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Study of Relationship between Carbohydrate components of Stem and Survival % by Genetic correlation and Path analysis for Submergence Tolerance in Rice (Oryza sativa L.)

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Abstract

Fifty paddy genotypes along with four tolerant and three susceptible checks were assessed for study of genetic correlation and path analysis between carbohydrate components of stem viz. total carbohydrate, non structural carbohydrate (NSC), starch and soluble sugar contents with survival% both in before and after submergence for ten days old seedlings and four days of complete submergence under drum and pot screening method. Genotype like Mahananda exhibited highest amount of NSC % of stem both in before & after submergence with 80% of survival. For the soluble sugar, sucrose% was higher among other components viz. glucose and fructose. Bivariate analysis of simple genetic correlation showed that all the four characters both in before and after submergence are significantly correlated with survival% at 0.01 and 0.05 probability level respectively. Genetic correlation among soluble sugars components of stem was significantly positive with survival % both in before and after submergence. Path analysis showed that it was only non structural carbohydrate %, soluble sugar % and starch % of stem after submergence has positive direct effect on survival%. Soluble sugar % has positive direct effect on survival both in before and after submergence. Total carbohydrate % of stem both in before and after submergence has negative effect on survival. Retention of higher NSC % after submergence would be the one of the most important criteria for better regeneration after submergence. Selection of specific characters such as NSC % and soluble sugar % of stem in pre vegetative stage will be the key to biochemical screening for submergence tolerance in rice.

Keywords: Submergence, Total carbohydrate, Non structural carbohydrate (NSC), Starch, Soluble sugar, Correlation and Path analysis

Introduction

Flooding related to submergence tolerance in rice is of two types i.e. flash flooding and deep water system. In flash flooding, the characters which are considered to be as tolerant traits are identified few in number and one of the most important is capacity to slow elongation of stem by conserving of high non structural carbohydrate contents during pre vegetative stage. Most of review studies have revealed that carbohydrate status before and during submergence period has been considered as one of the crucial characters for tolerance. Maintenance of high carbohydrate content in stem is observed prior to submergence in some paddy genotypes which includes some submergence tolerant and deepwater paddy genotypes, but this character does not seem to be an essential for tolerance after complete submergence[1]. Though most of the earlier studies have given less stress on the importance of the level of post submergence non-structural carbohydrate (NSC) content and its relation with the survival however it is very much important trait to maintain optimum level of resources of food matter for quick survival after submergence[2]. Non-structural carbohydrate of stem which includes soluble sugar and starch contents are important for supplying energy required for metabolic pathways during anoxic condition for proper recovery and regeneration of paddy seedlings after submergence[3,4]. In the plant life cycle soluble sugars (sucrose, glucose and fructose) are mobilized from source to sink as energy sources. Maintenance of proper soluble sugars level after submergence is crucial for fast regeneration and survival.

Selection of paddy genotypes will be preferred to those with high level of non structural carbohydrate (NSC) concentration in stem along with capacity of consumption of less energy during total anoxic condition could provide manifold increase of submergence tolerance which indicates that NSC % status in post submergence is considered to be the one of the most crucial for survival. For anaerobic respiration during total inundation condition stored carbohydrate of stem are reported to be linked with increment of survival after submergence[5,6].

For submergence tolerance in rice the most important objectives will be the improvement of genotypes for better survival % after submergence. Genetic correlation and path analysis of biochemical characters like carbohydrate content of stem with survival % may reveals the association of characters linked with submergence tolerance in rice. So, study has been carried out in this experiment for correlation and path analysis of carbohydrate components of stem of fifty paddy genotypes to link with the submergence tolerance.

Materials and Methods

The experiment was done at Department of Genetics and Plant Breeding, University of Calcutta in 2014-2015. Estimation of total carbohydrate, starch content, soluble sugar content and nonstructural carbohydrate content from ten days old paddy seedlings stem and survival% was done for all fifty paddy genotypes as in Table-1, which includes FR13A, FR43B, IR 64 sub1 and Swarna sub1 as tolerant checks and IR64, Swarna and IR42 as susceptible checks. All the experiment was done in three replications.

Table -1
Name of the genotypes

Name of Genotypes	Source
FR13A (Tolerant Check)	CRRS , WB
Dudheswar	CRRS , WB
Mahananda	CRRS , WB
Lalat	East Medinipur , WB
Medi	ODISHA
Sonom	BIHAR
Raspanchali	CRRS , WB
Kataribhog	CRRS , WB
B-20	CRRS , WB
Sita	BIHAR
Amulya	CRRS , WB
Vaidheli	CRRS , WB
SR26B	CRRS , WB
Swarna *sub1* (Tolerant Check)	CRRS , WB
Lankagore	CRRS , WB
FR43B (Tolerant Check)	CRRS , WB
Sabita	CRRS , WB
Barsatora	CRRS , WB
Ambika	CRRS , WB
IR64 *sub1* (Tolerant Check)	CRRS , WB
Bhuri	CRRS ,WB
Nagalmuda	CRRS,WB
Lakshmikajal	CRRS,WB
Khitish	CRRS,WB
Kalopahar	Balasore
Malabati	CRRS,WB
Bakulpryia	CRRS,WB
Altanuti	CRRS,WB
Rajendraban	BIHAR
Dadswal	Gosaba,WB
Morichswal	Namkhana,WB
Nonabakra	CRRS,WB
Pokkali	CRRS,WB
Ranjan	CRRS,WB
Bangalakshmi	Medinipur,WB
Moulow	CRRS,WB
Palui	CRRS,WB
Akandi	CRRS,WB
Purnendu	CRRS,WB
CR-1280	CRRS ,WB
Masuri	CRRS,WB
Niko	Gosaba,WB
IR64 (Susceptible check)	CRRS,WB
Swarna (Susceptible check)	CRRS,WB
N-Shankar	Mednipur,WB
IR42 (Susceptible check)	CRRS,WB
Jaladhi II	CRRS,WB
Khejurchori	Sunderban,WB
Kanakchur	Jaynagar,WB
Lilabati	CRRS,WB

CRRS- Chinsurah Rice Research Station

Statistical analysis: Each and every plant entries was evaluated for calculation of various traits and mean of the data was used for assessment for the experiment. The experimental set up was conducted by RBD in three replications in EXCEL software. Bivariate analysis of simple genetic correlation and path analysis was done in SPAR 2.0 version software.

Estimation of total carbohydrate from stem by anthrone reagent: To estimate total carbohydrate of stem of fifty paddy genotypes for submergence tolerance screening in paddy the 10 days old paddy seedlings were grown on pot filled with soil were taken for experiment and same set of materials were submerged fully in long drum for 4 days. After four days of submergence the rice seedlings were taken for carbohydrate estimation. In both before and after submergence the carbohydrate estimations was done in three replications as per procedure of Sadasivam and Manickam[7] by anthrone reagent.

Estimation of starch from stem by anthrone reagent: To estimate starch of stem of fifty paddy genotypes for submergence tolerance screening in paddy the 10 days old paddy seedlings grown on pot filled with soil were taken for experiment and same set of materials were submerged fully in long drum for 4 days. After completion of four days of submergence the rice seedlings were taken for starch estimation. In both before and after submergences the starch estimations was done in three replications as per procedure of Sadasivam and Manickam[7].

Total soluble sugar from stem: To estimate total soluble sugar from stem of fifty paddy genotypes for submergence tolerance screening, the ten days old paddy seedlings were grown on pot filled with soil were taken for experiment and same set of materials were submerged fully in long drum for four days. After four days of submergence the paddy seedlings were assessed for total soluble sugar estimation. In both before and after submergences the soluble sugar components like glucose, sucrose and fructose estimations was done in three replications. The following experiment was done by standard protocols. i. Estimation of glucose was done by dinitrosalicylic acid method as per procedure of Sadasivam and Manickam[7] ii. Estimation of sucrose was done by the modified anthrone method of Finley and Fellers[8]. iii. Estimation of fructose was done as per procedure of Sadasivam and Manickam[7].

Estimation of non structural carbohydrate from paddy stem: Non Structural Carbohydrate (NSC) is the term which is generally describe as the digestible carbohydrates which consists of the starch and sugar components of the food matters. NSC is considered as the sum total of the association of sucrose, fructose, glucose of total soluble sugar content and starch. Non structural carbohydrate = Soluble sugar% + starch content %[9]. Soluble sugars include glucose, sucrose and fructose. Total carbohydrate% includes all types of carbohydrates. Total carbohydrate contains both nonstructural and structural components. The structural components include the cell wall fiber contents.

Results and Discussion

Table-2 represents that the total carbohydrate% of stem before submergences ranges from 16.5% to 69.3% and after submergence ranges from 3% to 47.8%. In both before and after submergence Mahananda exhibited excellent performance over tolerant check genotypes. There was a plenty of intra varietal variability regarding the total carbohydrate retention capacity after submergence. The genotypes which carried more carbohydrate content before submergence not always performed to retain higher carbohydrate content after submergence. Excluding the tolerant checks genotypes like Mahananda, Sabita, Nagalmuda, Lakshmikajal, Altanuti, Rajendraban, Purnendu and Jaladhi II showed retention of 20% or more total carbohydrate of stem after submergence. The starch% from the paddy stem before and after submergence was range from 1.35% to 6.48% before submergence. The stem starch content ranged from 0.3% to 4.78% after submergence. In both before and after submergence Mahananda performed best in all over fifty rice genotypes. Starch as non structural carbohydrate component plays essential role in submergence stress. The soluble sugar from stem ranges from 10.8% to 51.8% before submergence. Mahananda exhibited highest value of all three sugar components before submergence. After submergence the total soluble sugar ranges from 2.4% to 38.2%.

Total soluble sugar before submergence includes glucose, sucrose and fructose. Table-3 showed that glucose% ranges from 2.48% to 11.92%; sucrose% ranges from 6.37% to 30.56% and fructose% ranges from 1.94% to 9.33% before submergence. It was found that sucrose% as a non reducing sugar was maximum approximately 60% of the total soluble sugar. After submergence the ranges of glucose was 0.55% to 8.78%; sucrose was 1.42% to 22.54% and fructose was 0.43% to 6.8%. Sucrose content was high among the sugar components. Glucose amount was higher than that of fructose. These soluble sugars parts will be the component parts of the non structural carbohydrate content.

The concentration of non structural carbohydrate was determined by the addition of total soluble sugar along with starch contents. Table 2 showed that before submergence the nonstructural carbohydrate% of the paddy stem was ranges from 12.15% to 58.28%. The maximum NSC showed by Mahananda (58.28%) followed by IR64sub1 (38.70%) and FR13A (32.18%). After submergence the NSC content was range from 2.7% to 43%. Excluding the tolerant checks genotypes like Mahananda, Sabita, Ambika, Nagalmuda, Purnendu and Jaladhi II showed 20% or more NSC content after submergence. After four days of submergence the same set of rice genotypes were recorded for survival%. The survival % ranges from 10% to 90%.

Table - 2
Mean values of total carbohydrate and non structural carbohydrate (NSC) components of stem of fifty rice genotypes for submergence tolerance

Serial No.	Name of the genotype	Before submergence				After submergence				
		Carbohydrate %	Starch %	NSC%	Soluble Sugar%	Carbohydrate %	Starch %	NSC %	Soluble Sugar %	Survival %
1	FR13A	42.8	3.58	32.18	28.60	29.0	2.90	26.1	23.2	80
2	Dudheswar	35.8	3.18	28.58	25.40	14.8	1.48	13.3	11.8	50
3	Mahananda	69.3	6.48	58.28	51.80	47.8	4.78	43.0	38.2	80
4	Lalat	27.3	2.03	18.23	16.20	15.8	1.58	14.2	12.6	30
5	Medi	36.8	3.33	29.93	26.60	18.8	1.88	16.9	15.0	30
6	Sonom	36.3	3.20	28.80	25.60	12.3	1.23	11.0	9.8	10
7	Raspanchali	18.3	1.60	14.40	12.80	12.0	1.20	10.8	9.6	30
8	Kataribhog	26.8	4.28	18.48	14.20	19.0	2.90	16.1	13.2	30
9	B-20	28.3	2.50	22.50	20.00	16.3	1.63	14.6	13.0	40
10	Sita	29.5	2.45	22.05	19.60	11.3	1.13	10.1	9.0	20
11	Amulya	22.8	1.88	16.88	15.00	9.5	0.95	8.6	7.6	30
12	Vaidheli	30.8	2.23	20.03	17.80	12.3	1.23	11.0	9.8	40
13	SR 26B	21.5	1.85	16.65	14.80	9.3	0.93	8.3	7.4	30
14	Swarna *sub1*	36.8	3.30	29.70	26.40	25.0	2.50	22.5	20.0	90
15	Lankagore	22.3	1.60	14.40	12.80	11.5	1.15	10.4	9.2	30
16	FR43B	29.9	4.45	24.05	19.60	23.8	2.70	20.1	17.4	70
17	Sabita	30.3	2.93	23.93	20.20	22.3	2.23	20.0	17.8	70
18	Barsatora	28.8	2.30	20.70	18.40	11.3	1.13	10.1	9.0	40
19	Ambika	27.5	2.33	20.93	18.60	22.3	2.23	20.0	17.8	50
20	IR64 *sub1*	46.5	4.30	38.70	34.40	32.7	2.70	28.3	25.6	90
21	Bhuri	30.5	2.20	19.80	17.60	12.5	1.25	11.3	10.0	30
22	Nagalmuda	31.8	2.18	25.58	23.40	24.20	1.58	20.58	19.0	70
23	Lakshmikajal	26.8	2.70	23.30	20.60	21.5	1.23	18.83	17.6	60
24	Khitish	16.5	1.35	12.15	10.80	7.5	0.75	6.8	6.0	30
25	Kalopahar	23.5	1.95	17.55	15.60	9.8	0.98	8.8	7.8	20

Serial No.	Name of the genotype	Before submergence				After submergence				
		Carbohydrate %	Starch %	NSC%	Soluble Sugar%	Carbohydrate %	Starch %	NSC %	Soluble Sugar %	Survival %
26	Malabati	26.8	2.23	20.03	17.80	10.0	1.00	9.0	8.0	30
27	Bakulpryia	28.8	2.30	20.70	18.40	16.3	1.63	14.6	13.0	40
28	Altanuti	31.5	2.78	24.98	22.20	21.8	2.18	19.6	17.4	40
29	Rajendraban	33.3	3.03	27.23	24.20	22.8	2.28	18.48	16.2	40
30	Dadswal	28.3	2.63	23.63	21.00	3.0	0.30	2.7	2.4	10
31	Morichswal	28.5	2.65	23.85	21.20	5.8	0.58	5.2	4.6	20
32	Nonabakra	24.8	1.88	16.88	15.00	6.0	0.60	5.4	4.8	40
33	Pokkali	27.8	1.70	15.30	13.60	7.8	0.78	7.0	6.2	20
34	Ranjan	24.5	1.83	16.43	14.60	8.5	0.85	7.7	6.8	10
35	Bangalakshmi	25.3	2.03	18.23	16.20	11.3	1.13	10.1	9.0	30
36	Moulow	26.3	2.10	18.90	16.80	8.0	0.80	7.2	6.4	20
37	Palui	26.8	1.68	15.08	13.40	12.5	1.25	11.3	10.0	40
38	Akandi	21.3	1.93	17.33	15.40	11.3	1.13	10.1	9.0	30
39	Purnendu	32.5	3.75	28.10	24.4	25.5	1.85	21.6	19.85	80
40	CR-1280	25.3	1.50	13.50	12.00	8.0	0.80	7.2	6.4	20
41	Masuri	24.8	1.53	13.73	12.20	8.1	0.81	7.3	6.5	20
42	Niko	25.8	2.05	18.45	16.40	10.3	1.03	9.2	8.2	30
43	IR64	32.3	2.25	20.25	18.00	11.3	1.13	10.1	9.0	30
44	Swarna	28.8	1.63	14.63	13.00	9.3	0.93	8.3	7.4	20
45	N-Shankar	26.3	1.88	16.88	15.00	9.5	0.95	8.6	7.6	20
46	IR 42	23.5	2.00	18.00	16.00	10.0	1.00	9.0	8.0	20
47	Jaladhi II	32.3	3.50	22.50	23.00	25.5	1.95	20.15	18.20	60
48	Khejurchori	31.3	3.03	27.23	24.20	19.0	1.90	17.1	15.2	50
49	Kanakchur	23.5	1.88	16.88	15.00	16.3	1.63	14.6	13.0	30
50	Lilabati	27.5	1.95	17.55	15.60	11.3	1.13	10.1	9.0	30
	CD	2.54	1.02	1.62	1.01	1.94	0.052	1.82	0.072	2.74

NSC-Non structural carbohydrate

Table - 3
Mean values of soluble sugar components from rice stem of fifty rice genotypes linked with survival%

Serial No.	Genotypes	Before submergence			After submergence			Survival%
		Glucose%	Sucrose%	Fructose%	Glucose%	Sucrose%	Fructose%	
1	FR13A	6.6	16.9	5.1	5.3	13.7	4.2	80
2	Dudheswar	5.8	15.0	4.6	2.7	7.0	2.1	50
3	Mahananda	11.9	30.6	9.3	8.8	22.5	6.9	80
4	Lalat	3.7	9.6	2.9	2.9	7.4	2.3	30
5	Medi	6.1	15.7	4.8	3.5	8.9	2.7	30
6	Sonom	5.9	15.1	4.6	2.3	5.8	1.8	10
7	Raspanchali	2.9	7.6	2.3	2.2	5.7	1.7	30
8	Kataribhog	3.3	8.4	2.6	3.0	7.8	2.4	30
9	B-20	4.6	11.8	3.6	3.0	7.7	2.3	40
10	Sita	4.5	11.6	3.5	2.1	5.3	1.6	20
11	Amulya	3.5	8.9	2.7	1.7	4.5	1.4	30
12	Vaidheli	4.1	10.5	3.2	2.3	5.8	1.8	40
13	SR 26B	3.4	8.7	2.7	1.7	4.4	1.3	30
14	Swarna *sub1*	6.1	15.6	4.8	4.6	11.8	3.6	90
15	Lankagore	2.9	7.6	2.3	2.1	5.4	1.7	30
16	FR43B	4.5	11.6	3.5	4.0	10.3	3.1	70
17	Sabita	4.6	11.9	3.6	4.1	10.5	3.2	70
18	Barsatora	4.2	10.9	3.3	2.1	5.3	1.6	40
19	Ambika	4.3	11.0	3.3	4.1	10.5	3.2	50
20	IR64 *sub1*	7.9	20.3	6.2	5.4	13.9	4.2	90
21	Bhuri	4.0	10.4	3.2	2.3	5.9	1.8	30
22	Nagalmuda	5.4	13.8	4.2	4.4	11.2	3.4	70
23	Lakshmikajal	4.7	12.2	3.7	4.0	10.4	3.2	60
24	Khitish	2.5	6.4	1.9	1.4	3.5	1.1	30
25	Kalopahar	3.6	9.2	2.8	1.8	4.6	1.4	20

Serial No.	Genotypes	Before submergence			After submergence			Survival%
		Glucose%	Sucrose%	Fructose%	Glucose%	Sucrose%	Fructose%	
26	Malabati	4.1	10.5	3.2	1.8	4.7	1.4	30
27	Bakulpryia	4.2	10.9	3.3	3.0	7.7	2.3	40
28	Altanuti	5.1	13.1	4.0	4.0	10.3	3.1	40
29	Rajendraban	5.6	14.3	4.4	3.7	9.6	2.9	40
30	Dadswal	4.8	12.4	3.8	0.6	1.4	0.4	10
31	Morichswal	4.9	12.5	3.8	1.1	2.7	0.8	20
32	Nonabakra	3.5	8.9	2.7	1.1	2.8	0.9	40
33	Pokkali	3.1	8.0	2.4	1.4	3.7	1.1	20
34	Ranjan	3.4	8.6	2.6	1.6	4.0	1.2	10
35	Bangalakshmi	3.7	9.6	2.9	2.1	5.3	1.6	30
36	Moulow	3.9	9.9	3.0	1.5	3.8	1.2	20
37	Palui	3.1	7.9	2.4	2.3	5.9	1.8	40
38	Akandi	3.5	9.1	2.8	2.1	5.3	1.6	30
39	Purnendu	5.6	14.4	4.4	4.6	11.7	3.6	80
40	CR-1280	2.8	7.1	2.2	1.5	3.8	1.2	20
41	Masuri	2.8	7.2	2.2	1.5	3.8	1.2	20
42	Niko	3.8	9.7	3.0	1.9	4.8	1.5	30
43	IR64	4.1	10.6	3.2	2.1	5.3	1.6	30
44	Swarna	3.0	7.7	2.3	1.7	4.4	1.3	20
45	N-Shankar	3.5	8.9	2.7	1.7	4.5	1.4	20
46	IR 42	3.7	9.4	2.9	1.8	4.7	1.4	20
47	Jaladhi II	5.3	13.6	4.1	4.2	10.7	3.3	60
48	Khejurchori	5.6	14.3	4.4	3.5	9.0	2.7	50
49	Kanakchur	3.5	8.9	2.7	3.0	7.7	2.3	30
50	Lilabati	3.6	9.2	2.8	2.1	5.3	1.6	30
CD		1.21	2.54	1.02	1.62	1.94	1.01	2.74

There is good positive correlation between nonstructural carbohydrate content and survival in most of the higher retaining NSC rice genotypes. Higher retention of NSC after submergence promotes higher survival. Genotypes like Mahananda exhibited highest amount of NSC% of stem both in before and after submergence with 80% survival.

Table-4 showed that bivariate analysis of simple genetic correlation between carbohydrate, non structural carbohydrate components of stem of fifty paddy genotypes with survival% both in before and after submergence, in which all the four characters are significantly positively correlated with survival% at 1% and 5% probability level respectively. The r values linked with survival% was ranges from 0.61 to 0.85. It clearly showed that apart from total carbohydrate contents, components like non structural carbohydrate (NSC), soluble sugar and starch content are most important cell wall components for better survival in post submergence.

Table-5 showed that among soluble sugar components viz. glucose sucrose and fructose are positively correlated with survival% both in before and after submergence at p level 1% and 5% respectively. The r value was ranges from 0.61 to 0.89. It indicates that food reserves of cell wall of stem of paddy genotypes prior to vegetative stage are very critical for survival after submergence.

Table-6 showed that the path analysis for the effect of carbohydrate, nonstructural carbohydrate components of stem of fifty paddy genotypes on survival% both in before and after submergence and except carbohydrate% of stem all other characters viz. starch%, NSC% & soluble sugar% has significant positive direct effect on survival after submergence. It is very clear that carbohydrate% of stem is no longer to be considered as prime factor for survival during submergence and post submergence, rather the energy consumption efficiency are selected by the paddy genotypes for better regeneration to avoid post submergence injury. NSC and soluble sugar component are most critical for providing optimum energy to the growing seedlings during submergence and after submergence for beneficial effect towards survival.

Table – 4
Simple correlation (Bivariate analysis) between carbohydrate, non structural carbohydrate components, starch% and soluble sugar% of stem of fifty paddy genotypes with survival% both in before and after submergence

Characters	Carbohydrate % BS	Starch % BS	NSC % BS	Soluble Sugar % BS	Carbohydrate % AS	Starch % AS	NSC % AS	Soluble Sugar % AS	Survival%
Carbohydrate % BS	1.00	0.75***	0.95***	0.95***	0.80***	0.83***	0.81***	0.81***	0.61***
Starch % BS		1.00	0.76***	0.74***	0.90***	0.84***	0.91***	0.88***	0.65***
NSC % BS			1.00	0.99***	0.83***	0.88***	0.84***	0.83***	0.64***
Soluble Sugar% BS				1.00	0.82***	0.86***	0.83***	0.83***	0.64***
Carbohydrate % AS					1.00	0.82***	0.99***	0.99***	0.84***
Starch % AS						1.00	0.82***	0.80***	0.64***
NSC % AS							1.00	0.99***	0.84***
Soluble Sugar % AS								1.00	0.85***
Survival %									1.00

*and** = Significant at 1% and 5% probability level respectively; BS- Before submergence; AS-After submergence; NSC-Non structural carbohydrate

Table – 5
Simple correlation (Bivariate analysis) between soluble sugar components of stem of fifty paddy genotypes with survival% both in before and after submergence

Characters	Glucose% BS	Sucrose% BS	Fructose% BS	Glucose% AS	Sucrose% AS	Fructose% AS	Survival%
Glucose% BS	1.00	0.99***	0.96***	0.83***	0.82***	0.83***	0.62***
Sucrose% BS		1.00	0.99***	0.81***	0.83***	0.82***	0.66***
Fructose% BS			1.00	0.83***	0.82***	0.83***	0.61***
Glucose% AS				1.00	0.99***	0.91***	0.81***
Sucrose% AS					1.00	0.99***	0.89***
Fructose% AS						1.00	0.82***
Survival%							1.00

* and ** = Significant at 1% and 5% probability level respectively; BS- Before submergence; AS-After submergence

Table – 6
Path analysis for effect of carbohydrate, nonstructural carbohydrate components, starch% and soluble sugar% of stem of fifty paddy genotypes on survival% both in before and after submergence

Characters	Effects								
	Direct	Indirect via characters							
		Carbohydrate % BS	Starch % BS	NSC% BS	Soluble Sugar % BS	Carbohydrate % AS	Starch % AS	NSC % AS	Soluble Sugar % AS
Carbohydrate % BS	-0.073		-0.634	-5.519	4.008	-6.587	1.561	3.314	4.534
Starch % BS	-0.841	-0.555		-4.432	-7.377	1.573	3.702	4.956	0.655
NSC % BS	-5.834	-0.069	-0.638		4.2101	-6.768	1.658	3.407	4.685
Soluble Sugar % BS	4.224	-0.06	-0.623	-5.814		-6.748	1.609	3.391	4.676
Carbohydrate % AS	-8.185	-0.059	-0.757	-4.824	3.483		1.547	4.058	5.586
Starch % AS	1.877	-0.061	-0.704	-5.153	3.621	-6.747		3.316	4.496
NSC % AS	4.068	-0.059	-0.765	-4.886	3.521	-8.165	1.531		5.597
Soluble Sugar % AS	5.601	-0.059	0.744	-4.879	3.527	-8.164	1.507	4.065	
Residual	0.46								

BS- Before submergence; AS-After submergence; NSC-Non structural carbohydrate

Conclusion

There is good positive correlation between non structural carbohydrate and survival in most of higher retaining NSC in paddy genotypes. Survival under total inundation is associated with the effective capacity to conserve high amount of storable carbohydrate such as NSC to maintain balance of energy after submergence for quick regeneration. Variability in tolerance level is not necessarily linked with the preliminary carbohydrate status prior to the submergence but it is very much linked with the proper maintenance of energy conservation for sustainable growth after submergence along with high level of NSC% of stem. Among the diverse rice genotypes taken in the experiment Mahananda performed excellent by conserving highest amount of non structural carbohydrate of stem both in before and after submergence. It can be postulated that maintenance of optimum levels of non structural carbohydrate in the seedlings in pre and post submergence condition in pre vegetative stage are well desirable traits for submergence tolerance in rice.

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