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Development of High Yielding Deep Water Rice Variety MTU 1184 Suitable for Semi-Deep Flooded Ecosystem of South Eastern Region of India

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Abstract

In recent years due to heavy and intense rainfall and cyclonic storms, paddy crop is experiencing damage due to flooding. If the flood water stagnation remains for more than a week the varieties are unable to sustain and there by the yield levels are drastically reduced. Hence, there is a need to develop submergence tolerant variety to minimize the yield losses. Acharya NG Ranga Agricultural University (ANGRAU), Regional Agricultural Research Station, Maruteru has developed flood tolerant variety MTU 1184 through conventional plant breeding using PLA 1100 and BM 71 as parents. The flood tolerant rice culture was extensively evaluated for yield in semi deep water ecosystem at RARS, Maruteru over the years of *kharif*, 2012 to *kharif*, 2016 in Station yield trials. The variety recorded superior grain yield (4370 kg/ha) against check PLA 1100 (3811 kg/ha) and yield advantage over check was 14.67%. The entry was tested in AICRIP trials from 2014 to 2017 at RARS, Maruteru and the results revealed that MTU 1184 registered 4650 kg/ha and found to be significantly superior over the national check, Sabitha (3703 kg/ha) and the per cent increase over check was 25.57. The variety recorded a mean grain yield of 4281 kg/ha and found to be significantly superior over the national check, Sabitha (3011 kg/ha) and yield advantage was 1270 kg/ha and per cent increase over national check was 42.17 and zonal check Poornendu in 8 locations of six states of south eastern region. Multi location testing of the variety from 2015 to 2017 revealed that the variety has out yielded (5370 kg/ha) and found superior over the best check PLA 1100 (4290 kg/ha) and the per cent increase over check was 25.18. Minikit testing in 890 locations for a period of three years from 2016 to 2018 revealed that the average mean yield of the variety over three years was 6039 kg/ha against local popular check PLA 1100 (5700 kg/ha) and per cent increase over check was 6.0 when tested in Andhra Pradesh.

Key words: Deep water rice variety, MTU 1184, Stagnant flooding, High yield, Late duration

Introduction

Deep water rice ecosystem represents the flood-prone rice ecosystem where rice plant requires elongation ability to reach the surface with a certain amount of plant height to withstand in stagnant flood water condition. Low yield potentiality of locally adapted deep water cultivars limits the total rice production in the country (Hossain, 1996). Rice crop is being cultivated in varied ecologies to feed increasing population. Coastal rice ecosystems, covering more than 16% of rice areas worldwide (20×10^6 ha) are adversely affected by annual flooding (Krishnaiah *et al.,* 1996). Paddy fields in these flood-prone lowlands are subjected to either flash floods (few days to two weeks) or long-term flooding *i.e.*, semi-deep

water (30-50 cm). Rice is the staple food for more than three billion people in Asia, where more than 90% of the world's rice is produced and consumed (Li and Xu, 2007). In recent years, climate change is increasing the incidence of both types of floods and yield loss due to floods ranges from 10 to 100% depending on the cultivated variety, flood duration, depth and floodwater conditions. Continuous high rainfall in a short span leading to water logging causes inundation of paddy fields and lodging of the crop at grain filling and maturity stages causes huge losses to the farmer. Deep water rice ecosystem represents the flood-prone rice ecosystem where stagnant flood water occurred in a depth usually exceeds 100 cm and continues for longer period of time ranging from more than 10 days to five months (Maclean *et al.,* 2002). Further, flood is a recurrent phenomenon in coastal areas of Andhra Pradesh, Assam, Orissa, West Bengal, Kerala, Karnataka and South Gujarat. The problem is accentuated due to poor drainage and topography of the land which impedes fast drainage from crop lands (Yamuna and Ashwini, 2016) In general, the submergence exists up to 15 days which coincides with the vegetative stage of the crop at 30 days after transplanting and recedes later. If the flood water stagnation remains for more than a week, the varieties are unable to sustain and there by the yield levels are drastically reduced. Apart from improving drainage and other preventive measures, farmers can adopt flood tolerant varieties that can withstand inundation for an extended period and reduce the risk from flood damage (Bhuiyan, 2004). Deep water ecosystem has been classified into two types based on stature and depth of water, traditional tall and floating cultivars. Traditional tall cultivars are tall with long leaves and grown at water depths between 50 and 100 cm while floating rice is grown in 100 cm or deeper situations (Shalahuddin *et al.,* 2019). However, this rice required elongation ability to reach the surface, such as the one found in floating rice up to 5 m length (Bouman *et al.,* 2007) Deep water rice is cultivated in the flood plains and deltas of rivers such as the Ganges and Brahmaputra of India and Bangladesh, Myanmar, Vietnam and Cambodia, the Chao Phraya of Thailand, and the Niger of West Africa of these types requires specific adaptive traits, which require the development of unique varieties (Lafitte *et al.,* 2006). Though deep water rice is cultivated in small areas with low yield, attention should be given to develop high yielding deep water rice to maintain stable rice production (Ahmed *et al.,* 2016). Rice is grown in diverse ecologies from submerged lowland in Assam to the coastal saline regions of Kerala (Sreelakshmi *et al.,* 2023).

Materials and Methods

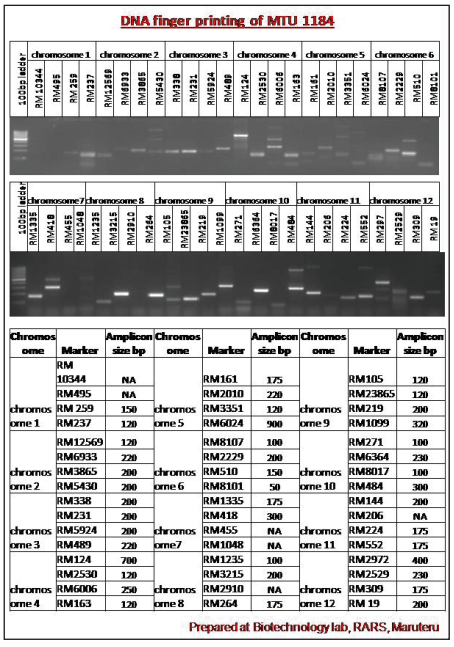
Many advanced breeding lines were developed by Acharya NG Ranga Agricultural University, Regional Agricultural Research Station (RARS), Maruteru. Among them flood tolerant genotype, MTU 1184 is an outcome of single cross between PLA 1100 and BM 71 with an objective to develop a semi deep water submergence tolerant rice variety. The pedigree of MTU 1184 is MTU 2060-1-1-1-1-1. Crossing was done in 2008 and developed through hybridization followed by pedigree selection. The local popular variety PLA 1100 was used as check for this study. The new variety, MTU 1184 with 150 days duration is tolerant to flash floods for 15 days at the tillering stage and suitable for stagnant flooding (50-60 cm) with good elongation ability possessing two weeks dormancy and good grain quality characteristics. It is a medium slender, brown glume, semi-tall plant type of 140-150 cm depending on water depth. The morphological description of the variety is given in **Annexure** and DNA finger printing was carried out by using different markers in **Plate 1** and field view in **Plate 2**.

Annexure: Description of the Variety MTU 1184

S. No	Characteristics	Description
1	Coleoptile: Colour	White
2	Basal Leaf: Sheath Colour	Green
3	Leaf: Intensity of Green Colour	Dark green
4	Leaf: Anthocyanin Colouration	Absent
5	Leaf: Distribution of Anthocyanin Colouration	Absent
6	Leaf Sheath: Anthocyanin Colouration	Absent
7	Leaf Sheath: Intensity of Anthocyanin Colouration	Absent
8	Leaf: Pubescence of Blade Surface	Weak
9	Leaf: Auricles	Absent
10	Leaf: Anthocyanin Colouration of Auricles	Absent
11	Leaf: Collar	White
12	Leaf: Anthocyanin Colouration Of Collar	Absent
13	Leaf: Ligule	Present
14	Leaf: Shape Of Ligule	Acute
15	Leaf Colour Of Ligule	White
16	Leaf: Length Of Blade	59
17	Leaf : Width Of Blade	1
18	Culm: Attitude(For Floating Rice Only)	Not applicable
19	Culm: Attitude	Erect
20	Time Of Heading(50% Of Plants With Panicles)	120
21	Flag Leaf: Attitude of Blade (Early Observation)	Erect
22	Spikelet: Density of Pubescence Of Lemma	Weak
23	Male Sterility	Absent
24	Lemma: Anthocyanin Colouration Of Keel	Absent
25	Lemma: Anthocyanin Colouration Of Area Below Apex	Absent
26	Lemma: Anthocyanin Colouration Of Apex	Absent
27	Spikelet: Colour Of Stigma	White
28	Stem: Thickness	Thick
29	Stem: Length (Excluding Panicle; Excluding Floating Rice)	118
30	Stem: Anthocyanin Colouration of nodes	Absent
31	Stem: Intensity Of Anthocyanin Coloration Of Nodes	Absent
32	Stem: Anthocyanin Coloration Of Internodes	Absent
33	Panicle: Length Of Main Axis	28.2 cm
34	Flag Leaf: Attitude Of Blade (Late Observation)	Erect
35	Panicle: Curvature Of Main Axis	Erect
36	Panicle: Number Per Plant	10
37	Spikelet: Colour Of Tip Of Lemma	Brown
38	Lemma And Palea: Colour	Brown
39	Panicle: Awns	Absent
40	Panicle: Colour Of Awns	Absent

S. No	Characteristics	Description
41	Panicle: Length Of Longest Awn	Absent
42	Panicle: Distribution Of Awns	Absent
43	Panicle: Presence Of Secondary Branching	Present
44	Panicle: Secondary Branching	Strong
45	Panicle: Attitude Of Branches	Semi erect
46	Panicle: Exertion	Well exerted
47	Maturity	150
48	Leaf Senescence	Moderate
49	Sterile Lemma colour	Present
50	Grain: Weight of 1000 Fully Developed Grains	16.19
51	Hulling (%)	77.5
52	Milling (%)	66.5
53	Head rice recovery (%)	67.0
54	Kernal length (mm)	4.91
55	Kernal width (mm)	1.97
56	L/B ratio	2.49
57	Grain type	Short bold
58	Chalkiness	Absent
59	Alakali spreading value	5.0
60	Gel Consistency	43
61	Amylose content (%)	24.55

Plate 1: DNA fingerprinting of MTU 1184



Chromosome	Marker	Amplicon size bp	Chromosome	Marker	Amplicon size bp	Chromosome	Marker	Amplicon size bp
	RM 10344	NA		RM161	175		RM105	120
	RM495	NA		RM2010	220		RM23865	120
chromosome 1	RM 259	150	chromosome 5	RM3351	120	chromosome 9	RM219	200
	RM237	120		RM6024	900		RM1099	320
	RM12569	120		RM8107	100		RM271	100
	RM6933	220		RM2229	200		RM6364	230
chromosome 2	RM3865	200	chromosome 6	RM510	150	chromosome 10	RM8017	100
	RM5430	200		RM8101	50		RM484	300
	RM338	200		RM1335	175		RM144	200
	RM231	200		RM418	300		RM206	NA
chromosome 3	RM5924	200	chromosome7	RM455	NA	chromosome 11	RM224	175
	RM489	220		RM1048	NA		RM552	175
	RM124	700		RM1235	100		RM2972	400
	RM2530	120		RM3215	200		RM2529	230
chromosome 4	RM6006	250	chromosome 8	RM2910	NA	chromosome 12	RM309	175
	RM163	120		RM264	175		RM 19	200

Barcode: A3B7C5D7E7F6G9H7I3J5K6L15 Unique allelles: RM

Field trials were performed under semi-deep water ecosystem in Randomized Block Design with three replications in three consecutive seasons from 2012 to 2014 in 50-60 cm deep water. The entry was tested in flash floods with a stagnant flooding of 60-65 cm for a period of 15-20 days from 2015-2017. All India Coordinated trials were conducted from 2014 to 2017 in seven states of Orissa (Bhuvaneswar, Cuttuck), West Bengal (Chinsurah), Uttar Pradesh (Ghaghraghat), Assam (Gerula), Bihar (Pusa), Karnataka (Sirsi) and Andhra Pradesh (Maruteru). Based on the superior performance of the entry in the Multi location testing when compared to best check PLA 1100 from *kharif,* 2015 to *kharif*, 2017, the culture was tested in minikit testing from *kharif*, 2016 to *kharif*, 2018 and per cent increase of yield over check was estimated. Land was well prepared in semi-dry condition. Sowing was done in second week of June and transplanting was done in the second week of July in each year. All recommended package of practices were followed as per schedule. When flood water or stagnant water

MTU 1184 (MTU 2060-1-1-1-1-1)

Field view at maturity

Field view at grain filling

Paddy, brown rice and rice kernel after cooking

Plate 2: Field view of MTU 1184 and paddy brown rice and rice

depth was more than 50 cm, urea application was avoided.

Evaluation of Agronomic traits: The data on plant height, days to 50% flowering, days to maturity, number of panicles/m^2, grain yield, grain type and test weight were recorded in accordance with Standard Evaluation System (SES., 2002). Growth duration was counted from the date of sowing to grain maturity. Grain yield was estimated from eight to ten square meter sample plot for each replication.

Screening for submergence and other important adaptability traits: The seed material was raised in raised bed nurseries and 30 days old seedlings were submerged in submergence ponds for 15 days. Then the water was drained out and the plants were kept for recovery. The plants were scored for submergence tolerance and survival per cent was recorded as per standard evaluation system for rice. The genotype was scored for adaptability parameters of elongation ability, kneeing ability, grain shattering and phenotypic acceptability based on SES system (SES., 2002).

Results and Discussions

The flood tolerant rice variety was extensively evaluated for yield in semi-deep water ecosystem at RARS, Maruteru over the years of *kharif*, 2012 to *kharif*, 2016 in station yield trials The variety recorded superior grain yield (4370 kg/ha) against check PLA 1100 (3811 kg/ha) and yield advantage over check was 14.67 percent (**Table1**).

The culture was tested in AICRIP trials from 2016 to 2017 at RARS, Maruteru and the results revealed that the culture registered 4650 kg/ha and found to be significantly superior over the national check, Sabitha (3703 kg/ha) and the per cent increase over check was 25.57 (**Table 2**).

Table 1: Performance of MTU 1184 in Station trials at RARS, Maruteru

Name of the Trial	Code/ IET No	Year of testing	Entry	Check (PLA 1100)	Percentage increase over check	Remarks
			Grain yield (kg/ha)	Grain yield (kg/ha)		
OYTSDW	ADW 59	*Kharif,* 2012	5330	4988	6.86	Yield under
PYT SDW	BDW 55	*Kharif,* 2013	4105	3878	5.85	Water depth
AYT SDW	CDW 69	*Kharif,* 2014	3968	3680	7.83	20-50 cm
AYT submergence	CSB 16	*Kharif,* 2016	4077	2697	51.16	Flash floods+ Stagnant flooding 60-65 cm
Mean under stress			**4370**	**3811**	**14.67**	

Table 2: Performance of MTU 1184 (IET 24486) in AICRIP trials at RARS, Maruteru

AICRIP trials						
Name of the Trial	**Code/ IET No**	**Year of testing**	**Entry MTU 1184**	**Sabitha National Check**	**Percentage increase over check**	**Remarks**
			Grain yield (kg/ha)			
AVT 1 SDW	IET No 24486	*Kharif* 2016	5994	4185	43.22	4820 kg/ha over all mean across the locations under semi deep water situation
AVT2 SDW	24486	*Kahrif* 2017	4881	4295	13.64	Performed well in AP
Mean yield under stress			**4650**	**3703**	**25.57**	**Under floods**

The culture was tested in AICRIP trials in six states and the results revealed that the entry registered 3818 kg/ha and was found to be significantly superior over the national check, Sabitha (2852 kg/ha) and zonal check Purnendu (2871 kg/ha). Per cent increase over National check was 33.87 and zonal Check was 32.99 (**Table 3**).

Table 3: Performance of MTU 1184 (IET 24486) in AICRIP trials across locations (2014) in National Semi Deep Water Screening Nursery

State	Location	IET 24486	NC Sabitha	ZC Purnendu	CD (0.05)	CV (%)
Orissa	BBN	5185	1235	2531	858	15.8
Orissa	CRR	2403	2963	3628	1223	17.78
WB	CHN	2924	4971	3728	439	5.38
UP	GGT	2800	2320	1120	742	13.5
ASSAM	GAR	4851	4386	4417	881	10.41
AP	MTU	4746	1235	1802	621	12.97
	Mean	3818	2852	2871		
	Yield advantage		**967**	**947**		
	% increase over checks		**33.87**	**32.99**		

The entry was tested in AICRIP trials in six states and the results revealed that the entry registered 4113 kg/ha and found to be significantly superior over the national check, Sabitha (3210 kg/ha) and zonal check Purnendu (3146 kg/ha). Per cent increase over national check was 28.13 and zonal check was 30.73 (**Table 4**).

Table 4: Performance of MTU 1184 (IET 24486) in AICRIP trials across locations 2015 in IVT

State	Location	IET 24486	NC	ZC	CD (0.05)	CV (%)
Orissa	BBN	6173	2099	2593	589	8.42
Orissa	CTK	4019	2908	1623	754	14.01
Bihar	PSA	2000	2357	2929	833	22.56
Up	GGT	3267	2567	2233	543	11.25
Assam	GAR	3427	3468	3049	618	12.41
Assam	NLP	4103	3977	4387	897	12.68
AP	MTU	4114	3211	3146	286	13.23
KA	SRS	5807	5100	5208	820	9049
	Mean	4113	3210	3146		
	Yield advantage		903	967		
	% increase over Check		28.13	30.73		

The entry was tested in AICRIP trials in six states and the results revealed that the entry registered 4820 kg/ha and found to be significantly superior over the national check, Sabitha (3120 kg/ha) and zonal check Purnendu (3150 kg/ha). Per cent increase over National check was 54.46 and zonal Check was 53.00 (**Table 5**).

Table 5: Performance of MTU 1184 (IET 24486) in AICRIP trials across locations in 2016 in AVT 1

State	Location	IET 24486	NC	ZC	CD (0.05)	CV (%)
Orissa	BBN	5391	2305	2140	1240	21.29
WB	CHN	4167	3712	3384	744	9.57
UP	GGT	2933	2189	2978	289	6.15
Assam	GER	5614	4654	4067	699	8.6
AP	MTU	5994	2742	3182	1135	14.29
	Mean	**4820**	**3120**	**3150**		
	Yield advantage		**1699**	**1670**		
	% increase over check		**54.46**	**53.00**		

The entry was tested in AICRIP trials in four states and the results revealed that the entry registered 4376 kg/ha and found to be significantly superior over the national check, Sabitha (2863 kg/ha) and zonal check Purnendu (2771 kg/ha). Per cent increase over National check was 52.85 and zonal Check was 57.93 (**Table 6**).

Table 6: Performance of MTU 1184 (IET 24486) in AICRIP trials across locations in 2017 in AVT2

State	Location	IET No 24486	Sabitha (NC)	Purnendu (ZC)	C.D. 5%	C.V.%
Orissa	CTK	3599	1583	1546	297	5.44
Orissa	BBN	5147	2778	2574	1240	19.15
West Bengal	CHN	4741	4296	4185	520	6.38
Assam	GGT	3511	3144	2956	483	7.80
AP	MTU	4881	2513	2593	588	10.99
	Mean	**4376**	**2863**	**2771**		
	Yield advantage kg		**1513**	**1605**		
	% increase over check		**52.85**	**57.93**		

The variety was tested in AICRIP trials from 2014 to 2017 over all mean performance of the variety in eight locations of six states of Orissa (Bhuvaneswar, Cuttuck), Bihar (Pusa), Uttar Pradesh (Ghaghraghat), Assam (Gerua, North Lakhimpur) Karnataka (Sirsi) and Andhra Pradesh (Maruteru) was presented in **Table 7**. The variety recorded a mean grain yield 4281 kg/ha and found to be significantly superior over the national check, Sabitha (3011kg/ha) and yield advantage was 1270 kg/ha and per cent increase over national check was 42.17 and zonal check Poornendu (1297 kg/ha and 43.46 respectively).

Multi location testing of the variety from 2015 to 2017 revealed that the variety has out yielded (5370 kg/ha) and found superior over Check PLA 1100 (4290 kg/ha) and per cent increase over check was 25.18 when tested in different locations **(Table 8)**.

Table 8: Performance of MTU 1184 under Multi location Yield Trials (MLTs)

Name of the Trial	Code/ IET No	Year of testing	Entry	PLA 1100 (Check)	Percentage increase over check	Remarks
			Grain yield (kg/ha)	Grain yield (kg/ha)		
MLT (I year)	L516	*Kharif* 2015	5376	4531	18.64	Normal condition
MLT (II year)	S32	*Kharif* 2017	5364	4048	32.51	Normal condition
MEAN			5370	4290	25.18	

The variety was tested in minikit in 890 locations for a period of three years from 2016 (245 locations), 2017 (350 locations) and 2018 (295 locations) and the average mean yield of the variety over three years was 6039 kg/ha against local popular check PLA 1100 (5700 kg/ha) and per cent increase over check was 6.0 when tested in Andhra Pradesh (**Table 9**).

Table 9: Compiled performance of three years in minikits

S. No	Year	No. of locations	Average minikit yield (kg/ha)	Check average yield (kg/ha)	Aver-age% increase
1	2016	245	6241	5883	6.10
2	2017	350	6154	5814	5.86
3	2018	295	5721	5404	5.86
Average		**890**	**6039**	**5700**	**6.00**

Table 7: Overall Mean Performance of MTU 1184 (IET 24486) for Grain Yield (Kg/ha) in AICRIP Trials from 2014-2017

S. No.	Year of study	Mean performance in Eight locations MTU 1184 (IET 24486)	Sabitha (National Check)	Purnendu (Zonal check)	Yield Advantage over NC	Yield Advantage over ZC	Per cent increase over National check	% increase over Zonal check
1	2014	3818	2852	2871	967	947	33.89	32.99
2	2015	4113	3210	3146	903	967	28.13	30.73
3	2016	4820	3120	3150	1699	1670	54.46	53.00
4	2017	4376	2863	2771	1513	1605	52.85	57.93
Overall Mean		**4281**	**3011**	**2984**	**1270**	**1297**	**42.17**	**43.46**

Conclusion

The performance of the variety in station yields trials, AICRIP trials, multi-location trials and minikit testing over 890 locations showed that the significant superiority of the variety performance not only in Andhra Pradesh but also in six states of coastal regions of India. It has good adaptability parameters of tillering ability, kneeing ability, elongation ability in deep water conditions, low grain shattering and good phenotypic acceptability. It has dark green foliage possessing long panicles with medium slender brown glume with semi-tall plant type of 140-150 cm depending upon water depth. It has good grain quality having translucency with grain length 5.28 mm, L/B ratio 2.5, milling 78% and head rice recovery 67%. In future, the new flood tolerant rice variety MTU 1184 could secure stable rice production in country's flood prone areas.

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References

Ahmed MME, Robin AH and Hosssain AM. 2016. Morphological Characterization of deep-water rice genotypes. *Agriculture and Food Science Research*, 3(2): 59-65.

AICRlP Hyderabad. 1970-96. Progress Reports, 1970 to 1996. All-India Co-ordinated Rice Improvement Project, Hyderabad, Andhra Pradesh.

Bhuiyan LS. 2004. Rice research and development in the flood-prone ecosystem. *International Rice Research Institute.* p. v. ISBN 978-971-22-0197-4.

Bouman BAM, Humphreys E, Tuong T P and Baker R. 2007. Rice and Water. Advanced Agronomy, 92:187-237.

DRR Hyderabad. 1986-95. Research Highlights, 1986-96. Directorate of Rice Research, Hyderabad, Andhra Pradesh.

DRR Hyderabad. 1995-96. Research Highlights. Directorate of Rice Research, Hyderabad, Andhra Pradesh.

DRR Hyderabad. 1996-97. Annual Reports. Directorate of Rice Research, Hyderabad, Andhra Pradesh.

Hossain M. 1996. Rice economy in India: Achievements, Challenges and Implications for Technology Development Research. IRRI-India Dialogue, New Delhi.

Krishnaiah K, Janaiah A, Kundu DK, Rao AV and Ramesh C. 1996. Productivity Trends of Rice in Intensively Farming Systems in India. Expert Consultation on Technology. Evaluation and Impact for Sustainable Rice Production in Asia and the Pacific, Bangkok, Thailand. pp. 29-31.

Lafiite RA Ismail and Bennett J. 2006. Abiotic stress tolerance in tropical rice: Progress and future, *Oryza*, 43(3): 171-186.

Li ZK and Xu JL 2007. Breeding for drought and salt tolerant rice (*Oryza sativa* L.): progress and perspectives. *In:* Jenks MA *et al.,* (eds) Advances in molecular breeding toward drought and salt tolerant crops. Springer, USA, pp. 531-564

Maclean JL, Dawe DC, Hardy B and Hettel GP, 2002. Rice Almanac. International Rice Research Institute, Los Banos; West Africa Rice Development Association, Bouake; International Center for Tropical Agriculture, Cali; Food and Agriculture Organization, Rome.

SES IRRI. 2002 Standard Evaluation System. International Rice Research Institute, Manila, Phillippines, pp.11-30.

Shalahuddin AKM, Masuduzzaman ASM, Ahmed MME, Aditya TL and Kabir MS. 2019 Development of High Yielding Deep Rice Variety BRRI Dhan 91 for Semi-Deep Flooded Ecosystem of Bangladesh. *Bangladesh Rice Journal,* 23(1): 57-63. doi.org/1.3329/brj.v23il.46081.

Sreelakshmi Ch, Ramesh Babu P, Krishna Naik R, Vineetha U, Madhusudhan P, Paramasiva I, Haritha PN, Rajasekhar P and Suryanarayana Y. 2003. NLR 3186: A long duration blast resistance rice culture suitable for irrigated ecology of Andhra Pradesh. *Journal of Rice Research*, 16(1): 109-115.

Yamuna BG and Ashwini M. 2016. Deep water rice cultivation: An Overview Progressive Research-*An International Journal Volume II,* (Special-V11): 4817-482.