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Effect of Submergence Stress on Morpho-Physiological Characters of Paddy

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ABSTRACT

Field experiment was conducted in Adaptive Research Station, Sakhigopal, Puri during kharif 2014 to screen out the rice genotypes for the relative tolerance to submerged condition basing upon morpho-physiological and biochemical characters. Twenty two varieties having duration more than 145 to 170 days were taken under transplant condition in lowland where the water depth ranged from 50-100 cm during vegetative to reproductive stage. From the investigation it was found that there was more number of internodes (7.12) and adventitious roots (4.45) in the submerged tolerant variety Varshadhan and FR-43A as compared to susceptible varieties like Badabankoi, Sukasari and T-90 etc. Varshadhan exhibited highest plant height, more number of effective tillers whereas minimum value of these characters was recorded from susceptible varieties. Under water logged and submerged condition Varshadhan showed higher physiological growth parameters such as LAI, RGR, CGR and LAD among the genotypes. Dry matter accumulation was highest in submerged tolerant variety Varshadhan (1331.11 g m^{-2}) and followed by FR-43A (1324 g m^{-2}) both before and after submergence. The suitable combination among these varies depending upon the submergence tolerance of the variety. Sabita had the highest productivity (38.43 q/ha) than the others due to the suitable combination among the yield attributing characters in study area.

Key words: *Kharif, Paddy, Roots, Morpho-physiological, Biochemical characters.*

INTRODUCTION

Rice is a major staple food of India, China, West Africa, Liberia, and Guinea. It is one of the most important cereal crops grown in varied ecosystems ranging from flood to drought condition and feeding the burgeoning human population which is about 60% of the world population. It consists 23% of global cereal acreage. The vast region on east coast India forms the rice bowl of country and supports the livelihood of several million rural poor.

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Eastern India alone accounts for nearly 60 per cent of India's 43 million hectare of rice, of which 80 percent is rainfed. An estimated 450 million people in the region depend on rainfed rice as their major source of livelihood (IRRI, 1997). The problems of flash floods, water logging/ submergence due to poor drainage are very common. Here, unexpected and uncontrollable flash floods upto 50 cm deep are common and sustained for several days. They are a result of overflowing rivers, accumulated runoff from higher land and huge industrialization[4]. Since deepwater rice is the only crop that can be grown in many flood-prone areas of eastern India, developing cultivars with increased yield and growth potential is of major agronomic importance. Prolong water logging during rainy season for the most part of crop growth reduces tillering and growth of the normal rice crop. Erratic or early heavy rain fall results in sudden water logging due to flash flood in rice field and submerges the crop in early seeding stage. In many cases, young rice seedlings are too small to escape by means of underwater leaf elongation and can't successfully develop a canopy under the water surface. The crop may damage completely if the situation continues. For the achievement of sustainable rice production in the lowlands it will therefore be necessary to incorporate adaptability to submergence in to rice cultivars.

MATERIALS AND METHODS

Field experiments on rice were conducted during *kharif* 2014 in Adaptive Research Station, Sakhigopal, Puri to study the morpho-physiological characters responsible for tolerance of rice varieties under submerged condition.

Details of Treatments	
CR DHAN 401- T_1	OR-2331/14 - T_{12}
FR-43B - T_2	IR 85085 SUB17- T_{13}
MANIKA- T_3	TANMAYEE- T_{14}
KALASIRA- T_4	RAMBHA- T_{15}
MAYURAKANTHA- T_5	JALAMGNA - T_{16}
OR-2328/05- T_6	MAHALAXMI- T_{17}
CR DHAN-500- T_7	OR142/99 - T_{18}
JALAMANI- T_8	SALIBAHANA- T_{19}
SABITA- T_9	BANKOI- T_{20}
CR-1030- T_{10}	CR DHAN-505- T_{21}
URBASI- T_{11}	JAYANTI DHAN- T_{22}

The nursery bed was developed for planting of 22 varieties of rice as mentioned above. Recommended package and practices of paddy were followed sincerely for this experiment. Prophylactic plant protection measures were also adopted to protect the crop from weeds, diseases and pests attack. The field was irrigated as and when required. Soil test based fertilizer doses were applied as recommended.

Shoot dry matter and its partitioning at successive growth stages

Two hills from each plot covering an area of 200 sq m. were randomly uprooted at heading and maturity stages for morpho-physiological observations. The plants were separated into roots, stems(leaf sheath+ culm), leaves(leaf blades)and panicles. The leaf area was measured by multiplying apparent leaf area(length and maximum breadth) with constant leaf area factor i.e, 0.725 at vegetative stage, 0.80 at maturity[5]. The plant parts were dried separately in a hot air oven at 90^0C for 48 hours. The dry weight of different plant parts was recorded at each growth stage and expressed in g m^{-2}. Then it was ground to powder for further laboratory analysis.

Leaf Area Index (LAI)

LAI is expressed as the ratio of leaf area (A) (only one side) to the ground area(P) occupied by the crop.

LAI=A/P

Leaf Weight Ratio(LWR)

LWR is expressed as the ratio of leaf dry weight (W_0) to the total plant dry weight (W)(Gregory,1926

$LWR= W_0/W$

Specific Leaf Area (SLA)

SLA is the ratio between leaf areas(A) and leaf dry weight(W_L)(Peacock,1975)

$SLA= A/W_L$

Specific Leaf Weight (SLW)

SLW is the ratio between leaf dry weight (W_L) and leaf area (A)

$SLW= W_L/A$

Leaf Area Duration (LAD)

LAD is defined as the leaf area index integrated over time

$LAD= A_2-A_1/LnA_2-LnA_1 X (t_2-t_1)$

Where

A_1= Leaf Area Index at the start of test period

A_2=Leaf Area Index at the end of test period

t_2-t_1= Period in days between initial and final observation

Leaf area ratio ((LAR)

LAR is defined as the ratio between leaf area (A) and total plant dry weight (W) LAR=A/W

RESULTS AND DISSCUSSION

Plant height

Plant height recorded before submergence indicated that highest value (118.77cm) was exhibited by Sabita, followed by FR-43B (108.73 cm) where the lowest value of the same was shown by Manika (72.73 cm). But when the crop was fully submerged for a period of 12 days Sabita recorded the maximum plant height (138.27 cm) followed by Bankoi (131.45 cm), whereas OR-2331/14 (91.29 cm) recorded the lowest value of the same. Elongation ability is an escape mechanism from partial or total submergence. Height of the plant was enhanced irrespective genotypes through the increase of shoot length. The percentage of increase of shoot length is greater in susceptible genotypes ranging from 24.72 % to 33.96%, whereas in the tolerant genotypes increased only 16.40 % to 22.70 % **(Table-1)**. From the present experiment it was found that Sabita and FR-43B showed greater shoot elongation than other cultivars under submerged condition with reduced elongation 16.40% and 19.98 % respectively for better survival.

Total number of tillers and effective tillers

The total number of tillers before the submergence recorded at 75 days i.e. before the submergence (water depth 35 cm) indicated that higher number of tillers was contributed by IR85085 sub-17 (28.90/hill) followed by Rambha (25.67/hill, **Table-1)**but when the crop was submerge d for 12 days there was degeneration of the tillers and the number of tillers irrespective of variety was reduced. Highest number of tillers/hill was observed in IR 85085sub-17 (28.90/hill) whereas highest number of effective tillers was recorded in Sabita (10.10/hill) followed by FR-43B (9.90/hill). The tillers that were developed after the submergence do not contribute gain yield. The number of effective tiller was higher in tolerant genotypes as compeer to the susceptible genotypes because there was damage of tillers due to anoxia stage under submerged condition and the energy required for survival was very less.

Number of internodes above 3.5 c.m, number of adventitious roots per plants and survival percentage (Table-2)

Number of internodes (above 3.5 cm) present in the same was the maximum (6.37) in FR-43B followed by Sabita(6.25) . But Kalasira recorded minimum number (4.25) under submerged condition. The significant difference was observed among the cultivars. The C.V. value indicated the wide difference among the varieties. Elongation of internodes (more than 3.5 cm) was maximum in FR -43B (6.37) followed by Sabita (6.25), where as minimum value of the same was exhibited by Bankoi (4.26) and Kalasira (4.25) which are as per (Table-4). Internodes elongation was started when the plants are submerged (at 90 days) after transplanting up to 150 DAP which is the most important mechanism for increasing the plant height under deep water condition for better survival. According to elongation of

internodes is caused due to increase and lengthening of number of cells. Under the submerged condition the ethylene production is higher which triggered the GA production in the plant cell. As a result of which it led 10 fold increases of cells in the zones. From the present experiment it was found that high correlation between plant height and submergence (survival) in deep water rice. The present investigation is aggraded with the findings of earlier workers[3]. It was also observed that maximum adventitious roots were exhibited by Sabita (3.97) which was significantly higher among the varieties. On the other hand Kalasira showed minimum value of the same (2.61) in response to submerged condition.

Leaf Area Index (LAI)

The LAI vary widely among the cultivars under test after the submergence as compared to before, CR dhan-505 concluded highest LAI by 10.30 (**Table-3**) where as minimum value (6.50) of the same was shown in Bankoi recorded at 75 days i.e before the submergence when the crop was submerged for a period of 12 days completely, there was degeneration of tillers and the leaf area was reduced in all the varieties. It was found that there was reduced of leaf area due to submergence and the LAI was reduced. It was observed that the maximum LAI was obtained from a rice plant during its vegetative stage to a tune of 10-12 but the critical LAI value for optimum photosynthesis is 67 under normal or optimum weather condition. It was revealed from the data that maximum LAI was observed 10.30 from CR dhan-505 followed by Jalamani (10.20)Where as the minimum value of the same was recorded from Bankoi (6.50) before the submergence. Due to submergence there was damage of tillers as anoxia was created and irrespective of varieties there was reduction of tiller number. Among the varieties maximum LAI was recorded from Sabita (6.7) followed by FR-43B (6.2) and Jalamagna (5.8) where as Kalasir showed the minimum value (2.60).

Specific Leaf Area (SLA)

In case of SLA the reverse trend was found. The SLA recorded before the submergence was maximum in Bankoi (393.82 cm2/g, **Table-3**), followed by Kalasira (375.68 cm2/g) where the minimum value of the same was shown in Sabita (181.24 cm2/g). After the submergence the maximum SLA (451.96 cm2/g) was contributed by Bankoifollowed by Mayurakantha (425.2 cm2/g).

Specific Leaf Weight (SLW)

The tolerant varieties showed highest value both and after submergence condition as compared to the susceptible genotypes. The maximum SLW was recorded both before and after CR Dhan-500 (5.51 & 4.78 mg/cm2,**Table-3**) whereas minimum value was recorded by Salibahana (2.96 & 2.66 mg/cm2). Significant difference among the varieties was noted(Table-5). Specific Leaf Weight (SLW) and Leaf Area Ratio decreased due to submergence. NAR is positively associated with SLW and negatively with LAR. So SLW can be selected as a useful parameter for selection of a variety to have higher NAR at vegetative stress under stress prone environment[1].

Leaf area ratio (LAR),

The LAR was influenced by submerged condition as compared with before submergence. It was found that Maximum LAR (80.08 cm^2/gm,**Table-4**) was recorded by Sabita followed by CR Dhan-505 (71.60 cm^2/gm) and followed by Jalamgna (71.36 cm^2/gm) where minimum value of the same was shown in OR-2331/14 (34.81 cm^2/gm) before the submergence. It was found that after submergence the tolerant variety FR-43 B exhibited maximum LAR (63.79 cm^2/gm) followed by Sabita (58.68 cm^2/gm) whereas minimum value was recorded from Bankoi (26.99 cm^2/g). Significant difference was found among the genotypes but not within the replication.

Relative growth rate(RGR)

The RGR of the genotypes varied from 17.05 mg/g/day to 21.88 mg/g/day (**Table-4**) before the submergence whereas RGR recorded from after the submergence to harvesting varied

from 12.63 mg/g/day to 19.23 mg/g/day. The highest RGR during the peak vegetative stage was highest in Sabita (21.88 mg/g/day) followed by FR-43B (21.69 mg/g/day). There was highly positive correlation of RGR with grain yield, grains/panicle, shoot dry matter and negatively correlated with sterility percentage (Table-6).

Leaf weight ratio (LWR)

The weight ratio (LWR) recorded before and after submergence was reflected in **Table-4**. Comparision of LWR among the genotypes revealed that Bankoi had the highest LWR (0.27) followed by Mayurakantha (0.24) where as the minimum value of the same was exhibited by CR-1030 (0.13) before the submergence. Data recorded after the submergence revealed that highest LWR was shown by Bankoi (0.19) but CR dhan-500 and OR-2328/05 noted the lowest value (0.11). The percentage of reduction of LWR range from 15.00% to 40.91% due to submergence as compared to before submergence. Significant difference was found among the replication and within the varieties.

Crop Growth Rate (CGR),

Among the cultivars highest CGR was obtained from Jalamgna (35.33mg/m^2/day, **Table-4**) followed by Sabita (33.42mg/m^2/day) while the lowest value was exhibited from Rambha (10.53 mg/m2/day) before the submergence. There was reduction of CGR due to submergence irrespective of genotypes. Highest CGR was obtained from Sabita (18.28 mg/m2/day) whereas the minimum CGR was recorded from Bankoi (5.34 mg/m2/day). There was significant difference among the varieties as well as within the replication.

Net Assimilation Rate (NAR)

Comparison between the varieties as regards to NAR activity which was revealed from the data presented in Table-7that Sabita exhibit the maximum value (38.15 mg/dm2/day,**Table-5**) followed by FR-43B (34.08 mg/dm2/day) but the minimum value was recorded from Bankoi (17.36 mg/dm2/day). As per the C.V. value there was variation among the cultivars in NAR activities.

Leaf Area Duration(LAD)

Variation in Leaf Area Duration (LAD) among the cultivars estimated from heading to maturity revealed that maximum LAD was recorded from Sabita (141.20 days,**Table-5**) followed by FR-43B (136.72days) but the minimum value of the same was recorded in Mayurakantha (115.62 days). The Leaf Area Duration (LAD) measured from the flowering to harvest was found highest in Sabita (141.2 Days) followed by FR-43B (135.7 Days). LAD expresses the persistence of leaf area or leafiness during the period of crop growth by which interception of light will be better.

Yield Attributing characters (Table-6)

Variation in panicle length among the varieties under test due to submergence was presented in the Table-13, which revealed that maximum panicle length was exhibited by IR 85085 Sub-17 (26.80 cm) followed by Sabita (26.68 cm) where as minimum value of the same was shown by OR-142/99 (21.49 cm). Significant difference among the genotypes was not exhibited.

The maximum number of grains/panicle was found in OR-2331/14 (209.5 cm) followed by Mayurakantha (200.17 cm) where as the lowest value of the same was observed in Kalasira (146.50 cm). There was significant difference among the cultivars as regard to number of grains/panicle (Table-13).

Among the cultivars the bold grains/panicle was highest in OR-2331/14 (99.80/panicle) which was significant greater than others varieties. On the contrary Bankoi a significant lower value (52.80/panicle)of the same than other genotypes. It was found that percentage of increase of the bold grains of OR-2331/14 (47.09%) as compared to the Bankoi. Significantly difference among the varieties as record to filled up grains was noted.

Comparison of 1000 seed weight among the genotypes indicated that highest value was

recorded from Jayanti Dhan (27.67g) followed by Kalasira (27.26 g) where as the minimum value of the same was exhibited by CR-1030 (20.50g).

Variation in grain yield was observed among the cultivars due to the effect of submergence data presented in the Table-14 indicated that highest grain yield (38.43 Q/ha) was recorded from Sabita followed by FR-43B (38.07 Q/ha) whereas the lowest yield was recorded from Kalasira (26.00 Q/ha) which was significantly lower than other cultivarsexceptBankoi.

Data presented in Table-14 reflected that the Harvest Index (HI) of the tested cultivars under submerged condition ranged from 23.94 to 32.46. This highest value of Harvest index was shown in FR-43B (32.46) followed by Sabita(32.45) whereas the lowest value of the same was shown in Bankoi (23.94) which was 26.24% % reduction from the former.

Table 1: Variation in plant height, number of tillers/hill and number of effective tillers/hill in response to submerged condition of rice cultivars

Variety	Plant height (cm)			No. of tillers		No .of effective tillers
	BS (75 DAS)	AS (90 DAS)	Harvest	BS (75 DAS)	AS (90 DAS)	
Sabita	118.77	138.27 (+16.41%)	172.17 (+19.69%)	16.50	11.97 (-27.40%)	10.10
FR-43B	108.73	130.45 (+19.98%)	149.70 (+12.85%)	16.87	11.97 (-29.04%)	9.90
Jalamgna	87.42	105.45 (+20.63%)	144.67 (+27.10%)	13.57	9.00 (-33.60%)	7.70
OR-2331/14	74.83	91.29 (+22.00%)	115.33 (+20.84%)	22.07	13.97 (-36.70%)	8.47
IR 85085 SUB-17	81.13	98.97 (+22.00%)	112.83 (+12.28%)	28.90	19.00 (-34.20%)	7.60
JayantiDhana	85.19	103.84 (+21.90%)	127.50 (+18.55%)	15.70	10.00 (-36.30%)	6.47
Jalamani	91.61	110.69 (+20.83%)	157.77 (+29.84%)	12.50	9.07 (-27.40%)	7.40
CR dhan-500	81.43	99.75 (+22.75%)	117.60 ((+15.17%)	11.83	9.00 (-23.9%)	7.30
CR dhan-401	84.82	103.98 (+22.60%)	116.67 (+10.87%)	22.43	15.97 (-28.80%)	7.30
CR dhan-505	100.43	123.22 (+22.70%)	136.00 (+9.39%)	12.77	10.00 (-21.60%)	7.27
Mahalaxmi	82.54	102.97 (+24.72%)	114.67 (+10.20%)	16.17	9.83 (-39.20%)	7.20
Manika	72.73	91.80 (+26.22%)	111.50 (+17.66%)	16.80	11.00 (-34.5%)	7.17
CR dhan-1030	89.67	111.83 (+24.67%)	129.60 (+13.71%)	21.10	12.83 (-39.1%)	7.10
OR-142/99	74.82	92.90 (+24.16%)	103.67 (+10.39%)	24.60	15.97 (-35.08%)	7.10
Tanmayee	73.10	97.30 (+33.10%)	115.50 (+15.76%)	16.03	10.17 (-36.50%)	7.10
Urbashi	74.40	99.67 (+33.96%)	116.43 (+14.40%)	16.40	10.33 (-37.01%)	6.90
Salibahana	77.37	97.92 (+26.57%)	120.17 (+18.51%)	22.70	15.03 (-30.90%)	6.80
Rambha	87.85	115.07 (+30.98%)	135.50 (+15.07%)	25.67	16.00 (-37.6%)	6.80
OR/2328/05	72.79	92.57 (+26.92%)	123.47 (+25.02%)	17.20	10.00 (-41.86%)	6.59
Mayurakantha	90.09	115.17 (+27.83%)	137.67 (+16.35%)	14.73	8.07 (-45.21%)	6.20
Kalasira	89.63	115.12 (+28.44%)	147.00 (+21.90%)	20.77	8.37 (-59.70%)	5.47
Bankoi	101.59	131.45 (+29.40%)	157.83 (+16.71%)	14.93	9.00 (-39.71%)	6.20
SEM	0.83	0.76	0.89	0.37	1.02	0.08
C.D 5%	2.38	2.18	2.54	1.06	2.91	0.24
C.V	1.68	1.22	1.20	3.54	5.18	2.04

Table 2: Variation in number of internodes, number of adventitious roots and survival percentage in response to submerged condition in different rice cultivars

Variety	No. of Internodes Above 3.5 cm	No. of Adventitious Roots	Survival Percentage (%)
Sabita	6.25	3.90	70.22
FR-43B	6.37	3.97	68.95
Jalamgna	6.00	3.73	65.21
OR-2331/14	5.98	3.72	66.23
IR 85085 SUB-17	5.97	3.71	66.06
JayantiDhana	5.76	3.60	64.10
Jalamani	5.73	3.58	63.18
CR dhan-500	5.76	3.58	63.60
CR dhan-401	5.71	3.56	63.20
CR dhan-505	5.63	3.52	62.48
Mahalaxmi	5.60	3.51	62.38
Manika	5.47	3.41	60.72
CR dhan-1030	5.48	3.40	60.71
OR-142/99	5.47	3.42	60.64
Tanmayee	5.47	3.41	60.57
Urbashi	5.25	3.27	58.21
Salibahana	5.13	3.19	56.80
Rambha	5.07	3.15	56.24
OR/2328/05	4.78	2.97	52.96
Mayurakantha	4.48	2.78	49.58
Kalasira	4.25	2.61	47.03
Bankoi	4.26	2.64	47.25
Sem	**0.03**	**0.02**	**0.36**
C.D 5%	**0.08**	**0.04**	**1.02**
C.V	**0.90**	**0.80**	**1.03**

Table 3: Variation in leaf area index (LAI), specific leaf area (SLA), specific leaf weight (SLW) in response to submerged condition in different rice cultivars

VARIETY	LAI		SLA(cm2/g)		SLW (mg/cm2)	
	BS	AS	BS	AS	BS	AS
Sabita	7.90	6.70 (-15.19%)	181.24	208.82 (+15.22%)	4.70	4.30 (-8.51%)
FR-43B	7.40	6.20 (-16.22%)	212.38	267.56 (+25.98%)	3.97	3.87 (-2.52%)
Jalamgna	8.50	5.80 (-31.76%)	243.78	258.38 (+5.99%)	4.07	3.57 (-12.29%)
OR-2331/14	9.90	4.00 (-59.60%)	245.69	271.15 (+10.36%)	4.10	3.73 (-9.02%)
IR 85085 SUB-17	7.10	5.30 (-25.35%)	248.41	267.34 (+7.62%)	4.02	3.74 (-6.97%)
JayantiDhana	8.90	5.30 (-40.45%)	251.78	285.51 (+13.40%)	3.86	3.68 (-4.66%)
Jalamani	10.20	5.30 (-48.04%)	257.14	288.66 (+12.26%)	3.88	3.50 (-9.79%)
CR dhan-500	5.30	4.60 (-15.22%)	258.48	290.1 (+12.23%)	5.51	4.78 (-13.25%)
CR dhan-401	7.00	5.00 (-28.57%)	258.95	291.93 (+12.74%)	3.87	3.46 (-10.59%)
CR dhan-505	10.30	4.90 (52.43%)	258.04	293.19 (+13.62%)	3.86	3.44 (-10.88%)
Mahalaxmi	6.90	4.70 (-31.88%)	264.49	294.69 (+11.42%)	3.78	3.42 (-9.52%)
Manika	6.60	4.40 (-33.33%)	264.89	297.36 (+12.26%)	3.77	3.41 (-9.55%)
CR dhan-1030	6.60	4.30 (-34.84%)	266.11	314.4 (+18.15%)	3.75	3.36 (-10.40%)
OR-142/99	7.90	4.20 (-46.84%)	275.92	332.34 (+20.45%)	3.62	3.39 (-6.35%)
Tanmayee	5.50	4.80 (-12.17%)	289.93	327.14 (+12.83%)	3.49	3.18 (-8.88%)
Urbashi	6.70	3.90 (-41.79%)	285.73	337.1 (+17.98%)	3.44	3.05 (-11.34%)
Salibahana	8.20	3.90 (-52.44%)	295.3	342.1 (+15.85%)	3.38	2.96 (-12.43%)
Rambha	7.40	3.80 (-48.65%)	304.59	359.85 (+18.14%)	3.28	2.87 (-12.50%)
OR/2328/05	7.00	3.60 (-48.57%)	321.88	383.49 (+19.14%)	3.10	2.66 (-14.19%)
Mayurakantha	7.40	2.90 (-60.81%)	342.44	425.2 (+24.17%)	2.92	2.77 (-5.14%)
Kalasira	6.90	2.60 (-62.32%)	375.68	400.24 (+6.54%)	2.53	2.49 (-1.58%)
Bankoi	6.50	4.00 (-38.46%)	393.82	451.96 (+14.76%)	2.66	2.21 (-16.92%)
SEM	0.16	0.17	0.02	0.03	0.04	0.03
C.D 5%	0.45	0.48	0.06	0.08	0.10	0.08
C.V	3.66	6.24	0.01	0.02	1.67	1.45

Table 4: Variation in leaf area ratio (LAR), relative growth rate (RGR), leaf weight ratio (LWR) in different rice cultivars

Variety	LAR (cm2/g)		RGR(mg/g/day)		LWR	
	BS	AS	BS	AS	BS	AS
Sabita	80.08	58.68 (-26.72%)	21.88	19.23 (-12.11%)	0.22	0.18 (-18.18%)
FR-43B	66.28	57.15 (-13.76%)	21.69	18.82 (-13.23%)	0.20	0.17 (-15.00%)
Jalamgna	71.36	54.65 (-23.42%)	21.45	18.47 (-13.89%)	0.18	0.14 (-22.22%)
OR-2331/14	62.82	37.44 (-40.40%)	21.22	18.17 (-14.37%)	0.16	0.10 (-37.50%)
IR 85085 SUB-17	48.93	42.57 (-12.98%)	21.05	17.97 (-14.63%)	0.18	0.14 (-22.22%)
JayantiDhana	50.97	48.29 (-5.26%)	20.97	17.81 (-15.07%)	0.21	0.13 (-38.10%)
Jalamani	56.12	46.86 (-16.50%)	21.15	17.87 (-15.51%)	0.18	0.13 (-27.78%)
CR dhan-500	47.43	46.35 (-2.28%)	21.25	17.89 (-15.81%)	0.17	0.11 (-35.29%)
CR dhan-401	52.42	46.88 (-10.57%)	21.28	17.76 (-16.54%)	0.21	0.14 (-33.33%)
CR dhan-505	71.60	45.77 (-36.08%)	21.15	17.58 (-16.88%)	0.22	0.13 (-40.91%)
Mahalaxmi	50.02	39.88 (-20.27%)	20.77	17.18 (-17.28%)	0.19	0.12 (-36.84%)
Manika	60.49	43.16 (-28.65%)	20.90	17.01 (-18.61%)	0.21	0.14 (-33.33%)
CR dhan-1030	44.81	36.93 (-17.59%)	21.91	17.11 (-21.91%)	0.13	0.09 (-30.77%)
OR-142/99	56.12	37.90 (-32.47%)	21.24	17.01 (-19.92%)	0.20	0.15 (-25.00%)
Tanmayee	47.81	46.84 (-2.86%)	21.02	16.73 (-20.41%)	0.13	0.09 (-30.77%)
Urbashi	48.60	38.54 (-20.70%)	21.14	16.72 (-20.91%)	0.18	0.12 (-33.33%)
Salibahana	55.15	39.98 (-27.51%)	21.40	16.73 (-21.82%)	0.17	0.13 (-23.53%)
Rambha	63.40	36.48 (-42.46%)	21.11	16.45 (-22.07%)	0.23	0.17 (-26.09%)
OR/2328/05	55.29	34.53 (-37.55%)	20.89	16.17 (-22.59%)	0.16	0.11 (-31.25%)
Mayurakantha	61.94	30.09 (-51.42%)	21.06	16.12 (-23.46%)	0.24	0.16 (-33.33%)
Kalasira	55.04	27.21 (-50.56%)	17.05	12.93 (-24.16%)	0.21	0.15 (-28.57%)
Bankoi	54.54	26.99 (-50.51%)	17.13	12.63 (-24.52%)	0.27	0.19 (-29.63%)
SEM	0.24	0.45	0.33	0.20	0.02	0.02
C.D 5%	0.67	1.30	0.76	0.58	0.05	0.05
C.V	0.71	1.85	6.07	2.06	16.16	22.12

Table 5: Variation in crop growth rate (CGR), net assimilation rate (NAR) & leaf area duration (LAD) in response to submerged condition in different rice cultivars

Sl. No.	Variety	CGR (mg/m2/day)		NAR (mg/dm^2/day)	LAD (days)
		BS	AS	AS	
1	Sabita	33.42	18.28 (-45.30%)	38.15	141.20
2	FR-43B	28.50	11.96 (-58.04%)	34.08	136.72
3	Jalamgna	35.33	17.03 (-51.80%)	29.82	134.55
4	OR-2331/14	27.95	15.77 (-43.58%)	26.73	130.34
5	IR 85085 SUB-17	27.91	14.34 (-48.62%0	27.54	128.43
6	JayantiDhana	25.59	12.53 (-51.04%)	24.15	130.92
7	Jalamani	32.62	12.29 (-62.32%)	26.47	128.35
8	CR dhan-500	26.97	11.94 (-55.73%)	21.43	129.00
9	CR dhan-401	24.02	11.41 (-52.50%)	21.65	126.21
10	CR dhan-505	20.77	10.88 (-47.62%)	21.53	126.72
11	Mahalaxmi	20.57	10.38 (-49.54%)	21.36	127.43
12	Manika	21.13	10.07 (-52.34%)	28.83	129.42
13	CR dhan-1030	20.44	9.68 (-52.64%)	22.19	126.32
14	OR-142/99	16.53	8.45 (-48.88%)	18.50	125.23
15	Tanmayee	15.46	7.96 (-48.51%)	23.20	124.77
16	Urbashi	14.00	7.67 (-45.21%)	21.75	123.63
17	Salibahana	18.98	7.28 (-61.64%)	20.96	121.73
18	Rambha	10.53	7.12 (-32.38%)	18.57	119.82
19	OR/2328/05	25.22	6.55 (-74.03%)	19.66	116.30
20	Mayurakantha	29.06	6.17 (-78.77%)	20.22	115.62
21	Kalasira	16.47	5.88 (-64.30%)	18.88	120.23
22	Bankoi	19.08	5.72 (-70.02%)	17.36	119.41
	SEM	0.03	1.28	0.02	0.03
	C.D 5%	0.08	3.64	0.06	0.08
	C.V	0.22	21.21	0.16	0.04

Table 6: Yield Attributing Characters In Response To Submerged Condition Of Rice Varieties

Variety	Panicle Length (cm)	No. Of Grains/ Panicle	No. Of Filled Grains/ Panicle	Sterility (%)	1000 Grain Wt.(g)	Harvest Index (%)	Yield (q/ha)
Sabita	26.68	156.00	86.80	44.3	25.70	32.45	38.43
FR-43B	24.08	162.00	83.00	48.7	24.70	32.46	38.07
Jalamgna	20.56	155.37	80.00	48.5	23.54	31.34	36.72
OR-2331/14	22.91	209.53	99.80	52.3	20.27	30.76	36.60
IR 85085 SUB-17	26.80	179.90	80.00	55.5	20.60	30.37	36.63
JayantiDhana	23.61	180.77	78.40	56.6	27.67	29.87	35.40
Jalamani	22.40	154.50	68.00	55.9	26.35	29.55	35.21
CR dhan-500	23.30	159.80	72.50	54.6	26.34	29.36	34.54
CR dhan-401	23.94	164.67	66.80	59.4	24.85	29.20	35.23
CR dhan-505	24.03	161.80	68.70	57.5	25.58	28.89	34.90
Mahalaxmi	24.50	198.47	88.00	55.3	23.57	28.94	34.48
Manika	22.25	191.47	81.00	57.6	20.74	28.39	33.48
CR dhan-1030	25.36	175.27	71.30	59.3	20.50	28.22	33.53
OR-142/99	21.49	179.60	69.20	61.4	20.54	27.90	33.59
Tanmayee	24.20	148.13	62.60	57.7	25.24	27.84	33.57
Urbashi	20.39	165.90	62.00	62.6	20.61	27.53	32.17
Salibahana	23.47	172.10	63.60	63.0	23.33	26.92	31.42
Rambha	25.42	156.87	59.40	62.1	24.50	26.33	31.10
OR/2328/05	21.60	165.47	59.00	64.3	22.18	25.16	29.47
Mayurakantha	22.57	200.17	72.00	64	22.64	24.80	27.13
Kalasira	24.75	146.50	55.00	62.4	27.26	24.31	26.00
Bankoi	22.13	152.07	52.80	65.0	24.73	23.94	26.10
SEM	0.49	1.09	1.02	1.09	0.83	0.10	0.47
C.D 5%	1.41	3.12	2.91	3.10	2.36	0.29	1.35
C.V	3.63	1.11	2.60	3.15	6.05	0.61	2.45

CONCLUSION

The present experiment revealed that the highest number of effective tillers/hill was found in Sabita (7.90/hill) followed by FR-43B (7.87/hill) which indicates the high survival percentage of the cultivars during submergence. There is a greater ability of sink tissues to store sugar. So the number of panicles/hill, effective tillers/hill and 1000 grain weight are regarded as the selection criteria for adequate production of grain yield under submergence[2] .There was variation in grain yield among the different genotypes ranging from 26.00 q/ha in Kalasira to 38.43 q/ha in Sabita under submerged condition. The suitable combination among these varies depending upon the submergence tolerance of the variety. Sabita had the highest productivity (38.43 q/ha) than the others due to the suitable combination among the yield attributing characters in study area.

REFERENCES

1. Chattha, TM and Khan MA.,Study on relationship between physiological parameters of indices. *Pakistan Journal of Scientific and Industrial Research*, **34(1):** 37-39 (1991).
2. Chen Song, Fang-Rong-Zeng, Zhi., Characterization of high yield performance as affected by genotypes and environment in rice, *Journal of Zhejiang University Science-B,* **9(5):** 363-370 (2008).
3. Mazerado AM and Vergara BS , Physiological difference in rice varieties tolerance and susceptible to complete submergence. In:Proceedings of the 1981 International Deep Water Rice Workshop.IRRI, Los Banos, The Phillipines, 327-341 (1982).
4. Puckridge DW and Senadhira D., Breeding flood prone rice, Internatinal Rice Research Institute, Manila (1995).
5. Yoshida S., Fundamental of Crop science. Intl. Rice Res. Institute, Los Banos, Leguna, Phillipines. 269 (1981).