The Agriculturists 13(2): 25-35 (2015) ISSN 2304-7321 (Online), ISSN 1729-5211 (Print)
A Scientific Journal of Krishi Foundation ***Indexed Journal***

Stability Analysis of Selected Jute (*Corchorus capsularis* L.) Genotypes in Saline and Non-saline Soils of Bangladesh

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Received: 04 April 2015 Accepted: 12 December 2015

Abstract

Ten white jute genotypes (*Corchorus capsularis* L.) were evaluated across three different locations including saline and non-saline soils of Bangladesh during 2014 to assess genotype × environment interaction and stability for plant height, base diameter, fresh weight with leaves, dry stick weight and dry fiber weight. Additive Main Effect Multiplicative Interaction (AMMI) model was used to assess the additive and multiplicative interaction of jute genotypes for these characters across three environments. Significant variations in genotype environment interaction were observed for all characters except plant height and base diameter. Based on stability parameters $b_i \approx 1$ and $b_i \approx 0$, the genotype C-3465 showed stability for plant height, D-154 for base diameter and fresh weight with leaves. The genotypes C-2753 showed stability for fresh weight with leaves, without leaves and dry stick weight, CVL-1 for fresh weight without leaves, C-2760 for fresh weight with leaves, without leaves and for dry fiber weight across saline and non- saline area. Heritability in broad sense was quite high for all characters (85-90%) except plant height (17%) indicating less environmental fluctuation. Expected genetic advanced of mean was moderate to high (14%-29.16%) except plant height (3.20%) indicating the good scope of selection for improving the traits.

Keywords: Jute, genotype, environment, stability, saline

1. Introduction

Jute (*Corchorus capsularis* and *Corchorus olitorius* L.) is an herbaceous annual plant from the Tiliaceae family, mostly grown in Southeast Asian countries (José *et al.*, 2009). Jute is used in the manufacture of a number of fabrics such as Hessian cloth, sacking, scrim, carpet backing cloth (CBC), and canvas. Hessian, lighter than sacking, is used for bags, wrappers, wall-coverings, upholstery and home furnishings. It is also used as a raw material for the production of paper and pulp (IJO, 1994). Jute plays a very important role in Bangladesh economy as the country earns about 12-13% of total foreign currency by exporting jute and jute product (BJRI, 1998). Bangladesh, the second largest producer of jute, produces the best quality jute in the world and leads the export market (Rayhan *et al.*, 2008). In addition, this crop is particularly important in Bangladesh where many small families depend on the income from growing and selling jute (Ghosh *et al*., 2013). Jute covered 6.95% of the total cultivated area occupying 0.5 million hectares and producing 0.96 million metric tons of jute fibre (AIS, 2003).

Salinity is a universal problem in agriculture of Bangladesh. In Bangladesh, the soils of around 1.02 million ha of farmland is somewhat saline (Haque, 2006). The area of land is considered as moderate to high saline (8-15 dS m^{-1}) or high saline (>15 dS m-1) and is quickly increasing in Bangladesh because of changing global weather (SRDI, 1998). At present, due to population density, Bangladesh needs more arable land for food crops. So, cultivation of jute is regularly being pressed to the marginal lands with higher grades of soil salinity year round. Jute can grow readily in saline soils (Ma *et al*., 2009). Screening and identifying genotypes that maintain productivity under saline conditions is an effective approach (Ashraf *et al.*, 2006). The present research was undertaken to; i) study the genetic variation within some white jute genotypes and estimate various genetic parameters for important economic characters, ii) evaluate the performance of some jute genotypes in saline and non-saline area of Bangladesh, and iii) screenout the saline stable genotypes for the coastal area.

2. Materials and Methods

Two separate experiments were conducted in this study; a) germination test at laboratory and b) the field experiment at multi locations (Pakhimara, Patuakhali; Benerpota, Satkhira and Dumki, Patuakhali).

2.1. Experimental site

The germination test was done at the laboratory of Genetics and Plant Breeding, of Patuakhali Science and Technology University (PSTU). The germination test was done during the month of January, 2013. Petridish, blotting paper, salt solution (640mg/L) of 4 dS/m, 6 dS/m, 8 dS/m level with control i.e., 0 dS/m salinity was used for germination. 100 seeds / petridish were sown and treatments were replicated three times.

The field experiment was conducted at the Bangladesh Jute Research Institute (BJRI) Sub-station at Pakhimara, Kolapara, Patuakhali and Benarpota, Satkhira and the experimental farm, Patuakhali Science and Technology University, Dumki, Patuakhali during the period from mid- April to mid-August 2013. These three places are located on southern part of the country. Patuakhali district is located at about $21^0 49' – 22^0 37'$ north latitude and $90^0 08' – 90^0 40'$ east longitude, Satkhirais located at $21^0 40' – 22^0 58'$ north latitude and $88^0 54' – 89^0 22'$ east longitude (Statistical pocket Book of Bangladesh Febuary-2011, BBS). The experimental field belongs to the Agro–ecological zone of AEZ–13 (UNDP and FAO, 1988). The experimental area is situated in the sub–tropical climatic zone and is characterized by heavy rainfall during the months of April to September (*Kharif* Season) and scanty rainfall during the rest period of the year (Biswas, 1987). The texture of soil was silt to heavy silt in Satkhira, Pakhimara and Dumki respectively. The soil were heavy silt clay, alkaline. Fertility condition and organic matter content were medium to high medium (Quddus, 2009). Land type is medium low to low. The average pH of Benarpota 7.4 to 7.3 and that of Pakhimara was 6.8. The highest salinity was at Satkhira 13.7 dS/m and at Patuakhali 11.8 dS/m.

2.2. Plant materials

Ten white jute (*Corchorus capsularis* L.) genotypes were used for this experiment. The name, source of collection and general character of these genotypes are presented in Table 1. Seeds of all the varieties were collected from Bangladesh Jute Research Institute, Dhaka.

2.3. Design and layout

The experiment (both germination test and field experiment) was conducted in Randomized Complete Block Design with three replications. Each plot had three rows of 3m length. Space between rows was 30 cm and plant to plant distance was 15 cm. The genotypes were randomly assigned to each plot.

2.4. Seed sowing

Seeds were sown in lines in each environment. The seeds were sown continuous in each line. The experimental environments as differentiated by sowing places are presented below.

Table1. List of selected ten white jute genotypes used in the experiment with their source

Genotypes Code	Varieties/ Genotypes	Source of collection	Characters
G1	C-3467	Breeding Div. BJRI	Full green
G2	C-12221	Breeding Div. BJRI	Full green
G3	CVL-1	Bangladesh (variety)	Full green
G4	C-83	Bangladesh (variety)	Full green
G5	C-2197	Nawgoan, Bangladesh	Stem green, Petiole deep, Pigmented petiole, red band between petiole and lamina
G6	C-2753	Borguna, Bangladesh	Full green
G7	C-2760	Barisal, Bangladesh	Full green
G8	C-3465	Tangail, Bangladesh	Stem green, petiole pigmented.
G9	D-154	Bangladesh(variety)	Stem green, long petiole and light pigmented in mature stage
G10	C-12083	Breeding Div. BJRI	Stem green, petiole light pigmented

Table 2. List of experimental environments used in the studies

Experimental environment	Sowing Places	Soil Salinity level
Env-1	Pakhimara (Patuakhali)	Soil salinity was 8.5 dS/m during sowing time and 2.5 dS/m during harvesting time, respectively.
Env-2	Benarpota (Satkhira)	Soil salinity was 13.3 dS/m during sowing time and 3.4 dS/m during harvesting time, respectively.
Env-3	Dumki (Patuakhali)	Soil salinity was below 4 dS/m during sowing time and 1.7 dS/m during harvesting time, respectively.

2.5. Data collection

Data were recorded on an individual plant basis from 10 randomly selected plants of each replication at the time of harvest which was 130 days from date of sowing. Data on Plant height, Base diameter, Fresh weight with leaves per plant, Dry stick yield per plant, Dry fibre yield plant per plant and Fresh weight without leaves per plant were collected.

2.6. Data analysis

In stability analysis, relevant biometrical methods cited in the standard texts were followed (Singh and Chaudhury, 1985; Dabhokar, 1992). The analysis of variance (ANOVA) was used and the G-E interaction was estimated by the AMMI model (Zobel *et al*., 1988; Durate and Zimmermann, 1991). In this procedure, the contribution of each genotype and each environment to the G-E interaction is assessed by using of the bi-plot graph display in which yield means are plotted against the scores of the first principle component of the interaction (IPCA 1). The computational program for AMMI analysis is supplied by Durate and Zimmermann (1991). The stability parameters, regression coefficient (bi) and deviation from regression (S^2di) were estimated according to Eberhart and Russell's (1966) model. Significance of differences among bi value and unity was tested by t-test, between S^2di and zero by F-test. The statistical approaches suggested by Eberhart and Russell (1966) were followed for genotype x environment interaction and estimating stability parameters.

3. Results and Discussion

The result of germination test at four levels of salinity (0 dS/m, 4 dS/m, 6 dS/m and 8 dS/m) of

ten white jute genotypes are presented in Table 3. Genotype G9 showed high germination percentage. Nasreen *et al*. (2002) reported that the percentage of germination decreased with the increase of salinity. Mondal *et al*. (1988) reported that germination was delayed and its percentage decreased as salinity level increased. The value of phenotypic indices (Pi), regression coefficient (bi) and deviation from regression (S^2di) for morphological parameters is presented in Table (4-9). The environmental index (Ij) directly reflected the favorable and unfavorable environments in terms of positive and negative Ij, respectively. However, positive environmental index (Ij) is the favorable environment for trait.

In case of plant height (Table 4), the genotypic mean and environmental mean ranged from 2.64 to 2.98 m and 2.81 to 2.83 m, respectively. Considering the Pi, bi, and S^2di, value, it was evident that all the genotypes showed different response to adaptability under differential conditions and the genotype G2 were the highest plant height contributing genotype and stable across all environmental conditions. G2, G4, G9 and G10 were the stable genotypes only in poor environment. Khandker and AIim (2004) reported that increasing salinity level decreased the plant height. They worked to identify the most tolerant species of jute and kenaf to salinity situation. In case of Base diameter (Table 5), the environmental mean and genotypic mean ranged from 17.21 to 17.32 mm and 15.17 to 20.97 mm, respectively.

Considering the Pi, bi and S^2di, it was evident that all the genotypes showed different response to adaptability under differential conditions. Genotype G1was stableacross a range of environments based on bi and S^2di value. 2G, G7G,8 10and G were stable genotypes only in poor environments. In case of fresh weight with leaves per plant (Table 6), the environmental mean and genotypic mean ranged from 249.4 to 274.7 g and 210.0 to 320.0 g, respectively. Considering the Pi, bi and S^2di, it was evident that all the genotypes showed different response to adaptability under differential conditions. Based on bi and S^2di, the genotypes 6G, G7 and G9 were stable across all environmental conditions. On the other hand G3 and G5 were the stable genotypes for poor environments and genotypes G1, G2, G8 and G10 stable only favorable environments. Oliveira *et al*. (1998) found that NaCl concentration above 4000 mg/litre water decreased total dry matter and plant height.

In case of fresh weight, without leaves per plant (Table 7), the environmental mean and genotypic mean ranged from 223.3 to 240.6 g and 199.4 to 311.7 g, respectively. Based on bi and S^2di values genotypes G3, G6 and G7 were stable across all environmental conditions. Genotypes G4, G5 and G9 showed suitability only in poor environments. In case of dry stick weight per plant (Table 8), considering the Pi, bi, and S^2di it was evident that the genotype G6 was stable across all environments.G1, G2, G7, G8, G9 and G10 genotypes are stable only in favorable environment. In case of dry fibre weight per plant (Table 9), the environmental mean and genotypic mean ranged from 10.56 to 10.95 g and 8.14 to 18.03 g, respectively.

Considering the Pi, bi, and S^2di it was evident that all the genotypes showed different response to adaptability under differential conditions and the genotypes G7was highly stable across all environmental conditions. G1, G2, G6 and G9 genotypes were stable only in poor environment. Waseque *et al*. (1954) observed Dry weight of bark declined gradually with increasing concentration of NaCl. Suraiya *et al*. (1992) carried out an experiment in petridish to study the salinity effect on jute (CVL- I and 0-9897), Mesta (HS-24) and Kenaf (HC-2) cultivars. Seeds were treated with deionized water (control), 1000, 4000 and 8000 ppm of NaCI. Total dry matter and length of root and shoot were significantly affected by treatment.

Considering the IPCA1 and IPCA2 (Figure 1) G1, G6, G7 and G8 were the stable genotypes for dry fibre weight of jute. From the Figure 2,

del wasthe mo 100 % fit for dry fibre weight in all environments. Broad-sense heritability (H_b), expected genetic advanced percentages and phenotypic and genotypic coefficient of variation under all environment for each morphological parameter studied are shown in Table 8. Heritability of all parameters was above 85% and above except plant height (17%). Such high heritability values indicate that selection based on these parameters would be effective for genetic improvement of salinity tolerance in jute. oderateAll chacracters showed low to m phenotypic and genotypic coefficient of variation. Expected genetic advanced of mean was moderate to high (14%-29.16%) except plant height (3.20%) indicating the good scope of selection for improving the trails. Talukdar and Haque (1992) reported high heritability (90.98) of *Corchorus capsularis* L. in different environment.

Table 3. Germination rate of ten white jute genotypes at different salinity levels

	Germination (%) at different Salinity Levels				
Genotypes	0 dS/m	4 dS/m	6 dS/m	8 dS/m	Average
G1	83.000	77.000	72.667	69.333	75.500
G2	83.667	77.333	76.333	69.667	76.750
G3	85.333	85.667	82.667	70.333	81.000
G4	83.667	79.000	78.667	74.667	79.000
G5	81.000	79.000	74.000	62.000	74.000
G6	81.667	77.000	76.000	61.333	74.000
G7	77.000	76.333	74.333	66.333	73.500
G8	75.667	70.333	67.000	63.000	69.000
G9	86.667	87.000	81.667	73.667	82.250
G10	81.333	75.667	75.667	69.333	75.500

Table 4.Stability analysis for plant height of ten Jute genotypes in three environments

Genotypes	Plant height						
	Environments			Overall mean			
	Env-1	Env-2	Env-3		Pi index	bi	S^2di
G1	2.71	2.88	2.85	2.816	0.11	3.709	0.01
G2	3.05	2.96	2.93	2.980	0.164	-4.490	0.00
G3	2.80	2.77	2.85	2.808	-0.766	2.990	0.00
G4	2.80	2.83	2.78	2.803	-0.121	-1.337	0.00
G5	2.72	2.62	2.78	2.708	-0.107	5.019	0.01
G6	2.61	2.62	2.68	2.636	-0.179	3.076	0.00
G7	2.72	2.76	2.87	2.782	-0.332	6.542	0.00
G8	2.91	3.06	2.97	2.978	0.162	0.037	0.01
G9	2.76	2.79	2.73	2.761	-0.543	-2.125	0.00
G10	2.98	2.82	2.85	2.883	0.679	-3.415	
Mean	2.807	2.810	2.829	2.815	-	1.006	-
E. Index (Ij)	-0.811	-0.511	0.13	-	-	-	-
SED (±)	-	-	-	0.39	-	0.13	-

Table 5. Stability analysis for base diameter of ten Jute genotypes in three environments

Genotypes	Base diameter (mm)						
	Environments				Pi index	bi	S^2 di
	Env-1	Env-2	Env-3	Overall mean			
G1	16.00	16.00	16.13	16.04	-1.230	0.924	0.01
G2	21.00	21.00	20.90	20.97	3.693	-0.682	0.00
G3	16.33	15.43	16.27	16.01	-1.262	8.610	0.04
G4	16.10	15.17	16.00	15.76	-1.518	8.716	0.05
G5	15.83	15.00	14.87	15.23	-2.040	1.738	0.53
G6	15.00	15.00	15.50	15.17	-2.107	3.451	0.09
G7	15.57	15.80	15.90	15.76	-1.518	-0.047	0.06
G8	19.77	21.43	20.17	20.46	3.180	-14.023	0.28
G9	18.00	18.00	18.20	18.07	0.793	1.384	0.01
G10	19.33	19.27	19.23	19.28	2.004	-0.011	0.01
Mean	17.29	17.21	17.32	17.27	-	1.006	-
E. Index (Ij)	0.200	-0.633	0.433	-	-	-	-
SED (±)	-	-	-	0.25	-	0.49	-

Table 6. Stability analysis for fresh wt. with leaves of ten Jute genotypes in three environments

Genotypes	Fresh weight with leaves/plant (g)						
	Environments				Pi index	bi	S^2 di
	Env-1	Env-2	Env-3	Overall mean			
G1	280.0	219.0	236.3	210.0	-27.22	2.429	935.79
G2	380.0	338.3	346.1	320.0	82.56	2.176	314.02
G3	227.3	255.0	244.1	250.0	-19.44	-0.716	263.79
G4	255.0	245.0	249.4	248.3	-14.11	0.194	39.30
G5	216.7	253.3	232.8	228.3	-30.78	-0.170	692.19
G6	225.0	223.3	220.6	213.3	-43.00	0.480	2.92
G7	255.0	258.3	250.3	237.7	-13.22	0.764	51.60
G8	333.3	305.3	306.4	280.7	42.89	1.986	75.55
G9	255.0	246.7	249.2	246.0	-14.33	0.308	18.73
G10	320.0	320.7	300.2	260.0	36.67	2.550	261.18
Mean	249.4	274.7	266.5	263.6	-	1.001	-
E. Index (Ij)	-14.1	11.18	2.944	-	-	-	-
SED (±)	-	-	-	11.26	-	0.140	-

Table 7. Stability analysis for fresh wt. without leaves of ten Jute genotypes in three environments

Genotypes	Fresh wt. without leaves/plant (g)						
	Environments				Pi index	bi	S^2di
	Env-1	Env-2	Env-3	Overall mean			
G1	186.7	240.0	208.3	211.7	-22.56	2.414	380.79
G2	290.0	336.7	308.3	311.7	77.44	2.097	307.58
G3	223.3	199.0	220.7	214.3	-19.89	0.918	203.18
G4	221.7	226.0	221.7	223.1	-11.11	0.151	8.35
G5	205.0	195.0	226.7	208.9	-25.33	0.201	516.75
G6	190.0	201.7	206.7	199.4	-34.78	0.831	20.91
G7	211.7	223.3	226.7	220.6	-13.67	0.789	11.14
G8	253.3	293.3	284.3	277.0	42.78	2.185	13.71
G9	217.7	212.3	220.0	216.7	-17.56	-0.130	27.95
G10	233.3	278.3	265.0	258.9	24.67	2.377	42.80
Mean	223.3	240.6	238.8	234.2	-	1.183	-
E. Index (Ij)	-10.96	6.34	4.611	-	-	-	-
SED (±)	-	-	-	8.74	-	0.13	-

Table 8. Stability analysis for dry stick wt. of ten Jute genotypes in three environments

Genotypes	Dry stick wt. (g)						
	Environments				Pi index	bi	S^2di
	Env-1	Env-2	Env-3	Overall mean			
G1	26.00	36.33	32.67	31.67	-3.689	1.625	0.22
G2	44.00	56.33	52.33	50.89	15.53	1.955*	0.07
G3	29.67	28.33	31.33	29.78	-5.578	-0.107	4.28
G4	35.33	33.33	33.33	34.00	-1.356	-0.343*	0.22
G5	29.33	24.33	27.67	27.11	-8.244	-0.723	2.15
G6	22.33	26.67	25.67	24.89	-10.47	0.703	0.05
G7	25.33	33.33	30.33	29.67	-5.689	1.251	0.24
G8	37.67	49.67	46.67	44.67	9.311	1.938	0.21
G9	27.67	36.00	32.33	32.00	-3.356	1.281	0.89
G10	40.67	56.33	49.67	48.89	13.53	2.418	2.53
Mean	31.80	38.07	36.20	35.36	-	0.999	-
E. Index (Ij)	-3.556	2.711	0.844	-	-	-	-
SED (±)	-	-	-	2.05	-	0.24	-

Table 9. Stability analysis for dry fibre wt. of ten Jute genotypes in three environments

Genotypes	Dry fibre wt./plant (g)						
	Environments						
	Env-1	Env-2	Env-3	Overall mean	Pi index	bi	S^2 di
G1	10.56	10.31	10.70	10.52	-0.252	-0.447	0.39
G2	18.07	17.82	18.21	18.03	7.259	-6.207	5.05
G3	9.636	9.389	9.776	9.600	-1.174	4.459	2.12
G4	10.68	10.43	10.82	10.64	-0.130	6.356	2.58
G5	8.180	7.933	8.320	8.144	-2.386	2.772	0.60
G6	8.424	8.178	8.564	8.389	-2.630	0.135	0.13
G7	8.947	8.700	9.087	8.911	-1.863	0.781	0.03
G8	11.76	11.51	11.90	11.72	0.947	1.179	0.06
G9	10.59	10.34	10.73	10.56	-0.218	-2.932	3.24
G10	11.26	11.01	11.40	11.22	0.447	3.904	0.63
Mean	10.81	10.56	10.95	10.77	-	1.00	-
E. Index (Ij)	0.355	-0.211	0.175	-	-	-	-
SED (±)	-	-	-	0.67	-	0.19	-

Table 10. Genetic parameters or six characters in G × E interaction in white jute

Characters	Genotypic variance	Error variance	GXE interaction	Phenotypic variance	Heritability	GCV (%)	PCV (%)	GA	GA in % of mean
Plant height (m)	0.01	0.15	0.10	0.06	17	3.55	8.70	0.09	3.20
Base diameter (mm)	1.64	1.406	0.41	1.94	85	7.42	8.10	2.44	14
Fresh wt. with leaves/plant (g)	494.59	293.718	28.78	536.82	92	8	9	43.91	18.11
Fresh wt. without leaves/plant (g)	413.51	268.802	17.84	449.33	92	8.68	9.05	40.19	17.15
Dry fibre wt. (g)	2.49	1.50	05	2.68	93	14.65	15.20	3.14	29.16
Dry stick wt. (g)	27.45	18.018	1.81	30.05	91	14.82	15.50	10.28	29.07

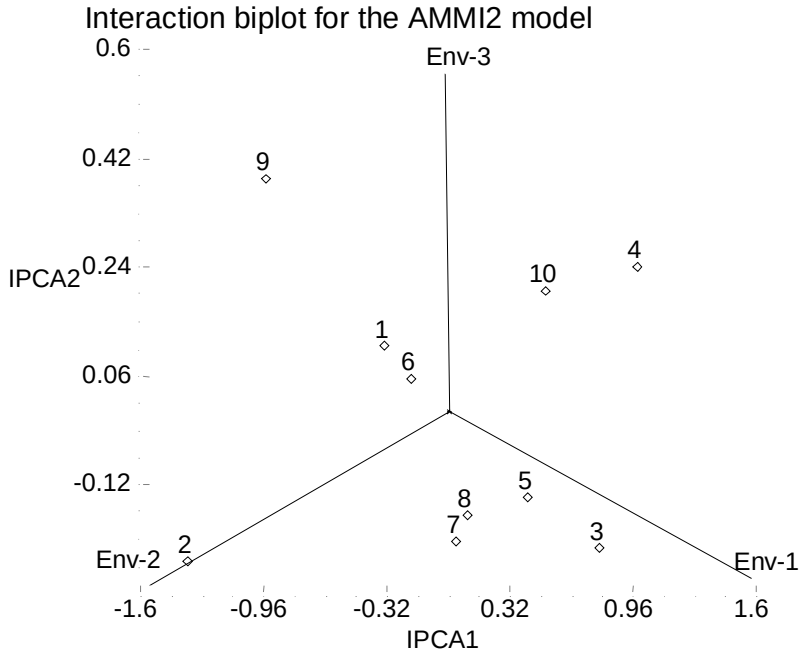

Figure 1. Bi plot of the first AMMI interaction (IPCA 2) score (Y-axis) plotted against AMMI interaction (IPCA 1) score (X-axis) for ten white jute genotypes

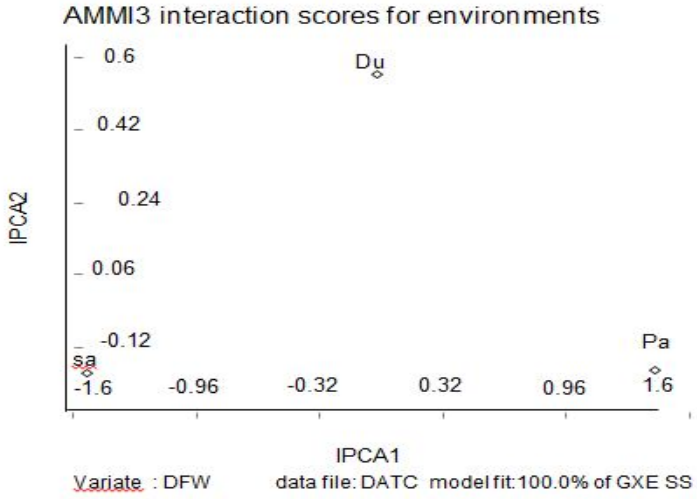

Figure 2. IPCA1 X IPCA2 interaction on environment

4. Conclusions

Among the genotypes G2, G4, G9 and G10 could be considered as stable under poor environment i.e. less sensitive to poor environments of Env-1 (Patuakhali) and Env-2 (Satkhira). Out of ten genotypes, G8 was highly stable under all environmental condition for plant height, G1 for base diameter (based on bi and s^2di value). G6, G7 and G9 could be considered as adaptive to environmental change for fresh weight with leaves per plant due to the bi value near to 1. Genotypes G3, G6 and G7 were less responsive to environmental change, therefore, more adaptive to environmental fluctuation based on bi value near 1 for fresh weight with leaves per plant. Genotypes G6 was stable under all environments for dry stick weight due to non -significant bi and S^2di value. Among these genotypes highest fibre producing genotypes were G2, G8 and G10 due to positive Pi value. G6 was highly stable for fibre yield in all environments due to non -significant bi and S^2di value. Based on IPCA1 X IPCA2 interaction score genotypes G6, G7 and G8 showed more stability in a range of environments. But G2 was stable in Env-2 (Satkhira).

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