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RESEARCH ARTICLE

High Yielding and Lodging Resistant Rice Variety Developed for Medium and Up-land Ecology

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Abstract

Hailstorms and violent thunderstorms are common during grain filling and maturity stages of *Boro* rice in West Bengal, Bihar, and Odisha, and it cause lodging, leading to pre-harvest sprouting and reduced grain yield. In view of the importance of the requirement of lodging-resistant rice genotypes, an effort was made to develop lodging-tolerant rice genotype. A dwarf variety was developed through the pedigree method of breeding. The variety was tested under AICRIP and subsequently released for cultivation in West Bengal. The average plant height of the variety was 87.0 cm, and was found to be highly lodging tolerant. The average grain yield was 5885.00 kg/ha with short, bold grain. Head rice recovery was 63.60%. As the variety is dwarf, no stables remain in the field after harvest. This is the added advantage for cultivation where the straw burning is outlawed. To characterize the DNA level, a total of 29 SSR markers were used with standard varieties. In a nutshell, the variety is suitable to cultivate in storm prone areas in up and medium land situations.

Keywords: Uttar Samir, Dwarf variety, Medium duration, Lodging tolerant, High yield potentiality

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Introduction

Rice is the major staple food for the people of Asia, Africa, and Latin America. Its popularity gradually increased in North America, Australia, and Europe. Rice contributes about 40% of the food grain production of India. The food grain production of India during 2022-23 was 239 million tonnes.

Rice in India is grown in three seasons: *Aus* (February-March to July-August), *Aman* or winter rice (June-July to November-December) and *Boro* or summer rice (November-December to May-June). *Boro* is the word derived from the Sanskrit '*Borob*,' meaning a special type of rice cultivation on residual or stored water in low-lying areas after the harvest of *Kharif* rice. *Boro* rice is cultivated in an area where the water retention capacity of soil is high as it requires irrigation. With improvement in irrigation facilities, *Boro* rice is now being cultivated in areas outside of its outmoded boundaries. The area under *Boro* rice is more than 3.0 million ha in India. Its productivity is much higher than the *Kharif* rice (Anonymous, 2009; Samanta *et al*., 2004; Lal *et al*., 2013), averaging 3.0 t/ha. Productivity in West Bengal and Assam is more than 3.5 t/ha. Accordingly, *Boro* production has a significant contribution to the production of rice in West Bengal.

Physiological maturity of *Boro* rice attains during the month of May in northern part and during April-May in the southern part of West Bengal. During the hot weather period spanning from April-June, regions in the Indo-Gangetic plains' states such as West Bengal, Assam, Bihar, and parts of Odisha, including Bangladesh,

witness violent thunderstorms that are locally known as Kal-Baishaki. The Kal-Baishaki and *Boro* rice grain maturity often coincide, which may cause lodging of rice and leading to partial crop losses. Cultivation of HYVs of rice is more beneficial compared to local rice (Singh *et al*., 2016). However, most of the modern HYVs suitable for this season are semi-dwarf to semi-tall type. Considering the importance of the Kal-Baishaki in the eastern part of the country, an attempt was made to develop a lodging-tolerant *Boro* rice variety with high yield potential.

Materials and Methods

Development of the Breeding Line

Uttar Samir (IET 26453) was developed through hybridization between Annada and Gontra Bidhan-1, followed by selection (Figure 1). Annada is a short-duration variety (110–112 days) recommended for rainfed upland ecosystems. Grain is short, bold, moderately resistant to blast and sheath blight, and susceptible to bacterial leaf blight, gall-midge, and brown plant hopper. It is medium-tolerant to lodging with a plant height of 85 to 90 cm (https://icar-nrri.in/released-varieties/). Gontra Bidhan-1 was developed through pure line selection, and it was selected from farmers' fields (Mitra *et al*., 2014). It is of medium duration and can be grown in both *Boro* and *Kharif* seasons. The plant height of Gontra Bidhan-1 is 95 to 100 cm, semi-dwarf, short, bold grains, tolerant to sheath blight and sheath rot, and moderately resistant to brown plant hopper. However, it is susceptible to lodging under hailstorms. It has the yield potentiality of 5 to 6 t/ha however, it is susceptible to neck blast.

Hybridization was done during *Kharif*, 2007 and selection continued till F_6. Based on plant and panicle traits and yield potential, an advanced line has been isolated and designated as PUR-B-36. This line carried forward for yield trials. Preliminary yield trials and purification were done for six consecutive *Boro* and six *Kharif* seasons at Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar (Figure 1). The line was nominated for IVT-*Boro* during 2016-17.

Yield Trials

Uttar Samir was tested in the All India Coordinated Rice Improvement Project under a multi-location trial for consecutive *Boro* seasons against four checks, namely

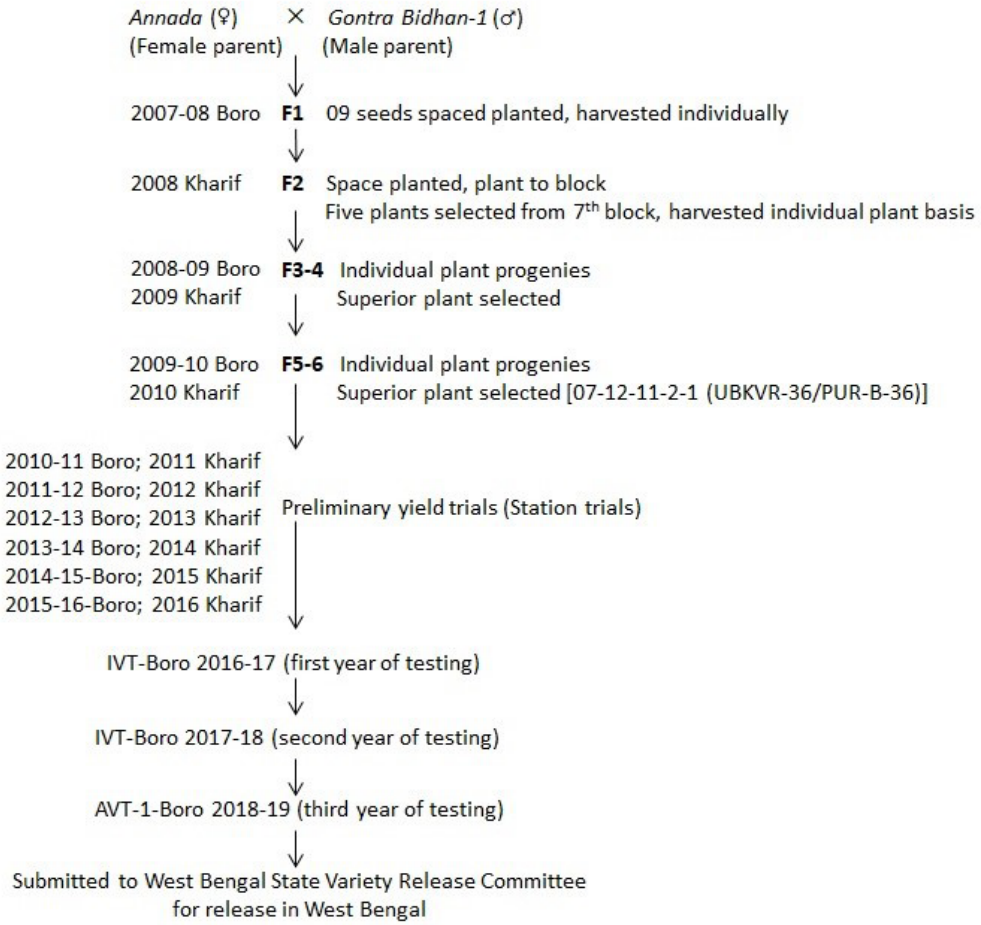

Figure 1: Flow chart of development of the variety, Uttar Samir

Gautam, IR-64, Rajlaksmi (hybrid check) and local checks of every location. It was tested in 12 locations in six states (AICRIP, Progress Report, 2017, 2018 & 2019). Based on the considerably better performance (10% yield advantage over check) in three consecutive seasons of trials by ICAR-AICRIP, the entry was considered by the State Variety Release Committee (West Bengal) for wide-scale adoption in the states of West Bengal. Consequently, the entry was accepted for release by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties. It was notified in The Gazette of India [S.O. 4065(E), dated 31st August 2022].

Agronomic Trial

A field experiment was conducted during *Boro* 2016-17 at the instructional farm to study the performance of Uttar Samir under various nutrient management options. The experiment was fitted out in a split-plot design with three replications. The experiment comprised six genotypes in the main plots and five different NPK doses (N, P_2O_5, and K_2O @ F1: 160:80:80 kg/ha; F2: 120:60:60 kg/ha; F3: 100:40:40 kg/ha; F4: 60:40:40 kg/ha; F5: No fertilizer) were assigned in the subplots. Nitrogen was applied in three splits, one fourth as basal, half at 25 days after transplanting, and the remaining one-fourth applied at 45 days after transplanting. The full dose of phosphorus was used as basal at the time of final land preparation and potassium was applied in two splits two third as basal and one-third at 45 days after transplanting. Standard agronomic and plant protection measures have been taken for all the genotypes.

Lodging Resistance

The lodging resistance ability of the genotypes (Uttar Samir, Annada, PU-B-154 and Uttar Sona) was measured following the method as outlined by Tarro *et al*. (2011). One healthy tiller from a hill was selected and the angle was measured considering the perpendicular line with field before bending. The tiller was then bent to the soil and released instantly to return back and the angle was measured when the tiller came back upward. The difference of the angle before bending and after bending was calculated. The experiment was conducted during *Boro* 2023-24.

DNA Fingerprint

DNA fingerprinting was performed to characterize Uttar Samir along with its parents and other checks. DNA was extracted from leaves following the standard CTAB method as described by Xu *et al*. (2005). A total of 29 SSR markers located across the 12 chromosomes of rice were used for the DNA fingerprinting of Uttar Samir with standard varieties, namely IR 64, Annanda and Goutam. Scoring of SSR markers was done with 0 or 1 matrix in case of absence or presence of the observed alleles, respectively.

Results and Discussion

Yield Performance under AICRIP Trials

The number of panicles per m^2 was 317 and it took 123 days to reach 50% flowering during *Boro* season under a multi-location trial of the All India Coordinated Rice Improvement Project of ICAR-IIRR, Hyderabad (Table 1). Uttar Samir is an exceptionally dwarf variety (Figure 2A, B & C), showing an average plant height of 81.0 cm and exceedingly lodging tolerant.

The results (Table 2) revealed that Uttar Samir recorded a grain yield of 5463.5 kg/ha, accounting for about 1.78 to 41.45% higher than the National check variety, IR 64 (5368.0 kg/ha), and the local check variety (3862.50 kg/ha) under the Coordinated Trial, IVT conducted during *Boro*, 2016-17 while yield estimation was done over two locations. The entry recorded required yield superiority over the best varietal check in Zone IV (Odisha, Bihar, Jharkhand, Uttar Pradesh, and West Bengal); thus, it was promoted to the second year of testing (AICRIP, 2017).

Figure 2: Field photographs of Uttar Samir. A&B) Single plant view; C) Comparative height; D) Adopted by the farmers

Table 1: Plant height, days to 50% flowering and number of panicles/m^2 as recorded by Uttar Samir in IVT-*Boro*, 2016-17, IVT-*Boro*, 2017-18 and AVT-1-*Boro*, 2018-19

Characters	*Boro*, 2016-17	*Boro*, 2017-18	*Boro*, 2018-19	*Mean*
Plant height (cm)	87.00	78.00	78.00	81.00
Days to 50% flowering	135.00	120.00	113.00	122.67
No. of panicles/m^2	311.00	349.00	292.00	317.33

Table 2: Performance of Uttar Samir in respect to grain yield under the Coordinated Trials, namely, IVT (*Boro*, 2016-17 as the first year of testing), IVT (*Boro*, 2017-18 as a second year of testing) and AVT-1 (*Boro*, 2018-19 as third year of testing)

Coordinated trials along with seasons & checks	*Grain yield (kg/ha)*			
	West Bengal	*Tripura*	*Mean over two locations*	*% increase in yield in IET 26453 over checks*
IVT (*Boro*, 2016-17)				
IET 26453	4000	6927	5463.50	-
IR 64 (NC)	5739	4997	5368.00	1.78
Goutam (RC)	6458	5079	5768.50	-
Local check	4708	3017	3862.50	41.45
IVT (*Boro*, 2017-18)				
IET 26453	7575	5235	6405.00	-
IR 64 (NC)	5225	4224	4724.50	35.57
Goutam (RC)	5375	3984	4679.50	36.87
Local check	6675	4063	5369.00	19.30
AVT-1 (*Boro*, 2018-19)				
IET 26453	5133	6159	5646.00	-
IR 64 (NC)	4667	7092	**5879.50**	-
Gautam (RC)	4467	5141	**4804.00**	17.53
Local check	4067	7293	**5680.00**	-
Mean yield of IET 26453	-	-	5838.17	-

NC: National Check, RC: Regional Check, IVT: Initial Varietal Trial, AVT: Advance Varietal Trial

Uttar Samir also recorded the highest grain yield of 6405.0 kg/ha, accounting for about 19.30 to 36.87% higher over all other check varieties (4679.5–5369.0 kg/ha) under the Coordinated Trial, IVT conducted during *Boro*, 2017-18 irrespective of locations. On a zone basis, the Uttar Samir recorded required yield superiority over the best varietal check in Zone III (Assam, Manipur, and Tripura) and Zone IV (AICRIP, 2018) and was promoted for the third year of testing.

Uttar Samir recorded a grain yield of 5646.0 kg/ha, accounting for about 17.53% higher than the regional check variety, Gautam (4804.0 kg/ha), when tested in the Coordinated Trial, AVT-1 conducted during *Boro*, 2018-19 while yield estimation was done over two locations. In a nutshell, Uttar Samir exhibited a considerable yield advantage over checks in West Bengal. Consequently, it was released by the 'State Variety Release Committee' for West Bengal.

Agronomic Trial

The results (Table 3) revealed that Uttar Samir recorded the highest grain yield of 6.30 t/ha under the application of N : P_2O_5: K_2O @ 120 : 60: 60 kg/ha and it was significantly superior to all the other NPK combinations (3.10–6.00 t/ha). Hence, a nutrient dose of N: P_2O_5:K_2O @ 120: 60: 60 kg/ha may be recommended for Uttar Samir to achieve higher productivity during *Boro* season in West Bengal.

Reaction to Biotic

Uttar Samir showed a disease reaction scale value of '0' with respect to PB, LB, SR, BLB, RTD, and SB infection, indicating its highly resistance reaction against those diseases. On the other hand, it showed a disease reaction scale value of '1' in respect of brown spot infection indicating its resistance reaction against brown spot. Uttar Samir did not show any incidence of BPH, WBPH, GM, LF, WM, and SB.

Resistant to Lodging

Frequent hailstorms (Kal Baisakhi) and violent thunderstorms are common during grain filling and maturity stages of *Boro* rice in West Bengal, Bihar and Odisha. Kal Baisakhi occurs during the transition from spring to summer. Kal Baisakhi is a

Table 3: Grain yield as influenced by different genotypes, including Uttar Samir grown under different levels of N, P_2O_5 and K_2O during *Boro*, 2016-17

Rice genotypes	*Yield (t/ha)*					
	F1	*F2*	*F3*	*F4*	*F5*	*Mean*
Uttar Lakshmi	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
Uttar Samir	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**	-
	F		V		VF	
CD (5%)	0.60		0.25		0.27	

F1: 160:80:80; F2: 120:60:60; F3: 100:40:40; F4: 60:40:40; F5: No fertilizer.

series of intense thunderstorms that bring heavy rain, strong winds, and sometimes hail. They are a regional phenomenon in the Gangetic plains of India. The storms originate from the Chota Nagpur Plateau and can cause significant damage to life and property. The strong thunderstorms cause lodging that leads to pre-harvest sprouting and reduced grain yield. In view of the importance of the requirement of lodging-resistant genotypes, an effort was made to develop a lodging-tolerant rice genotype for cultivation during the *Boro* season.

The plant height of Uttar Samir was 81.0 cm. According to PPV&FRA (2007), it is categorized as 'Very Short (<91 cm)'. Plant height is one of the key factors of the morphological traits for determining lodging resistance in rice plants (Shah *et al*., 2019). Anna Durai *et al*. (2015) also stated that the main stem plays an important role in the lodging resistance and may offer scope for improving taller genotypes. Further, Zhang *et al*. (2016) stated that the longer elongated basal internodes were responsible for higher plant height, leading to a higher lodging index. Surge *et al*. (2018) identified five farmers' varieties with very short stem lengths. In general, short to medium plant height is preferred as this makes easy all the intercultural activities. In addition, short-height rice varieties are usually considered lodging-resistant (Surje *et al*., 2018).

The visual lodging rate of Uttar Samir was 'zero' (Table 4) and it was found to be highly tolerant to lodging. Torro *et al*. (2011) also suggested visual estimation of plots for lodging resistance. Thunderstorms, even during the grain maturity stage of Uttar Samir, could not cause any lodging due to the strong culm and dwarf structure (81.00 cm) of the variety.

The method of Tarro *et al*. (2011) was followed to estimate the tiller angle difference. One healthy tiller was selected and the angle considering the perpendicular line with field plan before bending. The tiller was then bent to the soil and released instantly to return back and the angle was measured when the tiller came back upward. The difference of the angle before bending and after bending was calculated. The rice genotypes that showed no visual lodging had low values for tiller angle difference (Table 4). PUR-B-154 had the highest value for tiller angle difference (32) and this genotype had 56% of visual lodging. The tiller angle difference appeared to be as good estimator of the lodging resistance of rice genotype (Ookawa and Ishihara, 1992; Tarro *et al*., 2011).

Rice Straw Burning in the Field

The results (Table 1) indicated that Uttar Samir showed an average plant height of 81.0 cm. As the plant of this variety is very short, very negligible straw residues remain in the field. However, for semi-dwarf varieties of rice, the quantity of straw residues that remain in the field is huge. Due to the short period between harvesting and sowing, the burning of rice straw in Punjab, Haryana, and Uttar Pradesh is common in practice. Large-scale burning of rice residues is a severe problem that emits greenhouse gases while polluting the air, posing health problems and eliminating micronutrients from burned-out fields (Parihar *et al*., 2023; Kadian *et al*., 2024). As the plant height of this variety was very short, negligible straw remains in the field after harvest. This is the added advantage for cultivation where the straw burning is outlawed.

Table 4: Lodging, plant height and tiller angle difference of the rice genotypes

Variety	*Lodging (%)*	*Plant height (cm)*	*Tiller angle difference*
Uttar Samir	0	81	11
Annada	0	104	15
PUR-B-154	56	109	32
Uttar Sona	0	106	13

Qualitative Characters

Qualitative characters were collected from the AICRIP Progress Report (2018 and 2019), Vol. 1, Varietal Improvement. The results (Table 5) revealed that Uttar Samir showed milling, hulling and head rice recovery of 79.25, 69.95, and 63.60%, respectively, over different years. Based on kernel length, breadth and L:B ratio, it may be concluded that Uttar Samir is a rice genotype of Short Bold grain type. The grain chalkiness of Uttar Samir was found occasionally. The said entry showed an alkali spreading value of 4.0, amylose content of 25.09%, gel consistency of 22.00 mm and test weight of 20.60 g.

DNA Fingerprinting

A total of 29 SSR markers were used for the DNA fingerprinting of Uttar Samir with standard varieties, namely IR 64, Annanda and Goutam. Out of which, 15 markers (53%) were found

Table 5: Quality characteristics of Uttar Samir along with the national and regional checks

Characters	*IET 26453 (Uttar Samir)*	*IR64 (NC)*	*Goutam (RC)*
Hulling (%)	79.25	76.87	79.43
Milling (%)	69.95	66.47	68.93
Head rice recovery (%)	63.60	55.47	59.30
Kernel length (mm)	4.74	6.43	5.43
Kernel breadth (mm)	2.18	1.98	2.07
Length and breadth ratio	2.17	3.24	2.62
Grain type	SB	LS	MS
Grain chalkiness	OC	VOC	VOC
Alkali spreading value	4.0	4.33	7.0
Amylose content (%)	25.09	22.95	24.46
Gel consistency (mm)	22.00	36.33	52.33
Test weight (g)	20.60	-	-

SB: Short Bold; MS: Medium Slender; LS: Long Slender; VOC: Very Occasionally Chalkiness; OC: Occasionally Chalkiness

polymorphic and 13 markers were monomorphic (47%). Out of 15 polymorphic markers, one marker (RM10022) showed based allelic polymorphism, whereas remaining 14 markers (RM114, RM159, RM165, RM172, RM195, RM250, RM256, RM288, RM 291, RM 311, RM 342, RM 460, RM 3134, RM7376) showed polymorphism based on presence or absence of alleles.

References

AICRIP (2017) Progress Report 2017, Vol. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500003, Telangana State, India, pp 1.224- 1.234.

AICRIP (2018) Progress Report 2018, Vol. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500003, Telangana State, India, pp 1.262- 1.273.

AICRIP (2019) Progress Report 2019, Vol. 1, Varietal Improvement, All India Coordinated Rice Improvement Project, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500003, Telangana State, India, pp 1.296- 1.305.

Anna DA, JMS Tomar, Premila Devi, A Arunachalam and H Mehta (2015) Rice diversity – The genetic resource grid of north-east India. *Indian J. Plant Genet. Resour.* 28(2): 205-212.

Anonymous. (2009) Estimates of area & production of principal crops in West Bengal. Evaluation Wing, Directorate of Agriculture, Government of West Bengal, Kolkata-700025. p 227.

Kadian M, S Nagoria, S Monga and Meera (2024) Stubble burning in India: Environmental concern and alternative tools. *Curr. Agri. Res*. 12(1): 161-169.

Lal B, Priyanka Gautam, BB Panda and R Raja (2013) Boro Rice: A Way to crop intensification in Eastern India. *Popular Kheti*. 1(1): 5-9.

Mitra B, S Mookherjee and S Biswas (2014). Promotion of short duration rice variety Gotra Bidhan-1 (IET 17430) through frontline demonstrations in terai region of West Bengal. *J. Crop Weed* 10(1):11-114.

Ookawa T and K Ishihara (1992) Varietal difference of physical characteristics of culm related to lodging resistance in paddy rice. *Jpn. J. Crop Sci*. 61: 419-425.

Parihar DS, MK Narang, B Dogra, A Prakash and A Mahadik (2023) Rice residue burning in Northern India: an assessment of environmental concerns and potential solutions– A review. *Environ. Res. Commun*. 5: 062001.

PPV&FRA (2007) Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on Rice. Protection of Plant Varieties and Farmers' Rights Authority, New Delhi.

Samanta SK and S Mallik (2004) Varietal improvement of rice in West Bengal. Sharma SD, Rao UP (Eds.). Genetic improvement of rice varieties of India. Today & Tomorrow Printers and Publisher (India), pp. 1101-1159.

Shah L, M Yahya, SMA Shah, M Nadeem, A Ali, A Ali, J Wang, MW Riaz, Rehman, W Wu, RM Khan, A Abbas, A Riaz, GB Anis, H Si, H Jiang and C Ma (2019) Improving lodging resistance: Using wheat and rice s as classical examples. *Int. J. Mol. Sci*. 20: 4211.

Singh KJ, SM Feroze, R Singh and A Das (2016) How profitable is rice cultivation in hills of North Eastern region of India? A case study of Manipur. *Economic Affairs*. 61(2): 327-334.

Surje DT, V Kumar and B Roy (2018) Grouping of Farmers' Varieties of Rice (Oryza sativa L.) Collected from West Bengal and Adjoining States. *Indian J. Plant Genet. Resour.* 31(3): 251–259.

Torro I, P Breto and A Garcia-Yzaguirre (2011) Assessing lodging resistance in rice: a comparison of two indirect testing methods. *Spanish J. Agril. Res*. 9(4): 1245.

Xu X, S Kawasaki, T Fujimura and C Wang (2005) A protocol for high-throughput extraction of DNA from rice leaves. *Plant Mol. Biol. Rep*. 23: 291-295.

Zhang W, L Wu, X Wu, Y Ding, G Li, J Li, F Weng, Z Liu, S Tang, C Ding and S Wang (2016) Lodging resistance of japonica rice (*Oryza Sativa* L.): Morphological and anatomical traits due to top-dressing nitrogen application rates. Rice 9: 31.