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Original Research Article

Identification of Rice Genotypes for Submergence and Yield Attributing Traits

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A B S T R A C T

Altogether 334 rice lines alongwith8 global check varieties were tested for submergence survival and yield performance at Crop Research Station, Masodha, Ayodhya. These lines and check varieties, namely IR 64-Sub 1, Swarna-sub 1, Sambha Mahsuri-Sub 1,. Ciherang-Sub1, TDK1, Ciherang, RC18, SambhaMahsuri and 3 local check viz. Swarna, MTU 1010 and Sahabagidhan were laid out in augmented design with 10 blocks. For survival testing in submergence, the experiment was conducted in the submergence pool and for yield performance (optimal condition), the experiments was conducted in the irrigation field. Each entry was direct sown in two rows of 3 meter length and after 25 days of sowing complete submergence of one meter water depth was imposed for 20 days. Data recorded for submergence survival as no. of plant counted before and after submergence. In yield performance experiments observation recorded on days to 50% flowering, plant height, Ebt/m2, total biomass, harvest index and yield kg/ha. Among 334 lines none of the lines have recorded 100% survival however, eight lines viz., TTB 944-31-10-1-2 (95.2%), CR-2859-1-S-B-2-1-B-B-5-1 (94.7%), IR103410-B-B-2-3 (87.5%), CR 2851-S-1-B-4-1-4-1-1 (IET27051) (84.2%), IR 97034-21-2-1-3 (69.6%), IR09A130 (66.7), CR 2859-S-B-2-1-B-7-1 (60%) and NSIC 2016 RC 468 (57.9%) survived and 42 lines falls under 20-56 % survival, were recorded. The entries were selected on the basis of (i) selection based on survival % and vigor, (ii) selection based on productivity under submergence, (iii) selection based on the variables of morphological and agronomic characters. The entry IR103410-B-B-2-3 (87.5%) (4667 kg/ha),IR 97034-21-2-1-3 (69.6%)(4667 kg/ha),TTB 944-31-10-1-2(95.2%) (4000 kg/ha) and NSIC 2016 RC 468 (57.9%) (3333 kg/ha) also good for survival and yield. These lines are considered promising for tolerant to submergence as well as yield.

Keywords

Rice, Lines, Survival percentage, Submergence, Water depth and Yield

Introduction

Rice (*Oryza sativa* L.) is one of the most important crops of the world and provides food to more than 50% global population. More than 90% of the world's rice is grown and consumed in Asia, where 60% of the earth's people live. It was estimated that 35-60% of the calories consumed by 3 billion Asians comes from rice. Rice demand in urban areas has grown faster than elsewhere in the world (Balasubramanian *et al.*, 2007; WARDA, 2005). Submergence tolerance has long been regarded as an important breeding objective for rainfed lowland and deep water, rice areas. Despite this recognition there has been limited success in developing improved submergence tolerant varieties in India. Though a number of high-yielding rice varieties have been released for different lowland situations in different States, most of them do not have the required level of tolerance to submergence. In coastal areas, water stagnation is a common problem in most of the lowlands. Varietal differences in the degree of submergence tolerance havebeen observed many times and this genetic resource has been used in several conventional breeding programmes in Asia. Frequency and intensity of flash floods has increased due to changes in global weather patterns (Singh *et al.,* 2011). IPCC (2007) provides scientific evidence of climate change that will increase the intensity and severity of drought and flood. Impact of climate change is now increasingly visible. The agro ecosystems of South- East Asian countries are facing various environmental stresses (Kabir, 2010). Flash flood submergence is an important hazard to the agriculture. About 1/3rd of India‗s rice area was affected by submergence (Sarkar, 1997 and Sarkar *et al.*, 2006). Flash floods and excessive rainfalls regularly affect rain-fed lowland rice ecosystems in many parts of the country where flood water remains for around two weeks. The ecosystem affected by flash floods mainly constitutes low to medium lowland. Kharif season rice grown in India often gets submerged during seedling and vegetative stages, and suffers substantial yield losses. Submergence is one of the most important abiotic constraints in India, which accounts for near total yield loss of rice (Dey and Upadhyaya, 1996). Among the abiotic stress, submergence is one of the important factors in the flash flood prone rice growing environment (Mackill, 1986). Quiescence and elongation are two opposite strategies by which rice adapts to flood depending upon the nature of flooding (Luo *et al.*, 2011). Rice plants that exhibit only limited elongation during submergence often show tolerance to flash flooding. Analysis of flooding pattern in rainfed lowland of Southeast Asia reveals that about 20 million ha comes under medium-deep to deep and very deep ecology based on water stagnation. Here the ideal response to flooding is submergence tolerance (survival under water) together with some elongating ability (Mackill *et al.*, 2010; Bailey-Serres and Voesenek 2010). The slant-board test developed by Jones and Peterson (1976) was first used in studies of seedling vigor under submergence in relation to semi-dwarfism in rice McKenzie *et al.*, (1980). This test was applied in screening for rice breeding lines in California McKenzie *et al.*, (1994). Xu and Mackill (1996) developed a seedling recovery method for evaluating submergence tolerance under full inundation due to flash floods in rice, while Yamauchi and Winn (1996) developed a seedling emergence method for screening of fast seedling emergence under flooding. Submergence tolerance, which is partially a function of the character of flood water (Ram *et al.*, 1999), is an important breeding objective intended to reduce, to the barest minimum, yield losses recorded in rainfed lowland and deep water rice areas (Mackill, 1986; Mohanty and Chaudhary, 1986; Kawano, 2002; Kawano *et al.*, 2009). A strong negative correlation between percent survival and elongation growth is commonly observed (Ella and Ismail, 2006). Widawsky and O‗Toole, 1990 showed that out of 42 biotic and abiotic stresses which prevail in rainfed lowland rice areas of Eastern India, submergence stress is the third most important limitation to rice production. In areas where rainfed lowland rice is subjected to flash-floods, elongation growth results in lodging and death of plants after the water recedes. Hence plants adapted to these areas must have submergence tolerance (Setter & Laurels, 1996). A strong negative correlation was found between survival% and excessive stem elongation growth. According to Mohanty *et al.,* 2000, submergence tolerance by which certain rice genotypes survive submergence of 10 days or more particularly in shallow water depth up to 40 cm (as per the classification followed in India) and up to 50 cm (as per the classification followed at the International Rice Research Institute). Flash-floods are highly unpredictable and may occur at any growth stage of the rice crop and the yield loss may be anywhere between less than 10 and 100% depending on factors such as water depth, duration of submergence, temperature, turbidity of water, rate of nitrogen fertilization, light intensity and age of the crop (Setter *et al.*, 1997).

Materials and Methods

Experiments were conducted at Crop Research Station, Masodha, Ayodhyain view of above facts, the two set of experiments. Each set in different environmental conditions: 1st - submergence condition, which was conducted in a submergence pool and 2nd - optimal condition, which was conducted in the irrigation field.

In submergence condition each entry was direct sown in two rows of 3 meter length and after 25 days of sowing complete submergence was imposed for 20 days with one meter water depth. Observation was recorded on number of plant germinated and remains survived after submergence. Three hundred thirty fourlines and alongwith 8 global check varieties, namely IR 64-Sub 1, Swarna-sub 1, SambhaMahsuri-Sub 1, Ciherang-Sub1, TDK1, Ciherang, RC18, Sambha Mahsuri and 3 local check viz. Swarna, MTU 1010 and Sahabagidhan were tested in augmented design with 10 blocks. Survival percentage was calculated as (numbers of survive hills at 15 days of reemergence). Submergence condition: data were recorded on of plant before and after submergence, plant height before and after submergence, elongation (cm), elongation% and survival% days to 50% flowering, plant height, Ebt/m2, total biomass, harvest index and yield kg/ha.

Elongation, Survival % formula are given below.

Elongation (per day): = (Plant height after submergence-Plant height before submergence)/No. of days submerged.

Elongation%: = {(Plant height after submergence – Plant height before submergence)/ Plant height before submergence.} x 100

Survival% = {(No. of plants before submergence – No. of dead plants)/No. of plants before submergence} x 100

In optimal condition, days to 50% flowering, plant height, Ebt/m2, total biomass, harvest index and yield kg/ha were recorded for five plants randomly in each plots.

Results and Discussion

Analysis of variance for parameters evaluated at seedling stage in the submergence pool immediately after submergence stress showed significant difference for seedling height, showed the variation among genotypes in seedling height soon after submergence stress. Moreover, there were no significant differences in computed shoot elongation among genotypes showed, there is no enough evidence that variation of genotypes under submergence were different in terms of elongation rate. Among 334 lines none of the lines have recorded 100 % survival, however, eight lines viz., (95.2%), TTB 944-31-10-1-2,(94.7%), CR-2859-1-S-B-2-1-B-B-5-1,(87.5%), IR103410-B-B-2-3,(84.2%), CR 2851-S-1-B-4-1-4-1-1 (IET27051),(69.6%), IR 97034-21-2-1-3 (66.7), IR09A130,(60%) CR 2859-S-B-2-1-B-7-1 and (57.9%) NSIC 2016 RC 468 with 95-60%, survival, respectively, and 42 lines falls under 56-20 % survival, were recorded. The elongation for (66.7%) TTB 944-31-10-1-2,(64.6%) CR-2859-1-S-B-2-1-B-B-5-1,(58.6%)IR103410-B-B-2-3,(66.3%),CR 2851-S-1-B-4-1-4-1-1 (IET27051),(66.3%)IR 97034-21-2-1-3, (59.1) IR09A130,(48.4%) CR 2859-S-B-2-1-B-7-1 and (55.8%)NSIC 2016 RC 468 It ranged from 13.1% (TDK1) to 72.8% (HURS 19-4). Days to 50% flowering ranged95 days (IR79971-B-227-B-B) to 154 (days CR 2858-1-1-1) and survived entries 124 days (TTB 944-31-10-1-2), 129 days (CR-2859-1-S-B-2-1-B-B-5-1), 83 days (IR103410-B-B-2-3), 120 days (CR 2851-S-1-B-4-1-4-1-1 IET27051), 80 days (IR 97034-21-2-1-3), 81 days (IR09A130), 130 days (CR 2859-S-B-2-1-B-7-1) and 82 days (NSIC 2016 RC 468). The plant height ranged65 cm (IR14A216) to 223 cm (CR-2859-1-S-B-2-1-B-B-5-1)and survived entries 140 cm (TTB 944-31-10-1-2), 169 cm (CR-2859-1-S-B-2-1-B-B-5-1), 140cm (IR103410-B-B-2-3), 136cm (CR 2851-S-1-B-4-1-4-1-1 IET27051), 130cm (IR 97034-21-2-1-3), 110 cm(IR09A130), 132cm(CR 2859-S-B-2-1-B-7-1) and 85cm (NSIC 2016 RC 468).The grain yield ranged 50 kg/ha (CR 2860-S-B-189-1-1-1 IET 27060) to 4560 kg/ha (TTB 1348-1-and survived entries TTB 944-31-10-1-2 (3260 kg/ha), CR-2859-1-S-B-2-1-B-B-5-1 (560 kg/a), IR103410-B-B-2-3 (4060 kg/ha), CR 2851-S-1-B-4-1-4-1-1 (IET27051) (3660 kg/ha), IR 97034-21-2-1-3 (2560 kg/ha), IR09A130 (2390 kg/ha), CR 2859-S-B-2-1-B-7-1 (250 kg/ha) and NSIC 2016 RC 468 (2285 kg/ha). Optimal condition: Days to 50% flowering range IR79971-B-227-B-B 90 days to 147 days and survived entries130 days (TTB 944-31-10-1-2), 138 days (CR-2859-1-S-B-2-1-B-B-5-1), 102 days (IR103410-B-B-2-3), 128 days (CR 2851-S-1-B-4-1-4-1-1IET27051),94 days (IR 97034-21-2-1-3), 102 days (IR09A130), 141 days (CR 2859-S-B-2-1-B-7-1) and 93 days (NSIC 2016 RC 468), Plant height ranged85 cm (IR14A216) to 230 cm (CR-2859-1-S-B-2-1-B-B-5-1)and survived entries168cm (TTB 944-31-10-1-2), 222cm (CR-2859-1-S-B-2-1-B-B-5-1), 167 cm (IR103410-B-B-2-3), 150cm (CR 2851-S-1-B-4-1-4-1-1), 150cm (IR 97034-21-2-1-3), 130 cm (IR09A130), 150cm (CR 2859-S-B-2-1-B-7-1) and 126 cm (NSIC 2016 RC 468), yield kg/ha range 83 kg/ha (CR 2860-S-B-189-1-1-1 IET 27060) to 5667 kg/ha (TTB 1348-1-1), survived entries TTB 944-31-10-1-2 (4000 kg/ha), CR-2859-1-S-B-2-1-B-B-5-1 (667kg/ha), IR103410-B-B-2-3 (4667 kg/ha), CR 2851-S-1-B-4-1-4-1-1 (IET27051) (4000 kg/ha), IR 97034-21-2-1-3 (4667 kg/ha), IR09A130 (4000 kg/ha), CR 2859-S-B-2-1-B-7-1 (333 kg/ha) and NSIC 2016 RC 468 (3333 kg/ha)

The entry IR103410-B-B-2-3 (87.5%) (4667 kg/ha), IR 97034-21-2-1-3 (69.6%)(4667 kg/ha), TTB 944-31-10-1-2(95.2%) (4000 kg/ha) and NSIC 2016 RC 468(57.9%) (3333 kg/ha) also good for survival and yield.

The study revealed that four rice genotypes survival could be utilized in the rice breeding programme for submergence tolerance. Eight submergence tolerance rice lines may be used for front line demonstration among the farmers of flood prone area of Eastern Uttar Pradesh. This indicates that the hypothesis tested in this study is accepted the rice genotypes that are tolerant to seedling submergence among the available rice genotypes. It has also been observed that, the performance of genotypes under submergence stress depend on many factors in addition to depth and duration.

Survival after submergence seems to be strongly dependent on non-structural carbohydrate reserves remaining in the shoot after desubmergence, which is in turn equally dependent on the initial carbohydrate content before submergence as well as on the extent of stem elongation during submergence (Das *et al.,* 2005). Survival of seedling is positively correlated with stem starch along with chlorophyll concentration both in before and after submergence (Ella and Ismail, 2006). Survival is positively associated with limited stem elongation (Singh *et al.,* 2009).

Table.1 Submergence and elongation % of submergence pool

PLOT NO	ENT NO	DESIGNATION	Plant Height Before Submergence	Plant Height After Submergence	Elongation Cm	Elongation %	No. of plant Before Submergence	No. of plant after Submergence	Survival %
13	323	TTB 944-31-10-1-2	38	114	76	66.7	21	20	95.2
16	288	CR-2859-1-S-B-2-1-B-B-5-1	40	113	73	64.6	19	18	94.7
302	72	IR103410-B-B-2-3	48	116	68	58.6	16	14	87.5
217	290	CR 2851-S-1-B-4-1-4-1-1 (IET27051)	33	98	65	66.3	19	16	84.2
10	310	IR 97034-21-2-1-3	31	92	61	66.3	23	16	69.6
11	139	IR09A130	38	93	55	59.1	21	14	66.7
123	297	CR 2859-S-B-2-1-B-7-1	33	64	31	48.4	20	12	60.0
176	337	TDK 1	28	85	57	67.1	12	7	58.3
65	235	NSIC 2016 RC 468	44	85	41	48.2	19	11	57.9
94	330	IR 14L572	40	94	54	57.4	23	13	56.5
26	121	IR115838:5-5-5	33	110	77	70.0	20	11	55.0
130	293	CR 2582-3-35-2-1-1-3	34	56	22	39.3	20	11	55.0
55	231	BRRI dhan 47	40	69	29	42.0	17	9	52.9
64	125	IR93339:39-B-6-5-B-B-B-47	29	69	40	58.0	16	8	50.0
332	103	IR16F1014	44	62	18	29.0	15	7	46.7
78	64	IR103387-B-B-3-3	48	90	42	46.7	22	10	45.5
36	291	CR 3898-113-4-2-1(IET-25909)	44	122	78	63.9	15	6	40.0
328	128	IR99054-B-B-1	50	71	21	29.6	15	6	40.0
331	285	CRR759-B-12-B-1	45	64	19	29.7	15	6	40.0
190	76	IR103419-B-B-1-3	36	81	45	55.6	21	8	38.1
379	108	IR16F1097	40	56	16	28.6	16	6	37.5
15	233	BRRI dhan 55	44	96	52	54.2	19	7	36.8
127	331	IR90527-B-577-2-B?B	47	87	40	46.0	20	7	35.0
80	91	IR103803-B-B-2-1	40	78	38	48.7	24	8	33.3
126	94	IR108028-B-B-B-4-B-B	36	85	49	57.6	21	7	33.3
128	66	IR103390-B-B-2-3	41	61	20	32.8	21	7	33.3
282	73	IR103411-B-B-3-3	47	61	14	23.0	16	5	31.3
314	84	IR103786-B-B-1-3	47	90	43	47.8	10	3	30.0

Table.2 Yield and of submergence pool and Irrigated field

Sl No.	Genotypes	Days to 50% flowering		Plant Height		Yield kg/ha	
		submergence pool	Irrigated field	submergence pool	Irrigated field	submergence pool	Irrigated field
1.	TTB 944-31-10-1-2	124	130	140	168	3260	4000
2.	CR 2859-1-S-B-2-1-B-B-5-1	129	138	169	222	560	667
3.	IR 103410-B-B-2-3	83	102	140	167	4060	4667
4.	CR 2851-S-1-B-4-1-4-1-1	120	128	136	150	3660	4000
5.	IR 97034-21-2-1-3	80	94	130	150	2560	4667
6.	IR09A130	81	102	110	130	2390	4000
7.	CR 2859-S-B-2-1-B-7-1	130	141	132	150	250	333
8.	NSIC 2016 RC 468	82	93	85	126	2285	3333

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