PERSONNEL (July 2022-June 2023)

Name	Designation	Man-Month
Mst. Salma Pervin, PhD	CSO and Head	12
Md. Sazzadur Rahman, PhD	PSO	12
Hirendra Nath Barman, PhD	SSO	12
Salma Akter, PhD	SSO	12
Tuhin Halder, MS	SSO	12
Sadia Afrin Shupta, MS	SO	12
Jannatul Ferdous	SA	12
Shaddakat Hossain	SA	12
Rahima Khatun	PA D(Res)	12
Md. Nazim Uddin	LA	12
Runa Layla	LA	12
Sumaiya Binte Kabir	LA	12

CONTENTS

USEFUL SCIENTIFIC INFORMATION

- Two germplasm (BRRI Genebank Acc. no. 3870 and 3881), one advanced breeding line (BR12274-4R-113) and four (4) parental line of hybrid rice (namely, BHR37, BHR80, BHR259 and BHR260) were found tolerant to salinity stress and could be used for breeding program.
- Fourteen germplasms (namely, BRRI Genebank Acc. no. 2098, 2102, 2105, 2116, 2118, 2121, 2124, 2133, 2135, 2139, 2149, 2155, 2156 and 2157) have ability anaerobic tillering should produce ≥10 tillers/hill under water stagnant condition.
- Four BRRI Genebank Acc. no. 2312, 2320, 2451 and 2554 were consistently found drought tolerant in two consecutive evaluations under field and controlled drought condition which could be useful as donor parents in drought breeding program.
- Three BRRI Genebank Acc. no. 2092, 2093 and 2135 were found tolerant to heat during anthesis should maintain spikelet fertility 66, 70 and 80% respectively.
- KASP genotyping is advantageous over the combination of InDel and CAPS considering introgression of *qHTSF4.1* into diverse genetic background.
- The BRRI Genebank Acc. no. 2836, and advanced breeding lines BR12552-3R-179, BR12552-3R-199 and BR11337-5R-29 were found tolerant to cold stress at seedling stage showing 80% survivability having SES score1and 3.
- Optimum harvesting time was found between 29 to 33 DAF (days after flowering) and 33 to 37 DAF for dry and wet season respectively. A significant yield (about 20-50%) was reduced due to early harvesting (about 21 to 25 DAF) in wet season. At dry season about 12-28% yield could be reduced if harvesting done after three weeks after flowering. About 12% reduction in yield occurred when harvesting one week late than optimum time in both seasons.
- Uri dhan contains more vascular bundles in the lemma and palea than rice. Rice has 5 and 3 vascular bundles in the lemma and palea, compared to 11-15 and 8-12 in the Uri dhan lemma and palea.
- Two days of complete submergence and six days of recovery were found to be critical in differentiating submergence tolerant and sensitive cultivars using chlorophyll fluorescence imaging system.

SUMMARY

A total of 34 experiments and studies under nine different projects have been carried out during the reporting period 2022-23 in the Plant Physiology Division of BRRI.

SALINITY TOLERANCE

A total of 287 BRRI Genebank germplasm, 343 advanced breeding lines, 375 hybrid rice parental lines, and 10 hybrid varieties were characterized for salinity tolerance at the seedling stage in hydroponics culture at a salinity stress level of 12 dS/m. Out of the studied materials, 17 genotypes were found to be tolerant, while 163 have been classified as moderately tolerant.

SUBMERGENCE TOLERANCE

A total of 90 BRRI Genebank germplasm were evaluated for two weeks of complete submergence, however none were found to be submergence tolerant. Sixty BRRI Genebank germplasm were evaluated for anaerobic tillering capacity in water stagnant conditions. 14 germplasm (BRRI Genebank Acc. no. 2098, 2102, 2105, 2116, 2118, 2121, 2124, 2133, 2135, 2139, 2149, 2155, 2156, and 2157) produced ≥10 tillers per hill in water stagnant conditions.

DROUGHT TOLERANCE

In drought tolerance, 300 BRRI Genebank genotypes were evaluated, with 40 germplasm chosen for future evaluation. Furthermore, 44 previously selected BRRI Genebank germplasm were examined under control drought conditions in the rain-out shelter, with BRRI Genebank Acc. no. 2451 producing the highest yield, followed by BRRI Genebank Acc. no. 2554, 2312, and 2320. The sterility percentage of these genotypes was less than 50%.

HEAT TOLERANCE

- Fifty germplasm from the BRRI Genebank and 36 advanced breeding lines were evaluated for high temperature tolerance. One germplasm scored one (SES 1), but two others scored 3 (SES 3), indicating that they are very tolerant of extreme heat conditions.
- Two years of phenotyping of *qHTSF4.1* introgression lines under controlled high temperature and high relative humidity conditions resulted in a moderate influence on spikelet fertility of the introgression lines.
- The KASP-SNP genotyping technology has potential as a genotyping tool for rice breeding programs. The KASP approach revealed the presence of *qHTSF4.1* in the BRRI dhan71 background.

COLD TOLERANCE

- Cold tolerance at the seedling stage was evaluated with 300 BRRI Genebank germplasm and 1563 advanced breeding lines. SES score 3 for two Genebank accessions classed as tolerant, while SES 5 for 28 germplasm demonstrated moderate cold tolerance at the seedling stage. Three of the 1563 advanced breeding lines studied received a score of one (SES 1), whereas 472 lines and 23 local landraces with a score of five (SES 5) were categorized as moderately cold tolerant.
- Seeding times 24 October and 01 November were used to screen 8 advanced breeding lines and 3 local landraces for cold tolerance at the reproductive phase in natural field conditions. BR11894-R-105 (5.1 t/ha), BR11894-R-R-R-329 (5.20 t/ha), and check varieties BRRI dhan67 and BRRI dhan89 had considerably higher grain yield than BRRI dhan28 (3.28 t/ha) on the first seeding date of early sowing/planting. Other genotypes BR11894-R-R-R-R-169 and BR11894-R-228 had also comparable yield to BRRI dhan67 (5.09 t/ha) and BRRI dhan89 (5.35 t/ha). The advanced line BR11894-R-R-R-R-169 yielded 7.13 t/ha on November 1, followed by BR11894-R-R-R-R-110 (7.02 t/ha), which were statistically similar to the check varieties BRRI dhan67 (6.26 t/ha) and BRRI dhan89 (6.63 t/ha).

GROWTH STUDIES AND YIELD POTENTIAL

- Screening for photosensitivity of 267 advanced breeding lines and 20 local germplasm revealed that 51 advanced breeding lines and all local germplasm were strong photosensitive compared to the standard Nizersail, with the exception of Tepiboro and Rataboro.
- In T. Aman season 2022, BRRI dhan75, BRRI dhan79, and BRRI dhan80 were lodging tolerant while BRRI dhan76 and BRRI dhan77 were partially lodged compared to tolerant check BR11 and susceptible check BRRI dhan32 in several morphological characteristics. In Boro season 2022-2023, BRRI dhan47, 58, 61, 81, 89, 96, SVIN109, BR11318-5R-63, IR17A1694 has lodging resistance capacity in morphological and anatomical lodging parameters like less number of air space and higher inner or large vascular bundle.
- With nitrogen levels N200, N160 for long-duration varieties and N150, N120 for short-duration varieties, leaf, culm, and panicle dry matter partitioning and growth rates at different phenophases were higher. Total dry matter production was highly correlated with grain yield. Results showed that LAI, CGR, and NAR were lowest at the start and peaked at 75-90 DAT and 60-75 DAT for both short and long duration varieties, respectively. N160, N200, and N120 did best, and presumably N150, N120, N60, and N90 worked best in regard to physiological growth indices, resulting in increased grain yield.
- The harvesting period of rice is a significant factor in determining crop yield. It has been noticed that crops mature earlier in the dry season than in the wet season. Early harvesting (21 to 25 DAF) during the wet season can result in a large yield loss (approximately 20-50%), as can a 12% decline in field production when harvesting is done one week later than the optimum time.
- The phenological development phases acquired from the observation varied during the vegetative stage due to each variety's different seeding dates. The days from sprouting to PI changed from 63 to 68 days, 89 to 93 days, and 82 to 85 days for BRRI dhan88, BRRI dhan92, and IR64, respectively, as seeding time increased. The number of days required to reach each phenological stage varied by cultivar.

GENOME EDITING

- Improving rice salinity tolerance using the CRISPR/cas9 technique, the guide sequence of the OsRR22 gene was successfully cloned into the binary vector pC1300-Cas9. Plants were regenerated through Agrobacterium-mediated transformation. PCR amplifications were performed utilizing primer pairs, resulting in an amplicon containing the target site. The resultant amplicons were sequenced using the Sanger method, and a mutant plant was identified by the loss of two nucleotides at the target location.
- Developing a male sterile line using the CRISPR/cas9 technology, the guide sequence of the TMS5 gene was correctly cloned into the binary vector pC1300-Cas9. Plants were regenerated through Agrobacterium-mediated transformation. Hygromycin phosphotransferase positive plants were discovered using an HPT primer pair derived from the Cas9 vector's Hygromycin phosphotransferase resistant zone.

C4 RICE DEVELOPMENT

- The green tissues of rice and Uri dhan spikelets were examined structurally. Uri dhan contains more vascular bundles in its lemma and palea than rice spikelets.
- After two days of total submergence treatment and six days of recovery, Chlorophyll fluorescence imaging revealed significant variations in maximal quantum yield (Fv/Fm) between the submergence donor and BRRI dhan52 to submergence sensitive.

CROP WEATHER INFORMATION

Weather parameters (temperatures, humidity, rainfall, solar radiation, sunshine hour) were recorded and presented as monthly average basis from BRRI headquarter and seven regional stations viz. Rangpur, Barishal, Habiganj, Bhanga, Rajshahi, Sonagazi and Cumilla during the reporting year (July 2022 - June 2023).

PROJECT 1: SALINITY TOLERANCE

Expt. 1.1: Screening of rice germplasm for salinity tolerance at seedling stage

Tuhin Halder, Salma Akter and Mst. Salma Pervin

Objective: To identify saline tolerant rice germplasm at seedling stage

Materials and Methods: Two hundred eighty seven (287) rice germplasm were tested along with check IR58443 (Tolerant Check) and IR154 (Susceptible Check). The experiment was conducted by following method described Gregorio *et al.*, (1997) at Plant Physiology Net house, BRRI. Hydroponic culture of Yoshida solution was used to grow the seedling. Salinity stress @ 12dS/m was applied at 7 days of seedling growth. The pH of the culture solution was checked and maintained at 5.0 for daily basis and the solution was replaced with new at each week until susceptible check died and scored 9. The final score was taken after susceptible check died or SES scored 9. The experiment was carried out following RCB design with 2 replications.

Results: Among the 287 germplasm, none of the germplasm found with SES score 1, but two (2) germplasm namely BRRI Genebank Acc. no. 3870 and 3881 were found tolerant with SES score 3 and six (6) germplasm namely BRRI Genebank Acc. no.3750, 3865, 3867, 3893, 4176 and 4186 were found moderately tolerant salinity with SES score 5 and rest of the germplasm (279) were found moderately susceptible to susceptible and scored 7 and 9 (**Fig. 1.1 and Table 1.1**). The SES score of IR58443 and IR154 was 3 and 9 respectively.

Conclusion: Two germplasm BRRI Genebank Acc. no. 3870 and 3881 may be used for further investigation to confirm the salinity tolerance.

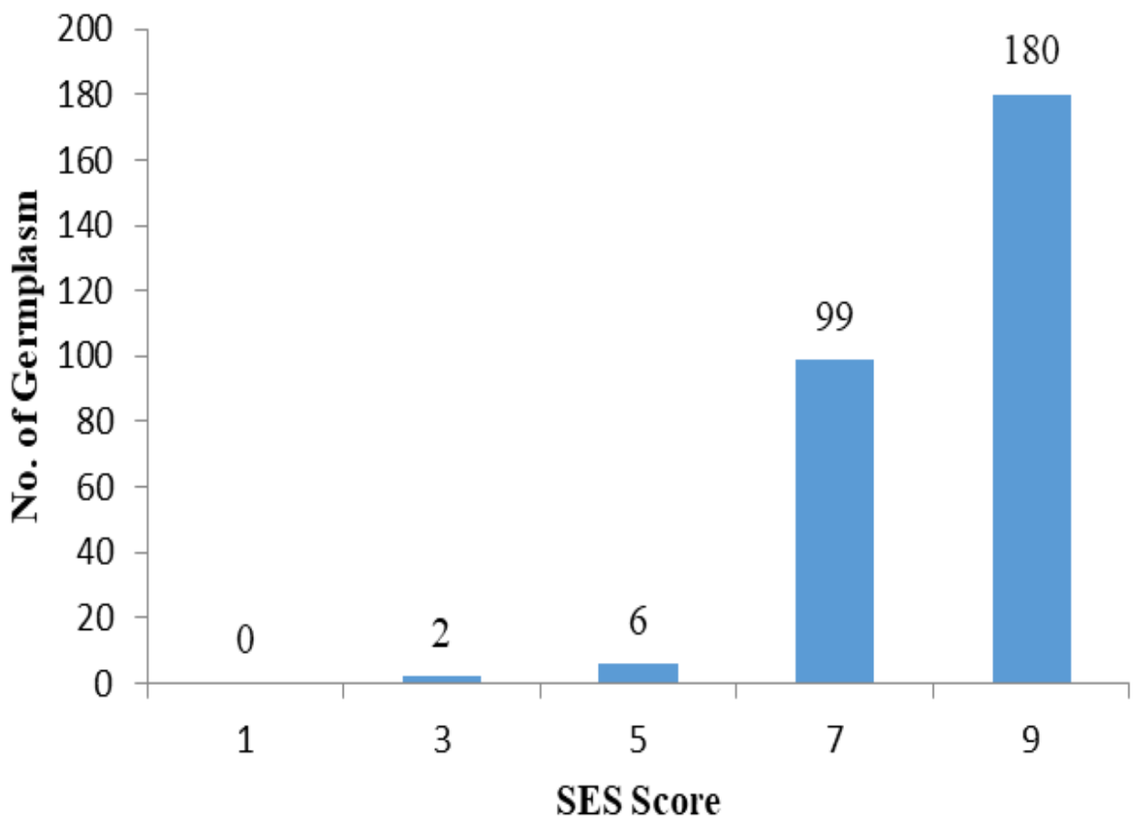

Fig. 1.1: Distribution of tested germplasm according to their SES score under 12dS/m salinity stress at seedling stage.

Table 1.1: SES score of tested germplasm according under 12dS/m salinity stress at seedling stage

Sl. No.	BRRI Genebank Acc. no.	SES score	Sl. No.	BRRI Genebank Acc. no.	SES score	Sl. No.	BRRI Genebank Acc. no.	SES score
1	3636	9	61	3745	7	121	3840	9
2	3638	9	62	3746	7	122	3841	9
3	3639	9	63	3748	7	123	3842	7
4	3643	9	64	3749	7	124	3844	9
5	3645	9	65	3750	5	125	3845	7
6	3647	7	66	3751	9	126	3846	9
7	3649	9	67	3752	9	127	3847	7
8	3650	7	68	3753	9	128	3848	7
9	3652	9	69	3754	9	129	3849	7
10	3653	9	70	3755	9	130	3850	7
11	3654	9	71	3756	9	131	3852	9
12	3655	9	72	3757	9	132	3854	7
13	3656	7	73	3758	7	133	3856	7
14	3657	7	74	3759	9	134	3857	9
15	3660	7	75	3760	9	135	3859	9
16	3662	9	76	3761	9	136	3860	7
17	3663	9	77	3764	9	137	3862	9
18	3664	9	78	3765	7	138	3863	9
19	3665	9	79	3766	7	139	3864	9
20	3667	7	80	3767	7	140	3865	5
21	3668	9	81	3768	7	141	3866	7
22	3670	7	82	3769	7	142	3867	5
23	3673	7	83	3770	9	**143**	**3870**	**3**
24	3674	9	84	3771	7	144	3872	9
25	3676	9	85	3772	7	145	3873	9
26	3677	9	86	3773	7	146	3874	9
27	3678	9	87	3774	7	147	3875	9
28	3680	9	88	3776	7	148	3876	9
29	3681	7	89	3777	9	149	3878	9
30	3682	7	90	3778	9	150	3880	9
31	3684	9	91	3780	9	**151**	**3881**	**3**
32	3686	9	92	3782	9	152	3883	9
33	3692	9	93	3784	9	153	3884	9
34	3693	9	94	3785	7	154	3885	9
35	3695	9	95	3786	7	155	3886	9
36	3696	9	96	3787	7	156	3887	9
37	3697	9	97	3790	7	157	3888	9
38	3698	9	98	3794	7	158	3889	9
39	3699	9	99	3795	9	159	3890	9
40	3700	9	100	3796	9	160	3893	5
41	3703	9	101	3797	9	161	3894	7
42	3704	9	102	3798	7	162	3895	7
43	3708	9	103	3799	7	163	3896	7
44	3709	9	104	3800	7	164	3901	7
45	3711	7	105	3803	7	165	3902	7
46	3712	7	106	3804	9	166	3903	9
47	3713	7	107	3805	9	167	3904	7
48	3715	7	108	3810	9	168	3907	7
49	3717	7	109	3813	9	169	3909	7
50	3718	7	110	3814	9	170	3911	7
51	3720	7	111	3815	9	171	3912	7
52	3721	7	112	3816	9	172	3913	9
53	3722	7	113	3825	7	173	3914	7
54	3728	7	114	3826	7	174	3915	7
55	3729	7	115	3827	9	175	3917	7
56	3730	9	116	3828	9	176	3918	7
57	3738	9	117	3831	9	177	3919	9
58	3739	7	118	3834	9	178	3926	9
59	3741	9	119	3835	9	179	3935	7
60	3744	7	120	3837	9	180	3936	7

Sl. No.	BRRI Genebank Acc. no.	SES score	Sl. No.	BRRI Genebank Acc. no.	SES score	Sl. No.	BRRI Genebank Acc. no.	SES score
181	3937	9	218	4064	9	255	4140	9
182	3939	9	219	4065	9	256	4143	9
183	3940	9	220	4066	9	257	4146	9
184	3941	9	221	4069	9	258	4147	9
185	3942	9	222	4072	9	259	4148	9
186	3959	9	223	4073	9	260	4154	7
187	3962	9	224	4075	9	261	4157	9
188	3963	9	225	4078	9	262	4158	9
189	3964	9	226	4079	7	263	4159	9
190	3987	9	227	4081	9	264	4162	9
191	3989	9	228	4082	9	265	4165	7
192	3990	9	229	4083	9	266	4166	9
193	3991	9	230	4086	9	267	4168	9
194	3992	9	231	4087	9	268	4169	7
195	4010	9	232	4090	9	269	4170	9
196	4011	9	233	4091	9	270	4171	7
197	4012	9	234	4093	9	271	4172	7
198	4013	9	235	4095	9	272	4173	7
199	4014	9	236	4098	9	273	4174	7
200	4015	9	237	4099	7	274	4176	5
201	4016	9	238	4100	7	275	4181	9
202	4017	9	239	4101	9	276	4182	7
203	4038	9	240	4102	9	277	4184	9
204	4039	7	241	4103	9	278	4185	9
205	4044	9	242	4104	9	279	4186	5
206	4046	9	243	4106	9	280	4188	7
207	4047	9	244	4112	7	281	4189	9
208	4048	7	245	4116	7	282	4190	7
209	4050	7	246	4120	7	283	4191	7
210	4053	9	247	4121	7	284	4193	9
211	4056	9	248	4122	9	285	4199	9
212	4057	9	249	4124	9	286	5052	9
213	4058	9	250	4125	9	287	38592	7
214	4059	9	251	4126	9	288	IR58443 (T. check)	3
215	4061	9	252	4127	7	289	IR154 (S. check)	9
216	4062	9	253	4134	7			
217	4063	9	254	4136	9			

Expt. 1.2: Screening of advanced breeding lines for salinity tolerance at seedling stage at Boro season

[1]Tuhin Halder, [2]Hasina Khatun, [2]Md. Akhlasur Rahman and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Plant Breeding Division

Objective: To identify advanced breeding lines tolerant to salinity at seedling stage.

Materials and Methods: One hundred and five (105) rice advanced breeding lines were tested along with check IR58443 (Tolerant Check) and IR154 (Susceptible Check). The experiment was conducted by following method described Gregorio *et al.,* (1997) at Plant Physiology Net house, BRRI. Hydroponic culture of Yoshida solution was used to grow the seedling. Salinity stress @12dS/m was applied at 7 days of seedling growth. The pH of the culture solution was checked daily and maintain at 5. The solution was replaced with new each week until susceptible check died or SES score 9. The final score was taken after susceptible check died or SES scored 9. The experiment was carried out following RCB design with 2 replications.

Results: Among the 105 advanced breeding lines one line (BR12274-4R-113) were found tolerant with SES score 3 and twenty one (21) lines were found moderately tolerant salinity with

SES score 5, fifty three (53) advanced breeding lines were found moderately susceptible to susceptible type scored 7 and 9 (**Fig. 1.2 and Table 1.2**).

Conclusion: One line (BR12274-4R-113) were found tolerant and could be proceed for further breeding program.

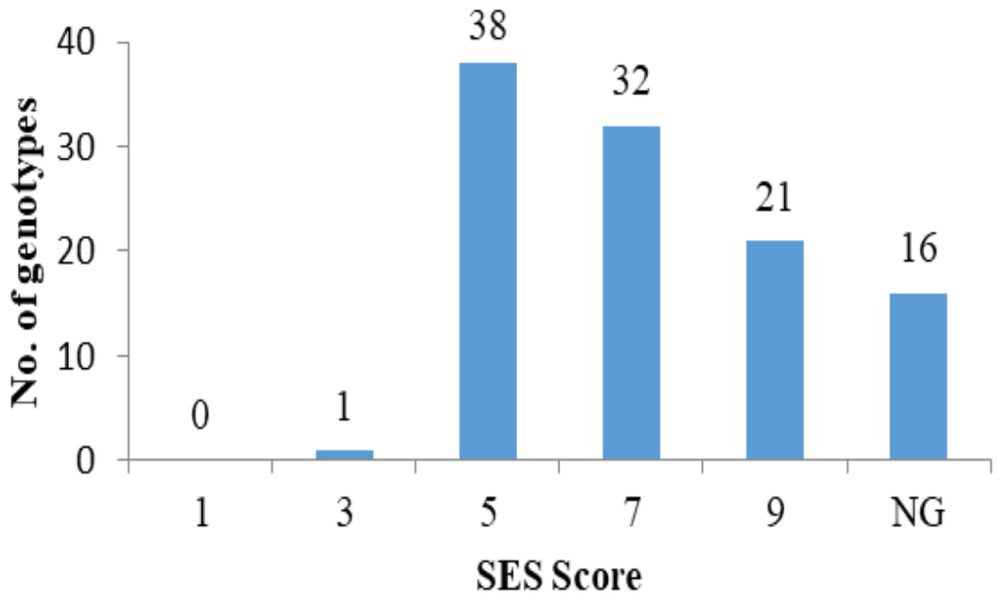

Fig. 1.2: Distribution of tested advanced breeding lines according to their SES score under 12dS/m salinity stress at seedling stage (NG= Seed did not germinate).

Table 1.2: SES score of tested advanced breeding lines according under 12dS/m salinity stress at seedling stage

Sl. No.	Genotype Code	SES Score	Sl. No.	Genotype Code	SES Score
AYT1					
1	BR11276-4R-100	9	16	BR11720-4R-89	7
2	BR11276-4R-104	9	17	BR11723-4R-236	NG
3	BR11276-4R-139	9	18	BR11723-4R-37	5
4	BR11276-4R-150	NG	19	BR12274-4R-183	7
5	BR11276-4R-152	7	20	BR12274-4R-193	NG
6	BR11276-4R-166	7	21	BR12274-4R-205	NG
7	BR11276-4R-21	7	22	BR12274-4R-310	NG
8	BR11276-4R-212	NG	23	BR12275-4R-13	5
9	**BR11276-4R-228**	**5**	24	BR12275-4R-215	5
10	BR11276-4R-67	NG	25	BR11276-4R-152	7
11	BR11718-4R-10	5	26	BR11718-4R-175	7
12	BR11718-4R-175	5	27	BR11276-4R-104	7
13	BR11718-4R-178	5	28	BR11276-4R-8	7
14	BR11718-4R-230	5	29	BR12274-4R-255	7
15	BR11718-4R-268	7	30	BR11718-4R-125	NG
AYT2					
1	BR11276-4R-132	NG	14	BR12273-4R-202	5
2	BR11276-4R-19	7	15	BR12274-4R-101	7
3	BR11276-4R-196	9	16	BR12274-4R-110	7
4	BR11276-4R-210	9	17	BR12274-4R-113	3
5	BR11276-4R-221	9	18	BR12274-4R-138	5
6	BR11276-4R-229	NG	19	BR12274-4R-339	5
7	BR11718-4R-110	5	20	BR12274-4R-9	NG
8	BR11718-4R-245	5	21	BR12274-4R-93	NG
9	BR11718-4R-379	5	22	BR12275-4R-125	7
10	BR11718-4R-46	7	23	BR12275-4R-90	5
11	BR11718-4R-78	5	24	BR12274-4R-37	7
12	BR11718-4R-84	7	25	BR12274-4R-188	9
13	BR11718-4R-92	NG			

Sl. No.	Genotype Code	SES Score	Sl. No.	Genotype Code	SES Score
RYT1					
1	BR11712-4R-44	5	5	BR11712-4R-346	7
2	BR11712-4R-93	9	6	BR11713-4R-70	9
3	BR11717-4R-12	9	7	BR11722-4R-398	5
4	BR11727-4R-6	5	8	BR11719-4R-22	9
RYT2					
1	BR11722-4R360	7	9	BR11714-4R-208	5
2	BR11712-4R-73	7	10	BR11722-4R-73	5
3	BR11723-4R-107	5	11	BR11719-4R-15	9
4	SVIN 208	7	12	BR11714-4R-418-21	5
5	BR11712-4R-121	9	13	BR11716-4R-55	5
6	BR11712-4R-328	9	14	BR11714-4R-148 (5)	7
7	BR11712-4R-149	5	15	BR11715-4R-16	5
8	BR11712-4R-60	9	16	BR11715-4R-24	5
RYT4					
1	BR11714-4R-203	5	14	BR11712-4R-231	9
2	BR11714-4R-418	NG	15	BR11716-4R-82	5
3	BR11714-4R-145	NG	16	BR11717-4R-12	7
4	BR11714-4R-75	7	17	BR11712-4R-637	5
5	BR11712-4R-151	9	18	BR11714-4R-322	5
6	BR11715-4R-34	5	19	BR11717-4R-52	5
7	BR11712-4R-143	5	20	BR11712-4R-81	7
8	BR11714-4R-223	5	21	BR11714-4R-87	5
9	BR11713-4R36	5	22	BR11717-4R-117	9
10	BR11712-4R-1	9	23	BR11276-4R-132	7
11	BR11712-4R-95	9	24	BR11276-4R-196	7
12	BR11714-4R-112	9	25	BR11718-4R-125	7
13	BR11720-4R-15	5	26	BR11276-4R-194	7
Check					
1	BRRIDHAN67	7	3	IR58443-6B-10-3	5
2	BRRI DHAN 99	7	4	IRRI154	9

Expt. 1.3: Screening of advanced breeding lines for salinity tolerance at seedling stage at Aman season

[1]Tuhin Halder, [2]Hasina Khatun, [2]Md. Akhlasur Rahman and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Plant Breeding Division

Objective: To identify saline tolerant advanced breeding lines at seedling stage

Materials and Methods: Two hundred thirty eight (238) advanced breeding lines were tested along with check IR58443 (Tolerant Check) and IR154 (Susceptible Check). The experiment was conducted by following method described Gregorio *et al.,* (1997) at Plant Physiology Net house, BRRI. Hydroponic culture of Yoshida solution was used to grow the seedling. Salinity stress @12dS/m was applied at 7 days of seedling growth. The pH of the culture solution was checked daily and maintain at 5. The solution was replaced with new each week until susceptible check died or SES scored 9. The final score was taken after susceptible check died or SES scored 9. The experiment was carried out following RCB design with 2 replications.

Results: Among the tested breeding lines ten (10) lines, BR11712-4R-333, BR11722-4R-73, BR11722-4R-398, BR11714-4R-69, BR11714-4R-74, IR108604-2-1-AJY3-B-1, TP24493, IR16T1661, IR18T1073, IR15T1319 was found tolerant with SES score 3, seventeen (17) advanced breeding lines were found moderately tolerant with SES score 5, 159 lines was found susceptible having the score 7 and 9 and rest of the 52 lines did not germinate (**Fig. 1.3 and Table 1.3**).

Conclusion: Ten (10) advanced breeding lines, (BR11712-4R-333, BR11722-4R-73, BR11722-4R-398, BR11714-4R-69, BR11714-4R-74, IR108604-2-1-AJY3-B-1, TP24493, IR16T1661, IR18T1073, IR15T1319) was found tolerant and could be proceed for further breeding program.

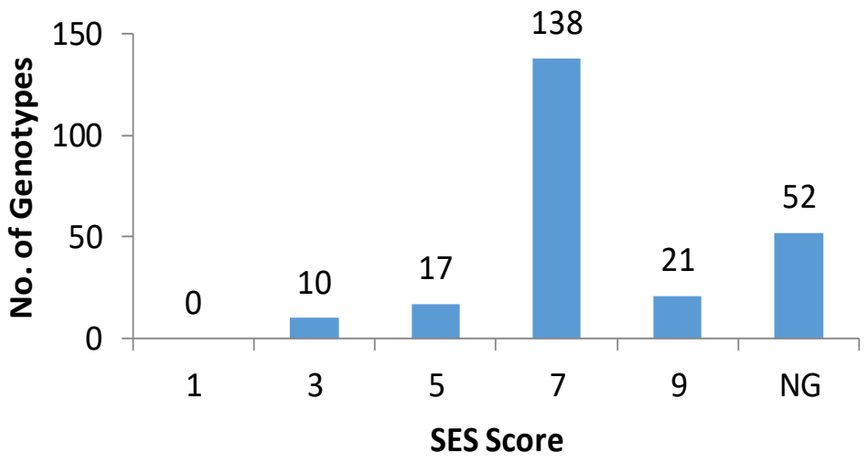

Fig. 1.3: Distribution of tested advanced breeding lines according to their SES score under 12dS/m salinity stress at seedling stage (NG= Seed did not germinate).

Table 1.3: SES score of tested advanced breeding lines according under 12dS/m salinity stress at seedling stage

Sl. No.	Designation	SES score	Sl. No.	Designation	SES score
1	BR11712-4R-1	9	43	BR11717-4R-101	NG
2	BR11712-4R-149	7	44	BR11722-4R-73	3
3	BR11712-4R-44	7	45	BR11723-4R-396	7
4	BR11712-4R-58	7	46	BR11722-4R-360	NG
5	BR11712-4R-60	NG	47	BR11722-4R-398	3
6	BR11712-4R-73	NG	48	BD89	7
7	BR11712-4R-83	7	49	BD67	7
8	BR11714-4R-179	NG	50	BD97	7
9	BR11714-4R-208	NG	51	BR11714-4R-322	NG
10	BR11714-4R-223	NG	52	BR11718-4R-3	NG
11	BR11715-4R-16	5	53	BR11714-4R-418	NG
12	BR11715-4R-34	7	54	BR11714-4R-145	NG
13	BR11717-4R-108	NG	55	BR11714-4R-148	NG
14	BR11717-4R-12	NG	56	BR11716-4R-64	NG
15	BR11723-4R-107	5	57	BR11714-4R-308	NG
16	BR11727-4R-6	5	58	BR11714-4R-134	NG
17	BR11716-4R-9	7	59	BR11714-4R-203	NG
18	BR11712-4R-302	NG	60	BR11714-4R-201	NG
19	BR11712-4R-149	7	61	BR11714-4R-75	NG
20	BR11715-4R-16	NG	62	BR11714-4R-69	3
21	SVIN208	7	63	BR11716-4R-30	5
22	BR11712-4R-336	7	64	BR11718-4R-2	NG
23	BR11712-4R-93	NG	65	BR11714-4R-74	3
24	BR11723-4R-38	7	66	BR11714-4R-112	NG
25	BR11716-4R-7	7	67	BR11714-4R-282	NG
26	BRRI dhan97	9	68	BR11714-4R-224	NG
27	BRRI dhan67	7	69	BR11714-4R-332	NG
28	BRRI dhan 89	9	70	BR11715-4R-24	NG
29	BR11712-4R-346	NG	71	BR11717-4R-6	NG
30	BR11712-4R-79	7	72	BR11712-4R-134	9
31	BR11712-4R-129	NG	73	BR11714-4R-228	NG
32	BR11712-4R-391	NG	74	BR11716-4R-55	7
33	BR11713-4R-70	NG	75	BR11714-4R-182	NG
34	BR11713-4R-256	NG	76	BD89	7
35	BR11712-4R-394	NG	77	BD97	7
36	BR11712-4R-121	9	78	BD67	7
37	BR11712-4R-328	NG	79	BR10182-5-4-2	NG
38	BR11712-4R-333	3	80	BR10187-1-4-12	7
39	BR11719-4R-22	NG	81	BR10187-1-5-11	NG
40	BR11723-4R-54	NG	82	BR10188-10-1-18	NG
41	BR11005-4R-1	5	83	BR9901-1-3-10	5
42	BR11719-4R-15	NG	84	BR9904-1-3-3	NG

Sl. No.	Designation	SES score	Sl. No.	Designation	SES score
85	BR9918-10-4-5	NG	147	IR19X1009	7
86	BR9926-7-7-6	NG	148	IR15F1729	7
87	IR 108175-B-22-AJY 3-B-1	NG	149	IR 108175-B-22-AJY 3-B-1	7
88	IR 108604-2-1-AJY 3-B-1	3	150	IR15T1319	3
89	IR 108604-2-3-AJY 3-B-1	5	151	IRRI 132	7
90	IR15T1399	NG	152	IR19L1045	7
91	TP20532	NG	153	IR 126998-B-10-5-1-3	7
92	TP21654	7	154	IR15F1697	7
93	TP24493	3	155	IR15F1868	5
94	TP30629	7	156	IR16F1251	5
95	TP30642	NG	157	IR18T1045	7
96	BR11715-4R-186	9	158	GSR IR 1-5-S14-S2-Y2	7
97	BR11723-4R-27	9	159	IR16F1065	7
98	BR11723-4R-12	9	160	IR16T1538	7
99	BR11712-4R-227	9	161	IR 127034-B-14-1-2-3	7
100	BR11716-4R-105	7	162	IR18T1337	7
101	BR11716-4R-102	7	163	IR 117833-21-1 RGA-1 RGA-1 RGA-1	7
102	IR16T1656	7	164	IR18T1021	7
103	IR18R1081	7	165	IR18R1208	7
104	IR18T1346	7	166	IR18T1135	5
105	IR18T1059	7	167	IR18T1137	5
106	IR17R1003	7	168	IR 99853-B-B-B-182	7
107	IR18T1104	7	169	IR17M1710	7
108	IR19R1181	7	170	IR 117750-B-25-3-1	7
109	IR19R1124	7	171	IR 121147-B-B-CMU 11-1-2	7
110	IR19R1158	7	172	IR15F1982	7
111	IR19R1057	7	173	IR 126952-443-12-47-8-59-B	7
112	IR19R1202	7	174	IR19L1024	7
113	IR19R1147	7	175	IR16F1026	5
114	IR19R1076	7	176	IR15F1943	7
115	IR16T1646	7	177	PR 25997-B-B-B	7
116	IR16T1356	7	178	IR18T1214	7
117	IR18T1186	5	179	HHZ 12-SAL2-Y3-Y2	7
118	IR16T1661	3	180	IR17L1609	9
119	IR19R1159	7	181	IR17F1053	7
120	IR18T1073	3	182	IR16T1054	7
121	IR16T1348	5	183	IR14G3595	7
122	IR19R1065	7	184	IR16F1147	7
123	IR19R1101	7	185	IR16F1148	5
124	IR18T1276	7	186	IR16T1317	7
125	IR20X1009	7	187	IR 97046-39-2-1-2	7
126	IR20X1011	7	188	IR 86385-276-2-2-B	7
127	IR20X1012	7	189	IRGC 139057	7
128	IR20X1013	7	190	IR16L1890	9
129	IR20X1014	7	191	IR 126999-B-32-2-1-3	7
130	IR20X1015	7	192	IR16L1860	7
131	IR20X1002	7	193	IR 129434-B-8-B-3-1	7
132	IR20X1007	7	194	IR 129391-B-35-B-1-1	7
133	IR20X1003	7	195	IR18L1298	7
134	IR19X1004	7	196	IR16T1661	5
135	IR19X1003	9	197	IR16M1904	7
136	IR20X1005	7	198	IR16T1503	7
137	IR20X1006	7	199	IR 121151-307-1-1-1-1	7
138	IR20X1008	7	200	IR 92831-22-BAY 2-1-CMU 1	7
139	IR19X1002	7	201	IR 126990-B-8-1-1-1	9
140	IR19X1006	7	202	IR14G3964	9
141	IR20X1004	7	203	IR16L1478	9
142	IR19X1005	7	204	IR16F1172	7
143	IR20X1001	7	205	IR 126952-28-55-9-9-53-1-27	9
144	IR19X1001	7	206	IR17L1415	9
145	IR19X1008	7	207	IR 129462-B-46-B-1-1	9
146	IR19X1007	7	208	IR18T1327	9

Sl. No.	Designation	SES score	Sl. No.	Designation	SES score
209	IR18M1011	7	227	IR14G2711	7
210	IR14L345	7	228	IR16T1339	7
211	IR 54447-3B-10-2	7	229	IR 126952-29-27-123-9-3-4-1	7
212	IR15T1303	7	230	IR 129420-B-30-B-2-1	7
213	IR 92546-8-3-1-4	7	231	IR18T1029	7
214	IR 126957-B-48-5-1-3	7	232	IR 99853-46-1-1-1	7
215	IR18T1330	7	233	IR15L1564	7
216	IR16L1795	5	234	IRRI 104	7
217	IR 80482-32-2-3-3	7	235	IRRI 147	7
218	IR15L1735	7	236	IRRI 154	9
219	IR19L1016	9	237	IGB 20140209-19	7
220	IR 95044:8-B-5-22-19-GBS	7	238	Salinas 31	7
221	IR 98786-13-1-2-1	7	239	IR58443	3
222	IR 83140-B-28-B	7	240	BRRI dhan67	7
223	IR 121113-314-1-1-1-2	7	241	BRRI dhan89	7
224	IR16T1662	7	242	IR154	9
225	IR 99853-B-B-B-275	7	243	BRRI dhan97	7
226	PAI CHUEH CHIU LIU::IRGC 34259-1	7			

Expt. 1.4: Screening of parental lines of hybrid rice for salinity tolerance at seedling stage

[1]Tuhin Halder, [2]Ruhul Kuddus, [2]Md. Jamil Hassan and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Hybrid Rice Division

Objective: To identify parental lines of hybrid rice tolerant to salinity at seedling stage

Materials and Methods: Some total of three hundred seventy five (375) parental lines of hybrid rice were tested along with check IR58443, Horkuch (Tolerant Check) and BRRI dhan28, IR154 (Susceptible Check)

The experiment was conducted by following method described Gregorio *et al.*, (1997) at Plant Physiology Net house, BRRI. Hydroponic culture of Yoshida solution was used to grow the seedling. Salinity stress @12dS/m was applied at 7 days of seedling growth. The pH of the culture solution was checked daily and maintain at 5. The solution was replaced with new every week until susceptible check died or SES scored 9. The final score was taken after susceptible check died or SES scored 9. The experiment was carried out following RCB design with 2 replications.

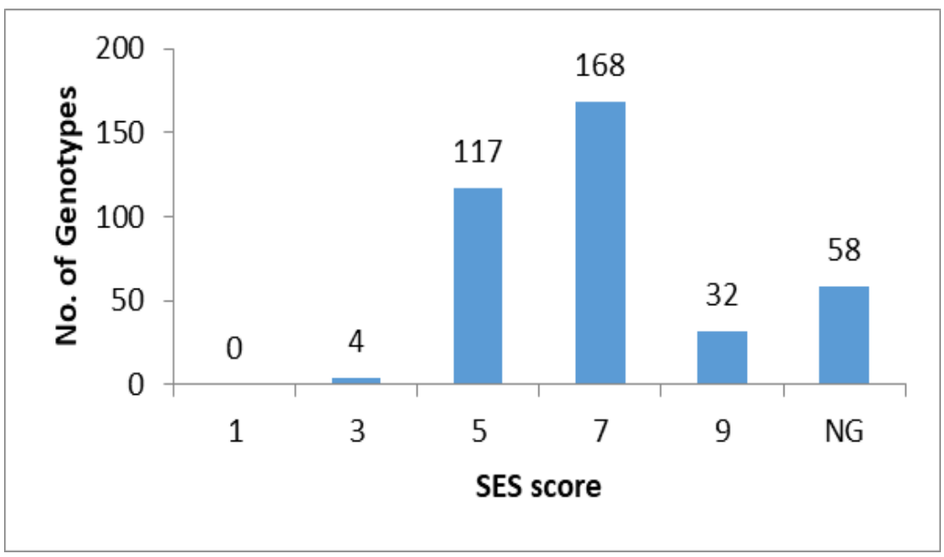

Fig. 1.4: Distribution of tested parental lines of hybrid rice with check according to their SES score under 12dS/m salinity stress at seedling stage (NG= Seed did not germinate).

Results: Out of 375 parental lines of hybrid rice four (4) lines were found tolerant (namely, BHR37, BHR80, BHR259 and BHR260) including tolerant check IR58443 and Horkuch with SES score 5 and one hundred and seventeen (117) parent lines were found moderately tolerant to salinity with SES score 5, two hundred lines were found moderately susceptible to susceptible with SES score 7 and 9 including S. check IR154 and BRRI dhan28 (**Fig. 1.4 and Table 1.4**).

Conclusion: Four (4) hybrid parental lines of hybrid rice were found tolerant (namely, BHR37, BHR80, BHR259 and BHR260) were found tolerant and could be used for further investigation.

Table 1.4: SES score of tested hybrid parent lines under 12dS/m salinity stress at seedling stage

Sl. No.	Designation	SES Score	Sl. No.	Designation	SES Score	Sl. No.	Designation	SES Score
1	BHR1	7	50	BHR50	5	99	BHR100	5
2	BHR2	7	51	BHR51	7	100	BHR101	7
3	BHR3	7	52	BHR52	7	101	BHR102	7
4	BHR4	7	53	BHR53	7	102	BHR103	NG
5	BHR5	9	54	BHR54	5	103	BHR104	7
6	BHR6	7	55	BHR55	5	104	BHR105	5
7	BHR7	7	56	BHR56	7	105	BHR106	9
8	BHR8	7	57	BHR57	5	106	BHR107	5
9	BHR9	5	58	BHR58	5	107	BHR108	7
10	BHR10	7	59	BHR59	5	108	BHR109	NG
11	BHR11	5	60	BHR60	5	109	BHR110	5
12	BHR12	9	61	BHR61	7	110	BHR111	NG
13	BHR13	9	62	BHR62	5	111	BHR112	5
14	BHR14	7	63	BHR63	7	112	BHR113	5
15	BHR15	7	64	BHR64	5	113	BHR114	NG
16	BHR16	7	65	BHR65	7	114	BHR115	NG
17	BHR17	9	66	BHR66	5	115	BHR116	NG
18	BHR18	7	67	BHR67	7	116	BHR117	NG
19	BHR19	7	68	BHR68	5	117	BHR118	5
20	BHR20	9	69	BHR69	5	118	BHR119	NG
21	BHR21	7	70	BHR70	5	119	BHR120	NG
22	BHR22	5	71	BHR71	9	120	BHR121	NG
23	BHR23	7	72	BHR72	7	121	BHR122	7
24	BHR24	5	73	BHR73	7	122	BHR123	NG
25	BHR25	7	74	BHR74	5	123	BHR124	NG
26	BHR26	7	75	BHR75	7	124	BHR125	NG
27	BHR27	7	76	BHR76	5	125	BHR126	9
28	BHR28	7	77	BHR77	7	126	BHR127	NG
29	BHR29	5	78	BHR78	7	127	BHR128	NG
30	BHR30	7	79	BHR80	3	128	BHR129	NG
31	BHR31	9	80	BHR81	NG	129	BHR130	7
32	BHR32	7	81	BHR82	5	130	BHR131	NG
33	BHR33	7	82	BHR83	5	131	BHR132	NG
34	BHR34	7	83	BHR84	NG	132	BHR133	NG
35	BHR35	5	84	BHR85	5	133	BHR134	9
36	BHR36	7	85	BHR86	NG	134	BHR135	NG
37	BHR37	3	86	BHR87	5	135	BHR136	NG
38	BHR38	5	87	BHR88	7	136	BHR137	5
39	BHR39	5	88	BHR89	7	137	BHR138	5
40	BHR40	5	89	BHR90	7	138	BHR139	5
41	BHR41	7	90	BHR91	5	139	BHR140	7
42	BHR42	5	91	BHR92	5	140	BHR141	7
43	BHR43	7	92	BHR93	NG	141	BHR142	7
44	BHR44	5	93	BHR94	7	142	BHR143	7
45	BHR45	5	94	BHR95	5	143	BHR144	9
46	BHR46	5	95	BHR96	7	144	BHR145	5
47	BHR47	7	96	BHR97	NG	145	BHR146	5
48	BHR48	5	97	BHR98	7	146	BHR147	7
49	BHR49	5	98	BHR99	7	147	BHR148	7

Sl. No.	Designation	SES Score	Sl. No.	Designation	SES Score	Sl. No.	Designation	SES Score
148	BHR149	7	210	BHR220	7	272	BHR283	NG
149	BHR150	7	211	BHR221	7	273	BHR284	NG
150	BHR151	5	212	BHR222	7	274	BHR285	NG
151	BHR152	7	213	BHR223	7	275	BHR286	NG
152	BHR153	5	214	BHR224	9	276	BHR287	NG
153	BHR154	5	215	BHR225	7	277	BHR288	5
154	BHR155	7	216	BHR226	5	278	BHR289	9
155	BHR156	NG	217	BHR227	7	279	BHR290	NG
156	BHR157	NG	218	BHR228	7	280	BHR291	NG
157	BHR158	7	219	BHR229	9	281	BHR292	NG
158	BHR159	5	220	BHR230	7	282	BHR293	NG
159	BHR160	5	221	BHR231	7	283	BHR294	NG
160	BHR161	NG	222	BHR232	9	284	BHR295	NG
161	BHR162	5	223	BHR233	7	285	BHR296	NG
162	BHR163	7	224	BHR234	7	286	BHR297	NG
163	BHR164	7	225	BHR235	9	287	BHR298	7
164	BHR165	7	226	BHR236	7	288	BHR299	7
165	BHR166	7	227	BHR237	5	289	BHR300	7
166	BHR167	7	228	BHR238	7	290	BHR301	7
167	BHR168	7	229	BHR239	7	291	BHR302	5
168	BHR169	7	230	BHR240	7	292	BHR303	9
169	BHR170	9	231	BHR241	9	293	BHR304	NG
170	BHR171	9	232	BHR242	9	294	BHR305	5
171	BHR172	7	233	BHR243	7	295	BHR306	NG
172	BHR173	5	234	BHR244	5	296	BHR307	NG
173	BHR174	7	235	BHR246	7	297	BHR308	7
174	BHR175	NG	236	BHR247	7	298	BHR309	7
175	BHR176	5	237	BHR248	7	299	BHR310	5
176	BHR181	7	238	BHR249	5	300	BHR311	NG
177	BHR182	5	239	BHR250	7	301	BHR312	9
178	BHR183	5	240	BHR251	7	302	BHR313	NG
179	BHR184	7	241	BHR252	5	303	BHR314	NG
180	BHR185	5	242	BHR253	7	304	BHR315	7
181	BHR186	5	243	BHR254	7	305	BHR316	NG
182	BHR187	7	244	BHR255	5	306	BHR317	5
183	BHR188	5	245	BHR256	5	307	BHR318	NG
184	BHR189	7	246	BHR257	5	308	BHR319	5
185	BHR190	5	247	BHR258	5	309	BHR320	5
186	BHR191	7	248	BHR259	3	310	BHR321	7
187	BHR192	7	249	BHR260	3	311	BHR322	5
188	BHR193	5	250	BHR261	5	312	BHR323	5
189	BHR194	5	251	BHR262	5	313	BHR324	9
190	BHR195	7	252	BHR263	5	314	BHR325	5
191	BHR196	5	253	BHR264	5	315	BHR326	5
192	BHR202	7	254	BHR265	5	316	BHR327	7
193	BHR203	7	255	BHR266	7	317	BHR328	7
194	BHR204	5	256	BHR267	7	318	BHR329	7
195	BHR205	5	257	BHR268	7	319	BHR330	7
196	BHR206	5	258	BHR269	5	320	BHR331	5
197	BHR207	7	259	BHR270	7	321	BHR332	7
198	BHR208	7	260	BHR271	5	322	BHR333	7
199	BHR209	7	261	BHR272	NG	323	BHR334	7
200	BHR210	9	262	BHR273	NG	324	BHR335	7
201	BHR211	7	263	BHR274	5	325	BHR336	7
202	BHR212	5	264	BHR275	NG	326	BHR337	5
203	BHR213	5	265	BHR276	NG	327	BHR338	7
204	BHR214	7	266	BHR277	NG	328	BHR339	9
205	BHR215	7	267	BHR278	5	329	BHR340	7
206	BHR216	9	268	BHR279	7	330	BHR341	5
207	BHR217	7	269	BHR280	9	331	BHR342	7
208	BHR218	7	270	BHR281	NG	332	BHR343	7
209	BHR219	5	271	BHR282	NG	333	BHR344	9

Sl. No.	Designation	SES Score	Sl. No.	Designation	SES Score	Sl. No.	Designation	SES Score
334	BHR345	5	350	BHR361	7	366	BHR377	7
335	BHR346	5	351	BHR362	7	367	BHR378	9
336	BHR347	7	352	BHR363	7	368	BHR379	7
337	BHR348	7	353	BHR364	7	369	BHR380	7
338	BHR349	7	354	BHR365	7	370	BHR381	7
339	BHR350	7	355	BHR366	5	371	BHR382	7
340	BHR351	7	356	BHR367	7	372	BHR383	5
341	BHR352	7	357	BHR368	7	373	BHR384	7
342	BHR353	7	358	BHR369	5	374	BHR385	5
343	BHR354	7	359	BHR370	7	375	BHR386	5
344	BHR355	7	360	BHR371	5	376	BRRI dhan28	7
345	BHR356	5	361	BHR372	5	377	Horkuch	5
346	BHR357	7	362	BHR373	7	378	IR154	7
347	BHR358	7	363	BHR374	5	379	IR58443	9
348	BHR359	5	364	BHR375	9			
349	BHR360	5	365	BHR376	7			

Expt. 1.5: Screening of BRRI hybrid rice varieties for salinity tolerance at seedling stage

[1]Tuhin Halder, [1]Md. Shafikul Islam and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Hybrid Rice Division

Objective: To determine the saline tolerant level of hybrid varieties at seedling stage.

Materials and Methods: Six BRRI hybrid rice varieties and four hybrid varieties of different companies were tested along with check IR58443 (Tolerant Check) and IR154 (Susceptible Check). The experiment was conducted by following the method described by Gregorio *et al.*, (1997) at Plant Physiology Net house, BRRI. Hydroponic culture of Yoshida solution was used to grow the seedling. Salinity stress was applied @12dS/m at 7 days of seedling growth. The pH of the culture solution was checked daily and maintained at 5. The solution was replaced with new every week until susceptible check died or SES scored 9. The final score was taken after susceptible check died or SES scored 9. The experiment was carried out following RCB design with 2 replications.

Results: Among the 10 hybrid varieties BRRI hybrid dhan5 and one company (Lal Teer) hybrid dhan (HTM707) found moderately tolerant salinity with SES score 5 and rest of the variety found moderately susceptible with SES score 7 (**Table 1.5**).

Conclusion: BRRI hybrid dhan5 was found moderately tolerant to salinity.

Table 1.5: SES score of hybrid variety of BRRI and different company under 12dS/m salinity stress at seedling stage

Sl. No.	Variety Name	SES Score
1	BRRI hybrid dhan2	Seed Not germinated
2	BRRI hybrid dhan3	7
3	BRRI hybrid dhan4	7
4	**BRRI hybrid dhan5**	**5**
5	BRRI hybrid dhan6	7
6	BRRI hybrid dhan7	7
7	**HTM707 (Lal Teer)**	**5**
8	Golden-1 (Lal Teer)	7
9	AZ7006 (Bayer Hybrid6)	7
10	INH 16019) Bayer Hybrid8)	7

Expt. 1.6: Characterization of Rice Germplasm for Reproductive Stage at Different Saline Condition

Salma Akter and Mst. Salma Pervin

Introduction: Bangladesh is a rich source of diverse rice landraces adapted to its variable rice environments, including the large stretch of salt-affected areas in the southern coastal zones. Generally, landraces are highly adapted to adverse environment and also have varying levels of resistance to biotic and abiotic stresses (Li *et al.*, 2004). Several physiological mechanisms have been suggested to explain the salt tolerance of these tolerant germplasms earlier. So screening of the local germplasm based on morphological, physiological and biochemical traits is vital for the selection of new donors. As efficient phenotyping remains one of the main factors limiting breeding advances (Araus *et al.*, 2012). Moreover, selection based on only a few traits is generally not considered the most appropriate strategy, because there is no assurance of genetic gains in other important traits (Jahufer and Casler 2015). Since screening is considered as an essential part of the breeding programs, several screening and selection schemes have been proposed for salt tolerance improvement in wheat and other crops (Dewey, 1962; Kingsbury & Epstein, 1984, Kelman & Qualset, 1991; Karadimova & Djambova, 1993; Pecetti & Gorham, 1997).

Objective: To find out the yielding ability and to determine the tolerance ability in varying salinity level at reproductive stage

Materials and methods: The experiment was conducted in the net house of Plant Physiology Division of BRRI during T. Aman season. Three rice germplasm namely Basmoti, Binnidhan, Gourkajol and one breeding line BR(Bio)8961-AC26-16 with tolerant check i.e. IR58443-6B-10-3 and susceptible check i.e. IRRI154 were considered for this study. Plants were grown in the perforated plastic pots filled with grinded soil. The soil was fertilized with culture solution. The pots were placed inside a plastic bowl serving as water bath. Three to four pre germinated seeds were sown at the soil surface of each pot. Seedlings were thinned to 2 plants per pot two weeks after sowing. Salt stress was applied 40 days after sowing; stress was made by adding NaCl in the bucket at 6, 8 and 12dS/m. One set of plants were used as control. The experiment was laid out in RCB design with 3 replications. Water level was maintained daily (1 cm above soil surface) by adding culture solution. At maturity plants were harvested and yield and yield components were measured. Water salinity and soil salinity was also recorded during the growth period.

Results and Discussion: The experiment was conducted to evaluate the performance of three germplasm and one advanced breeding line at different salinity level in the net house condition during T. Aman, 2022-23. Different morphological and yield related traits were measured to evaluate the tested genotypes. In this study, genotypes × salinity interaction showed significant results for all the tested parameters except number of panicle per plant and panicle exertion rate. Yield potentiality is the most important criteria for selecting a genotype as future tolerant variety at stress condition. At control condition, maximum yield was obtained with Baismoti, Binni dhan and Gourkajol. With the increase of salinity to 6 and 8 dS/m, Baismoti and Binni dhan produced higher yield than the other tested genotypes including tolerant check. Increasing salinity level to 12 dS/m, all the tested genotypes produced lower yield than tolerant check (**Fig. 1.6.1**). All the tested genotypes and checks had shown increasing trends of yield reduction with increasing salinity level (**Fig. 1.6.2**). But the reduction was minimum for Baismoti and Binni dhan at6dS/m salinity stress which was below 50%. At 8dS/m, Baismoti and Binni dhan reduced yield about ~38% and ~48% which is better than tolerant check (61%). Increasing salinity level to 12 dS/m, yield reduction ranged from ~85 to ~99% for all the tested genotypes (**Fig. 1.6.2**). Days to heading were earlier for tolerant and susceptible check than other tested genotypes at all salinity level (**Fig. 1.6.3**).

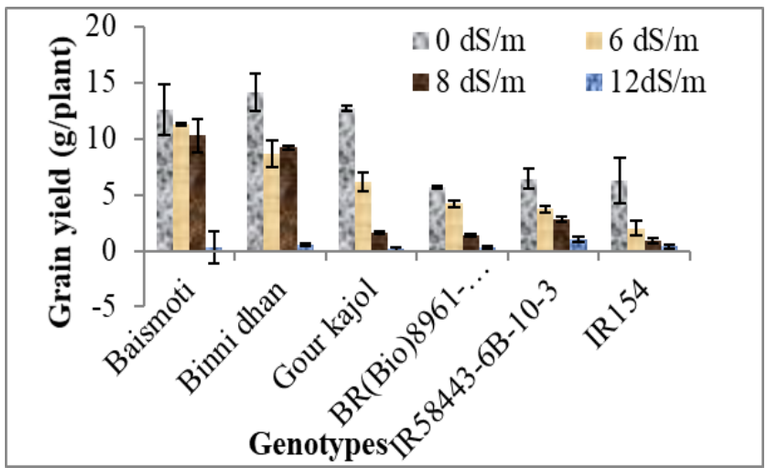

Fig. 1.6.1: Yield potential of tested genotypes and checks in varying salinity level. Error bar represents ±SE.

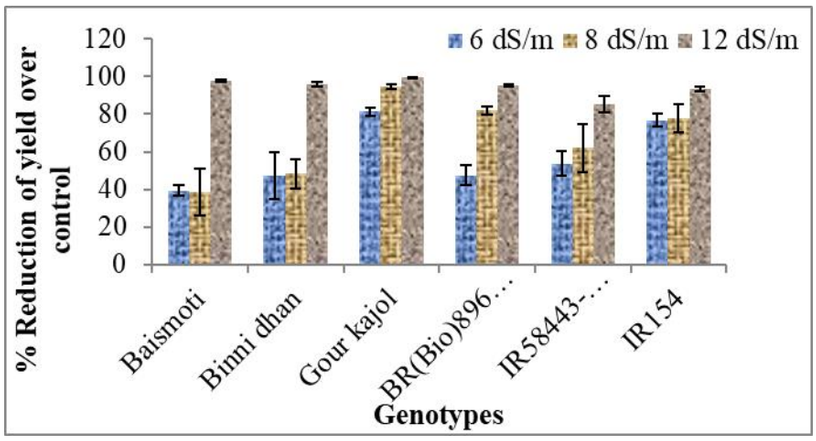

Fig. 1.6.2: Reduction of yield over control (%) among the tested genotypes and checks in varying salinity level. Error bar represents ±SE.

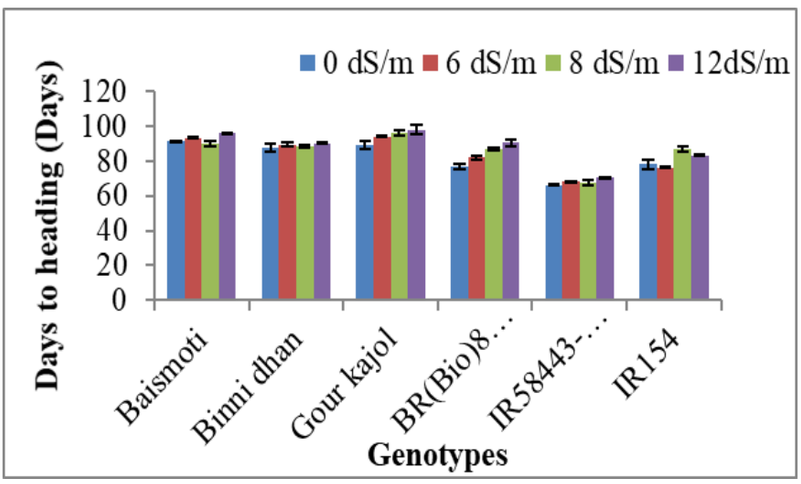

Fig. 1.6.3: Days to heading of tested genotypes and checks in varying salinity level. Error bar represents ±SE.

Soil salinity and water salinity

The level of salinity developed in the soil ranged from 0.63 to 1.20dS/m, 2.93 to 3.91dS/m, 4.53 to 5.90dS/m and 6.30 to 8.63dS/m for 0, 4, 6 and 12 dS/m salt application level, respectively. On the other hand, water salinity level decreased to 2.32, 4.03 and 6.26dS/m for 4, 6 and 12 dS/m salt application level during the growing period (**Fig. 1.6.4 & 1.6.5**).

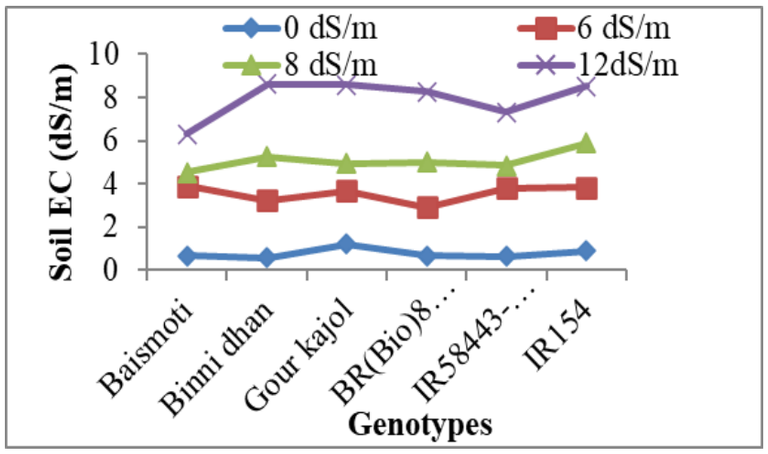

Fig. 1.6.4: Electrical conductivity of saturation paste extract (ECe) in dS/m in varying salinity level during harvest.

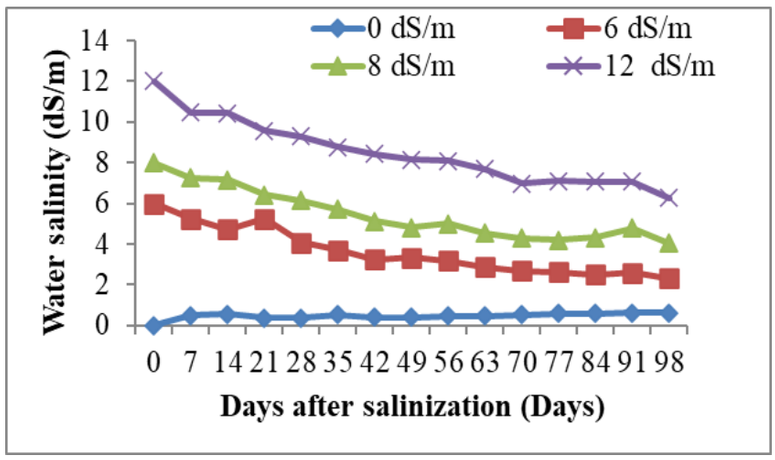

Fig. 1.6.5: Water salinity (dS/m) in varying salinity level during the growing period.

Conclusion: Considering the yield potentiality and tolerance ability at different salinity level, Basmoti and Binnidhan could be selected for further breeding program upto 8 dS/m salinity stress.

Expt. 1.7: Characterization of BRRI hybrid rice varieties for whole growth period at different saline condition

Salma Akter, Tuhin Halder and Mst. Salma Pervin

Objective: To find out the yielding ability and to determine the tolerance ability in varying salinity level at reproductive stage.

Materials and methods: The experiment was conducted in the net house of Plant Physiology Division of BRRI during Boro, 2022-23. Four hybrid varieties named BRRI hybrid dhan3, BRRI hybrid dhan4, BRRI hybrid dhan7 and BRRI hybrid dhan8 with tolerant and susceptible check variety i.e., IR58443-6B-10-3 and IRRI154 was considered for this study. Plants were grown in the perforated plastic pots filled with grinded soil. The soil was fertilized with NPKS @ 100, 25, 40 and 25 mg/kg soil. The pots were placed inside a plastic bowl serving as water bath. Three to four pre germinated seeds were sown at the soil surface of each pot. Seedlings were thinned to two plants per pot 2 weeks after sowing. Salt stress was applied 40 days after sowing; stress was made by adding NaCl in the bucket at 6, 8 and 12 dS/m. One set of plants were used as control. The experiment was laid out in RCB design with 3 replications. Water level was maintained daily (1 cm above soil surface) by adding culture solution. At maturity plants were harvested and yield and yield components were measured. Water salinity was also recorded during the growth period. To check soil salinity level gained by the soil at the end of the experiment, sampling of

soil and saturation paste extract was carried out and soil salinity was recorded after harvesting using EC meter. Statistical analysis was done by using Crop STAT-C.

Results and Discussion: Different morphological and yield related traits were measured to evaluate the tested genotypes. In this study, genotypes × salinity interaction showed significant results for yield and yield components.

Tiller number per plant: The interaction effect of genotype and salinity varied significantly for tiller number. At 0 dS/m, the highest tiller number was observed for BRRI hybrid dhan3 followed by sensitive check IRRI154. Moreover, BRRI hybrid dhan3 produced the highest tiller number at all salinity level than other tested genotypes (**Fig. 1.7.1**).

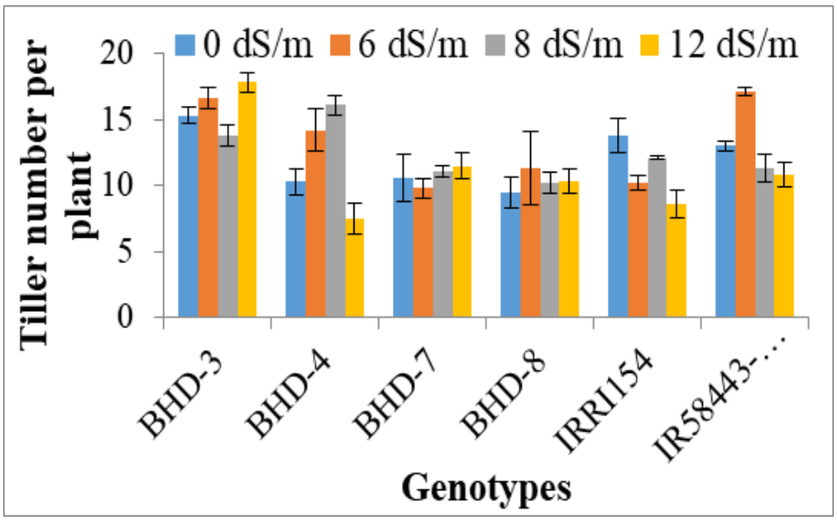

Fig. 1.7.1: Tiller number of tested genotypes and checks in varying salinity level. Error bar represents ±SE.

Panicle number per plant: Panicle number per plant showed significant variation for salinity × genotype interaction. The highest panicle number was observed at control (without salt) for sensitive check IRRI154 followed by BRRI hybrid dhan3. Panicle number decreased with the increase of salinity for the tested genotypes except BRRI hybrid dhan4 and BRRI hybrid dhan8. Increasing salinity level to 8 dS/m and 12 dS/m, BRRI hybrid dhan3 and BRRI hybrid dhan8 showed the highest panicle number, respectively (**Fig. 1.7.2**).

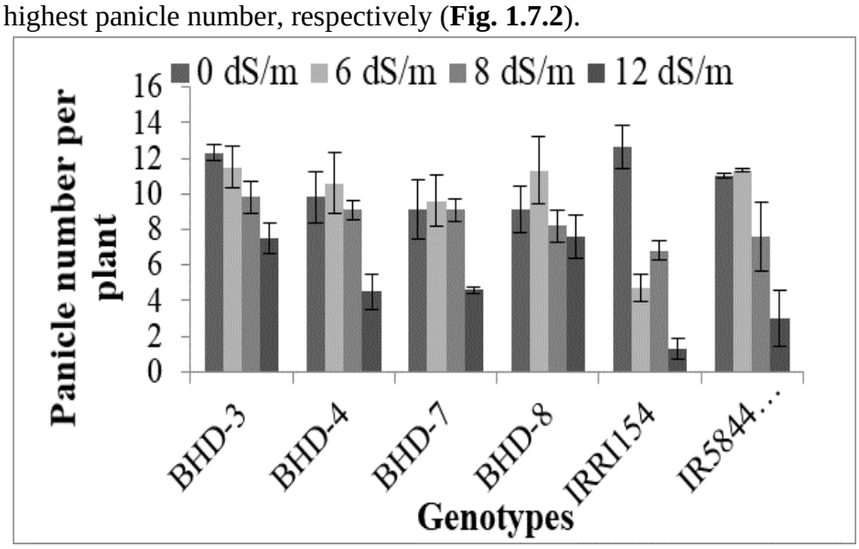

Fig. 1.7.2: Panicle number of tested genotypes and checks in varying salinity level. Error bar represents ±SE.

Grain per panicle: Salinity × genotype interaction demonstrated significant effect on grain per panicle. At 0 dS/m and 6 dS/m salinity level highest grain per panicle was observed for BRRI hybrid dhan8. With increasing level of salinity to 8 and 12 dS/m BRRI hybrid dhan3 showed the highest grain per panicle. At all the salinity level BRRI hybrid dhan8 showed the highest grain per panicle than other tested genotypes (**Fig. 1.7.3**).

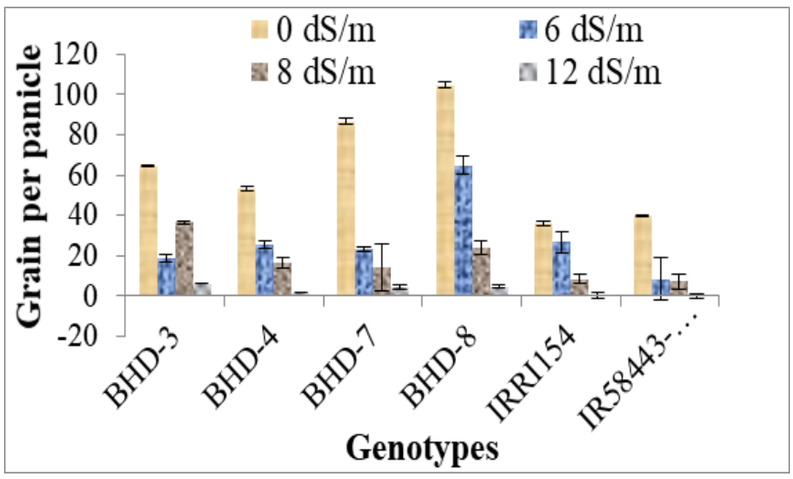

Fig. 1.7.3: Grain per panicle of tested genotypes and checks in varying salinity level. Error bar represents ±SE.

Grain yield and yield reduction: Yield potentiality is important character for selecting a genotype at stress condition. At control condition, maximum yield was obtained with BRRI hybrid dhan3 followed by other tested hybrid varieties than inbred checks. With the increase level of salinity to 6dS/m, BRRI hybrid dhan8 produced higher yield than the other tested genotypes including tolerant check (**Fig. 1.7.4**). All the tested genotypes and checks had shown increasing trends of yield reduction with increasing salinity level (**Fig. 1.7.5**). But the reduction was minimum for BRRI hybrid dhan8at6dS/m salinity stress which was below 50%. All the tested hybrid varieties along with tolerant check reduced yield from ~80 to ~100% with increasing salinity level to 8 and 12 dS/m (**Fig. 1.7.5**).

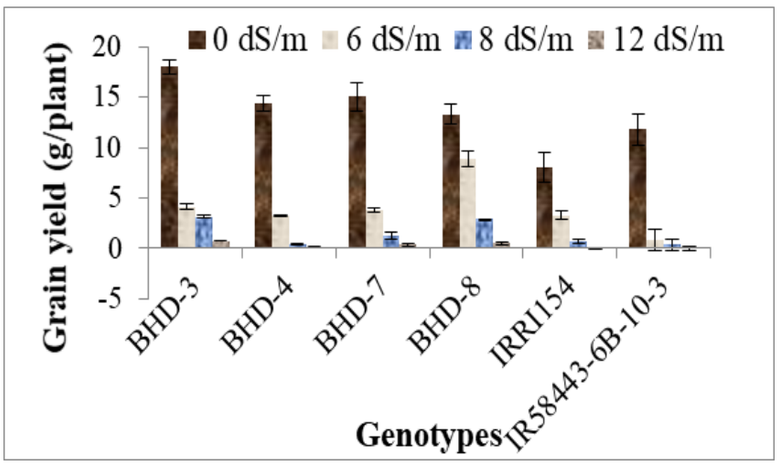

Fig. 1.7.4: Yield potential of tested genotypes in varying salinity level. Error bar represents ±SE.

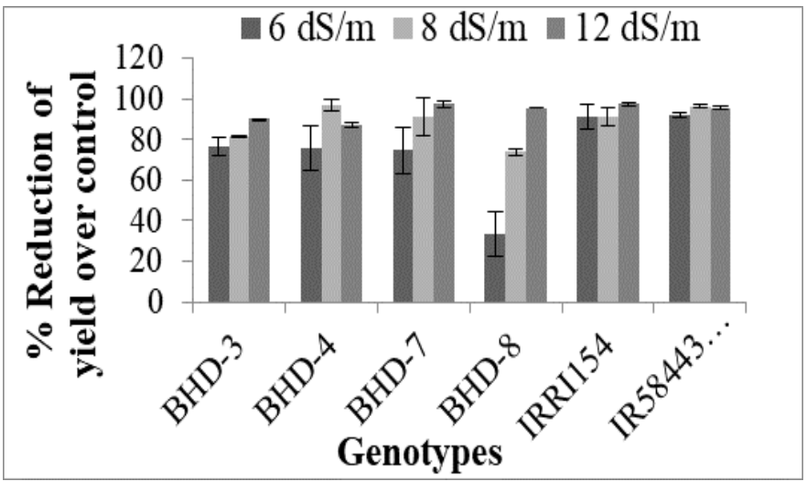

Fig. 1.7.5: Percent reduction of yield of tested genotypes in varying salinity level. Error bar represents ±SE.

Soil salinity and water salinity: The level of salinity developed in the soil ranged from 1.67 to 2.23 dS/m, 3.09 to 5.99 dS/m, 6.60 to 7.84 dS/m and 9.35 to 11.78 dS/m for 0, 6, 8 and 12 dS/m salt application level, respectively. On the other hand, water salinity level remained 1.40 dS/m at non saline condition. However, water salinity level decreased to 4.62, 5.40 and 8.92 dS/m for 6, 8 and 12 dS/m application level during the growing period (**Fig. 1.7.6 & 1.7.7**).

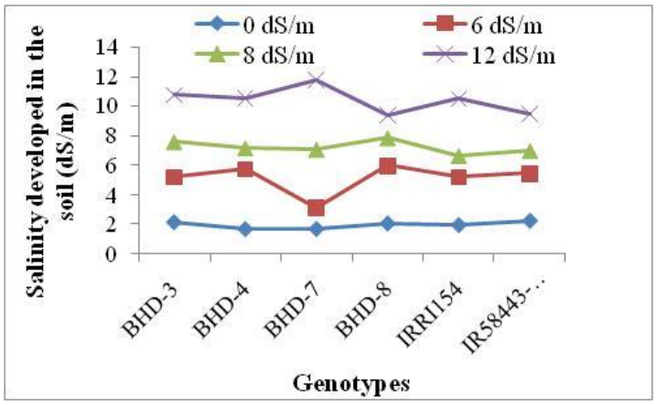

Fig. 1.7.6: Electrical conductivity of saturation paste extract (ECe) in dS/m in varying salinity level during harvest.

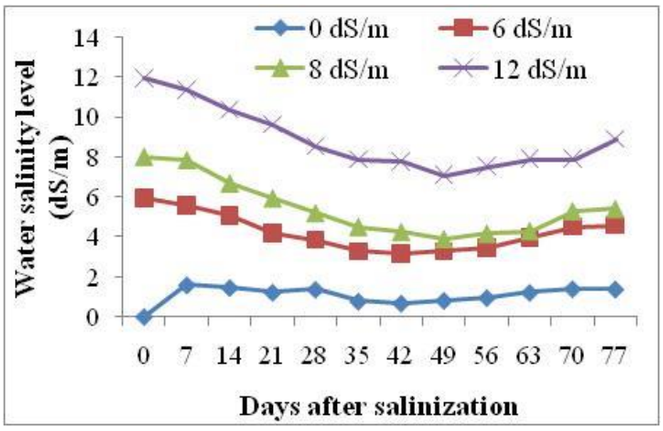

Fig. 1.7.7: Water salinity (dS/m) in varying salinity level during the growing period

Conclusion: Considering the grain per panicle, yield potentiality and tolerance ability at different salinity level, BRRI hybrid dhan8 could be tolerate salinity stress upto 6 dS/m.

PROJECT 2: SUBMERGENCE TOLERANCE

Expt. 2.1: Identification of local rice germplasm for two weeks flash flood submergence tolerance

[1]Hirendra Nath Barman, [1]Md. Sazzadur Rahman, [2]Sharmistha Goshal, [2]K.M. Iftekharuddaula, [3]M. Khalequzzaman and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Plant Breeding Division, [3]Director (Res.) BRRI

Objective: To identify the tolerant germlasm for two weeks under complete submerged condition at vegetative phase.

Materials and methods: Ninety local germplasms were tested along with tolerant checks (FR13A and BRRI dhan79) and sensitive checks (IR42 and BR5). Twenty days old seedlings were transplanted using 20 cm x 20 cm in a concrete submergence tank. Two weeks after transplanting plants were submerged completely at 1 meter water level and kept submerged condition for 14 days. During submergence period the water of the tank was made turbid twice daily, and the water pH, temperature, dissolve O_2 and turbidity were measured. After 21 days of drain out of water, recovery or survivability score was taken. Survival scoring was done by

following standard evaluation system (SES) (IRRI, 2014). Data for different parameters were taken following the methodologies described below:

Elongation (%): $\frac{(\text{Seedling height after desubmergence} - \text{Seedling height just before submergence}) \times 100}{\text{Seedling height just before submergence}}$

Survivability (%): $\frac{(\text{No. of plants before submergence} - \text{No. of plants after desubmergence}) \times 100}{\text{No.of plants before submergence}}$

Standard evaluation system:

SES score	Comparative survival (%)
1	100
3	95-99
5	75-94
7	50-74
9	0-49

Results: The results showed that most of the germplasms were non-elongating type and percent elongation was ranged from 3.30 to 51.68% but did not recover after de-submergence. Out of 90 germplasm 21 germplasm was survived after de-submergence, and the percent survivability was ranged from 16.67 to 33.33% (SES score 9) (**Table 2.1.1**). Survivability of the tolerant check varieties FR13A and BRRI dhan79 had 100% and 83.33%, respectively whereas susceptible check varieties did not survive (**Table 2.1.1**). The average water pH, temperature and dissolve O_2 of the submergence tank were 8.28, 29.95 ℃ and 5.24 mg/L, respectively. The average turbidity of the water tank was 157.23 and 404.60 FNU (Formazin Nephelometric Units) before and after made turbid, respectively during submergence.

Table: 2.1.1: Plant height, %Elongation, %Survivability and SES score of the tested germplasm under 2 weeks complete submerged condition

Sl. No.	Genebank Acc. No.	Plant height (cm)		% Elongation	% Survivability	SES Score
		before submergence	after submergence			
1	1724	54.00	67.67	20.20	0.00	9
2	1731	36.67	55.67	34.13	0.00	9
3	1737	42.67	61.67	30.81	16.67	9
4	1744	49.00	63.33	22.63	0.00	9
5	1757	49.33	54.00	8.64	0.00	9
6	1758	50.67	75.00	32.44	16.67	9
7	1759	57.67	74.33	22.42	16.67	9
8	1767	57.00	74.67	23.66	0.00	9
9	1775	55.33	70.33	21.33	33.33	9
10	1778	39.00	68.33	42.93	0.00	9
11	1779	42.67	60.00	28.89	0.00	9
12	1780	42.00	70.00	40.00	0.00	9
13	1781	45.00	79.00	43.04	0.00	9
14	1783	42.00	79.67	47.28	0.00	9
15	1784	43.00	83.67	48.61	16.67	9
16	1787	44.33	59.33	25.28	0.00	9
17	1788	38.33	68.00	43.63	0.00	9
18	1789	45.33	74.67	39.29	0.00	9
19	1790	52.67	72.33	27.19	0.00	9
20	1792	53.33	61.00	12.57	16.67	9
21	1793	54.00	89.67	39.78	0.00	9
22	1794	45.67	59.67	23.46	0.00	9
23	1795	56.33	63.00	10.58	0.00	9
24	1796	45.67	63.33	27.89	0.00	9
25	1797	53.33	77.67	31.33	0.00	9

Sl. No.	Genebank Acc. No.	Plant height (cm)		% Elongation	% Survivability	SES Score
		before submergence	after submergence			
26	1798	58.67	60.67	3.30	0.00	9
27	1799	64.33	70.00	8.10	16.67	9
28	1800	44.33	52.33	15.29	0.00	9
29	1801	55.33	66.67	17.00	0.00	9
30	1802	52.33	72.00	27.31	0.00	9
31	1803	62.67	65.33	4.08	0.00	9
32	1804	47.33	56.67	16.47	0.00	9
33	1805	58.00	61.00	4.92	16.67	9
34	1806	54.00	65.00	16.92	0.00	9
35	1807	50.00	65.67	23.86	0.00	9
36	1808	51.00	54.67	6.71	0.00	9
37	1809	58.67	68.67	14.56	0.00	9
38	1810	60.33	77.33	21.98	0.00	9
39	1811	55.67	66.67	16.50	0.00	9
40	1812	36.67	68.00	46.08	0.00	9
41	1813	51.00	72.33	29.49	16.67	9
42	1814	42.00	55.67	24.55	0.00	9
43	1815	60.67	68.33	11.22	0.00	9
44	1816	58.00	65.67	11.68	0.00	9
45	1817	39.33	78.00	49.57	16.67	9
46	1818	53.00	60.00	11.67	0.00	9
47	1819	50.67	81.00	37.45	0.00	9
48	1820	54.33	73.00	25.57	0.00	9
49	1822	45.33	73.67	38.46	0.00	9
50	1824	41.00	58.00	29.31	0.00	9
51	1825	50.33	61.00	17.49	16.67	9
52	1828	43.67	72.67	39.91	16.67	9
53	1829	54.33	79.00	31.22	0.00	9
54	1831	52.00	85.67	39.30	0.00	9
55	1833	47.67	76.67	37.83	0.00	9
56	1834	51.67	86.00	39.92	0.00	9
57	1836	42.33	70.00	39.52	0.00	9
58	1847	51.00	61.67	17.30	0.00	9
59	1848	42.33	61.00	30.60	0.00	9
60	1855	45.00	88.67	49.25	0.00	9
61	1856	42.67	81.00	47.33	0.00	9
62	1857	59.00	75.67	22.03	0.00	9
63	1858	46.00	67.67	32.02	0.00	9
64	1859	42.00	72.33	41.94	16.67	9
65	1860	60.00	92.33	35.02	0.00	9
66	1861	50.33	91.00	44.69	0.00	9
67	1862	54.33	73.33	25.91	0.00	9
68	1863	67.00	80.00	16.25	0.00	9
69	1864	60.33	66.67	9.50	0.00	9
70	1865	53.33	70.00	23.81	0.00	9
71	1960	45.67	53.00	13.84	33.33	9
72	1961	47.67	62.00	23.12	0.00	9
73	1964	45.33	48.00	5.56	16.67	9
74	1966	53.67	78.00	31.20	0.00	9
75	1967	52.33	67.00	21.89	0.00	9
76	1968	53.33	58.00	8.05	0.00	9
77	1969	55.00	62.33	11.76	0.00	9
78	1970	64.33	103.33	37.74	0.00	9
79	1971	48.00	99.33	51.68	0.00	9

Sl. No.	Genebank Acc. No.	Plant height (cm)		% Elongation	% Survivability	SES Score
		before submergence	after submergence			
80	1972	68.33	75.33	9.29	33.33	9
81	2052	52.00	92.00	43.48	0.00	9
82	2053	56.67	73.33	22.73	16.67	9
83	2055	49.67	81.00	38.68	0.00	9
84	2062	47.67	63.67	25.13	16.67	9
85	2063	56.00	91.67	38.91	16.67	9
86	2065	56.67	86.00	34.11	16.67	9
87	2066	52.67	76.67	31.30	0.00	9
88	2069	52.67	57.33	8.14	16.67	9
89	2071	50.00	87.00	42.53	0.00	9
90	2072	45.00	57.00	21.05	0.00	9
91	BR5	44.00	82.67	46.77	0.00	9
92	IR42	39.33	45.00	12.59	0.00	9
93	BRRI dhan79	39.33	47.67	17.48	83.33	5
94	FR13A	64.00	81.33	21.31	100.00	1

Expt. 2.2: Screening of local germplasms for Anaerobic tillering ability under water stagnant condition at T. Aman season

[1]Hirendra Nath Barman, [2]K.M. Iftekharuddaula, [3]M. Khalequzzaman and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Plant Breeding Division, [3]Director (Res.) BRRI

Objective: To observe the anaerobic tillering ability of the local germplasms under water stagnant conditions.

Materials and methods: Sixty local germplasms along with two BRRI varieties BR10 and BRRI dhan30 were tested for this study. Twenty days old seedlings were transplanted using 20 cm x 20 cm in a concrete tank. The water pressure @ 5 cm/week was started from 7 days after transplanting and was continued up to 60 cm. The stagnant water was maintained up to maturity. Data of the plant height, tiller number and yield (at 14 % moisture) was taken from average of 3 hills.

Results: The experiment was conducted to observe the anaerobic tillering ability under medium stagnant (60 cm water pressure) conditions. The plant height, tiller/hill, yield/hill and survivability were found to ranges from 89-136 cm, 3.33-14.67 tillers/hill, 2.24-26.52 gm/hill and 100%, respectively. Forty two grmplasms out of 60 were produced higher tiller/hill (>6) compare to check varieties BR10 and BRRI dhan30 under water stagnant condition. Among the 42 higher tiller producing germplasms 14 germplasms (namely, BRRI Genebank Acc. No.2098, 2102, 2105, 2116, 2118, 2121, 2124, 2133, 2135, 2139, 2149, 2155, 2156 and 2157) were produced ≥10 tillers/hill under water stagnant condition (**Table 2.2.1**). Further validation could be done to confirm the above mentioned germplasms for anaerobic tillering ability.

Table 2.2.1: Plant height, tillering ability, yield and survivability of the germplasms under water stagnant condition

Sl. No.	Genebank Acc. No.	Plant height (cm)	Tiller/hill	Yield/hill (gm)	Survivability (%)
1	2091	121	5.33	2.99	100
2	2092	124	7.67	8.96	100
3	2093	111	7.33	7.63	100
4	2094	99	6.00	3.10	100
5	2095	103	4.00	2.24	100
6	2096	92	7.00	3.63	100
7	2097	133	7.67	11.89	100

Sl. No.	Genebank Acc. No.	Plant height (cm)	Tiller/hill	Yield/hill (gm)	Survivability (%)
8	2098	112	11.67	14.74	100
9	2099	107	8.00	10.91	100
10	2100	98	5.67	2.63	100
11	2101	107	5.33	8.57	100
12	2102	123	10.00	19.78	100
13	2103	91	7.33	4.72	100
14	2104	124	4.00	4.27	100
15	2105	99	11.00	12.22	100
16	2106	113	9.33	6.83	100
17	2107	120	7.33	13.60	100
18	2108	107	6.00	9.24	100
19	2109	105	5.00	4.87	100
20	2110	115	6.33	6.66	100
21	2111	124	4.33	8.71	100
22	2112	104	7.33	7.29	100
23	2113	103	8.67	13.71	100
24	2114	117	3.33	5.58	100
25	2115	115	4.33	5.04	100
26	2116	111	11.33	11.09	100
27	2117	116	5.67	9.31	100
28	2118	111	10.67	11.14	100
29	2119	102	8.00	8.33	100
30	2120	99	7.67	7.66	100
31	2121	107	10.00	8.80	100
32	2122	115	6.33	6.49	100
33	2123	107	5.00	7.49	100
34	2124	111	11.33	12.32	100
35	2125	118	4.33	6.19	100
36	2126	115	8.33	9.91	100
37	2127	129	7.33	7.67	100
38	2128	131	4.67	8.71	100
39	2130	127	4.67	6.93	100
40	2132	108	6.67	9.74	100
41	2133	119	10.00	13.48	100
42	2135	117	10.33	12.30	100
43	2136	116	7.33	12.97	100
44	2137	118	9.00	8.67	100
45	2138	114	6.00	11.15	100
46	2139	125	14.67	26.52	100
47	2140	114	9.33	12.12	100
48	2141	119	6.00	10.32	100
49	2142	117	8.67	12.60	100
50	2144	123	8.00	10.42	100
51	2145	107	9.33	4.09	100
52	2146	103	9.67	12.29	100
53	2147	136	8.33	17.12	100
54	2149	121	10.00	15.35	100
55	2150	122	6.67	10.08	100
56	2153	123	9.33	12.36	100
57	2154	136	8.00	10.22	100
58	2155	130	12.00	15.00	100
59	2156	102	10.33	11.88	100
60	2157	111	11.00	18.83	100
61	BR10	109	6.00	3.79	100
62	BRRI dhan30	89	3.33	6.54	100

PROJECT 3: DROUGHT TOLERANCE

Expt. 3.1: Screening of rice germplasm for drought tolerance at reproductive phase, T. Aman 2022

[1]Mst. Salma Pervin, [1]Tammana Sultana, [2]M Fazlul Islam and [3]M Khalekuzzaman
[1]Plant Physiology Division; [2]In-charge, BRRI R/S Rajshahi; [3]Director (Res.) BRRI

Introduction: Drought is a common feature in Bangladesh especially in dry season (winter and Pre-monsoon), which causes a substantial reduction of rice yield. It occurs mainly for uneven distribution of rainfall and thus, north-western part of the country is treated as drought-prone for poor rainfall. Rice is more susceptible to drought than other cereals. Drought can affect rice plant in any growth stage. However, T. Aman cultivars usually suffer from drought stress at reproductive and /or early ripening phase resulting poor yield. Rice plant is most sensitive to water stress from panicle initiation to heading stage (Yoshida, 1981). Irreversible damage is caused when water deficit occurs during heading and flowering. Most of the high yielding varieties developed so far are not bred specifically for drought situation. Traditional landraces are important reservoirs of many valuable traits (Hanamaratti *et al.*, 2008). Generally, landraces are highly adapted to adverse environment and also have varying levels of resistance to biotic and abiotic stresses (Li *et al.*, 2004). Bangladesh is a land of rice and it has a lot of landraces, which may endure drought sufficiently. Study of diverse genotypes of a crop is necessary to assess their performances, which help to develop a new variety suitable for commercial cultivation. Grouping or classification of genotypes based on suitable scale is quite imperative to understand the usable variability existing among them. Selection of suitable genetically diverse parent to develop heterotic combinations can be facilitated by determining genetic divergence among them. But there is a little work on the analysis of genetic divergence of land race genotypes in relation to drought stress in Bangladesh context. So, the following investigation was carried out to find out the genetic divergence of BRRI rice germplasm and evaluate them for identification of drought tolerant donor.

Objective: To identify rice germplasm tolerant to drought stress at reproductive phase.

Materials and methods: Three hundred rice germplasm collected from BRRI gene bank along with check variety BRRI dhan71 and IR64 were tested during T. Aman season 2022 at farmer's field, Alimganj, Paba, Rajshahi following Field-managed screening protocol (IRRI, 2008). Thirty-day old seedlings were transplanted at a spacing of 20 cm x 20 cm. The experiment was laid out in Alpha lattice design with two replications. Standard agronomic management practices were followed. The experiment was conducted in two sets where 1st set were grown under well-watered conditions and 2nd sets under stress condition. To apply water stress, irrigation water was withheld four weeks after transplanting and field were drained out properly for not allowing any standing water until maturity. The parch water table depth was determined daily. Soil sample was collected at 2 days interval for determining moisture content. Soil water potential was also monitored. Data on plant height, tiller number per plant, panicle number per plant, panicle length, filled grain number per plant, sterility percentage, filled grain weight per plant, and percentage of yield reduction were recorded. Mean data for each character were subjected to multivariate analysis viz. Principal Component Analysis (PCA), Non-hierarchical Clustering and Canonical Variate Analysis using Genestat 5.5 [Release 4.1 (PC/Windows NT] (Mahalanobis, 1936; Jager *et al.*, 1983; Digby *et al.*, 1989).

Results and discussion: Flowering of the tested genotypes started from 1st week of October to 4th week of October. So, before starting flowering i.e. during booting stage crop receive some rain water (**Fig. 3.1.1**). But there was no standing water in the field. During this period crop receive only 13 mm rain on 2nd week of September and about 50 mm rainwater on 4th week of September. However, there was no any rain for 5 consecutive days. After that during flowering and ripening period to maturity no rainfall occurred. As a result, crop did not receive any rain

water at these phases. The water table depth was below 30 cm from the soil surface after 18 days of drainage of water and 27 days after drainage of water it was 80 cm below the soil surface (**Fig. 3.1.2**). The average soil moisture of the experimental plot was 27.9 to 36.2% during booting stage (**Fig. 3.1.3**). During flowering it was 19.7 to 25.3%. However, the soil moisture was more than 30% only when rainfall occurred. During ripening period, it was around 18.9 to 21.3%. At this stage the soil water tension was 30-60% kPa (data not shown). Consequently, crop experiences severe drought stress at ripening phase.

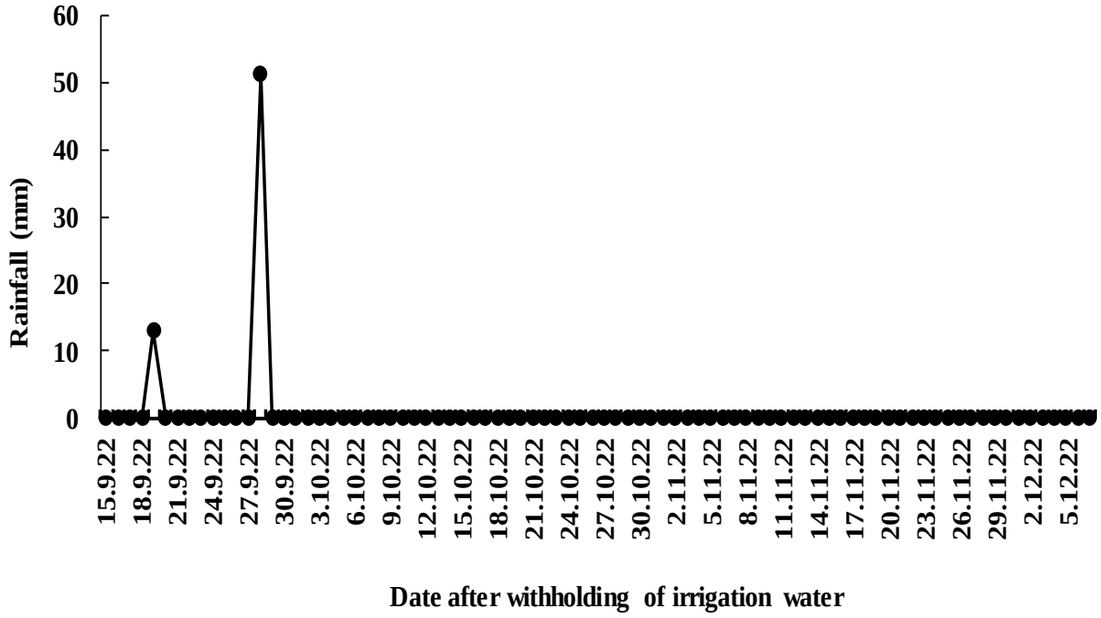

Fig. 3.1.1: Daily rainfall at farmer's field, Alimganj, Paba, Rajshahi during T. Aman' 2022.

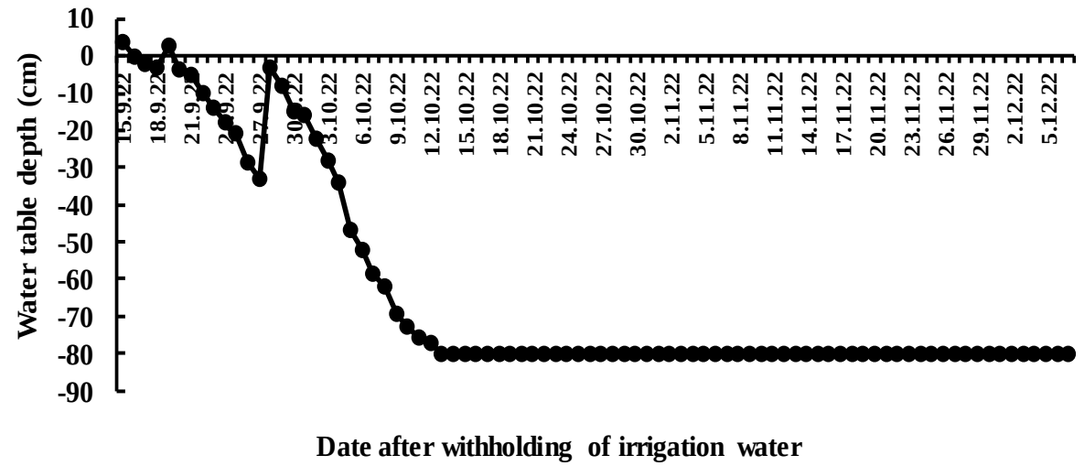

Fig. 3.1.2: Water table depth in stress field during T. Aman'2022 after initiation of stress.

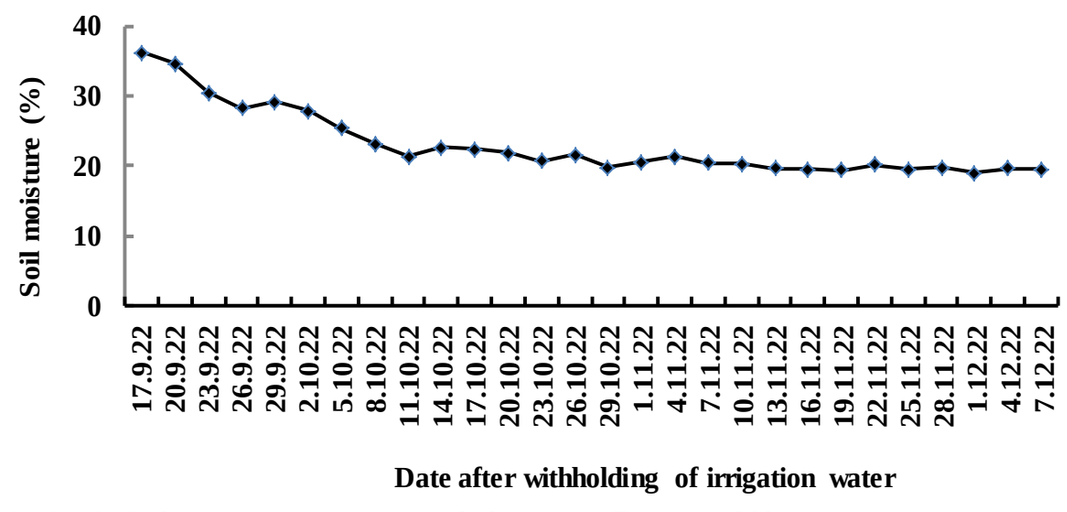

Fig. 3.1.3: Soil moisture at experimental plot during T. Aman' 2022.

Significant variations were recorded among the genotypes for all the ten characters. Eigen values (latent roots) of 8 principal component axes and percentage of total variations accounted for them obtained from the principal component analysis (PCA) are presented in **Table 3.1.1**. The result revealed that the first axis largely accounted for the variation among the genotypes (97.19%) followed by the second axes (1.38%). The first two axes accounted 98.57% of the total variations among the 8 characters describing 302 genotypes of rice.

Table 3.1.1: Latent roots (Eigen values) and their variations in 8 morpho-physiological characters of 302 rice genotypes

Principal component axes	Latent roots (Eigen values)	Percentage of variation	Cumulative % of variation
1	2487299	97.19	97.19
2	35342	1.38	98.57
3	23834	0.93	99.50
4	10233	0.40	99.90
5	1114	0.04	99.94
6	827	0.03	99.97
7	535	0.02	99.99
8	63	0.00	99.99

PCA scores also indicated a high degree of genetic diversity among the genotypes (Data not shown). On the basis of D^2 analysis, 302 genotypes of rice were grouped into ten clusters (**Table 3.1.2**). Maximum number of genotypes (58) were included in cluster III followed by cluster VIII (44). Cluster II included the minimum number of genotypes (13). Cluster I and IV included 18 genotypes. Cluster V, VI, VII, IX and X included 32, 30, 38, 28 and 23 genotypes respectively. **Table 3.1.3** shows the mean values for all the 8 characters along with the marking of the highest (H) and lowest (L) for each of the cluster. Differences in cluster mean existed for all the characters studied. In this study, cluster I had the most tolerant genotypes possess the lowest mean value for sterility percentage (35.2%) and percentage of yield reduction (45.9%). This group had the highest average in comparison with the other groups considering most of the other traits such as tiller number per plant (12.8), panicle number per plant (9.4), filled grain number per plant (349.6) and filled grain weight per plant (6.67g).

Similarly, the genotypes of cluster X showed better performance than other groups. The sterility percentage and percentage of yield reduction was also lower in this cluster. The sterility percentage was below 50% (37.6%). The percentage of yield reduction was around 50%. Considering traits such as filled grain number per plant (272.9) and filled grain weight per plant (5.19 g) this cluster had the second highest average among all cluster. In contrast to I and X, cluster VII had the highest percentage of sterility and yield reduction (80.2% and 96.3% respectively). In respect of filled grain number per plant and filled grain weight per plant it had the lowest mean value. Similar performance was also observed in cluster III. So the genotypes of cluster VII and III were sensitive to drought stress.

Table 3.1.2: Distribution of 302 rice genotypes in different clusters

Cluster no.	No. of population	BRRI Genebank Acc. no. of entry
I	18	2706, 2712, 2718, 2728, 2730, 2732, 2808, 2865, 2875, 2880, 3016, 3019, 3020, 3022, 3023, 3059, 3070, BRRI dhan71
II	13	2737, 2743, 2775, 2778, 2801, 2828, 2845, 2867, 2872, 2881, 2887, 2964, 3027
III	58	2704, 2709, 2711, 2713, 2750, 2753, 2754, 2757, 2768, 2777, 2779, 2782, 2790, 2821, 2841, 2849, 2852, 2853, 2857, 2858, 2862, 2863, 2876, 2891, 2899, 2902, 2909, 2911, 2917, 2922, 2930, 2933, 2935, 2937, 2938, 2946, 2978, 2979, 2983, 2985, 3001, 3005, 3006, 3008, 3011, 3012, 3013, 3014, 3041, 3044, 3045, 3053, 3058, 3060, 3061, 3066, 3068, IR64

Cluster no.	No. of population	BRRI Genebank Acc. no. of entry
IV	18	2715, 2716, 2725, 2731, 2733, 2735, 2739, 2785, 2802, 2810, 2829, 2870, 2878, 2879, 2903, 2929, 2943, 3039
V	32	2729, 2751, 2765, 2773, 2787, 2794, 2795, 2807, 2820, 2842, 2843, 2859, 2896, 2906, 2944, 2945, 2970, 2972, 2973, 2977, 2989, 2998, 2999, 3002, 3010, 3018, 3026, 3033, 3034, 3049, 3052, 3054
VI	30	2702, 2710, 2714, 2738, 2740, 2741, 2742, 2748, 2789, 2803, 2805, 2809, 2811, 2822, 2824, 2830, 2837, 2838, 2844, 2866, 2886, 2932, 2954, 2965, 2974, 3000, 3004, 3038, 3048, 3055
VII	38	2767, 2769, 2771, 2781, 2783, 2784, 2788, 2798, 2812, 2839, 2854, 2856, 2864, 2877, 2884, 2885, 2894, 2900, 2901, 2904, 2905, 2908, 2910, 2913, 2916, 2921, 2923, 2924, 2925, 2926, 2927, 2934, 2976, 2987, 3036, 3043, 3046, 3047
VIII	44	2708, 2721, 2734, 2744, 2745, 2766, 2774, 2776, 2792, 2793, 2796, 2797, 2799, 2800, 2804, 2806, 2816, 2826, 2813, 2834, 2846, 2848, 2850, 2855, 2860, 2889, 2898, 2956, 2960, 2971, 2984, 2993, 2994, 2996, 3015, 3025, 3028, 3029, 3030, 3035, 3056, 3062, 3064, 3065
IX	28	2720, 2749, 2758, 2762, 2763, 2770, 2780, 2818, 2819, 2832, 2833, 2851, 2890, 2928, 2936, 2941, 2949, 2950, 2951, 2961, 2967, 2969, 2975, 2981, 3003, 3009, 3031, 3040
X	23	2701, 2707, 2719, 2722, 2723, 2724, 2726, 2727, 2736, 2756, 2759, 2813, 2814, 2823, 2840, 2871, 2882, 2963, 2997, 3021, 3042, 3057, 3069

Table 3.1.3: Intra-cluster means for 8 morpho-physiological characters in 302 rice genotypes

Cluster no.	Plant height (cm)	Tiller no./plant	Panicle no./plant	Panicle length (cm)	Filled grain no./plant	% Sterility	Grain wt. (g/plant)	Yield Reduction (%)
I	120.5	12.8 (H)	9.4 (H)	21.6	349.6 (H)	35.2 (L)	6.67 (H)	45.9 (L)
II	116.7 (L)	12.3	7.0	22.3 (H)	141.3	35.7	2.96	74.0
III	120.7	12.6	6.9	21.3	60.3	71.3	1.05	91.2
IV	117.3	12.2	9.2	21.0	210.1	49.7	3.89	67.6
V	123.4	12.4	7.7	21.3	93.4	69.0	1.68	85.6
VI	125.6 (H)	12.6	8.6	21.6	161.0	53.5	2.59	78.8
VII	119.0	12.3	6.1 (L)	21.4	27.7 (L)	80.2 (H)	0.43 (L)	96.3 (H)
VIII	124.0	12.6	7.7	21.4	121.2	59.9	2.26	80.8
IX	119.5	12.1 (L)	6.3	20.9 (L)	88.0	54.2	1.61	85.8
X	122.5	12.2	8.9	22.0	273.0	37.6	5.19	54.7

The canonical variate analysis, complementary to Mahalanobis's D^2 statistics, was carried out to obtain the cluster distances (Mahalanobis's D^2 values) that indicated the index of genetic diversity among them. Regarding inter-cluster distance, cluster I showed maximum genetic distance (23.07) from cluster VII followed by the distance between cluster I and III (20.58), cluster I and IX (18.32), cluster I and V (18.26), cluster VII and X (17.96) and cluster I and VIII (16.11) suggesting diversity between them and the genotypes in these cluster could be used as parents in hybridization program (**Table 3.1.4**). Cluster V had minimum D^2 value (1.95) with cluster IX indicating the genotypes in these clusters to be close in genetic make-up. Intermediate or moderate inter-cluster divergence was observed between cluster I and II, cluster I and VI, cluster III and X, cluster IV and VII, cluster V and X and cluster IX and X. Within a certain limit, hybridization between the more diverged parents is expected to generate wide range of variability in segregation generations. However, maximum heterosis is generally expressed through crossing between moderately diverged parents.

Table 3.1.4: Average inter- cluster distance (D^2) for 302 rice genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	0									
II	14.56	0								
III	20.58	7.10	0							
IV	9.82	5.25	10.88	0						
V	18.26	5.29	2.39	8.59	0					
VI	13.07	3.12	7.71	3.46	5.44	0				
VII	23.07	9.61	2.63	13.40	4.92	10.27	0			
VIII	16.11	3.37	4.53	6.42	2.28	3.25	7.10	0		
IX	18.32	4.40	2.86	8.63	1.95	5.48	5.35	2.54	0	
X	5.30	9.35	15.45	4.68	13.14	7.88	17.96	10.95	13.13	0

The relative contribution of different characters towards divergence is presented in **Table 3.1.5**. Vector I and vector II values were obtained from Principal Component Analysis. In first axis vector I, among the 8 studied characters 2 characters such as, % sterility and Yield reduction (%) having positive impact towards divergence. In vector II, 6 characters such as Plant height, tiller number per plant, panicle number per plant, Panicle length, % sterility and percentage of yield reduction having positive impact towards divergence. Among the characters that showed positive value in both the axis % sterility and percentage of yield reduction contributed most for divergence in the studied genotypes than other characters.

Table 3.1.5: Relative contribution of 8 morpho-physiological characters towards total divergence in rice genotypes

Characters	Vector I	Vector II
1. Plant height (cm)	-0.0250	0.5095
2. Tiller no./plant	-0.0298	0.6059
3. Panicle no./plant	-0.2535	0.1524
4. Panicle length (cm)	-0.0836	0.5785
5. % Sterility	0.4304	0.0713
6. Filled grain (no./plant)	-0.4993	-0.0504
7. Filled grain wt. (g/plant)	-0.4995	-0.0645
8. Yield reduction (%)	0.4931	0.0602

From the results of cluster analysis, inter-cluster distance and mean value of studied characters especially yield and yield components under drought stress condition it was observed that cluster I included the most tolerant genotypes and cluster VII included the sensitive genotypes. So based on the performance of genotypes under drought stress condition 10 clusters could be classified accordingly (**Table 3.1.6**). Cluster I and X would be ranked as tolerant and obtained score 1, cluster IV and VI as moderately tolerant and obtained score 3, cluster II and VIII as intermediate and obtained score 5, cluster V and IX as moderately sensitive and obtained score 7 and finally cluster III and VII as sensitive and obtained score 9.

Table 3.1.6: Tolerant score and remarks of 10 clusters of 302 rice genotypes

Cluster no.	Tolerant Score	Remarks
I & X	1	Tolerant
IV & VI	3	Moderately tolerant
II & VIII	5	Intermediate
V & IX	7	Moderately sensitive
III & VII	9	Sensitive

Conclusion: The overall data of this study concluded that 18 genotypes including BRRI dhan71 of cluster I and 23 genotypes of cluster X showed better performance in relation to yield and other morpho-physiological characters under rainfed condition at reproductive and ripening

phase. Under rainfed condition crop actually experienced severe drought at ripening phase. So out of 300 germplasms, 40 genotypes were selected for further confirmation under control drought condition in rainout shelter.

Expt. 3.2: Evaluation of selected germplasm under drought stress at reproductive phase in the rain-out shelter

Mst. Salma Pervin and Tamanna Sultana

Objective: To evaluate previously selected germplasm under control drought condition in the rain-out shelter.

Materials and methods: This experiment was conducted in the rain-out shelter, Plant Physiology Division at BRRI HQ, Gazipur during T. Aman season, 2022 to evaluate previously selected 44 germplasm with check variety BRRI dhan71 and IR64. Thirty-day old seedlings were transplanted in puddled soil at a spacing of 20 cm x 20 cm. Standard agronomic management practices were followed. Weeds were controlled when needed. Four weeks after transplanting, the plots were drained out for inducing drought stress at reproductive phase. The water table depth and soil moisture were recorded. Vegetative growth and yield characteristics were measured.

Results and discussion: Irrigation has been stopped and excess water has been drained out from the plot at four weeks after transplanting. The average water table depth was shown in **Fig. 3.2.1**. Four days after withholding of irrigation water the parched water table remained 30 cm depth below surface which was 40 cm after 6 days of withholding irrigation water. Twenty nine days after withholding water there was no water in the PVC pipe.

The average soil moisture was ranged from 28.1 to 33.3 percent at twenty days after withholding of irrigation water. After that the average soil moisture was ranged about 19.5 to 27.9 percent which is below field capacity (**Fig. 3.2.2**) which reveals that plants experienced water stress both at reproductive and ripening phase. During flowering to ripening period, the mean soil water tension in rainout shelter ranged from 10-52 KPa (**Fig. 3.2.3).**

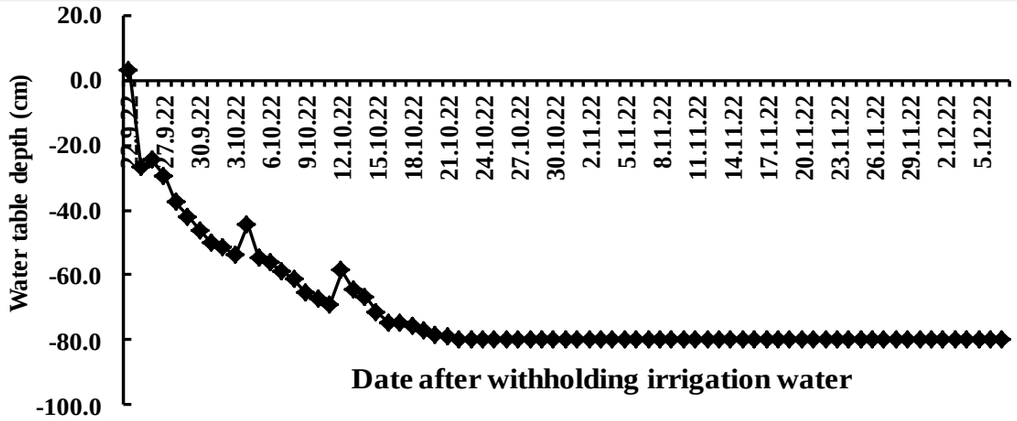

Fig. 3.2.1: Parch water table depth at rainout shelter after withholding of irrigation water.

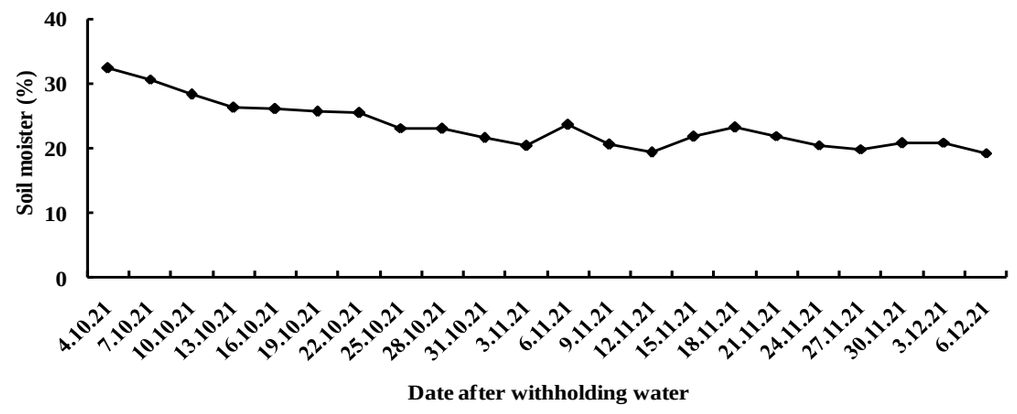

Fig. 3.2.2: Soil moisture status after withholding of irrigation water in the rainout shelter.

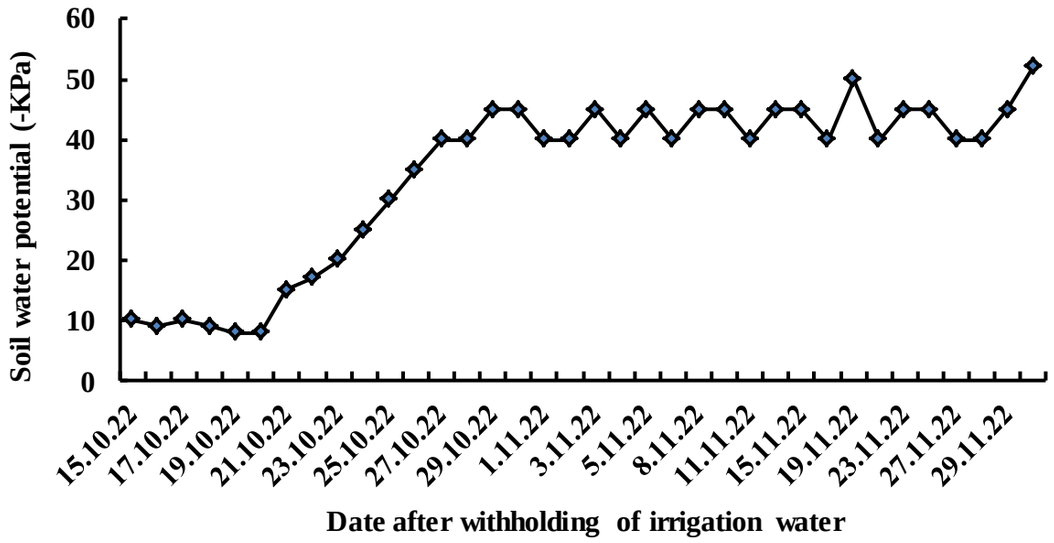

Fig. 3.2.3: Soil water tension in the rainout shelter after withholding of irrigation water in the rainout shelter.

Vegetative growth and Yield characteristics: Significant variation was observed in all the growth characters, yield and yield components (**Table 3.2.1**). Plant height varied from 100.7 cm to 136.2 cm among the tested entries. Among the germplasm highest number of tiller (10.3/plant) was found in BRRI Genebank Acc. no. 2336 while the highest panicle number was in BRRI Genebank Acc. no. 2320 (10/plant). BRRI Genebank Acc. no. 2649 produced the longest panicle (24.6 cm) followed by BRRI Genebank Acc. no. 2603 (23.7 cm). Among the tested genotypes, BRRI Genebank BRRI Genebank Acc. no. 2320 produced highest number of grain (414.2 no./plant) followed by BRRI Genebank Acc. no. 2312 (355.8 no/plant). The check variety BRRI dhan71 produced 579.0 grain per plant. The grain yield varied from 0.40 to 11.59 g/plant. The tolerant check variety BRRI dhan71 produced the highest grain yield (11.59 g/plant). Among the tested genotypes BRRI Genebank Acc. no. 2451 produced highest grain yield (8.64 g/ plant) followed by BRRI Genebank Acc. no. 2554, 2312, and 2320 (8.06, 7.74 and 7.42 g/plant respectively). The sterility percentage of these genotypes was less than 50%.

Table 3.2.1: Observed growth characteristics, yield and yield components of tested 44 genotypes

SL. No.	BRRI Genebank Acc. no.	Plant height (cm)	Tiller /Plant (no.)	Panicle /Plant (no.)	Panicle Length (cm)	Filled grain /Plant (no.)	Sterility (%)	Grain wt. (g/plant)
1	2301	133.0	9.5	6.2	20.0	223.0	30.3	4.52
2	2312	124.3	10.2	9.3	20.3	355.8	21.0	7.74
3	2320	104.0	9.0	10.0	18.4	414.2	17.7	7.42
4	2323	112.0	6.0	8.8	18.1	224.0	23.9	4.15
5	2330	111.2	7.2	9.3	17.2	209.5	52.8	3.80
6	2333	116.2	9.3	8.0	18.1	275.7	20.3	6.45
7	2336	106.7	10.3	8.5	18.9	417.3	33.2	5.68
8	2346	131.2	9.8	6.2	17.4	201.7	29.6	4.12
9	2451	115.7	9.2	8.3	21.5	349.7	26.7	8.64
10	2464	103.0	7.0	6.0	21.7	82.5	61.2	1.55
11	2479	120.8	7.3	6.7	20.8	211.7	58.0	2.99
12	2493	111.5	8.2	7.2	19.5	132.0	65.0	1.47
13	2494	113.5	8.0	7.0	21.4	87.7	62.1	1.08
14	2495	122.5	7.5	6.7	22.9	139.2	41.1	1.52
15	2496	122.2	7.3	7.2	20.8	128.3	47.3	1.43
16	2500	122.5	7.8	7.5	21.4	161.8	56.4	1.82
17	2509	100.7	5.8	5.7	18.2	85.0	42.8	0.61
18	2525	110.5	5.2	5.0	19.2	166.8	32.9	0.40
19	2552	136.2	7.3	6.5	18.3	348.8	39.8	6.48

SL. No.	BRRI Genebank Acc. no.	Plant height (cm)	Tiller /Plant (no.)	Panicle /Plant (no.)	Panicle Length (cm)	Filled grain /Plant (no.)	Sterility (%)	Grain wt. (g/plant)
20	2553	120.5	8.7	7.3	20.5	113.3	59.5	1.22
21	2554	132.8	9.8	9.0	19.3	384.5	15.4	8.06
22	2555	118.2	8.0	7.0	20.5	179.2	59.5	1.26
23	2575	120.8	6.7	5.2	22.0	74.2	62.4	1.40
24	2577	120.7	7.3	5.8	21.6	101.5	41.5	2.11
25	2578	128.5	7.5	6.3	23.0	211.5	33.6	4.69
26	2579	121.0	8.2	7.0	20.9	145.3	39.2	2.78
27	2580	126.0	8.5	7.7	21.8	212.0	41.2	4.57
28	2586	126.3	7.5	6.8	22.0	122.5	68.8	2.11
29	2600	118.0	6.8	6.2	22.7	292.7	28.4	3.31
30	2603	130.7	7.7	6.5	23.7	187.5	62.0	2.88
31	2605	131.0	6.8	6.3	22.4	93.3	65.2	1.40
32	2607	126.8	6.2	5.3	20.9	53.8	62.0	0.81
33	2609	115.5	7.5	6.7	22.1	35.2	69.3	0.61
34	2612	120.3	6.2	5.5	21.6	147.5	21.5	2.59
35	2630	141.0	6.5	5.8	22.7	46.7	80.3	0.69
36	2639	128.0	6.7	4.7	22.1	45.0	50.4	0.60
37	2641	118.0	7.8	7.0	20.8	150.8	47.5	2.49
38	2649	138.3	7.7	7.7	24.6	211.3	48.7	4.61
39	2656	158.8	7.8	6.3	21.9	249.2	34.5	5.92
40	2662	125.5	6.5	5.3	21.4	96.0	57.0	1.82
41	2672	121.0	6.0	6.0	21.9	143.0	58.9	2.61
42	2682	108.8	6.5	5.5	19.5	106.7	26.6	1.95
43	2684	108.0	8.0	6.3	17.0	188.0	60.2	2.95
44	2689	128.8	9.2	7.8	22.9	321.0	50.5	6.13
45	BRRI dhan71	102.2	10.3	9.3	23.2	579.0	23.8	11.59
46	IR64	99.2	10.8	10.0	18.8	166.0	61.6	4.18
LSD (5%)		14.4	2.6	2.7	4.0	165.2	27.2	3.00
CV (%)		5.9	16.8	19.4	9.5	42.5	29.8	43.6

Conclusion: Under control drought condition in the rain-out shelter, out of 44 germplasm BRRI Genebank Acc. no. 2451 yielded highest followed by BRRI Genebank Acc. no. 2554, 2312, and 2320. The sterility percentage of these genotypes was less than 50.

Expt. 3.3: Growth and Physiological Performance of Aerobic Rice as Affected by Low water

Mst. Salma Pervin and Salma Akter

Introduction: Aerobic rice production is a revolutionary way of growing rice in non-puddled, non-flooded fields (Singh *et al.,* 2008; Rajakumar *et al.,* 2009) and rice is grown like an upland crop (unsaturated condition) with adequate inputs and supplementary irrigation when rainfall is insufficient (Bouman, 2001). This system uses input-responsive specialized rice cultivars and complementary management practices to achieve at least 4-6 t ha^{-1} using only 50-70% of the water required for irrigated rice production. Varieties suitable for this type of cultivation also possess ability to withstand intermittent drought spells with minimum yield loss with maximum yield potential of 6 tons per hectare. Aerobic rice could be cultivated with 600 to 700 mm of total water in summer and entirely on rainfall in wet season (Hittalmani, 2007). So aerobic rice recommended in areas where water is too scarce or expensive to allow traditional irrigated rice cultivation. Growing rice aerobically saves water by eliminating continuous seepage and percolation, reducing evaporation and eliminating wetland preparation. It is also reported that

amount of methane emitted under aerobic situation is very low and contributes to lowering of greenhouse gas emission (Hittalmani, 2007).

Suitable rice genotypes for aerobic cultivation are limited. Searching of aerobic rice genotypes and their potentialities at water stress condition is needed to be investigated. Field testing of the aerobic rice lines encounters difficulties in moisture control. Therefore, their potentiality needs to be tested under control net house conditions with different moisture regimes. Physiological characteristics along with yield and yield contributing characters of the aerobic lines need to be compared with regular varieties.

Objectives: To observe the performance of aerobic rice lines under low water condition.

Materials and methods: The experiment was conducted in Plant Physiology Division during Boro season, 2022-23. Two breeding lines along with standard Boro variety BRRI dhan58 were considered for this study. Forty days old seedlings were transplanted in drum (56 cm x 43 cm) containing 110 kg puddled soil. The soil was fertilized with Urea-TSP-MP @ 50-25-25 g/drum. Three hills per genotypes were maintained in each drum. Upto thirty five days after transplanting all the plants were grown in well-watered condition. After that the experiment was conducted in 3 sets where 1st set was grown in well-watered condition maintaining 4 cm standing water considering as control, the 2nd set under saturated condition and the 3rd set at field capacity condition. The experiment was laid out following RCB design with five replications. To avoid rainfall all the drums were shaded by polythene sheet. The water table depth was measured daily by installing PVC pipe. The portion of PVC pipe (35 cm) below the ground surface was perforated. The soil moisture was also recorded once a week only for field capacity. Applied amount of water was also recorded regularly. Data on different growth parameter and on yield and yield components was taken after harvest.

Water application during growing period: During the growing period at control condition, total water application was recorded 120L, 124L and 120L for BR11206-5B-351, BR11204-5B-224 and BRRI dhan58, respectively. At saturated condition, total water was applied 75L, 77L and 75L, respectively for the two lines and standard check BRRI dhan58. However, 52L, 56L and 66L water was applied for the tested entries at field capacity condition which was minimum than control and saturated condition. At saturated condition, the reduced amount of water than control was also recorded which was 37%, 38% and 37% whereas at field capacity condition it was 56%, 55% and 45% for BR11206-5B-351, BR11204-5B-224 and BRRI dhan58, respectively (**Fig. 3.3.1 & 3.3.2**). The water table depth was below soil surface both at saturation and field capacity condition (**Fig. 3.3.3**). The average soil moisture of the drum at field capacity varies 22.3 to 41.7% (**Fig. 3.3.4**).

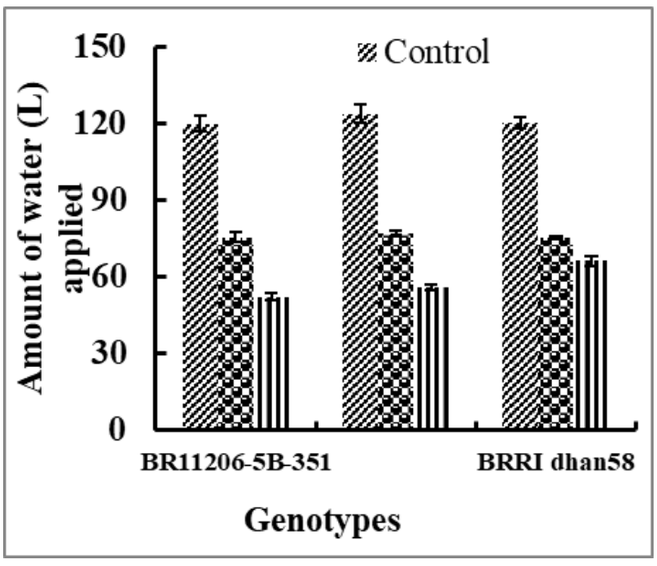

Fig. 3.3.1: Amount of water applied during the growing period.

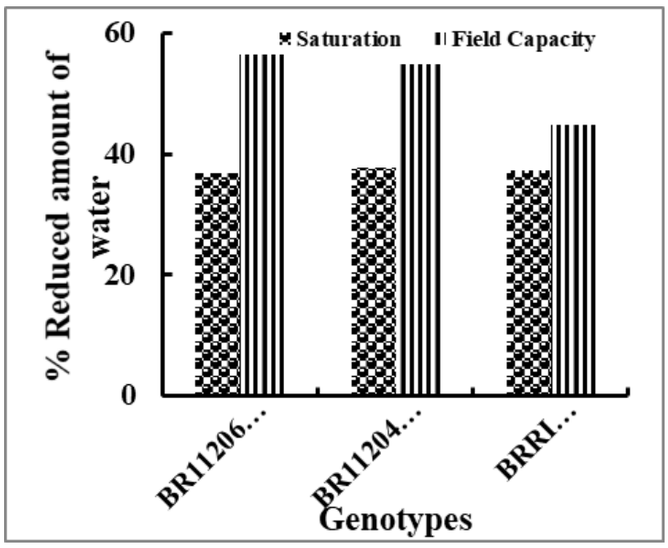

Fig. 3.3.2: Reduced amount of water at saturated and field capacity condition over control during the growing period.

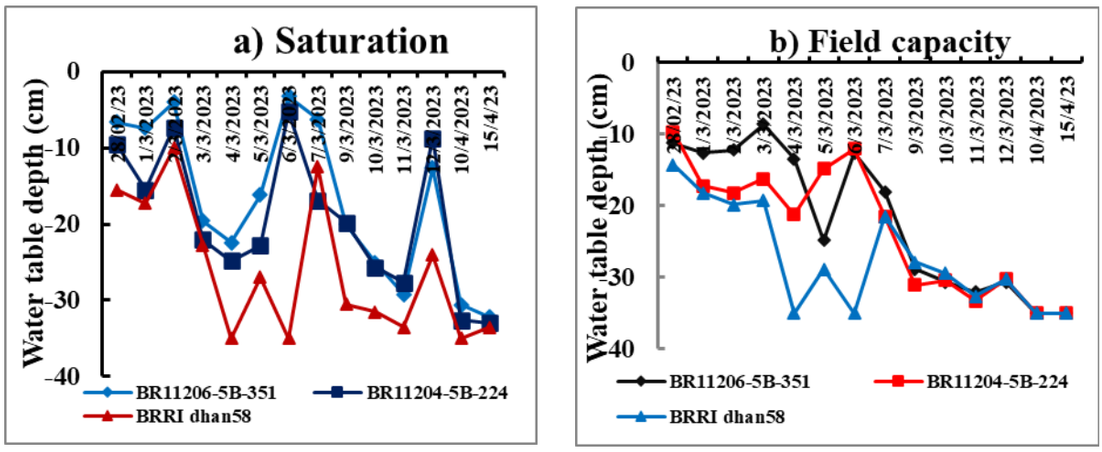

Fig. 3.3.3: Water table depth at a) saturation and b) field capacity after starting of treatment.

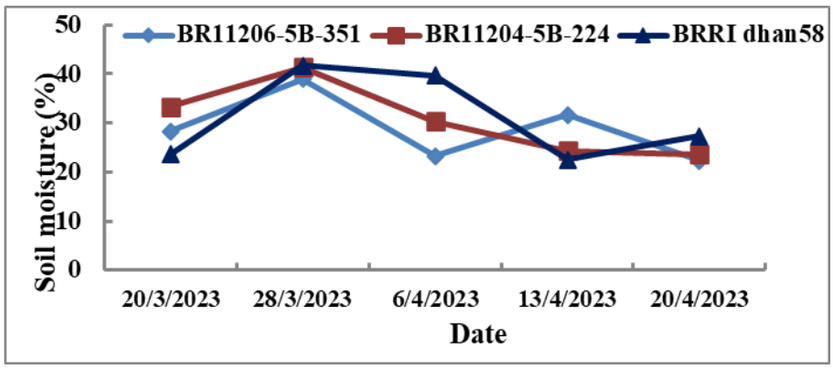

Fig. 3.3.4: Soil moisture of drum at field capacity during growing period.

Results and Discussions:

Growth characteristics: Variation was observed in all the growth parameters. Plant height significantly affected by low water irrespective of genotypes. Compared to well- watered control, under saturation plant height significantly decreased in BR11206-5B-351 but in BR11204-5B-224 and BRRI dhan58 it was statistically similar. However, under field capacity plant height drastically reduced in all the genotypes. Regarding tiller number significant reduction was also observed in all the genotypes except in BR11204-5B-224 under saturation where tiller number was slightly increased. In case of straw yield similar trend was found which indicating growth was affected by low water (**Fig. 3.3.5, 3.3.6 & 3.3.7).**

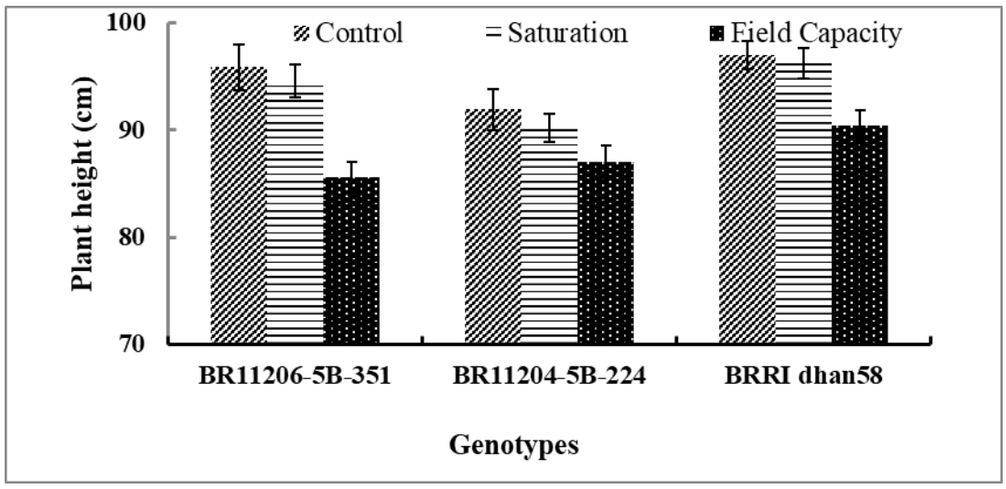

Fig. 3.3.5: Plant Height of three genotypes as affected by low water.

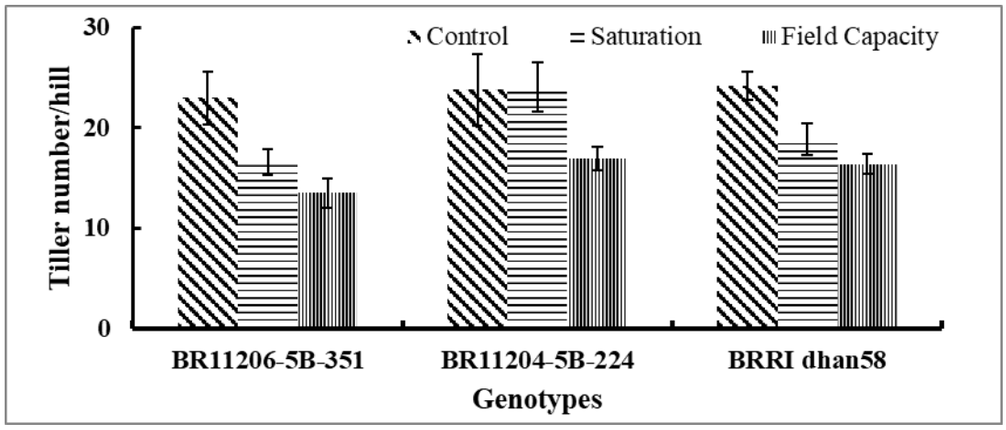

Fig. 3.3.6: Tiller number of three genotypes as affected by low water.

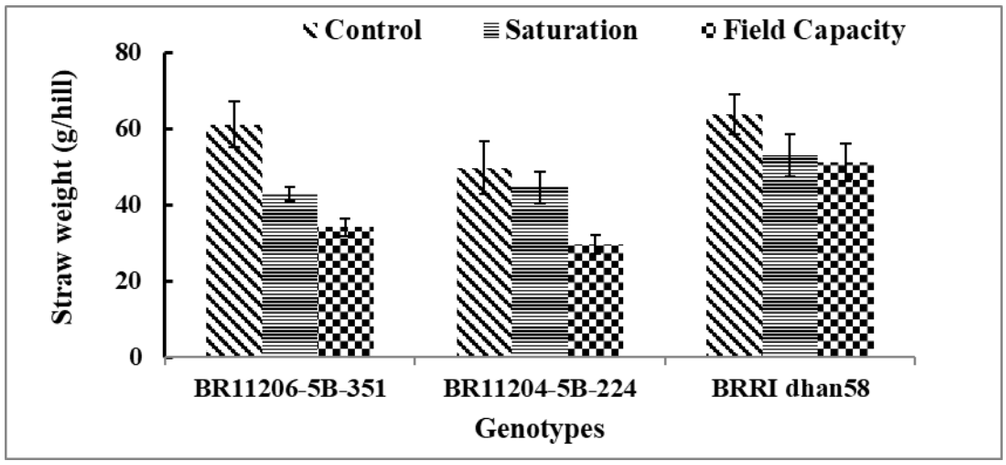

Fig. 3.3.7: Straw weight of three genotypes as affected by low water.

Yield and yield components: Due to low water, panicle number per plant drastically reduced in all the genotypes except in BR11204-5B-224 under saturation. Highest reduction was observed in BR11206-5B-351 under field capacity (**Fig. 3.3.8**). Irrespective of genotypes filled grain number reduced both under saturation and field capacity (**Table 3.3.1**). The highest number of filled grain was observed in BRRI dhan58 both under control and low water condition. However, under control condition grain yield varied from 30.31 to 76.22 g/ plant. Highest yield (76.22 g/ plant) was observed in BRRI dhan58 under well-water control condition followed by BR11206-5B-351 (58.94 g/ plant). But under saturation lowest reduction was observed in BRRI dhan58. This was might be contributed by the lowest percent sterility and lowest reduction of filled grain number. On the other hand, under field capacity grain yield drastically reduced in all the genotypes. Highest reduction was observed in BR11206-5B-351 which was about 76% followed by BRRI dhan58 which was about 74%. Although the per cent yield reduction was comparatively low in BR11204-5B-224 but the yield under control condition was also very low. However, HI was satisfactory only in BRRI dhan58 under control and saturated condition (**Table 3.3.1**).

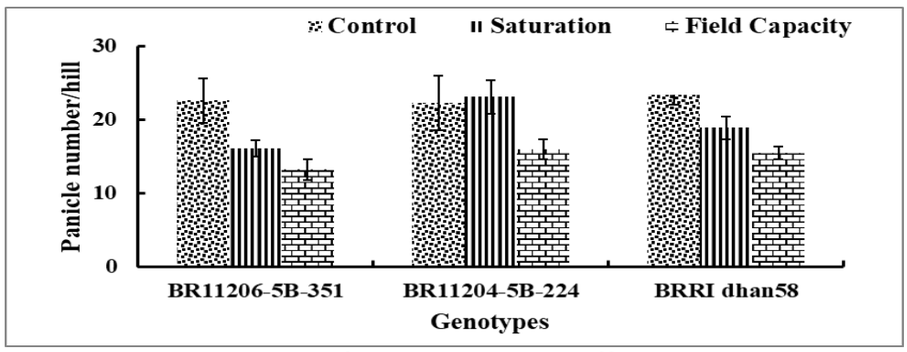

Fig. 3.3.8: Panicle number of three genotypes as affected by low water.

Table 3.3.1: Grain yield, filled grain number, %sterility and HI of 3 tested genotypes as affected by low water

Designation	Treatments	Grain yield (g/plant)	% Yield Reduction	Filled grain (no/plant)	% Sterility	HI
BR11206-5B-351	Control	58.94	-	2926	43.2	0.44
	Saturation	45.41	23.0	2191	44.0	0.45
	Field capacity	14.00	76.2	715	67.2	0.25
BR11204-5B-224	Control	30.31	-	1327	59.1	0.34
	Saturation	21.52	29.0	922	59.8	0.29
	Field capacity	13.93	54.0	692	60.4	0.27
BRRI dhan58	Control	76.22	-	3621	27.1	0.50
	Saturation	67.17	11.9	3156	25.0	0.52
	Field capacity	19.91	73.9	1062	70.1	0.24
LSD (5%)	-	11.2	-	570	9.1	0.06
CV (%)	-	22.5	-	24.0	13.9	13.9

Conclusion: None of the tested genotypes performed better than BRRI dhan58 under any condition. At saturated condition lowest reduction (11.9%) was found in BRRI dhan58.

PROJECT 4: HEAT TOLERANCE

Expt. 4.1: Screening of rice germplasm for high temperature tolerance

Tuhin Halder, Md. Sazzadur Rahman and Mst. Salma Pervin

Objectives: To identify heat tolerant rice germplasm at reproductive phase.

Materials: Fifty (50) Aus and Boro rice germplasm along with tolerant check N22 and susceptible check BRRI dhan28 were tested.

Methodology: Twenty-five days old seedlings were transplanted in earthen pot. Each entry had six pots and each pot has three plants. At least three tillers from each hill at just heading stage from four pots were selected. The selecting plant immediately transferred into a glasshouse prior flowering, where temperature and humidity were controlled at 35°C and 75% RH from 8:30 to 14:30 and rest of the time at 30°C and 70% RH. The plants were kept here for seven days then transferred to normal environmental condition and continue to maturity. After harvesting of heat treated sample, filled grain and unfilled grain were counted to determine fertility percentage.

Results: Out of 50 germplasm one (1) germplasm (BRRI Genebank Acc. no. 2135) had found more than 80% spikelet fertility with scored 1, two (2) germplasm (BRRI Genebank Acc. no. 2092 and 2116) found with SES 3 with spikelet fertility of 66 and 70 % respectively. Five (5) germplasm (BRRI Genebank Acc. no. 2094, 2100, 2102, 2140 and 2144) had SES score 5 with spikelet fertility 42-59% and rest of the germplasm were found susceptible type and score 7 or 9

(**Table 4.1 and Fig. 4.1**). The tolerant check N22 and susceptible check BRRI dhan28 had 51 and 1% spikelet fertility with SES score 5 and 7 respectively.

Conclusion: Three germpalsm BRRI Genebank Acc. no. 2092, 2116 & 2135 could be used for further investigation to confirm the heat tolerance.

Table 4.1: Spikelet fertility and SES score of tolerant to medium tolerant germplasm at control glass house high temperature condition

Sl. No.	Acc. No.	Spikelet fertility (%)	SES Score
1	2135	88	1
2	2092	66	3
3	2116	70	3
4	2094	42	5
5	2100	59	5
6	2102	51	5
7	2140	46	5
8	2144	52	5
9	BRRI dhan28	1	7
10	N22	51	5

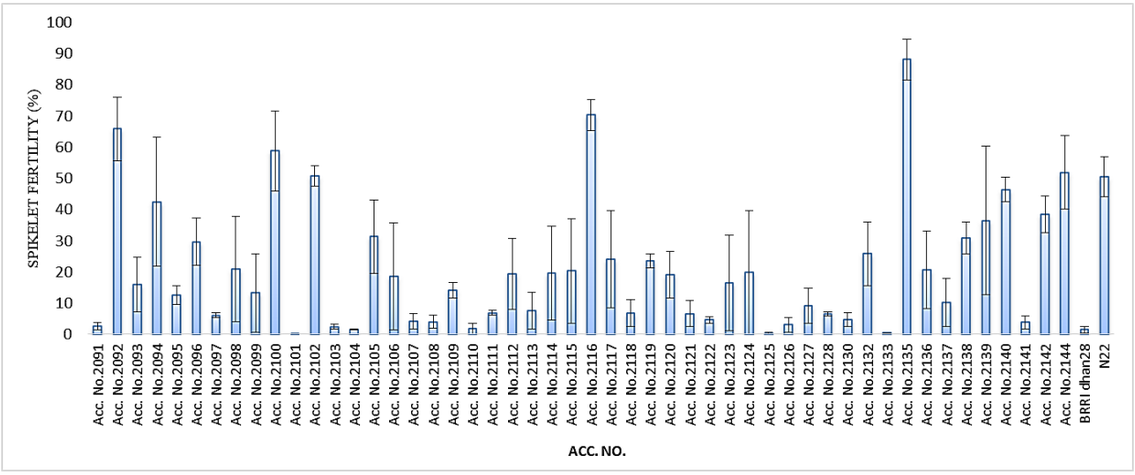

Fig. 4.1: Spikelet fertility percentage of the tested germplasm under controlled glass house high temperature condition.

Expt. 4.2: Screening for high temperature tolerance of advanced breeding lines

[1]Md. Sazzadur Rahman, [1]Tuhin Halder, [2]Mahmuda Khatun and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Plant Breeding Division

Rationale: Global warming has become a serious threat to the productivity of rice in the tropical and sub-tropical regions like South-Asia including Bangladesh. It was estimated and reported that, every 1 ℃ increase in global mean temperature will reduce global rice yields by 3.2%. To reduce the high temperature induced spikelet sterility problem, a high temperature spikelet fertility QTL (*qHTSF4.1*) was introgressed in to BRRI dhan28 and BRRI dhan29 through marker-assisted selection. To facilitate breeding for heat tolerance, a screening facility was developed in the Plant Physiology Division of BRRI. In this facility, temperature and humidity can be effectively controlled according to the requirement (Temp: 35-38 ℃ and Humidity: 70-80%). During reporting period, 8 spikelet fertility QTL introgression lines were evaluated in the controlled Glass house condition. The present study was under taken to check the phenotypic effects of *qHTSF4.1* in the background of BRRI dhan28 and BRRI dhan29 under controlled high temperature condition.

Materials and methods: Twenty-day old seedlings of 36 advanced breeding lines along with 5 checks BRRI dhan28, BRRI dhan98, IR64, IRRI154 and N22 were transplanted in earthen pots

in the natural condition. Three hills per pot and 6 pots per line were maintained. All pots were placed in natural condition until heading with recommended management practices. During heading (appearance of first spikelet), panicles were tagged (mother/primary tiller panicle) and 3 pots from each line was kept in normal condition and 3 pots were transferred in to controlled glass house having high temperature (38±2 $^{\circ}C$) and high humidity (75±5%) till all panicles flower. After completion of flowering, all pots were transferred to natural condition till maturity. At harvest tagged panicles were carefully collected and count the fertile and sterile grains of the harvested panicles. The scoring based on spikelet fertility was carried out according to the Standard Evaluation System (SES) for Rice (IRRI, 2014) (**Table 4.2.1**).

Table 4.2.1: Heat tolerance scoring system in rice (IRRI, 2014)

Score	Spikelet fertility (%)	Description
1	>80	Highly tolerant
3	61-80	Tolerant
5	41-60	Moderately tolerant
7	11-40	Susceptible
9	<11	Highly susceptible

Results: At harvest, spikelet fertility of high temperature treated plants was tested and rated against control plants. Six of the 36 advanced breeding lines evaluated were classed as fairly tolerant, with spikelet fertility ranging from 19.03 to 36.10%. However, the remaining lines scored 9 and were classed as susceptible to heat stress (**Table 4.2.2**). N22 outperformed compared to other checks, scoring 1 and 3 for the two sets of experiments, respectively. The results of this trial, notably spikelet fertility of the control plants, were very poor, indicating that the experiments were not correctly conducted, and the advanced lines should be assessed again in the upcoming Aus 2024 season.

Table 4.2.2. Spikelet fertility (%) under controlled high temperature (35±3°C) and high humidity (75±5%) condition during flowering of 36 advance breeding lines along with checks. Values are the mean±SE (n=9).

Sl. No.	Lines/Parents	Spikelet Fertility under control condition	Spikelet Fertility under HT* stress condition	SES# based on Spikelet Fertility under HT stress
1	BR11607-4R-184	44.67±4.09	**23.23±0.79**	7
2	BR11607-4R-192	27.26±3.82	2.04±0.41	9
3	BR11607-4R-72	54.47±5.93	13.15±1.32	7
4	BR11723-4R-72	48.13±8.87	0.00±0.00	9
5	BR11723-4R-172	7.34±1.08	0.00±0.00	9
6	BR11864-5R-99	87.36±2.66	**21.69±1.53**	7
7	BR11868-5R-23	36.23±1.74	9.13±1.57	9
8	BR8781-16-1-3-P2	29.03±9.90	0.69±0.34	9
9	BR9829-78-1-3-2	71.98±5.37	**26.66±1.40**	7
10	BRBa-1-4-9	13.22±3.80	0.37±0.19	9
11	IR121N177	47.10±7.32	1.24±0.44	9
12	IR64-EMF3	36.02±4.15	**36.10±5.98**	7
13	IRBL9-W(Pi9)	8.26±4.21	5.55±4.31	9
14	IRRI154-Pi9	46.42±4.89	**22.36±4.46**	7
15	N22	85.96±6.55	**81.93±1.30**	1
16	BRRI dhan98	64.02±2.59	2.84±0.78	9
17	HHZ5-DT20-Dt250-DT1	0.17±0.17	0.00±0.00	9
18	IR99853-B-B-B-310	52.48±2.34	**19.03±4.43**	7
19	IR18C1001	42.71±6.17	0.39±0.04	9
20	IR18C1002	35.16±3.34	0.29±0.19	9
21	IR18C1003	12.63±6.33	2.99±0.65	9
22	IR18C1004	39.7±7.47	2.74±1.81	9

Sl. No.	Lines/Parents	Spikelet Fertility under control condition	Spikelet Fertility under HT* stress condition	SES# based on Spikelet Fertility under HT stress
23	IR18C1005	64.92±8.33	1.65±0.59	9
24	IR18C1007	49.46±4.28	6.48±0.99	9
25	IR18C1008	19.87±4.07	1.33±0.69	9
26	IR18C1009	31.01±11.35	1.44±0.81	9
27	IR18C10010	76.54±2.04	5.76±2.03	9
28	IR18C10011	44.42±6.06	1.30±0.83	9
29	IR18C10012	29.85±6.45	0.63±0.39	9
30	IR18C10013	52.91±9.01	2.20±1.34	9
31	BR10966-B-3R-23	64.24±4.32	2.63±0.88	9
32	BR11845-4R-1	51.86±4.95	1.04±0.79	9
33	BR11845-4R-178	56.19±6.71	0.45±0.45	9
34	BR12605-4R-109	50.31±4.69	3.66±2.11	9
35	BR12605-4R-275	Germination fails		
36	BR1206-4R-298	68.36±4.09	2.04±0.45	9
CK	BRRI dhan28	51.64±0.43	1.85±0.68	9
CK	BRRI dhan98	67.05±3.93	0.23±0.14	9
CK	IR64	59.28±9.69	1.89±1.14	9
CK	IRRI154	10.54±2.44	0.00±0.00	9
CK	N22	77.51±0.22	**76.51±1.29**	3

*HT = High temperature, #SES = Standard Evaluation System.

Conclusion: Six of the 36 advanced breeding lines tested were considered fairly tolerant, However, N22 performed better than other checks, scoring 1 and 3 for the two sets of studies, respectively. The findings of this trial, particularly spikelet fertility in the control plants, were quite poor, hence the advanced lines should be evaluated again in the forthcoming Aus 2024 season.

Expt. 4.3: Evaluation of performances of high temperature spikelet fertility QTL (*qHTSF4.1*) introgression lines

[1]Md. Sazzadur Rahman, [2]Munnujan Khanam, [1]Avijit Biswas, [1]Tuhin Halder, [1]Hirendra Nath Barman and [1]Rumena Yasmeen
[1]Plant Physiology Division, BRRI; [2]CASR, BRRI

Rationale: Global warming poses a significant threat to rice productivity in tropical and sub-tropical regions such as South-Asia, including Bangladesh. It is estimated that every 1 ℃ increase in global mean temperature reduces global rice yields by 3.2%. To address this issue, a high temperature spikelet fertility QTL (qHTSF4.1) was introduced into BRRI dhan28 and BRRI dhan29 through marker-assisted selection. To aid in heat tolerance breeding, BRRI's Plant Physiology Division established a screening facility. The current study was conducted to assess the phenotypic effects of qHTSF4.1 on the background of BRRI dhan28 and BRRI dhan29 under controlled high temperature conditions, as well as yield potential in the field during the Boro season.

Materials and methods:

Phenotypic characterization under controlled high temperature condition: Twenty-day old seedlings of high temperature spikelet fertility QTL introgression lines were transplanted in earthen pots in the natural condition. Three hills per pot and 6 pots per line were maintained. All pots were placed in natural condition until heading with recommended management practices. During heading (appearance of first spikelet), panicles were tagged (mother/primary tiller panicle) and 3 pots from each line was kept in normal condition and 3 pots were transferred in to controlled glass house having high temperature (38±2 $^{\circ}C$) and high humidity (75±5%) till all

panicles flower. After completion of flowering, all pots were transferred to natural condition till maturity. At harvest tagged panicles were carefully collected and count the fertile and sterile grains of the harvested panicles. The scoring based on spikelet fertility was carried out according to the Standard Evaluation System (SES) for Rice (IRRI, 2014) (**Table 4.3.1**).

Table 4.3.1: Heat tolerance scoring system in rice (IRRI, 2014)

Score	Spikelet fertility (%)	Description
1	>80	Highly tolerant
3	61-80	Tolerant
5	41-60	Moderately tolerant
7	11-40	Susceptible
9	<11	Highly susceptible

Field evaluation for yield potential of the introgression lines: Fifty-two selected high temperature spikelet fertility QTL introgression line under the background of BRRI dhan28 and BRRI dhan29 respectively, along with parents BRRI dhan28 and BRRI dhan29 were evaluated in the field condition. The trial was carried out in the West Byed during Boro season. Each line comprised 25 plants per row × 4 row, therefore a total 100 plants per line were evaluated in the systematic arrangements. Single seedling/hill and 20 cm × 20 cm spacing was maintained. BRRI recommended management practices including fertilizer dose was followed. Days to heading and grain yield data were recorded, yield data were adjusted to 14% moisture content by harvesting whole plot (i.e., 100 plants/hills per line).

Results: A two years phenotyping of *qHTSF4.1* introgression lines under controlled high temperature (>35±3 °C) and high relative humidity (75±5%) condition showed a moderate effect to maintained spikelet fertility. The percent spikelet fertility was ranged from 4.16 to 73.31 with mean and median value is 36.91 and 36.62 respectively. However, under natural conditions percent spikelet fertility of the introgression lines ranged from 12.90 to 96.08 with mean and median value is 75.50 and 84.65 respectively. The recipient and donor parents showed a huge difference 10.81 and 77.70 under high temperature condition but very narrow differences 81.37 and 86.67 under natural conditions respectively (**Fig. 4.3.1**). Yield potential of the introgression lines showed less than the parents if we consider the median values but some introgression lines outperformed than the parents could be selected for regional trial (**Fig. 4.3.2**). Despite the modest effects of this QTL, the introgression of *qHTSF4.1* continued to be mainstreaming to the rice breeding programs for developing heat tolerance.

Conclusion: After two years of phenotyping, the *qHTSF4.1* introgression lines had a median spikelet fertility of 36% under controlled high-temperature and high humidity stress, demonstrating a modest impact of the QTL in the genetic background of BRRI dhan28 and BRRI dhan29. Despite the moderate effects of this QTL, *qHTSF4.1* introgression has continued to be mainstreamed into rice breeding programs improving heat tolerance.

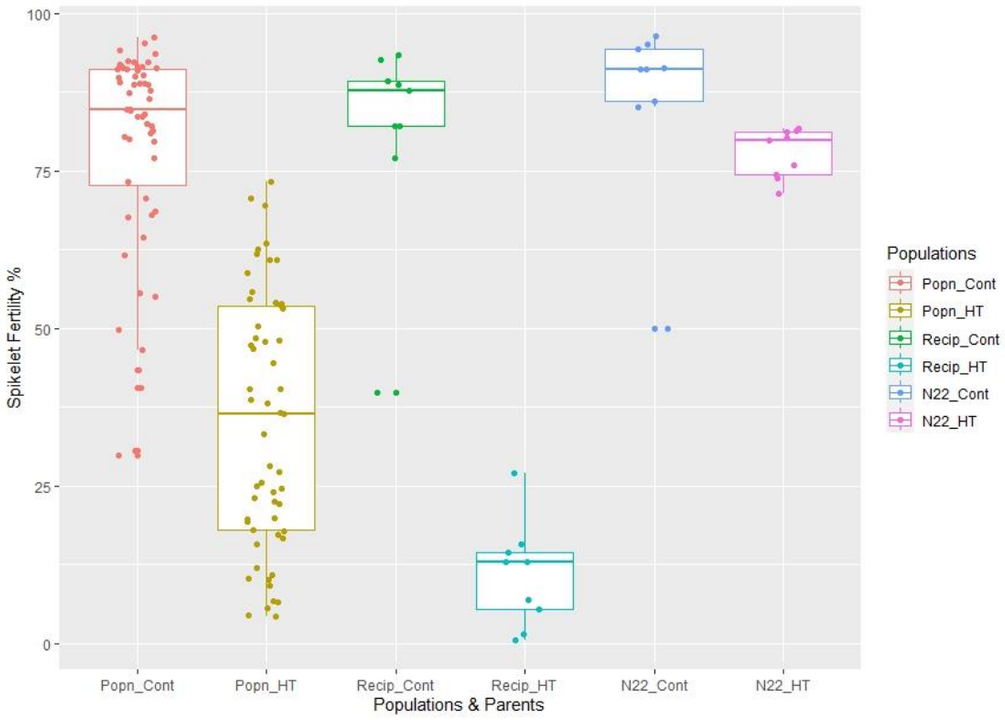

Fig. 4.3.1: Phenotyping of *qHTSF4.1* introgression lines under controlled high temperature and high humidity conditions in the glass house.

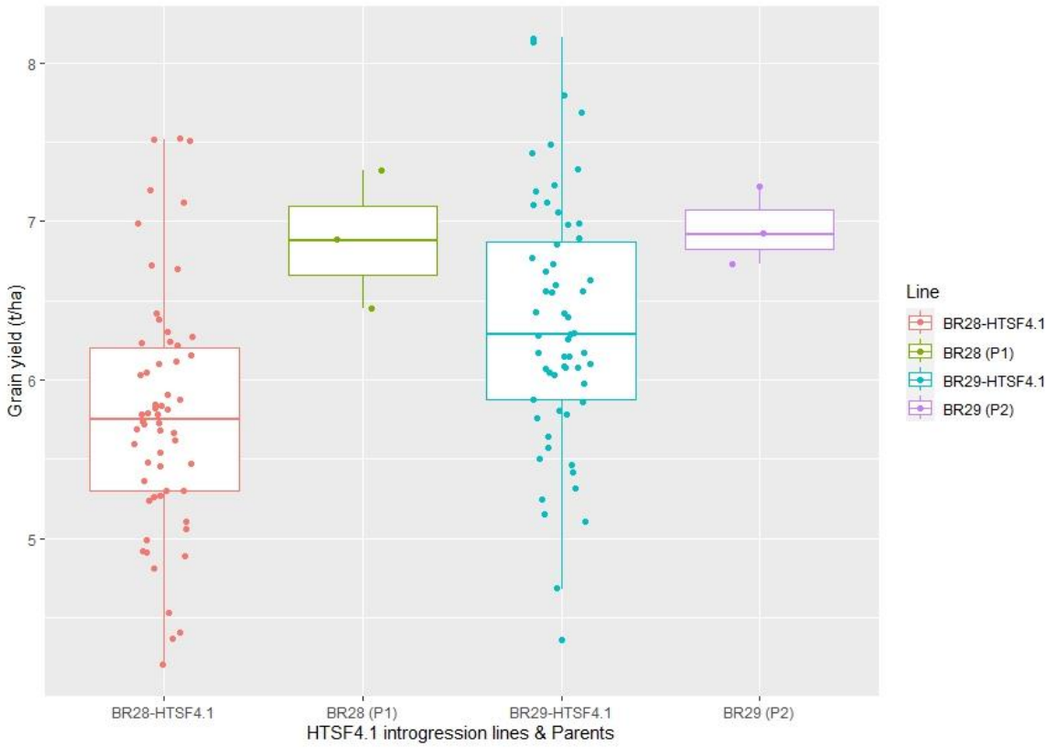

Fig. 4.3.2: Performance of *qHTSF4.1* introgression lines under field conditions.

Expt. 4.4: Marker assisted introgression of high temperature induced spikelet fertility QTL (*qHTSF4.1*) in the background of BRRI dhan48, BRRI dhan62 and BRRI dhan71

[1]Md. Sazzadur Rahman, [1]Md. Hridoy Hussain, [1]Mamunul Hasan, [2]Habibul Bari Shozib and [3]Munnujan Khanam

[1]Plant Physiology Division, [2]Rice Analytical Laboratory, [3]CASR, BRRI

Rationale: High temperature is often one of the most limiting factors affecting plant growth and crop yield in tropical and sub-tropical areas. Reproductive phase in rice is more sensitive to heat

than the vegetative phase. To reduce the effects of temperature-induced sterility, several desirable characteristics have been proposed that may overcome projected yield losses if current varieties are retained. Recently, not only long duration Boro but also late Boro varieties cultivated after potato harvest, early cultivated Aus rice and short duration photo-insensitive T. Aman rice varieties also faces high temperature stress at the flowering stage and induce floret sterility of rice in Bangladesh. An increase in the concentration of greenhouse gases, such as carbon dioxide and others, in the atmosphere is thought to have been responsible for increasing the air temperature. Amongst other things, global warming is expected to result in the occurrence of high temperature-induced floret sterility in rice. Selection of tolerant breeding lines from current breeding materials is necessary for the development of new high temperature tolerant variety with high yield potential. The potential of genetic variability exists in the current genetic resources for resistance to heat stress could be explored to screen rice germplasm with heat tolerance for developing current well-adapted varieties for future warmer climates. To facilitate breeding for heat-tolerant rice varieties, in addition to introgression into Boro varieties (BRRI dhan28 and 29) new research for introgression of *qHTSF4.1* into Aus and T. Aman (short duration) lines started.

Materials and methods: BRRI dhan48 (Aus), BRRI dhan62 (T. Aman) and BRRI dhan71 (T. Aman) were targeted to introgression of *qHTSF4.1*. A total of 36, 17 and 7 BC_1F_1 progenies of BRRI dhan48, 62 and 71 respectively, were planted in field condition. During tillering stage leaves were collected for DNA isolation and subsequent genotyping through InDel marker R4M30. In addition to the PCR based InDel (Insertion-Deletion) and CAPS (Cleaved Amplified Polymorphic Sequences) marker combination, KASP (Kompetitive Allele Specific PCR) genotyping technique was used to track and transfer *qHTSF4.1* into the breeding populations.

Results: A total of 36, 17, 7 BC_1F_1 progenies of BRRI dhna48, BRRI dhan62, and BRRI dhan71 were genotyped. Among the tested progenies, 8 from BRRI dhan48 were shown to be heterozygous by using R4M30 (Insertion/Deletion marker) (**Fig. 4.4.1**), but extra one progeny was discovered when using KASP (Kompetitive Allele Specific PCR) technique. However, progenies of BRRI dhan62 exhibited monomorphism for InDel R4M30 (**Fig. 4.4.1**), although KASP revealed polymorphism and identified ten of them as heterozygous (**Fig. 4.4.2**). Again, five of the BRRI dhan71 progenies were identified as heterozygous by R4M30; however, when the seven progenies were tested by KASP, all possessed the N22 alleles in homozygous, indicating that *qHTSF4.1* was inherently carried by the BRRI dhan71 (**Fig. 4.4.2**). Based on this information, the KASP technique appears to be a promising genotyping tool for breeding programs.

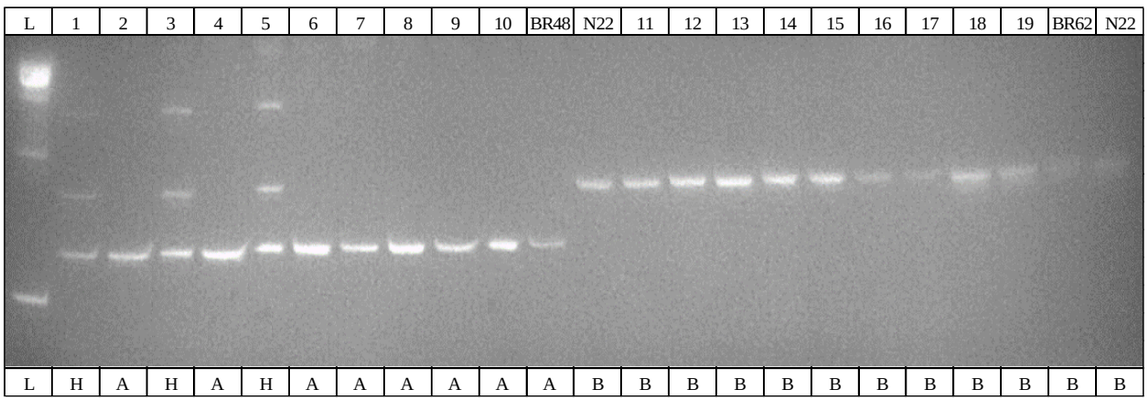

Fig 4.4.1: PAGE (8%) representing heterozygous (H), recipient (A) and donor (B) alleles segregating at BC_1F_1 of BRRI dhan48/N22 population from SL 1-10, recipient parent (BR48) and donor N22; BRRI dhan62/N22 population from SL 11-19, recipient parent (BR62) and donor (N22) using InDel marker R4M30. L represents' ladder.

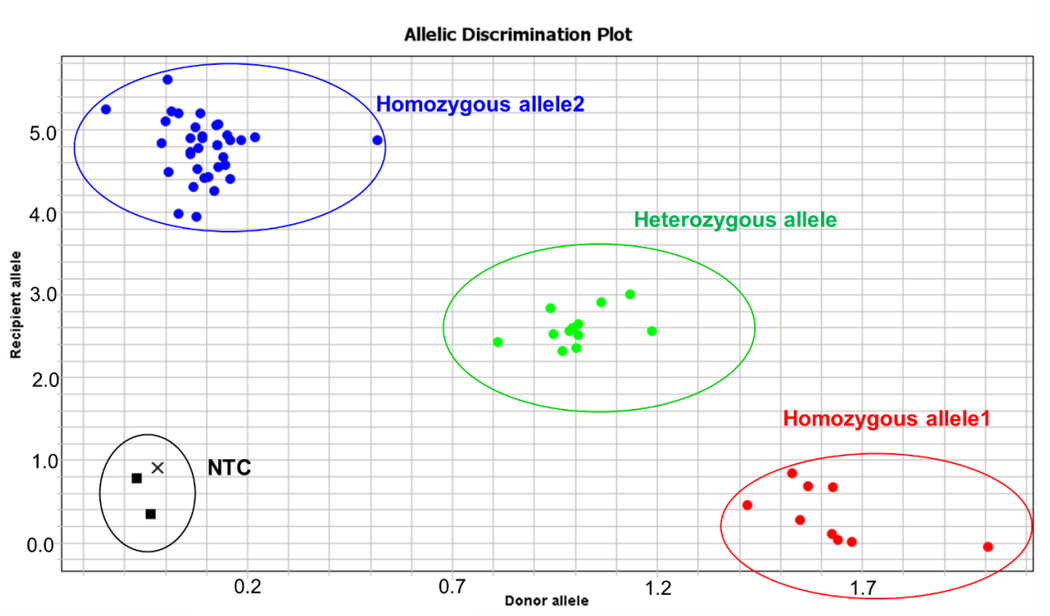

Fig 4.4.2: Allelic Discrimination Plot of KASP genotyping for the backcross populations derived from recipient parent BRRI dhan48, BRRI dhan62, BRRI dhan71 with donor N22.

Conclusion: KASP genotyping is advantageous over the combination of InDel and CAPS considering introgression of *qHTSF4.1* into diverse genetic background. Being a drought-tolerant variety, BRRI dhan71 inherently carried *qHTSF4.1*.

PROJECT 5: COLD TOLERANCE

Expt. 5.1: Screening of rice germplasms for seedling stage cold tolerance

[1]Mst. Salma Pervin, [1]Salma Akter, [1]Tamanna Sultana, and [2]M S U Ahmed
[1]Plant Physiology Division, [2]GRS Division

Introduction: Screening for cold tolerance ability at seedling stage of local germplasm is very essential to identify short duration cold tolerant rice varieties. Bangladesh is a land of rice and it has a lot of rice germplasm which may have many valuable traits. Generally, local rice germplasm is highly adapted to adverse environment and also have varying levels of resistance to biotic and abiotic stresses. Development of cold tolerant rice variety largely depends on using suitable cold tolerant doner parents in breeding programs. So, we have to find out new sources of donors and tolerant lines with more specific traits which might contribute to produce new cold tolerant variety. Leaf discoloration score is the most common method of screening for cold tolerance at seedling stage. In this experiment, SES score on the basis of leaf discoloration was considered as the parameter for the estimation of cold tolerance.

Objective: Identification of cold tolerant rice germplasm at seedling stage

Materials and method: Some 300 BRRI Genebank germplasm along with four check varieties namely BRRI dhan28, BRRI dhan36, Vutan and HbjB.VI were tested for seedling stage cold tolerance in cold water tanks at artificial condition (**Table 5.1.1**). Seeds were sown in plastic trays (6°Cm length x 30 cm breadth x 2.5 cm height) filled with gravels and crop residue free granular soil. Seeds of twenty entries along with four check varieties were sown in each tray. Twenty-five to thirty seeds of each entry were sown in single row. Each tray contained 20 genotypes and four checks at the end. Seedlings were allowed to grow until three leaf stage which required about 10 days to 13 days at ambient temperature. The plastic trays were then placed into cold water tanks. A total of six trays were placed in each tank. The experiment was designed in RCBD with two replications. The cold-water tanks were adjusted to constant temperature at 13°C. The depth of water in the tank was maintained at 5 cm. Leaf discoloration score was recorded at 6 days after cold water treatment using the scale of 1 to 9, when

susceptible cheek BRRI dhan28 died and scored 9. Recovery ability of rice seedlings after two weeks of releasing from cold water tank was also recorded.

Scale for cold tolerance according to SES

1 Seedlings dark green
3 Seedlings light green
5 Seedlings yellow
7 Seedlings brown
9 Seedlings dead

Results: Scoring was done when susceptible cheek BRRI dhan28 died and scored 9 using the scale of 1 to 9. Among the tested rice genotypes, BRRI Genebank Acc. Number 2833 and 2836 showed cold tolerant having the SES score 3 and 28 BRRI Genebank germplasm showed moderately cold tolerant at seedling stage having the SES score 5. Rest of the genotypes were susceptible to highly susceptible. The tolerant check Vutan and HbjB.VI scored 3 and BRRI dhan36 scored 5 (**Table 5.1.1 & Fig. 5.1.1**). The selected BRRI Genebank Acc. number are 2776, 2777, 2778, 2783, 2826, 2828, 2829, 2832, 2833, 2834, 2835, 2836 2837, 2843, 2844, 2847, 2855, 2860, 2867, 2868, 2869, 2875, 2884, 2919, 2922, 2971, 2973, 2987, 2991, 2998.

Table 5.1.1: Cold tolerance score of tested genotypes

Sl. No.	Acc. No.	SES Score	Sl. No.	Acc. No.	SES Score	Sl. No.	Acc. No.	SES Score
1	2776	5	42	2817	7	83	2858	7
2	2777	5	43	2818	9	84	2859	9
3	2778	5	44	2819	7	85	2860	5
4	2779	7	45	2820	7	86	2861	7
5	2780	9	46	2821	7	87	2862	9
6	2781	9	47	2822	7	88	2863	7
7	2782	9	48	2823	9	89	2864	9
8	2783	5	49	2824	7	90	2865	9
9	2784	9	50	2825	7	91	2866	7
10	2785	9	51	2826	5	92	2867	5
11	2786	9	52	2827	7	93	2868	5
12	2787	7	53	2828	5	94	2869	5
13	2788	9	54	2829	5	95	2870	7
14	2789	9	55	2830	7	96	2871	7
15	2790	9	56	2831	7	97	2872	7
16	2791	9	57	2832	5	98	2873	7
17	2792	9	58	2833	3	99	2874	9
18	2793	7	59	2834	5	100	2875	5
19	2794	7	60	2835	5	101	2876	7
20	2795	9	61	2836	3	102	2877	7
21	2796	7	62	2837	5	103	2878	7
22	2797	9	63	2838	7	104	2879	7
23	2798	9	64	2839	7	105	2880	7
24	2799	9	65	2840	7	106	2881	9
25	2800	9	66	2841	7	107	2882	9
26	2801	9	67	2842	7	108	2883	9
27	2802	9	68	2843	5	109	2884	5
28	2803	9	69	2844	5	110	2885	9
29	2804	7	70	2845	7	111	2886	9
30	2805	7	71	2846	7	112	2887	7
31	2806	7	72	2847	5	113	2888	9
32	2807	9	73	2848	7	114	2883	9
33	2808	7	74	2849	7	115	2890	9
34	2809	7	75	2850	7	116	2891	9
35	2810	7	76	2851	7	117	2892	7
36	2811	9	77	2852	7	118	2893	7
37	2812	9	78	2853	9	119	2894	9
38	2813	9	79	2854	9	120	2895	9
39	2814	7	80	2855	5	121	2896	9
40	2815	9	81	2856	7	122	2897	9
41	2816	9	82	2857	9	123	2898	9

Sl. No.	Acc. No.	SES Score	Sl. No.	Acc. No.	SES Score	Sl. No.	Acc. No.	SES Score
124	2899	9	182	2961	7	241	3020	9
125	2900	9	183	2962	7	242	3021	9
126	2901	9	184	2963	9	243	3022	9
127	2902	9	185	2964	7	244	3023	9
128	2903	9	186	2965	7	245	3024	9
129	2904	9	187	2966	9	246	3025	9
130	2905	9	188	2967	7	247	3026	9
131	2906	9	189	2968	7	248	3027	9
132	2907	9	190	2969	7	249	3028	9
133	2908	9	191	2970	7	250	3029	9
134	2909	9	192	2971	5	251	3030	9
135	2910	7	193	2972	7	252	3031	9
136	2911	7	194	2973	5	253	3032	9
137	2912	7	195	2974	7	254	3033	9
138	2913	9	196	2975	7	255	3034	9
139	2914	9	197	2976	9	256	3035	9
140	2915	9	198	2977	9	257	3036	9
141	2916	9	199	2978	9	258	3037	9
142	2917	7	200	2979	9	259	3038	9
143	2918	9	201	2980	9	260	3039	9
144	2919	5	202	2981	9	261	3040	9
145	2920	7	203	2982	9	262	3041	9
146	2921	9	204	2983	9	263	3042	9
147	2922	5	205	2984	9	264	3043	7
148	2923	9	206	2985	9	265	3044	7
149	2924	9	207	2986	9	266	3045	9
150	2925	7	208	2987	5	267	3046	9
151	2926	9	209	2988	7	268	3047	9
152	2927	7	210	2989	7	269	3048	7
153	2928	7	211	2990	7	270	3049	7
154	2929	7	212	2991	5	271	3050	7
155	2930	7	213	2992	9	272	3051	9
156	2931	9	214	2993	9	273	3052	9
157	2932	7	215	2994	9	274	3053	9
158	2933	7	216	2995	9	275	3054	9
159	2934	7	217	2996	9	276	3055	9
160	2935	7	218	2997	9	277	3056	9
161	2936	7	219	2998	5	278	3057	9
162	2937	7	220	2999	7	279	3058	9
163	2938	7	221	3000	9	280	3059	9
164	2939	9	222	3001	9	281	3060	9
165	2940	7	223	3002	9	282	3061	9
166	2941	7	224	3003	9	283	3062	9
167	2944	9	225	3004	9	284	3063	9
168	2946	9	226	3005	9	285	3064	9
169	2948	9	227	3006	9	286	3065	9
170	2949	7	228	3007	9	287	3066	9
171	2950	7	229	3008	9	288	3067	9
172	2951	9	230	3009	9	289	3068	9
173	2952	7	231	3010	9	290	3069	9
174	2953	7	232	3011	9	291	3070	9
175	2954	9	233	3012	9	292	3071	9
176	2955	9	234	3013	9	293	3072	9
177	2956	9	235	3014	9	294	3073	9
178	2957	7	236	3015	9	295	3074	9
179	2958	7	237	3016	9	296	3075	9
180	2959	9	239	3018	9	297	3076	9
181	2960	9	240	3019	9	298	3077	9

Sl. No.	Acc. No.	SES Score	Sl. No.	Acc. No.	SES Score	Sl. No.	Acc. No.	SES Score
299	3078	9	301	BRRI dhan28 (Sus ck)	9	303	Vutan (Tol ck)	3
300	3079	9	302	BRRI dhan36 (ck)	5	304	HbjB.VI (Tol ck)	3

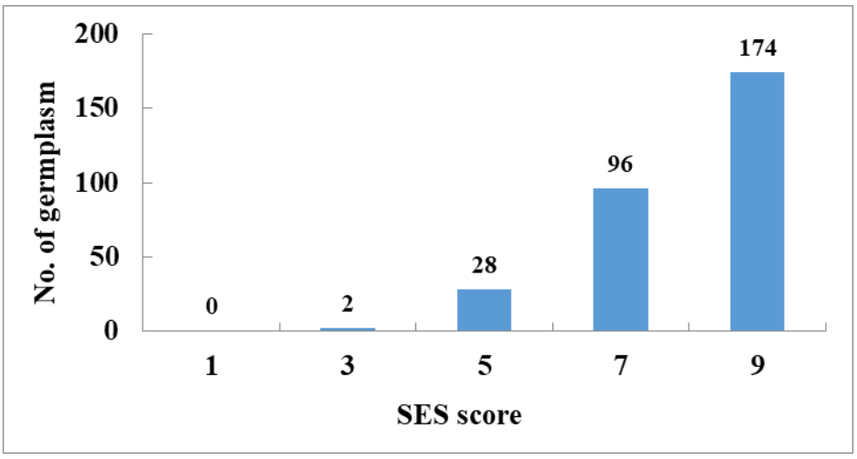

Fig. 5.1.1: Frequency distribution of SES score for seedling stage cold tolerance of 300 rice germplasm.

Expt. 5.2: Screening of rice genotypes (advanced breeding lines and land races) for seedling stage cold tolerance

[1]Mst. Salma Pervin, [1]M Mamunur Rashid, [1]Salma Akter and [2]Partha S Biswas
[1]Plant Physiology Division, [2]Plant Breeding Division

Introduction: We expect a variety with cold tolerance during its both vegetative and reproductive stages for Rangpur region of Bangladeh. While we need a variety with short growth duration and cold tolerance during its reproductive phase for Haor area of Sylhet region of the country. Screening for cold tolerance ability at seedling stage of advanced breeding lines is very essential task to identify short duration cold tolerant lines. Besides this, identification of donor parent also important for hybridization program.

Visual characteristics as yellowing and wilting of leaves are related to cold stress at the seedling stage. Tolerance to cold can be evaluated by scoring chilling injury and low temperature chlorosis at this stage. The degree of leaf withering is also used as a criterion for scoring chilling injury. However, leaf discoloration score is the most common method of screening for cold tolerance at seedling stage. Cold tolerance at the seedling stage has also been evaluated by determining survival percentages, because susceptible seedlings have problems in maintaining normal metabolic rates under cold and eventually die. In this experiment, SES score on the basis of leaf discoloration and survival percentages after two weeks of releasing from cold water tank was considered as the parameters for the estimation of cold tolerance.

Objective: Identification of cold tolerant advanced breeding lines as well as donor parent at seedling stage.

Materials and method: Some total 1563 genotypes including 1513 advanced breeding lines and 50 land races collected from Haor areas along with four check varieties namely BRRI dhan28, BRRI dhan36, Vutan and HbjB-VI were tested for seedling stage cold tolerance in cold water tanks at artificial condition. Seeds were sown in plastic trays (6°Cm length x 30 cm breadth x 2.5 cm height) filled with gravels and crop residue free granular soil. Seeds of twenty entries along with four check varieties were sown in each tray. Twenty-five to thirty seeds of each entry were

sown in single row. Each tray contained 20 genotypes and four checks at the end. Seedlings were allowed to grow until 3 leaf stage which required about 10 to 14 days at ambient temperature. The plastic trays were then placed into cold water tanks. A total of six trays were placed in each tank. The cold-water tanks were adjusted to constant temperature at 13°C. The depth of water in the tank was maintained at 5 cm. Leaf discoloration score was recorded at 6 days after cold water treatment using the scale of 1 to 9, when susceptible cheek BRRI dhan28 died and scored 9. Recovery ability of rice seedlings after two weeks of releasing from cold water tank was also recorded.

Scale for cold tolerance according to SES

1 Dark green seedlings
3 Light green seedlings
5 Yellow seedlings
7 Brown seedlings
9 All seedlings apparently dead

Results: Among the tested genotypes 3 advanced breeding lines BR12552-3R-179, BR12552-3R-199 and BR11337-5R-29 from favorable Boro and cold tolerant rice showed more than 80% survivability having the SES score 1. However, some total of 695 genotypes have a survivability rate ranging from 50 to 70%. From these lines 191 advanced breeding lines and 9 germplasm with SES score 3 and survivability >50% were selected as cold tolerant at seedling stage **(Table 5.2.1).** Moreover, 472 advanced breeding lines and 23 germplasm with SES score 5 and survivability ≥50% were selected as moderately cold tolerant. The check variety BRRI dhan36 and HbjB-vi have the SES score 3. Rest 653 genotypes were susceptible to highly susceptible with SES score 7 and 9 respectively (**Fig. 5.2.1**). It is notable that 212 genotypes did not germinate.

Table 5.2.1: List genotypes having the SES score 1 and 3

SL. No.	Designation	SL. No.	Designation	SL. No.	Designation
1	BR12552-3R-179	31	BR13027-BC1-3R-152	61	BR11663(14A2)-5-28
2	BR12552-3R-199	32	BR13027-BC1-3R-161	62	BR11894-R-R-R-R-293
3	BR11337-5R-29	33	BR13027-BC1-3R-171	63	BR11894-R-R-R-R-328
4	BR13026-BC1-3R-115	34	BR13027-BC1-3R-173	64	BR11894-R-R-R-R-146
5	BR13026-BC1-3R-172	35	BR13027-BC1-3R-179	65	BR11894-R-R-R-R-193
6	BR13026-BC1-3R-175	36	BR13027-BC1-3R-187	66	BR11662-14-2-3
7	BR13026-BC1-3R-179	37	BR13027-BC1-3R-196	67	BR11894-R-R-R-R-125
8	BR13026-BC1-3R-180	38	BR13027-BC1-3R-2	68	BR11663(132A3)-17-12
9	BR13026-BC1-3R-182	39	BR13027-BC1-3R-219	69	BR11894-R-R-R-R-60
10	BR13026-BC1-3R-184	40	BR13027-BC1-3R-24	70	BR11894-R-R-R-R-95
11	BR13026-BC1-3R-188	41	BR13027-BC1-3R-41	71	BR11894-R-R-R-R-165
12	BR13026-BC1-3R-197	42	BR13027-BC1-3R-43	72	BR11894-R-R-R-R-102
13	BR13026-BC1-3R-202	43	BR13027-BC1-3R-44	73	BR11894-R-R-R-R-164
14	BR13026-BC1-3R-208	44	BR13027-BC1-3R-45	74	BR11663(14A2)-1-26
15	BR13026-BC1-3R-40	45	BR13027-BC1-3R-58	75	BR11894-R-R-R-R-272
16	BR13026-BC1-3R-5	46	BR13027-BC1-3R-59	76	BR11894-R-R-R-R-228
17	BR13026-BC1-3R-58	47	BR13027-BC1-3R-65	77	BR11894-R-R-R-R-207
18	BR13026-BC1-3R-75	48	BR13027-BC1-3R-69	78	BR11894-R-R-R-R-133
19	BR13026-BC1-3R-80	49	BR13027-BC1-3R-7	79	BR11894-R-R-R-R-132
20	BR13026-BC1-3R-86	50	BR13027-BC1-3R-70	80	BR11894-R-R-R-R-121
21	BR13026-BC1-3R-93	51	BR13027-BC1-3R-71	81	BR11894-R-R-R-R-319
22	BR13026-BC1-3R-98	52	BR13027-BC1-3R-76	82	BR11894-R-R-R-R-143
23	BR13027-BC1-3R-102	53	BR13027-BC1-3R-82	83	BR11894-R-R-R-R-262
24	BR13027-BC1-3R-11	54	BR13027-BC1-3R-85	84	BR11894-R-R-R-R-34
25	BR13027-BC1-3R-112	55	BR13027-BC1-3R-93	85	BR11894-R-R-R-R-75
26	BR13027-BC1-3R-127	56	BR13026-BC1-3R-46	86	BR11894-R-R-R-R-131
27	BR13027-BC1-3R-130	57	BR11894-R-R-R-R-80	87	BR11663(132A3)-11-2
28	BR13027-BC1-3R-132	58	BR11894-R-R-R-R-243	88	BR11663(132A3)-6-12
29	BR13027-BC1-3R-133	59	BR11894-R-R-R-R-267	89	BR11894-R-R-R-R-149
30	BR13027-BC1-3R-145	60	BR11894-R-R-R-R-109	90	BR11663(132A3)-29-17

SL. No.	Designation	SL. No.	Designation	SL. No.	Designation
91	BR11894-R-R-R-R-300	129	BR12552-3R-155	167	BR12570-5R-112-3
92	BR11894-R-R-R-R-260	130	BR12552-3R-158	168	BR12570-5R-117-3
93	BR11894-R-R-R-R-29	131	BR12552-3R-159	169	BR12570-5R-118
94	BR11894-R-R-R-R-264	132	BR12552-3R-161	170	BR12570-5R-118-2
95	BR11894-R-R-R-R-248	133	BR12552-3R-164	171	BR12570-5R-120-1
96	BR11663(132A3)-21-4	134	BR12552-3R-170	172	BR12570-5R-12-1
97	BR11894-R-R-R-R-199	135	BR12552-3R-172	173	BR12570-5R-128-3
98	BR11663(132A3)-29-25	136	BR12552-3R-174	174	BR12570-5R-156-2
99	BR11894-R-R-R-R-316	137	BR12552-3R-175	175	BR12570-5R-166-2
100	BR11894-R-R-R-R-284	138	BR12552-3R-177	176	BR12570-5R-203-3
101	BR11894-R-R-R-R-16	139	BR12552-3R-178	177	BR12570-5R-204-3
102	BR11894-R-R-R-R-10	140	BR12552-3R-196	178	BR12570-5R-38-2
103	BR11894-R-R-R-R-307	141	BR12552-3R-20	179	IR83222-F11-173
104	BR11894-R-R-R-R-185	142	BR12552-3R-203	180	BR11318-5R-63
105	BR11894-R-R-R-R-84	143	BR12552-3R-208	181	BR11318-5R-148
106	BR12421-4R-229	144	BR12552-3R-215	182	IR17A1694
107	BR12421-4R-43	145	BR12552-3R-221	183	IR17A1723
108	BR12421-4R-82	146	BR12552-3R-223	184	IR17A1735
109	BR12552-3R-1	147	BR12552-3R-23	185	BR11338-5R-104
110	BR12552-3R-10	148	BR12552-3R-236	186	BR11338-5R-22
111	BR12552-3R-101	149	BR12552-3R-24	187	BR11338-5R-43
112	BR12552-3R-110	150	BR12552-3R-240	188	BR11338-5R-73
113	BR12552-3R-111	151	BR12552-3R-27	189	BR11338-5R-75
114	BR12552-3R-115	152	BR12552-3R-29	190	BR11894-R-R-R-R-410
115	BR12552-3R-116	153	BR12552-3R-34	191	BR11894-R-R-R-R-420
116	BR12552-3R-118	154	BR12552-3R-37	192	Shanir Haor2
117	BR12552-3R-12	155	BR12552-3R-42	193	Shanir Haor6
118	BR12552-3R-125	156	BR12552-3R-56	194	Korchar Haor3
119	BR12552-3R-133	157	BR12552-3R-57	195	Korchar Haor6
120	BR12552-3R-14	158	BR12552-3R-70	196	Korchar Haor10
121	BR12552-3R-142	159	BR12552-3R-75	197	Rongila tepi
122	BR12552-3R-146-	160	BR12552-3R-8	198	Gochi
123	BR12552-3R-147	161	BR12552-3R-88	199	Paura
124	BR12552-3R-15	162	BR12552-3R-89	200	Kali boro
125	BR12552-3R-150	163	BR12552-3R-96	201	BRRI dhan36
126	BR12552-3R-151	164	BR12570-5R-107-3	202	HbjB-vi
127	BR12552-3R-152	165	BR12570-5R-110-2		
128	BR12552-3R-154	166	BR12570-5R-110-3		

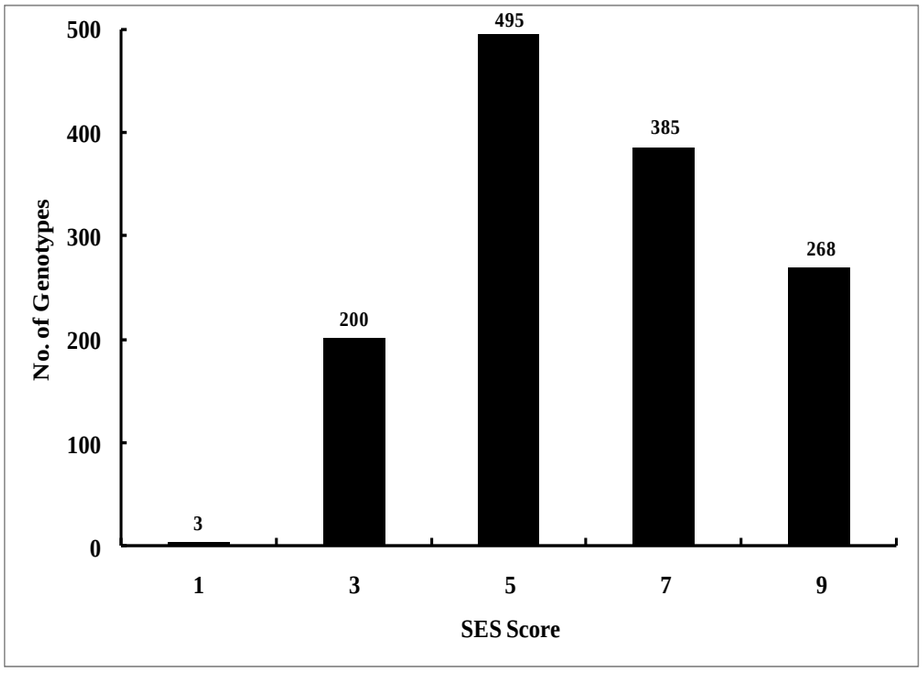

Fig. 5.2.1: Frequency distribution of SES score for seedling stage cold tolerance of 1563 rice genotypes.

Conclusion: A total of 200 (191lines + 9 germplasm) genotypes were selected from 1563 were found cold tolerant at seedling stage. Further investigation is needed both at natural and artificial cold condition to confirm these results.

Expt. 5.3: Evaluation of breeding lines for reproductive stage cold tolerance

[1]Mst. Salma Pervin, [1]Salma Akter and [2]Partha S Biswas
[1]Plant Physiology Division, [2]Plant Breeding Division

Introduction: Cold injury of dry season irrigated Boro rice is a common problem for many areas in Bangladesh. Low temperatures at reproductive stages of rice plants cause spikelet sterility and ultimately cause yield loss. It is a major problem in early planted Boro rice. Farmers of Haor areas of Bangladesh have to transplant Boro rice seedlings earlier to utilize recession of residual flood water and also to avoid flash flood at the maturity. But the early transplanted Boro rice has every probability to face low temperature at the reproductive phase. So, development of short duration and reproductive stage cold tolerant rice variety is urgent need to mitigate flash flood damage in Haor areas of Bangladesh.

Objective: To identify short duration and cold tolerant lines through characterization and evaluation of some advanced breeding lines of rice.

Materials and methods: Some 8 advanced breeding lines and 3 local land races along with BRRI dhan28, BRRI dhan67, and BRRI dhan89 as check varieties were evaluated in natural field condition. There were two seeding times 24 October and 01 November. Thirty-day-old seedlings were transplanted in main field. Early planting was done with a view to falling rice reproductive phase at cold stress. Cold tolerance of rice genotypes was measured visually based on growth and leaf discoloration score at vegetative phase. For reproductive phase cold tolerance, we mainly focus on spikelet sterility. However, data on date of flowering and maturity, plant height, panicle per hill, panicle length, last internode length, last leaf sheath length, panicle degeneration and exertion, filled and unfilled grain per panicle, grain yield and yield components were recorded for better understanding of cold tolerance of specific rice genotypes. Changes in different parameters of rice in early planted set due to natural cold temperature were compared with normal planting set last year. This year we observed the degree of performance of these genotypes at early planting. During the experimental period, the maximum, minimum and mean temperature was recorded.

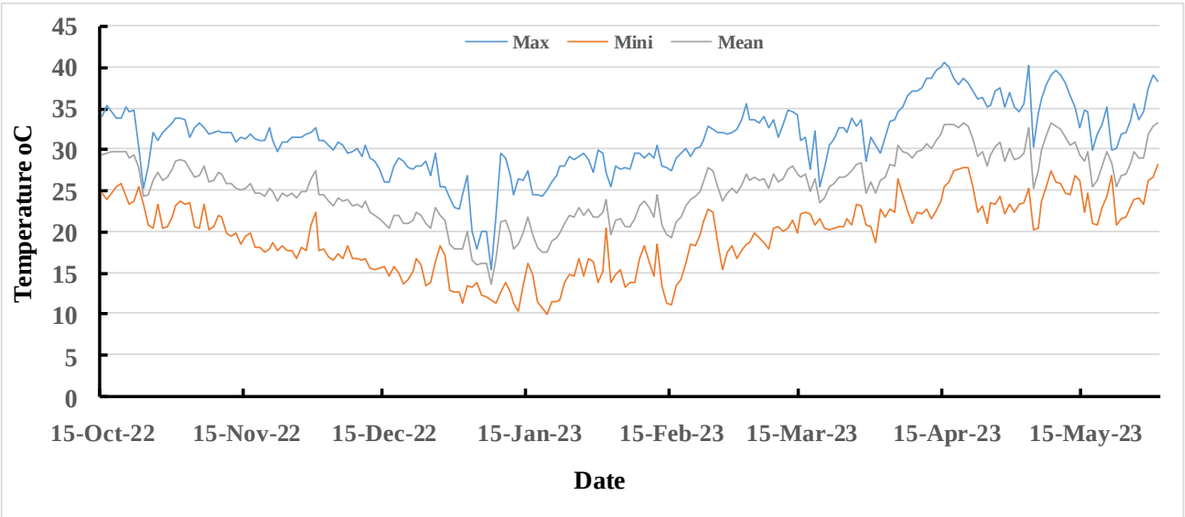

Fig. 5.3.1. Temperature status of Gazipur during the Experimental period (Oct 2022 to May 2023).

Weather report: The maximum, minimum and mean temperature during the experimental period is presented in Fig. 5.3.1. In first set of 24 October seeding, reproductive phase of different rice genotypes started from 2nd week of January to 3rd week of February when the daily

mean temperature was below critical level (20 ºC) of rice with some exception. It varied from 16.7 to 24.8 ºC. From mid-February the maximum temperature was above 30 ºC. However, the minimum temperature during reproductive phase was 11.6 to 20.4 ºC. Panicle initiation of short duration genotypes start from 2nd week of January while it starts at mid-February and 3rd week of February for medium and long duration rice genotypes, respectively. As a result, all the rice genotypes of 1st set experienced some cold stress at reproductive phase. But short duration rice genotypes affected more than other genotypes. The long duration rice genotypes had to experience less cold stress at reproductive phase. Flowering of these genotypes started from 2nd week of February to 1st week of March when the minimum temperature varied from 11.2 to 22.8 ºC and mean temperature varied from 19.3 to 27.8 ºC. The maximum, minimum and mean temperature ranged from 26.0 to 34.8 ºC, 11.2 to 22.8 ºC and 16.7 to 27.1 ºC in PI to flowering stage (2nd week of January to 2nd week of March) respectively. In second set of 01 November seeding, panicle initiation stage of different rice genotypes starts from 16 January to 10 February when average temperature was below critical level only 5 days. So, the genotypes experienced very little cold stress at reproductive phase in second set.

Results:

Growth characteristics: Early planted sets of both the sowing dates (24 October and 01 November) caused longer growth duration for all rice genotypes. In 24 October sowing, it varied from 159.0 to 172.0 days and in 01 November sowing it was 156.0 to 166.0 days. It was lowest in BR11894-R- R-R-R- 329 when sowing was done on01 November. However, growth durations of all rice genotypes were significantly higher when they were sown on 24 October than 01 November sowing and it ranged from 3.7 to 9.0 days (**Table 5.3.1**). Irrespective of seeding date short plant was observed in both the seeding date. Plant height of all rice genotypes reduced in 24 October compared to 01 November sowing. The advanced breeding line IR18A1859 had the lowest plant height (69.3 cm) at 24 October seeding. The check variety BRRI dhan67 showed the highest plant height in both the seeding date although significant reduction was found in 1st seeding compared to 2nd seeding. Similar observation was also observed in BR11894-R-R-R-R-105. The plant height of advanced breeding line BR11894-R-R-R-R-169, BR11894-R- R-R-R-329, BRRI dhan28 and BRRI dhan89 was statistically similar in both the seeding date. Other tested genotypes had lower plant height than check varieties BRRI dhan67. Less plant height reduction indicating the vegetative stage cold tolerance due to better vegetative growth (**Table 5.3.1**). Scoring for phenotypic acceptability was done at hard dough stage. Among the tested genotypes, BR11894-R-R-R-R-169 scored 1.6 and 3.0 in 24 October and 01 November sowing respectively. The advanced line BR11894-R- R-R-R- 329 showed fair to good having the score 3.0 to 5.0. The check varieties BRRI dhan67 showed 3.0 to 3.6 score and BRRI dhan89 showed 3.6 to 5.0 score (**Table 5.3.1**).

Table 5.3.1: Growth duration, plant height, and PAcp of tested genotypes

Genotypes	**Growth duration (days)**		**Plant height (cm)**		**PAcp**	
	24 Oct	**01 Nov**	**24 Oct**	**01 Nov**	**24 Oct**	**01 Nov**
BR11894-R-R-R-R-105	172.0	165.0	82.2	92.3	7.0	5.0
BR11894-R-R-R-R-169	169.3	164.0	87.6	88.7	3.0	3.0
BR11894-R- R-R-R- 329	165.0	156.0	77.4	80.9	3.0	5.0
BR11894-R-228	159.0	-	78.4	-	5.0	-
BR11646-5R-388	160.0	-	73.4	-	4.7	-
IR18A1859	163.0	-	69.3	-	7	-
BR11894-R-R-R-R-110	-	164.0	-	89.2	-	5.0
BRRI dhan69-phy1	-	166.0	-	95.9	-	5.6
Zira	-	166.0	-	86.2	-	5.6
Khatobabu	-	164.0	-	81.0	-	5.6
Shubollata	-	164.0	-	92.7	-	3.6
BRRI dhan28 (ck)	161.6	156.5	80.4	81.4	5.3	6.6
BRRI dhan67 (ck)	167.0	163.7	88.5	99.3	3.6	3.0
BRRI dhan89 (ck)	169.0	163.3	82.2	82.1	5	3.6
LSD (5%)	3.2		9.3		2.2	
CV (%)	1.2		6.6		26.7	

Panicle exertion: Cold stress in early planting caused reduction of last leaf sheath and last internode length in all rice genotypes. In 24 October sowing, last internode length was larger than last leaf sheath length in BR11894-R-R-R-R-169 and BR11894-R- R-R-R- 329. So that panicle could exerted fully and scored 3 while in other genotypes last internode length was smaller or more or less equal to last leaf sheath length. As a result panicle could not exerted properly and scored 5 to 9. In 01 November sowing, both last leaf sheath and last internode length was larger than that of 24 October sowing. The advanced lines BR11894-R-R-R-R-169, BR11894-R- R-R-R- 329 and BRRI dhan67 had complete panicle exertion and scored 1. The panicle exertion of local land race Shubollata was moderately well having the score 3. Others scored 5 where panicle just exerted (**Table 5.3.2**). Under normal condition the last internode length was higher than last leaf sheath length or more or less equal which contributed to the exertion of panicle fully while under stress condition last internode length was smaller than last leaf sheath length (**Table 5.3.2**). So that panicle could not exert fully in some genotypes.

Table 5.3.2: Last leaf sheath, internode length and panicle exertion Score of tested genotypes

Genotypes	**24 Oct**		**01 Nov**		**Panicle exertion Score**	
	Last leaf sheath length (cm)	**Last internode length (cm)**	**Last leaf sheath length (cm)**	**Last internode length (cm)**	**24 Oct**	**01 Nov**
BR11894-R-R-R-R-105	28.0	27.3	29.9	27.8	5.0	5.0
BR11894-R-R-R-R-169	27.8	30.3	30.0	34.6	3.0	1.0
BR11894-R- R-R-R-329	26.1	28.5	29.7	32.5	3.0	1.0
BR11894-R-228	24.8	26.2	-	-	5.0	-
BR11646-5R-388	28.0	25.9	-	-	7.0	-
IR18A1859	25.0	23.3	-	-	9.0	-
BR11894-R-R-R-R-110	-	-	31.2	29.7	-	5.0
BRRI dhan69-phy1	-	-	30.1	27.7	-	5.0
Zira	-	-	28.0	26.0	-	5.0
Khatobabu	-	-	28.3	25.5	-	5.0
Shubollata	-	-	28.1	29.3	-	3.0
BRRI dhan28 (ck)	27.4	26.1	29.6	26.8	7.0	5.0
BRRI dhan67 (ck)	31.1	30.2	31.0	38.5	5.0	1.0
BRRI dhan89 (ck)	29.2	28.7	31.2	26.4	5.0	5.0
LSD (5%)	1.9	6.0	1.9	6.0	1.1	
CV (%)	4.1	13.0	4.1	13.0	13.2	

Table 5.3.3: Grain yield, yield components and spikelet sterility of tested genotypes

Genotypes	**Yield (t/ha)**		**Panicle/hill (no.)**		**Filled grain/panicle (no.)**		**1000 grain wt. (g)**		**Sterility (%)**	
	24 Oct	**01 Nov**	**24 Oct**	**01 Nov**	**24 Oct**	**01 Nov**	**24 Oct**	**01 Nov**	**24 Oct**	**01 Nov**
BR11894-R-R-R-R-105	5.10	5.35	15.7	11.2	102.9	134.9	22.9	23.1	28.5	13.1
BR11894-R-R-R-R-169	4.69	7.13	13.9	12.9	102.9	124.4	24.0	22.1	21.0	17.6
BR11894-R-R-R-R- 329	5.20	5.63	18.7	13.1	84.1	101.7	24.0	24.3	33.9	19.7
BR11894-R-228	4.49	-	15.7	-	89.0	-	23.9	-	16.2	-
BR11646-5R-388	3.83	-	14.4	-	89.0	-	21.4	-	31.5	-
IR18A1859	2.81	-	15.1	-	53.4	-	20.8	-	27.8	-
BR11894-R-R-R-R-110	-	7.02	-	9.9	-	124.8	-	23.6	-	30.5
BRRI dhan69-phy1	-	4.96	-	12.4	-	113.1	-	21.9	-	27.7
Zira	-	4.65	-	10.7	-	140.7	-	19.4	-	32.9
Khatobabu	-	5.16	-	12.8	-	148.3	-	23.2	-	8.1
Shubollata	-	5.29	-	14.1	-	142.04	-	19.4	-	15.0

Genotypes	Yield (t/ha)		Panicle/hill (no.)		Filled grain/panicle (no.)		1000 grain wt. (g)		Sterility (%)	
	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov
BRRI dhan28 (ck)	3.28	5.41	20.4	14.1	67.1	107.9	22.6	23.0	29.3	12.4
BRRI dhan67 (ck)	5.09	6.26	16.1	14.3	118.3	121.5	22.7	22.4	16.8	9.6
BRRI dhan89 (ck)	5.35	6.63	12.1	11.0	122.7	162.0	23.2	23.2	35.7	14.3
LSD (5%)	1.8		4.1		27.5		3.4		7.6	
CV (%)	21.7		18.2		14.8		9.2		20.7	

Grain yield and yield components: Grain yield differed significantly among different rice genotypes and sowing times. Irrespective of rice varieties it was significantly higher in 01 November sowing than 24 October sowing. In 1st seeding date of early sowing/planting, grain yield of BR11894-R-105 (5.1 t/ha), BR11894-R- R-R-R- 329 (5.20 t/ha) and check variety BRRI dhan67 and BRRI dhan89 was significantly higher than BRRI dhan28 (3.28 t/ha). Other genotypes BR11894-R-R-R-R-169 and BR11894-R-228 had also comparable yield to BRRI dhan67 (5.09 t/ha) and BRRI dhan89 (5.35 t/ha) (**Table 5.3.3**). In 01 November sowing, the advanced line BR11894-R-R-R-R-169 produced highest yield (7.13 t/ha) followed by BR11894-R-R-R-R-110 (7.02 t/ha) which were statistically similar to the check variety BRRI dhan67 (6.26 t/ha) and BRRI dhan89 (6.63 t/ha). However, other genotypes had statistically similar yield to check variety BRRI dhan28 (5.41 t/ha) (**Table 5.3.3**).

Early planting rice genotypes had more number of panicle per hill (**Table 5.3.3**). This is might be due to longer growth duration in early planting. Filled grain per panicle was significantly less in 24 October sowing than 01 November **(Table 5.3.3).** This is due to higher percentage of sterility in 24 October sowing. Thousand grain weights did not differed significantly in between two sowing times (**Table 5.3.3**). Sterility percentage differed significantly among different varieties sown in different sowing times. Percent sterility was increased significantly in 24 October sowing over 01 November (**Table 5.3.3**).

Conclusion: All rice genotypes experienced cold stress in 1st planted crops. Natural cold stress at reproductive phase of rice genotypes sown on 24 October changed different physiological parameters. It caused longer growth duration, shorter length of plant height and last internode, more panicle degeneration, poor panicle exertion, higher percentage of sterility and lower grain yield in all rice genotypes. Among the tested breeding lines BR11894-R-R-R-R-169 had the highest yield (7.13 t/ha) followed by BR11894-R-R-R-R-110 (7.02 t/ha) when sowing was done on 01 Nov. The yield of check varieties BRRI dhan67 and BRRI dhan89 were 6.26 and 6.63 t/ha respectively.

PROJECT 6: GROWTH STUDIES AND YIELD POTENTIAL

Expt. 6.1: Photoperiod sensitivity test of advanced breeding lines

Sadia Afrin Shupta, Md. Sazzadur Rahman,Tuhin Halder and Mst Salma Pervin

Introduction: Rice is a short day plant and sensitive to photoperiod, long day treatments can prevent or considerably delay its flowering. Rice cultivars exhibit wide range of variation in the degree of sensitivity to photoperiod (strong sensitive to nearly insensitive). In the Aman season with Rainfed Lowland Rice (RLR)-ecosystem in Bangaldesh characterized by longer day vegetative phase and shorter day at reproductive phase and ripening phase with gradual decrease of temperature and humidity. Heavy downpour in the upstream (India & Nepal) and huge monsoon rainfall of Bangladesh causes floods every year in the low-laying Aman growing areas. Slow receding of flood water may cause unusual delay of planting of Aman rice in the RLR-ecosystem. Therefore, late Aman variety is essential for low-lying flood affected areas of Bangladesh. BRRI has released a number of late Aman variety suitable to grow in the flood

affected areas for different regions of Bangladesh. But more varieties with superior yield and good grain qualities are needed. Considering above fact an investigation was undertaken to find out the photoperiodic responses for supplied advanced breeding lines.

Objectives: To know the photoperiod sensitivity of advanced breeding lines.

Materials: A total of 201 advanced breeding materials and 3 varieties with Nizersail as a check variety were taken.

Methodology: An experiment was conducted to know the response to photoperiod of 201 advanced breeding lines and 3 varieties in the east byde, BRRI, Gazipur. Seeds of all the tested lines with Nizersail as a check variety were directly sown to the well-prepared field on 10 April, 2022. After emergence the plants were thinned and the experiment was replicated for three times. Ten-hour photoperiodic treatment (7.00 AM to 5.00 PM) was started from seed sowing by using black cloth cover and another set were grown at natural day length. After emergence 6 healthy plants were maintained for each entry. Observations were made on date of seeding and date of heading to determine the Basic Vegetative Phase (BVP), Photoperiod Sensitive Phase (PSP) and Relative Photoperiod Sensitivity (RPS).

The following equation was used to determine BVP (Days), PSP (Days) and RPS (%).

BVP= Growth duration at 10 hours photoperiod (sowing to Heading)-30 days (Mohapatra *et,al.*, 2011 Advances in Agronomy, Vol 110, Elsevier Inc)

PSP= Growth duration in natural day length (sowing to heading) photoperiod- Growth duration at 10 Hours photoperiod (sowing to heading).

RPS=PSP of the entry/PSP of Nizersail X 100

According to Vergara and Chang (1985) a more practical grouping could be as follows (using also the length of the BVP and PSP).

1. **Photoperiod insensitive:** Very short PSP (less than 30 d) and BVP varying from short to long.
2. **Weekly photoperiod sensitive:** Marked increase in growth duration when photoperiod is larger than 12 h; PSP may exceed 30 d, but flowering occurs under any long photoperiod.
3. **Strongly photoperiod sensitive:** Sharp increase in growth duration with increase in photoperiod; no flowering beyond critical photoperiod; BVP usually short (not more than 40 d).

Results: The BVP and PSP varied greatly among the tested genotypes. The PSP or lag phase is a phase indicative of the rice plant's sensitivity to photoperiod. Compared to Nizersail, out of 201 advanced lines and 3 varieties, 17 lines were insensitive, 14 advanced breeding lines were strong photosensitive and 3 varieties all were strongly photoperiod sensitive. Others lines were weakly photoperiod sensitive (**Table 6.1.1**). TL Aus-Gaz10-40-5-11* has relative photoperiod sensitivity 104% considered as strong photoperiod sensitive higher than standard check variety Nizersail (**Table 6.1.1**).

Table 6.1.1: BVP, PSP and RPS of 201 advanced breeding lines and three varieties. Each value is average of three replications. Sowing date: (10.04.2022)

Sl. No.	Designation	PSP (±) SE (Days)	BVP (±) SE (Days)	RPS (%)	Remarks
1	BR 12459-4R-3	24±1.20	73±1.20	44	WPPS
2	BR 12459-4R-9	25±3.33	84±2.67	51	WPPS
3	BR 12459-4R-14	22±0.33	84±0.00	51	WPPS
4	BR 12459-4R-16	21±1.20	91±1.86	55	WPPS
5	BR 12459-4R-26	25±0.88	87±1.45	53	WPPS
6	BR 12459-4R-27	21±0.88	39±2.08	24	WPPS
7	BR 12459-4R -39	28±0.88	80±2.73	48	WPPS

Sl. No.	Designation	PSP (±) SE (Days)	BVP (±) SE (Days)	RPS (%)	Remarks
8	BR 12459-4R -40	30±1.00	76±1.20	46	WPPS
9	BR 12459-4R -41	31±1.33	72±1.00	44	WPPS
10	BR 12459-4R -44	34±0.33	50±12.58	30	WPPS
11	**BR 12459-4R -45**	14±0.67	137±0.33	**83**	**SPPS**
12	BR 12459-4R -61	26±1.33	58±0.88	35	WPPS
13	BR 12459-4R -75	24±1.20	69±2.08	42	WPPS
14	BR 12459-4R -88	28±0.88	65±0.88	39	WPPS
15	BR 12459-4R -97	26±1.20	75±1.20	46	WPPS
16	BR 12459-4R -103	26±1.67	53±1.53	32	WPPS
17	BR 12459-4R -105	22±0.33	62±1.20	38	WPPS
18	BR 12459-4R -106	28±0.88	55±1.67	34	WPPS
19	BR 12459-4R -113	26±1.53	75±1.45	46	WPPS
20	BR 12459-4R -114	23±0.00	82±0.88	50	WPPS
21	BR 12459-4R -117	29±1.73	71±0.88	43	WPPS
22	BR 12459-4R -118	24±0.33	81±1.20	49	WPPS
23	BR 12459-4R -119	34±1.15	68±2.03	42	WPPS
24	BR 12459-4R -120	28±0.33	81±0.88	49	WPPS
25	BR 12459-4R -122	26±1.53	82±3.46	50	WPPS
26	BR 12459-4R -126	30±2.00	80±5.17	48	WPPS
27	BR 12459-4R -127	23±1.00	82±2.96	50	WPPS
28	BR 12459-4R -140	29±0.88	66±5.03	40	WPPS
29	BR 12459-4R -172	24±0.67	64±2.96	39	WPPS
30	BR 12459-4R -183	27±1.45	80±2.00	49	WPPS
31	BR 12459-4R -203	28±1.33	63±1.67	38	WPPS
32	BR 12459-4R -205	28±0.67	77±3.33	47	WPPS
33	BR 12459-4R -209	29±0.58	70±4.26	43	WPPS
34	BR 12459-4R -238	23±2.03	63±1.45	39	WPPS
35	BR 12459-4R -241	37±2.08	72±3.71	44	WPPS
36	BR 12459-4R -247	28±0.88	64±2.19	39	WPPS
37	BR 12459-4R -265	31±5.04	65±7.36	40	WPPS
38	BR 12459-4R -271	23±0.58	73±3.46	44	WPPS
39	BR 12459-4R -277	29±2.91	80±3.46	49	WPPS
40	BR 12459-4R -283	23±1.33	65±1.45	40	WPPS
41	BR 12459-4R -286	22±0.00	83±1.20	51	WPPS
42	BR 12459-4R -301	22±0.00	76±4.70	47	WPPS
43	BR 12460-4R -5	48±1.15	52±5.70	32	WPPS
44	BR 12460-4R -9	31±1.86	64±2.91	39	WPPS
45	BR 12460-4R -12	38±7.37	65±9.06	40	WPPS
46	BR 12460-4R -24	35±1.86	70±1.20	43	WPPS
47	BR 12460-4R -44	33±0.67	62±2.33	38	WPPS
48	BR 12460-4R -50	46±2.52	29±8.08	18	Insensitive
49	BR 12460-4R -66	29±1.86	55±1.76	33	WPPS
50	BR 12460-4R -72	25±0.33	63±12.50	38	WPPS
51	BR 12460-4R -91	34±0.58	64±1.76	39	WPPS
52	BR 12460-4R -100	28±1.86	58±8.62	35	WPPS
53	BR 12460-4R -102	32±1.45	76±5.86	46	WPPS
54	BR 12460-4R -107	31±1.45	55±2.33	33	WPPS
55	BR 12460-4R -116	28±1.67	52±3.06	32	WPPS
56	BR 12460-4R -120	33±0.58	67±2.00	41	WPPS
57	BR 12460-4R -122	28±1.20	77±2.65	47	WPPS
58	BR 12460-4R -145	34±1.00	69±0.88	42	WPPS
59	BR 12460-4R -156	38±0.33	64±2.31	39	WPPS
60	BR 12460-4R -189	28±1.45	66±4.06	40	WPPS
61	BR 12461-4R-6	35±2.00	58±5.86	35	WPPS
62	BR 12461-4R-23	45±1.53	57±1.20	35	WPPS
63	BR 12461-4R-28	26±1.73	81±1.20	50	WPPS
64	BR 12461-4R-51	26±1.15	67±1.15	41	WPPS
65	BR12461-4R-70	37±3.18	60±3.84	36	WPPS
66	BR12462-4R-82	29±3.28	69±4.36	42	WPPS
67	BR2462-4R-147	39±6.33	58±7.00	35	WPPS
68	BR12462-4R-160	44±0.88	49±2.67	30	WPPS
69	BR12462-4R-204	34±1.20	69±0.88	42	WPPS
70	BR12462-4R-241	44±0.88	64±7.88	39	WPPS

Sl. No.	Designation	PSP (±) SE (Days)	BVP (±) SE (Days)	RPS (%)	Remarks
71	BR12462-4R-253	44±1.53	67±4.91	41	WPPS
72	BR12462-4R-283	37±1.45	74±4.36	45	WPPS
73	BR12462-4R-358	39±0.00	58±0.33	35	WPPS
74	BR12463-4R-370	45±0.33	11±4.67	7	Insensitive
75	BR12463-4R-416	46±2.19	10±2.19	6	Insensitive
76	BR12463-4R-500	47±2.08	10±3.51	6	Insensitive
77	BR12463-4R-527	39±3.67	17±3.28	11	Insensitive
78	BR12464-4R-86	36±2.67	79±2.67	48	WPPS
79	BR12464-4R-134	33±1.20	79±2.52	48	WPPS
80	BR12464-4R-179	40±2.31	64±3.00	39	WPPS
81	BR12464-4R-273	51±1.73	17±6.98	10	Insensitive
82	BR12464-4R-298	35±0.58	59±0.88	36	WPPS
83	BR12464-4R-345	38±1.67	57±2.73	34	WPPS
84	BR12465-4R-14	33±0.88	84±0.88	46	WPPS
85	BR12465-4R-18	26±1.33	77±0.58	47	WPPS
86	BR12465-4R-22	28±0.88	88±1.00	54	WPPS
87	BR12465-4R-26	26±1.20	80±3.84	48	WPPS
88	BR12465-4R-27	30±2.52	72±3.18	44	WPPS
89	BR12465-4R-28	22±0.67	71±2.73	43	WPPS
90	BR12465-4R-30	33±0.58	54±2.40	33	WPPS
91	BR12465-4R-38	28±0.88	86±2.96	52	WPPS
92	BR12465-4R-50	31±1.20	82±3.84	50	WPPS
93	BR12465-4R-59	36±0.67	73±1.00	44	WPPS
94	BR12465-4R-61	32±0.33	72±0.67	44	WPPS
95	BR12465-4R-63	23±0.33	55±0.33	33	WPPS
96	BR12465-4R-68	29±1.45	60±1.76	36	WPPS
97	BR12465-4R-85	28±1.67	57±1.33	34	WPPS
98	BR12465-4R-91	28±1.67	69±0.88	42	WPPS
99	BR12465-4R-100	34±0.67	68±2.96	41	WPPS
100	BR12465-4R-113	35±1.20	53±4.33	32	WPPS
101	BR12465-4R-118	32±2.40	73±1.00	44	WPPS
102	BR12465-4R-126	30±2.19	54±5.17	33	WPPS
103	BR12465-4R-130	48±2.03	65±1.86	39	WPPS
104	BR12465-4R-132	34±3.48	76±6.66	46	WPPS
105	BR12465-4R-170	28±0.33	72±2.52	44	WPPS
106	BR12465-4R-181	27±0.58	77±0.67	47	WPPS
107	BR12465-4R-201	21±3.71	70±9.77	42	WPPS
108	BR12465-4R-220	32±0.33	72±1.00	44	WPPS
109	BR12465-4R-223	30±2.00	76±1.86	46	WPPS
110	BR12465-4R-228	27±4.26	75±6.66	46	WPPS
111	BR12465-4R-231	26±0.33	77±1.33	47	WPPS
112	BR12465-4R-309	24±2.00	61±6.33	37	WPPS
113	BR12465-4R-312	33±0.88	51±5.24	31	WPPS
114	BR12465-4R-321	29±0.88	63±6.44	38	WPPS
115	BR12466-4R-14	26±0.33	51±0.88	31	WPPS
116	BR12466-4R-20	25±1.76	73±0.33	45	WPPS
117	BR12466-4R-42	30±1.86	31±2.52	19	Insensitive
118	BR12466-4R-49	25±0.33	70±4.04	43	WPPS
119	BR12466-4R-61	30±1.73	68±7.84	41	WPPS
120	BR12466-4R-106	28±1.15	70±0.88	42	WPPS
121	BR12466-4R-117	26±2.60	29±2.52	18	Insensitive
122	BR12466-4R-134	24±0.67	86±2.00	52	WPPS
123	BR12466-4R-159	24±0.33	78±1.76	47	WPPS
124	BR12466-4R-167	28±1.00	79±1.73	48	WPPS
125	BR12466-4R-169	23±0.67	51±1.86	31	WPPS
126	BR12466-4R-179	26±5.17	72±6.84	44	WPPS
127	BR12466-4R-180	25±0.88	88±4.84	53	WPPS
128	BR12466-4R-275	23±0.33	65±3.84	40	WPPS
129	BR12468-4R-317	39±1.00	54±0.67	33	WPPS
130	BR12468-4R-337	22±2.65	60±2.60	37	WPPS
131	BR12460-4R-18	22±0.88	69±16.20	42	WPPS
132	BR12469-4R-204	34±0.55	29±2.30	18	Insensitive
133	BR12469-4R-228	37±1.67	27±4.63	17	Insensitive

Sl. No.	Designation	PSP (±) SE (Days)	BVP (±) SE (Days)	RPS (%)	Remarks
134	BR12473-4R-214	40±0.33	57±10.00	35	WPPS
135	BR12474-4R-273	22±0.58	43±4.33	26	WPPS
136	BR12474-4R-311	39±1.33	28±2.19	17	Insensitive
137	BR12474-4R-352	33±1.53	35±4.10	21	WPPS
138	BR12474-4R-377	32±0.33	34±2.52	21	WPPS
139	BR12474-4R-428	24±0.33	39±4.70	24	WPPS
140	BR12474-4R-531	33±1.15	29±4.73	18	Insensitive
141	BR12477-4R-11	43±1.73	28±2.03	17	Insensitive
142	BR12477-4R-13	28±1.53	44±3.61	27	WPPS
143	BR12477-4R-15	39±4.33	67±5.24	41	WPPS
144	BR12477-4R-22	37±1.76	34±0.33	21	WPPS
145	BR12477-4R-43	41±1.53	26±0.88	17	Insensitive
146	BR12477-4R-64	26±0.55	32±1.38	20	Insensitive
147	BR12477-4R-73	35±0.33	60±2.60	37	WPPS
148	BR12477-4R-186	33±1.00	67±3.18	41	WPPS
149	BR12477-4R-198	46±0.33	19±0.58	12	Insensitive
150	BR12477-4R-205	29±6.17	60±14.62	37	WPPS
151	BR12477-4R-253	43±3.67	16±5.77	10	Insensitive
152	BR12477-4R-358	45±1.20	17±4.98	11	Insensitive
153	BR12477-4R-371	35±2.19	67±2.73	41	WPPS
154	BR12477-4R-383	29±1.00	62±3.61	38	WPPS
155	BR13711-4R-1	30±1.45	34±1.53	21	WPPS
156	BR13711-4R-190	19±0.67	39±1.45	24	WPPS
157	BR11686-5R-179	28±0.67	93±1.67	56	WPPS
158	BR11694-5R-161	46±1.33	61±1.86	37	WPPS
159	BR11196-5R-38	33±0.00	77±1.20	47	WPPS
160	**BR10212-4-3-1**	21±0.67	132±2.52	**80**	**SPPS**
161	BR10212-5-5-7	33±1.20	69±3.18	42	WPPS
162	BR9793-13-2-1	32±1.20	68±1.15	41	WPPS
163	**BR10212-7-5-1**	17±0.88	142±1.33	**86**	**SPPS**
164	IR16F1996-PS1	28±0.88	84±4.70	51	WPPS
165	IR13F450-4	34±0.67	75±0.88	45	WPPS
166	IR16F1097-P1	32±3.84	74±3.28	45	WPPS
167	BR11690-5R-331	22±0.33	113±4.58	69	WPPS
168	**BR10212-10-3-1**	18±0.33	142±0.67	**86**	**SPPS**
169	BR12154-5R-258	47±0.88	92±2.91	56	WPPS
170	Br12154-5R-258	35±2.19	64±7.13	39	WPPS
171	**BR10212-17-3-2-1**	31±1.20	138±1.20	**84**	**SPPS**
172	**BR10212-17-3-2-2**	26±1.20	145±0.88	**88**	**SPPS**
173	BR10211-22-9-2-3	21±4.18	74±7.51	45	WPPS
174	**BR10212-5-5-3**	17±0.88	143±1.20	**87**	**SPPS**
175	IR16F1097-P2	35±1.33	75±3.28	46	WPPS
176	IR13F652-1-P3	41±2.33	88±2.60	53	WPPS
177	IR13F478-3	33±1.45	70±4.67	42	WPPS
178	IR15F1754	45±1.53	103±5.90	63	WPPS
179	IR16F1243	29±2.03	74±6.23	45	WPPS
180	IR16F1097	33±0.33	80±4.91	49	WPPS
181	IR13F441	40±1.53	83±2.00	51	WPPS
182	BR10211-32-3-1-1	60±0.33	90±8.09	55	WPPS
183	BR10211-30-2-1-4	34±1.20	89±2.85	54	WPPS
184	BR10211-30-2-1-5	28±2.33	54±3.33	33	WPPS
185	BR11693-5R-156	25±0.88	47±7.84	28	WPPS
186	IR16F1201	40±0.88	54±8.02	33	WPPS
187	IR108042-B-B-B-4-B-B	35±0.58	74±0.58	45	WPPS
188	BR10212-20-1-3	38±0.67	65±1.86	40	WPPS
189	IR16F1709	35±1.00	80±1.33	48	WPPS
190	IR15F1869	27±1.86	53±4.04	32	WPPS
191	BR8845-21-1-10-3-5	26±1.76	69±2.19	42	WPPS
192	**TL Aus-Gaz10-40-5-11***	11±1.45	171±0.67	**104**	**SPPS**
193	BR8845-21-1-10-3-6	24±1.53	71±1.73	43	WPPS

Sl. No.	Designation	PSP (±) SE (Days)	BVP (±) SE (Days)	RPS (%)	Remarks
194	**BR8540-2-4-1-3***	20±0.88	163±1.20	**99**	**SPPS**
195	BR8845-21-1-10-6-1*	34±1.20	68±1.53	41	WPS
196	**BR8540-2-4-1-3 (Black)***	45±0.58	136±0.67	**83**	**SPPS**
197	**BR10820-2-3-3-5-3**	47±2.19	126±1.73	**77**	**SPPS**
198	**BR10821-15-7-8-5***	52±3.00	129±3.18	**78**	**SPPS**
199	BR11768-10-4-6-P2	60±2.67	74±5.57	45	WPPS
200	**BR8515-8-7-8-2**	34±2.19	139±3.06	**85**	**SPPS**
201	**BR9590-45-4-5-2**	19±2.31	148±2.60	**90**	**SPPS**
202	**Gainza**	46±0.67	132±0.88	**80**	**SPPS**
203	**BR22**	17±1.86	160±1.53	**97**	**SPPS**
204	**BR23**	38±1.45	139±2.33	**85**	**SPPS**
205	**Nizersail (Ck)**	19±0.67	164±0.67	100	SPPS

Note: BVP and PSP values are the Mean ± SE (n=3), Insensitive = Nearly insensitive to photoperiod, SPPS = strongly photoperiod sensitive, WPPS = weakly photoperiod sensitive.

Expt. 6.2: Photoperiod sensitivity test of local germplasm and four BRRI released varieties

Sadia Afrin Shupta, Md. Sazzadur Rahman,Tuhin Halder and Mst Salma Pervin

Introduction: Rice is a short day plant and sensitive to photoperiod, long day treatments can prevent or considerably delay its flowering. Rice cultivars exhibit wide range of variation in the degree of sensitivity to photoperiod (strong sensitive to nearly insensitive). In the Aman season with Rainfed Lowland Rice (RLR)-ecosystem in Bangaldesh characterized by longer day vegetative phase and shorter day at reproductive phase and ripening phase with gradual decrease of temperature and humidity. Heavy downpour in the upstream (India & Nepal) and huge monsoon rainfall of Bangladesh causes floods every year in the low-laying Aman growing areas. Slow receding of flood water may cause unusual delay of planting of Aman rice in the RLR-ecosystem. Therefore, late Aman variety is essential for low-lying flood affected areas of Bangladesh. BRRI has released a number of late Aman variety suitable to grow in the flood affected areas for different regions of Bangladesh. But more varieties with superior yield and good grain qualitites are needed. Considering above fact an investigation was undertaken to find out the photoperiodic responses for local germplasms.

Objectives: To know the photoperiod sensitivity of local germplasm.

Materials: Total 9 local germplasm and 4 BRRI variety. **Check:** Nizersail

Methodology: An experiment was conducted with 9 local germplasm and 4 varieties with Nizersail as a check variety were directly sown to the well-prepared field beds during 27 April 2022 in east byde BRRI, Gazipur. After emergence the plants were thinned and the experiment was replicated two times. Ten-hour photoperiodic treatment (7.00 AM to 5.00) PM was started from seed sowing by using black cloth cover and another set was grown at natural day length. Total 5 healthy plants were maintained for each entry. Observations were made on date of seeding and date of heading to determine the Basic Vegetative Phase (BVP), Photoperiod Sensitive Phase (PSP) and Relative Photoperiod Sensitivity (RPS).

The following equation was used to determine BVP (Days), PSP (Days) and RPS (%).

BVP= Growth duration at 10 hours photoperiod (sowing to Heading)-30 days (Mohapatra*et,al.*, 2011 Advances in Agronomy, Vol 110, Elsevier Inc)

PSP= Growth duration in natural day length (sowing to heading) photoperiod- Growth duration at 10 Hours photoperiod (sowing to heading).

RPS=PSP of the entry/PSP of Nizersail X 100

According to Vergara and Chang (1985) a more practical grouping could be as follows (using also the length of the BVP and PSP).

1. **Photoperiod insensitive:** Very short PSP (less than 30 d) and BVP varying from short to long.
2. **Weekly photoperiod sensitive:** Marked increase in growth duration when photoperiod is larger than 12 h; PSP may exceed 30 d, but flowering occurs under any long photoperiod.
3. **Strongly photoperiod sensitive:** Sharp increase in growth duration with increase in photoperiod; no flowering beyond critical photoperiod; BVP usually short (not more than 40 d).

Results: The BVP and PSP varied greatly among the entries ranging from 4 to 36 and 62 to 151, respectively. The PSP or lag phase is a indicative of the rice plants sensitivity to photoperiod. Dudlucki and BR22 has relative photoperiod sensitivity 107% and 113%, respectively considered as strong photoperiod sensitive higher than standard check Nizersail.

Conclusion:
All the tested germplasm were strongly photoperiod sensitive. Among 4 BRRI varieties only BR11 was weakly photosensitive and other three BRRI released varieties were strongly photoperiod sensitive (**Table 6.2.1**).

Table 6.2.1: BVP, PSP and RPS of nine local germplasm and four varieties. Each values are average of three replications. (Sowing date: 27.04.2022)

Sl. No.	Designation	Basic Vegetative Phase (Day)	Photoperiod Sensitive Phase (Day)	Relative Photoperiod Sensitivity (%)	Remarks
1	Laxmidigha	27±2.91	129±8.66	89	SPPS
2	Bashiraj	24±0.33	126±1.76	95	SPPS
3	Lalmohan	31±1.33	107±1.33	80	SPPS
4	Dudlucki	4±0.33	143±0.88	107	SPPS
5	Fulkuri	16±3.8	128±2.03	96	SPPS
6	Khoyamotor	27±.6	118±0.33	89	SPPS
7	Shorshoriya	26±1.7	111±2.85	84	SPPS
8	Malshira	36±5.3	109±2.91	82	SPPS
9	Biroi	32±3.2	115±2.08	86	SPPS
10	**Nizersail (ck**	19± 0.00	133±0.00	100	SPPS
11	**BR11**	**32±1.2**	**62±3.38**	**47**	**WPPS**
12	BR22	13±2.0	151±0.33	113	SPPS
13	BR23	31±2.1	132±0.67	99	SPPS
14	BRRI dhan54	19±1.5	129±1.15	97	SPPS

Note: BVP and PSP values are the Mean ± SE (n=5) Insensitive= Nearly insensitive to photoperiod, SPPS= strongly photoperiod sensitive, WPPS=weakly photoperiod sensitive.

Expt. 6.3: Investigation of photoperiod sensitivity test of different genotypes

Sadia Afrin Shupta, Md. Sazzadur Rahman and Mst. Salma Pervin

Introduction: Rice is a short day plant and sensitive to photoperiod, long day treatments can prevent or considerably delay its flowering. Rice cultivars exhibit wide range of variation in the degree of sensitivity to photoperiod (strong sensitive to nearly insensitive). In the Aman season with Rainfed Lowland Rice (RLR)-ecosystem in Bangaldesh characterized by longer day vegetative phase and shorter day at reproductive phase and ripening phase with gradual decrease of temperature and humidity. Heavy downpour in the upstream (India & Nepal) and huge monsoon rainfall of Bangladesh causes floods every year in the low-laying Aman growing areas. Slow receding of flood water may cause unusual delay of planting of Aman rice in the RLR-

ecosystem. Therefore, late Aman variety is essential for low-lying flood affected areas of Bangladesh. BRRI has released a number of late Aman variety suitable to grow in the flood affected areas for different regions of Bangladesh. But more varieties with superior yield and good grain qualities are needed. Considering above fact an investigation was undertaken to find out the photoperiodic responses for supplied genotypes from Plant Breeding Division, Biotechnology Division and Rangpur regional station respectively.

Objectives: To know the photoperiod sensitivity of tasted genotypes.

Materials: Total 67 advanced line.

Check variety: Nizersail, Gainza.

Methodology: Seeds of 66 advanced lines with Gainza and Nizersail as check variety were directly sown to the well-prepared field on 4 April 2023. After emergence the plants were thinned and 5 healthy plant maintained for each entries. Ten-hour photoperiodic treatment (7.00 AM to 5.00 PM) was started from seed sowing by using black cloth cover and another set were grown at natural day length. Observations were made on date of seeding and date of heading to determine the Basic Vegetative Phase (BVP), Photoperiod Sensitive Phase (PSP) and Relative Photoperiod Sensitivity (RPS).

The following equation was used to determine BVP (Days), PSP (Days) and RPS (%).

BVP= Growth duration at 10 hours photoperiod (sowing to Heading)-30 days (Mohapatra *et,al.*, 2011 Advances in Agronomy, Vol 110, Elsevier Inc)

PSP= Growth duration in natural day length (sowing to heading) photoperiod- Growth duration at 10 Hours photoperiod (sowing to heading).

RPS=PSP of the entry/PSP of Nizersail X 100

According to Vergara and Chang (1985) a more practical grouping could be as follows (using also the length of the BVP and PSP).

1. **Photoperiod insensitive:** Very short PSP (less than 30 d) and BVP varying from short to long.
2. **Weekly photoperiod sensitive:** Marked increase in growth duration when photoperiod is larger than 12 h; PSP may exceed 30 d, but flowering occurs under any long photoperiod.
3. **Strongly photoperiod sensitive:** Sharp increase in growth duration with increase in photoperiod; no flowering beyond critical photoperiod; BVP usually short (not more than 40 d).

Results: The BVP and PSP varied greatly among the tested lines. The PSP or lag phase is a indicative of the rice plants sensitivity to photoperiod. Out of 67 tested genotypes, 3 entries could not germinate due to seed quality. Out of 64 tested genotypes, 4 genotypes observed insensitivity to photoperiod (Taiboro, Rataboro, BRRI dhan71, BRRI dhan75), 37 was strongly photoperiod sensitive and 23 weakly photoperiod sensitive (**6.3.1**)

Table 6.3.1: BVP, PSP and RPS of tested genotype and 2 standard check (Gainza, Naizersail) (Sowing date: 04.04.2023)

Sl. No.	Genotypes	BVP (Days)	PSP (Days)	RPS (%) Gainza (CK)	RPS (%) Nizersail (CK)	Remarks
1	258 (Tapiboro)	29	9	6	5	Insensitive
2	5286 (Raniselut)	29	158	101	91	SPPS
3	4376 (Rataboro)	16	23	15	13	Insensitive
4	4791 (Katarivhog)	18	159	101	91	SPPS
5	4755 (Kalogira)	13	166	106	95	SPPS
6	1229 (Nizersail)	17	163	104	94	SPPS

Sl. No.	Genotypes	BVP (Days)	PSP (Days)	RPS (%) Gainza (CK)	RPS (%) Nizersail (CK)	Remarks
7	723 (Jalkomari)	9	165	105	95	SPPS
8	4182 (Jabra)	16	157	100	90	SPPS
9	1436 (Gandisail)	18	160	102	92	SPPS
10	1046(Komragaur)	17	164	104	94	SPPS
11	241 (Biroi)	12	161	103	92	SPPS
12	118 (Shorsoria)	11	158	101	91	SPPS
13	8680 (Lalmohon)	9	165	105	95	SPPS
14	6352 (Lokkhidhigha)	13	136	87	78	SPPS
15	20 (Dudhlucky)	8	158	101	91	SPPS
16	1149 (Khoyamotor)	24	149	95	85	SPPS
17	805 (Bashiraj)	9	149	95	85	SPPS
18	924 (Fulkuri)	9	150	96	86	SPPS
19	BR13103-4R-37	7	175	111	100	SPPS
20	BR13103-4R-7	20	60	38	34	WPPS
21	BR13115-4R-159	24	44	28	25	WPPS
22	BR13115-4R-106	41	45	29	26	WPPS
23	BR13115-4R-93	43	55	35	32	WPPS
24	BR13105-4R-37	7	172	110	99	SPPS
25	BR13115-4R-60	38	65	41	37	WPPS
26	BR13115-4R-122	36	57	36	33	WPPS
27	BR13115-4R-8	37	53	34	30	WPPS
28	BR13103-4R-52	2	175	111	100	SPPS
29	BR13121-4R-40	27	63	40	36	WPPS
30	BR13117-4R-95	23	53	34	30	WPPS
31	BR13115-4R-63	37	51	32	29	WPPS
32	BR13115-4R-70	37	46	29	26	WPPS
33	BR13115-4R-32	31	53	34	30	WPPS
34	BR10212-10-4-1	21	65	41	37	WPPS
35	BR11195-5R-5	29	58	37	33	WPPS
36	BR12502-5R-286	27	74	47	42	WPPS
37	BR12506-5R-142	21	63	40	36	WPPS
38	BR9053-16-3-4-1	22	91	58	52	WPPS
39	BR22	8	174	111	100	SPPS
40	**Gainza (ck)**	18	157	100	90	SPPS
41	Line 1 (Rangpur)	28	77	49	44	WPPS
42	Line 2 (Rangpur)	20	78	50	45	WPPS
43	Line 3 (Rangpur)	21	151	96	87	SPPS
44	Line 4 (Rangpur)	20	69	44	40	WPPS
45	**Nizersail (CK)**	18	174	111	100	SPPS
46	BR10538-2-1-2-3-2	15	35	22	20	WPPS
47	BR10540-4-1-2-4-1	18	43	27	25	WPPS
48	BRRI dhan71	19	16	10	9	Insensitive
49	BRRI dhan75	29	19	12	11	Insensitive
50	BR (Bio)8033-AC1-1-2	16	145	92	83	SPPS
51	BR (Bio)8033-AC1-2-1 HR2	16	145	92	83	SPPS
52	BR (Bio)8033-AC1-2-2-HR1	17	146	93	84	SPPS
53	BR (Bio) 8033-AC1-2-2 HR2	17	142	90	81	SPPS
54	BR (Bio) 8033-AC1-3-1 HR1	19	138	88	79	SPPS
55	BR (Bio) 8033-AC1-3-1 HR2	20	138	88	79	SPPS
56	BR (Bio)8033-AC2-1-2 HR1	11	148	94	85	SPPS
57	BR (Bio)8033-AC2-1-2 HR2	17	141	90	81	SPPS
58	BR (Bio)8033-AC4-1-2 HR1	22	134	85	77	SPPS
59	BR (Bio)8033-AC5-1-1 HR1	9	149	95	85	SPPS

Sl. No.	Genotypes	BVP (Days)	PSP (Days)	RPS (%) Gainza (CK)	RPS (%) Nizersail (CK)	Remarks
60	BR (Bio)8033-AC5-1-1-HR2	9	147	94	84	SPPS
61	BR (Bio)8033-AC5-1-2-HR1	9	150	96	86	SPPS
62	BR (Bio)8032-AC5-1-2-HR2	9	150	96	86	SPPS
63	BR (Bio)8033-AC7-1-1 HR1	9	149	95	85	SPPS
64	BR(Bio)8033-AC7-1-1 HR2	9	150	96	86	SPPS
65	BRRI dhan76	12	92	59	53	WPPS
66	Sada Mota	19	169	108	97	SPPS

Note: Insensitive=nearly insensitive to photoperiod, SPPS= strongly photoperiod sensitive, WPPS=weakly photoperiod sensitive.

Expt. 6.4: Evaluation for lodging tolerance of BRRI developed T. Aman varieties

Sadia Afrin Shupta, Dr. Md. Mamunur Rashid and Dr. Mst. Salma Pervin

Rationale:Lodging of rice plants is caused mainly by the action of wind. Culm of rice plants becomes weakened under heavy application of nitrogenous fertilizers, dense planting, water logging, and sunlight deficiency. Lodging tends to occur in vigorously growing plants after heading, when ripening progresses and panicles drop. Lodging, prior to harvest results in appreciable losses in both quality and quantity of rice. Yoshida (1981) reported that tall varieties fail to yield more in response to increased nitrogen applications mainly because they tend to lodge at high nitrogen levels. In recent past, T. Aman rice in our country had been damaged every year at reproductive to ripening phases of rice during October to November due to natural disaster like cyclone. High bending moment, minimum wrapping score, and higher leaf angle has positive correlation with lodging susceptibility. It was reported that lodging is related to the plant morphology indices.

Objectives: To determine the lodging characters of five BRRI varieties at different planting time.

Materials and method: An experiment was conducted at BRRI research farm, Gazipur during T. Aman season of 2022. Thirty-day-old-seedlings of BRRI developed modern rice varieties BRRI dhan75, BRRI dhan76, BRRI dhan77, BRRI dhan79, BRRI dhan80 along with tolerant check variety BR11 and susceptible check variety BRRI dhan32 were transplanted using 20 cm X 20 cm spacing. There were four sowing time 15 June, 30 June, 15 July, 30 July. Urea was applied in the three equal splits. Other fertilizer such as TSP, MP, gypsum were applied in three basal dose and intercultural operation maintained properly by time to time monitoring. Experiment was laid out in Randomized Complete Block Design with three replications in the west byde at BRRI research field.

At milking stage 5 randomly selected plants from each replication were cut at culm base. They were put into the bucket dipping base into water to restore the turgidity and then various morphological data were recorded. Plant height (cm), culm length (cm), visible internodes length (1^{st} to 5^{th}) was measured by using measuring scale. Visual observation of wrapping score was done by me. Internodes diameter (mm) and internodes thickness (mm) were measured with the help of slide calipers and micrometer respectively. Fresh above ground part (gm) was measured by weight machine. Flag leaf angle (degree), panicle exertion (cm), panicle length (cm), panicle weight (gm) was measured at maturity.

- According to Hoshikawa and Wang (1990) bending moment (gm. cm) was calculated as a product of total fresh weight of above ground part and culm length.
- Stem density (mg/cm) were measured in terms of dry weight (mg) per unit length of total culm length (cm) (Rao *et al.*, 2017).
- The visual lodging rate was measured at maturity stage using the formula: Visual lodging rate= (Lodged area in plot / total plot area) x 100% as reported by (Lu *et al.*, 2014).

Data analysis: Done by R package.

Results:

Plant height (cm): Plant height differed significantly among the tested varieties. Among the varieties all were longer plant height than tolerant check variety BR11 except BRRI dhan75. BRRI dhan76 and BRRI dhan77 has highest plant height and statistically similar which was also higher than susceptible check variety BRRI dhan32 (**Table 6.4.1**).

Flag leaf angle (degree): All the tested varieties were statistically similar with susceptible check variety BRRI dhan32 except BRRI dhan75. BRRI dhan75 has lowest leaf angle than any other variety and statistically similar with BR11 (**Table 6.4.1**).

Panicle exertion (cm): Among the tested varieties BRRI dhan75, BRRI dhan79 and BRRI dhan80 has highest level of leaf exertion and statistically similar. Others varieties were statistically similar lettering with both susceptible and tolerant check variety (**Table 6.4.1**).

Panicle length (cm): BRRI dhan76 had significantly largest panicle. Among the tested varieties BRRI dhan75 and BRRI dhan79 had statistically similar panicle length and which was lower than tolerant check BR11. But BRRI dhan80 had statistically similar panicle length with tolerant check BR11. BRRI dhan76 and BRRI dhan77 were statistically similar with susceptible check BRRI dhan32 (**Table 6.4.1**).

Panicle dry weight (gm): Among the tested varieties BRRI dhan76 and BRRI dhan77 hadhighest panicle dry weight than tolerant check variety which was statistically similar with susceptible check BRRI dhan32 (**Table 6.4.1**).

Table 6.4.1: Characters concerned for canopy architecture and plant stature of T. Aman rice varieties

Name of genotypes	Plant height (cm)	Flag leaf Angle (^{0})	Panicle exertion (cm)	Panicle length (cm)	Panicle dry weight (gm)
BRRI dhan75	113.4f	13.56b	6.45a	22.93d	2.73c
BRRI dhan76	160.53a	35.62a	-1.78c	30.21a	5.21a
BRRI dhan77	163.4a	41.53a	1.07b	27.86b	4.27ab
BRRI dhan79	125.33e	32.15a	4.91a	22.31d	3.16b
BRRI dhan80	143.53c	42.22a	5.47a	26.06c	3.48bc
BR11 (Tol. CK)	133.87d	20.56b	-0.08bc	26.03c	3.38bc
BR32 (Sus. CK)	149.53b	34.1a	-0.34bc	28.16b	3.87abc
LSD (0.05)	3.61	10.56	1.92	1.49	1.53

Length of different internodes (cm): Different visible internode length was found in tested varieties. Internodes length also depends on season and management issues regarding weather. The top most internodes that bear panicle was considered as the first internode. Significant variation observed in each internodes in the tested varieties. The range of 1st internode lengths was from 36.45 cm (tolerant check BR11) to 44.93 cm (BRRI dhan80). Similarly, the 2nd internode range from 18.30 cm (BRRI dhan79) to 27.93 cm (BRRI dhan77). As the same trend BRRI dhan79 has shortest third internode 13.40 cm and largest internode length 21.40 cm in BRRI dhan77. BRRI dhan75 has shortest 4th and 5th internode and largest 4th and 5th internode recorded in BRRI dhan76. BRRI dhan79 and BRRI dhan80 had statistically similar with tolerant check variety BR11 (**Table 6.4.2**).

Table 6.4.2: Visible internodes length variation in the tasted varieties (average of three replications)

Name of genotypes	Length of different internodes (cm)				
	1st	**2nd**	**3rd**	**4th**	**5th**
BRRI dhan75	41.13b	25.33ab	14.60d	**6.40e**	2.47d
BRRI dhan76	38.67bc	20.03cd	18.73b	**18.53a**	15.00a
BRRI dhan77	39.40b	27.93a	21.40a	**19.47a**	13.93a
BRRI dhan79	40.13b	18.30d	13.40d	**11.0d**	8.8°C
BRRI dhan80	44.93a	21.6°Cd	16.33c	**12.67c**	8.07c
BR11 (Tol. CK)	36.45c	21.27cd	17.33bc	**9.87d**	8.13c
BR32 (Sus. CK)	41.33b	23.20bc	18.20b	**15.27b**	10.20b
LSD (0.05)	2.85	3.31	1.64	**1.49**	1.28

Table 6.4.3: Culm stiffness of T. Aman rice varieties (average of three replications)

Name of genotypes	Culm wall thickness (mm)	Culm diameter (mm)	Bending moment (gm cm)	Total Wrapping score	Culm length (cm)	Stem density (mg/cm)
BRRI dhan75	0.72d	4.67e	1225.92d	31.69b	89.31d	27.71e
BRRI dhan76	1.09a	7.44a	2572.54a	35.58a	130.66ab	58.43ab
BRRI dhan77	1.08a	6.91b	2550.22a	31.58b	137.67a	54.04bc
BRRI dhan79	0.95b	6.53c	1609.95c	37.67a	99.71cd	63.98ab
BRRI dhan80	0.82cd	6.69bc	2298.70b	37.18a	107.71c	70.36a
BR11 (Tol CK)	0.94b	6.00b	1508.24c	32.54b	103.19c	42.73c
BR32 (Sus CK)	0.83c	6.16d	2094.87b	32.64b	127.71b	42.68c
$LSD_{0.05}$	0.09	0.33	244.71	2.29	9.69	12.16

Culm wall thickness (mm) and diameter (mm): Among the tested genotypes highest culm thickness and diameter observed in BRRI dhan76 (1.09 mm and 7.44 mm respectively) and lowest thickness and diameter in BRRI dhan75 (0.72 mm and 4.67 mm respectively) (**Table 6.4.3**).

Bending moment (gm cm): Highest bending moment observed in BRRI dhan76 followed by BRRI dhan77 which was statistically similar but lowest in BRRI dhan75 and BRRI dhan79 which was statistically similar with tolerant check variety BR11 (**Table 6.4.3**).

Total wrapping score: Highest wrapping score 37.67 observed in BRRI dhan79 which were statistically similar followed by BRRI dhan76 and BRRI dhan80. Lowest wrapping score 31.58 observed BRRI dhan77 (**Table 6.4.3**).

Culm length (cm): Lowest culm length was observed in BRRI dhan75 (89.31 cm) followed by tolerant check BR11(103.19cm) (**Table 6.4.3**).
Stem density (mg/cm): Highest density observed 63.98mg/cm in BRRI dhan79 and 70.36 mg/cm in BRRI dhan80, which was statistically similar (**Table 6.4.3**).

Discussion: Plant height has positive correlation with lodging susceptibility. Higher plant height means prone to lodging due to higher bending moment. BRRI dhan75 and BRRI dhan79 has lowest plant height and showed good response for lodging tolerant. Flag leaf angle has significant effect on lodging. Leaf angle is associated with the efficient utilization of solar energy, erect leaves favoring the deep penetration of sunlight and minimum mutual shading. BRRI dhan75 has lowest flag leaf angle and statistically similar with tolerant check BR11. Panicle exertion has positive relation with increasing bending tendency of rice plant, But panicle exertion depends on various environmental stress. Panicle length and panicle weight has positive relation with lodging tolerance. Lower panicle length and panicle weight means lower bending tendency of rice plant. Physiologically lower panicle length and panicle weight has positive relation with lodging tolerance. BRRI dhan75, BRRI dhan79 and BRRI dhan80 has statistically similar panicle length and weight with tolerant check BR11.

Visible internode length is an important parameter for lodging tolerance. Normally 3rd, 4th internode and sometimes 5th internode most critical portion and vulnerable to lodging. Breaking strength measured at the midpoint of this internode. With the comparison of tolerant check BR11 lowest internode length specially 3rd, 4th and 5th internode length has positive impact on stem strength. BRRI dhan79 and BRRI dhan80 has statistically similar 4th and 5th visible internode length with tolerant check BR11 and BRRI dhan75 has lower most 4th and 5th internode length. For lodging tolerant variety basal internode will be shorter because lower internodes are vulnerable to lodged.

Culm wall thickness and diameter has positive relation with lodging resistance. Total wrapping score and bending moment is important and has vital impact on lodging resistance. Bending moment depends on stem length and fresh weight of above ground part. When bending moment will be high plant will be lodged easily. BRRI dhan76 and BRRI dhan77 has highest level of bending moment and it has lodging susceptibility. On the other hand wrapping score means how much tightly packed the stem by leaf sheath. BRRI dhan79 and BRRI dhan80 has highest wrapping score and has lodging resistance capacity.

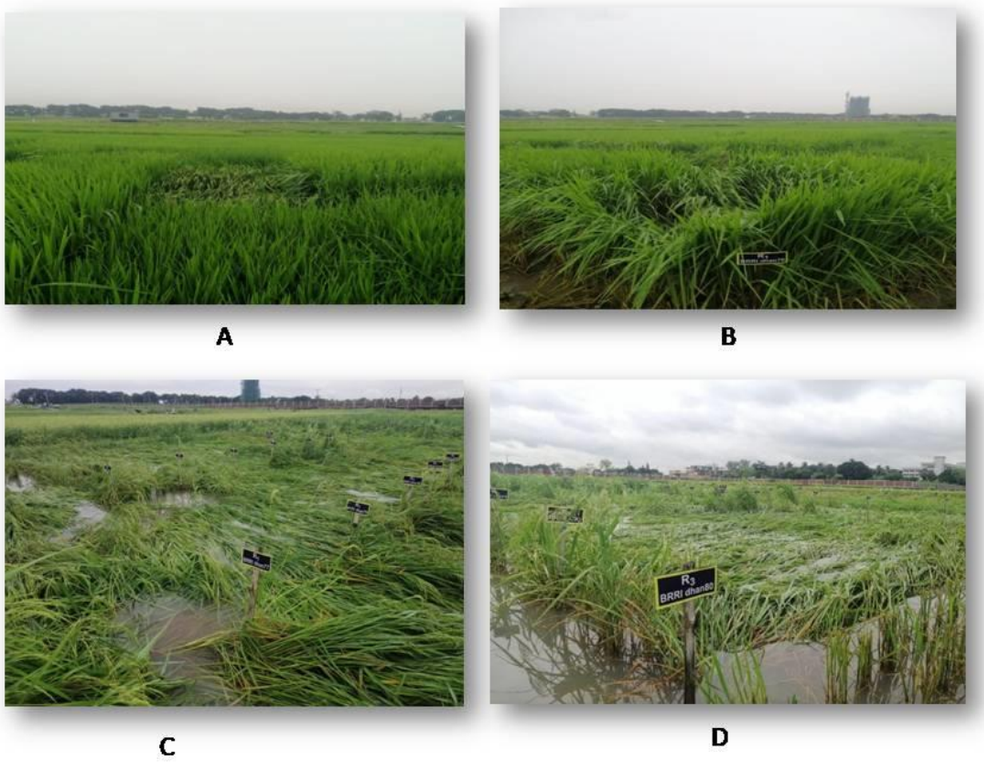

Fig. 6.4.1: (A and B) Plant lodged before sitrang cyclone and (C and D) full field lodged after sitrang cyclone at T. Aman season 2022.

Visual lodging rate:

Before Sitrang cyclone (25-10-2022):

BRRI dhan76 BRRI dhan77 were found lodging susceptible (sowing date 15 June). None of the varieties lodged at sowing date 3**0** June, 15 July and 3**0** July 2022 (**Table 6.4.4**).

After Sitrang cyclone (25-10-2022):

Remaining all varieties (Sowing date at 3**0** June, 15 July and 3**0** July) at different stage were lodged completely due to water level raising. That was the environmental negative impact on this study (**Table 6.4.4**).

Table 6.4.4: Visual lodging rate of T. Aman varieties (average data of three replications before cyclone Sitrang 25-20-2022)

Name of genotypes	Lodging rate (%)			
	15 June	**30 June**	**15 July**	**30 July**
BRRI dhan75	0b	No lodging observed		
BRRI dhan76	6.24b			
BRRI dhan77	2.67b			
BRRI dhan79	0b			
BRRI dhan80	0b			
BRRI dhan32 (Sus. check)	28.27a			
BR 11 (Tol. Check)	0b			
Maximum	28.27			
Minimum	0			
CV (%)	187.09			
LSD (0.05)	17.68			

Conclusion: According to sowing date 15 June, among the tested varieties BRRI dhan75, BRRI dhan79, BRRI dhan80 was lodging tolerant. BRRI dhan76 and BRRI dhan77 were lodged partially compared with tolerant check BR11 and susceptible check BRRI dhan32. With aspect of low plant height, short panicle length, less panicle weight, low bending moment, high wrapping score, low flag leaf angle might be the reason of lodging tolerance compared with lodging susceptible and tolerant check. On the other hand, at other sowing date all the tested varieties were completely lodged due to cyclone. From this study it clear that weather has significant impact on lodging. If weather goes unfavorable there completely lodged can be occurred, not only susceptible variety but also lodging tolerant variety can be lodged. The study has provided a database of canopy character and lodging concerned morphological parameters of BRRI developed T. Aman varieties. All the tested variety has wider genetic variability, by using this variability we have enough possibility to improve our plant type by successful breeding programs.

Expt. 6.5: Characterization for lodging tolerance of BRRI released Boro varieties and advanced breeding lines

Sadia Afrin Shupta, Dr. Md. Sazzadur Rahman and Dr. Mst. Salma Pervin

Rationale: Lodging of rice plants is caused mainly by the action of wind. Culm of rice plants becomes weakened under heavy application of nitrogenous fertilizers, dense planting, water lodging, and sunlight deficiency. Lodging tends to occur in vigorously growing plants after heading, when ripening progresses and panicles drop. Lodging, prior to harvest results in appreciable losses in both quality and quantity of rice. Yoshida (1981) reported that tall varieties fail to yield more in response to increased nitrogen applications mainly because they tend to lodge at high nitrogen levels. In recent past, T. Aman rice in our country had been damaged every year at reproductive to ripening phases of rice during October to November due to natural disaster like cyclone. High bending moment, minimum wrapping score, and higher leaf angle has positive correlation with lodging susceptibility. It was reported that lodging is related to the plant morphology indices.

Objectives: To know the lodging tolerance capacity of 9 BRRI varieties and 9 advanced breeding lines.

Methods and materials: An experiment was conducted in Boro season 2023 in BRRI HQ farm Gazipur to determine the lodging characters of 9 BRRI varieties viz BRRI dhan47, BRRI dhan58, BRRI dhan61, BRRI dhan67 and BRRI dhan81, BRRI dhan88, BRRI dhan89, BRRI

dhan96, Bangabandhu dhan100 and 9 advanced breeding lines along with lodging tolerant check variety BRRI dhan29 and lodging sensitive variety BRRI dhan28. Forty-day-old seedlings were transplanted in the main field with 20cm X 20 cm spacing. Experiment was laid out in Randomized Complete Block Design with three replications. Urea was applied in the three equal splits. Other fertilizer such as TSP, MP, gypsum were applied in three basal dose and intercultural operation maintained properly by time to time monitoring.

At milking stage 3 randomly selected plants from each replication were cut at culm base. They were put into the bucket dipping base into water to restore the turgidity and then various morphological data were recorded. Plant height (cm), culm length (cm), visible internodes length (1^{st} to 4^{th}) was measured by using meter scale. Visual observation of wrapping score was done. Internodes diameter (mm) and internodes thickness (mm) measured by me with the help of slide calipers and micrometer respectively. Fresh above ground part (gm) was measured by weight machine. Flag leaf angle (degree), panicle exertion (cm), panicle length (cm), panicle weight (gm) was measured at maturity.

- According to Hoshikawa and Wang (1990) bending moment (gm. cm) was calculated as a product of total fresh weight of above ground part and culm length.
- Stem density (mg/cm) were measured in terms of dry weight (mg) per unit length of total culm length (cm) (Rao *et al.*, 2017).
- At maximum tillering stage anatomical study like outer layer thickness, large and small vascular number, number of air space was measured by light microscope.
- The visual lodging rate was measured at maturity stage using the formula: Visual lodging rate= (Lodged area in plot / total plot area) x 100% as reported by (Lu *et al.*, 2014).

Data analysis: Done by R package

Results and Discussion: Among the tasted genotypes BRRI dhan67 showed highest plant height 109.67 cm and lowest 80.89 cm in BRRI dhan61. The plant height of BRRI dhan67 and breeding lines BR12454-BC2-56-81-27-3-30, BR12454-BC2-75-32-31-39-7 was also statistically similar with susceptible check BRRI dhan28 (**Fig. 6.5.1**).

Bending moment depends on plant height and above ground fresh weight. Significant variation were recorded among genotypes. Among the tested genotypes highest bending moment observed 1061.53 gm cm in BRRI dhan81 and lowest 445.84 gm cm in BRRI dhan61. Due to lowest bending moment BRRI dhan61 has lodging resistance capacity (**Fig. 6.5.2**).

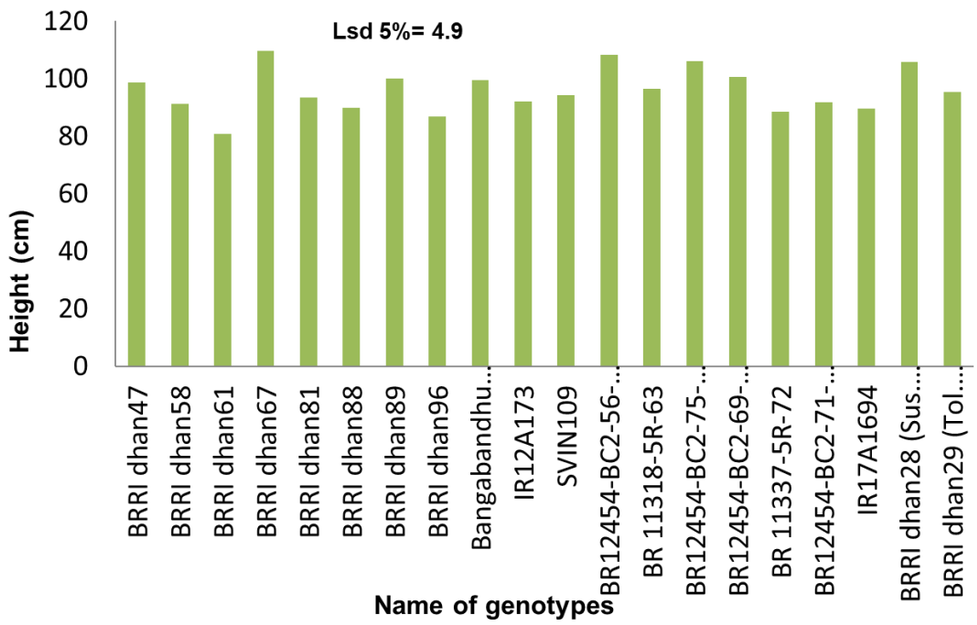

Fig. 6.5.1: Graphical representation of Plant height (cm) of tested genotypes in Boro season.

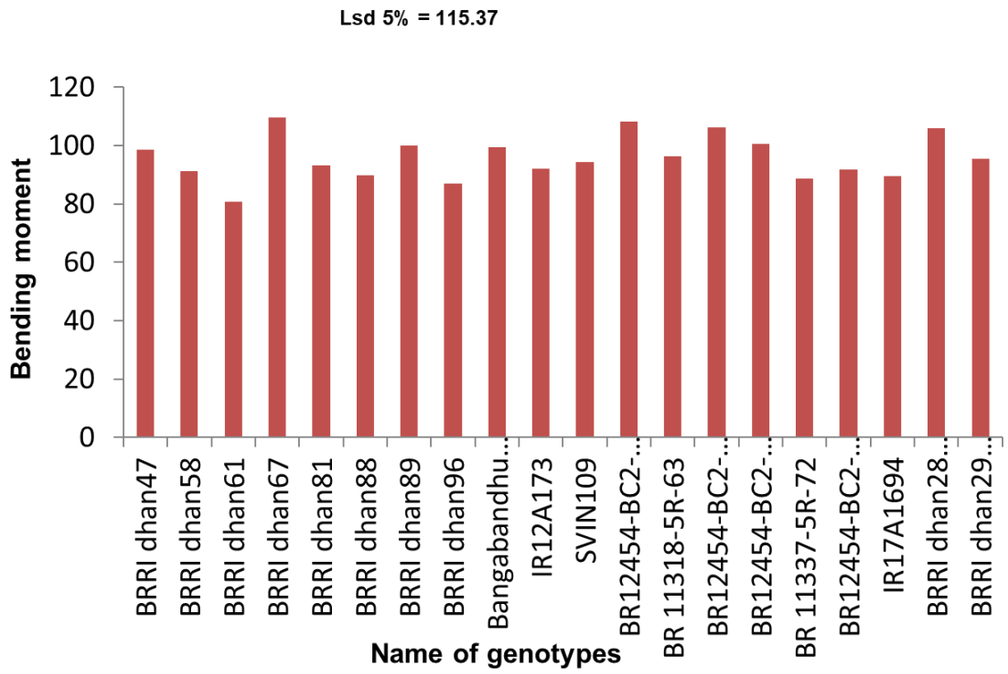

Fig. 6.5.2: Graphical representation of bending moment (gm. cm) of tested genotypes in Boro season**.**

Flag leaf angle has significant effect on lodging. Leaf angle is associated with the efficient utilization of solar energy, erect leaves favoring the deep penetration of sunlight and minimum mutual shading. All the genotypes significantly showed variation. Highest flag leaf angle 22.22 ^{o} observed in BRRI dhan58 and BRRI dhan89. Lowest flag leaf angle observed in BRRI dhan47 and IR12A173 (**Table 6.5.1**).

Highest panicle length observed in BR12454-BC2-71-91-6-23-26, BR12454-BC2-69-97-39-5-44, BR12454-BC2-56-81-27-3-30, BR12454-BC2-75-32-31-39-7 and lowest length in BRRI dhan81, BRRI dhan88 and BRRI dhan58. Panicle length and panicle weight has positive relation with lodging tolerance. Lower panicle length and panicle weight means lower bending tendency of rice plant. Physiologically lower panicle length and panicle weight has positive relation with lodging tolerance (**Table 6.5.1**).

Lowest panicle fresh weight measured in BRRI dhan61 which was statistically similar with tolerant check BRRI dhan29 but incase dry weight lowest was 2.96 gm in Bangabandhu dhan100 which was statistically similar with susceptible check BRRI dhan29. Breeding line BR12454-BC2-75-32-31-39-7 had highest panicle fresh and dry weight (6.26 and 4.96 gm respectively) (**Table 6.5.1**).

Table. 6.5.1 Characters concerned for canopy architecture tasted genotypes in Boro season (average of three replications)

Name of the genotypes	**Flag leaf angle (^{o})**	**Panicle length (cm)**	**Panicle fresh weight (gm)**	**Panicle dry weight (gm)**
BRRI dhan47	8.33 gh	25.48 bcde	5.55 abcd	4.29 abc
BRRI dhan58	22.22 a	21.48 i	6.04 ab	4.66 ab
BRRI dhan61	9.33 fgh	23.46 gh	3.89 h	3.4 e
BRRI dhan67	16.48 bcd	25.29 cdef	4.55 efgh	3.99 bcd
BRRI dhan81	14.07 def	21 hi	4.58 abcde	3.92 bcd
BRRI dhan88	13.85 def	21.3 i	4.78 cdefgh	3.25 de
BRRI dhan89	22.22 a	26.81 abc	5.71 abc	4.52 abc
BRRI dhan96	17.59 abcd	23.3 gh	5. 04 cdefg	3.1 bcd

Bangabandhu dhan100	10.55 efgh	23.38 gh	4.11 gh	2.96 e
IR12A173	7.59 h	24.76defg	5.19 bcdef	3.93 bcd
SVIN109	10.3 efgh	24.76 defg	5.33 abcde	4.22 abc
BR12454-BC2-56-81-27-3-30	13.14 defg	26.93 ab	5.37 abcde	4.44 abc
BR 11318-5R-63	14.59 def	23.44 gh	5.3 bcde	3.85 cd
BR12454-BC2-75-32-31-39-7	14.45 def	26.81 abc	6.26 a	4.96 a
BR12454-BC2-69-97-39-5-44	15.52 cde	27.26 a	5.22 bcde	4.15 bc
BR 11337-5R-72	10.63 efgh	24.54 efg	5.52 abcd	4.15 bc
BR12454-BC2-71-91-6-23-26	14.59 def	27.66 a	5.3 bcde	4.59 abc
IR17A1694	16.67 bcd	23.82 fg	4.26 fgh	3.4 e
BRRI dhan28 (Sus. Check)	21.74 ab	24.22 efg	4.74 defgh	3.93 bcd
BRRI dhan29 (Tol. Check)	20. 32 abc	26.29 abcd	3.93 h	2.96 e
LSD 5%	5.33	1.55	0.95	0.78

The highest culm length 83.78 cm observed at BRRI dhan67 which was statistically similar with

susceptible check BRRI dhan28. The lowest culm length 57.26 cm was observed in BRRI dhan61 which was statistically similar with tolerant check BRRI dhan29.

Maximum culm diameter measured in BRRI dhan81mm and minimum culm diameter was found in Banganbandhu dhan100 (4.37 cm). The highest culm thickness 1.02 mm was observed in IR12A173. Culm diameter and thickness is important morphological character of the stem strength. Higher diameter and thickness increase lodging resistance capacity. Due to higher diameter BRRI dhan81 has lodging tolerant capacity (**Table 6.5.2**). The highest stem density was observed in BRRI dhan58, BRRI dhan89, BRRI dhan96 and IR12A173 and lowest stem density observed 28.69 mg/cm in Bangabandhu dhan100 (**Table 6.5.2**). Wrapping means how much tightly packed the stem by leaf sheath. Maximum wrapping score was observed 31.48 at BRRI dhan81 and lowest 23.33 in BRRI dhan67 (**Table 6.5.2**).

Table 6.5.2. Culm stiffness of tasted genotypes in Boro season (average of three replications)

Name of the genotypes	**Culm length (cm)**	**Culm diameter (mm)**	**Culm thickness (mm)**	**Stem dry weight (gm)**	**Stem density (mg/cm)**	**Wrapping score**
BRRI dhan47	71.89 bcd	5.89 ab	0.88 bcde	2.68 abcd	37.28 abcd	28 bcde
BRRI dhan58	68.22 cdefg	5.48 bcde	0.83 defg	2.88 a	42.11 a	27.28 bcdef
BRRI dhan61	57.26 j	4.44 hi	0.83 cdefg	1.71 g	29.8 efg	26.56 cdef
BRRI dhan67	83.78 a	4.1 defgh	0.87 bcdef	2.71 abcd	32.27 def	23.33 g
BRRI dhan81	67.7 defg	6.18 a	0.91 bc	2.65 abcde	39.11 abc	31.48 a
BRRI dhan88	66.92 efgh	4.93 efghi	0.88 bcde	2.8 fg	31.1 efg	29.11 abc
BRRI dhan89	71.22 bcde	5.51 bcd	0.84 cdefg	3.4 a	42.66 a	26.78 cdef
BRRI dhan96	58.82 ij	5.07 defg	0.84 cdefg	2.4 cdef	40.82 a	29.55 ab
Bangabandhu	72.41	4.37 i	0.88 bcde	2.7 fg	28.69 efg	26.04 ef

Name of the genotypes	Culm length (cm)	Culm diameter (mm)	Culm thickness (mm)	Stem dry weight (gm)	Stem density (mg/cm)	Wrapping score
dhan100	bc					
IR12A173	68.92 cde	4.96 defgh	1. 02 a	2.84 ab	41.56 a	26. 07 ef
SVIN109	68.59 cdef	5.26 cdef	0.78 g	2.7 abcd	39.33 ab	28.67 bcd
BR12454-BC2-56-81-27-3-30	80.26 a	5.4 bcde	0.79 fg	2.72 abcd	33.91 bcdef	26.93 cdef
BR 11318-5R-63	71.37 bcde	5.4 bcde	0.94 ab	2.85 ab	39.1 ab	26.3 def
BR12454-BC2-75-32-31-39-7	74.82 b	5.77 abc	0.8 efg	2.83 abc	37.89 abcd	27.72 bcde
BR12454-BC2-69-97-39-5-44	70. 07 cde	5.15 def	0.81 efg	2.32 def	33.12 cdef	28 bcde
BR 11337-5R-72	62.59 hi	5.18 def	0.9 bcd	2.44 bcdef	38.9 abc	27.48 bcde
BR12454-BC2-71-91-6-23-26	64.11 fgh	4.81 fghi	0.88bcde	2.2 f	34.31 bcde	27.55 bcde
IR17A1694	63.93 gh	5.03 defg	0.89 bcd	2.3 fg	32.73 def	27.95 bcde
BRRI dhan28 (Sus. Check)	80.52 a	4.93 efghi	0.83defg	2.24 ef	27.83 fg	24.84 fg
BRRI dhan29 (Tol. Check)	66.96 efgh	4.51 ghi	0.8 efg	1.67 g	24.98 g	28.11 bcde
LSD 5%	4.6	0.56	0.08	0.43	6.13	2.59

Significance differences was recorded for each of internodes in different rice genotypes. Internodes length also depends on season and management issues regarding weather. The top most internodes that bear panicle was considered as the first internode. Significant variation observed in each internodes in the tasted varieties. The range of top internode lengths was from 35.89 cm in BRRI dhan67 to 28.67 cm in BRRI dhan58. Similarly, the 2nd internode range from 14.85 cm BR 11337-5R-72 to 23.55 cm in BRRI dhan67. As the same trend BRRI dhan61 has shortest 3rd internode 7.11 cm and largest internode length 17. 07 cm in BR12454-BC2-56-81-27-3-30. In case 4th internode 8.52 cm observed in advanced lines BR12454-BC2-56-81-27-3-30 and lowest 3.56 cm in BRRI dhan61. Due to lowst 3rd and 4th internode length BRRI dhan47, BRRI dhan58, BRRI dhan61, BRRI dhan89, BRRI dhan96, IR17A1694 has lodging tolerance capacity (**Fig. 6.5.3)**.

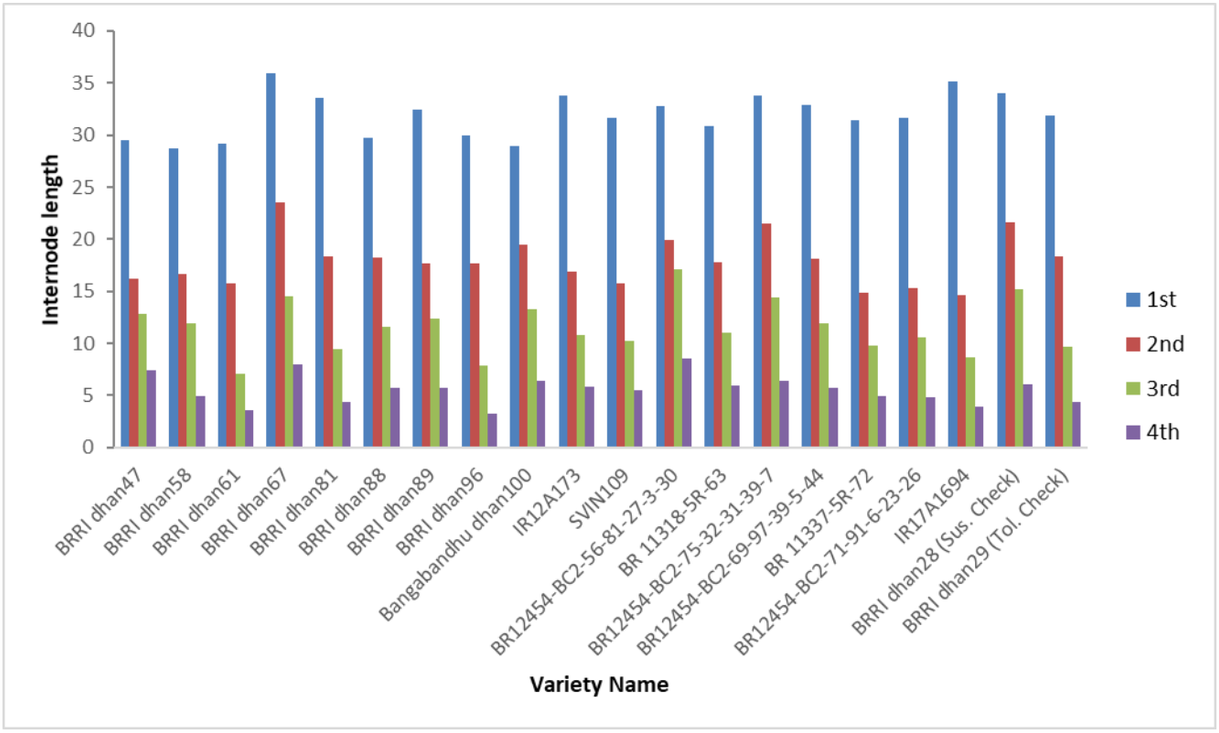

Fig. 6.5.3. Visible internode length of tested genotypes.

Outer layer thickness was not statistically significant among all the tasted genotypes. Others all anatomical parameters was statistically significant. Number of inner or large vascular bundle was statistically significant among the tested genotypes. Highest inner VB observed in SVIN109 and lowest in susceptible check BRRI dhan28. Number of small or outer vascular bundle was highest (32.0) in BRRI dhan89 and lowest 26.33 in susceptible check variety BRRI dhan28. No lacunae or air space present in BRRI dhan61 and BRRI dhan96. Highest number of lacunae present in line IR12A173. Due to highest no of outer and inner VB plants has lodging tolerant capacity but lacunae present in the stem weaken stem strength (**Table 6.5.3, Fig. 6.5.4 and Fig. 6.5.5**).

Table 6.5.3. Anatomical data of tested genotypes. Each data is average of three sample and three replications.

Name of the genotypes	**Outer layer thickness (mm)**	**No. of inner Vascular Bundle**	**No. of outer Vascular Bundle**	**No. of lacuna**
BRRI dhan47	0.017 b	29.67c defg	28.33cdef	8.0 bcde
BRRI dhan58	0.017 b	33.00 b	28.67bcdef	21.78 a
BRRI dhan61	0.02 b	28.67defg	28.33cdef	0.0 e
BRRI dhan67	0.02 b	28.67defg	28.67bcdef	8.33 bcde
BRRI dhan81	0.02 b	32.00bc	31.67a	23.78 a
BRRI dhan88	0.02 b	29.00defg	27.67ef	16.11 abc
BRRI dhan89	0.02 b	32.0a	32.0a	19.00 ab
BRRI dhan96	0.027a	30.0°Cdefg	28.33cdef	0.0 e
Bangabandhu dhan100	0.02b	31.00bcd	26.67ef	7.34 bcde
IR12A173	0.02b	30.67bcde	27.00ef	25.67 a
SVIN109	0.02 b	36.00 a	30.33 abcd	4.22 cde
BR12454-BC2-56-81-27-3-30	0.017 b	32.00 bc	31.00 ab	16.00 abc
BR 11318-5R-63	0.020 b	28.33 efg	28.67 bcdef	7.11 bcde
BR12454-BC2-75-32-31-39-7	0.02 b	29.0 defg	30.67 abc	4.89 cde
BR12454-BC2-69-97-39-5-44	0.02 b	29.67 cdefg	29.00 bcde	3.61 de

Name of the genotypes	Outer layer thickness (mm)	No. of inner Vascular Bundle	No. of outer Vascular Bundle	No. of lacuna
BR 11337-5R-72	0.020 b	28.00f g	28.00 def	23.00 a
BR12454-BC2-71-91-6-23-26	0.02 b	29.00 defg	30.33 abcd	14.33 abcd
IR17A1694	0.017 b	30.67 bcde	28.67bcdef	9.33 bcde
BRRI dhan28 (Sus. Check)	0.02 b	27.67 g	26.33 f	17.78 ab
BRRI dhan29 (Tol. Check)	0.02 b	30.33 cdef	27.33 ef	8.67 bcde
LSD (5%)	0.004	2.63	2.47	12.05

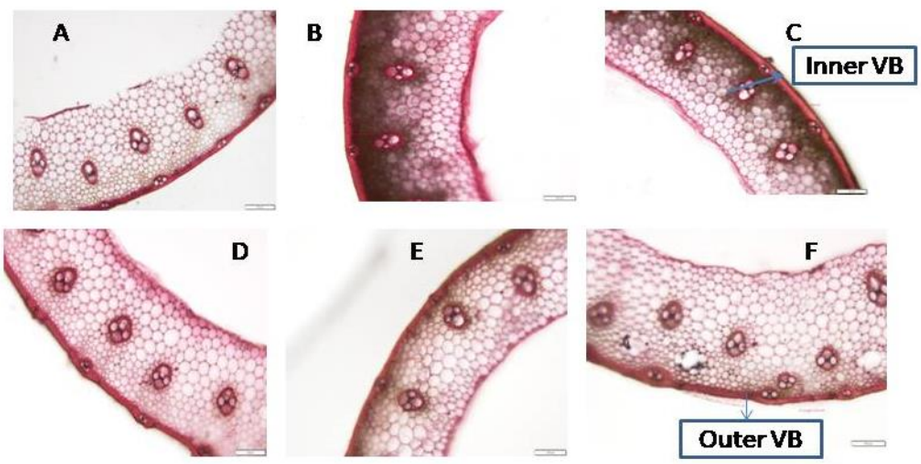

Fig. 6.5.4: Anatomical structure of A) BRRI dhan29, B) BRRI dhan61, C) BRRI dhan96, D) SVIN109, E) BR11318-5R-63, F) BRRI dhan58 showing lodging tolerant characteristics in the 4th internode.

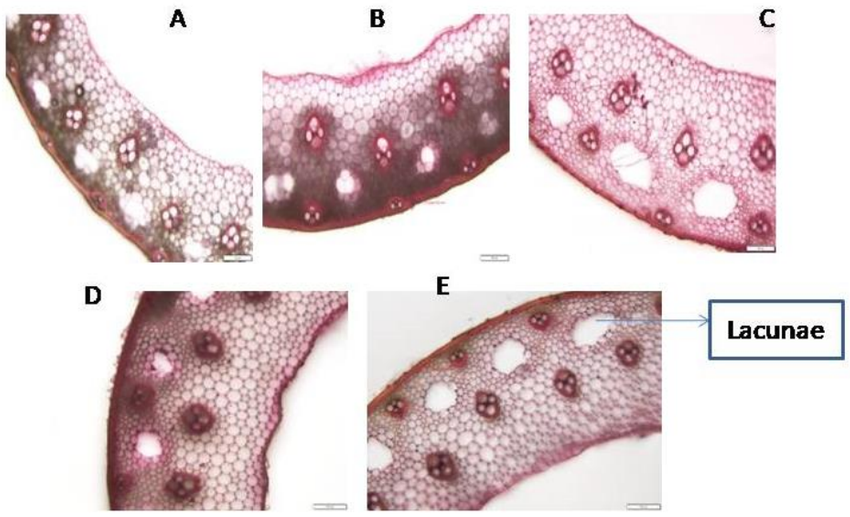

Fig. 6.5.5: Anatomical structure of A) BRRI dhan28, B) BRRI dhan67, C) BRRI dhan88, D) Bangabandhu dhan100, E) BR12454-BC2-56-81-27-3-30 sowing lodging susceptible characteristics in the 4th internode.

Conclusion: Compared with check variety results revealed that BRRI dhan96, BRRI dhan89, BRRI dhan81, BRRI dhan61, BRRI dhan58, BRRI dhan47, SVIN109, BR11318-5R-63, IR17A1694 has lodging resistance capacity in various aspect of morphological and anatomical lodging parameters**.** The study has provided a database of canopy character and lodging concerned morphological parameters of BRRI developed T. Aman varieties. All the tested

variety has wider genetic variability, by using this variability we have enough possibility to improve our plant type by successful breeding programs.

Expt. 6.6: Partitioning of dry matter and growth rates at different phenophases in two long duration rice varieties with variable doses of nitrogen

[1]Salma Akter, [1]Sadia Afrin Shupta, [2]ATM Sakhawat Hossain and [1]Mst. Salma Pervin
[1]Plant Physiology Division and [2]Soil Science Division

Introduction: Rice growth is apparently influenced by many factors throughout its lifecycle. Nutrient limitation is one of them. Among various nutrients, nitrogen plays a pivotal role for rice growth and development. But, for the enhancement of nitrogen use efficiency require the increment of N uptake, utilization and harvest index which involves many crop physiological mechanisms and agronomic characters. It is the most yield-limiting nutrient in lowland rice production all around the world (Fageria *et al*., 2001). Nitrogen is involved in all the metabolic processes in plants and about 75% of leaf N is associated with chloroplast, which are essential for dry matter production during photosynthesis (Mae, 1997). Nitrogen requirement is higher in rice than that of other nutrients. High nitrogen availability to the plant has been associated with increase in plant height, high chlorophyll content and leads to increase productivity (Arima, 1995). Moreover nitrogen is the important source to increase the dry matter production which ultimately partitioned into the grain yield. Therefore, the present study was undertaken to investigate the effect of variable levels of nitrogen on dry matter accumulation and partitioning of rice varieties at different growth period and to observe the response of different N levels on growth rate at different period.

Materials and Method: A field experiment was conducted at West byde Bangladesh Rice Research Institute during Boro, 2022-2023. Two long duration varieties BRRI dhan29 and BRRI dhan89 were tested under different doses of nitrogen as N_0, N_{40}, N_{80}, N_{120}, N_{160}, N_{200}.The experiment was conducted in RCB design with three replications. The recommended dose of other fertilizer (P-K-S-Zn) was applied at the rate of 12-60-10-1 kg/ha. All the fertilizer was applied as basal dose except nitrogen which was applied as top dressed at three splits. Forty days old seedling were transplanted on January, 2022 with the planting geometry of 20 cm × 20 cm. Nine plants were taken randomly from each plots as representative sample for dry matter production and other growth parameter data at 15 days interval. The samples were cleaned, separated into leaves, culm, and panicle and then oven-dried at 70 ºC until a constant weight is obtained and dry weight of leaves, culm and panicle were recorded separately. Total dry weight was calculated as the sum of dry weights of the plant components. At harvest yield data was recorded. The data on different physiological parameters of rice varieties were determined using the following formulae:

$$Leaf\,areaindex(LAI) = \frac{Leaf\,Area\ (A)}{GroundArea\ (P)}$$

Watson (1952)

$$Crop\ growth\ rate(CGR) = \frac{W2 - W1}{P(T2 - T1)}\, g\ m^{-2} day^{-1}$$

Watson (1952)

Where,

W1 = Dry weight of plant m-^{2} at time T1

W2 = Dry weight of plant m^{-2} at time T2

P = Ground area (m2)

T1 and T2 are the two consecutive time period

$$Relative\ growth\ rate\ (RGR) = \frac{LnW2 - LnW1}{T2 - T1}\, g\ g^{-1} day^{-1}$$

Watson (1952)

Where,

W1 = Dry weight of plant m^{-2} at time T1

W2 = Dry weight of plant m^{-2} at time T2

Ln = Natural log
T1 and T2 are the two consecutive time period

$$Net\ assimilation\ rate\ (NAR) = \frac{W2 - W1}{T2 - T1} \times \frac{1}{LA}$$

Where,
W1 = Dry weight of plant m^{-2} at time T1
W2 = Dry weight of plant m^{-2} at time T2
T1 and T2 are the two consecutive time period
LA= Leaf area

Results: Dry matter accumulation is important factor for grain yield production. The enhancement of rice yield potentiality might come from the increased dry matter production. Total dry matter production varied significantly due to the effect of N-levels at different growth stages. Total dry matter production (TDM) increased progressively with the increase of growth stages and N-levels. At 30 DAT the highest culm dry matter was obtained with $N_{80,}$ N_{160} and N_{200}. Culm dry matter at N_0, N_{40} and N_{120} level was similar. At nitrogen level N_{80}, N_{160} and N_{200} leaf dry matter production was highest. At 60 DAT, culm and leaf dry matter production was higher in N_{200} followed by N_{160} than other treatment. However, leaf dry matter was the lowest at N_0 followed by N_{40} level. At 75 DAT the highest culm dry matter was obtained with N_{160} and N_{200}. Leaf dry matter was highest under the treatment$N_{200.}$ At nitrogen level N_0 lowest culm and leaf dry matter was observed.

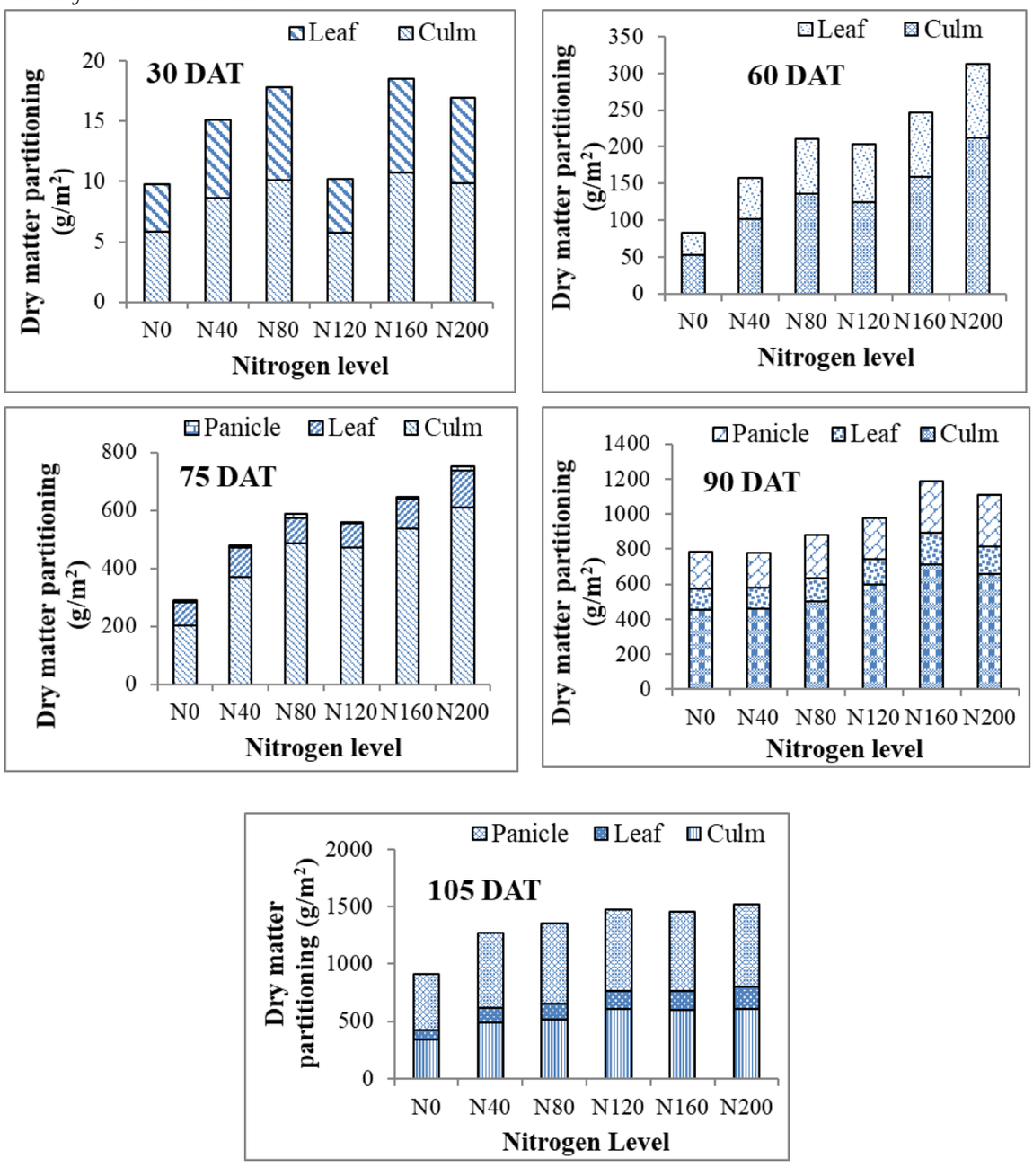

Fig. 6.6.1: Dry matter partitioning (g/m^2) in rice at different days after transplanting.

Leaf and culm dry matter was similar at nitrogen level N_{80} and N_{120} at this stage. At this stage panicle weight was higher in the treatments with N_{80} nitrogen level. However, lowest panicle weight was obtained with nitrogen level N_{120}.At 90 DAT leaf, culm and panicle dry matter production was higher in nitrogen level N_{160} and N_{200}.At 105 DAT leaf and culm dry matter production decreased for all treatments. However, panicle dry weight was similar at this stage. The rapid growth of dry matter at the higher nitrogen level may be due to the robust growth of plants (**Fig. 6.6.1**).

Correlation studies of TDM with grain yield: From the figure it is stated that total dry matter production at 60 DAT, 75 DAT, 90 DAT and 105 DAT were positively correlated with the grain yield of the tested rice varieties which indicates that grain yield was greatly influenced by total dry matter production (**Fig. 6.6.2**).

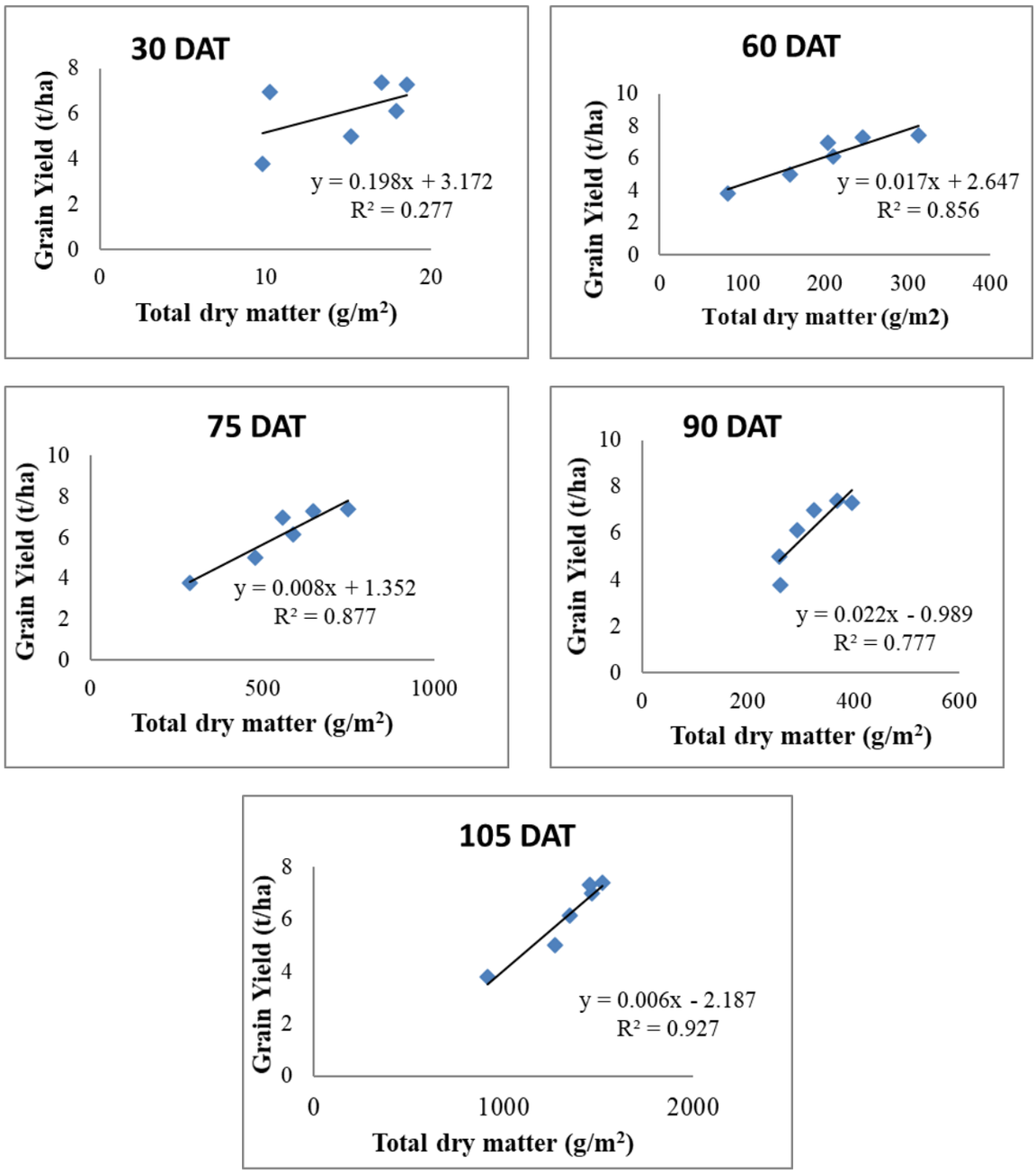

Fig. 6.6.2: Relationship between total dry matter production and grain yield in rice at different days after transplanting.

Leaf area index (LAI): Leaf area index is important physiological parameters which accounts for the production of photosynthate and finally determines crop yield because it influences the light interception by the crop canopy (Fageria *et al.*, 2006). Interaction effect of variety and nitrogen level for leaf area index was insignificant. The average leaf area index (LAI) of the rice increased gradually up to 60 DAT and thereafter it increased sharply reaching a peak value at 90

DAT that is heading or flowering, but there after it decreased gradually towards maturity due to senescence of leaves. The LAI of rice increases as crop growth advances and reaches a maximum at about heading or flowering (Yoshida, 1981). Leaf area index was higher in nitrogen level N_{80}, N_{160} and N_{200} at 30 DAT, 75 DAT and 90 DAT irrespective of varieties. At maturity stage N_{200} produced the highest leaf area index. Higher leaf area index may be due to the higher number of leaves and increased leaf area. Navinkumar *et al*., (2018) also reported that the higher LAI was associated with the increased tiller production and size of the leaves (**Table 6.6.1**).

Table 6.6.1: Leaf area index of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	**Leaf area index (LAI)**				
	30 DAT	**60 DAT**	**75 DAT**	**90 DAT**	**105 DAT**
Varieties					
V1-BRRI dhan29	0.05	0.87	1.42	1.68	1.09
V2-BRRI dhan89	0.06	0.86	1.41	1.51	0.59
SEd ±	0.01	0.71	0.11	0.11	0.16
CD. at 5%	NS	NS	NS	0.22	0.01
Nitrogen (N) (kg/ha)					
N_0	0.03	0.32	1.12	1.21	0.54
N_{40}	0.05	0.65	1.37	1.26	1.00
N_{80}	0.07	0.92	1.54	1.65	0.98
N_{120}	0.02	1.05	1.37	1.96	1.07
N_{160}	0.08	0.91	1.48	1.53	1.09
N_{200}	0.06	1.33	1.62	1.98	1.45
SEd ±	0.017	1.23	0.20	0.19	0.28
CD. at 5%	0.035	NS	0.41	0.39	0.59
Interaction (V × N)					
SEd ±	0.024	2.46	0.28	0.27	0.40
CD. at 5%	NS	NS	NS	NS	NS

Crop growth rate (CGR): Insignificant interaction was present between variety and nitrogen level for this trait. Crop growth rate was very minimum at the initial stage as 0-30 DAT which increased gradually towards the ongoing growth stages. It reached to peak at flowering stage and then decreased gradually to 90-105 DAT as harvest. Higher crop growth rate was obtained with nitrogen level N_{120}, N_{160} and N_{200} at 0-30 DAT. At 30-60 DAT and 60-75 DAT highest crop growth rate was observed in N_{160} and N_{200} nitrogen level. However, at 90-105 DAT highest CGR was found in N_{160} and N_{200} followed by N_{80} and N_{120}. The higher CGR may be due to the higher LAI produced by this nitrogen level. Lower CGR in the initial growth stage appears to be mainly due to low leaf area, while higher CGR at flowering and grain development stages may be due to higher LAI and decrease in CGR towards maturity may be attributed to decrease in leaf area as a result of senescence of leaves (Sridhar *et al*., 2019) (**Table 6.6.2**).

Table 6.6.2: Crop growth rate of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	**Crop growth rate (g m^{-2} day^{-1})**				
	0-30 DAT	**30-60 DAT**	**60-75 DAT**	**75-90 DAT**	**90-105 DAT**
Varieties					
V1-BRRI dhan29	0.46	6.28	22.4	28.03	23.42
V2-BRRI dhan89	0.52	6.20	23.3	26.77	26.45
SEd ±	0.04	0.58	3.00	4.76	7.53
CD. at 5%	NS	NS	NS	NS	NS
Nitrogen (N) (kg/ha)					
N_0	0.33	2.42	13.8	27.03	8.84
N_{40}	0.50	4.73	21.4	28.15	19.8
N_{80}	0.34	6.42	23.5	29.94	22.53
N_{120}	0.59	6.44	23.7	37.90	22.78
N_{160}	0.61	7.58	26.7	32.84	25.94
N_{200}	0.56	9.86	28.2	32.84	25.30
SEd ±	0.07	1.00	5.20	13.05	8.25
CD. at 5%	0.14	2.06	10.73	NS	17.02
Interaction (V × N)					

Treatments	Crop growth rate (g m^{-2} day^{-1})				
	0-30 DAT	**30-60 DAT**	**60-75 DAT**	**75-90 DAT**	**90-105 DAT**
SEd ±	0.11	1.43	7.36	11.66	18.46
CD. at 5%	NS	NS	NS	NS	NS

Net assimilation rate (NAR): NAR is the increase in plant dry mass per unit leaf area per unit time. It is the physiological potential for converting the total dry matter into grain yield. The interaction effect of variety and nitrogen level was not significant. Significant influence of nitrogen level was only observed for net assimilation rate at 0-30 DAT and 75-90 DAT. At 0-30 DAT and 75-90 DAT highest NAR was observed in N_{120} nitrogen level followed by N_{160} and N_{200}. NAR was low at initial growth stage that is 0-30 DAT. Then it increased linearly upto 75-90 DAT. Finally it dropped to maturity that is 90-105 DAT for all treatments. The higher NAR with the growth stages was due to higher LAI and dry matter production with those stages (**Table 6.6.3**).

Table 6.6.3: Net assimilation rate of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	Net assimilation rate (g m^{-2} day^{-1})				
	0-30 DAT	**30-60 DAT**	**60-75 DAT**	**75-90 DAT**	**90-105 DAT**
Varieties					
V1-BRRI dhan29	0.0010	0.0007	0.0016	0.0016	0.001
V2-BRRI dhan89	0.0009	0.0008	0.0016	0.0022	0.001
SEd ±	0.001	0.001	0.001	0.001	0.001
CD. at 5%	0.002	NS	NS	0.002	NS
Nitrogen (N) (kg/ha)					
N_0	0.0007	0.0007	0.0012	0.0012	0.0006
N_{40}	0.0009	0.0007	0.0015	0.0015	0.0018
N_{80}	0.0008	0.0007	0.0016	0.0014	0.0016
N_{120}	0.001	0.0006	0.0017	0.0019	0.0010
N_{160}	0.001	0.0010	0.0020	0.0017	0.0015
N_{200}	0.001	0.0007	0.0017	0.0039	0.0009
SEd ±	0.001	0.001	0.001	0.001	0.001
CD. at 5%	0.002	NS	NS	0.002	NS
Interaction (V × N)					
SEd ±	0.001	0.001	0.001	0.002	0.001
CD. at 5%	NS	NS	NS	NS	NS

Relative growth rate (RGR): The rate at which a plant incorporates new material of dry matter accumulation into its sink is measured by RGR and is expressed in g g^{-1} day^{-1}. Insignificant interaction effect of variety and nitrogen level was observed for this trait. RGR was maximum at 30-60 DAT and then it was decreased gradually towards growth stages and become very low to maturity stage that is 90-105 DAT. Maximum RGR was obtained with nitrogen level N_{200} and for other treatments RGR was statistically similar except N_0. Maximum RGR at 30-60 DAT was mainly due to the higher accumulation of photosynthetic biomass started and then it tend to decrease towards growth stages due to the incretion of non photosynthetic biomass. Moreover, the decrease in RGR is attributed for several reasons *viz*., non photosynthetic biomass increases, the top leaves of a plant began to shade lower leaves and soil nutrients become limiting (Sridhar *et al*., 2019) (**Table 6.6.4**).

Table 6.6.4: Relative growth rate of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	Relative growth rate (g g^{-1} day^{-1})			
	30-60 DAT	**60-75 DAT**	**75-90 DAT**	**90-105 DAT**
Varieties				
V1-BRRI dhan29	0.08	0.068	0.040	0.021
V2-BRRI dhan89	0.08	0.069	0.037	0.023
SEd ±	0.004	0.007	0.006	0.007
CD. at 5%	NS	NS	NS	NS
Nitrogen (N) (kg/ha)				
N_0	0.07	0.056	0.027	0.012

Treatments	Relative growth rate (g g^{-1} day^{-1})			
	30-60 DAT	60-75 DAT	75-90 DAT	90-105 DAT
N_{40}	0.07	0.075	0.032	0.032
N_{80}	0.08	0.065	0.031	0.026
N_{120}	0.09	0.068	0.046	0.018
N_{160}	0.08	0.066	0.031	0.022
N_{200}	0.09	0.084	0.064	0.021
SEd ±	0.007	0.011	0.011	0.012
CD. at 5%	0.014	0.022	0.022	NS
Interaction (V × N)				
SEd ±	0.009	0.016	0.015	0.016
CD. at 5%	NS	NS	NS	NS

Grain yield (t/ha): Grain yield had significant effect for nitrogen level. However, interaction effect was observed insignificant for this trait. The highest grain yield was produced at nitrogen level N_{120}, N_{160} and N_{200} where as the lowest yield production was obtained with nitrogen level N_0 (**Fig. 6.6.3**).

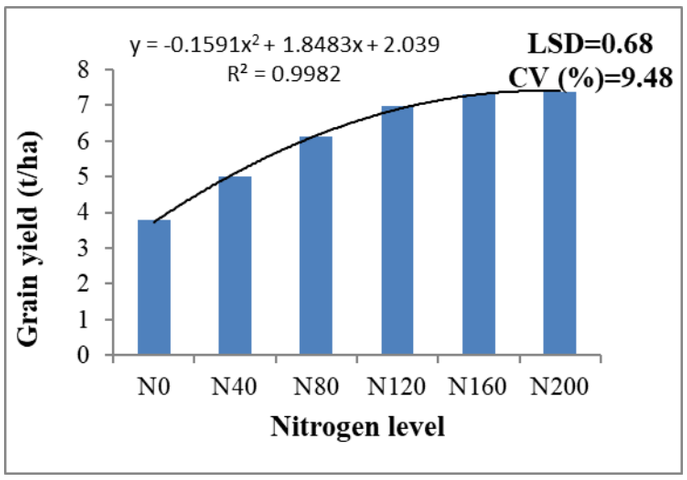

Fig. 6.6.3: Grain yield production at variable nitrogen level.

Conclusions: The experimental results revealed that higher dry matter partitioning of leaf, culm and panicle were obtained with nitrogen level N_{200} and N_{160} at all growth stages. Total dry matter production showed strong relationship with grain yield. Results also revealed that growth parameters as LAI, CGR and NAR were minimum at initial stage and reached to peak at 75-90 DAT. Nitrogen level N_{160} and N_{200} exhibited best performance in relation to its physiological growth parameters which in turn resulted in higher grain followed by N_{120}.

Expt. 6.7: Partitioning of dry matter and growth rates at different phenophases in two short duration rice varieties with variable doses of nitrogen

[1]Salma Akter, [1]Sadia Afrin Shupta, [2]ATM Sakhawat Hossain and [1]Mst. Salma Pervin
[1]Plant Physiology Division and [2]Soil Science Division

Materials and Method: A field experiment was conducted at West byde Bangladesh Rice Research Institute during Boro, 2022-2023. Two short duration varieties as BRRI dhan81 and BRRI dhan88 were tested under different doses of nitrogen as N_0, N_{30}, N_{60}, N_{90}, N_{120}, N_{150}. The experiment was conducted in RCB design with three replications. The recommended dose of other fertilizer (P-K-S-Zn) was applied at the rate of 12-60-10-1 kg/ha. All the fertilizer was applied as basal dose except nitrogen which was applied as top dressed at three splits. Forty days old seedling were transplanted on January, 2022 with the planting geometry of 20 cm × 20 cm. Nine plants were taken randomly from each plots as representative sample for dry matter production and other growth parameter data at 15 days interval. The samples were cleaned, separated into leaves, culm, and panicle and then oven-dried at 70 ºC until a constant weight is obtained and dry weight of leaves, culm and panicle were recorded separately. Total dry weight

was calculated as the sum of dry weights of the plant components. At harvest yield data was recorded. The data on different physiological parameters of rice varieties were determined using the following formulae:

$$Leaf areaindex(LAI) = \frac{Leaf Area\ (A)}{GroundArea\ (P)}$$

Watson (1952)

$$Crop\ growth\ rate(CGR) = \frac{W2 - W1}{P(T2 - T1)} g\ m^{-2} day^{-1}$$

Watson (1952)

Where,

W1 = Dry weight of plant m-^{2} at time T1

W2 = Dry weight of plant m^{-2} at time T2

P = Ground area (m2)

T1 and T2 are the two consecutive time period

$$Relative\ growth\ rate\ (RGR) = \frac{LnW2 - LnW1}{T2 - T1} g\ g^{-1} day^{-1}$$

Watson (1952)

Where,

W1 = Dry weight of plant m^{-2} at time T1

W2 = Dry weight of plant m^{-2} at time T2

Ln = Natural log

T1 and T2 are the two consecutive time period

$$Net\ assimilation\ rate\ (NAR) = \frac{W2 - W1}{T2 - T1} \times \frac{1}{LA}$$

Where,

W1 = Dry weight of plant m^{-2} at time T1

W2 = Dry weight of plant m^{-2} at time T2

T1 and T2 are the two consecutive time period

LA= Leaf area

Results: Dry matter accumulation is important factor for grain yield production. The enhancement of rice yield potentiality might come from the increased dry matter production. Total dry matter production varied significantly due to the effect of N-levels at different growth stages. Total dry matter production (TDM) increased progressively with the increase of growth stages and N-levels.

Insignificant interaction effect was found in culm, leaf and panicle dry matter production for different growth stages. Significant effect was observed only for different nitrogen level. At 30 DAT the highest culm and leaf dry matter was obtained withN_{150}. Culm dry matter at N_{30}, N_{60} N_{90} and N_{120} level was similar. Lowest culm and leaf dry matter was produced by N_0. At 60 DAT, culm and leaf dry matter production was higher in N_{150} followed by N_{120} than other treatment. However, culm and leaf dry matter was the lowest at N_0 followed by N_{30} level.At 75 DAT the highest culm dry matter was obtained with N_{150} and N_{120}. Culm dry matter was statistically similar at nitrogen level N_{60} and N_{90}. However, lowest culm dry matter was found in N_{30} and N_0. Leaf dry matter was highest under the treatmentN_{150} followed by N_{120} and N_{90}.Lowest leaf dry matter was observed in nitrogen level N_0 followed by N_{30} and N_{60}. At this stage panicle weight was higher in the treatments with N_{150} nitrogen level. However, lowest panicle weight was obtained with nitrogen level N_0. At 90 DAT, culm dry matter production was higher in nitrogen level N_{150} which was statistically similar with N_{120} and N_{90}. Leaf and panicle dry matter production was observed highest in N_{150} followed by N_{120}. The rapid growth of dry matter at the higher nitrogen level may be due to the robust growth of plants (**Fig. 6.7.1**).

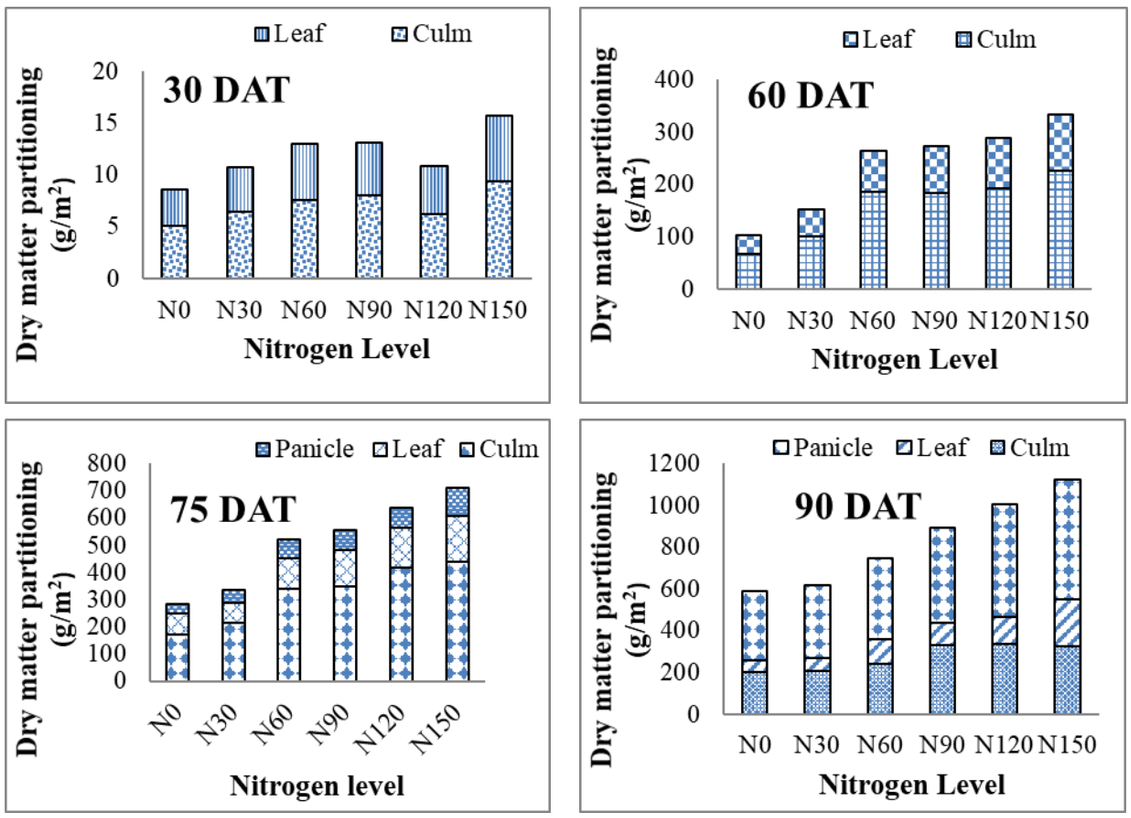

Fig. 6.7.1: Dry matter partitioning (g/m^2) in rice at different days after transplanting.

Correlation studies of TDM with grain yield: From the figure it is stated that total dry matter production at 30 DAT, 60 DAT, 75 DAT and 90 DAT were positively correlated with the grain yield of the tested rice varieties which indicates that grain yield was greatly influenced by total dry matter production (**Fig. 6.7.2**).

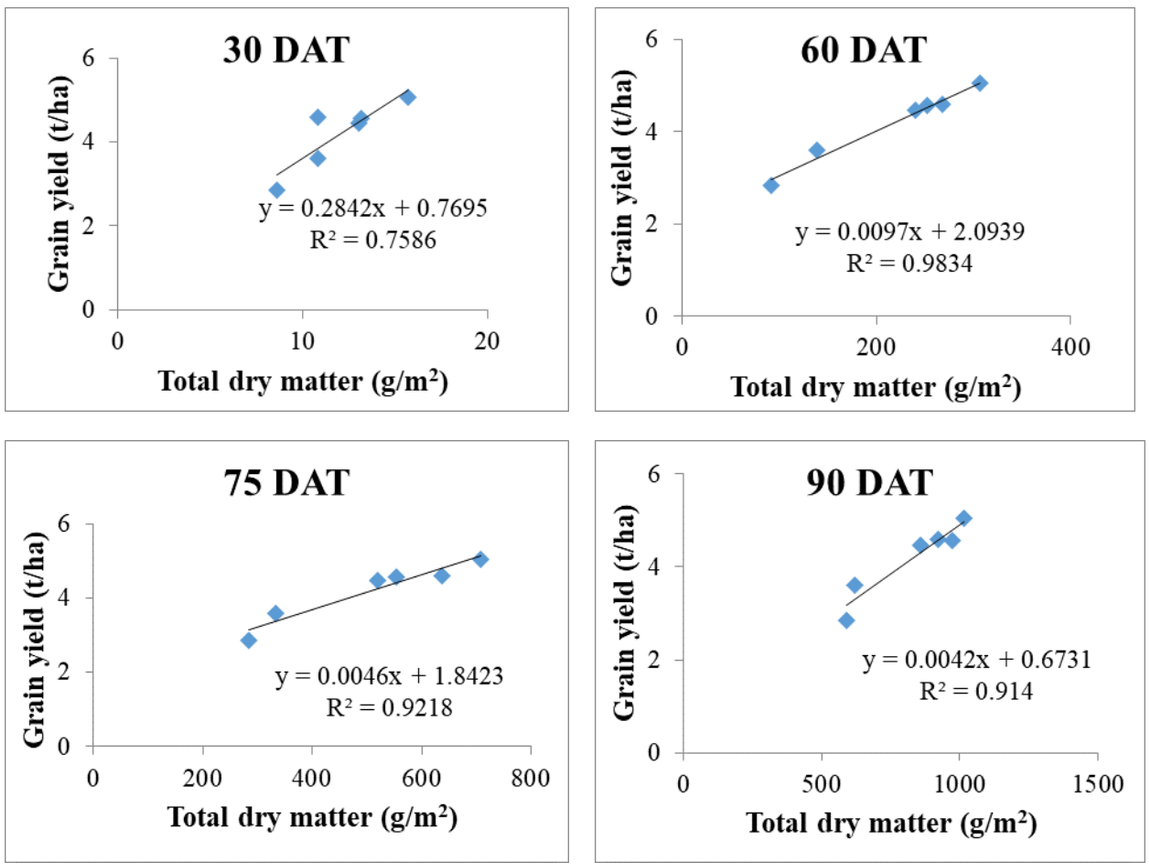

Fig. 6.7.2: Relationship between total dry matter production and grain yield in rice at different days after transplanting.

Leaf area index (LAI): Leaf area index is important physiological parameters which accounts for the production of photosynthate and finally determines crop yield because it influences the light interception by the crop canopy (Fageria *et al.,* 2006). Interaction effect of variety and nitrogen level for leaf area index was insignificant for all growth stage except 90 DAT. The average leaf area index (LAI) of the rice increased gradually up to 60 DAT and thereafter it increased sharply reaching a peak value at 75 DAT that is heading or flowering, but there after it decreased gradually towards maturity due to senescence of leaves. The LAI of rice increases as crop growth advances and reaches a maximum at about heading or flowering (Yoshida, 1981). Significant effect of nitrogen level was found for all growth stages except 30 DAT. Leaf area index was higher in nitrogen level N_{150}, N_{120} and N_{90} andN_{60} at 60 DAT, 75 DAT and 90 DAT irrespective of varieties. At maturity stage N_{120} and N_{150} produced the highest leaf area index. Higher leaf area index may be due to the higher number of leaves and increased leaf area. Navinkumar *et al*., (2018) also reported that the higher LAI was associated with the increased tiller production and size of the leaves (**Table 6.7.1**).

Table 6.7.1: Leaf area index of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	**Leaf area index (LAI)**			
	30 DAT	**60 DAT**	**75 DAT**	**90 DAT**
Varieties				
V1-BRRI dhan81	0.05	1.05	2.09	1.36
V2-BRRI dhan88	0.06	1.18	2.19	0.67
SEd ±	0.01	0.089	0.253	0.147
CD. at 5%	NS	NS	NS	0.303
Nitrogen (N) (kg/ha)				
N_0	0.05	0.43	1.03	0.50
N_{30}	0.07	0.79	1.23	0.44
N_{60}	0.07	1.09	2.01	0.62
N_{90}	0.05	1.39	2.59	1.23
N_{120}	0.05	1.29	2.83	1.79
N_{150}	0.07	1.69	3.17	1.52
SEd ±	0.018	0.154	0.439	0.255
CD. at 5%	NS	2.06	0.90	0.526
Interaction (V × N)				
SEd ±	0.025	0.218	0.62	0.36
CD. at 5%	NS	NS	NS	0.743

Crop growth rate (CGR): Insignificant interaction was present between variety and nitrogen level for this trait. Crop growth rate was very minimum at the initial stage as 0-30 DAT which increased gradually towards the growth stages. It reached to peak at flowering stage and then decreased gradually to 75-90 DAT as harvest. Higher crop growth rate was obtained with nitrogen level N_{120}, N_{160} and N_{200} at 0-30 DAT. Significant effect of nitrogen level was found for 30-60 DAT and 60-75 DAT. At 30-60 DAT and 60-75 DAT highest crop growth rate was observed in N_{120} and N_{150} nitrogen level. However, at 75-90 DAT CGR decreased drastically. Higher CGR may be due to the higher LAI produced by this nitrogen level. Lower CGR in the initial growth stage appears to be mainly due to low leaf area, while higher CGR at flowering and grain development stages may be due to higher LAI and decrease in CGR towards maturity may be attributed to decrease in leaf area as a result of senescence of leaves (Sridhar *et al*., 2019) (**Table 6.7.2**).

Table 6.7.2: Crop growth rate of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	**Crop growth rate (g m^{-2} day^{-1})**			
	0-30 DAT	**30-60 DAT**	**60-75 DAT**	**75-90 DAT**
Varieties				
V1-BRRI dhan81	0.36	6.91	17.50	0.03
V2-BRRI dhan88	0.44	7.98	18.64	0.03
SEd ±	0.047	0.481	2.812	0.006

Treatments	Crop growth rate (g m^{-2} day^{-1})			
	0-30 DAT	**30-60 DAT**	**60-75 DAT**	**75-90 DAT**
CD. at 5%	NS	0.992	NS	NS
Nitrogen (N) (kg/ha)				
N_0	0.34	3.62	14.15	0.03
N_{30}	0.38	8.46	20.20	0.04
N_{60}	0.48	8.51	15.71	0.02
N_{90}	0.30	4.22	10.02	0.03
N_{120}	0.49	10.35	25.28	0.03
N_{150}	0.40	9.50	23.06	0.03
SEd ±	0.082	0.833	4.871	0.01
CD. at 5%	NS	1.719	10.05	NS
Interaction (V × N)				
SEd ±	0.116	1.178	6.888	0.014
CD. at 5%	NS	NS	NS	NS

Net assimilation rate (NAR): NAR is the increase in plant dry mass per unit leaf area per unit time. It is the physiological potential for converting the total dry matter into grain yield. The interaction effect of variety and nitrogen level was not significant. Significant influence of nitrogen level was only observed for net assimilation rate at 75-90 DAT. At 75-90 DAT highest NAR was observed in N_{60} nitrogen level followed by N_{120} and N_{150}. NAR was low at initial growth stage that is 0-30 DAT and 30-60 DAT. Then it increased linearly upto 60-75 DAT. Finally it dropped to maturity that is 75-90 DAT for all treatments. The Higher NAR with the growth stages was due to higher LAI and dry matter production with those stages (**Table 6.7.3**).

Table 6.7.3: Net assimilation rate of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	Net assimilation rate (g m^{-2} day^{-1})			
	0-30 DAT	**30-60 DAT**	**60-75 DAT**	**75-90 DAT**
Varieties				
V1-BRRI dhan81	0.00067	0.00078	0.00097	0.0031
V2-BRRI dhan88	0.00076	0.00062	0.00088	0.0035
SEd ±	0.00	0.00	0.00	0.001
CD. at 5%	NS	0.00	NS	NS
Nitrogen (N) (kg/ha)				
N_0	0.00066	0.00070	0.00135	0.0020
N_{30}	0.00073	0.00068	0.00090	0.0030
N_{60}	0.00083	0.00080	0.00093	0.0073
N_{90}	0.00076	0.00066	0.00098	0.0040
N_{120}	0.00066	0.00078	0.00071	0.0050
N_{150}	0.00065	0.00058	0.00070	0.0050
SEd ±	0.00	0.00	0.00	0.001
CD. at 5%	NS	NS	NS	0.002
Interaction (V × N)				
SEd ±	0.00	0.00	0.00	0.002
CD. at 5%	NS	NS	NS	NS

Relative growth rate (RGR): The rate at which a plant incorporates new material of dry matter accumulation into its sink is measured by RGR and is expressed in g g^{-1} day^{-1}. Insignificant interaction effect of variety and nitrogen level was observed for this trait. RGR was maximum at 30-60 DAT and then it was decreased gradually towards 60-75 DAT. After that it become very low to maturity stage that is 75-90 DAT. Maximum RGR was obtained with nitrogen level $N_{150,}$ $N_{120,}$ N_{60} and N_{30}. Maximum RGR at 30-60 DAT was mainly due to the higher accumulation of photosynthetic biomass started and then it tend to decrease towards growth stages due to the incretion of non-photosynthetic biomass (**Table 6.7.4**).

Grain yield (t/ha): Grain yield had significant effect for nitrogen level. However, interaction effect was observed insignificant for this trait. The highest grain yield was produced at nitrogen level N_{150} followed by $N_{120,}$ N_{90} and $N_{60}$where as the lowest yield production was obtained with nitrogen level N_0 (**Fig. 6.7.3**).

Table 6.7.4: Relative growth rate of rice as influenced by varieties and nitrogen levels at different DAT

Treatments	Relative growth rate (g g^{-1} day^{-1})		
	30-60 DAT	60-75 DAT	75-90 DAT
Varieties			
V1-BRRI dhan81	0.09	0.05	0.03
V2-BRRI dhan88	0.09	0.04	0.03
SEd ±	0.004	0.006	0.006
CD. at 5%	NS	NS	NS
Nitrogen (N) (kg/ha)			
N_0	0.08	0.06	0.03
N_{30}	0.10	0.05	0.04
N_{60}	0.10	0.05	0.02
N_{90}	0.08	0.04	0.02
N_{120}	0.10	0.04	0.03
N_{150}	0.10	0.05	0.03
SEd ±	0.008	0.001	0.01
CD. at 5%	0.01	NS	NS
Interaction (V × N)			
SEd ±	0.011	0.015	0.015
CD. at 5%	NS	NS	NS

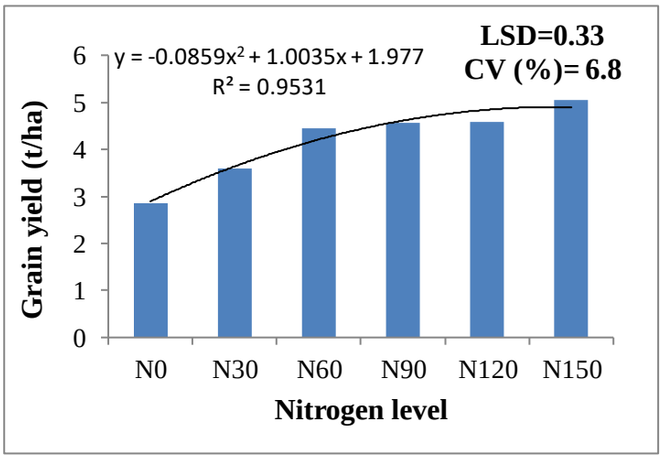

Fig.3: Grain yield production at variable nitrogen level.

Conclusions: The experimental results revealed that higher dry matter partitioning of leaf, culm and panicle were obtained with nitrogen level N_{150} and N_{120} followed by N_{60} and N_{90} at all growth stages. Total dry matter production showed strong relationship with grain yield. Results also revealed that growth parameters as LAI, CGR and NAR were minimum at initial stage and reached to peak at 60-75 DAT. Nitrogen level N_{150} and N_{120} exhibited best performance in relation to its physiological growth parameters which in turn resulted in higher grain followed by N_{60} and N_{90}.

Expt. 6.8: Effect of harvesting time on yield of rice at wet and dry season

Tuhin Halder, Sharifa Sultana Dipti and Mst. Salma Pervin

Rationale: Harvesting time of rice is an important variable which determines the field yield of rice. At unfavorable condition farmers force to harvest their crop very early or late and face them to loss of yield and reduce the grain quality.

Objectives: i. To estimate the yield loss, and **ii.** To assess the change of the grain physico-chemical properties due to early or late harvesting

Materials and methodology: BRRI dhan87 and BRRI dhan88 was used at wet and dry season respectively. Crop was grown in normal environmental condition at Plant Physiology west byde plot. Recommended cultural practices was followed for field management. Six different

Harvesting was done at 21, 25, 29, 33, 37 and 42 days after 50% flowering. Yield and yield loss over different harvesting time with their contributing parameter data was taken. Different grain physico-chemical properties data was generated with help of GQN division of BRRI.

Results:

Yield and Yield Contributing parameter: The yield and all yield contributing parameter data was found statistically significant in both season (**Table 6.8.1**). It was observed that crop mature earlier in dry season than wet season. Highest yield was found between 29 to 33 DAF and 33 to 37 DAF for dry and wet season respectively. A significant yield (about 20-50%) can be reduced due to early harvesting (about 21 to 25 DAF) in wet season (**Fig. 6.8.1**). On the other hand, as the crop matured earlier in dry season, the percentage of reduction in yield was quiet less. It was about 18-28% yield could be reduced if harvesting done at three weeks after flowering. Interestingly, the yield loss was at dry season after optimum harvesting time found similar with wet season. It was observed that, about 12% reduction in field yield when harvesting was done one week later than optimum time. This reduction can be explain with the reduced 1000 grain weight, higher empty grains and lower harvest index in early harvesting. Due to early harvesting the spikelet was not enough matured as well as influence the harvest index and yield. Maximum 1000 grain weight was found after 33 days after flowering for both dry and weight season (21.40 and 24.01g respectively), (**Table 6.8.1**). However, after optimum time of harvesting it had no significant change. Early harvesting also causes increasing in empty grains (highest 40 and 32% in wet and dry season respectively) in 21 DAF which also influenced the yield reduction. The percentage of empty grains gradually decreased as harvesting time forwarding. Among the two season dry season had more empty grain during optimum harvesting time (13 and 18% for wet and dry season respectively).

Grain Physico-chemical Properties: Among the tested physico-chemical properties of the harvested sample Amylose % (both season), protein% (dry season), imbibition ratio (wet season), head rice % (both season), chalkiness and Milled rice length (wet season) was found significant difference among the different harvesting time. The amylose percentage was found lower in early harvesting at wet season (**Table 6.8.2 and 6.8.3**), between 33 DAF to 42 DAF the highest statistically similar amylose percentage was found which ranges from (27.17-27.30 %) but at dry season there is no significant differences in amylose percentage. The protein content was observed higher in BRRI dhan88 than BRRI dhan87. BRRI dhan88 at dry season found lower protein content at early harvesting but there is no significant difference found in BRRI dhan87. There was no significant variation found of milled rice percentage in both season but the head rice percentage was found significantly lower at early harvesting in wet season. On the other hand head rice was gradually decrease over late harvesting. Highest head rice percentage was found at 42 DAF (64.53%) in wet season and at 25 DAF (59.37%) (**Table 6.8.4 and 6.8.5)**. The chalkiness percentage also found significantly lower in early harvesting then gradually increasing over maturation of seed in wet season.

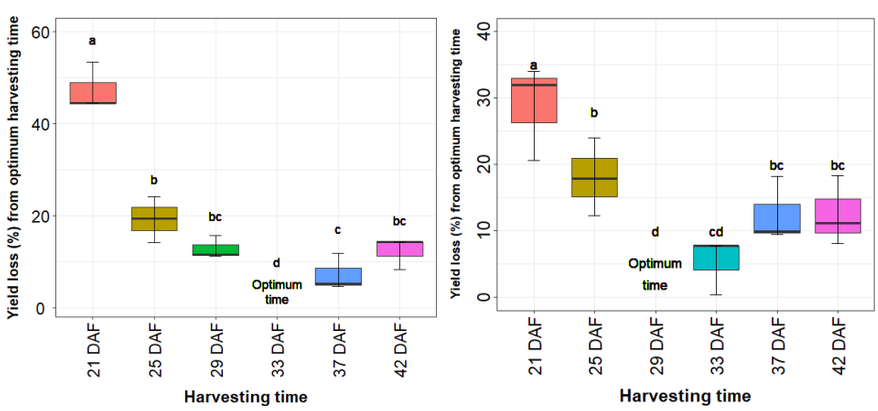

Fig. 6.8.1: Percent reduction in yield due to early and late harvesting than optimum harvesting time. (Figure a and b represents wet and dry season respectively).

Table 6.8.1: Effect of different harvesting time after flowering on yield and yield contributing parameter in wet and dry season

	Wet season (BRRI dhan87)				Dry Season (BRRI Dhan88)			
Harvest Time	**Yield (t/ha)**	**1000gw**	**Harvest Index (%)**	**Sterility (%)**	**Yield (t/ha)**	**1000gw (g)**	**Harvest Index (%)**	**Sterility (%)**
21 DAF	3.19	21.04	35.33	39.71	5.56	18.86	41.18	32.68
25 DAF	4.90	21.30	39.16	24.41	6.40	19.14	43.71	35.37
29 DAF	5.29	22.44	45.14	17.86	7.81	21.11	47.28	25.17
33 DAF	6.08	24.01	47.70	13.03	7.42	21.40	44.59	18.35
37 DAF	5.63	23.92	47.01	8.72	6.83	21.13	44.85	16.47
42 DAF	5.33	23.55	47.83	11.19	6.83	21.14	45.60	14.25
Lebel of significance	***	***	***	***	**	***	***	**
LSD	0.48	0.90	**5.12**	9.23	0.77	0.74	4.16	10.12

Table 6.8.2: Effect of different harvesting time after flowering on some chemical properties in wet season

Wet season (BRRI dhan87)						
Harvest Time	**Alkali Spreading Value**	**Amylose (%)**	**Protein (%)**	**Cooking time (min)**	**Elongation Ratio**	**Imbibition ratio**
21 DAF	3.97	27.00	6.97	17.10	1.47	3.00
25 DAF	4.10	27.00	7.03	17.10	1.40	2.97
29 DAF	4.10	27.03	7.17	17.10	1.43	2.83
33 DAF	4.23	27.17	6.97	17.00	1.47	2.97
37 DAF	3.87	27.20	7.00	17.20	1.50	3.00
42 DAF	4.17	27.30	6.97	17.10	1.50	3.00
Leb. of sig.	ns	*	ns	ns	ns	**
LSD	0.55	0.20	0.25	0.30	0.06	0.86

Table 6.8.3: Effect of different harvesting time after flowering on some chemical properties in dry season

Dry (BRRI Dhan88)						
Harvest Time	**Alkali Spreading Value**	**Amylose (%)**	**Protein (%)**	**Cooking time (min)**	**Elongation Ratio**	**Imbibition ratio**
21 DAF	4.37	26.43	9.80	16.53	1.50	2.93
25 DAF	4.67	26.27	9.73	16.77	1.50	2.90
29 DAF	4.23	26.43	9.60	16.67	1.50	2.97
33 DAF	4.20	26.30	9.70	16.67	1.50	2.93
37 DAF	4.17	26.10	9.50	17.00	1.50	3.07
42 DAF	4.07	26.42	10.20	17.10	1.50	3.03
Leb. of sig.	ns	**	**	ns	ns	ns
LSD	0.45	0.13	0.29	0.92	-	0.17

Table 6.8.4: Effect of different harvesting time after flowering on some physical properties in wet season

Wet season (BRRI dhan87)						
Harvest Time	**Milled Rice (%)**	**Head Rice (%)**	**Chalk (%)**	**Milled rice length L (mm)**	**Milled rice Breadth B (mm)**	**L/B ratio**
21 DAF	67.50	59.47	63.33	6.37	2.03	3.13
25 DAF	67.67	60.93	76.00	6.40	2.03	3.17
29 DAF	68.33	62.07	85.33	6.37	2.03	3.17
33 DAF	68.40	62.77	86.33	6.33	2.00	3.17
37 DAF	68.90	64.07	89.33	6.23	2.00	3.10
42 DAF	68.83	64.53	93.00	6.20	2.00	3.10
Lebel of sig.	ns	***	*	*	ns	ns
LSD	1.07	1.74	15.69	0.11	0.05	0.09

Table 6.8.5: Effect of different harvesting time after flowering on some physical properties in dry season

Dry season (BRRI dhan88)						
Harvest Time	**Milled Rice (%)**	**Head Rice (%)**	**Chalk (%)**	**Milled rice length L (mm)**	**Milled rice Breadth B (mm)**	**L/B ratio**
21 DAF	71.73	58.40	71.33	6.13	2.00	3.10
25 DAF	72.07	59.37	78.67	6.17	2.00	3.10
29 DAF	71.70	56.30	79.00	6.17	2.00	3.10
33 DAF	72.67	59.20	76.00	6.20	2.00	3.10
37 DAF	71.73	46.87	81.00	6.20	2.00	3.13
42 DAF	72.50	29.17	78.67	6.10	2.00	3.10
Lebel of sig.		***	ns	ns	ns	ns
LSD	1.18	4.75	12.47	0.11	-	-

Expt. 6.9: Phenological development of newly released two BRRI varieties in T. Aman season

[1]Munnujan Khanam and [2]Hirendra Nath Barman
[1]CASR, BRRI, [2]Plant Physiology Division

Introduction: Crop phenology is important for choosing cultivars with an appropriate growth period and for determining the timing of management practices such as planting, fertilizer application and harvesting. The accurate rice phenological development stages estimation is also important for rice yield estimation in different climatic condition. During crop growth period, the occurrence of various phenological events can be estimated by computing accumulated growing degree days (Gouri *et. al.*, 2005). Accumulated growing degree days (GDD) provides an estimate of harvest date as well as development stages of crop (Ketring and Wheless, 1989). Various developmental stages as well as harvest date of crop can be estimated from the knowledge of accumulated GDD. Thermal time can be used as a tool for characterizing thermal responses in different crops as it is an independent variable to describe plant development (Dwyer and Stewart, 1986).

The evaluation of phenology plays a pivotal role in assessment of the effects of climate change and the development of adaptation practices. In this study, we investigated the responses of rice phenology and yield to the change in day length as well as growing season. The experiment was conducted to observe the phenological development at different growing season with the following objectives.

i) to observe the phenological development at different growing season
ii) to estimate the genetic co-efficient for crop simulation.
iii) to investigate the duration of different developmental stages of rice varieties when seeded at different time.
iv) to find out the required degree-days for developmental phase of rice.

Materials and Methods

Plant materials: Three rice cultivar BRRI dhan87, BR(Bio)8961-AC26-16 and IR64 were selected to execute the experiment on two different sowing dates. BR(Bio)8961-AC26-16 was an advanced breeding line developed by BRRI which was released later as BRRI dhan103. This study has been conducting in the same field in three seasons. The previous experiment conducted in Boro 2022 occupied the field so only two sowing date was considered for T Aman 2022 season. The first experiment was conducted In Aus 2021 season.

Growing rice plants in the field: We experimented in the Plant Physiology Division's research field located at BRRI farm Gazipur, Bangladesh, during Aman season in 2022. Two different sowing dates were 7 July, 22 July. Seedlings were grown in seedbed. Thirty days old seedlings were transplanted in the field using single seedling per hill at 20×20 cm spacing. The plot size was 3×6 m^2. The study was laid out in RCBD with four replications.

Fertilizers were applied as urea, triple superphosphate, muriate of potash and gypsum at the rate of 165-60-105-67 $kgha^{-1}$ for urea, TSP, MoP and Gypsum respectively. Full doses of triple superphosphate, muriate of potash, and gypsum were incorporated at the final land preparation time. Urea was applied in the three equal splits at 10, 25 days after transplanting and 3rd dose 7 days before PI.

The crop was kept weed free throughout the growth period. Adequate measures were taken to keep the insect infestation to a minimal.

Observations were made on days taken to panicle initiation (PI), days to 50% flowering and days to maturity. For determination of PI stage mother tiller section was done every alternate day from

active tiller stage. Grain yield was measured from an area of $5m^2$ and adjusted to 14% moisture level. Data were subjected to Analysis of Variance (ANOVA) and the means were compared using LSD test.

Plants require a specific amount of heat to develop from one point in their lifecycle to another, such as from sprouting of seed to the PI stage. Measuring the heat accumulated over time provides a more accurate physiological estimate than counting calendar days. "Growing degree days" (abbreviated GDD or DD) is a way of assigning a heat value to each day. The values are added together to give an estimate of the amount of seasonal growth our plants have achieved. So, the GDD can be calculated as follows:

GDD = (Tmean - Tb)
Where Tmean = (Tmax + Tmin)/2
Tmax = Daily maximum temp.
Tmin = Daily minimum temp.
Tb= Base temp (9°C)

Results and Discussions: The results of different parameters at Aman season indicated that there was significant difference among the variety and date of seeding.

Plant height of rice cultivars recorded varied significantly at two seeding dates (**Table 6.9.1**). Plant height was higher when seeds were sown on 7 July for BRRI dhan87 and IR64. Among the varieties the maximum plant height was recorded with BRRI dhan87 (143 cm). Number of panicles per m^2 varied from 217 to 235. Due to high sterility grain yield reduced in the varieties BRRI dhan87 and BRRI dhan103 when seeds were sown on the 1st week of July.

Due to high sterility grain yield reduced for BRRI developed varieties and when critical stage (flowering stage) faced high temperature (35 ℃ or more) when seeds were sown on 7 July 2022 (**Fig. 6.9.1**). The percent sterility was highest (about 43%) in BRRI dhan103 at 1st seeding and lowest (about 19%) in BRRI dhan87 when sowing time was 22 July 2023. It is the number of filled spikelets and the spikelet size that govern grain yield of rice (Yoshida, 1981). The percent sterility was 32 and 36 for IR64 when seeds were sown 1st and 3rd week of July respectively. IR64 produced higher number of unfilled grains for both the sowing dates.

Grain size (1000 grain weight) was similar for BRRI dhan87 (23.80 g) and BRRI dhan103 (23.79) and smaller (21.67g) for IR64 (Table 2). Seeding date did not exhibit any significant influence on grain size. Our results are in agreement with Yoshida (1981). Grain size is a varietal character and is genetically controlled (1981).

Grain yield reduced when seeds were sown on 7 July for the varieties BRRI dhna87 and BRRI dhan103 while IR64 produced higher yield on 7 July seeding. It is the number of filled spikelets and the spikelet size that govern grain yield of rice (Yoshida, 1981). There was no significant difference in number of $panicle^{-2}$, filled spikelet for the variety IR64 for seeding dates. Number of panicles and number of filled spikelets per unit area and 1000-grain weight (grain size) are the major determinants of grain yield.

Among the rice varieties, BRRI dhan103 gave the highest grain yield (4.97 tha^{-1}) at 22 July seeding and lowest (3.25 tha^{-1}) when the seeding time was 1st week of July (**Table 6.9.1**). For BRRI dhan103, the grain yield decreased remarkably on 1st seeding while grain yield decreased for IR64 on 2nd seeding. Although BRRI dhan103 gave the highest grain yield (4.97 t ha^{-1}) this was statistically similar to the grain yield obtained from BRRI dhan87. There was no significant difference in grain yield obtained from BRRI dhan87 on two sowing dates. BRRI developed two varieties faced high temperature at flowering stage at early sowing and increased sterility percent (**Fig. 6.9.1** and **Table 6.9.1**).

Graphical representation of maximum temperature of flowering period (5 days before and after 50% flowering) of the varieties are shown in figure 6.9.1. The emerged panicle exposed to temperatures higher than the critical threshold of 35°C might increase spikelet sterility of the modern varieties (**Table 6.9.1**). Environmental temperature extremes coinciding with the critical stage of plant development reduced the spikelet fertility of the tested varieties. The variety IR64 had high sterility on both the sowing date although higher grain yield observed on 1st seeding (7 July). The variety faced higher critical temp during flowering on 1st seeding but two days after flowering the maximum temperature declined abruptly due to rainfall (**Fig. 6.9.1**).

Table 6.9.1: Interaction effects between variety and date of seeding on yield and yield components

Variety × date of seeding	Plant height (cm)	Panicle m^{-2} (number)	Filled grains per panicle (number)	Sterility (%)	1000-grain weight (gm)	Yield (tha^{-1})	Growth duration (from seeding to maturity) (days)
BRRI dhan87 × Set 1	143	235.45	104.27	30.50	23.52	4.45	125
BRRI dhan87 × Set 2	126	233.33	116.10	19.17	24.17	4.70	130
BRRI dhan103 × Set 1	124	222.90	64.92	42.65	23.65	3.25	124
BRRI dhan103 × Set 2	129	227.77	122.47	21.73	23.97	4.97	127
IR64× Set 1	140	220.85	90.92	31.75	21.62	4.08	130
IR64 × Set 2	124	216.66	89.30	35.90	21.73	3.47	134
LSD at 5% level	3.705	34.243	12.38	7.280	0.866	0.399	2.15
CV	2.41	13.00	11.03	20.19	3.22	8.38	1.44

Seed sowing: Set 1: 07July 2022, Set 2:22 July 2022

Duration of developmental stages: Although the duration of the seed sprouting to panicle initiation increased with the advancement of sowing time for the tested varieties, the variation was not much. BRRI dhan87 took 69 days when seed was sown at the 1st week of July and 73 days for 22 July sowing. Similar trend was observed for the variety BRRI dhan103 and IR64. The days required from PI to 50% flowering was taken in consideration for flowering stage. The time required for 50% flowering (from PI to 50% flowering) and maturity (from 50% flowering to maturity) more or less similar irrespective of varieties and sowing time (**Table 6.9.2**).

Table 6.9.2: Growth stage of rice varieties as affected by sowing time in Aman season, 2022, Plant Physiology, BRRI

Sprouting date	Variety	Days to PI (from sprouting)	Days to 50% flowering (from PI)	Days to Maturity (from 50% flowering)	Days to Maturity (from sprouting)
07 July 2021	BRRI dhan87	69	28	28	125
	BRRI dhan103	70	26	28	124
	IR64	77	26	27	130
22 July 2021	BRRI dhan87	73	28	29	130
	BRRI dhan103	72	27	28	127
	IR64	79	27	28	134

Growing degree days (GDD): Growing degree days (GDD) of rice cultivars taken in different phenophases at different growing environment have been presented in (**Table 8.9.3**). Among the varieties it is evident that GDD was highest in cultivar IR64, 2670.38 (±33.16) followed by BRRI dhan87, 2588.50 (±11.06) and BRRI dhan103, 2557.54 (±25.23). BRRI dhan87 and BRRI dhan103 did not vary too much in growing degree days (°Cd) requirements for panicle initiation and maturity (**Table 6.9.3**). The degree days (°Cd) requirements for panicle initiation were 1521.20±33.26, 1521.49±11.47, 1670.90±14.12, while for flowering 569.48±23.88, 541.28±9.58, 526.08±21.83 for BRRI dhan87, BRRI dhan103 and IR64 respectively.

Table 6.9.3: Degree days of rice varieties as affected by sowing time in Aman season, 2022, Plant Physiology, BRRI

Varieties	Required DD (°Cd)			
	from Sprouting to PI	from PI to 50% flowering)	from 50% flowering to maturity)	from sprouting to maturity)
BRRI dhan87	1521.20 (±33.26)	569.48 (±23.88)	494.15 (±23.35)	2588.50 (±11.06)
BRRI dhan103	1521.49 (±11.47)	541.28 (±9.58)	491.45 (±29.70)	2557.54 (±25.23)
IR64	1670.90 (±14.12)	526.08 (±21.83)	457.85 (±17.40)	2670.38 (±33.16)

Conclusion: The experimental results showed that the phenological development stages obtained from the observation did not vary too much for vegetative stage due to shifting seeding date. The numbers of days for attaining different phenological stages did not differ for the varieties. Results of this experiment suggested that the varieties BRRI dhan87 and BRRI dhan103 exhibited high sterility when seeds were sown on 1st week of July and IR64 produced higher percent of unfilled grains for both sowing dates.

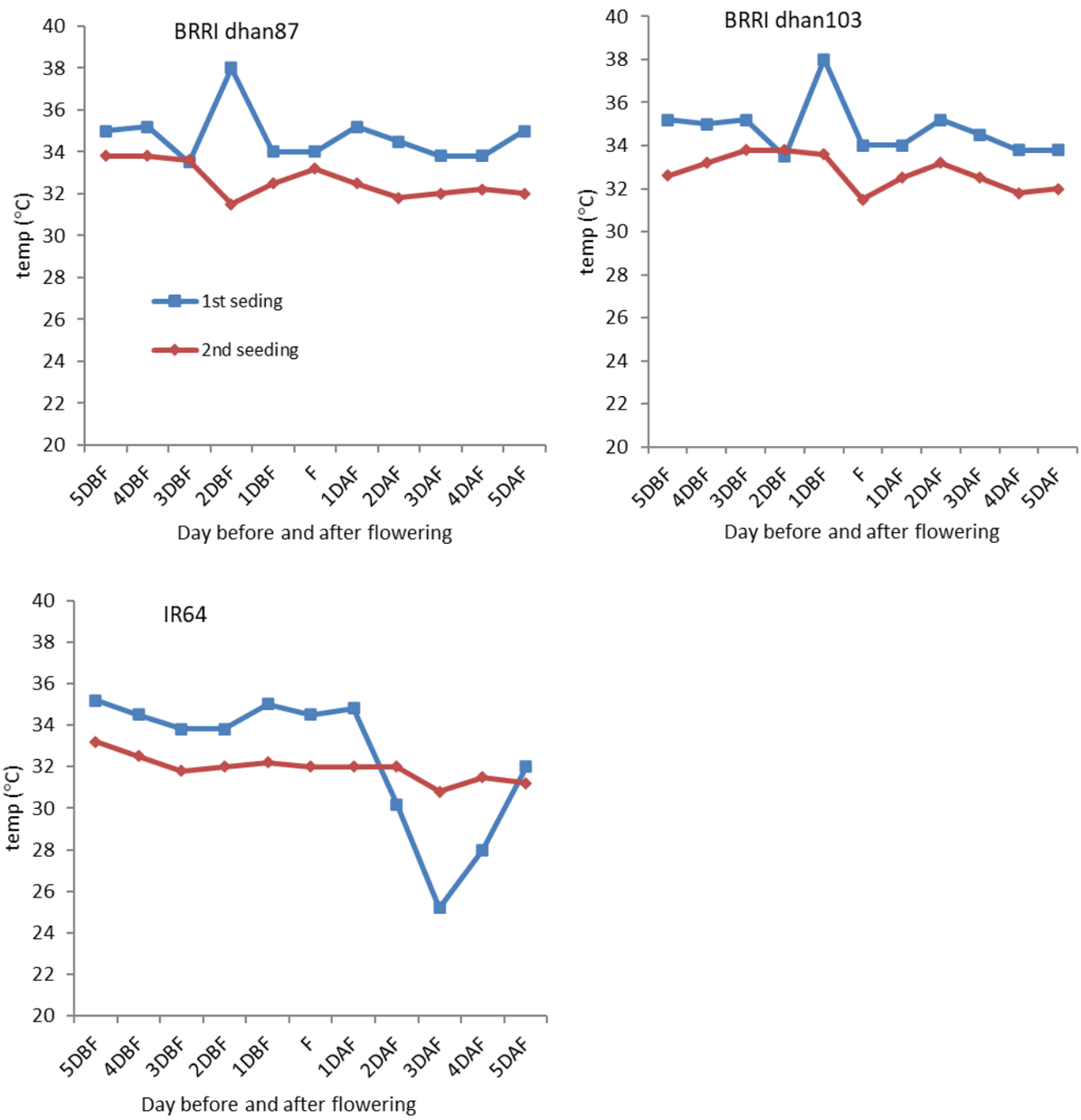

Fig: 6.9.1: Maximum temp. during flowering in Aman 2022 season

Expt. 6.10: Phenological development of some modern varieties as affected by sowing time

[1]Munnujan Khanam and [2]Hirendra Nath Barman
[1]CASR, BRRI, [2]Plant Physiology Division

Introduction: Crop phenology is important for choosing cultivars with an appropriate growth period and for determining the timing of management practices such as planting, fertilizer application and harvesting. The accurate rice phenological development stages estimation is also important for rice yield estimation in different climatic condition. During crop growth period, the occurrence of various phenological events can be estimated by computing accumulated growing degree days (Gouri *et. al.,* 2005). Accumulated growing degree days (GDD) provides an estimate of harvest date as well as development stages of crop (Ketring and Wheless, 1989). Various developmental stages as well as harvest date of crop can be estimated from the knowledge of accumulated GDD. Thermal time can be used as a tool for characterizing thermal responses in different crops as it is an independent variable to describe plant development (Dwyer and Stewart, 1986).

The evaluation of phenology plays a pivotal role in assessment of the effects of climate change and the development of adaptation practices. In this study, we will investigate the responses of rice phenology and yield to the change in day length as well as growing season. For this reason the experiments need to conduct in three seasons to observe the phenological development at different growing season with the following objectives.

i) to observe the phenological development at different growing season
ii) to estimate the genetic co-efficient for crop simulation.
iii) to investigate the duration of different developmental stages of rice varieties when seeded at different time in three seasons.
iv) to find out the required degree-days for developmental phase of rice.

Materials and Methods

Plant materials: BRRI developed two modern Boro rice varieties BRRI dhan92, Bangabandhu dhan100 and IR64 were selected to execute the experiment on different sowing dates in Boro 2022-23 season.

Growing rice plants in the field: This experiment was conducted in the Plant Physiology Division's research field located at BRRI farm Gazipur, Bangladesh, during Boro season in 2022-23. Four different sowing dates were 25 November 2022, 2nd December 2022, 12 December 2022 and 23 December 2022. Seedlings were grown in seedbed. At five leaf stage seedlings were transplanted in the field using single seedling per hill at 20×20 cm spacing. The plot size was 3×6 m^2. The study was laid out in RCBD with three replications

Fertilizers were applied as urea, Diammonium Phosphate (DAP), Muriate of potash (MoP), Gypsum and zinc at the rate of 262-90-150-112-11 $kgha^{-1}$ for urea, DAP, MoP, Gypsum and Zinc respectively. Full doses DAP, MoP, Gypsum and Zinc were incorporated at the final land preparation time. Urea was applied in the three equal splits at 10, 25 days after transplanting and 3rd dose 7 days before PI. The crop was kept weed free throughout the growth period. Adequate measures were taken to keep the insect infestation to a minimal.

Observations were made on days taken to panicle initiation (PI), days to 50% flowering and days to maturity. For determination of PI stage mother tiller section was done every alternate day from active tiller stage. Grain yield was measured from an area of 5m^2 and adjusted to 14% moisture level. Data were subjected to Analysis of Variance (ANOVA) and the means were compared using LSD test.

Plants require a specific amount of heat to develop from one point in their lifecycle to another, such as from sprouting of seed to the PI stage. Measuring the heat accumulated over time provides a more accurate physiological estimate than counting calendar days. “Growing degree days” (abbreviated GDD or DD) is a way of assigning a heat value to each day. The values are added together to give an estimate of the amount of seasonal growth our plants have achieved. So, the GDD can be calculated as follows:

GDD = (Tmean - Tb)
Where Tmean = (Tmax + Tmin)/2
Tmax = Daily maximum temp.
Tmin = Daily minimum temp.
Tb= Base temp (9°C)

Results and Discussions: Interaction effect of variety and sowing date influenced significantly on sterility percent and growth duration.

Plant height of rice cultivars recorded varied significantly among the varieties (**Table 6.10.1**). Averaged over the sowing dates the maximum plant height was recorded with BRRI dhan92 (109.0 cm) and lowest with IR64 (89.0 cm).

There was no significant difference among the variety and sowing date for panicle number per unit area. Averaged over sowing dates, number of panicles ranged between 282 and 287 per m^2 across varieties which were statistically similar. All the varieties produced higher number of panicles per m^2 when sowing time was at 25 November.

Averaged over seeding date filled grain per panicle ranged between 70 to 102 across the varieties. Filled grain per panicle was highest in the variety Bangabandhu dhan100 and lowest in IR64.

Due to high sterility grain yield reduced irrespective of varieties and when critical stage (flowering stage) faced high temperature (35 °C or more) due to shifted sowing date (**Fig. 6.10.1**). Percent sterility increased with the advancement of sowing date. For BRRI dhan92 and Bangabandhu dhan100 the lowest sterility was observed when the sowing was done on 25 November. But in case of IR64 the percent sterility was lowest when the sowing time was 12 December.

The percent sterility (43.88%) was maximum in BRRI dhan92 on 23 December seeding and minimum in IR64 (17.88%) when sowing time was 12 December (**Table 6.10.3**). It is the number of filled spikelets and the spikelet size that govern grain yield of rice (Yoshida, 1981).

Grain size (1000 grain weight) was almost similar for BRRI dhan92 (22.93g) and Bangabandhu dhan100 (22.55g) and smaller (20.22g) for IR64 (Table 2). Seeding date did not exhibit any significant influence on grain size. Our results are in agreement with Yoshida (1981) who stated that grain size is a varietal character and is genetically controlled. It appeared that the number of filled spikelets per unit area and grain size (1000 grain wt) created the difference in grain yield across varieties.

Table 6.10.1: Effect of different sowing date on yield and yield component, Plant Physiology Division, BRRI, 2022-23

Sowing date	Plant height (cm)	No. of panicle m^{-2}	No filled grain $panicle^{-1}$	1000 grain wt (g)	Grain yield (tha^{-1})
S1	105.56	293.52	91.79	21.51	4.89
S2	98.77	287.04	84.13	21.24	4.42
S3	97.22	283.33	86.47	21.13	4.38

Sowing date	Plant height (cm)	No. of panicle m^{-2}	No filled grain $panicle^{-1}$	1000 grain wt (g)	Grain yield (tha^{-1})
S4	98.89	274.08	75.66	21.07	3.49
LSD at 5%	3.72	27.95	10.85	0.55	0.43
CV (%)	3.81	10.05	13.13	2.65	10.18

Means with the same letter are not significantly different

Table 6.10.2: Effect of different varieties on yield component, Plant Physiology, BRRI, 2022-23

Variety	Plant height (cm)	No. of panicle m^{-2}	No filled grain $panicle^{-1}$	1000 grain wt. (g)	Grain yield (tha^{-1})
BRRI dhan92	108.83	286.8	101.61	22.93	4.47
Bangabandhu dhan100	102.25	284.7	82.23	22.55	4.45
IR64	89.25	281.95	69.70	18.24	3.96
LSD at 5% level	3.23	24.21	9.39	0.48	0.37
CV (%)	3.81	10.09	13.12	2.65	10.18

Table 6.10.3: Interaction effects between variety and date of seeding on percent sterility and growth duration

Variety × date of seeding	Sterility (%)	Duration (from seeding to maturity) (days)
BRRI dhan92 × 1st seeding	28.60	160.00
BRRI dhan92 × 2nd seeding	36.52	156.00
BRRI dhan92 × 3rd seeding	37.36	151.00
BRRI dhan92 × 4th seeding	43.80	144.00
Bangabandhu dhan100 × 1st seeding	18.05	149.00
Bangabandhu dhan100 × 2nd seeding	18.79	142.00
Bangabandhu dhan100 × 3rd seeding	25.09	137.00
Bangabandhu dhan100 × 4th seeding	29.02	134.00
IR64 × 1st seeding	24.71	149.00
IR64 × 2nd seeding	26.80	142.00
IR64 × 3rd seeding	17.88	137.00
IR64 × 4th seeding	37.00	134.00
LSD at 5% level	5.17	2.212494e-14
CV	10.67	9.037065e-15

Seed sowing: 1st seeding: 25/11/22, 2nd seeding: 02/12/22, 3rd seeding:12/12/22 and 4th seeding: 23/12/2022

Among the rice varieties, BRRI dhan92 and Bangabandhu dhan100 gave the highest grain yield (**Table 6.10.1**). There was no significant difference between the grain yield obtained from BRRI dhan92 and Bangabandhu dhan100. The lowest grain yield was observed in IR64. With the advancement of sowing dates, the grain yield decreased remarkably. The lowest yield obtained from all the varieties when the sowing was done on 23 December. Grain yield reduced drastically irrespective of varieties when sowing time was shifted. All the varieties faced high temperature at flowering stage at delay sowing and increased sterility percent (**Table 6.10.1**). Due to higher disease and insect infestations, storm-related lodging, and probable heat or cold damage during the heading and filling stages, rice grown after the recommended dates may result in poor yields (Groth and Lee, 2003 and Reza *et al*., 2011).

Graphical representation of maximum temperature of flowering period (5 days before and after 50% flowering) of the varieties are shown in figure 6.10.1. The emerged panicle exposed to

temperatures higher than the critical threshold of 35°C might increase spikelet sterility of the tested varieties specially the long duration BRRI dhan92 for all the sowing time (**Table 6.10.3**). Environmental temperature extremes coinciding with the critical stage of plant development reduced the spikelet fertility of the tested varieties.

Duration of developmental stages: Irrespective of varieties there was a decrease in the duration of the sprouting to panicle initiation with the advancement of sowing time. It took 103 days when seeds were sown on 25 November and decreased to 89 days for the variety

Table 6.10.4: Growth stage of rice varieties as affected by sowing time in Boro season, 2022-23, Plant Physiology, BRRI

Sprouting date	Variety	Days to PI (from sprouting)	Days to 50% flowering (from PI)	Days to Maturity (from 50% flowering)	Days to Maturity (from sprouting)	Required DD (°Cd) (from sprouting to maturity)
25 November 2022	BRRI dhan92	103	28	29	160	2449.342
	Bangabandhu dhan100	93	28	28	149	2226.408
	IR64	93	28	28	149	2226.408
02 Dec 2022	BRRI dhan92	100	28	28	156	2397.531
	Bangabandhu dhan100	87	27	28	142	2112.821
	IR64	87	27	28	142	2112.821
12 Dec2022	BRRI dhan92	94	28	29	151	2366.329
	Bangabandhu dhan100	82	27	28	137	2068.551
	IR64	82	27	28	137	2068.551
23 Dec2022	BRRI dhan92	89	27	28	144	2310.803
	Bangabandhu dhan100	79	27	28	134	2090.797
	IR64	79	27	28	134	2090.797

BRRI dhan92. Similar trend was observed for the variety Bangabandhu dhan100 and IR64. The days required from PI to 50% flowering was taken in consideration for flowering stage. The time required for 50% flowering (from PI to 50% flowering) and maturity (from 50% flowering to maturity) more or less similar irrespective of varieties and sowing time (**Table 6.10.4**).

Growing degree days (GDD): Growing degree days (GDD) of rice cultivars taken in different phenophases at different growing environment have been presented in Table 6.10.5. It is evident that the highest value of growing degree days was taken by 1st date of seeding (25 November) followed by the 2nd December seeding and lowest was recorded on 23 December but Bangabandhu dhan100 and IR64 took the lowest at 12 December seeding (**Table 6.10.5**). Among the varieties it is evident that GDD was highest {2381.00 (±28.99)} in cultivar BRRI dhan92. GDD was identical for Bangabandhu dhan100 and IR64 {2124.64 (±35.10)}. Similar way growing degree days (°Cd) requirement for panicle initiation and flowering was identical for these two varieties. (**Table 6.10.5**). For BRRI dhan92 the degree day (°Cd) requirements for panicle initiation was 1187.63±96.60, while for flowering it was 511.43±9.46.

Table 6.10.5: Average degree days of rice varieties as affected by sowing time in Boro season, 2022-23, Plant Physiology, BRRI

Varieties	Required DD (°Cd)			
	from Sprouting to PI	from PI to 50% flowering)	from 50% flowering to maturity)	from sprouting to maturity)
BRRI dhan92	1187.633 (±96.60)	511.43 (±9.46)	674.85 (±59.39)	2381.00 (±28.99)
Bangabandhu dhan100	936.30 (±30.05)	471.94 (±4.84)	584.45 (±5.14)	2124.64 (±35.10)
IR64	936.30 (±30.05)	471.94 (±4.84)	584.45 (±5.14)	2124.64 (±35.10)

(Values in the parentheses denote standard error)

Conclusion: The experimental results showed that the phenological development stages obtained from the observation varied for vegetative stage due to shifting seeding date for each variety. Irrespective of varieties the days required to reach at PI was highest when sowing time was 25 November and decreased succeeding of seeding time. Days from sprouting to PI varied from 89 to 103 days for BRRI dhan92 and 79 to 93 days for Bangabandhu dhan100 and IR64. The number of days for attaining different phonological stages differed from cultivar to cultivar. Results of this experiment suggested that the varieties did not exhibit their yield potential not only for environmental condition, might be for poor inherent nutrient supplying capacity as the land is occupied by rice crop for several consecutive seasons. Yield potential is defined as the yield of a variety when grown in environments to which it is adapted; with nutrients and water non-limiting; and with pests, diseases, weeds, lodging, and other stresses effectively controlled (Evans, 1993).

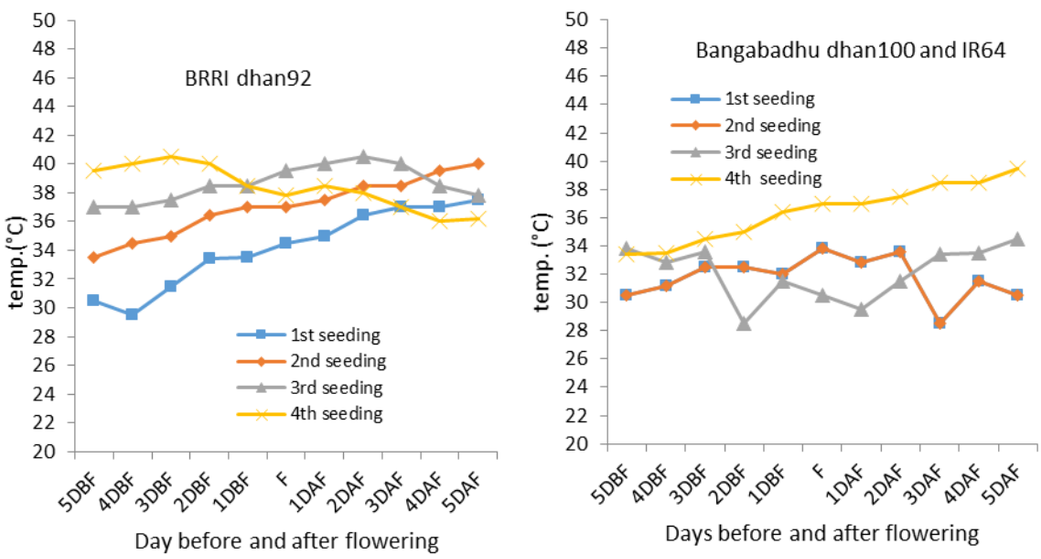

Fig. 6.10.1: Maximum temp. during flowering in Boro 2022-23 season

PROJECT 7: GENOME EDITING

Expt. 7.1: CRISPR-Cas9 mutagenesis of the *OsRR22* gene for improving salinity tolerance of rice

[1]Hirendra Nath Barman, [1]Md. Sazzadur Rahman, [2]Shahanaz Sultana, [2]Shampa Das Joya and [1]Mst. Salma Pervin
[1]Plant Physiology Division, [2]Biotechnology Division

Rationale: Salinity is one of the most important abiotic stress affecting the world rice production. Numerous salt tolerance quantitative trait loci were identified and few of them had been transferred into popular rice varieties via marker-assisted selection (MAS) but none of them showed greater promise. The *OsRR22* gene encodes a 696–amino acid B-type response regulator transcription factor that is involved in both cytokinin signal transduction and metabolism; its loss of function has been reported to significantly increase salt tolerance. In recent years, CRISPR/Cas9 systems have been widely used for target-site genome editing; here we target the improvement of the rice salinity tolerance by engineering *OsRR22* gene.

Materials and methods:

Target selection: The target site 19bp nucleotide sequence (5′-AGAGGGATCAATTCCCCGT-3′) was selected which consist of a protospacer adjacent motif (PAM) lying within the *OsRR22*

coding sequence (Os01g54890). The target site was checked by using BLAST (http://ensembl.gramene.org/Multi/Tools/Blast) to ensure the uniqueness of the site for avoiding the off-target mutation.

Intermediate vector construction: An intermediate vector SK-gRNA (*E. coli* cells harbouring Sk-gRNA) 100 µl was added into 25 ml Amp+LB solution (Luria Bertani culture solution with Ampicillin) and cultured for 12-15 hrs at 250 rpm, 37 ^{o}C in an incubator shaker. Plasmid was extracted using a plasmid extraction kit and store at -20 ^{o}C for long term use. The plasmid of SK-gRNA was digested using *AarI* restriction enzyme to form sticky end. The digested plasmid of SK-gRNA was run into 1% Agarose gel and extracted plasmid using gel extraction kit. After that guide sequence (5′-AGAGGGATCAATTCCCCGT-3′) was ligated into digested plasmid of SK-gRNA using T4 DNA ligase buffer. Transformation was done of the constructed plasmid into competent DH5α cells and cultured into Amp+LB plate. Single bacterial colony was picked up and cultured into Amp+LB solution. Positive colonies were sequenced after PCR using T3-F primer (ATTAACCCTCACTAAAGGGA) to verify the correctness of the guide sequence ligation with SK-gRNA.

Final vector construction: The final vector pC1300-Cas9 (*E. coli* cells harboring pC1300-Cas9) 100 µl was added into 25 ml Kan+LB solution (Luria Bertani culture solution with Kanamycin) and cultured for 12-15 hrs at 250 rpm, 37 ^{o}C in an incubator shaker. Plasmid was extracted using a plasmid extraction kit and store at -20 ^{o}C for long term use. The plasmid of pC1300-Cas9 was digested using *KpnI and BamHI* restriction enzyme to form sticky end. The digested plasmid of pC1300-Cas9 was run into 1% Agarose gel and extracted plasmid using gel extraction kit. On the other hand, recombinant Sk-gRNAwas digested using KpnI and BglII restriction enzyme. Then the fragment of Sk-gRNA harboring guide sequence was ligated into digested plasmid of pC1300-Cas9 using T4 DNA ligase buffer. Transformation was done of the constructed plasmid into competent DH5α cells and cultured into Kan+LB plate. Single bacterial colony was picked up and cultured into Kan+LB solution. Positive colonies were sequenced after PCR using pC1300-F primer (ACACTTTATGCTTCCGGCTC) to verify the correctness of the guide sequence ligation with pC1300-Cas9.

Results: The guide sequence was properly cloned into the binary vector pC1300-Cas9 (**Fig. 7.1.1**). The binary vector pC1300-Cas9 harboring Cas9/*OsRR22* sgRNA was mobilized into *Agrobacterium tumefaciens* LBA4404 by freeze-thaw method and confirmed through PCR-gel electrophoresis. Plants were regenerated through *Agrobacterium*-mediated transformation (**Fig. 7.1.2A**). Genomic DNA was extracted from the leaves of transformed plants using the sodium dodecyl sulfate (SDS) method. Hygromycin phosphotransferase positive plants were identified using HPT primer pair designed from Hygromycin phosphotransferase resistant zone of the Cas9 vector. PCRs amplifications have been performed using primer pairs, which generated an amplicon harboring the target site. The resulting amplicons have been sequenced using the Sanger method and mutant plant have been identified where deletion of two nucleotides occurred at the target site (**Fig. 7.1.2B**).

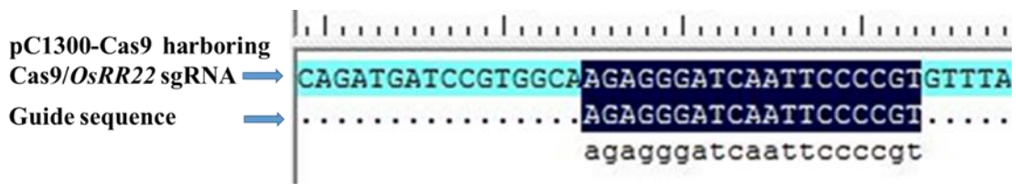

Fig. 7.1.1: Confirmation of vector constructs by sequence alignment of recombinant pC1300-Cas9 harboring Cas9/*OsRR22* sgRNA with guide sequence.

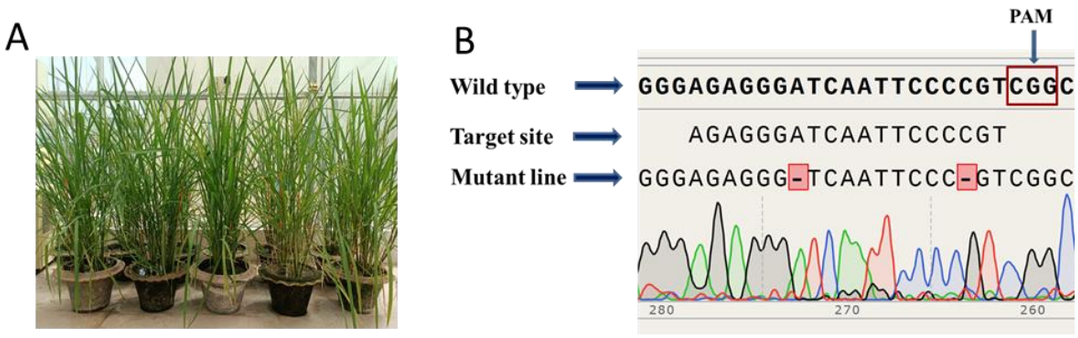

Fig. 7.1.2: A) T0 mutant plants and B) nucleotide sequences at the target site of the T0 plants

Expt. 7.2: Generation of male sterile rice line for two-line hybrid system by editing *TMS5* gene using CRISPR/Cas9 system

[1]Hirendra Nath Barman, [1]Md. Sazzadur Rahman, [2]Shahanaz Sultana, [2]Shampa Das Joya and [1]Mst. Salma Pervin

[1]Plant Physiology Division, [2]Biotechnology Division

Rationale: The two-line hybrid rice is based on the discovery and application of environmentally sensitive genic male sterile (EGMS) lines, which serve as both the male sterile lines and maintainer lines under different environmental conditions. The two-line hybrid rice system is an important innovation for the better exploitation of hybrid vigor (heterosis). Two-line based hybrid rice currently has a 5-10% higher yield compared with that of three-line hybrid rice. The development of male sterile lines through conventional breeding is a lengthy and laborious process, whereas developing thermo-sensitive genic male sterile (TGMS) lines for two-line hybrid breeding by editing a temperature-sensitivity gene by CRISPR/Cas9 is efficient and convenient. Application of genome editing tools in crop improvement to enhance yield, nutritional value, disease resistance and other traits are a prominent areas of work. The main advantages of the CRISPR/Cas9 system in its ability to genetically modify an organism without leaving any foreign DNA behind and its versatility and simplicity of programming. In the present study, male sterile line could be developed by editing *OsTMS5* gene using CRISPR/Cas9 system.

Materials and methods

Target selection: The target site 19bp nucleotide sequence (5′-ACCGTCGAGGGCTACCCCG-3′) was selected which consist of a protospacer adjacent motif (PAM) lying within the Os*TMS5* coding sequence (Os02g12290). The target site was checked by using BLAST (http://ensembl.gramene.org/Multi/Tools/Blast) to ensure the uniqueness of the site for avoiding the off-target mutation.

Intermediate vector construction: An intermediate vector SK-gRNA (*E. coli* cells harbouring Sk-gRNA) 100 µl was added into 25 ml Amp+LB solution (Luria Bertani culture solution with Ampicillin) and cultured for 12-15 hrs. at 250 rpm, 37 ºC in an incubator shaker. Plasmid was extracted using a plasmid extraction kit and store at -20 ºC for long term use. The plasmid of SK-gRNA was digested using *AarI* restriction enzyme to form sticky end. The digested plasmid of SK-gRNA was run into 1% Agarose gel and extracted plasmid using gel extraction kit. After that guide sequence (5′-ACCGTCGAGGGCTACCCCG-3′) was ligated into digested plasmid of SK-gRNA using T4 DNA ligase buffer. Transformation was done of the constructed plasmid into competent DH5α cells and cultured into Amp+LB plate. Single bacterial colony was picked up and cultured into Amp+LB solution. Positive colonies were sequenced after PCR using T3-F primer (ATTAACCCTCACTAAAGGGA) to verify the correctness of the guide sequence ligation with SK-gRNA.

Final vector construction: The final vector pC1300-Cas9 (*E. coli* cells harboring pC1300-Cas9) 100 µl was added into 25 ml Kan+LB solution (Luria Bertani culture solution with Kanamycin)

and cultured for 12-15 hrs at 250 rpm, 37 ^{o}C in an incubator shaker. Plasmid was extracted using a plasmid extraction kit and store at -20 ^{o}C for long term use. The plasmid of pC1300-Cas9 was digested using *KpnI and BamHI* restriction enzyme to form sticky end. The digested plasmid of pC1300-Cas9 was run into 1% Agarose gel and extracted plasmid using gel extraction kit. On the other hand recombinant Sk-gRNAwas digested using KpnI and BglII restriction enzyme. Then the fragment of Sk-gRNA harboring guide sequence was ligated into digested plasmid of pC1300-Cas9 using T4 DNA ligase buffer. Transformation was done of the constructed plasmid into competent DH5α cells and cultured into Kan+LB plate. Single bacterial colony was picked up and cultured into Kan+LB solution. Positive colonies were sequenced after PCR using pC1300-F primer (ACACTTTATGCTTCCGGCTC) to verify the correctness of the guide sequence ligation with pC1300-Cas9.The binary vector pC1300-Cas9 harboring Cas9/*OsTMS5* sgRNA was mobilized into *Agrobacterium tumefaciens* LBA4404 by freeze-thaw method and confirmed through PCR-gel electrophoresis.

Results: The guide sequences were properly cloned into the binary vector pC1300-Cas9 (**Fig. 7.2.1**). The binary vector pC1300-Cas9 harboring Cas9/*TMS5* sgRNA was mobilized into Agrobacterium tumefaciens LBA4404 by freeze-thaw method and confirmed through PCR-gel electrophoresis. Plants were regenerated through Agrobacterium-mediated transformation (**Fig. 7.2.2A**). Genomic DNA was extracted from the leaves of transformed plants using the sodium dodecyl sulfate (SDS) method. Hygromycin phosphotransferase positive plants were identified using HPT primer pair designed from Hygromycin phosphotransferase resistant zone of the Cas9 vector (**Fig. 7.2.2B**).

Fig. 7.2.1: Confirmation of vector constructs by alignment of sequence of recombinant pC1300-Cas9 harboring Cas9/*OsTMS5* sgRNA with guide sequence.

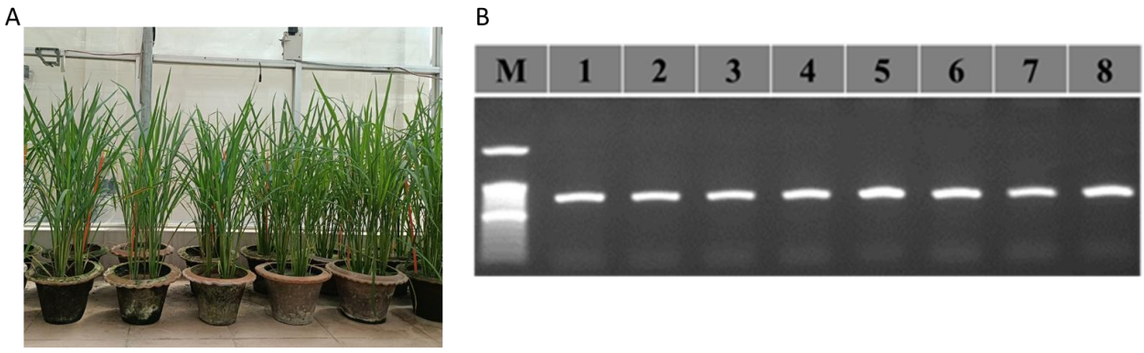

Fig. 7.2.2: A) T0 regenerated plants and B) Confirmation of *Agrobacterium* transformation through PCR-gel electrophoresis. *Agrobacterium tumefaciens* LBA4404 with recombinant pC1300-Cas9 harboring Cas9/*OsTMS5* sgRNA (Lane 1-8). M: marker (50 bp DNA ladder).

PROJECT 8: C4 RICE DEVELOPMENT

Expt. 8.1: Investigation of anatomical differences in the spikelets of rice and Uri dhan

[1]Md. Sazzadur Rahman, [1]Md. Hridoy Hussain, [2]SM Hisam Al Rabbi and [3]Munnujan Khanam
[1]Plant Physiology Division, [2]Biotechnology Division, [3]CASR, BRRI

Rationale: Leaf structure strongly controls leaf photosynthesis and plays a key role in every step starting from light interception up to the biochemical fixation of carbon dioxide. The potential

photosynthetic activity of different plant parts especially green chloroplast containing parts i.e. leaf blade, leaf sheath, culm and panicle (green spikelets) etc. The potential net photosynthesis of the leaves was about 94% of the total. However, the contribution of leaf sheath (5%) and panicles (8%) are relatively small (Yoshida, 1981). But research on leaf structure in cultivated rice is mostly confined to leaf shape and leaf angle. However, there has been growing interest in the characterization of rice leaf anatomical differences between C3 (rice) and C4 species such as maize, sorghum, green foxtail millets, uri dhan etc. Engineering the leaf structure of cultivated rice could, therefore, be of direct interest to current research efforts that aim to increase photosynthetic efficiency and thereby achieve improved yields. Despite leaf anatomy being a central component that determines leaf photosynthesis and gas exchange, very little attention has been paid to quantify the diversity of leaf and spikelet anatomical traits within *Oryza* to use for genetic improvement or plant breeding programs in rice. Unfortunately, the functional significance of leaf structure, especially at the cellular level, and its regulation is still not very clear in rice. Considering the above things, the current research aimed to studies anatomical differences of cultivated high yielding rice varieties and Uri dhan.

Materials and Methods: For spikelet anatomical studies, milk stage green spikelets were taken from HYV rice and Uri dhan. For uniformity, middle (widest) part of the spikelets was taken for dissection. Anatomical information was obtained from spikelet transverse (TS) section through free hand dissection (~10 µm thick). Images of these sections was taken by using BX63 compound microscope and photographed with the attached DPI74 digital image documentation system.

Results: Chowrasia and Mondal (2020) have claimed that Uri dhan (*Oryza coarctata*) should possess C4 photosynthesis based on anatomical, cell ultra-structural, and molecular evidences. Based on these information, anatomical differences between the spikelets of Uri dhan and rice were investigated. Uri dhan contains more vascular bundles in the lemma and palea than rice, in comparison. Rice only has 5 and 3 vascular bundles in the lemma and palea, compared to 12-15 and 8-12 in the Uri dhan lemma and palea (Fig. 8.1.1 and 8.1.2).

Fig. 8.1.1: Vascular bundles in the rice spikelets lemma (left) (4×) and palea (right) (10×).

Fig. 8.1.2: Vascular bundles in the Uri dhan spikelets lemma (left) (10×) and palea (right) (10×)

Conclusion: Uri dhan has more vascular bundles in its lemma and palea than rice. Rice's lemma and palea only have 5 and 3 vascular bundles, whereas the Uri dhan lemma and palea have 12-15 and 8-12, respectively.

Expt. 8.2: Optimizing chlorophyll fluorescence imaging system for photosynthetic efficiencies of rice in the submergence stress

[1]Md. Sazzadur Rahman, [1]Md. Hridoy Hossain, [1]Hirendra Nath Barman and [2]Munnujan Khanam
[1]Plant Physiology Division, BRRI; [2]CASR, BRRI

Rationale: Chlorophyll fluorescence is popular technique in plant physiology used for rapid non-invasive measurement of photosystem II activity. PSII activity is very sensitive to a range of biotic and abiotic factors and therefore chlorophyll fluorescence technique is used as rapid indicator of photosynthetic performance of plants in different developmental stages and/or in response to changing environment. The advantage of chlorophyll fluorescence measurements over other methods for monitoring stresses is that changes in chlorophyll fluorescence kinetic parameters often occur before other effects of stress are apparent. Advances made in image-based phenotyping techniques provided an opportunity to use non-destructive imaging to screen for submergence tolerance traits in a wide range of germplasm in a reliable, quantitative and efficient way. However, the application of image-based phenotyping in the development of submergence-tolerant rice remains limited. Therefore, the present investigation aimed to explore the use chlorophyll fluorescence-based imaging to characterize the submergence tolerance of rice at seedling stage.

Materials and Methods: FR13A (original *SUB1* donor) and IR42 (standard sensitive check) were tested under complete submergence stress. Ten-day-old seedlings were submerged for 1, 2, 3, 4, and 5 days in 100 cm of turbid floodwater. An image of chlorophyll fluorescence was captured after each of the five days of submergence treatments as well as the stage of recovery following the receding of the floodwaters.

Results: In both tolerant and sensitive cultivars, the maximum quantum yield of photosystem II (Fv/Fm) dropped as the duration of the flood increased. Six days of recovery time were required for each submergence treatments, however this was what allowed for the distinct separation of tolerant and sensitive varieties. Results demonstrated that any length of submerged up to six days after recovery caused irreparable harm. For the submerged treatment, other fluorescence-related metrics as NPQ, qP, qL, qN, and Rfd behaved differently. However, the ratios of fluorescence declining between tolerant and sensitive varieties are notably different (**Fig. 8.2.1 and Fig. 8.2.2**). Chlorophyll fluorescence imaging could be a non-invasive and best approach to differentiate and identify submergence tolerances in rice.

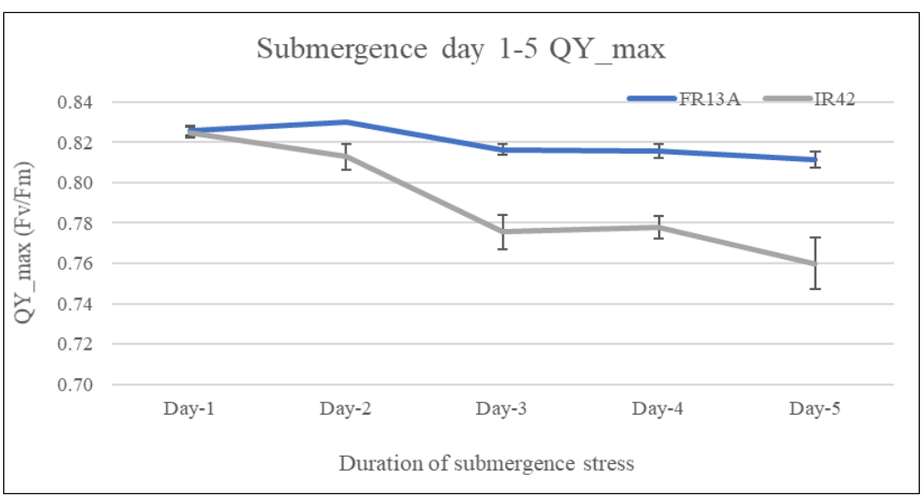

Fig. 8.2.1: Maximum quantum yield (Fv/Fm) of dark-adapted submergence stress plants following a period of one to five days of complete submergence.

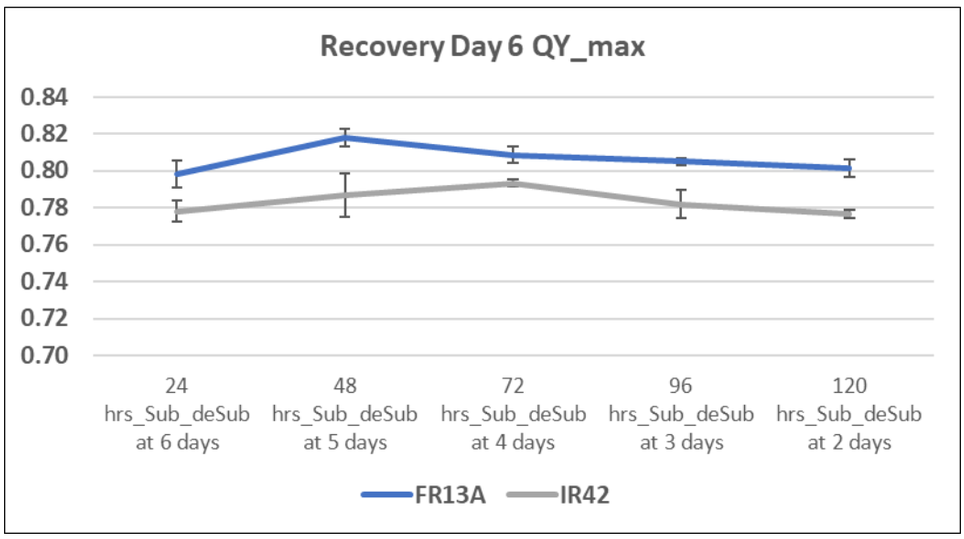

Fig. 8.2.1: Maximum quantum yield (Fv/Fm) of dark-adapted submergence stress plants following a recovery period of six days.

Conclusion: Significant differences in maximum quantum yield (Fv/Fm) were observed between the tolerant and sensitive cultivars following two days of complete submergence and six days of recovery.

PROJECT 9: CROP WEATHER INFORMATION

Study 9.1: Collection, preservation and maintenance of weather data (July 2022-June 2023)

Md. Sazzadur Rahman, Tuhin Halder, Hirendra Nath Barman, Md. Jalal Uddin and Mst. Salma Pervin

During the reporting year (July'2022 to June'2023) from BRRI Gazipur and other different seven regional station (Barishal, Rangpur, Bhanga, Habiganj, Sonagazi, Comilla and Rajshahi) several weather parameter information were collected and stored in Plant Physiology Division. A brief summary of the data were presented below:

Temperature: Among the eight weather station both highest mean maximum and lowest mean minimum temperature was observed at Rajshahi at June'2023 and January'2023 (38.82°C and 10.28 °C respectively). Considering other station, April'2023 has the highest mean maximum temperature at Comilla (35.5 $^{\circ}C$) Barishal (34.99°C), Sonagazi (34.65°C) and Habiganj (34.4°C). At Gazipur hottest month was feel at May (34.91 °C). The July and August was the hottest month of Rangpur (30.95°C) and Bhanga (35.16°C).

As usually January was the coolest month observed all of the station. The lowest mean minimum temperature observed at Gazipur (13.0°C), at Comilla (14.41°C), Barishal (13.01°C), Sonagazi (13.81°C), Rangpur (10.3°C), Bhanga (12.39) and Habiganj (14.59°C) (**Fig. 9.1.1**).

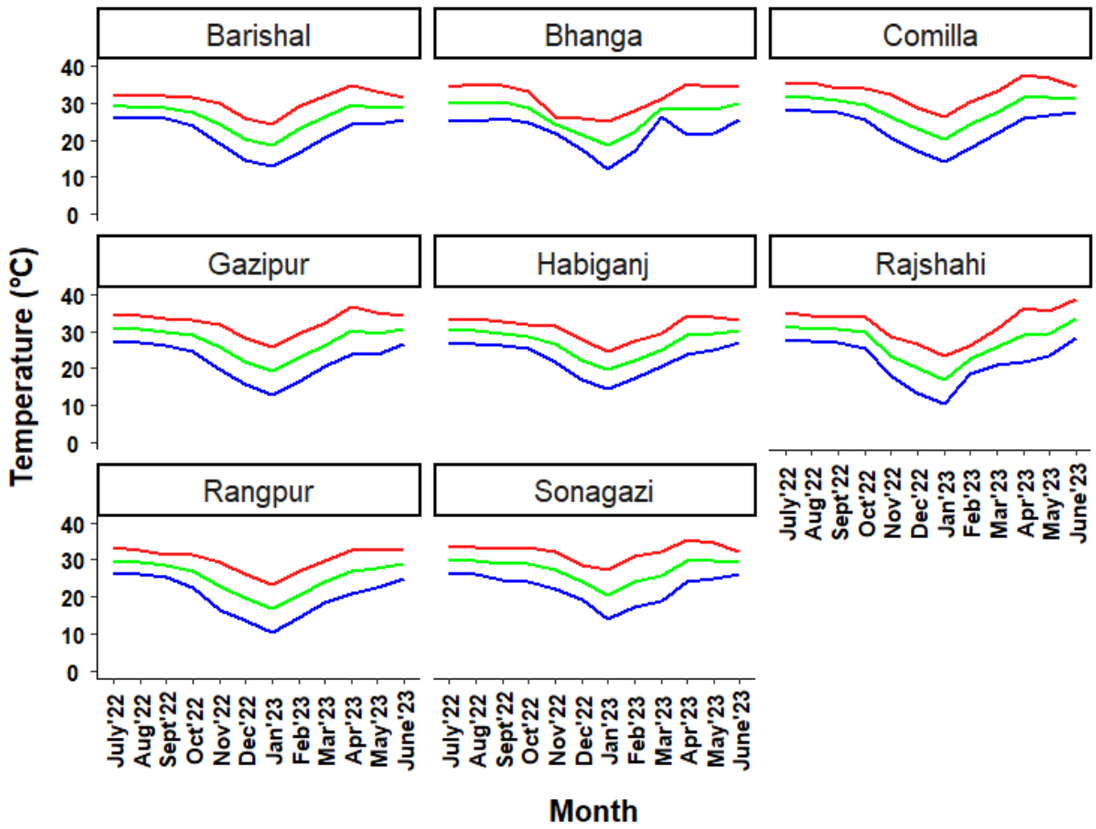

Fig. 9.1.1: Monthly mean maximum (top line), average (middle line) and minimum (lower line) temperature of BRRI Gazipur and Seven regional station during July'2022 to June'2023.

Rainfall: During the reporting year highest rainfall was received by Barishal (1630 mm) followed by Sonagazi (1626 mm), Comilla (1616 mm), Habiganj (1570 mm), Rangpur (1391 mm), Gazipur (1372 mm), Rajshahi (807 mm) and lowest rainfall received by Bhanga (425 mm). At June'2023 highest rainfall received by Comilla (452 mm), Gazipur (303.6 mm) and Rangpur (410.8 mm) at August' 2023 by Habiganj (281.1 mm) and Rajshahi (276.6 mm). At Sonagazi highest rainfall was received at September'2022 (470 mm). Highest rainfall received at the month of October'2022 at Barishal (495 mm) (**Fig. 9.1.2** and **Fig. 9.1.3**)

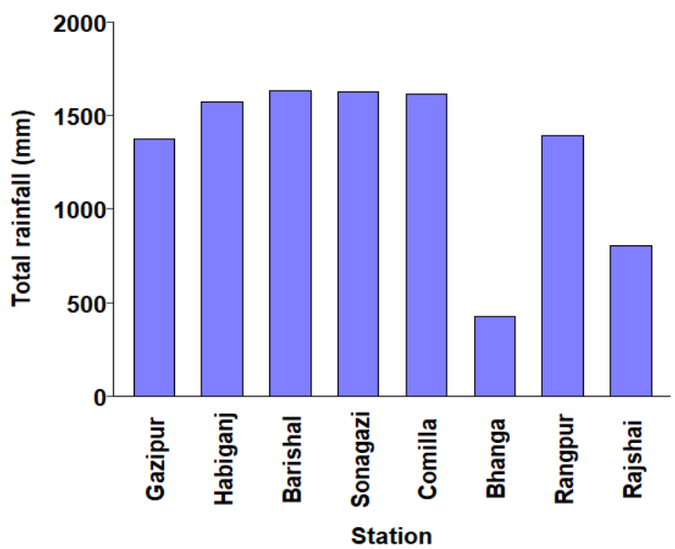

Fig. 9.1.2: Total Rain fall received at different stations during reporting year (July-2022 to June 2023).

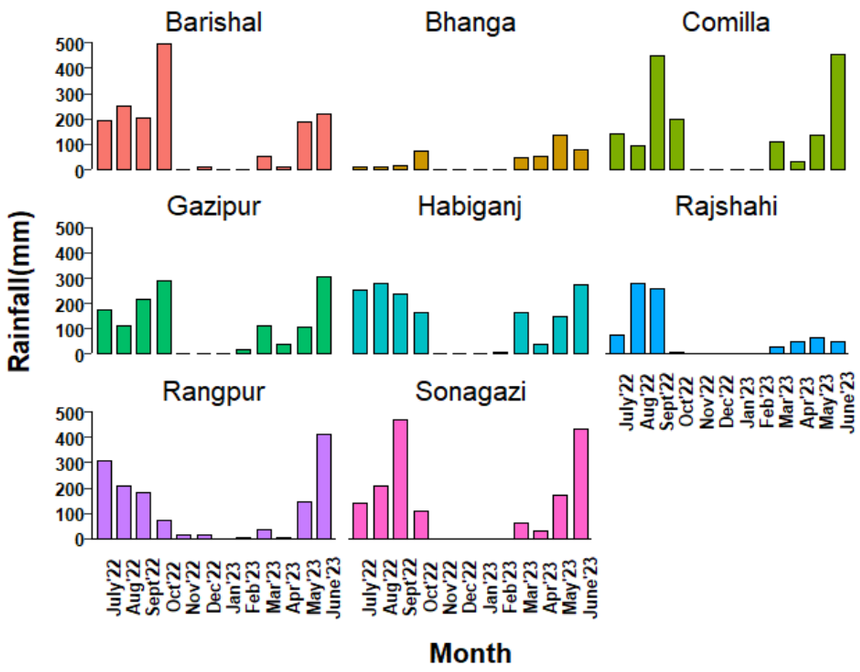

Fig. 9.1.3: Monthly total rainfall and of BRRI Gazipur and Seven regional station during July'2022 to June'2023

Relative Humidity (RH): Relative humidity was higher at morning for all the station of which highest was observed at June'2023 at Bhanga and Sonagazi and at May'2023 at Gazipur, at September'2022 at Barishal, and Comilla. On the other hand it was lowest at Sonagazi and Bhanga on February'2023, at Barishal, Rajshahi and Gazipur and Rangpur on April'2023, at Comilla on January'2023 (**Fig. 9.1.4**).

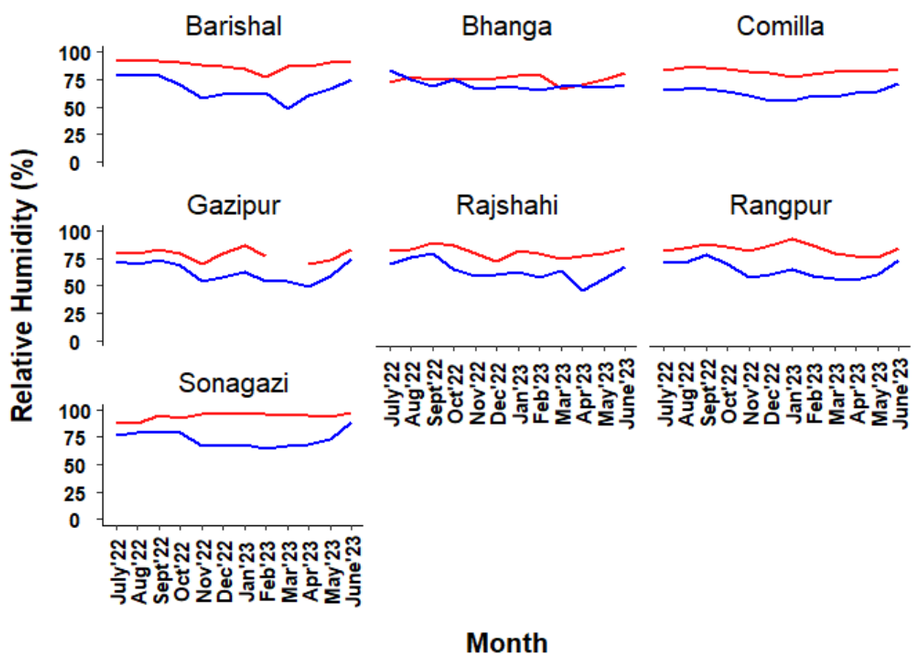

Fig. 9.1.4: Monthly mean Relative Humidity (%) of BRRI Gazipur and Six regional station during July'2022 to June'2023. (Top line RH at 9 am and lower line RH at 2pm).

Sunshine hours and solar radiation: Gazipur, Comilla and Barishal faced higher sunshine hours at March'2023 as well 'as higher solar radiation intensity. At month of November' 2022 Sonagazi and Rangpur received higher sun shine hour, at July Bhanga received higher solar radiation intensity as well as sunshine hours (**Fig. 9.1.5**).

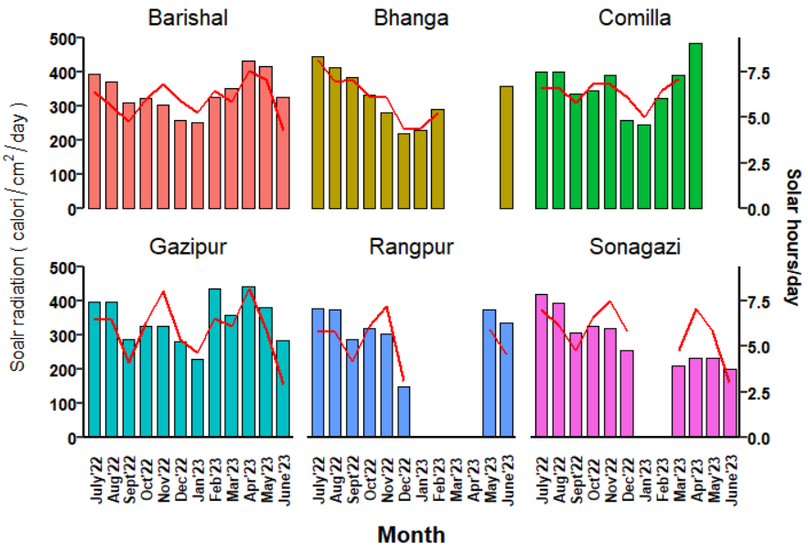

Fig. 9.1.5: Monthly mean sunshine hrs (line graph) and solar radiation of BRRI Gazipur and five regional stations during July'2022 to June'2023.