.

Results

Yield performance in Gujarat state

Based on yield performance of genotypes under the aerobic rice trials of the Gujarat state during 2019 to 2022, the genotype NWGR-13031 had superior performance for grain yield over the check varieties. Experimental results revealed that the genotype NWGR-13031 (3988 kg/ha) had exhibited 29.3% higher grain yield over the check variety NAUR 1 (3084 kg/ha) for 10 different tests and the NWGR-13031 (4027 kg/ha) has shown 22.3 and 13.4 percent higher yield over the check varieties GNR 8 (3294 kg/ha) and GNR 3 (3550 kg/ha), respectively for 8 corresponding tests (Table-1).

Yield performance in AICRP

In the aerobic rice trials of the AICRIP testing the genotype NWGR-13031 (IET-27208) was tested at 11 different locations of five different zones of India during 2017. Where it has achieved 4525 kg/ha average grain yield, which was 8.4% higher over the best check (Table-2). Therefore, it was promoted to AVT I Aerobic trial for second year of testing in Zone-III. This finding was in accordance with Senguttuvel *et al*., 2021. The genotype was further tested at Cuttack, Bikramgunj, Pusa, Pantnagar, Ranchi and Varanasi locations of the Zone-III during 2018 (Table-3). Where it achieved 4781 kg/ha grain yield under aerobic condition and was 8.1 and 2.2 per cent higher yielder over the zonal check and local check varieties but it was not found superior over the National check variety CR Dhan 201. This indicated that the genotype NWGR-13031have potential to give more than 4500 kg/ha yield under the aerobic direct seeded condition in different ecological situations.

Performance for yield attributing traits in Gujarat state

NWGR-13031 (GAR 201/Anand Akshat) had early maturity (100 to 117 days). The yield attributing traits *viz.,* panicles per m^2 (284.30) and number of productive tillers per plant (7.40) were found superior over all three check varieties. This genotype was medium tall (102-126 cm plant height) and possesses 29.60g average test weight, 9.72 mm grain length with breadth 2.83 mm having grain length/breadth ratio of 3.43 which is enough categorised in long bold grain type (Table-4).

Table 1 : Yield performance of NWGR-13031 in comparison with check varieties in the Gujarat State under Direct Seeded Aerobic condition

Season/ Year/	Name of Trial	Locations	Grain yield (kg/ha)				S. Em. ±	C.D. at 5%	C.V. %
			NWGR-13031	NAUR 1 (a)	GNR 8 (b)	GNR 3 (c)			
Kharif-2019	PET-Aerob.	DER	3979[a]	3016	-	-	296	869	16.8
		% Increase over check		31.9	-	-	-	-	-
Kharif-2020	SSVT-Aerob.	DER	3682 [a]	3067	-	-	167	489	11.1
		% Increase over check		20.1	-	-	-	-	-
Kharif-2021	LSVT-Aerob.	DER	2396 [abc]	1336	1919	1650	121	343	13.0
		THAS	4639 [abc]	2738	3207	3386	173	490	09.3
		VYA	3928	3593	4233	3929	510	1448	19.0
		NVS	5234	4783	4906	4522	333	947	12.1

		Mean(4)	4049	3113	3566	3372	-	-	-
		% Increase over check		30.1	13.5	20.1	-	-	-
Kharif-2022	LSVT-Aerob.	NWG	3738 [ab]	1978	1439	3203	220	631	12.8
		THAS	4652 [ab]	3285	3812	4194	189	542	08.3
		VYA	2617	2180	2118	2697	191	545	14.0
		NVS	5015	4862	4720	4821	387	1107	15.3
		Mean(4)	4006	3076	3022	3729	-	-	-
		% Increase over check		30.2	32.6	7.4	-	-	-
Overall Mean (10) – (M_1)			3988	3084	-	-	-	-	-
Mean over check (8) – (M_2)			4027	-	3294	3550	-	-	-
Over all % increase over respective checks				29.3	22.3	13.4	-		-

Note: 1. *a=, b=, c = indicates statistically significant at 5% level than respective check.* Figures in parenthesis indicate number of trials.

2. NWG= Nawagam, DER= Derol, THAS= Thasara, NVS= Navsari, VYA= Vyara locations.

Grain quality trait performance

The Grain quality characteristics of the NWGR-13031 (GAR 201/Anand Akshat) were derived at MRRS, Nawagam (Table-5) revealed that the amylose content was intermediate (25.55%) and was found at par with all three check varieties. The head rice recovery was satisfactory (61.52%) and the alkali spreading value of this genotype indicated its better cooking qualities, which is in accordance with the findings of Prajapati *et al*., 2020. The moderate proportion of Fe, Zn and protein (Table-6 & 7) was found in the unpolished and polished rice of NWGR-13031 (GAR 201/Anand Akshat). This genotype had shown higher popped rice recovery (71.47%) than all the check varieties (Table-8).

Screening for disease and insects

The genotype NWGR-13031 (GAR 201/Anand Akshat) had shown moderately resistant reaction against leaf blast, neck blast and grain discoloration diseases while it showed moderately resistant and resistant reaction against white backed plant hopper (WBPH) and leaf folder, respectively under the screening trials conducted at Nawagam and Navsari locations during *kharif* 2022 (Table-9 & 10). This finding was in accordance with Parmar *et al*. (2019).

Table 2 : Yield performance of IET-27208 (NWGR-13031) in the IVT-Aerobic AICRIP Trial

Year/ Season & Name of Trial	Zone	Location	IET-27208 (NWGR-13031)	CR Dhan 201 (NC) (a)	PA 6129 (HC) (b)	Zonal Check (c)	Local check (d)	C.D. at 5%	CV %
Kharif- 2017 IVT-Aero.	Zone-II	Ludhiana	2866	3390	3516	2940	4523	1026	17. 2
		Kaul	7100	5800	5650	4950	5450	1359	12.7
	Average		4983	4595	4583	3945	4987		
	% Inc. Over			8.4	8.7	26.3	-		
	Zone-III	Cuttack	5400	2975	5200	3800	4175	966	11.9
		Pusa*	2167	3167	2500	2500	2333	826	16.2
		Patna	2792	3940	3982	4123	3426	909	14.3
		Ranchi	5400	4650	6450	4700	4150	1308	16.7
		Vanarasi	5120	4560	6790	4640	4910	830	8.8
	Average		4678	4031	5605	4316	4165		
	% Inc. Over			16.1	-	8.4	12.3		
	Zone-V	Jagdalpur	4981	5846	6569	5500	4496	1316	13.1
		Rewa*	0267	-	1298	1046	-	600	23.1
		Raipur*	2634	2938	3003	2484	2837	718	16.9
	Average		4981	5846	6569	5500	4496		
	% Inc. Over			-	-	-	10.8		
	Zone-VI	Vyara*	1615	2945	3256	2136	1615	904	19.9
		Parbhani*	3102	2698	2924	2329	2036	456	8.9
	Average		2359	2847	3090	2232	1826		
	% Inc. Over			-	-	5.7	29.3		
	Zone-VII	Mandya	2539	3847	4082	3801	4360	946	14.5
	% Inc. Over			-	-	-	-		
Overall mean (8)			4525	4376	5280	4307	4436		
% Inc. Over				3.96	-	4.82	2.00		

* data were not considered in statistical analysis (IIRR Annual Progress Report 2017 Vol. I Varietal Improvement, pp. 1.293)

Table 3 : Yield performance of IET-27208 (NWGR-13031) in the AVT-I-Aero in Zone-III

Year/ Season	Name of Trial	Location (Zone-III)	IET-27208 (NWGR-13031)	CR Dhan 201 (NC) (a)	PA 6129 (HC) (b)	Zonal Check (c)	Local check (d)	C.D. at 5%	CV %
Kharif-2018	AVT- I –Aero.	Cuttack	4466	3518	4304	2149	3182	478	8.5
		Bikramgunj	6289	6489	9000	6067	6867	1154	10.2
		Pusa	2867	6667	4000	4200	4067	630	7.6
		Pantnagar	5500	5580	5597	5277	4603	652	7.7
		Ranchi *	1333	2444	3711	2844	2867	797	18.5
		Varansi *	3995	3293	5681	4252	3620	328	4.7
Mean			4781	5564	5725	4423	4680		
% Inc. Over the checks			-	-	-	8.1	2.2		

* data were not considered in Statistical analysis (IIRR Annual Progress Report 2018 Vol.I Varietal Improvement, pp. 1.464-1.465)

Table 4 : Ancillary observations of economic attribute of NWGR-13031 along with checks

Sr. No.	Characters	NWGR-13031	NAUR 1 (C)	GNR 8 (C)	GNR 3 (C)
1	DFF (days)	81.17 (70-87)	78.50 (67-86)	76.60 (67-82)	83.00 (78-93)
2	Days to Maturity	111.17 (100-117)	108.50 (97-116)	106.60 (97-112)	113.00 (108-123)
3	Plant height (cm)	114.83 (102-126)	107.00 (84-131)	126.00 (111-140)	119.80 (106-135)
4	Panicle length (cm)	24.15 (22-27)	25.40 (22-28)	25.02 (23-26)	24.92 (22-27)
5	No. of grains/ Panicle	148.00 (126-167)	154.50 (102-229)	148.00 (126-170)	152.00 (116-188)
6	No. of productive tillers/ Plant	**7.40 (6-9)**	6.40 (5-9)	5.30 (3-8)	6.00 (4-9)
7	Panicles/ m^2	**284.30 (229-365)**	201.00 (194-208)	200.30 (162-230)	260.00 (224-304)
8	Grain length (mm)	9.72 (9.64-10.0)	9.29 (9.00-9.72)	8.30 (8.00- 8.41)	9.18 (8.95-9.42)
9	Grain breadth (mm)	2.83 (2.70-2.97)	2.37 (2.22-2.53)	2.90 (2.83-3.00)	2.77 (2.63-2.89)
10	Grain L/B ratio	3.43 (3.27-3.70)	3.92 (3.66-4.38)	2.87 (2.80-2.95)	3.31 (3.10-3.58)
11	1000 grain wt. (g)	29.60 (28-33)	23.80 (22-28)	26.10 (25-27)	30.30 (30-31)
12	Grain classification	LB	LS	SB	LB
13	Aroma	Absent	Absent	Absent	Absent
14	Cooking	Good	Good	Good	Good

Note: Upper data are average value and value in bracket are range found in experiments during year 2019-2022

Table 5 : Bio-chemical parameters of NWGR-13031 along with checks

Sr. No	Character (Quality)	NWGR-13031	NAUR 1 (C)	GNR 8 (C)	GNR 3 (C)
1	HULL (%)	84.92	77.48	77.87	83.66
2	Mill (%)	71.10	65.17	61.67	66.08
3	HRR (%)	61.52	61.28	57.60	61.49
4	KL (mm)	6.12	6.12	5.17	6.13

5	KB (mm)	2.17	2.29	2.16	2.20
6	L/B ratio	2.82	2.67	2.39	2.79
7	ASV	4	4	6	3
8	VER	3.44	3.54	3.40	3.75
9	KLAC(mm)	9.5	9.3	8.3	9.7
10	KER	1.55	1.52	1.61	1.58
11	AC (%)	25.55	25.15	24.03	25.42
12	WU (ml)	405	410	420	425
13	Grain Chalkiness	VOC	VOC	VOC	VOC
14	Grain Type	LB	LB	SB	LB
15	Cooking	Good	Good	Good	Good

HULL: Hulling (%); Mill: Milling (%): HRR: Head Rice Recovery (%); KL: Kernel Length(mm); KB: Kernel Breadth (mm); L/B: Length and breadth ratio; Grain Chalk: Grain Chalkiness; VOC: Very Occasionally present; A: Absent; KLAC: Kernel Length after cooking; WU: Water uptake; VER: Volume expansion ratio; ASV: Alkali Spreading Value; AC: Amylose Content (%); MB: Medium Bold; SB: Short Bold.

Table 6 : Nutrient content of polished and unpolished rice of NWGR-13031 (mg/kg)

Sr. No.	Variety/ Genotype	Fe		Mn		Zn		Cu	
		Unpolished	Polished	Unpolished	Polished	Unpolished	Polished	Unpolished	Polished
1	NWGR-13031	22.95	7.03	15.69	9.79	31.89	18.22	4.20	3.51
2	NAUR 1	21.29	11.22	16.74	13.51	25.91	17.60	4.31	3.55
3	GNR 8	15.69	7.44	17.56	11.86	30.41	17.94	3.68	3.35
4	GNR 3	17.47	5.99	14.63	7.60	24.95	13.90	4.52	3.22

Table 7 : Biochemical properties of polished rice of NWGR-13031

Sr. No.	Variety/ Genotype	Moisture (%)	TSS (%)	Phenol (%)	ß-carotene (ppm)	Starch (%)	Total Carbohydrates	Protein (CP) (%)
1	NWGR-13031	9.41	2.02	0.141	1.08	67.05	70.37	8.06
2	NAUR 1	9.11	2.07	0.134	0.80	67.23	69.06	7.78
3	GNR 8	9.14	2.48	0.139	1.07	66.78	67.04	7.57
4	GNR 3	8.97	1.92	0.129	0.83	67.14	68.25	7.64

Table 8 : Popped rice recovery of NWGR-13031

Sr. No.	Name of Variety	Popped rice recovery (%)
1	NWGR-13031	71.47
2	NAUR 1	50.82
3	GNR 8	11.71
4	GNR 3	58.86

Table 9 : Rating of incidence of diseases at Nawagam and Navsari centres (Name of trial: Screening of advance breeding material against important diseases)

Diseases	Season / Year	Location	Varieties			
			NWGR-13031	NAUR 1 (C)	GNR 8 (C)	GNR 3 (C)
Bacterial leaf blight (BLB)	*Kharif* -2022	NWG	5	7	5	7
		NVS	5	5	5	5
	Range		5	5-7	5	5-7
			MS	MS	MS	MS
Leaf Blast (LB)	*Kharif* -2022	NWG	5	6	5	6
		NVS	4	4	4	5
	Range		4-5	4-6	4-5	5-6
			MR	MS	MR	MS
Neck Blast (NB)	*Kharif* -2022	NWG	3	5	3	7
		NVS	#	#	#	#
	Range		3	5	3	7
			MR	MS	MR	S
Sheath Rot (ShR)	*Kharif* -2022	NWG	5	5	3	7
		NVS	5	5	5	5
	Range		5	5	3-5	5-7
			MS	MS	MR	MS
Grain |Discolaration	*Kharif* -2022	NWG	3	5	3	5
		NVS	3	5	5	5
	Range		3	5	3-5	5
			MR	MS	MR	MS

#: Disease not appeared at Waghai location, *R= Resistant (<3), MR= Moderately Resistant (3-5), MS=Moderately Susceptible (5-7), susceptible (7-9)*
NWG: Nawagam, NVS: Navsari, NWG - Nawagam

Rating scale	Damage %				
	BLB(1-9)	LB (0-9)	NB (0-9)	ShR (0-9)	GD(0-9)
0	-	No lesion	No incidence	No incidence	No incidence
1	1-5	Pin point lesion	< 5	< 1	< 1
2	-	1-2 mm lesion	-	-	-
3	6-12	More no. of lesions	5-10	1-5	1-5
4	-	3 mm or large lession	-		
5	13-25	2-10% leaf area	11-25	6-25	6-25
6	-	11-25% leaf area	-	-	-
7	26-50	26-50% leaf area	26-50	26-50	26-50
8	-	51-75% leaf area	-	-	-
9	51-100	76-100% leaf area	>50	51-100	51-100
SES, IRRI Scale (2014)					

Note: The screening against bacterial leaf blight (BLB), leaf blast (LB) and neck blast (NB) was carried out under artificial inoculation conditions, while screening against sheath rot (ShR) and grain discoloration (GD) under natural conditions at Nawagam centre. Whereas at Navsari center the screening against bacterial leaf blight was carried out under artificial inoculation conditions, while for other diseases it was carried out under natural conditions.

Table 10 : Rating of incidence of insect-pests at Nawagam and Navsari centres (Name of trial: Screening of advance breeding materials against insect-pests)

Name of insect-pests	Season/ Year	Location	Varieties			
			NWGR-13031	NAUR 1 (C)	GNR 8 (C)	GNR 3 (C)
White backed plant hopper (WBPH)	*Kharif* - 2022	NWG NVS	3 #	3 #	3 #	3 #
		Range	3	3	3	3
			MR	MR	MR	MR
Stem borer	*Kharif* - 2022	NWG NVS	5 5	7 3	3 5	7 3
		Range	5	3-7	3-5	3-7
			MS	MS	MS	MS
Leaf folder	*Kharif* - 2022	NWG NVS	1 3	3 1	1 1	1 0
		Range	1-3	1-3	1	0-1
			R	R	R	R

#: Pest not appeared at Navsari location, R-Resistant (<3), MR-Moderately Resistant (3-5), MS-Moderately Susceptible (5-7), S- Susceptible (7-9), NWG: Nawagam, NVS: Navsari.

Damage scale

Damage scale (0-9)	No. WBPH/hill	% Damaged leaves (Leaf folder)	% White earheads (Stem borer)
0	0	0	0
1	<5	1-10	1-5
3	6-10	11-20	6-10
5	11-20	21-35	11-15
7	21-40	36-50	16-25
9	>41	51-100	26 and above
SES, IRRI Scale (2014)			

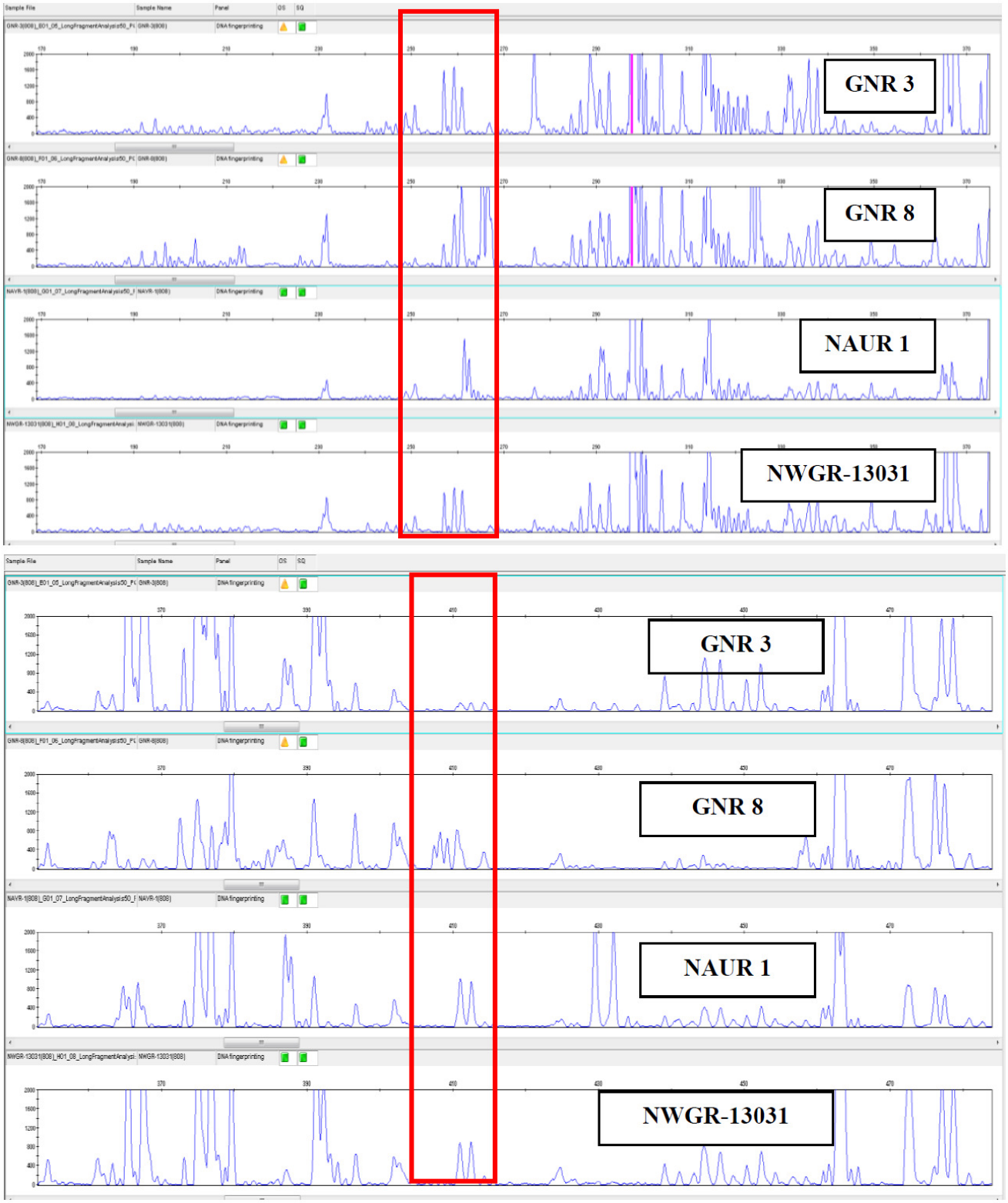

Fig. 2 : DNA fingerprinting Report of Rice genotype NWGR-13031 along with check NAUR 1, GNR 8 and GNR 3 generated by ISSR marker UBC-808

DNA fingerprinting using ISSR

The DNA fingerprinting profile of NWGR-13031 (GAR 201/Anand Akshat) was generated along with the check varieties NAUR 1, GNR 8 and GNR 3 using the ISSR marker UBC-808 at Biotechnology laboratory Department of Agricultural Biotechnology,

Anand (Figure-2). This showed that the variety GAR 201/Anand Akshat (NWGR-13031) was genetically different from its check varieties. The characterization of NWGR-13031 was done according to the Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on rice given by PPV & FR Authority, GOI, New Delhi (Table-11) had indicated its distinctness from other check varieties.

Table 11 : Distinguished Morphological characters of NWGR-13031 along with checks as per DUS Guidelines

Character	NWGR-13031	NAUR 1 (C)	GNR 8 (C)	GNR 3 (C)
Basal leaf: sheath colour	**Purple**	Green	Green	Purple
Leaf sheath: anthocyanin colouration	**Present**	Absent	Absent	Present
Leaf sheath: intensity anthocyanin colouration	**Weak**	-	-	Weak
Leaf: (*) pubescence of blade surface	**Medium**	Absent	Absent	Medium
Leaf: (*) anthocyanin colouration of auricles	**Purple**	Colourless	Colourless	Purple
Leaf: anthocyanin colouration of collar	**Present**	Absent	Absent	Absent
Leaf: shape of ligule	**Split**	Split	Split	Split
Leaf: colour of ligule	**White**	White	White	White
Flag leaf: attitude of blade	**Semi-erect**	Semi-erect	Erect	Semi-erect
Spikelet: density of pubescence of lemma	**Medium**	Weak	Medium	Medium
Panicle: length of main axis	**Medium**	Long	Medium	Medium
Panicle: curvature of main axis	**Semi-straight**	Semi-straight	Deflexed	Semi-straight
Spikelet: colour of tip of lemma	**Purple**	Yellowish	Brown	Brown
Panicle : secondary branching	**Strong**	Strong	Weak	Strong
Panicle: attitude of branches	**Semi-erect**	Semi-erect	Semi-erect	Erect
Grain: weight of 1000 fully developed grains	**Very high**	Medium	High	Very high
Decorticated grain: length	**Long**	Long	Short	Long
Decorticated grain: width	**Medium**	Medium	Broad	Medium
Decorticated grain: shape	**Long bold**	Long bold	Short bold	Long bold

Discussion

Considering the recommendation of the nineteenth meeting of Combined Joint Agricultural Research Council of the SAUs, and 54th meeting of the State Variety Release Committee (SSVC, 2023) has approved release of the NWGR-13031 as GUJARAT AEROBIC RICE 201 (GAR 201/Anand Akshat) for the irrigated direct seeded *i.e.* aerobic rice condition of the state. The proposal of this variety was further submitted to the Central Varietal Release Committee for its notification then it will be included in the Breeder Seed channel for the benefit of the farmers.

The variety GAR 201 (Anand Akshat) is highly suitable for dry direct seeded aerobic conditions with intermittent irrigation. Dry direct seeding is preferably during the second week of June to second week of July (with the onset of rain or with pre-sowing irrigation). Immediately after sowing, lifesaving irrigation should be ensured for uniform germination and crop establishment. Weed management is a big menace in aerobic rice. In order to resolve this, apply Pendimenthalin herbicide 30% EC @ 3.3-5.0 liter per hectare dusting after mixing with sand at field capacity moisture within 3 days of sowing. Further, it is recommended to apply Post Emergence, broad spectrum systemic herbicides like Bispyribac Sodium 10% SC @ 0.20-0.25 liter per hectare or the ready mix formulation of Triafamone 20% + Ethoxysulfuron 10% WG at field capacity moisture within 10-15 days of sowing. One or two intermittent weeding is recommended during vegetative growth period. Need based irrigation should be followed up to physiological maturity.

Conclusion

The variety Gujarat Aerobic Rice 201 (GAR 201/ Anand Akshat) has an advantage of 10-15 days (100-117 seed to seed duration) in comparison with transplanted rice and can yield up to 3500-4500 kg/ha subject to use under area of adaptation and recommended climate conditions and adaptation of package and practices. It is suitable for direct seeding of *kharif* season. Therefore, owing to its suitability under aerobic system of rice cultivation, high yielding performance under water limiting conditions, wider adaptability, multiple pest resistance and desirable grain quality traits, cultivation of GAR 201 (Anand Akshat) would stabilize rice yields in the state under constrained water resources.

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