Selection of Lowland Rice Cultivars That Have Potential Tolerance to Water Flooding

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Abstract

This study aimed at: 1) Lowland rice genotypic selection in order to find out genotypes which tolerant to water flooding, 2) To find genotypes that have higher yield under flooding condition and 3) more understanding in lowland rice growth characters that correlated with water flooding tolerance.

Experimental design for experiment was factorial in split plot design with three replications. Main factor was flooding duration which had four levels, namely 0, 3, 6 and 9 days. Second factor was 100 lowland rice genotypes which were advanced generation of swamp rice genotypes and introduction genotypes from IRRI. Research was conducted at Sawah Baru Experimental Station (06°33', S, 106°45', 250m altitude), Bogor Agricultural University, Darmaga, Bogor, Indonesia.

Tolerance mechanism that are used for this experiment namely re-growth ability of shoot after one week flooding, lower percentage of plant that running dry and collapse plant after four days flooding, number of tillers and plant height.

Flooding duration, genotypes and their interaction significantly affected yield decrease, productivity, percentage of plants that running dry after four days flooding, percentage of plants that collapse after four days flooding, plant height at 11 and 13 Weeks After Planting (WAP), tiller numbers per hole at 11 and 13 WAP, panicle numbers per hole, rice water content at harvest, rice yield (14%) and 100 seed weight. Before flooding treatment, genotypes significantly affected plant height at 4, 5, 6 and 7 WAP.

Result of study showed that some lowland rice genotypes tolerance to the three days flooding and have higher yield, namely B10336F-KN-11-1-1-3, B10544E-KN-21-1, B10544E-KN-21-3, B10544E-KN-33-2, B10891B-MR-3-KN-4-1-1-MR-1, B10891B-MR-3-KN-7-1-2-MR-2 and B10528F-KN-35-2-2. Lowland rice genotypes that have higher yields and tolerant to 6 days flooding are IR70181-5-PMI-1-2-B-1, IR70213-9-CPA-12-UBN-2-1-3-1, B10590E-KN-4-PN-1-2-1-MR-1, B9831C-KN-21-2, B10408E-KN-2, B10130F-KN-25-1-1-2, B10590E-KN-4-PN-1-2-1-MR-1, B10894B-MR-2-3-KN-2-1, BP1027F-PN-1-2-1-KN-1-MR-3-1, B10528F-KN-31-2-1-MR-2 and B10528F-KN-35-2-1-MR-1. While lowland rice genotypes that tolerant to 9 days flooding and still have higher yields are IR70213-9-CPA-12-UBN-2-1-3-1, SWARNA, BP80E-TB-102-1, B10426B-KN-122, B10213F-KN-25-1-1-2, B10214F-KN-2-1-1-2, B10216F-TB-6-2-2-KY-2, B11586F-MR-11-2-2, B10891B-MR-3-KN-8-1-2-MR-1, B10528F-KN-35-2-1-MR-1, B11586F-MR-11-2-2, B10891B-MR-3-KN-4-1-1-MR-1 and KAL9418F-MR-2-KN-0.

Introduction

Water flooding decreased rice production up to 30 to 100% in farmer land, and as a result can decreased national rice production as much as 20 to 30%. Rice land area that is faced water flooding increased from year to year, and it was coverage 263 036 ha during year 2003. Most of water flooding occurred in areas of Java Island that has most fertile lowland in Indonesia (Deptan, 2005).

Genotype races and water flooding types will influence the magnitude of decreasing in rice yield. Rice genotypes that tolerance to water flooding such as valley rice (deepwater rice, floating rice) and submerged rice are not well known by the farmer. Submerged rice is appropriate for sudden flood and river flood. Sudden flood occur in the hilly and mountainous area with steep slope with short and high density of rain. While river flood occur when water excess the capacity of river bank, and the damage effect of this type of flooding is commonly lower than sudden flood type.

This research objectives are: 1) To select lowland rice genotypes in order to find out genotypes which tolerant to water flooding, 2) To find genotypes that have higher yield under flooding condition and 3) more understanding in lowland rice growth characters that correlated with water flooding tolerance.

Methodology

Experimental design for experiment was factorial in split plot design with three replications. Main factor was flooding duration which had four levels, namely 0, 3, 6 and 9 days. Second factor was 100 lowland rice genotypes which were advanced generation of swamp rice genotypes and introduction genotypes from IRRI (Table 1). Research was conducted at Sawah Baru Experimental Station (06°33', S, 106°45', 250 m altitude), Bogor Agricultural University, Darmaga, Bogor, Indonesia.

Water flood simulation was done in simulator pods with size 10 m in length, 5 m width, and 2 m depth. Simulator ponds were 3 ponds, and each pond represented flooding duration which was 3, 6 and 9 days. These simulator ponds arranged flooding up to 2 m depth. Water flooding treatment was done at 8 WAP and covered up to the highest part of the plant.

Observation were done for yield decrease, productivity, percentage of running dry plant after four days flooding, percentage of collapse plant after four days flooding, plant height, tiller number per hole, panicle number per hole, rice water content at harvest, rice yield (14%) and 100 seed weight. Before flooding treatment were plant height and tiller number per hole at 4, 5, 6 and 7 WAP.

Result and Discussions

Flooding duration, genotypes and their interaction significantly affected yield decrease, productivity, percentage of plants that running dry after four days flooding, percentage of plants that collapse after four days flooding, plant height at 11 and 13 Weeks After Planting (WAP), tiller numbers per hole at 11 and 13 WAP, panicle numbers per hole, rice water content at harvest, rice yield (14%) and 100 seed weight. Before flooding treatment, genotypes significantly affected plant height at 4, 5, 6 and 7 WAP, number of tillers per hole at 4, 5. 6 and 7 WAP.

Selection of Genotypes that Tolerance to Water Flood

Tolerance level to the water flood was determined by yield decreasing in yield after water flood treatment. If decreasing in yield was smaller, it means the higher level of tolerance to the water flood. Experimental result showed that interaction between genotypes and flood duration significantly affected yield decrease (R^2=0.90, P=0.0001). Selection of genotypes to water flood can be done for various flood duration, because there is interaction between genotypes and flood duration.

Yield decrease that affected by three days flooding are from 12.28 to 92.57% for genotypes number 47 and 27. Twenty genotypes that have highest level of flood tolerance are genotypes number 47,43,51,45,46,2,33,92,42,60,38,72,67,65,97,96,62,80,61 and 57. Decreasing in yield of these genotypes was 12.28 to 32.98% (Table 2).

Table 1. Rice Genotypes used in The Experiment

No.	Name	No.	Name
1	BATANGHARI	51	B11016D-KN-2-1
2	IR69502-6-SKN-UBN-1-B-1-3	52	B11016D-KN-7-1
3	IR70181-5-PMI-1-2-B-1	53	B11017D-KN-53-2
4	IR70213-9-CPA-12-UBN-2-1-3-1	54	B10894B-MR-2-3-KN-2-1
5	IR70215-2-CPA-2-1-B-1-2	55	B10553E-KN-99-1-2
6	SWARNA	56	BP367E-MR-42-4-PN-3-KN-3-MR-2
7	B10018G-TB-42-1	57	BP367E-MR-42-4-PN-3-KN-3-MR-3
8	B10018G-TB-56-1	58	BP367E-MR-42-4-PN-3-KN-3-MR-4
9	B10018G-TB-63-1	59	B10216F-TB-6-2-2-KY-2
10	B10018G-TB-63-2	60	B11586F-MR-11-2-1
11	B10018G-TB-68-1	61	B11586F-MR-11-2-2
12	B10018G-TB-97-2	62	B10891B-MR-3-KN-4-1-1-MR-1
13	B10018G-TB-97-3	63	B10891B-MR-3-KN-4-1-1-MR-3
14	B10214G-TB-32-1	64	B10891B-MR-3-KN-7-1-2-MR-1
15	BP80E-TB-102-1	65	B10891B-MR-3-KN-7-1-2-MR-2
16	B9856D-MR-93-3	66	B10891B-MR-3-KN-8-1-2-MR-1
17	B9856D-MR-93-33	67	B10891B-MR-3-KN-8-1-2-MR-3
18	B9856D-MR-93-40	68	BP1027F-PN-1-2-1-KN-1-MR-1-2
19	IR42	69	BP1027F-PN-1-2-1-KN-1-MR-3-1
20	B10590E-KN-4-PN-1-2-1-MR-1	70	B10687D-KN-17-3-3-MR-7-4
21	B9856D-MR-93-41	71	B10868F-MR-15-1
22	B9833C-KA-III-13-4	72	B10528F-KN-35-2-2
23	B9833C-KA-III-13-5	73	TOX4236-5-1-1-KY-3
24	B9833C-KA-III-13-6	74	B10687D-KN-7-3
25	B9831C-KN-21-2	75	BP1035F-PN-1-3-1-KN-8
26	B10426B-KN-122	76	IR77077-B-2B-1-2
27	B104047E-KN-41	77	B10528F-KN-14-3-1-MR-1
28	B10408E-KN-2	78	B10528F-KN-31-2-1-MR-2
29	B10130F-KN-25-1-1-2	79	B10528F-KN-33-1-1-MR-2
30	B10213F-KN-25-1-1-2	80	B10528F-KN-35-2-1-MR-1
31	B10214F-KN-2-1-1-2	81	B10528F-KN-35-2-2-MR-3
32	B10214F-KN-2-3-2-1	82	B10528F-KN-56-2-2-MR-3
33	B10336F-KN-11-1-1-3	83	BP1019F-PN-6-3-1-KN-3-MR-5-3
34	B10336F-KN-1-3-3	84	BP1027F-PN-1-2-1-KN-1-MR-3-3
35	BP74F-MR-61	85	B10861F-MR-12-4
36	BP75F-MR-5	86	B10862F-MR-5-1
37	B10604E-KN-69-1-MR-1	87	B11377F-MR-34-2
38	BP384E-KN-1-1-MR-6-1-2	88	BP367E-MR-42-4-PN-3-KN-3-MR-4
39	B11230-10-1-PN-1-2-2-1-2	89	B11586F-MR-11-2-2
40	B11237-6-17-PN-3-3-4-1-3	90	B10891B-MR-3-KN-4-1-1-MR-1
41	B10533F-KN-34-2	91	B9858D-KA-55

No.	Name	No.	Name
42	B10544E-KN-7-1	92	B9833C-KA-14
43	B10544E-KN-7-3	93	B9852E-KA-66
44	B10544E-KN-19-2	94	B5524G-SM-61-2-1
45	B10544E-KN-21-1	95	B7003D-MR-24-3-1
46	B10544E-KN-21-3	96	KAL9414F-MR-2-KN-0
47	B10544E-KN-33-2	97	KAL9418F-MR-2-KN-0
48	B10580E-KN-94-2	98	B10214F-TB-7-2-3
49	B10590E-KN-4-PN-1-2-1-MR-1	99	IR61242-3B-B-2
50	BP143-MR-4-3-1-PN-2	100	B10329F-TB-13-2-3-MR-1

Table 2. Yield Decrease and Level of Genotype Tolerance to Three Days Water Flood

Genotype Number	Yield Decrease (%)	Tolerance Levels	Genotype Number	Yield Decrease (%)	Tolerance Levels
47	12.3	1	41	47.9	51
43	12.8	2	20	48.8	52
51	14.4	3	76	49.1	53
45	14.6	4	68	50.0	54
46	19.7	5	14	50.8	55
2	20.4	6	73	51.2	56
33	21.5	7	55	51.3	57
92	22.3	8	30	51.5	58
42	22.9	9	34	52.5	59
60	25.1	10	87	53.7	60
38	25.5	11	17	54.9	61
72	25.5	12	19	55.2	62
67	26.2	13	31	56.3	63
65	28.0	14	37	57.0	64
97	29.7	15	21	58.0	65
96	31.3	16	12	58.3	66
62	31.7	17	9	59.1	67
80	32.4	18	1	60.2	68
61	32.8	19	64	60.5	69
57	33.0	20	5	60.7	70
39	34.2	21	82	61.1	71

Yield decreased by water flooding during 6 days between 14.74 to 100%. Twenty genotypes that have highest tolerance levels to 6 water flooding were genotype number 20, 28, 4, 49, 53, 78, 23, 29, 5, 3, 54, 85, 59, 19, 6, 38, 80, 13, 69 and 25. Yield decreasing of those 20 genotypes were between 14.74 to 44.82% (Table 3).

Table 3. Yield Decrease and Level of Genotype Tolerance to Six Days Water Flood

Genotype Number	Yield Decrease (%)	Tolerance Levels	Genotype Number	Yield Decrease (%)	Tolerance Levels
20	14.7	1	66	73.9	51
28	18.8	2	32	74.4	52
4	22.6	3	63	74.9	53
49	22.9	4	15	76.1	54
53	25.4	5	22	76.7	55
78	28.0	6	95	76.8	56
23	32.3	7	31	77.6	57
29	32.6	8	90	77.7	58
5	32.8	9	37	77.9	59
3	33.0	10	74	78.8	60
54	34.4	11	27	78.9	61
85	34.5	12	92	79.7	62
59	36.0	13	52	81.4	63
19	38.8	14	98	82.2	64
56	39.2	15	16	83.2	65
38	40.1	16	87	83.3	66
80	43.3	17	93	84.7	67
13	43.9	18	44	85.5	68
69	44.3	19	65	85.6	69
25	44.8	20	24	86.3	70

Yield decreased by water flooding during 9 days between 24.63 to 100%. Twenty genotypes that have highest tolerance levels to 6 water flooding were genotype number 26, 31, 4, 61, 95, 6, 15, 30, 5, 94, 80, 90, 53, 97, 59, 60, 42, 75, 89 and 66. Yield decreasing of those 20 genotypes were between 24.63 to 72.57 % (Table 4).

Table 4. Yield Decrease and Level of Genotype Tolerance to Nine Days Water Flood

Genotype Number	Yield Decrease (%)	Tolerance Levels	Genotype Number	Yield Decrease (%)	Tolerance Levels
26	4.6	1	76	89.7	51
31	27.3	2	70	89.8	52
4	27.9	3	83	89.8	53
61	30.7	4	49	90.3	54
95	42.7	5	58	91.0	55
6	51.6	6	23	91.0	56
15	59.4	7	81	91.3	57
30	60.1	8	64	92.0	58
5	62.1	9	87	94.1	59
94	63.7	10	99	94.4	60
80	65.2	11	69	94.5	61
90	68.3	12	74	94.8	62
53	68.5	13	25	95.1	63
97	68.8	14	50	95.6	64
59	69.2	15	48	98.2	65
60	69.8	16	1	100.0	66
42	70.9	17	7	100.0	67
75	71.0	18	8	100.0	68
89	72.2	19	9	100.0	69
66	72.6	20	10	100.0	70

Effect of Interaction between Genotype and Flood Duration to Production

Interaction between genotype and flood duration significantly influenced rice yield. Twenty genotypes that have the highest levels of productivity after three days water flood are genotype number 46,45,47,74,8,40,68,7,33,9,17,70,65,34,28, 62, 73 ,39 ,72 and 37. Productivity of those genotypes was more than 6 ton/ha (Table 5).

Table 5. Lowland Rice Genotype Productivities under Three Days Water Flooding

Genotype Number	Productivity (ton/ha)	Productivity Levels	Genotype Number	Productivity (ton/ha)	Productivity Levels
46	18.286	1	91	3.365	51
45	14.654	2	51	3.313	52
47	13.696	3	11	3.263	53
74	12.525	4	77	3.263	54
8	10.718	5	30	3.231	55
40	10.039	6	1	3.212	56
68	9.861	7	55	3.206	57
7	9.691	8	4	3.183	58
33	8.486	9	92	3.149	59
9	8.175	10	56	3.126	60
17	8.135	11	31	3.092	61
70	8.067	12	75	3.039	62
65	7.683	13	90	3.018	63
34	7.546	14	53	3.008	64
28	6.832	15	38	2.946	65
62	6.787	16	85	2.888	66
73	6.759	17	94	2.828	67
39	6.412	18	98	2.807	68
72	6.374	19	93	2.795	69
37	6.371	20	36	2.788	70

Twenty genotypes that have the highest levels of productivity after 6 days water flood are genotype number 8, 69,28,70,49 ,54,29,17,20,78,50,34,64,25,74,3,80,86,27 and 4. Productivity of those genotypes was more than 4.2 ton/ha (Table 6) The other twenty genotypes have the highest levels of productivity after 9 days water flood, namely genotype number 26,31,6,4,34,65,80,30,45,89,61,3,72,29, 15,97,66,90,24, and 59. Productivity of those genotypes was more than 1.69 ton/ha (Table 7).

Genotypes that have higher productivity and also tolerance to the water flooding are genotype number 33,45,46,47,62,65 and 72 (for 3 days water flooding), genotype number 3,4,20,25,28,29,49,54,69,78 and 80 (for 6 days), and genotype number 4,6,15,26,30,31,59,61,66,80,89,90 and 97 (for 9 days).

Table 6. Lowland Rice Genotype Productivities under Six Days Water Flooding

Genotype Number	Productivity (ton/ha)	Productivity Levels	Genotype Number	Productivity (ton/ha)	Productivity Levels
8	14.209	1	2	1.687	51
69	9.969	2	97	1.675	52
28	8.678	3	87	1.667	53
70	6.995	4	52	1.637	54
49	6.837	5	65	1.538	55
54	6.698	6	94	1.527	56
29	6.346	7	60	1.493	57
17	5.472	8	51	1.406	58
20	5.458	9	31	1.374	59
78	5.365	10	83	1.372	60
50	5.182	11	26	1.367	61
34	4.809	12	88	1.340	62
64	4.680	13	16	1.296	63
25	4.663	14	90	1.282	64
74	4.612	15	33	1.255	65
3	4.586	16	61	1.248	66
80	4.503	17	76	1.247	67
86	4.431	18	15	1.135	68
27	4.364	19	24	1.104	69
4	4.286	20	45	0.977	70

Table 7. Lowland Rice Genotype Productivities under Nine Days Water Flooding

Genotype Number	Productivity (ton/ha)	Productivity Levels	Genotype Number	Productivity (ton/ha)	Productivity Levels
26	11.782	1	49	0.812	51
31	4.837	2	36	0.805	52
6	4.211	3	98	0.803	53
4	3.993	4	51	0.673	54
34	3.192	5	85	0.624	55
65	2.819	6	2	0.623	56
80	2.803	7	87	0.610	57
30	2.799	8	71	0.590	58
45	2.404	9	81	0.587	59
89	2.298	10	48	0.539	60
61	2.223	11	83	0.496	61
3	2.044	12	50	0.470	62
72	1.962	13	23	0.423	63
29	1.947	14	25	0.388	64
15	1.926	15	99	0.385	65
97	1.900	16	1	0	66
66	1.831	17	7	0	67
90	1.719	18	8	0	68
24	1.716	19	9	0	69
59	1.699	20	10	0	70

Effect of Flood Duration to Rice Plant Growth

Water flooding also influenced plant height and panicle number. The longer duration of flooding plant height and tiller number became lower (Table 8). The lower plant height and tiller number caused by plant organ was destructed, and then inhibited plant metabolism.

Tabel 8. Effect of Water Flood to Plant Height and Maximum Tiller Numbers

Flooding Duration	Plant Height (cm)	Tiller Number
0 days	97.7683 a	21.03 a
3 days	89.1703 b	13.42 b
6 days	66.5250 c	6.80 c
9 days	46.4900 d	3.31 d

Note: Data in the same column followed by similar alphabet mean not significant by Tuckey Analysis (0.05)

Interaction between flood duration and genotypes significantly effected plant height (R2=0.99, P=0.0001) and tiller number (R2=0.99, P=0.0001). Genotypes that have taller plant height under no flood, 3, 6 and 9 days flooding are genotype number 12, 31 and 97,with height in average 130.6, 125.0, 120.3, and 115.0 cm, respectively. Genotypes that have bigger tiller number under no flood, 3, 6 and 9 days flooding are genotype number 17, 33 , 74, and 24 which tiller number 59.0, 53.3, 25.7, and 11.7 (data is not shown).

Conclusions

1. Lowland rice genotypes that tolerance to 3 days water flooding are B10336F-KN-11-1-1-3, B10544E-KN-21-1, B10544E-KN-21-3, B10544E-KN-33-2, B10891B-MR-3-KN-4-1-1-MR-1, B10891B-MR-3-KN-7-1-2-MR-2, and B10528F-KN-35-2-2.
2. Lowland rice genotypes that tolerance to 6 days water flooding are IR70181-5-PMI-1-2-B-1, IR70213-9-CPA-12-UBN-2-1-3-1, B10590E-KN-4-PN-1-2-1-MR-1, B9831C-KN-21-2, B10408E-KN-2, B10130F-KN-25-1-1-2, B10590E-KN-4-PN-1-2-1-MR-1, B10894B-MR-2-3-KN-2-1, BP1027F-PN-1-2-1-KN-1-MR-3-1, B10528F-KN-31-2-1-MR-2, and B10528F-KN-35-2-1-MR-1.
3. Lowland rice genotypes that tolerance to 3 days water flooding are IR70213-9-CPA-12-UBN-2-1-3-1, SWARNA, BP80E-TB-102-1, B10426B-KN-122, B10213F-KN-25-1-1-2, B10214F-KN-2-1-1-2, B10216F-TB-6-2-2-KY-2, B11586F-MR-11-2-2, B10891B-MR-3-KN-8-1-2-MR-1, B10528F-KN-35-2-1-MR-1, B11586F-MR-11-2-2, B10891B-MR-3-KN-4-1-1-MR-1, dan KAL9418F-MR-2-KN-0.
4. Tolerance mechanism to water flooding such as re-growth ability of bud one after water flooding, percentage of running dry plant and collapse plant after 4 days water flooding, plant height and tiller number are appropriate for this research.

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