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Research Article

STABILITY ANALYSIS FOR GRAIN YIELD AND ITS COMPONENT TRAITS IN RICE (*Oryza sativa* L.) AGAINST VARIED SALINITY STRESS

ROY ANITA AICH[1], AICH S.[2], DAS ARPITA[1*], MAJI A.[1] AND MANDAL G.S.[1]

[1]Department of Genetics & Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, 741252, West Bengal
[2]Rice Research Station, Govt. of West Bengal, Chinsurah, 712101, West Bengal
*Corresponding Author: Email - arpitacoh@gmail.com

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Abstract- The present investigation was conducted to evaluate 50 rice landraces for their stability parameters with respect to grain yield and its component characters across three different saline environments. The pooled analysis of variance revealed that genotype x environment interactions were significant for three characters plant height, days to 50% flowering and grain yield (q/ha) implying differential response of genotypes under three environments for these characters. From the current study it was concluded that considering yield and its component characters, Nonabokra and Saraswati were found suitable for all environments. Jalamagna, Golok and Dinesh were suitable for better environment for the characters plant height and days to 50% flowering. Kaushalya, Dudheshwar, Nalini and Sashi were suitable for better environments for grain yield whereas Biraj, Kunti, Mandira, Ranjeet, Bhudeb, Purnendu, Lalat, NC 678, Dadsal, Mohan, Jarava, Lunishree, Gobindobhog, Sadamota, Khejurchari and Aduisen were identified as suitable for poor environments.

Key words- Genotype x environment interaction, germplasm, salinity, yield, rice

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Introduction

Rice is the second most important cereal crop providing staple food for more than one third of the world's population. Today, rice has special position as a source of providing over 75% of Asian population and more than three billion of world populations meal which represents 50 – 80% of their calorie intake [1, 2]. As this crop is grown under a varied range of agro-climatic conditions ranging from upland to lowland and irrigated to rainfed situations, their phenotypic responses vary greatly in accordance with the environment. Rice, grown under different ecologies and water regimes, suffer severe yield losses due to several biotic and abiotic stresses. Around 20% of the irrigated land in the world is affected by salinity stress due to the accumulation of salt in agricultural soils by artificial application or natural disasters like intrusion of sea water [3]. The rice growing environments were analyzed and have been reported on decline in rice production that was due to physical environmental constraints [4]. Varietal adaptability to environmental fluctuations is important for the stabilization of crop production over both the regions and years. The major efforts in crop technology, under unfavorable environment should be yield stabilizing, cost reducing, risk minimizing and returns enhancing [5]. Therefore, beside high yield potential genotypic stability is also important requisite of consideration for selection of promising genotypes. Genotypes having minimum genotype and environment interaction reflect the potential of having genetic homeostasis, therefore suitable for general cultivation. There are a number of statistical methods for consideration of genotype x environment interaction and its relationship with stability. From all of these methods, regression of mean of each genotype on environmental index is one of the most applicable methods [6]. This method has been suggested and modified by several workers [7, 8]. In this analysis adaptability and stability of the genotypes are determined by partitioning genotype and environmental interaction into two components, regression coefficient (bi) as parameter of response and variance of deviation from regression (S^2di) as parameter of stability in consideration with mean of genotypes. These models are helpful in identification of adaptable genotypes over a wide range of environments; achieving stabilization in crop production over locations; developing phenotypically stable high potential cultivars; effective selection for yield stability and prediction of varietal responses under changing environments. The present investigation was aimed to assess the extent of genotype x environment interaction for grain yield and its component characters, to evaluate the rice genotypes for their yield performance and stability and to select and release genotypes with high grain yield with salt tolerance ability.

Materials and Methods

Fifty genotypes along with landraces were collected from Regional Research Station, Chinsurah. Phenotypic screening for salinity tolerance of rice accessions at seedling stage was carried out as per established protocol [9]. The genotypes were scored based on the usual symptoms using standard evaluation scale (SES) of 1 to 9 for rice [10]. The characters plant height, days to 50% flowering, number of filled grains/panicle and grain yield was calculated over the non-salinized control. Further, shoot samples (from all three replications) were collected, oven dried. Since, salinity tolerance is related to sodium and potassium uptake, the powdered shoot samples were analyzed for sodium and potassium concentration by flame photometry [11]. However, reduction in dry weight was measured by substracting the total plant dry weight in salinized condition from its respective non–salinized control.

Results and Discussion

In the present investigation, 50 genotypes were subjected to pooled analysis of variance for four characters [Table-1]. The pooled analysis of variance revealed that genotype x environment interactions were significant for three characters plant height, days to 50% flowering and grain yield (q/ha) implying differential response of genotypes under three environments for these characters. Present reports corroborated with the previous findings [12-16]. The genotype x environment interaction for the character number of filled grains/panicle was found to be non-significant. Therefore, further analysis of stability was not carried out for this character. Significant variation due to environments represented adequate heterogeneity among the environments for all the component characters. Partitioning of mean sum of squares in to that of genotypes, environments + (genotypes x environments) and pooled error revealed that the genotypes were highly significant for mean squares due to genotype x environment (GXE) interaction which revealed that the genotypes interacted considerably with environmental conditions. This is in accordance with previous reports on rice by several workers [17-20].

The yield of different genotypes under study varied from 2050 q/ha (Vikash) to 5450 q/ha (Talmugur) in first environment from 2050 q/ha (Vikash) to 5488 q/ha (Jarava) in second environment; from 2100 q/ha (Vikash) to 5350 q/ha (Jarava) in third environment. Nineteen genotypes were recorded to give better yield than the average yield [Table-2] and among them Pratiksha, Swarna Dhan, Sashi and Kaushalya were recorded for highest yield. The days to 50% flowering was ranged from 90 days (Mohan) to 132 days (Jaladhi 1) with an average of 120 days. The plant height was ranged from 92 cm (IR-64 Sub 1), 95 cm (Pankaj) to 180 cm (Saraswati) with an average of 140 cm. Highly sensitive genotypes do not come upto flowering stage while medium tolerant and tolerant genotypes reduce the days to flower.

Table-1 *Analysis of Variance for Stability of Grain Yield over Environments*

		Mean Square			
Source of Variation	Df	DFF	PH	FG	Y
Genotypes (G)	49	240.84**	1981.14**	15.63**	104.93**
Env. + (G X Env.)	100	20.07**	118.47**	1.10	15.35**
Environments (Env.) (Lin.)	1	1196.25**	741.61**	18.89**	155.04
G X Env. (Lin.)	49	14.101**	218.36**	0.63	19.57**
Pooled Deviation	50	2.4	8.11	1.22	8.41**
Pooled Error	150	2.1	26.38	1.39	0.36

*significant at 0.05% level

DFF: Days to 50% Flowering **PH:** Plant Height (cm)

FG: Number of Filled Grains/ Panicle **Y:** Grain Yield (q/ha)

The mean performance coupled with the regression coefficient (b_i) and variance of deviation from the regression (S^2di) of each genotype was represented in [Table-3]. With these conditions the rice genotypes were classified according to adaptability and stability in respect of yield and its component characters studied. Rice yield and it's component characters fluctuates considerably with the change in environmental conditions. Hence, a variety possessing reasonable stability for yield is desirable for minimizing the risk of yield loss in harsh environments of unfavorable saline situation. The variance due to G x E was partitioned into linear and non linear components. Relatively higher value of linear component as compared to non-linear one suggested the possibility of prediction of performance for grain yield over the environments. Therefore, linear (bi) and non-linear (S^2di) components of G x E interactions were considered while judging the phenotypic stability of a genotype [7, 8]. They further suggested that an ideal variety should have high mean with linear regression co-efficient equal to unity and S^2di as small as possible. They have emphasized the use of deviation from regression as a measure of stability, whereas the linear regression could be treated as a measure of varietal response to environments [21-23]. The significant mean square due to genotype x environment (linear) interaction indicated that a considerable proportion of genotype x environment interaction was contributed by the linear component [Table-1]. Therefore, predictions for most of the genotypes appeared feasible for yield. Highly significant mean squares due to pooled deviation for yield revealed the importance of a nonlinear component accounting for the total genotype x environment interaction [Table-1]. Therefore, the genotypes differed considerably with respect to their stability for yield and its component characters. Similar results were obtained by in the previous study [24, 25].

Over all mean of days to 50% flowering [Table-3] showed 29 rice genotypes out of 50 genotypes possess higher days to flowering than the average which revealed they are moderately tolerant to saline condition and among these 29 genotypes Nona Bokra had lowest days to 50% flowering (120) which indicated that this variety may be salt tolerant. For the character days to 50% flowering genotypes Mandira, Jalamagna, Bhudeb, Swarna, Dinesh and Nonabokrawere recorded with maximum days to 50% flowering with minimum deviation from regression line and regression coefficient value was around unity, hence they are considered to be widely adaptable to differing environmental conditions. Among the 29 genotypes the genotypes with Saraswati and Jaladhi 1 were found to be least responsive though they had grain yield higher than average but their b_i values were negative. The genotypes with negative b_i values were suitable for poor environments. In the present finding out of 50 genotypes again 29 genotypes showed higher mean value for plant height (cm) than the average value. The highest plant height was obtained by Saraswati (186.33 cm) followed by Jalamagna (175.33 cm), Golok (172.83 cm) and Niroja (175.50 cm). The genotype Saraswati was found to have maximum plant height more than average mean with minimum deviation from regression line and regression coefficient value was around unity, hence they can be considered to be highly adaptable to different saline environments. Among the 50 genotypes with plant height higher than average mean some of the genotypes Mandira, Nalini, Purnendu, NC-678, Rupsail, Patnai 23, Nona Bokra, Dadsal, Lunishree, Talmugur and Khejurchari had negative regression coefficient (b_i) which indicated that they were not suitable for all environment but for only poor environment. The genotypes Bhagirathi, Golok, Vaidehi, Ambika, Niroja, Amulya, Dinesh, Jaladhi 1, Gobindobhog, Aduisen, Altaluti, Matla and Pokkali exhibited high mean with high regression coefficient which indicated that these genotypes were highly suitable for better environment.

In the present study, the genotypes Nona Bokra and Saraswati were found to be suitable for a general adaptation, i.e., suitable for all environmental conditions as their b_i (linear response) was around 1.0 with least deviation from linearity and above or around average mean [Table-3]. The highest yielding genotypes Pratiksha, SwarnaDhan, Sashi and Kaushalya were found to be suitable for better environments as their b_i values are significantly higher than 1.0. Among them Pratiksha, Swarna Dhan and Sashi exhibited high mean, high bi and high S^2di which indicated that these genotypes were highly sensitive to environment responding 2-3 times for a unit change in the environmental fluctuations. In poor environment these genotypes will not perform better. The genotypes Biraj, Kunti, Bhudeb and Lalat were found to be least responsive though they had grain yield higher than average but their b_i values were negative. The genotypes with negative b_i values were suitable for poor environments. Therefore, these genotypes reflected negligible response to the environmental changes i.e. remain steady under poor conditions but could not exploit the positive improvement in the environment. In the present study only two genotypes Nona Bokra and Saraswati fulfilled the conditions for an ideal variety with high mean, linear response and least deviation from linear regression for grain yield. Hence, these genotypes were identified as suitable for general adaptation i.e. suitable for growing over all environments under study.

Any generalization regarding the stability of a genotype for all the traits is quite difficult as many genotypes had average stability to the environments for yield and its component characters. If the traits associated with high yield showed stability, the selection of genotype only for yield could be effective [26]. It is inferred that alleles that confer broader adaptation might be involved to achieve yield and stability across environments.

Conclusion

Evaluation of genotypic and environmental performance of 50 rice genotypes including landraces over a range of saline environments depicted significant differences among the genotypes and environment for yield suggesting the presence of wide variability. Major portion of interaction was linear and prediction about the environments was possible. It could further be concluded that identified superior performing genotypes were Nona Bokra and Saraswati being stable over three environments for yield and its important component characters and might be grown successfully for obtaining more economical yield in saline soils being adaptive to such particular saline area.

Application of research: The performance of two genotypes *viz.,* Nona Bokra and Saraswati were stable in the saline environments in terms of yield and other yield attributing characters. These two genotypes might be used in hybridization programme as a donor parent to develop high yielding salinity resistant genotypes in future breeding programme.

Research Category: Crop Improvement, Stability

Abbreviations:
GxE: genotype x environment

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*** Principle Investigator: Dr Arpita Das**
University: Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, 741252, West Bengal
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Table-2 *Genotype Mean for Grain Yield (kg/ha) and its Component Character over Three Different Environments*

Sl No	Genotypes	DFF			PH			Yield		
		Env 1	Env 2	Env 3	Env 1	Env 2	Env 3	Env 1	Env 2	Env 3
1	Biraj	120.00	121.00	116.50	132.50	126.50	153.00	3650.00	3520.50	2775.00
2	Kunti	102.00	102.50	102.50	112.50	105.00	123.00	3950.00	3986.50	3525.00
3	Mandira	127.50	127.00	120.00	157.50	155.00	122.50	3150.00	3087.50	2675.00
4	Swarna S1	121.50	121.00	111.00	92.50	93.50	100.00	3200.00	3087.50	3275.00
5	Pankaj	111.00	112.50	117.50	111.00	122.00	124.00	2675.00	2700.00	3700.00
6	Vikash	102.50	104.50	97.50	112.50	106.50	109.00	2050.00	2050.00	2100.00
7	Ranjeet	127.50	126.50	121.00	104.50	106.00	119.50	2400.00	2400.00	2375.00
8	Jalamagna	128.00	129.00	120.00	175.00	174.00	177.00	2200.00	2245.50	2450.00
9	Sashi	122.50	121.50	110.00	126.50	122.50	126.50	3675.00	3675.00	4775.00
10	Nalini	120.00	120.50	117.50	173.00	170.50	171.00	3200.00	3064.50	4725.00
11	Bhudeb	127.50	126.50	120.00	112.50	112.50	127.00	3300.00	3325.00	3300.00
12	Bhagirathi	130.00	127.50	122.00	147.50	144.50	177.50	2850.00	2679.00	3075.00
13	SwarnaDhan	131.00	132.50	120.00	111.00	102.50	127.50	3750.00	3750.00	4925.00
14	Pratiksha	116.50	121.00	112.50	115.00	116.50	123.50	3955.00	3956.00	4775.00
15	Bipasha	124.50	122.50	122.50	110.00	107.50	122.00	3150.00	3175.00	4275.00
16	Golok	132.00	129.50	124.50	167.50	170.50	180.50	2775.00	2675.00	2825.00
17	Purnendu	126.50	131.00	122.50	167.50	167.00	122.50	3550.00	3520.50	2575.00
18	Samba masu	124.00	126.00	115.00	102.50	98.50	99.50	2650.00	2550.00	2550.00
19	IR-64 Sub1	105.00	105.00	90.00	94.00	92.50	92.50	2075.00	2175.00	2200.00
20	Haneswari	131.00	132.00	126.50	167.50	166.00	181.00	2634.00	2754.00	3275.00
21	Vaidehi	129.00	130.00	129.00	157.50	160.00	177.00	2094.00	2083.00	2575.00
22	Saraswati	129.00	130.00	131.00	181.50	185.00	192.50	2968.00	2916.00	3250.00
23	Lalat	104.50	104.00	97.50	101.00	102.50	94.00	3487.50	3162.00	2800.00
24	Masuri	120.00	117.50	112.50	122.50	120.00	138.00	2800.00	2750.00	3725.00
25	Ambika	125.50	126.50	122.50	142.50	142.50	167.00	3150.00	2549.50	3625.00
26	Niroja	130.00	132.50	122.50	172.50	172.00	182.00	3575.00	3570.50	3575.00
27	Amulya	127.00	122.00	123.00	162.00	162.50	177.50	2775.00	2754.00	3800.00
28	Dinesh	131.00	132.50	123.00	157.50	156.50	177.50	2575.00	2529.50	2825.00
29	Swarna	126.00	121.00	116.00	115.00	116.50	131.00	3250.00	3074.50	3250.00
30	Jaladhi 1	134.00	132.50	134.00	144.50	146.00	155.50	2725.00	2700.00	2775.00
31	ManasSarobar	113.50	116.50	115.50	121.00	119.00	119.00	2850.00	2887.00	3400.00
32	NC 678	122.50	121.00	114.50	165.00	170.00	157.50	3830.00	3672.50	2575.00
33	Rupsail	120.50	121.00	121.50	162.50	161.50	151.00	2850.00	3000.00	3025.00
34	Patnai 23	122.50	122.50	121.00	162.50	162.50	145.50	2902.50	2875.00	3100.00
35	Nona Bokra	123.00	124.00	113.00	167.50	165.50	161.50	3250.00	3275.00	3650.00
36	Kaushalya	114.50	119.00	100.00	127.50	126.00	118.50	4250.00	2983.00	5000.00
37	Dudheswar	121.00	118.50	110.00	162.50	159.50	163.50	3650.00	2995.50	3550.00
38	Dadsal	125.50	124.00	119.00	152.50	155.00	152.50	3075.00	3124.00	2575.00
39	Mohan	95.00	92.00	83.50	102.50	100.00	102.50	3650.00	3050.00	2775.00
40	Jarava	121.00	123.50	112.00	121.00	122.50	133.50	3075.00	5488.00	5350.00
41	Lunishree	122.00	124.00	116.50	171.50	175.00	131.00	3125.00	3124.00	2875.00
42	Talmugur	113.50	115.00	112.50	152.50	155.00	153.50	5450.00	2700.00	2800.00
43	Gobindobhog	121.00	119.00	111.00	145.00	153.00	166.00	3150.00	2549.50	2200.00
44	Sadamota	121.00	121.00	110.00	161.00	162.00	164.00	2750.00	3062.50	2800.00
45	Marichsal	122.00	125.00	117.00	116.50	119.00	148.00	2575.00	2779.00	3000.00
46	Khejurchari	134.00	131.50	124.00	141.50	144.50	134.00	3087.50	3075.00	2950.00
47	Aduisen	121.00	121.00	117.00	151.00	147.50	164.00	2675.00	2320.50	2250.00
48	Altaluti	120.00	122.50	117.00	155.00	152.50	172.50	3050.00	2337.50	2600.00
49	Matla	109.50	107.50	110.00	151.00	148.50	173.50	3270.50	2390.00	3100.00
50	Pokkali	109.50	108.50	97.00	139.00	141.50	186.50	3300.00	2657.50	3400.00
	Mean	121.18	121.30	115.24	139.55	139.26	145.38	3121.08	2976.22	3226.50

DFF: Days to 50% Flowering **PH:** Plant Height (cm)

FG: Number of Filled Grains/ Panicle **Y:** Grain Yield (q/ha)

Table-3 *Mean performance and Stability Parameters for Grain Yield*

Sl No	Genotyoes	DFF			PH			Y		
		Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
1	Biraj	119.17	0.67	-1.67	137.33	5.07	-21.64	33.15	-2.99	16.58
2	Kunti	102.33	-0.04	-1.98	95.17	-8.44	51.35	38.21	-1.85	2.18
3	Mandira	124.83	1.21	-1.92	145.00	-7.07	-4.36	29.71	-1.65	4.49
4	Swarna S1	117.83	1.71	-1.88	95.33	1.46	-24.66	31.87	0.75	-0.34
5	Pankaj	113.67	-0.95	-0.83	124.50	-0.05	-10.91	30.25	4.01	18.19
6	Vikash	101.50	1.01	-0.30	109.33	0.01	-8.21	20.67	0.20	-0.32
7	Ranjeet	125.00	0.99	-1.50	110.00	2.97	-21.16	23.92	-0.10	-0.35
8	Jalamagna	125.67	1.42	-1.73	175.33	0.55	-26.14	22.98	0.82	1.11
9	Sashi	118.00	2.00	-1.38	125.17	0.50	-19.41	40.42	4.41	20.01
10	Nalini	119.33	0.46	-2.01	171.50	-0.11	-23.05	36.63	6.66	32.19
11	Bhudeb	124.67	1.16	-1.48	117.33	3.06	-24.79	33.08	-0.10	-0.35
12	Bhagirathi	126.50	1.12	1.31	156.50	6.69	-25.98	28.68	1.59	-0.31
13	SwarnaDhan	127.83	1.96	-1.26	113.67	4.54	-8.97	41.41	4.71	22.88
14	Pratiksha	116.67	1.05	7.55	118.33	1.60	-23.39	42.29	3.28	10.99
15	Bipasha	123.17	0.16	-0.07	113.17	2.84	-26.00	35.33	4.41	21.89
16	Golok	128.67	1.04	1.28	172.83	2.37	-16.70	27.58	0.60	-0.32
17	Purnendu	126.67	1.05	7.55	152.33	-9.42	-8.37	32.15	-3.79	16.61
18	Samba masu	121.67	1.67	-0.43	100.17	-0.13	-17.97	25.83	0.00	0.31
19	IR-64 Sub1	100.00	2.50	-2.07	93.00	-0.13	-25.12	21.50	0.10	0.49
20	Haneswari	129.83	0.84	-1.68	171.50	3.03	-26.34	28.88	2.09	9.36
21	Vaidehi	129.33	0.08	-1.61	164.83	3.79	-15.19	22.51	1.97	3.36
22	Saraswati	130.00	-0.24	-1.58	186.33	1.88	-15.71	30.45	1.34	0.54
23	Lalat	102.00	1.12	-1.92	99.17	-1.66	-26.23	31.49	-1.45	16.80
24	Masuri	116.67	1.03	1.28	126.83	3.58	-26.29	30.92	3.91	12.54
25	Ambika	124.83	0.58	-1.66	150.67	5.16	-21.84	31.08	4.32	-0.11
26	Niroja	128.33	1.47	0.66	175.50	2.06	-26.13	35.74	0.02	-0.36
27	Amulya	124.00	0.24	10.52	167.33	3.20	-23.56	31.09	4.19	16.61
28	Dinesh	128.83	1.46	-1.18	163.83	4.34	-25.21	26.43	1.18	0.35
29	Swarna	121.00	1.24	11.02	120.83	3.18	-20.71	31.92	0.71	0.15
30	Jaladhi 1	133.50	-0.13	-1.00	148.67	2.13	-22.59	27.33	0.30	-0.35
31	Manassarobar	115.17	-0.77	2.42	119.67	-0.17	-24.15	30.46	2.06	5.44
32	NC 678	119.33	1.21	-0.79	164.17	-2.21	-19.38	33.59	-4.39	33.14
33	Rupsail	121.00	-0.12	-1.97	158.33	-2.29	-23.62	29.92	0.10	-0.09
34	Patnai 23	122.00	0.25	-2.11	156.83	-3.58	-24.19	29.59	0.90	0.13
35	Nona Bokra	120.00	1.75	-1.77	164.83	-1.01	-22.98	33.92	1.50	2.68
36	Kaushalya	111.17	2.81	6.79	124.00	-1.71	-22.24	40.78	8.10	3.94
37	Dudheswar	116.50	1.62	1.44	161.83	0.58	-22.79	33.98	2.23	9.06
38	Dadsal	122.83	0.95	-0.84	153.33	-0.31	-23.65	29.25	-2.20	3.07
39	Mohan	90.17	1.66	2.91	101.67	0.31	-23.66	29.93	-1.10	2.67
40	Jarava	118.83	1.72	0.60	125.67	2.44	-22.06	54.29	-0.55	-0.29
41	Lunishree	120.83	1.08	-0.32	159.17	-8.97	-24.91	30.49	-1.00	1.16
42	Talmugur	113.67	0.29	-1.02	153.67	-0.10	-23.37	27.50	0.40	-0.36
43	Gobindobhog	117.00	1.49	0.20	154.67	3.43	24.07	24.42	-1.40	2.34
44	Sadamota	117.00	1.75	-1.42	163.00	0.26	-21.36	30.04	-1.30	0.69
45	Marichsal	121.33	1.09	2.07	127.83	6.33	-7.12	28.18	0.89	2.72
46	Khejurchari	129.83	1.45	1.39	146.00	-1.96	-24.62	30.25	-0.50	-0.26
47	Aduisen	119.67	0.66	-2.10	154.17	3.18	-24.99	26.14	-0.27	64.38
48	Altaluti	119.83	0.71	0.84	160.00	4.00	-26.36	27.46	1.06	45.64
49	Matla	109.00	-0.25	-0.16	157.67	5.06	-26.29	27.80	2.85	0.36
50	Pokkali	105.00	2.00	-1.39	155.67	9.70	7.02	29.69	2.98	1.82
Mean		119.23	0.98		141.27	1.00		31.02	1.00	
SE (m)		2.05			2.05			2.05		
SE (b)		0.26			0.59			1.21		

DFF: Days to 50% Flowering **PH:** Plant Height (cm)
FG: Number of Filled Grains/ Panicle **Y:** Grain Yield (q/ha)
b_i: Regression Coefficient **S^2di:** Deviation from Regression
SE (m): Standard Error of Mean **SE (b):** Standard Error of b_i