DEVELOPMENT OF NEW FLOOD TOLERANT RICE VARIETIES FOR COASTAL ANDHRA PRADESH

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Abstract: Flood is one of the major abiotic stresses limiting rice productivity in coastal areas due to unpredicted cylonic rains. Rice crop is very often prone to submergence at different growth stages. There is need to develop rice varieties withstanding more than one type of flood during crop growth to realize sustainable yields under adverse climatic conditions. Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station Maruteru is one of the renowned rice centre has developed flood tolerant variety MTU 1140 by conventional Plant Breeding tolerating 3 types of floods *i.e.,* submergence during germination for 2weeks (anaerobic germination), flash floods for 10 days up to pre reproductive stage followed by stagnant flooding (30-50 cm water depth) till the harvesting stage prevailing in Andhra Pradesh. This MTU 1140 has non lodging tendency posessing 2 weeks seed dormancy with duration of 140-145 days gave higher yield (6.0 tons/ha) under flooding compared to existing local stagnant flooding variety PLA1100. Advanced back cross lines of sub 1 introgressed Amara and Sona Mahsuri population showed highest plant survival percentage (>85%) compared to recurring parents under flash floods at 15 days after transplanting for 10 days followed by stagnant flooding. Identified 9 varieties showing more than 80% plant survival under 2 weeks anaerobic germination can be used as directly as variety or genetic stock in further breeding programmes of development of varieties suitable for direct seeding under wet season. Identified flood tolerant varieties MTU1140 and advanced back cross lines with sub 1 gene would give sustained yields even under flash floods cum stagnant flooding situations prevailing in coastal areas due to vagaries of climatic change.

Keywords: Anaerobic germination, flash floods, rice, stagnant flooding.

Introduction: Rice crop is very often subjected to floods from sowing to harvesting stage due to unpredicted cyclonic rains in coastal areas during monsoon season. This leads to drastic reduction in rice productivity. Submergence during germination (anaerobic germination), flash floods (complete submergence up to 2 weeks) and stagnant flooding (30-50cm water depth) are mostly prevailing types of floods in coastal Andhra Pradesh affecting rice crop severely. Recently occurrence of flash floods followed by stagnant flooding is becoming a major problem due to vagaries of climate change. Submergence during germination is another major constraint in cultivation of rice by direct seeding under wet puddled soils in monsoon season. Constant research efforts lead to the development of eight flash flood tolerant varieties like Swarna sub1, Samba Mahsuri sub1, PSBRC18 sub1, Ciherang sub1, CR1009 sub1, BR11 sub1, TDK sub1 and IR 64 sub1 but they are vulnerable to stagnant flooding situation [1]. Varieties bred for stagnant flooding are unable to survive under flash floods and also have lodging tendency due to elongation ability [5]. So far no cultivated rice variety has anaerobic germination to suit under direct seeding condition for wet direct seeding in monsoon season.

Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station(APRRI & RARS), Maruteru of Acharya NG Ranga Agricultural University is catering research needs of not only rice farmers of Andhra Pradesh but also rice farmers globally by its mega rice varieties Swarna (MTU 7029), Cottondora sannalu (MTU 1010), Vijetha (MTU 1001) apart from other mega variety Samba Mahsuri of university. Upscaling rice varieties Indra (MTU1061), Amara (MTU1064), Pushyami (MTU1075) are performing well even under adverse climatic conditions. Badavamahsuri (PLA 1100) developed from Agricultural Research Station, Pulla and other variety Amara (1064) of APRRI & RARS, Maruteru are suitable varieties for cultivation under stagnant flooding (30-50cm water depth). PLA 1100 does not tolerate flash floods more than 7 days but MTU 1064 can tolerate flash floods up to 10 days. Development of flood tolerant varieties at APRRI & RARS, Maruteru is strengthened from 2008 by conventional plant Breeding and Marker Assisted Selection. Intensified research efforts in development of flood tolerant varieties suitable to coastal areas lead to identification of flood tolerant variety MTU 1140 and introgression of sub1 into moderate elongating varieties Amara, Sona Mahsuri and Pushyami to cope up in both flash floods and stagnant flooding is under way.

Methodology:

Conventional Plant Breeding Varieties developed by pedigree method were screened for flash flood tolerance at 15 days after transplanting for 10 days

followed by stagnant flooding till the harvesting stage in advanced breeding lines at F_6 generation, entries in yield trials of stagnant flooding. Plant survived at 10 days after de-submergence and total shoot elongation under submergence was recorded to assess fast recovery and regeneration of growth after de-submergence from 2009 to 2010. Survived entries were promoted to Multi location yield trials in 2011 and 2012. Yield trials were replicated 3 times in each season. Spacing of 20X15cm was adopted. As shift in rice cultivation under direct seeding in wet puddled soil is increasing due to labor shortage, released and promising cultures were screened for anaerobic germination by sub surface seeding of pregerminated seeds (3 days after sowing) in puddled soil using plastic cups of size 4.5 X10.5 cm [2]. Plastic cups were submerged up to 50 cm depth in concrete tank for 14 days and plant survived 7 days after de-submergence were counted.

Marker Assisted Selection: Incorporation of Sub1 into Amara (MTU1064), Sona Mahsuri (BPT3291) and Pushayami (MTU1075) is under way by marker assisted selection. Phenotypic screening from BC_2F_2 generation is followed by complete submergence of the material at 15 days after transplanting for 10 days followed by stagnant flooding till the harvesting stage apart from genotyping for sub1[3].

Results and discussion : Identified flood tolerant variety MTU 1140 developed from cross combination of MTU 5249/ PLA 8572 tolerating 10 days flash floods and suitable for cultivation under stagnant flooding (30-50cm water depth) possessing 2 weeks anaerobic germination, nonlodging tendency with strong culm, 2 weeks seed dormancy with yield potential of 6tons/ha. It performed well under Multilocation trials in 2011 and 2012. Yield data particulars were furnished in Table 1. It has added advantage over exiting varieties PLA 1100 and MTU 1064 under stagnant flooding by possessing 2 weeks of anaerobic germination, nonlodging nature with strong culm, has moderate elongation ability (score:5) and shorter in duration compared to existing flood tolerant varieties. Seed was distributed to the farmers in kharif 2013 for minkit testing.

Physiological, morphological and quality characters of MTU 1140 in comparison with existing varieties PLA 1100, MTU 1064 and Swarna sub1 is furnished in Table 2. MTU 1140 is unique in its identity by its long broad leaf, strong culm with erect habitat of growth showing elongation ability under stagnant flooding.

Performance of sub1 introgressed lines under flash floods cum stagnant flooding: Identified sub 1 introgressed BC_2F_4 lines 2250-6-1 (90.52%) and 2250-10-1 (89.66%) of BPT3291/swarna of cross combination and 2244-39-20(95.69) and 2244-119-23 (91.38%) of MTU 1064/swarna sub cross combination showing highest plant survival % than corresponding recurring parent BPT 3291 (51.29%), MTU 1064 (68.00%) and swarna sub (36.0%) under 10days complete submergence at 15 days after transplanting coupled with stagnant flooding up to 50 cm water depth till harvesting stage and details are depicted in Table 3. These lines performed well under flash floods followed by stagnant flooding. Sub1 introgressed mega variety like Swarna sub confers only flash flood tolerance [4] and our sub 1 introgressed lines showing flash flood tolerance coupled with stagnant flooding would with stand under adverse climatic condition of flash floods followed by stagnant flooding.

Screening for anaerobic germination: Nine rice genotypes sabitha (95%), Isukaravalu (90%), PSRCsub82 (85%), MTU1158 (85%), IR 85956/23-1-2 (85%), Nandi (80%), PLA720 (80%), MTU 1140 (80%), Chaithanya (80%) exhibited more than 80% plant survival under submergence during germination (anaerobic germination) with good seedling establishment were identified. Among them, three genotypes Isukaravalu, IR 85956/23-1-2, MTU1140 co segregated with markers RM 341 linked to qAG2 on chromosome 2, RM 206 to qAG11 on chromosome 11 conferring presence of anaerobic germination for 2 weeks in these genotypes (Table 4). Identified lines can be used in further breeding programmes to develop varieties with anaerobic germination which can be used for direct seeding in wet season.

Conclusion: Constant research efforts lead to the development of flood tolerant rice variety MTU 1140 which can with stand three types of floods i.e submergence during germination, flash floods up to pre reproductive stage followed by continuous stagnant flooding. Sub1 introgressed advanced back cross lines of Amara and Sona mahsuri performing well under flash floods followed by stagnant flooding. Now a days flood tolerant rice varieties should posses different types of flood tolerance to with stand under adverse climatic conditions. The above identified flood tolerant varieties would provide sustained yields even under unpredicted water extremity of flooding due to recent trend of climatic change.

Future thrust: Efforts are under way to identify new sources for prolonged flooding, anaerobic germination and introgression of sub1 into moderately elongating varieties to cope under flash floods cum stagnant flooding. Breeding efforts to combine three types of floods into single variety is under way.

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Table 1: Yield data particulars of flood tolerant rice varieties

Name of the Trial	Year of testing	Grain yield (Kg/ha)		Percentage increase over check
		Entry	Check	
Observation yield trial	Kharif 2008	5469	4242 (PLA1100)	28.9
Preliminary yield trial	Kharif 2009	5810	4993 (PLA 1100)	16.4
Advanced yield Trial	Kharif 2010	5207	3903 (PLA1100)	33.4
MLT- (I year)	Kharif 2011	5980	5740 (MTU7029)	4.2
MLT- (I I year)	Kharif 2012	5851	5683 (MTU1061)	3.0

Table 2 Physiological, Morphological and quality characters of flood tolerant varieties

Variety	**MTU1140**	**PLA1100**	**MTU1064**	**Swarna**
Cross combination	MTU5249/ PLA8572	Vijaya/ Mahsuri	PLA1100/ MTU1010	Vasista/ Mahsuri
Duration days	140-145	155	145-150	145-150
Physiological characters				
Plant survival % at 35 days after transplanting	76.75	58.3	62.4	29.2
Total shoot elongation	38	24.6	29	19
Relative shoot Elongation	282	112	57	129
Anaerobic germination%	80	10	55	45
Morphological characters				
Plant height	125 cm	105 cm	115cm	100cm
Habit of growth	Errect, semi tall, non lodging with strong culm	Errect, semi tall, non lodging	Errect, semi tall, non lodging	Errect semi dwarf
Leaf sheath colour	light green	Green	Green	Dark green
Flag leaf	Errect	Errect	Errect	Errect
Leaf blade	Long broad leaf light green	Green	Green	green
Panicle type	Compact long fully exerted	Compact moderately exerted	Compact long fully exerted	Compact fully exerted
Grain size, shape	Medium slender	Medium slender	Medium slender	Medium slender
Glumes	straw	Brown	Brown	brown
Dormancy(weeks)	2	0	3	3
1000 grain weight gms	20.3	20.8	19.2	19.2
Quality characters				
Kernal length mm	5.88	5.6	5.51	5.5
Width mm	2.214	2.1	2.14	2.11
L/B	2.6	2.6	2.7	2.6
Chalkiness	Low	Low	Low	not present
Hulling %	78	77	75	76
Milling	69	69	67	68
HRR	65	65	64	63
Kernal Elongation ratio	2.08	1.62	1.74	1.68
ASV	4	5.5	6	2.8
GT	intermediate	intermediate	intermediate	intermediate
Water uptake	175	130	190	185
Gel consistency	43	65	65	48

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Table 3 Performance of advanced back cross lines (BC2F4) in Rabi 2012			
S. No.	**Code**	**Plant survival %**	**Total shoot elongation under submergence**
1	2244-39-20	95.69	25.00
2	2244-119-83	91.38	22.00
3	MTU 1064	68.00	24.30
4	Swarnasub	12.06	18.33
5	2250-10-1	89.66	17.67
6	2250-6-1	90.52	12.67
7	BPT3291	51.29	24.67
8	Swarnasub	36.0	18.33

Table 4 Summary of anaerobic germination in 2012					
S.No	**Genotype**	**Anaerobic germination %**		**Seedling vigour (14 days treated)**	
		7 days treated	**14 days treated**	**Shoot length (cm)**	**Root length (cm)**
1	SABITHA	100	95	26.5	5.5
2	ISUKARAVVALU	95	90	27.5	5.1
3	PSBRC82SUB	92.5	85	26	4.75
4	MTU1158	90	85	22.5	6.5
5	IR 85956/23-1-2	90	85	25	6.5
6	NANDI	80	80	21	5.25
7	PLA720	90	80	22	5.75
8	MTU 1140	82.5	80	13.5	8.5
9	CHAITHANYA	82.5	80	20.5	5
	Mean	80.2	42.9	16.6	5.15
	Range	22.5-100	0-95	0-29	0-8.75
	CD at 5%	5.2	1.8	1.72	0.55
	CV%	16.2	10.9	26.7	26.9

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