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RESEARCH ARTICLE

APPROACHES TOWARDS THE DEVELOPMENT OF SUBMERGENCE TOLERANCE IN RICE (*Oryza sativa* L.) THROUGH HYBRIDIZATION

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ABSTRACT

In the present investigation hybridization has been employed for the development of some submergence tolerant high yielding lines. Fifty diverse paddy genotypes were screened for submergence tolerance in low land submerged field condition at Calcutta University Experimental Farm, Baruipur, West Bengal, India in 2010 where water level was more than 50 cm at least for two weeks in the vegetative stage of crop growth. Four submergence tolerant genotypes namely Mahananda, Nagalmuda, Purnendu, Lakshmikajal and one susceptible genotypes namely Sonom were taken for the crossing programme and Mahananda x Nagalmuda, Nagalmuda x Purnendu, Lakshmikajal x Purnendu and Mahananda x Sonom crosses were made in 2011. The parents were selected on the basis of seed yield/plant. Crossing success varied from 6.25-8.33%. The F_1 seeds were grown in the kharif season of the 2012 under submergence condition. Some promising plants were selected from F_1. They were referred as F_2 lines. The F_2 lines were sown in the kharif season of 2013 in three replications at submergence prone areas of Calcutta University Experimental Farm, Baruipur, West Bengal, India, in which water level was more than 50 cm at least for 14 days. Total of seven F_2 individual were selected from the four different cross. Six individuals produced very high seed yield per plant than their respective control. Two individual in particular derived from the cross of Mahananda and Nagalmuda appear to be most outstanding because of their high seed yield performances. So these selections have an outstanding scope to introduce as submergence tolerant lines in future breeding programme under low land submergence prone field area of West Bengal and Eastern India.

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INTRODUCTION

Submergence is a recurring problem in the rice-producing rain fed lowlands of south and south-east Asia. In some areas, farmers plant landraces that are moderately tolerant of submergence but have low yield. In areas where high-yielding but submergence-intolerant rice varieties have been cultivated, farmers suffer from crop losses caused by periodic flash floods during the monsoon season. Recently, the extent of submergence stress has increased due to extreme weather events such as unexpected heavy rains that have inundated wider areas across many regions in Asia.

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More sustainable and permanent solutions are needed to overcome this problem. One of the most promising solutions is to develop high yielding varieties that are submergence tolerant and that are more likely to be rapidly adopted by the farmers in the target regions (Septiningsih *et al*. 2009). Considerable efforts have been made by plant breeders for creating flooding tolerant employing traditional method of selection of suitable donor genotypes and introgression flooding tolerant traits through sexual hybridization (Mallik *et al*. 1995, Kundu *et al*. 1993, Mohanty *et al*. 1994). It is desirable to use as large an F_1 population as the resources permit to provide the maximum chance for recombination (Coffman and Herrera, 1980). Based on some traits related to growth development and yield components, hybrid rice under complete submergence or deepwater stress, it had been shown that the yield per plant of hybrid rice was significantly higher than that of conventional rice, which resulted from more rapid growth development, higher tillers no. per plant, higher effective panicles, better tolerance ability, higher survival and more rapid recovery growth in under deepwater stress (Li *et al*, 2002). It has been reported that Swarna-Sub1, the first example of a submergence-tolerant mega variety through hybridization, is currently being evaluated in submergence-prone areas of India and Bangladesh and under non-submerged control conditions no significant differences in agronomic performance, grain yield and grain quality between Swarna and Swarna-*sub1* were observed indicating complete restoration of the Swarna background in Swarna-*sub1*, but Swarna-*sub1* showed a double or higher yield advantage over Swarna after submergence for 10 days or more during the vegetative stage (Sarkar *et al*., 2006; Neeraja *et al*., 2007). Submergence tolerance characters could be combined in the same rice genotype provided the strongly submergence tolerance genes are available in donor plants (Saha Ray *et al*, 1993). It should be possible to have all other advantages together with desired submergence tolerance if specific genes for submergence tolerance are transferred into high yielding cultivars (Minhas and Grover, 1999).In this context hybrid rice has been viewed as a promising approach that can be used as a vehicle to boost rice production under submergence stress condition.

Evaluation of F_2 plants under field submergence conditions revealed the presence of continuous variation for the targeted quantitative traits viz., plant height, panicle length, number of grains per panicle, grain weight etc. and indicated the suitability of population for selection process (Raha, 2009). A more effective introduction of diverse genetic material for submergence tolerance in breeding programmes can be done by exchange of material for screening populations of F_2 generations at target locations (Setter *et al*, 1997). Genetics research has demonstrated the inheritance of submergence tolerance from tolerant genotypes by analysis of segregating populations. F_2 populations produced by crossing submergence tolerant with intolerant cultivars were tested along with the parents for submergence tolerance in field established the submergence tolerance by segregation and variability (Mazaredo and Vergara, 1982; Mohanty and Chaudhary, 1986). So the objective of the present study was to incorporate submergence tolerance within a submergence susceptible genotype through crossing and development of some submergence tolerant high yielding superior paddy lines.

MATERIALS AND METHOD

Field performance

Fifty diverse rice genotypes were screened along with four tolerant check and three susceptible checks at the Calcutta University Experimental Farm, Baruipur, South 24 Parganas, West Bengal, in the year of 2010 in the kharif season (July-November) in low land submerged field condition with water level more than 50 cm for at least two weeks at vegetative stage of the plant growth. The germinated seeds were sown in Randomized Block Design (RBD) with 3 replications under direct sowing methods. After puddling and final land preparation, farmyard manure (FYM) was given at the rate of 1 ton/hectare. Two germinated seeds were sown in each pit along the line with a spacing of 15 cm and the spacing between two lines was 20 cm. After harvest the mean performances was observed for seven agro morphological characters.

Hybridization for the development of high yielding submergence tolerant lines

1st Year Crossing: In the 1st year (2011) crossing was done between the following genotypes in the respective pattern at Baruipur under low land submerged field condition as in the field performances. Four submergence tolerant genotypes namely Mahananda, Nagalmuda, Purnendu, Lakshmikajal and one susceptible genotype namely Sonom were taken for the crossing programme as soon in Table 1 .The parents were selected on the basis of seed yield/plant. Emasculation was done between 4-6pm one day before the anther was expected to dehisce and stigma was likely to become fully receptive. The glassine bag was marked and used to cover the emasculated panicle with the date of emasculation. Pollination was done in the next morning between 8 to 9 am, by putting burst anther.

2nd Year: Raising of F_1 and harvesting of F_2 seeds: The F_1 seeds were grown in the kharif season month of July, 2012, at Baruipur, under low land submerged field conditions with water level > 50 cm at least two weeks in vegetative stage. The F_1 seeds were grown in the hill of line with spacing 15 cm and the spacing between two lines was 20 cm. Normal cultivation practices were followed and the crop was harvested separately in the month of November. The following parameters were recorded.

- Plant heights: Height of the each of the every plant was measured in cm. and their mean was calculated.
- No of tillers/plant: The tiller numbers of each of the every plant (during plant height) were counted and their mean was computed.
- No. of panicles/plant: The number of panicles was counted for each of the every plants and their mean was calculated.
- No. of filled grains/ panicles: Number of filled grains of five randomly selected panicle from each of the every plant was taken and their mean was calculated.
- Length of the panicle: Length of five previously selected panicle (during grains/panicle) for each of the every plant was taken in cm and their mean was calculated.
- 1000 seed weight: 100 seeds were counted for each genotype and then their weight was taken in gram which was multiplied by 10 and their mean was calculated.
- Seed yield/plant: Seed yield/plant was taken for each of the every plant for each replication and their mean were computed.

3rd Year: Raising of F_2 and harvesting of F_3 seeds

Some promising plants were selected from F_1. They were referred as F_2 lines. The lines were selected on the basis of yield and yield related characters. The F_2 lines were sown in 2013 in kharif season in low land submerged field at Baruipur with water level at least > 50 cm at least for two weeks during vegetative stage of the crop with three replications. The normal cultivation practices were followed as per F_1. The observation was recorded from randomly taken 5 plants in each replication as in second year.

Statistical Analysis

F_1 –Normal statistical procedures were followed to calculate the mean, standard deviation (SD) and coefficient of variation (CV) for different agro morphological characters.

Table 1. Hybridization programme at Baruipur under low land submerged condition

Cross		Genotype	Seed yield(g)
♀	♂		
Mahananda	Nagalmuda	Mahananda(Control)	40.5
Nagalmuda	Purnendu	Nagalmuda(Control)	30.0
Lakshmikajal	Purnendu	Purnendu(Control)	31.0
Mahananda	Sonom	Lakshmikajal(Control)	29.3
		Sonom(Control)	15.2

Table 2. Performances of Fifty Paddy Genotypes In Low Land Submerged Field Condition at Baruipur

Genotypes	Characters						
	Plant height (Cm)	Tillers/ hill	Panicle / Plant	No. of filled grains/Panicle	Panicle length (cm)	1000 Seeds weight (g)	Seed yield /Plant(g)
FR13A(TC)	155.3	22.7	15.4	192.7	26.9	32.9	35.57
Dudheswar	140.8	20.6	13.7	155.7	26.6	21.3	28.17
Mahananda	170.6	22.4	16.3	176.7	27.0	28.7	40.5
Lalat	173.9	21.2	11.7	92.0	22.7	21.0	19.00
Medi	163.8	24.1	12.7	82.3	26.1	26.3	17.23
Sonom	99.7	23.4	14.0	74.7	24.8	20.2	15.2
Raspanchali	150.7	19.9	13.0	84.7	22.0	29.4	16.27
Kataribhog	141.6	18.8	14.1	73.3	20.5	21.4	14.90
B-20	104.8	21.6	12.9	118.0	25.0	17.7	23.07
Sita	101.5	21.2	13.2	102.7	24.8	22.6	20.83
Amulya	161.2	23.9	12.0	125.0	25.6	21.1	22.13
Vaidheli	156.1	23.1	13.6	116.3	28.3	28.0	23.00
SR26B	151.5	22.3	13.3	126.7	27.9	21.6	22.10
Swarna sub1 (TC)	99.6	22.6	12.7	158.3	25.6	19.3	29.33
Lankagore	164.9	19.7	13.0	141.0	27.1	27.3	27.03
FR43B(TC)	126.6	22.2	12.6	142.7	25.8	26.6	29.2
Sabita	151.8	21.7	13.7	150.7	24.8	21.2	28.23
Barsatora	121.8	19.9	13.3	117.7	25.8	24.5	21.83
Ambika	150.4	20.6	13.0	123.0	26.5	28.0	20.87
IR64 sub1(TC)	90.3	21.5	13.0	167.7	26.6	21.5	30.33
Bhuri	152.7	20.0	13.0	150.0	25.4	26.6	26.60
Nagalmuda	161.2	19.3	12.0	159.3	24.8	31.4	30.0
Lakshmikajal	165.5	17.2	12.7	147.7	24.4	24.8	29.3
Khitish	100.9	17.7	13.0	105.7	22.0	21.6	19.90
Kalopahar	162.2	19.8	13.2	123.7	22.0	26.7	23.67
Malabati	143.3	20.3	13.1	105.0	23.1	25.7	21.63
Bakulpryia	156.1	20.2	12.8	145.0	21.8	20.6	26.17
Altanuti	165.2	20.0	12.0	140.0	24.9	22.3	26.07
Rajendraban	164.5	18.0	12.4	125.0	22.7	20.8	24.10
Dadswal	113.6	13.0	11.9	141.3	21.7	31.7	25.50
Morichswal	110.0	12.2	11.0	102.3	22.2	20.8	19.03
Nonabakra	130.7	18.6	12.0	120.0	24.8	30.1	23.80
Pokkali	151.9	14.8	12.3	127.7	26.6	28.9	23.53
Ranjan	99.9	17.2	12.8	97.3	25.0	21.0	18.80
Bangalakshmi	135.8	16.8	11.9	107.3	27.0	24.5	23.27
Moulow	138.4	16.7	13.0	125.0	25.1	26.8	23.17
Palui	142.1	18.3	12.3	105.0	25.3	29.6	21.60
Akandi	140.2	18.1	12.9	109.3	25.4	22.6	22.63
Purnendu	160.3	19.2	12.2	155.7	25.2	18.7	31.0
CR-1280	136.2	17.9	12.3	102.7	26.5	17.6	21.07
Masuri	141.6	15.7	12.6	92.7	26.4	30.5	19.80
Niko	131.8	16.0	11.1	135.3	27.0	27.2	28.47
IR64(SC)	93.7	15.0	11.8	125.0	21.5	14.0	21.73
Swarna(SC)	122.3	13.3	10.5	97.3	27.7	26.3	17.53
N-Shankar	97.6	12.2	9.1	111.7	23.0	22.4	21.73
IR42(SC)	118.9	11.5	9.9	83.7	24.6	23.2	12.60
Jaladhi II	167.3	17.1	11.1	151.7	24.9	26.2	28.73
Khejurchori	156.2	13.3	8.9	137.3	29.3	28.1	28.47
Kanakchur	136.6	14.6	9.3	111.7	29.0	18.1	22.07
Lilabati	132.2	15.3	11.0	120.0	25.8	30.9	23.00
CD	2.18	2.2	1.3	14.5	1.3	1.5	1.9

F_2 - Normal statistical procedures were followed to calculate mean, standard deviation (SD) and coefficient of variation (CV) as per F_1 procedures were already given.

RESULTS AND DISCUSSION

Mean of field performances

Table 2 showed that genotypes like Mahananda, Purnendu, Nagalmuda, Lakshmikajal, performed well in compare with the tolerant checks under low land submerged field condition in relation to yield and other yield related components. On the basis of mean values of field screening these four genotypes performed appreciably better in submerged field conditions. These genotypes have a good scope in future breeding programme for submergence tolerance in rice.

Table 3. Crossing Success

Cross		No. of Cross Attempted	No. of Cross Recovered	Cross Recovered %
♀	♂			
Mahananda	Nagalmuda	240	20	8.33
Nagalmuda	Purnendu	170	13	7.65
Lakshmikajal	Purnendu	150	12	8.00
Mahananda	Sonom	160	10	6.25

Table 4. Mean and Coefficient of Variation (CV) of F_1 of Different Crosses

Cross		Plant Height (Cm)		No. of Tillers/ Hill		No. of Panicles/ Plant		No. of Filled Grains /Panicle		Length of The Panicle (Cm))		1000 Seed Weight (G)		Seed Yield/ Plant (G)	
		Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Mahananda	Nagalmuda	151.00	3.05	33.33	5.2	31.67	6.23	183.9	12.1	27.63	10.3	32.67	3.57	42.4	7.1
Nagalmuda	Purnendu	152.67	5.34	16.33	5.23	15.00	4.64	165.5	10.3	23.33	5.6	22.13	2.8	33.5	3.1
Lakshmikajal	Purnendu	157.33	2.13	17.67	6.41	15.33	11.34	158.3	12.3	24.33	3.2	23.33	5.41	32.3	4.7
Mahananda	Sonom	152.33	5.16	25.67	8.9	24.33	5.6	157.5	9.7	25.33	15.6	28.27	3.65	29.5	13.6
Mahananda	Control	163.20	7.2	25.00	6.1	23.00	7.1	173.20	3.7	28.63	3.21	29.33	1.97	40.5	2.3
Lakshmikajal	Control	169.70	3.14	14.33	2.13	11.00	1.76	145.20	2.2	22.13	5.3	25.33	2.3	29.3	1.67
Purnendu	Control	160.30	6.43	16.67	3.32	16.00	3.26	153.70	1.7	25.33	3.26	29.57	3.12	31.00	2.1
Nagalmuda	Control	158.30	1.61	15.00	2.36	14.33	1.76	158.65	2.1	25.03	2.56	32.00	1.43	30.00	1.87
Sonom	Control	98.60	2.1	15.3	1.67	12.33	2.13	85.35	1.8	23.57	3.13	20.27	3.27	19.3	3.79

Crossing Success

Crossing was done in different cross combinations namely Mahananda x Nagalmuda, Nagalmuda x Purnendu, Lakshmikajal x Purnendu and Mahananda x Sonom (Table 3) involving five different genotypes namely Mahananda, Nagalmuda, Purnendu, Lakshmikajal and Sonom. Crossing success varied from 6.25-8.33%. Germination percentage of the F_1 seeds was more than 90%.

F_1 Population: The Performance and Variability

The four different cross combinations involving five different genotypes constitute the F_1 population. Seven different agro-morphological characters namely were studied and mean value of these characters were recorded along with their CV estimates (Table 4). Plant height was reduced in the F_1 plants from their parents. The CV estimates was not very high signifying not much variation was observed for plant height. The tiller number as well as the panicle number increased for all the crosses than their respective parents and even their CV magnitudes were high signifying there was variation among the population. There was also increase in the grains per panicle and even the CV estimates were high. So there was quite an amount of variation in the grains per panicle among the population of different crosses. Length of the panicle, 1000 seed weight did not show much variation among mean estimates and even the CV values were low signifying not much variation among population. Seed yield per plant was also enhanced for the cross combination than their respective parents and their CV values were also high.

Mean, SD, CV of F_2 Lines Of Different Crosses

The F_2 lines were tabulated on the basis of mean yield and yield related characters along with their mean, SD and CV in Table 5**.** Plant height for the first cross Mahananda x Nagalmuda was within the range of 151cm to 171.5 cm. The tiller number varied for the F_2 population suggesting that the vegetative growth of the plant was altered. The CV and SD estimates exhibited deviations from the parental genotypes. The panicle number represented variation among the population ranging from 22.7 to 37.3. The filled grains per panicle were ranged from 153.2 to 210.4. The CV values were highly variable among the population.

The seed yield per plant ranged between 28.7 to 42.3g with high CV estimates in comparison to the parental genotypes signifying variation among the lines. The second cross between Nagalmuda x Purnendu recorded more or less similar response as that of the previous cross. The seed yield per plant was highest for the 4^{th} line with 35.6g. Thus there was increase in seed yield with respect to parental. The third cross representing Lakshmikajal x Purnendu revealed similar observations as that of the first cross to some extent. The mean seed yield was between 28.8g to 34.8g.The fourth cross was between Mahananda x Sonom revealed more or less similar mean values for the agro-morphological characters as in the first cross. The seed yield/plant was between 27.5 g to 32.3g. It is the least value among the different crosses. Based on the yield and yield related characters individuals were selected for further study.

Selection and Characterization

Total of seven F_2 individual were selected from the four different cross (Table 6**)**. Two plants were selected from each of the cross of Mahananda and Nagalmuda , Nagalmuda x Purnendu , Lakshmikajal and Purnendu and only one was selected from the cross Mahananda x Sonom. These individuals except Mahananda x Sonom produced very high seed yield per plant than their respective control.

Table 5. Mean, Standard Deviation (SD) and Coefficient of Variation (CV) of Different F_2 Lines

Cross		Plant height			Tiller /hill			Panicles /plant			Grains /panicle			Panicle length			1000 seed weight			Seed yield / plant		
		Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Mahananda	Nagalmuda	151.00	3.05	4.5	31.3	2.1	6.23	30.67	1.3	12.1	188.4	3.9	11.8	27.3	0.5	6.3	33.6	1.0	2.1	37.5	1.5	20.3
		154.00	4.2	3.4	34.3	1.3	13.4	32.3	1.2	13.3	199.4	5.0	12.8	27.7	0.8	5.4	34.7	0.8	2.3	41.5	1.7	24.3
		163.0	5.5	4.2	23.3	2.3	12.2	21.3	0.7	11.3	175.3	3.9	11.3	27.5	0.8	7.6	33.5	0.8	2.1	30.3	1.3	21.3
		153.5	6.3	6.5	37.3	1.9	15.7	37.0	1.7	14.2	210.4	4.1	17.6	28.6	1.1	9.1	35.0	0.8	1.3	42.3	0.9	23.3
		164.5	10.3	11.2	26.3	5.7	18.6	24.3	0.9	15.9	167.3	6.1	16.7	27.0	1.6	6.2	31.0	2.3	0.4	29.6	2.1	21.5
		158.2	8.2	4.2	29.0	3.7	10.2	27.3	3.4	16.1	174.4	5.6	11.9	27.5	1.6	9.1	32.5	0.4	1.7	30.2	1.6	23.5
		160.5	3.1	5.5	23.3	1.3	15.4	19.3	0.9	14.9	169.4	4.0	12.7	27.2	0.6	6.7	30.5	0.4	1.8	30.6	0.7	22.3
		171.5	7.1	12.3	24.0	4.9	15.2	21.3	4.6	18.6	161.1	5.3	11.3	26.3	4.8	7.2	29.4	4.9	2.2	32.7	6.2	22.5
		156.5	6.2	9.2	27.0	4.8	13.2	26.3	4.4	19.1	179.4	5.6	12.9	28.0	1.6	9.1	30.0	0.4	1.7	31.2	1.6	24.5
		165.6	5.5	8.7	22.7	2.1	17.3	19.3	1.7	19.6	153.2	7.5	15.3	28.3	1.0	8.4	29.6	0.5	2.3	28.7	1.4	24.1
Mahananda(Control)		163.20		7.2	25.00		6.1	23.00		7.1	173.20		3.7	28.63		5.1	29.33		1.97	40.5		2.3
Nagalmuda(Control)		158.30		1.61	15.00		2.36	14.33		1.76	158.65		2.1	25.03		2.56	32.0		1.43	30.0		1.87
Nagalmuda	Purnendu	150.5	6.3	11.33	19.3	5.1	10.5	18.3	4.1	10.5	170.5	4.9	12.6	24.0	2.3	5.3	30.1	4.1	10.7	34.5	3.9	10.5
		159.5	6.1	10.5	18.4	3.9	9.5	16.4	5.3	9.5	158.5	5.3	10.5	23.5	4.5	5.7	29.5	3.5	10.5	30.6	4.4	8.5
		155.7	10.5	12.1	17.5	4.1	9.0	17.0	6.1	10.2	160.1	4.2	11.1	24.3	3.6	6.2	29.1	4.3	12.3	29.2	4.6	9.6
		145.3	11.3	13.1	21.3	4.5	9.2	19.5	4.9	11.1	180.5	5.2	12.3	23.2	4.1	4.9	28.5	3.9	14.1	35.6	3.9	11.2
		160.7	9.3	10.1	18.4	5.1	9.9	17.2	5.2	9.1	155.1	5.5	14.1	23.6	4.7	5.2	30.4	5.2	10.2	29.4	4.2	10.2
		159.7	9.1	11.1	17.5	4.9	9.5	16.3	5.7	11.2	160.5	4.7	10.5	23.1	5.2	6.5	29.3	5.1	11.1	28.6	5.2	9.9
		162.5	10.5	12.1	20.3	4.6	9.7	18.1	4.9	10.3	158.2	6.1	11.3	24.5	5.6	4.9	29.4	4.8	11.4	31.2	6.4	9.2
		161.4	11.1	11.3	17.1	4.7	10.2	15.5	5.2	8.9	149.5	7.2	10.2	24.2	6.1	5.1	26.5	5.7	10.2	29.5	5.1	9.4
Nagalmuda(Control)		158.30		1.61	15.00		2.36	14.33		1.76	158.65		2.1	25.03		2.56	32.0		1.43	30.0		1.87
Purnendu		160.30		6.43	16.67		3.32	16.00		3.26	153.70		1.7	19.57		3.12	29.57		3.12	31.00		2.1
Lakshmikajal	Purnendu	158.3	10.6	9.1	18	4.1	2.3	17.0	4.8	2.2	161.6	13.7	16.7	24.3	4.9	2.2	26.3	4.9	2.2	30.1	5.5	2.3
		150.4	8.7	12.3	21	5.2	18.3	19.7	4.7	22.2	170.9	13.6	15.7	24.5	4.9	12.2	26.0	4.9	8.0	30.5	5.5	22.3
		145.3	11.7	10.1	24	6.2	20.3	22.4	4.7	21.0	175.9	13.2	17.6	23.7	4.8	7.2	26.5	4.8	7.9	33.4	5.3	20.1
		162.4	10.6	13.3	20.0	3.5	11.3	19.3	4.5	21.4	156.5	13.3	17.7	24.1	4.9	9.2	25.8	4.8	8.1	30.5	5.3	20.6
		165.6	10.8	11.5	18.0	5.6	19.3	17.2	4.8	19.1	150.6	14.0	16.7	23.8	5.0	7.3	26.7	4.8	9.2	29.5	5.7	19.8
		155.4	10.7	14.1	17.4	6.3	19.3	16.3	4.7	17.3	165.9	12.9	18.6	23.4	4.8	6.2	27.5	4.9	8.8	31.5	5.3	22.0
		142.6	9.5	13.2	24.7	5.1	22.2	22.7	4.5	18.1	180.6	13.3	20.7	23.3	4.9	8.4	28.0	4.9	10.0	34.8	5.3	20.0
		170.8	8.4	13.4	15.4	6.1	20.3	14.2	4.8	21.2	150.4	12.8	16.6	24.3	4.8	7.2	25.8	4.8	9.2	28.5	5.0	21.2
		166.6	9.6	9.1	16.3	5.6	2.3	15.1	4.8	18.2	150.4	13.7	16.7	24.5	4.9	2.2	25.5	4.9	2.2	29.1	5.5	2.3
		161.4	11.6	12.3	15.8	5.4	18.3	12.7	4.7	22.2	152.6	13.6	15.7	23.5	4.9	12.2	25.6	4.9	8.0	28.8	5.5	22.3
Lakshmikajal (Control)		169.7		3.1	14.3		2.1	11.0		1.7	145.2		2.2	22.1		5.3	25.33		2.3	29.3		1.67
Purnendu(Control)		160.3		6.43	16.67		3.32	16.00		3.26	153.70		1.7	19.57		3.12	29.5		3.12	31.00		2.1
Mahananda	Sonom	155.4	9.5	8.1	18.7	4.9	15.1	15.4	4.6	15.6	164.5	12.1	13.5	25.3	4.9	6.2	29.4	4.8	8.9	28.5	4.9	12.2
		153.3	9.6	7.6	24.5	5.2	10.3	21.4	4.6	18.1	177.1	12.1	15.2	23.5	4.8	5.8	29.0	4.9	9.2	30.5	5.0	14.3
		157.5	9.4	9.4	21.3	4.9	14.3	17.3	4.5	15.7	165.4	12.5	13.9	24.0	4.9	5.7	30.4	4.8	10.0	29.6	5.3	16.0
		159.8	9.3	8.2	26.6	5.2	13.6	24.6	4.8	19.0	180.3	12.1	16.0	25.1	4.8	6.0	30.3	4.8	9.8	32.3	5.0	11.2
		160.8	9.4	10.0	14.3	4.9	7.2	12.3	4.5	16.3	155.3	12.5	14.4	23.5	4.9	6.3	29.8	4.9	9.7	27.5	5.1	11.8
		159.3	9.5	7.9	15.5	5.3	16.0	14.3	5.1	15.5	167.6	11.7	15.5	25.3	4.8	5.5	28.5	4.8	9.5	29.4	4.8	10.9
Mahananda(Control)		163.20		7.2	25.00		6.1	23.00		7.1	173.20		3.7	28.63		5.1	29.33		1.97	40.5		2.3
Sonom(Control)		98.60		2.1	15.3		1.67	12.33		2.13	85.35		1.8	23.57		3.13	20.27		3.27	19.3		3.79

Table 6. Selected F_2 Hybrid Lines

Cross		Line No.	Plant height (cm)	Tillers per hill	Panicles per plant	Grains per panicle	Panicle length (cm)	1000 seed weight (g)	Seed yield per plant (g)
Mahananda	Nagalmuda	C1L2P5	156.5	36.4	34.2	205.4	28.0	32.2	46.2
		C1L4P7	152.2	39.2	37.3	222.4	29.0	33.5	47.5
Mahananda(Control)			158.30	25.00	23.00	173.20	28.63	29.33	40.5
Nagalmuda(Control)			160.30	15.00	14.33	158.65	25.03	32.0	30.0
Nagalmuda	Purnendu	C2L1P4	151.2	20.3	19.3	180.2	24.5	30.5	35.6
		C2L4P6	144.2	23.3	21.3	196.4	23.5	29.3	38.2
Nagalmuda(Control)			158.30	15.00	14.33	158.65	25.03	32.0	30.0
Purnendu(Control)			160.30	16.67	16.00	153.70	19.57	29.57	31.00
Lakshmikajal	Purnendu	C3L3P5	146.5	26.5	24.3	190.4	24.5	27.5	34.4
		C3L7P6	140.5	25.2	23.1	192.2	24.3	28.3	36.5
Lakshmikajal(Control)			169.7	14.3	11.0	145.2	22.1	25.33	29.3
Purnendu(Control)			160.30	16.67	16.00	153.70	19.57	29.57	31.00
Mahananda	Sonom	C4L4P5	160.2	26.5	24.5	190.5	25.5	29.5	34.3
Mahananda(Control)			158.30	25.00	23.00	173.20	28.63	29.33	40.5
Sonom(Control)			98.60	15.3	12.33	85.35	23.57	20.27	19.3

Two individual in particular derived from the cross of Mahananda and Nagalmuda appear to be most outstanding because of their high seed yield performances. So this would offer a good promise to introduce these selections as submergence tolerant lines in future breeding programme. Mackill *et al*, 1993 introduced the submergence tolerance trait into an agronomical useful paddy cultivar by conventional plant breeding method. Xu and Mackill, 1996, utilized an F_3 generation derived from a cross between intolerant *japonica* rice and *indica* rice receiving its tolerance genes from FR13A. It has been reported that the potential for identifying mechanism of tolerance derived from resilient cultivars unrelated to FR13A remains unexplored and represent a promising additional resource of plant breeding (Jackson and Ram, 2003). These kinds of findings support the present investigation further.

Conclusion

On the basis of seed yield/plant from field performances under low land submerged condition in which the water level was more than 50 cm at least for two weeks during the vegetative growth of the crop, four submergence tolerant genotypes namely Mahananda, Nagalmuda, Purnendu, Lakshmikajal and one susceptible genotypes namely Sonom were taken for the crossing programme and Mahananda x Nagalmuda, Nagalmuda x Purnendu, Lakshmikajal x Purnendu and Mahananda x Sonom crosses were made. The seed yield/plant of the four tolerant genotypes was better in compare the tolerant check genotypes. The parents were selected on the basis of seed yield/plant. Crossing success varied from 6.25-8.33%. The F_1 seeds were grown in the kharif season of the 2012. Some promising plants were selected from F_1 were referred as F_2 lines. Total of seven F_2 individual were selected from the four different cross in segregating generation. Six individuals produced very high seed yield per plant than their respective control. Two individual in particular derived from the cross of Mahananda and Nagalmuda appear to be most outstanding because of their high seed yield performances. So these selections have an outstanding scope to introduce as submergence tolerant lines in future breeding programme.

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