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Evaluation of newly developed deep water rice line NDGR 706: Yield and adaptability parameters for abiotic stress

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Abstract

Submergence is a major threat in rice growing areas of South and South-East Asia. Investigation were undertaken at Crop Research Station, (ANDUAT) Ghaghrahat, Bahraich during 2018 and 2019 under AICRIP experiment to study the performance of deep water rice line NDGR 706 for submergence, yield and yield characters under the agro-ecological conditions of Eastern Uttar Pradesh. The experiment was laid out in Split Plot Design (SPT) with having three replications. The mean value of survival % of NDGR 706 (85%) compared to national check (65%), regional check (73%) and local check (75%). The mean value of grain yield kg/ha was recorded maximum was NDGR 706 (3093 kg/ha) compared to national check CR Dhan 500 (2167 kg/ha), regional check Dinesh (2486 kg/ha) and local check Jal Nidhi (2138kg/ha). The increase yield over check of CR Dhan 500, Dinesh and Jal Nidhi (42.73, 24.41 & 44.67%). The mean value of plant height of NDGR 706 was 176 cm, days to 50% flowering 119. Highest number of panicle/m² was observed of NDGR 706 (200) compared to national check, regional check and local check 175,175 and 151. NDGR 706 can be used as commercial cultivars in deep water rice of Uttar Pradesh.

Keywords: Rice, deep water, check, evaluation, yield

Introduction

Rice (*Oryza sativa* L.) is one of the cereals of major significance in the world and the main food resource, after wheat, for more than half of the world population (Ruiz *et al.*, 2005; Acevedo *et al.*, 2006; Álvarez *et al.*, 2008; Canfalonieri *et al.*, 2011) [2-4, 9], mainly in developing countries. World per capita consumption is placed around the 56.9 kg (FAO, 2013) [6]. Improving rice (*Oryza sativa* L.) production per unit area will be a major threat in future due to the increasing global population and rice demand in the world. Rice is the main food of majority of the world's population. It provides at least 27% of the nutritional diet and 20% of the protein consumption in the developing world. Climatic variation is one of the fundamental causes for yield variability of several crops, in particular on rice (Akinbile, 2013) [6]. More than 16 million ha of rice lands of the world in lowland and deep-water rice areas are unfavorably affected by flooding due to complete submergence. The estimated annual economic loss of this is more than US\$ 600 Million. Rice is the only crop plant adapted to aquatic environments because of its well-developed aerenchyma tissues that facilitate oxygen diffusion through continuous air spaces from shoot to root and avoid anoxia development in roots. However, complete submergence due to frequent flooding can adversely affect plant growth and yield. Flood is a major abiotic stress in most lowland and rainfed ecosystem. The flooded rice field areas increased due to the rising earth atmosphere temperature (global warming) that induces heavy precipitation and tropical cyclone in the most part of Asia (Easterling *et al.* 2007; Zeigler dan Barclay 2008) [5, 10]. It is the major crop in most flood-prone areas of South and South-East Asia (A. M. Ismail *et al.*, 2013) [1, 8]. Complete submergence annually affects about 16 million ha of rice in South and Southeast Asia, and about one third of the total rice growing area in Africa. The effect of damage caused by transient submergence is dependent on the characteristics of flood waters, including temperature, turbidity, concentration of dissolved gases, and extent of light penetration (K. Das *et al.*, 2009) [8]. Deep-water rice (DWR) is grown in flooded conditions with water more than 50 cm (20 inch) deep. More than 100 million people in South and Southeast Asia rely on deep-water rice for their sustenance.

Many districts of Uttar Pradesh are flooded during the rice cultivation season every year and thus, curtail the national rice yield by causing severe damage to the rice cultivated field. When water levels rise above 1 m for long periods, usually for 1–5 months, submergence tolerance will not suffice. Plants adapted to such an environment resort to avoidance of anaerobiosis with rapid elongation growth and extensive aeration as the most important features. Both responses serve to improve the oxygen supply in the submerged plant parts.

The two types of flooding cause damages to rice

Flash flooding

Which results in rapid ascending of water levels with submergence for 1–2 weeks? This type of flooding could also occur after sowing in areas where direct seeding is practiced and could result in substantial reduction in stand establishment.

Deep-water and floating rices

Where water depth exceeds 100 cm and remains at these depths for several months. Plants may become completely submerged for short periods if flooding is severe. Elongation ability of leaves and internodes are essential to keep pace with increasing water levels and escape complete submergence. Traditional varieties adapted to these environments are low yielding due to their low-tillering ability, long droopy leaves, and susceptibility to lodging, and poor grain quality. Improved varieties are needed that combine high yield attributes with submergence tolerance and elongation ability. Elongation ability of the coleoptiles of germinating seeds is also considered a desirable trait especially with direct seeding to effect emergence above anaerobic waterlogged soils. Rice is a semi-aquatic plant and one of the most important crops cultivated in both tropical and temperate regions. DWR is grown in more than 50 cm water for one month or longer during the cropping season. Based on stature and depth of water, these are of two types: (i) traditional tall, and (ii) floating. Traditional tall cultivars are tall with long leaves, and grown at water depths between 50 and 100 cm; floating rice is grown in 100 cm or deeper situations. In Bangladesh most of the rice grown in the low lying areas during monsoon are floating rice, generally called as deep-water rice.

Early establishment of crop is necessary for DWR to face the flood water throughout the growing season (typically one or two months). The crop established before monsoon begins or floodwater enters can withstand better in raising water level situation. Thus, effective crop growth can boost up total grain production at the end of the season. Crop improvement against moisture stress has been difficult mainly for 1) lack of suitable screening technique that allows large population and 2) complexity in its arrival times and extents, since it occurs with different intensity and extent in different years. Growth study along with different plant structures is of utmost necessity for crop improvement under stress condition.

Material and Methods

Experiment were conducted at Crop Research Station, (ANDUAT) Ghaghrahat, Bahraich, which is situated at of Latitude (North) 27°50'N, Longitude (East) 81°20'E and Elevation (m. from MSL) 112m. The soil is sandy loam low in organic carbon. It is rich in potassium, medium in

phosphorus and possesses good water holding capacity and PH 7.50. NDGR 706 deep water rice line evaluated during 2018 and 2019 under AICRIP experiment to study for the submergence, yield and yield characters under the agro-ecological conditions of Eastern Uttar Pradesh. The experiment was laid out in Split Plot Design (SPT) with having three replications. The experiment was direct sown in 4th week of June, in 15m² plot size, variety specific agronomic practices were raise the crop. Recommended dose of fertilizer 60:30:30:25 kg N: P: K: and ZnSo₄/ha recommended half of the dose of N and full dose of P: K and ZnSo₄ were applied basal, while remaining N were top-dressed in 2 equal splits—at tillering and panicle initiation stage. To control weeds, nomini gold @ 0.25 litre/ha was applied after 25 days old crop. Crop was harvested at physiological maturity and grain yield was calculated at 14% grain moisture. Single plant observations were recorded on five plants selected at random per genotype per replication for characters viz., seedling survival%, kneeling ability, elongation, PACP, days to 50% flowering (stress), plant height cm (stress), panicle per sqm, (stress), hulling, mulling, head rice recovery, kernel length, kernel bright, L/B ratio, ASV, AC and GC for the grains. The data on grain yield of each plot were recorded separately by threshing the harvested rice genotypes. The data so obtain were subjected to statistical analysis after necessary transformation for final statistical analysis (Gomez and Gomez, 1983) [7]. Two season data on grain yield separately recorded the mean value.

Results and Discussion

Survival % grain yield and yield attributing traits: The mean value of survival % of NDGR 706 (85%) compared to national check (65%), regional check (73%) and local check (75%) presented in table 1 and figure 1. The data presented in table-2 and figure 3 clearly revealed that the increase grain yield significantly higher over check. The mean value of grain yield kg/ha was recorded maximum was NDGR 706 (3093 kg/ha) compared to national check CR Dhan 500 (2167 kg/ha), regional check Dinesh (2486 kg/ha) and local check Jal Nidhi (2138kg/ha). The increase yield over check of CR Dhan 500, Dinesh and Jal Nidhi (42.73, 24.41 & 44.67%). The mean value of plant height of NDGR 706 was 176, days to 50% flowering 119. Highest panicle/m² was observed of NDGR 706 (200) compared to national check, regional check and local check 175, 175 and 151.

Grain quality characteristics: Head rice recovery percent maximum was 63.1. Followed by CRR Dhan 500 (62.9). Variation in head rice recovery in different varieties is closely related with moisture content and force of the milling machine. Kernel length of the rice line NDGR 706 was 5.54 mm. It was found that kernel breadth was 2.28 mm. Maximum kernel breadth was recorded in Dinesh (2.56 mm). The variations in kernel breadth in different varieties may be due to its genetic characteristics. L/B ratio was recorded highest in CRR Dhan 500 (2.52) followed by NDGR 706 (2.42) Maximum amylose content was recorded in NDGR 706 (25.08) followed by Dinesh (24.52). Gel consistency maximum was recorded in NDGR 706 (48) followed by Dinesh (37).

NDGR 706 can be used as commercial cultivars in deep water rice of Eastern Uttar Pradesh.

Table 1: Seedling survival%, adaptability parameters of deep water rice line

Sl. No.	Genotypes	Seedling survival (%)			Kneeing ability			Elongation		
		2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
1	NDGR 706 (IET 26741)	85	85	85	3	3	3	1	1	1
2	CR Dhan 500 (NC)	70	60	65	3	3	3	3	3	3
3	Dinesh (RC)	75	70	73	3	3	3	1	1	1
4	Jal Nidhi (LC)	70	80	75	1	1	1	1	1	1

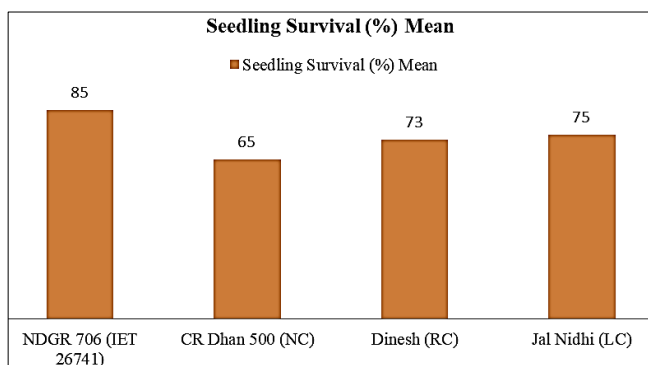


Fig 1: Seedling survival% of NDGR 706

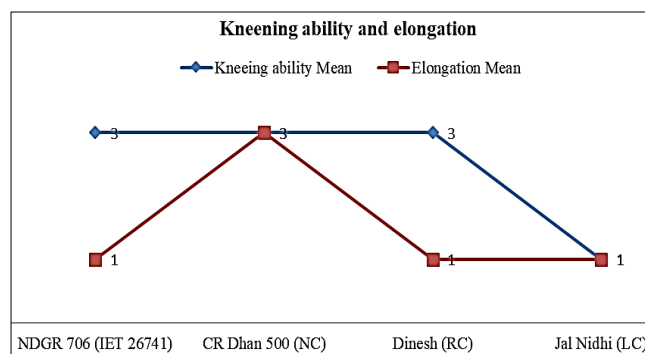


Fig 2: Kneeing ability and elongation adaptability

Table 2: Yield (kg/ha) and yield attributing traits of deep water rice

Sl. No.	Genotypes	Yield kg/ha			% increase over check	Days to 50% flowering			Plant height (cm)			Panicle/m ²		
		2018	2019	Mean		2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
1	NDGR 706 (IET 26741)	2619	3567	3093		120	117	119	167	184	176	210	190	200
2	CR Dhan 500 (NC)	2333	2000	2167	42.73	126	133	130	156	143	150	196	153	175
3	Dinesh (RC)	2571	2400	2486	24.41	129	133	131	151	172	162	180	169	175
4	Jal Nidhi (LC)	1543	2733	2138	44.67	135	117	126	178	209	194	142	160	151
	CD (0.05%)	278	583.88											
	CV	14.72	11.25											

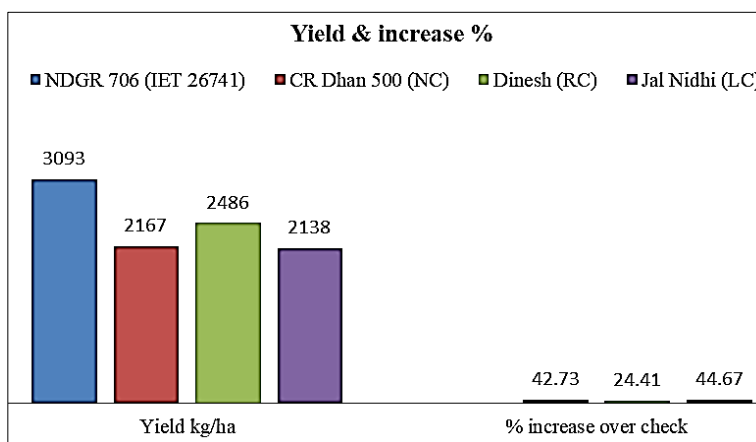


Fig 3: Yield (kg/ha) and % increase over checks

Table 3: Grain quality characteristics of NDGR 706

Quality characteristics	NDGR 706	CRR Dhan 500 (NC)	Dinesh (RC)
Hulling	76.6	78.1	78.7
Milling	67.7	69.7	67.7
Head Rice Recovery	63.1	62.9	63.1
Kernel length	5.54	5.54	5.08
Kernel breadth	2.28	2.19	2.56
L/B ratio	2.42	2.52	1.98
Grain Type	SB	MS	SB
Grain chalk.	VOC	VOC	OC
ASV	5	5	5
AC	25.08	22.58	24.52
GC	48	22	37

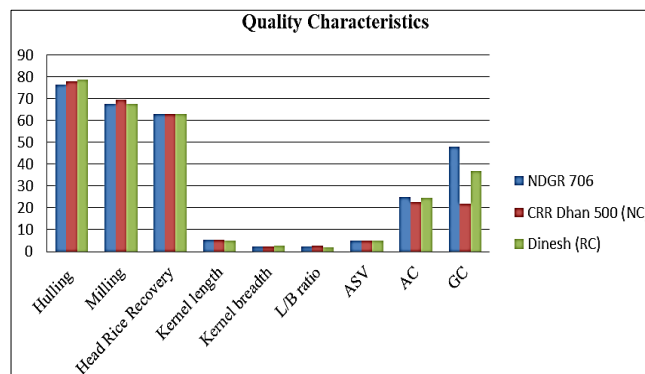


Fig 4: Grain quality characteristics.

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