Chapter IV
RESULTS AND DISCUSSION

In the present research, a total of 53 diverged Tossa jute genotypes were included to study genetic diversity as well as similarity, identification of yield contributing characters, combining ability of yield and yield contributing characters in F_1 generations and selection of potential segregants from F_2 generations on 11 characters such as plant height (cm), base diameter (mm), green bark thickness (mm), leaf length (cm), leaf width (mm), leaf angle (0), petiole length (cm), green weight with leaves (g), green weight without leaves (g), fiber weight (g) and stick weight (g) to create segregants from where outstanding advanced lines may evolve for the development new varieties. The results of the research work carried out under the purview of this dissertation are presented and discussed experiment wise with relevant sub-headings as follows:

4.1 Experiment I: Evaluation and Character Association of Tossa Jute Germplasm

4.1.1 Analysis of variance different phenotypic characters in Tossa jute

Analysis of variance (ANOVA) revealed significant difference among the 53 Tossa jute genotypes for 11 studied characters. The confidence level for each character exhibited 95%, indicated sufficient amount of differential expression of the characters in the genotypes. The results (Table 4.1) suggested that the wide variation for the characters might be exploited for enhancing fibre yield potential in the Tossa jute genotypes.

4.1.2 Mean performance of fifty three Tossa jute genotypes for eleven agro-morphological characters

The mean performance of 53 Tossa Jute genotypes for 11 agro-morphological characters are presented in Table 4.2. The data of the table showed a wide range of variation for each of the characters. The significant and non-significant differences among the genotypes for a particular character were estimated by LSD test.

4.1.3 Genetic parameters for 11 characters in Tossa jute germplasms

The analysis of variance revealed remarkable variation and significant differences for almost all the characters viz. plant height, base diameter, green bark thickness, leaf length, leaf width, petiole length, leaf angle, green weight with leaves, green weight without leaves, fibre weight and stick weight (Table 4.3). The results indicated the presence of adequate variability among the fifty three Tossa jute genotypes studied. In general, phenotypic variances for characters were higher than genotypic variances indicating the role of environmental effects in the expression of characters. In this study also phenotypic coefficient of variation (PCV) for all the characters were higher than corresponding genotypic coefficient of variation (GCV). The highest PCV was observed for the character green wt. with leaves (22.94). The coefficients of variation at phenotypic and genotypic levels were higher for fibre weight, stick weight, green bark thickness and green wt. without leaves and low for characters, plant height, base diameter, leaf length, leaf width, petiole length and leaf angle. Practically, heritability estimates are of greater value to the breeders, since, they emphasize on the degree of dependence of genotypic value on phenotypic value. Heritability was highest for green bark thickness (98%) followed by green wt. without leaves (93%), base diameter (81%) and leaf length (79%) (Table 4.3). Similar results were also reported by Sobhan *et al*. (1993); Islam *et al*. (2002); Akter *et al*. (2001); Mostofa *et al.* (2002) and Hari *et al.* (2017). All the characters have high heritability indicating that improvement of these characters would be effective through selection.

The estimates of heritability, however, indicate only the effectiveness with which the selection of genotypes can be made based on their phenotypic performance, but fail to indicate the amount of progress expected from selection. For an effective selection, the knowledge alone on the estimates of heritability is not sufficient and genetic advance (%) of mean if studied along with heritability is more useful. High estimates of heritability does not always mean high genetic advance. High heritability coupled with high genetic advance of mean was observed for the traits green bark thickness, green wt. with leaves, fibre weight and stick weight (Table 4.3). These findings were corroborated with the results of Islam *et al.* (2002), Mostofa *et al.* (2002), Bhattacharya *et al.* (2007), Nagaraja *et al.* (2009), Ghodke and Wadikar (2011), Satyanarayana *et al.* (2015) and Hari *et al.* (2017).

High heritability coupled with high genetic advance as percent of mean for these traits indicated the operation of additive genes and offered the best possibility for improvement of these traits through the selection. Genetic advance expressed as percentage of mean was highest for green bark thickness followed by green wt. with leaves, stick weight and fibre weight (Table 4.3). Like heritability almost all the characters except leaf width had high genetic advance. Relationship of heritability and genetic advance also gave an idea about the type of gene action. It was found that all the characters were under the influence of mainly additive gene action which suggested that simple selection methods would be effective for

Table 4.1 Analysis of variance of different phenotypic characters in Tossa jute

Source of variation	d f	Mean square (MS) of different characters										
		Plant height(m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (kg)/m^2	Green wt. without leaves (kg)/m^2	Fibre wt. (g)/m^2	Stick Wt. (g)/m^2
Replication	2	0.59	25.63	0.01	12.41	0.01	0.16	0.30	6.22	4.56	176.17	27841.68
Genotype	52	0.08^{**}	1.87^{**}	0.44^{**}	2.93^{**}	0.55^{**}	29.30^{**}	0.89^{**}	2.29^{**}	0.88^{**}	8854.77^{**}	44460.51^{**}
Error	104	0.05	1.59	0.01	0.62	0.02	6.09	0.002	0.62	0.45	2876.74	12307.63

*&** significant at 5% and 1%level of significance, respectively.

Table 4.2 Mean performance of fifty three Tossa Jute genotypes for eleven agro-morphological characters

Genotypes	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (kg)/m^2	Green wt. without leaves(kg)/m^2	Fibre wt. (g)/m^2	Stick wt. (g)/m^2
G1	3.37	15.90	14.60	6.16	1.44	58.33	6.84	4.20	3.00	283.67	559.33
G2	3.54	16.40	16.57	5.99	1.91	53.33	6.85	4.57	3.37	310.00	652.33
G3	3.34	15.53	16.28	6.34	1.64	58.33	6.67	4.23	3.13	262.67	609.33
G4	3.42	14.90	16.37	6.90	1.75	60.00	5.35	3.37	2.37	214.33	517.33
G5	3.42	15.23	16.06	7.02	2.01	56.67	6.03	3.93	2.77	235.67	509.67
G6	3.31	15.40	14.81	6.71	1.79	60.00	5.68	3.43	2.42	237.00	610.33
G7	3.48	15.17	15.63	6.27	2.31	53.33	6.40	4.90	3.80	324.00	721.00
G8	3.31	14.30	15.39	7.07	2.28	55.00	6.55	3.80	2.90	283.33	638.67
G9	3.31	16.30	15.30	6.97	2.40	56.67	6.73	3.77	2.50	265.00	656.33
G10	3.38	15.53	14.98	6.96	2.22	56.67	6.67	3.40	2.53	256.00	623.67
G11	3.36	15.67	14.45	6.19	1.35	60.00	5.73	3.70	3.05	242.33	551.00
G12	3.39	15.13	14.77	7.08	2.19	56.67	7.26	4.03	3.13	210.67	487.33
G13	3.38	16.83	14.97	6.39	2.25	60.00	6.40	3.83	3.23	238.00	581.67
G14	3.26	16.23	15.63	6.78	1.74	56.67	6.03	3.83	3.08	210.67	447.00
G15	3.33	15.37	16.02	7.09	2.16	53.33	6.76	4.03	3.03	242.67	560.33
G16	3.46	16.67	15.37	7.00	1.65	56.67	7.18	3.90	3.23	256.67	629.00
G17	3.42	16.47	15.97	6.60	2.41	53.33	6.18	5.53	3.73	290.00	677.67
G18	3.50	17.23	16.41	6.27	2.11	53.33	6.05	4.67	3.67	309.00	710.00
G19	3.42	15.93	14.83	6.60	2.30	58.33	6.74	3.13	2.67	224.33	493.33
G20	3.45	16.60	15.73	6.00	1.31	55.00	7.00	2.77	2.43	228.67	499.33
G21	3.38	15.90	15.59	5.96	1.89	53.33	6.04	3.50	3.07	213.67	464.33
G22	3.42	15.53	15.67	6.63	2.13	56.67	5.93	4.27	3.27	325.00	709.33
G23	3.32	15.10	15.63	6.24	2.25	56.67	6.22	4.03	3.07	292.67	693.00
G24	3.34	16.60	15.89	6.17	1.55	60.00	5.72	3.30	2.80	220.00	503.00
G25	3.24	15.57	15.89	6.82	1.29	61.67	7.09	3.47	2.77	228.00	625.33
G26	3.29	16.97	15.37	6.30	1.86	51.67	6.64	5.33	3.83	285.00	649.67

Table 4.2 Mean performance of fifty three Tossa Jute genotypes for eleven agro-morphological characters (Cont'd)

Genotypes	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (kg)/m^2	Green wt. without leaves(kg)/m^2	Fibre wt. (g)/m^2	Stick wt. (g)/m^2
G27	2.86	14.40	14.74	6.55	2.03	61.67	6.30	3.47	2.80	224.67	412.33
G28	3.45	16.50	16.25	6.21	2.25	53.33	6.03	4.53	3.53	280.00	631.33
G29	3.16	15.93	14.65	6.68	1.52	60.00	6.69	3.10	2.67	216.33	369.33
G30	3.22	17.13	15.83	6.42	1.41	56.67	6.45	3.23	2.83	227.33	507.00
G31	3.31	16.53	15.55	5.75	1.93	51.67	5.75	3.80	3.17	246.67	627.33
G32	3.24	16.43	15.65	6.54	1.91	55.00	6.55	3.53	3.03	203.00	495.00
G33	3.40	15.47	14.49	6.42	1.60	56.67	6.55	3.77	3.17	223.67	581.00
G34	3.25	16.10	15.88	6.29	1.55	61.67	5.59	3.80	3.07	258.33	569.67
G35	3.25	15.30	15.48	6.40	1.65	55.00	5.10	3.83	3.27	265.67	579.67
G36	3.26	16.83	14.78	6.90	1.58	58.33	6.07	2.80	2.40	217.33	484.67
G37	3.22	14.67	15.27	6.68	1.57	60.00	6.50	3.27	2.77	241.33	627.33
G38	3.45	15.97	16.13	6.55	2.16	55.00	6.24	4.37	3.37	300.00	729.33
G39	2.99	16.10	11.34	6.33	2.11	61.67	6.30	2.70	2.30	243.00	457.00
G40	2.96	16.80	14.53	5.94	1.42	56.67	4.85	2.57	2.50	227.33	422.33
G41	3.19	15.83	15.90	6.32	1.64	60.00	6.13	3.27	2.67	204.33	398.33
G42	3.09	16.23	15.55	6.05	1.81	55.00	5.99	3.57	2.97	213.00	567.33
G43	3.10	16.13	14.33	6.13	1.24	53.33	5.10	2.50	2.20	230.33	551.33
G44	3.18	16.43	16.20	6.11	1.74	58.33	5.60	2.53	2.13	210.33	459.67
G45	3.15	16.93	14.55	5.73	1.22	55.00	5.35	3.43	3.03	245.67	553.67
G46	3.25	16.63	12.82	5.93	1.33	58.33	5.73	2.53	2.23	221.00	479.67
G47	3.26	15.87	16.84	6.10	1.39	61.67	6.01	3.30	2.90	225.67	499.33
G48	3.22	15.33	16.72	7.05	1.21	58.33	6.29	3.00	2.50	204.00	393.33
G49	3.35	16.30	15.81	5.53	2.31	53.33	6.82	4.93	3.87	323.00	741.00
G50	3.29	15.37	15.70	6.73	1.82	56.67	5.66	3.00	2.60	203.00	444.33
G51	3.70	18.25	16.88	6.46	2.60	53.33	6.46	6.00	4.20	427.00	914.00
G52	3.75	17.38	16.30	6.03	2.45	51.67	6.50	6.20	4.25	440.00	890.00
G53	3.60	17.00	17.43	5.17	2.36	48.33	6.25	5.80	4.10	415.00	865.00

Table 4.3 Genetic parameters on eleven characters in Tossa jute germplasms

Characters	Range		Mean	F test	PCV	GCV	Heritability % (h^2_b)	Genetic Advance as % over mean
	Min.	Max.						
Plant height (m)	2.44	4.20	3.32	HS	4.86	3.01	60	3.91
Base diameter (mm)	13.10	20.70	16.04	HS	4.92	3.60	81	21.50
Green bark thickness (mm)	1.10	2.72	1.85	HS	20.58	20.37	98	41.62
Leaf length (cm)	10.42	17.85	15.47	HS	6.40	5.67	79	10.41
Leaf width (cm)	5.05	7.16	6.41	HS	6.66	5.54	77	13.26
Petiole length (cm)	4.78	7.35	6.22	HS	8.76	7.26	79	15.92
Leaf angle (^{0})	45.00	65.00	56.57	HS	5.53	4.92	79	8.96
Green wt. with leaves (kg)/m^2	1.30	7.00	3.81	HS	22.94	19.58	49	18.15
Green wt. without leaves (kg)/m^2	1.20	5.20	3.03	HS	17.93	15.52	93	44.38
Fibre weight (g)/m^2	111.00	464.00	257.09	HS	21.13	17.36	68	29.60
Stick weight (g)/m^2	210.00	949.00	577.92	HS	21.06	17.91	72	31.24

jute breeding programme. The preponderance of additive type of gene action in tossa jute in the inheritance of all these characters was also reported by Saha *et al.* (1996).

4.1.4 Genetic diversity analysis based on 11 characters of Tossa jute

4.1.4.1 Principal Component Analysis (PCA)

The Principal Component Analysis gave Eigen values of each principal component axes of coordination of genotypes with the first axes totally accounting for the variation among the genotypes, whereas two of these Eigen values above unity accounted for 66.46% (PCA I is 51.03 and PCA II is 15.43) (Table 4.4). The scatter diagram showed five arbitrary clusters. The genotypes were distantly located from each other (Fig. 4.1).

4.1.4.2 Principal Coordinate Analysis (PCO)

Principal coordinate analysis was performed on auxiliary of principal component analysis. Intra-cluster distance were estimated using the inter genotypic distance, as quoted in Singh and Chaudhary (1985). The highest intra-cluster distance (Table 4.7) was estimated for cluster IV (0.338) which consisted of fourteen genotypes and, this was followed by cluster III (0.330) that was composed of eighteen genotypes, cluster V (0.297) that was composed of seven genotypes and cluster II (0.284) that was composed of eleven genotypes. The cluster I showed the lowest intra-cluster distance (0.184) composed of three genotypes. Yahiya (2007) reported that clusters with lesser magnitude of divergence showed instability, while widely divergent clusters remained distance in different environments. These results revealed that the genotypes in cluster IV were distantly related with the genotypes of other clusters. On the other hand the genotypes in cluster I were closely related.

4.1.4.3 Clustering of 53 genotypes of Tossa jute

On the basis of D^2 analysis fifty three genotypes were grouped into five clusters (Table 4.5). Shrestha (1991) reported seven clusters in *C. capsularis* and eleven clusters in *C. olitorius*. These results confirmed the clustering pattern of the genotypes according to the principal component analysis.

Cluster III contained the largest number of genotypes (eighteen) followed by cluster IV (fourteen) and cluster II (eleven). The remaining ten genotypes were distributed in two clusters of which seven in cluster V and three in cluster I. It was observed from the distribution pattern that the geographic divergence did not influence the clustering pattern as the varieties/ genotypes within the same cluster originated from different districts/countries, rather, those were distributed in random (Table 4.5).

Table 4.4 Eigen values and percentages of variation in respect of eleven characters in 53 genotypes of Tossa jute

Principal component characters	Eigen values	Percentage of total variation	Cumulative percentage
PC1	5.613	51.03	51.03
PC2	1.697	15.43	66.46
PC3	0.872	7.93	74.39
PC4	0.776	7.06	81.45
PC5	0.525	4.78	86.23
PC6	0.494	4.49	90.72
PC7	0.059	0.54	91.26
PC8	0.351	3.20	94.46
PC9	0.304	2.77	97.23
PC10	0.221	2.02	99.25
PC11	0.082	0.75	100.00

Table 4.5 Distribution of 53 genotypes of Tossa jute in five clusters

Clusters	No. of genotypes	Name of genotypes	Accession No.
I	3	G_5, G_{48}, G_{51}	2667, 4892, O-9897.
II	11	G_3, G_7, G_8, G_9, G_{18}, G_{22}, G_{23}, G_{25}, G_{38}, G_{47}, G_{49}	2541, 3031, 3032, 3033, 3424, 3430, 3432, 3433, 3435, 3860, 5103.
III	18	G_1, G_6, G_{10}, G_{11}, G_{13}, G_{15}, G_{16}, G_{17}, G_{26}, G_{28}, G_{31}, G_{33}, G_{34}, G_{35}, G_{37}, G_{42}, G_{43}, G_{45}	1148, 2670, 3035, 3038, 3340, 3342, 3343, 3423, 3438, 3533, 3538, 3543, 3731, 3733, 3857, 4674, 4756, 4828.
IV	14	G_2, G_4, G_{12}, G_{19}, G_{20}, G_{21}, G_{24}, G_{30}, G_{32}, G_{36}, G_{39}, G_{44}, G_{46}, G_{52}	2381, 2666, 3339, 3425, 3426, 3429, 3536, 3542, 3856, 3985, 4785, 4848, 4851, O-795.
V	7	G_{14}, G_{27}, G_{29}, G_{40}, G_{41}, G_{50}, G_{53}	3341, 3439, 3535, 3986, 3987, 5138, JRO-524.

The eighteen genotypes included in the cluster III originated from Bangladesh, Kenya and Tanjania. Similarly the cluster I, II, IV and V consisted of three, eleven, fourteen and seven genotypes respectively, which were from Bangladesh, Kenya, Tanjania, Syria, Guinea, Ivorycost and India. Hence, the same cluster included genotypes from different eco-geographical regions. This geographical distribution was in agreement with Devi *et al*. (2004), who reported that the pattern of clustering had no general association between ecological distribution of genotypes and its genetic divergence. This might be due to differential adaptation, genetic drift, selection pressure and environment. The grouping of genotypes of same origin into different clusters was an indication of broad genetic base of the genotypes belonging to that origin or vice-versa.

Table 4.6 shows the comparison of cluster means for different characters. Cluster I had the highest mean values for plant height (3.68), base diameter (17.54), leaf length (16.87), green bark thickness (2.47), green weight with leaves (6.0), green weight without leaves (4.18), fibre weight (427.33) and stick weight (889.67) Cluster II ranked 1st for petiole length (6.42). None of the eleven characters had high mean values under clusters III and IV. Cluster V ranked 1st for leaf width (6.53) and leaf angle (58.57).

4.1.4.4 Canonical Vector Analysis (CVA)

To compute the inter-cluster Mahalonobis's (D^2) values canonical variate analysis was used. Table 4.7 presents the intra and inter-clusters distance (D^2) values. The inter cluster distance was maximum between cluster I and V (20.616) followed by the distance between clusters I and IV (18.405), I and III (14.857), II and V (10.984), I and II (10.277) indicating that the genotypes grouped within these cluster were highly divergent from each other. Choosing of parents belonging to the maximum divergent clusters is expected to manifest maximum heterosis in crossing and also wide variability in genetic architecture. The least genetic distance at inter-cluster level was observed between cluster IV and V (2.871), followed by the distance between clusters III and IV (4.296), and between II and III (4.584) indicating that the genotypes of these clusters were genetically closely related.

The clustering pattern of D^2 analysis (Table 4.7) followed the similar trend of distribution of genotypes in PCA (Fig 4.1**).** The D^2 and PCA were found to be alternative methods to yield information regarding the clustering pattern presented in Fig. 4.2 and Fig. 4.3. Moreover, the PCA provided information on contribution of the characters towards divergence.

The pattern of clustering revealed that germplasm originating from the same country did not form a single cluster. The genotypes belonging to different countries were grouped in the same cluster. This indicated that geographic diversity was not always related to genetic diversity and therefore, it was not adequate as an index of genetic diversity. This might be due to continuous exchange of genetic materials in different places of the country even among the counties of the world. Similar results were reported by Shrestha (1991) in Deshi jute.

The free clustering of the genotypes suggested dependence upon the directional selection pressure applied for realizing maximum yield in different regions, the nicely evolved homeostatic devices would favor constancy of the associated characters and would thus form indiscriminate clustering. This would suggest that not to choose diverse parents from diverse geographic regions rather choose parents from two extremes for a particular trait for hybridization.

4.1.4.5 Contribution of the characters towards divergence of the genotypes

The contributions of 11 characters on genetic diversity pertained in 53 genotypes of Tossa jute are presented in Table 4.8. The maximum contribution was paid by the character, base diameter (0.5335) followed by green wt. without leaves (0.4790), green bark thickness (0.4672) and plant height (0.3858). The summations of both the vectors for 11 characters were considered to describe relative contributions on genetic diversity. Interestingly it is noted that higher contributions of the four characters were measured due to positives values obtained in both the vectors. On the contrary, the minimum contribution toward genetic diversity was waged by the character, petiole length (-0.6142) because both the vectors yielded negative magnitudes. Other characters contributed medium to lower contributions on genetic diversity as projected by summations of both the vector values against the characters under consideration. Therefore, base diameter, green wt. with leaves, green bark thickness and stick weight appeared as the important characters in Tossa jute to assess genetic diversity based on morphological features.

4.1.4.6 Ranking of the genotypes

All 53 genotypes under studied were subjected to analyze for the determination of individual relative position based on 7 characters. The highest mean of a character was denoted by the rank 1 and then the genotypes were arranged from higher to lower order of mean values. The cumulative value was employed to determine the relative position of a genotype in the testing materials. The data presented in Table 4.9 revealed that none of the genotype occupied rank 1 for all the characters, hence jute breeders should rely on the relative position of the genotypes

Table 4.6 Cluster mean value for yield and yield contributing characters of Tossa jute

Characters	Cluster				
	I	II	III	IV	V
Plant height (m)	3.68	3.40	3.30	3.30	3.13
Base diameter (mm)	17.54	15.98	15.91	16.12	15.70
Leaf length (cm)	16.87	15.81	15.26	15.19	15.41
Leaf width (cm)	5.89	6.40	6.41	6.43	6.58
Green bark thickness (mm)	2.47	2.19	1.70	1.75	1.63
Petiole length (cm)	6.40	6.42	6.17	6.20	5.99
Leaf angle (dg)	51.11	54.39	57.04	57.86	58.57
Green wt. with leaves (kg)	6.00	4.56	3.70	3.19	3.18
Green wt. without leaves (kg)	4.18	3.49	2.98	2.65	2.69
Fibre weight (g)	427.33	300.64	247.32	221.07	212.90
Stick weight (g)	889.67	688.94	591.04	489.76	412.43

Table 4.7 Inter and intra-cluster (bold) distance (D^2) of fifty three genotypes of Tossa jute

Cluster	I	II	III	IV	V
I	**0.184**				
II	10.277	**0.284**			
III	14.857	4.584	**0.330**		
IV	18.405	8.425	4.296	**0.338**	
V	20.616	10.984	7.129	2.871	**0.297**

Table 4.8 Contribution of different characters towards genetic diversity of Tossa jute

Characters	Vector-I	Vector-II	Total
Plant height (m)	0.3394	0.0464	0.3858
Base diameter (mm)	0.1795	0.4540	0.5335
Leaf length (cm)	0.2268	0.0724	0.2992
Leaf width (cm)	0.1222	-0.6302	-0.5080
Green bark thickness (mm)	0.2849	0.1823	0.4672
Petiole length (cm)	-0.1222	-0.4920	-0.6142
Leaf angle (dg)	0.3068	-0.1958	0.1110
Green wt. with leaves (kg)	0.3778	0.0070	0.3848
Green wt. without leaves (kg)	0.3976	0.0814	0.4790
Fibre weight (g)	-0.3860	0.0565	-0.3295
Stick weight (g)	0.3723	0.0105	0.3828

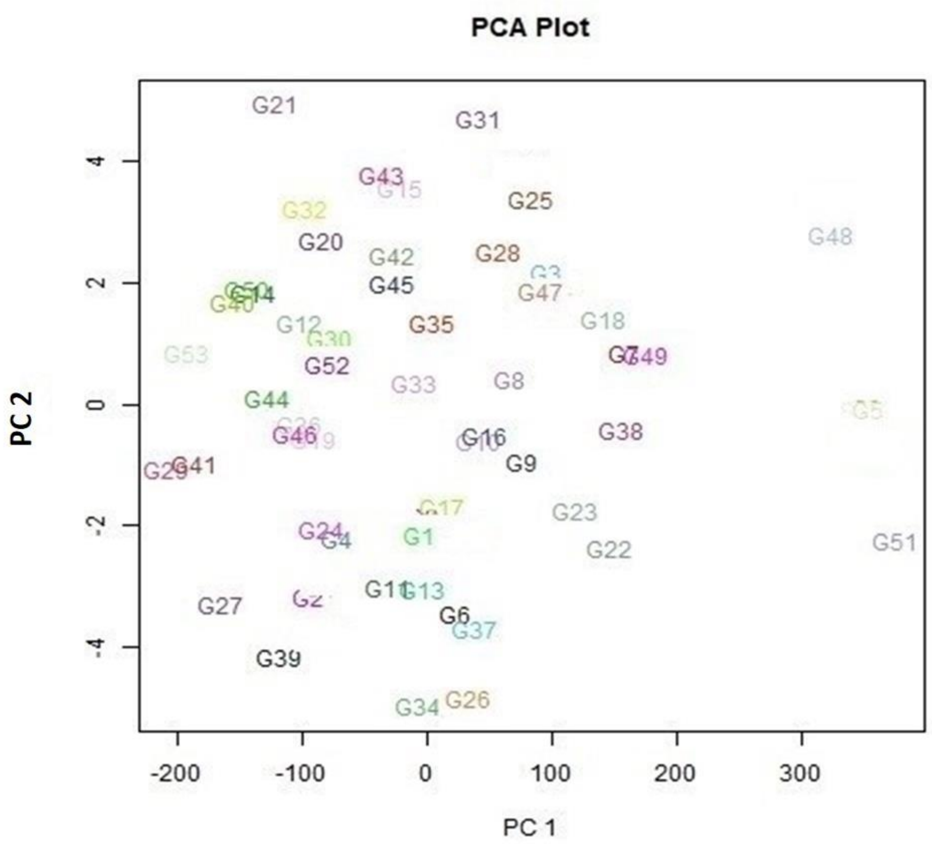

Fig. 4.1 Scattered diagram of fifty three genotypes of Tossa jute based on their principal component scores

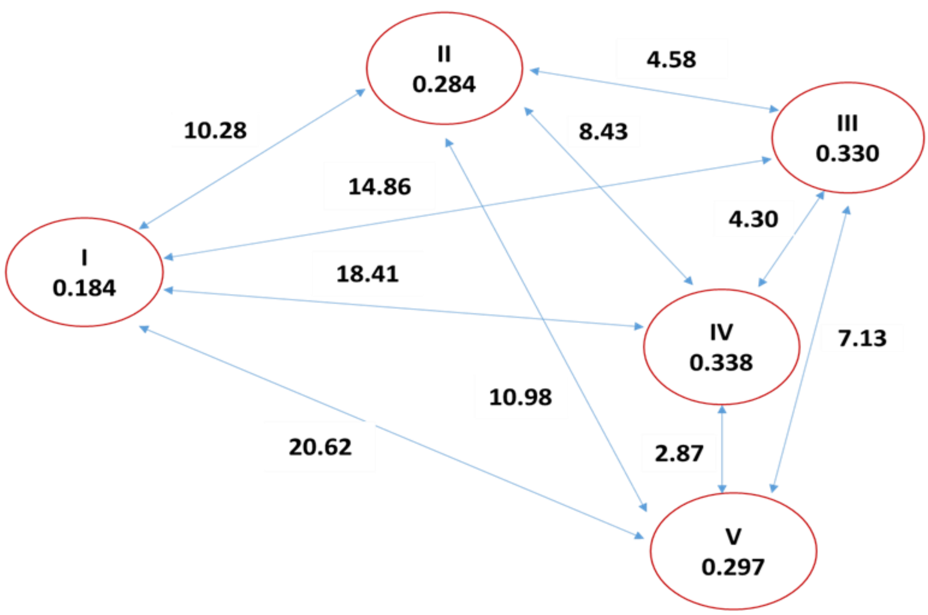

Fig. 4.2 Graphical representation of Intra and Inter cluster distances in Tossa jute genotypes

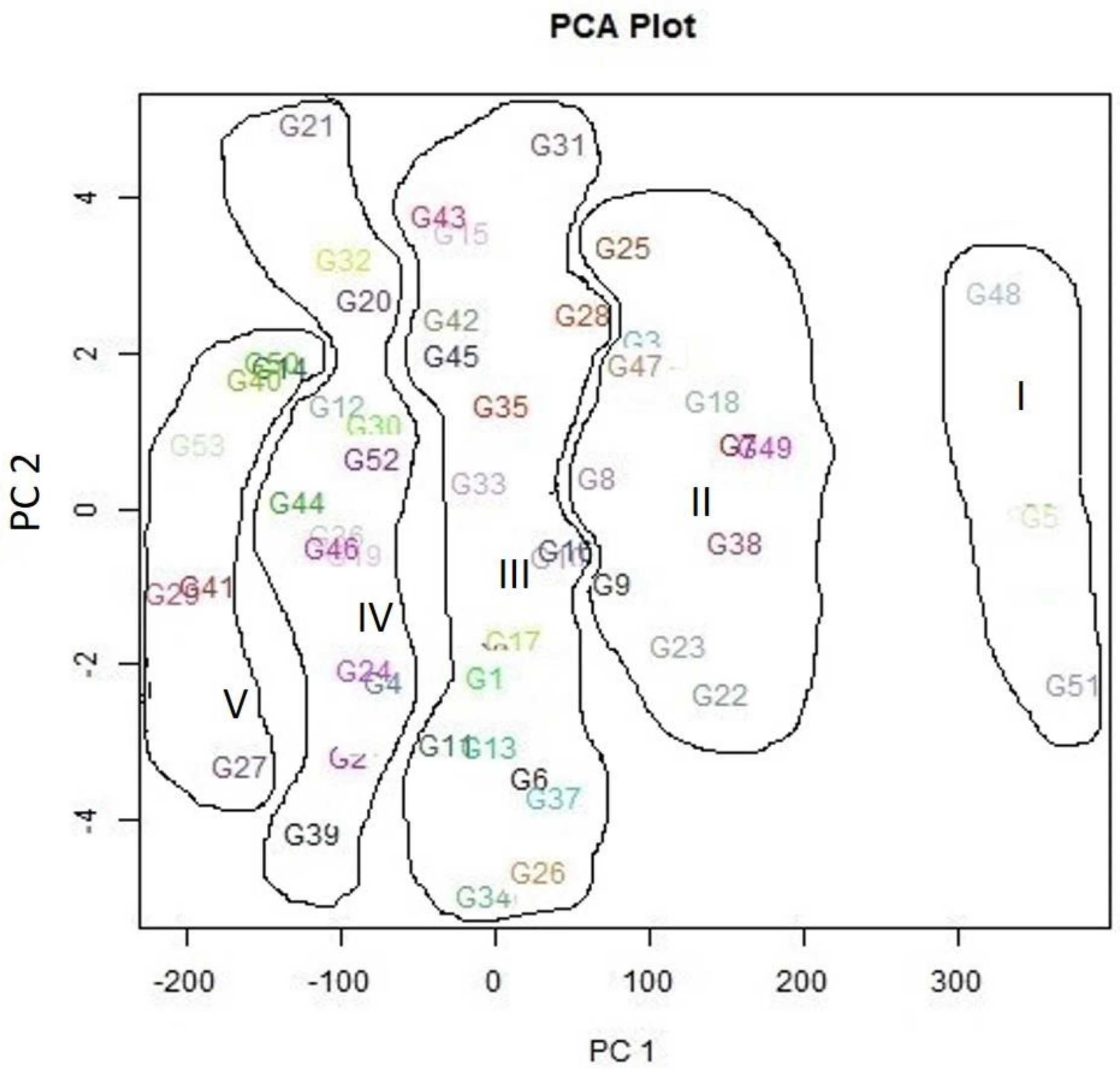

Fig. 4.3 Scattered diagram of 53 genotypes of Tossa jute based on their principal component score superimposed with D^2 values

Table 4.9 Ranking distribution of different characters in Tossa jute genotypes

Genotypes	Plant height (m)	Base diameter (mm)	Leaf length (cm)	Petiole length (cm)	Green wt. with leaves (kg)	Fibre weight (g)	Stick weight (g)	Total	Position
1	21	43	46	6	14	13	29	173	21
2	4	24	5	5	9	7	12	68	1
3	24	36	9	12	13	18	22	137	11
4	11	30	7	49	37	44	33	215	26
5	14	21	13	37	18	30	34	172	20
6	31	29	41	45	34	29	21	236	29
7	6	6	26	23	7	5	6	86	3
8	30	9	33	15	23	14	14	146	14
9	28	4	36	10	26	17	11	141	13
10	18	13	38	13	36	21	20	169	19
11	22	47	50	42	28	26	32	258	35
12	17	14	43	1	15	48	41	191	23
13	19	10	39	22	20	28	23	174	22
14	34	31	28	35	21	47	47	257	34
15	26	15	14	8	16	25	28	147	15
16	7	34	35	2	19	20	16	149	16
17	13	3	15	30	4	11	10	103	6
18	5	18	6	33	8	8	7	103	7
19	15	8	40	9	43	38	40	212	24
20	10	49	22	4	48	32	37	222	28
21	20	25	29	34	31	45	44	249	31
22	12	17	24	40	12	4	8	139	12
23	27	12	27	29	17	10	9	154	17
24	25	41	18	44	38	41	36	267	38

Table 4.9 Ranking distribution of different characters in Tossa jute genotypes (Cont'd)

Genotypes	Plant height (m)	Base diameter (mm)	Leaf length (cm)	Petiole length (cm)	Green wt. with leaves (kg)	Fibre weight (g)	Stick weight (g)	Total	Position
25	41	50	17	3	32	33	19	220	27
26	32	26	34	14	5	12	13	162	18
27	53	20	44	24	33	37	50	288	41
28	9	11	10	36	10	15	15	134	10
29	47	42	45	11	44	43	53	314	45
30	43	45	20	21	42	34	35	270	39
31	27	22	30	41	24	22	17	214	25
32	40	23	25	17	30	52	39	258	36
33	16	37	49	16	27	39	24	241	30
34	38	40	19	48	25	19	26	249	32
35	39	33	32	51	22	16	25	253	33
36	35	38	42	32	47	42	42	314	46
37	42	39	37	18	40	27	18	258	37
38	8	16	12	28	11	9	5	127	9
39	51	19	53	25	49	24	46	306	43
40	52	44	48	53	50	35	49	371	53
41	45	35	16	31	41	50	51	310	44
42	50	28	31	39	29	46	27	292	42
43	49	51	51	52	53	31	31	361	51
44	46	32	11	47	51	49	45	325	48
45	48	52	47	50	35	23	30	330	50
46	37	48	52	43	52	40	43	361	52
47	36	46	3	38	39	36	38	283	40
48	44	53	4	26	45	51	52	323	47

Table 4.9 Ranking distribution of different characters in Tossa jute genotypes (Cont'd)

Genotypes	Plant height (m)	Base diameter (mm)	Leaf length (cm)	Petiole length (cm)	Green wt. with leaves (kg)	Fibre weight (g)	Stick weight (g)	Total	Position
49	24	7	21	7	6	6	4	124	8
50	33	27	23	46	46	53	48	326	49
51	2	1	2	20	2	2	1	81	2
52	1	2	8	19	1	1	2	86	4
53	3	5	1	27	3	3	3	98	5

Fifty three genotypes of Tossa jute were sequentially arranged according to order of merits and the rank total against the genotype indicated the position among the lot constructed on 7 characters. The presented ranking results proved that the genotype 2 (Acc.-2381) occupied 1st position, followed by the genotypes 51 (O-9897) and 7(Acc.-3031), indicates that these three genotypes may be considered during exercise of pure line selection. Since selection indices were not constructed, the ranking results may be exploited in addition during application other statistical tools to identify the fiber yield enhancing characters and potential genotypes for hybridization through diallel fashion. Fasinately, during selection of parents by D^2 statistics and positive and significant GCA, the ranking positions of the 53 genotypes have been considered. Since ranking of genotypes by numbering has no statistical basis, it is not a powerful tool in quantitative genetics but here the genotypes ranked according to their character expression potentials to have an impressive reflection of the genotypes to use in the investigation. Further to satisfy the answer the inherent potentials of the genotypes, ranking is an effective tool to assess relative performance considering the selected 7 characters. Noteworthy, it is stated that what may the position of the genotypes, the most important character, and the contribution of fiber yield alone was considered. The results presented in table 4.9 revealed that the genotype 2 (Acc.-2381) occupied the 1st rank followed by the genotypes, 51(O-9897 and 7(Acc.-3031), hence these three genotypes might be considered through the investigation. Finally the order of merits of 53 genotypes has been come into focus by such type of ranking results.

4.1.5 Interrelationship among different characters of Tossa jute

4.1.5.1 Correlation coefficient analysis among different characters of Tossa jute

Interrelationships of the characters and their associations with fibre weight in Tossa jute were examined through the study of genotypic and phenotypic correlation coefficients. Such study would also offer to know the suitability of various characters for indirect selection because selection of one or more character results in correlated response in several other traits. The study on correlation (Table 4.10) showed that all the correlation coefficients at genotypic level were greater than the corresponding phenotypic ones. The higher values of genotypic than those of phenotypic correlations suggested that the genotypic effects were more important than the environmental factors. In the present investigation fibre weight was highly positively correlated with plant height (0.677 and 0.962), base diameter (0.382 and 0.878), green bark thickness (0.614 and 0.744), leaf length (0.379 and 0.551), petiole length (0.170 and 0.217), green wt. with leaves (0.854 and 0.952), green wt. without leaves (0.801 and 0.945) and stick wt. (0.913 and 0.973) at both phenotypic and genotypic levels. Similar relationship was also reported by Khatun *et al.* (1998), Islam *et al.* (2001). Pullibai *et al.* (2005), Rani *et al.* (2006), and Hari *et al.* (2017).

Only two characters, leaf width and leaf angle exhibited highly negative correlation with fibre weight. When interrelationships among different characters were considered, significant highly positive correlations were observed between plant height and green bark thickness, plant height and leaf length, plant height and green weight with leaves , plant height and green weight without leaves, plant height and stick weight, base diameter and leaf length, base diameter and green weight without leaves, base diameter and green weight with leaves, base diameter and stick weight, green bark thickness and leaf length, green bark thickness and petiole length, green bark thickness and green weight with leaves, green bark thickness and green weight without leaves, green bark thickness and stick weight, leaf length and green weight with leaves, leaf length and green weight without leaves, leaf length and stick weight, leaf width and leaf angle, leaf width and petiole length, petiole length and green weight with leaves, petiole length and green weight without leaves ,petiole length and stick weight, green weight with leaves and green weight without leaves, green weight with leaves and stick weight, green weight without leaves and stick weight.

It therefore follows that selection for any of these four characters is likely to generate a correlated response over the remaining three characters. Such correlation may arise due to linkage or pleiotropy. But in this investigation it is not possible to conclude the cause of correlation. Highly significant but negative correlation was observed between base diameter and leaf width, base diameter and leaf angle, green bark thickness and leaf angle, leaf length and leaf angle, leaf width and green wt. with leaves, leaf width and green wt. without leaves, leaf width and stick wt., leaf width and fibre weight, leaf angle and green wt. with leaves, leaf angle and green wt. without leaves, leaf angle and stick wt., leaf angle and fibre weight.

4.1.5.2 Path analysis among different characters of Tossa jute

Since the genotypic correlation between the pairs of characters is the inherent property of the genotypes, therefore, cause and effect were analyzed both at genotypic and phenotypic levels. Estimates of correlation do not alone provide comprehensive pictures of the direct and indirect influences of each of the characters to the fibre weight as this trait is the resultant product of combined effect of various factors complementing and counter acting with each other. So the path coefficient analysis of fibre weight was carried out to assess the extent of relationship of fibre weight and its attributes, and establish the impact of the individual component on fibre yield of Tossa jute. In the present genotypes, direct positive effects of plant height, base diameter, green bark thickness, green wt. with leaves, green wt. without leaves and stick wt. were observed on fibre weight (Table 4.11). These direct effects of plant

Table 4.10 Phenotypic (P) and genotypic (G) correlation coefficient for eleven characters of Tossa jute

Characters		Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (kg)m^2	Green wt. without leaves (kg)/m^2	Stick wt.(g)/m^2	Fibre wt.(g)/m^2
Plant height (m)	P	0.305**	0.506**	0.528**	-0.046	-0.507**	0.340**	0.708**	0.630**	0.711**	0.677**
	G	-0.074	0.779**	0.835**	-0.085	-0.955**	0.542	0.947**	0.969**	0.959**	0.962**
Base diameter (mm)	P		0.056	0.114	-0.472**	-0.393**	-0.034	0.301**	0.317**	0.314**	0.382**
	G		0.160	0.412**	-0.999**	-0.999**	-0.098	0.680**	0.795**	0.538**	0.878**
Green bark thickness (mm)	P			0.195**	0.070	-0.437**	0.337**	0.668**	0.558**	0.599**	0.614**
	G			0.237**	0.084	-0.514**	0.308**	0.774**	0.807**	0.709**	0.744**
Leaf length (cm)	P				-0.053	-0.356**	0.113	0.507**	0.455**	0.398**	0.379**
	G				-0.047	-0.468**	0.103	0.665**	0.742**	0.504**	0.551**
Leaf width (cm)	P					0.375**	0.301**	-0.183	-0.281**	-0.245**	-0.328**
	G					0.433**	0.287**	-0.241**	-0.436**	-0.311**	-0.424**
Leaf angle (dg)	P						-0.074	-0.618**	-0.598**	-0.582**	-0.587**
	G						-0.066	-0.812**	-0.986**	-0.790**	-0.795**
Petiole length (cm)	P							0.305**	0.235**	0.221**	0.170
	G							0.363**	0.329**	0.252**	0.217**
Green wt. with leaves (kg)/m^2	P								0.917**	0.833**	0.854**
	G								0.924**	0.949**	0.952**
Green wt. without leaves (kg)/m^2	P									0.768**	0.801**
	G									0.938**	0.945**
Stick wt.(g)m^2	P										0.913**
	G										0.973**

*&** significant at 5% and 1%level, respectively.

Table 4.11 Path coefficient at phenotypic (P) and genotypic (G) levels taking dependent variable (fibre weight) and direct effects in bold

Characters		Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (kg)/m^2	Green wt. without leaves (kg)/m^2	Stick wt. (g)/m^2	Correlation with fibre wt.
Plant height(m)	P	**0.054**	0.045	0.047	0.009	0.031	0.027	0.021	0.136	0.022	0.265	0.677**
	G	**0.088**	0.079	0.081	0.043	0.065	0.061	0.055	0.171	0.056	0.299	0.962**
Base diameter (mm)	P	0.025	**0.051**	0.014	0.014	0.045	0.012	0.014	0.051	0.010	0.154	0.382**
	G	0.073	**0.099**	0.062	0.062	0.093	0.060	0.063	0.099	0.058	0.203	0.878**
Green bark thickness (mm)	P	0.024	0.016	**0.080**	0.002	0.004	0.015	0.005	0.206	0.005	0.222	0.614**
	G	0.037	0.030	**0.094**	0.016	0.018	0.029	0.019	0.220	0.019	0.235	0.744**
Leaf length (cm)	P	0.024	0.017	0.028	**-0.059**	0.022	0.017	0.014	0.135	0.011	0.146	0.379**
	G	0.041	0.034	0.045	**-0.043**	0.038	0.034	0.031	0.152	0.028	0.163	0.551**
Leaf width (cm)	P	-0.010	-0.018	-0.004	-0.006	**-0.145**	-0.009	-0.017	-0.056	-0.004	-0.077	-0.328**
	G	-0.018	-0.027	-0.012	-0.015	**-0.154**	-0.017	-0.026	-0.064	-0.013	-0.086	-0.424**
Leaf angle (dg)	P	-0.027	-0.028	-0.043	-0.003	-0.059	**-0.021**	-0.019	-0.173	-0.012	-0.191	-0.587**
	G	-0.048	-0.049	-0.065	-0.024	-0.080	**-0.042**	-0.040	-0.195	-0.033	-0.212	-0.795**
Petiole length (cm)	P	0.009	0.001	0.023	-0.003	-0.033	0.004	**-0.028**	0.109	-0.001	0.077	0.170
	G	0.012	0.004	0.026	0.001	-0.030	0.007	**-0.024**	0.113	0.002	0.080	0.217**
Green wt. with leaves(kg)/m^2	P	0.025	0.021	0.049	-0.006	0.034	0.017	0.009	**0.408**	-0.008	0.293	0.854**
	G	0.041	0.037	0.065	0.010	0.049	0.033	0.024	**0.424**	0.007	0.308	0.952**
Green wt. without leaves (kg)/m^2	P	0.024	0.022	0.042	0.005	0.041	0.019	0.013	0.383	**0.008**	0.253	0.801**
	G	0.045	0.043	0.063	0.021	0.062	0.040	0.034	0.404	**0.012**	0.274	0.945**
Stick wt.(g)/m2	P	0.031	0.028	0.045	-0.005	0.037	0.016	0.011	0.251	0.002	**0.475**	0.913**
	G	0.041	0.039	0.056	0.005	0.047	0.027	0.022	0.262	0.013	**0.486**	0.973**

Residual effect (G) = 0.1942   Residual effect (P) = 0.3473

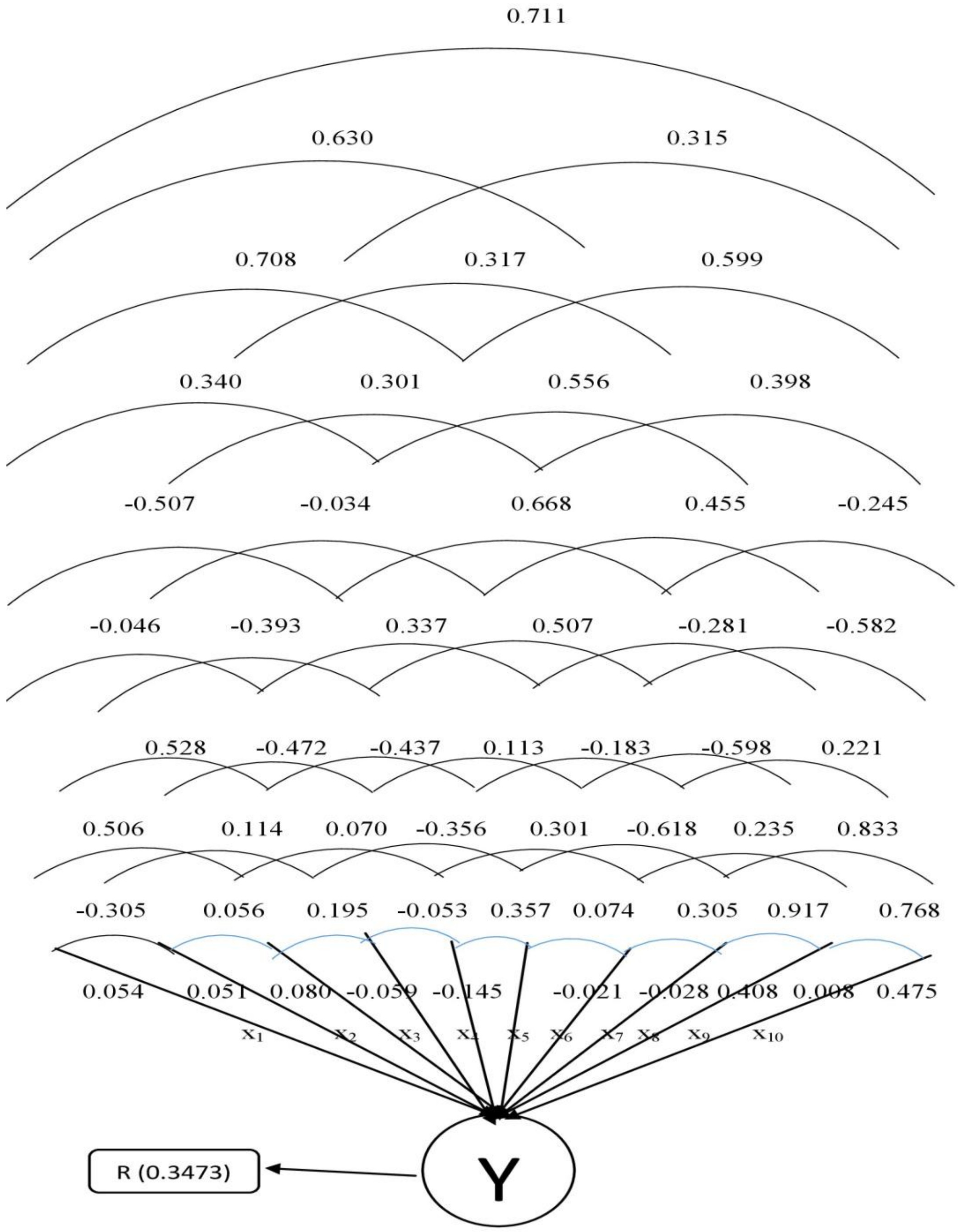

Fig. 4.4 (a) Path diagram and phenotypic coefficient of factors influencing fibre yield in Tossa jute

x_1: Plant height (m) | x_2 : Base diameter (mm)
x_3 : Green bark thickness (mm) | x_4 : Leaf length (cm)
x_5 : Leaf width (cm) | x_6 : Leaf angle (^{0})
x_7 : Petiole length (cm) | x_8 : Green wt. with leaves (kg)/m^2
x_9 : Green wt. without leaves (kg)/m^2 | x_{10} : Stick wt. (g)/m^2

Y : Fibre yield (g)/m^2

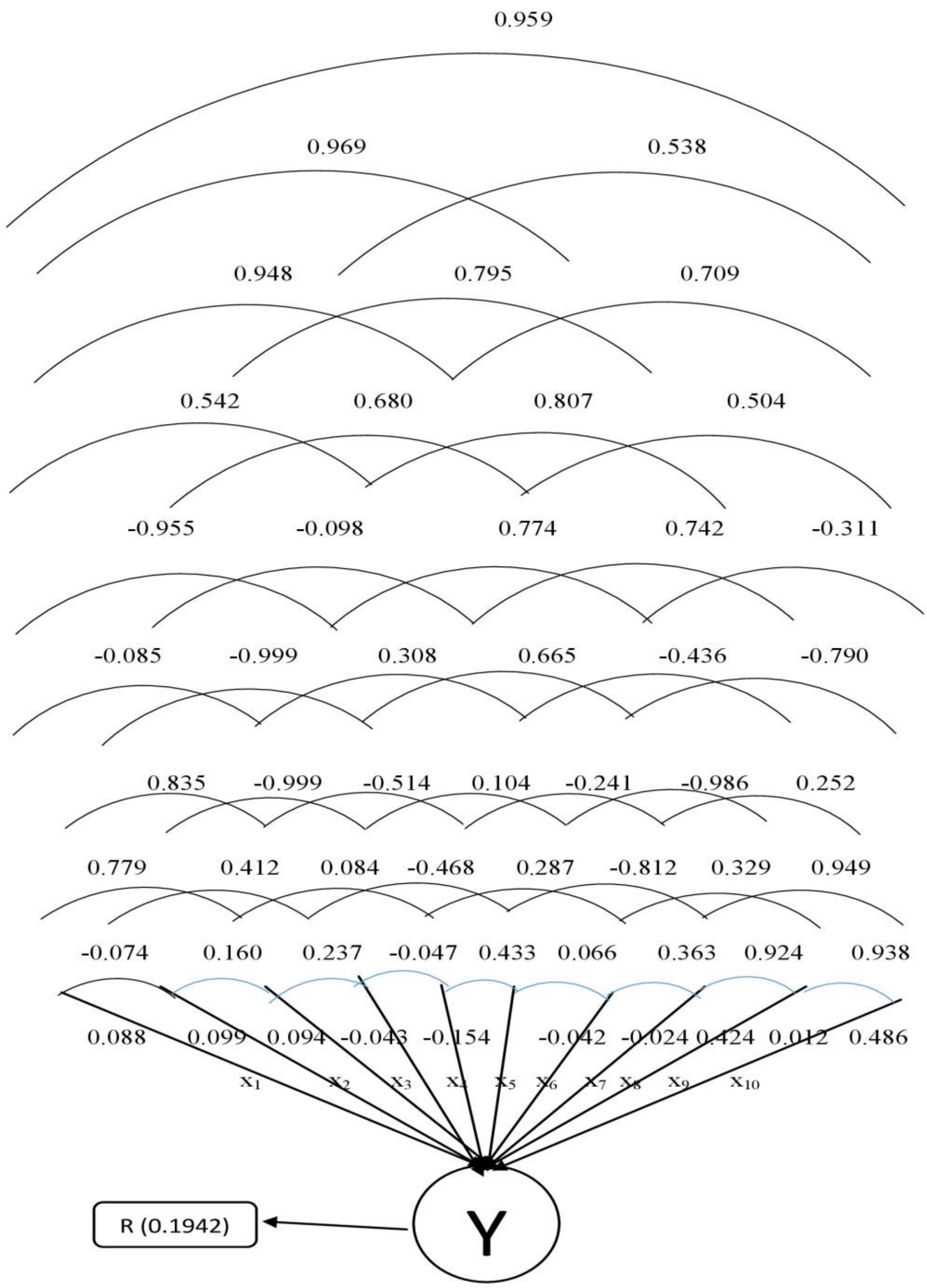

Fig. 4.4 (b) Path diagram and genotypic coefficient of factors influencing fibre yield in Tossa jute

x_1: Plant height (m) x_2 : Base diameter (mm)

x_3 : Green bark thickness (mm) x_4 : Leaf length (cm)

x_5 : Leaf width (cm) x_6 : Leaf angle (^{0})

x_7 : Petiole length (cm) x_8 : Green wt. with leaves (kg)/m^2

x_9 : Green wt. without leaves (kg)/m^2 x_{10} : Stick wt. (g)/m^2

Y : Fibre yield (g)/m^2

height, base diameter, green bark thickness, green wt. with leaves, green wt. without leaves and stick wt. were mostly positive via other characters. This result corroborated with the finding of Sardana *et al.,* (1990). Islam *et al.,* 2001., Anuradha and Suryakumari (2002); Nayak *et al.* (2008) and Pervin and Haque (2012). However, significant positive correlation was obtained in plant height, base diameter, green bark thickness, green weight with leaves, green weight without leaves and stick weight with fibre weight. On the other hand leaf length, leaf width, petiole length, leaf angle produced negative direct effect with fibre weight. Thus plant height, base diameter, green bark thickness, green wt. with leaves, green wt. without leaves and stick wt. appeared to be most important fibre yield attributing characters in Tossa jute.

4.2 Experiment II. Combining Ability Analysis for Yield and Yield Contributing Characters in Tossa Jute

Eight parents were selected based on visual scoring of the parents for important quantitative characters as well as clustering of the germplasms. Fifty three genotypes were distributed in five clusters. At first one genotype was selected from each of the clusters and then additional genotypes were taken out according the number of genotypes included in the clusters, likely the highest the number of genotypes in a cluster offered the highest number of additional genotypes for combining ability in Tossa jute.

4.2.1 Combining ability analysis among different characters of Tossa jute

Analysis of variance for combining ability revealed that variance due to GCA and SCA were highly significant for all the characters (Table 4.12) indicating additive and non-additive gene actions which played predominant role for the expression of these characters. The magnitudes of GCA variance were higher than the corresponding SCA variance for all the characters indicated preponderance of additive effects in controlling the expression of these traits. Additive variance is fixable, and therefore, selection for traits governed by such variance is very effective (Singh and Narayanan, 1993). Reciprocal differences were also significant for plant height, base diameter, green bark thickness, leaf length, leaf width, leaf angle, petiole length, green wt. with leaves, green wt. without leaves, fiber wt. and stick wt. Significant reciprocal variance indicated cytoplasmic genetic effects of parents in their offspring's.

4.2.2 Combining ability effects

4.2.2.1 Plant height

Plant height is an important component of fibre yield in *Chorchorus olitorius*. Among the treatments, the highest mean plant height (3.48 m) for parents was found in P_8 and the lowest (3.09 m) was observed in P_6 (Table 4.13, Fig. 4.5). In case of hybrids, the highest mean plant height (3.79 m) was observed in the cross combination $P_2 \times P_8$ which exceeded from it parental limits. Again the lowest mean plant height (3.08 m) was found in $P_6 \times P_5$, which was almost same as its pollen and female parents (Table 4.13).

A positive general combining ability (GCA) effect is desired for plant height to get a taller stature combination. The GCA effects varied from -0.087 to 0.075 (Table 4.13). The parent P2 exhibited the highest (0.075) and highly significant positive GCA effect indicating the parent was the best general combiner for plant height and this was followed by P_8 (0.065), P_3 (0.030) and P_4 (0.010). On the other hand, the parents P_6 (-0.047), P_5 (-0.077) and

Table 4.12. Analysis of variance for combining ability in Tossa jute for 11 agro-morphological characters

Source of variation	d f	Mean square (MS) of different characters										
		Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (g)	Green wt. without leaves (g)	Fibre wt./plant (g)	Stick wt./plant (g)
GCA	7	0.056**	3.84**	0.103**	0.56**	0.07**	12.67**	0.42**	1145.16*	707.81**	11.48**	55.96**
SCA	28	0.012**	1.01**	0.016	0.26**	0.07**	6.59**	0.08**	425.87*	261.45**	5.65**	20.10**
Reciprocal	28	0.022**	1.87**	0.048**	0.41**	0.06**	9.70**	0.09**	767.27*	512.27**	8.61**	37.77**
Error	126	0.011	0.98	0.023	0.18	0.03	2.90	0.05	403.27	239.29	4.31	18.66

*&** significant at 5% and 1%level, respectively.

Table 4.13 Estimates of general combining ability (GCA) effects for 11 agro-morphological characters of Tossa jute

Parents	Accessions	Plant height (m)		Base diameter (mm)		Green bark thickness (mm)		Leaf length (cm)		Leaf width (cm)		Leaf angle (dg)	
		Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
P_1	(O-9897)	3.22	-0.001	16.07	-0.020	1.73	0.095**	14.84	0.104**	6.10	0.106**	47.66	1.344**
P_2	(O-795)	3.40	0.075**	16.13	0.484**	1.40	-0.007	15.01	-0.109**	5.94	0.096*	51.33	-0.156**
P_3	(JRO-524)	3.30	0.030**	15.80	0.175**	1.33	-0.063**	15.33	-0.120**	5.80	-0.029*	49.00	1.115**
P_4	(Acc.2381)	3.43	0.010	16.53	-0.054**	1.60	-0.019**	14.85	-0.229**	5.77	-0.084**	49.66	-0.802**
P_5	(Acc.3423)	3.19	-0.077**	14.23	-0.499**	1.37	-0.069**	14.92	0.292**	5.61	0.003	46.33	-1.198**
P_6	(Acc.3438)	3.09	-0.087**	15.07	-0.441**	1.33	-0.007	15.04	-0.190**	6.32	-0.026*	48.66	0.135**
P_7	(Acc.3533)	3.28	-0.015	14.67	-0.495**	1.23	-0.075**	15.26	0.159**	6.04	-0.013	46.66	-0.594**
P_8	(Acc.3860)	3.48	0.065*	17.47	0.850**	1.67	0.145**	15.20	0.093*	6.05	-0.052*	50.33	0.156**
SE (gi)	-	-	0.014	-	0.023	-	0.035	-	0.039	-	0.019	-	0.040
SE(gi-gj)	-	-	0.017	-	0.035	-	0.053	-	0.050	-	0.026	-	0.063

*&** significant at 5% and 1%level, respectively.

Table 4.13 Estimates of general combining ability (GCA) effects for 11 agro-morphological characters of Tossa jute (Cont'd)

Parents	Accessions	Petiole length (cm)		Green wt. with leaves (g)		Green wt. without leaves (g)		Fibre wt./plant (g)		Stick wt./plant (g)	
		Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
P_1	(O-9897)	4.89	-0.217**	145.33	-16.552**	113.66	-13.396**	14.93	-1.473**	32.00	-3.892**
P_2	(O-795)	5.02	-0.066*	153.00	5.740**	120.33	4.146**	14.66	0.518**	35.33	1.304**
P_3	(JRO-524)	5.32	-0.110**	144.33	5.677**	113.00	4.083**	14.13	0.689**	31.00	1.025**
P_4	(Acc.2381)	5.45	0.058*	150.66	0.365	118.00	-0.292	14.33	-0.213**	33.66	0.267*
P_5	(Acc. 3423)	5.00	-0.077*	142.66	-5.740**	111.33	-4.792**	13.00	-0.863**	31.66	-1.317**
P_6	(Acc.3438)	6.52	0.325*	140.00	-3.052**	109.66	-0.917	13.26	-0.148**	31.13	-0.225*
P_7	(Acc.3533)	5.38	0.074*	175.00	3.073**	136.33	3.333**	16.80	0.441**	38.40	0.825*
P_8	(Acc.3860)	5.25	0.071*	192.66	10.490**	151.33	7.833**	18.93	1.049**	42.33	2.012**
SE (gi)	-	-	0.034	-	1.696	-	1.617	-	0.086	-	0.101
SE(gi-gj)	-	-	0.052	-	3.010	-	2.469	-	0.134	-	0.153

*&** significant at 5% and 1%level, respectively.

P_7 (-0.015) showed significant negative GCA effects and were considered as poor general combiners for tall stature of plants.

The best hybrids with significant and positive specific combining ability (SCA) effects were $P_3 \times P_5$ (0.157) and $P_4 \times P_6$ (0.108) which were considered as good specific recombination for tallness. Conversely, the hybrids $P_3 \times P_8$ (-0.085), $P_2 \times P_4$ (-0.073), $P_5 \times P_8$ (-0.060) and $P_5 \times P_6$ (-0.059) were identified as poor specific combinations for this trait as revealed by the negative SCA effects **(**Table 4.14**)**.

The best hybrids with significant and positive reciprocal effects were $P_5 \times P_2$ (0.165), $P_8 \times P_2$ (0.157), $P_7 \times P_5$ (0.142) and $P_6 \times P_5$ (0.117) which were considered as good specific combinations for tallness. The results indicated the presence of cytoplasmic (mt genes and ct genes) on the expression of the trait in the reciprocal crosses. Conversely, the hybrids $P_8 \times P_7$ (-0.208) and P_3x P_2 (-0.115) were identified as poor specific combinations for this trait as revealed by the significant negative reciprocal effects **(**Table 4.15**)**. Plate 4.1 showing F_1 hybrid of experiment in the field.

4.2.2.2 Base diameter

Base diameter is another important fibre yield component of *Chorchorus olitorius.* Base diameter ranged from 14.23 to 17.47 mm and 13.60 to 22.80 mm in parents and hybrids, respectively (Table 4.13, Fig. 4.6). The highest mean value for base diameter observed in $P_3 \times P_2$ (22.80 mm), which was higher than its both parents. Contrary, the lowest mean value was observed in $P_6 \times P_7$ (13.60 mm).

All of the parents exhibited highly significant GCA effects in which three parents had positive values (desirable effect) and the rest five had negative effects (Table 4.13). The positive and desired GCA effects were found in P_8 (0.850), P_2 (0.4839) and P_3 (0.175), which were considered as good general combiners for this trait. Another five parents possessed negative and significant GCA effects and, therefore, they are considered as poor general combiners.

The SCA effects ranged from -1.196 to 2.166 for base diameter. One cross showed highly significant and eight crosses showed significant positive SCA effects and these nine cross combinations $P_2 \times P_{3,}$ $P_1 \times P_{4,}$ $P_1 \times P_{5,}$ $P_1 \times P_{7,}$ $P_3 \times P_{7,}$ $P_5 \times P_{6,}$ $P_5 \times P_{8,}$ $P_6 \times P_8$ and $P_7 \times P_8$ were identified as good specific combiners for this trait. Another seven crosses showed

F_1 hybrids in experiment -III

Plate 4.1 Photograph showing F_1 hybrid of experiment II in the field

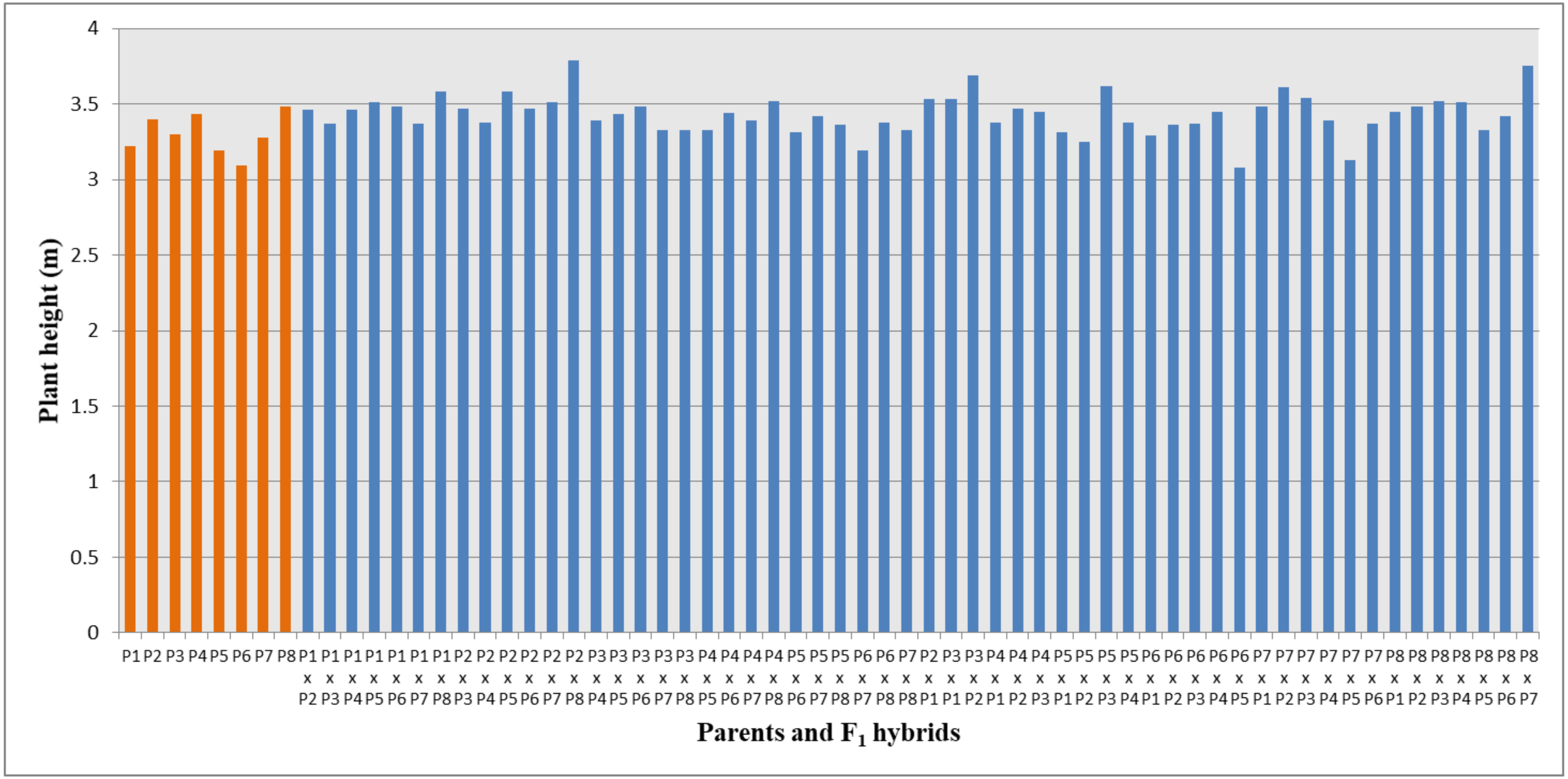

Fig. 4.5 Plant height of parents and F_1 hybrids in Tossa jute

positive but non-significant SCA values, which could be considered as average combiners. Other crosses showed negative SCA effects and of them, ($P_1 \times P_3$) showed highly significant negative SCA value (-1.196). This cross combination, therefore, considered as the poor specific combiner (Table 4.14).

Five crosses showed significant positive reciprocal effects, of which the best one was $P_4 \times P_2$ (1.233). This was followed by $P_8 \times P_2$ (1.167), $P_5 \times P_2$ (1.133), $P_7 \times P_2$ (0.833), and $P_7 \times P_5$ (0.467). Another ten crosses showed positive but non-significant reciprocal effects and they could be treated as average specific combiners (Table 4.15).The rest crosses showed negative reciprocal effects and of them, six viz. $P_3 \times P_2$, $P_3 \times P_1$, $P_5 \times P_4$, $P_6 \times P_4$, $P_7 \times P_3$, $P_8 \times P_3$, $P_8 \times P_4$, $P_8 \times P_6$ and $P_7 \times P_6$ showed significant reciprocal values. So, they were considered as poor specific combiner for this trait. The significant effects of reciprocal crosses have no consistency in inheritance because of irregular multiplication of cell organelles during gamete formation. Similar kinds of results were also reported by Kumar and Palve (1995) in white jute and Sengupta *et al*., (2005), Kumar *et al*. (2018) in tossa jute.

4.2.2.3 Green bark thickness

It was observed that green bark thickness varied from 1.23 to 1.73 mm in parents and from 0.97 to 1.90 mm in hybrids (Table 4.13, Fig. 4.7). The cross combination $P_8 \times P_6$ produced the highest (1.90 mm) green bark thickness which was much higher than its both parents. On the other hand, the lowest mean (0.97 mm) was observed in $P_4 \times P_2$ that was less than it's both parents.

All of the parents exhibited significant GCA effect in which two parents had positive values (desirable effect) and the rest six had negative effects (Table 4.13). Parent P_8 gave the highest positive GCA effect (0.145) while parent P_7 showed the lowest negative GCA effect (-0.075). So, there parents considered as the best and the poorest general combiners, respectively. Parent P_1 showed positive and significant GCA effects and treated as good general combiner. Out of 28 crosses, two viz. $P_6 \times P_8$ (0.259) and $P_3 \times P_7$ (0.119) showed highly significant positive SCA values. Ten hybrids showed non-significant positive SCA effects and two showed significant but negative SCA effects (Table 4.14). So the best specific combiner for green bark thickness was $P_6 \times P_8$ and $P_3 \times P_7$.

The reciprocal effects ranged from -0.283 to 0.367 for green bark thickness. Four crosses showed highly significant and positive reciprocal effects and these cross combinations $P_4 \times P_2$, $P_5 \times P_1$, $P_5 \times P_2$ and $P_5 \times P_3$ were identified as good specific combiners for this trait.

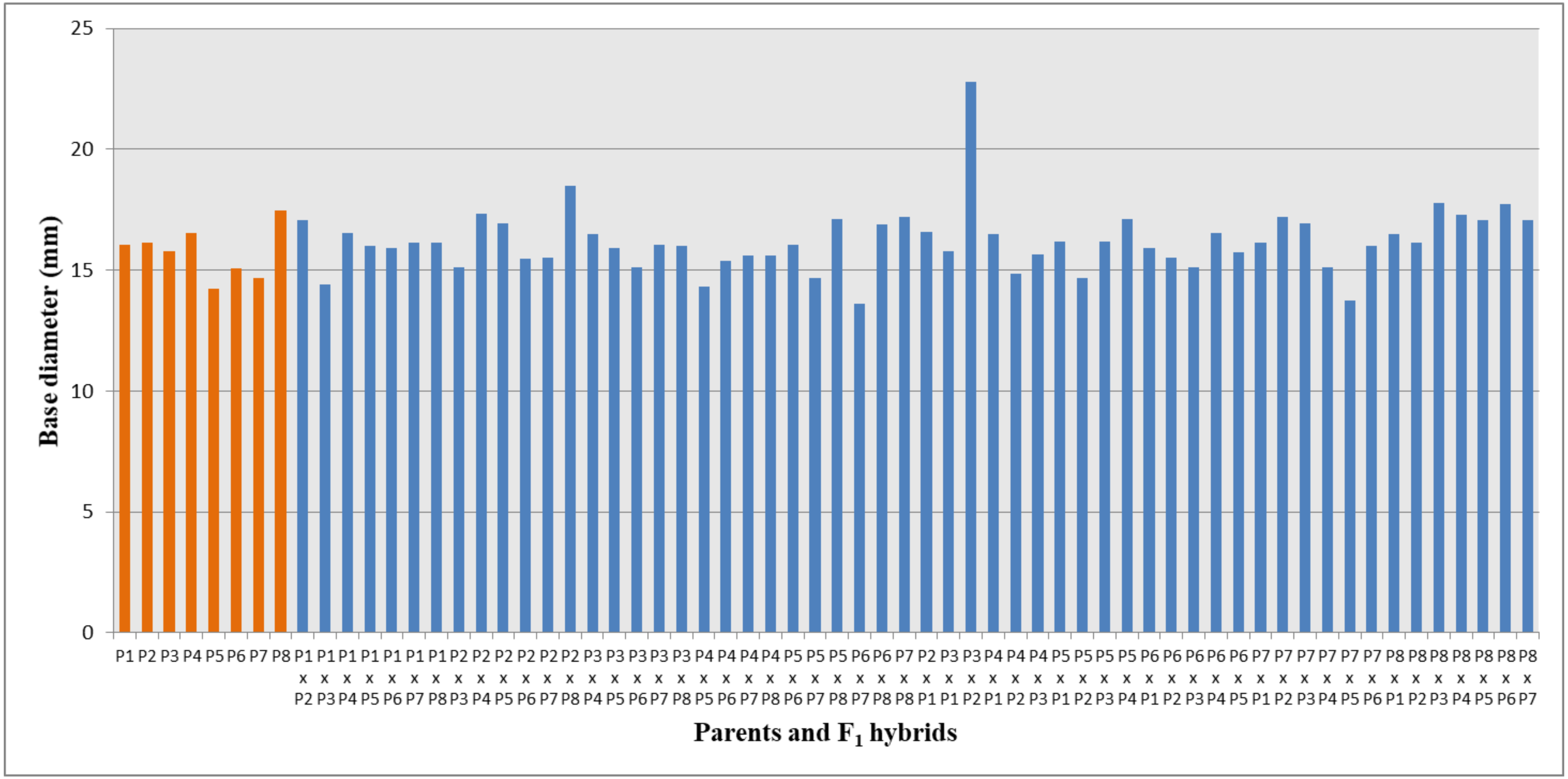

Fig. 4.6 Base diameter of parents and F_1 hybrids in Tossa jute

Another nine crosses showed positive but non-significant reciprocal effects, which could be treated as average combiners. Other crosses showed negative reciprocal effects and of them, eight ($P_3 \times P_2$), $P_4 \times P_1$, $P_6 \times P_1$, $P_6 \times P_3$, $P_6 \times P_4$, $P_7 \times P_6$, $P_8 \times P_3$ and $P_8 \times P_4$ showed significant reciprocal effects. These cross combinations, therefore, considered as the poor specific combiners (Table 4.15).

4.2.2.4 Leaf length

Leaf length varied from 14.84 to 15.33 cm in parents and 14.29 to 16.97 cm in hybrids (Table 4.13, Fig. 4.8). The cross combination $P_2 \times P_5$ produced the highest (16.97 cm) leaf length which was much higher than its both parents. On the other hand, the lowest mean (14.29 cm) was observed in $P_6 \times P_7$ that was less than both of its parents.

Among the parents four exhibited highly significant GCA effect with positive values (desirable effect) and the rest four had significant negative effects (Table 4.13). The positive and desired GCA effects were found in P_5 (0.292), P_7 (0.159), P_1 (104) and P_8 (0.093) which were considered as good general combiners for this traits. Another four parents were possessed negative and significant GCA effects and, therefore, they are considered as poor general combiners.

The SCA effects ranged from -0.541 to 0.521 for leaf length. Six crosses showed highly significant and one cross showed significant positive SCA effects and these seven cross combinations $P_2 \times P_5$, $P_1 \times P_7$, $P_1 \times P_8$, $P_2 \times P_8$, $P_3 \times P_5$, $P_4 \times P_7$, and $P_7 \times P_8$ were identified as good specific combiners for this trait. Another nine crosses showed positive but non-significant SCA values, which could be treated as average combiners. Other crosses showed negative SCA effects and of them, ($P_2 \times P_4$) showed highly significant negative SCA value (-0.361). This cross combination, therefore, considered as the poor specific combiner (Table 4.14).

The reciprocal effects ranged from -0.817 to 0.877 for leaf length. Four crosses showed highly significant and one cross showed significant positive reciprocal effects and these five cross combinations $P_5 \times P_2$, $P_6 \times P_5$, $P_7 \times P_1$, $P_7 \times P_5$, and $P_6 \times P_4$, were identified as good specific combiners for this trait. Another eight crosses showed positive but non-significant reciprocal effects, which could be considered as average combiners. Other crosses showed negative reciprocal effects and the crosses were $P_3 \times P_1$, $P_3 \times P_2$, $P_4 \times P_1$, $P_2 \times P_4$) $P_7 \times P_6$, $P_8 \times P_1$, $P_8 \times P_3$, $P_8 \times P_4$, $P_5 \times P_1$, $P_6 \times P_2$ and $P_8 \times P_5$ showed highly significant reciprocal effects.

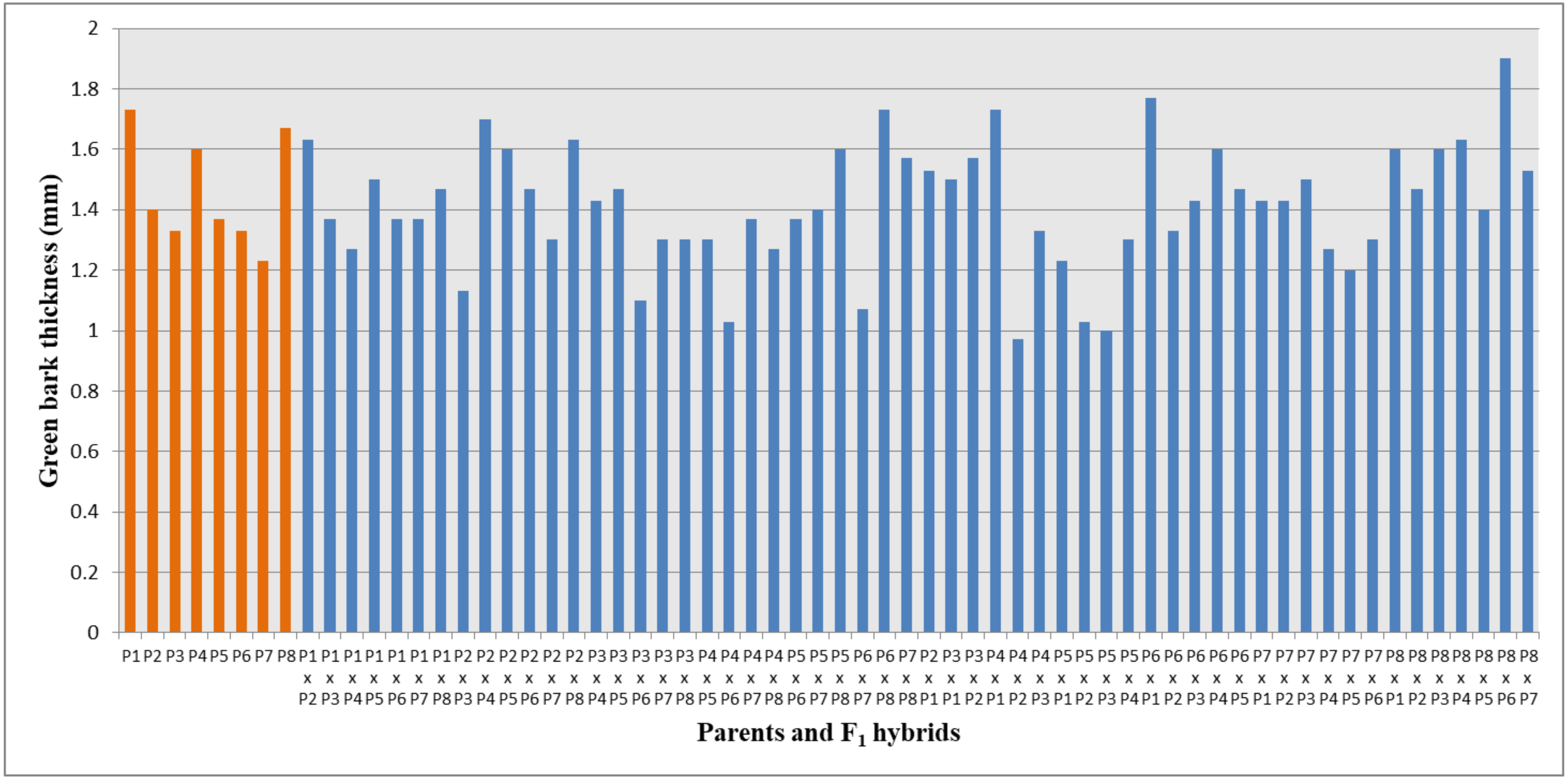

Fig. 4.7 Green bark thickness of parents and F_1 hybrids in Tossa jute

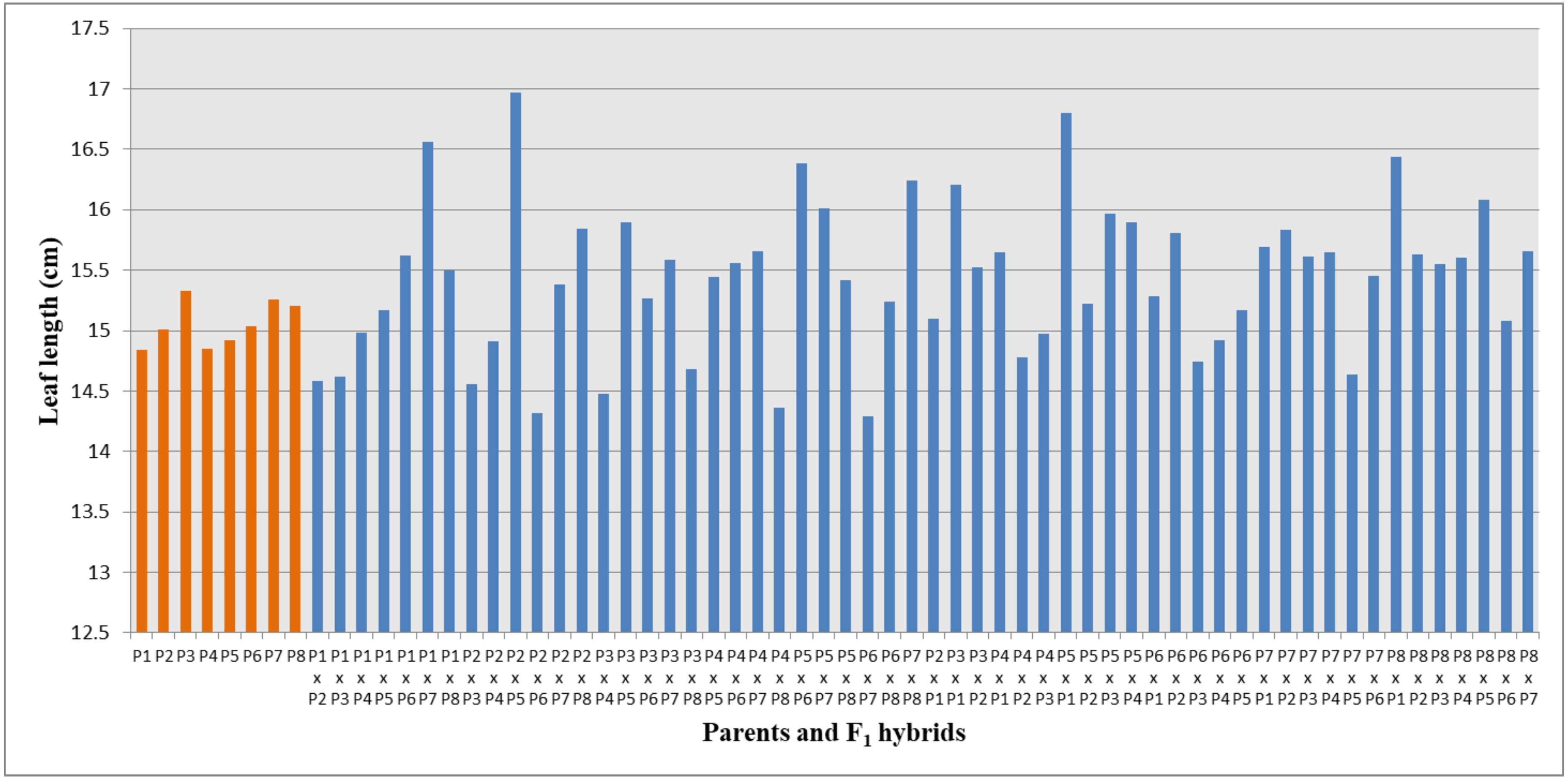

Fig. 4.8 Leaf length of parents and F_1 hybrids in Tossa jute

These cross combinations, therefore, considered as the poor specific combiner (Table 4.15)

4.2.2.5 Leaf width

It was found that the highest mean leaf width (6.32 cm) for parents was found in P_6 and the lowest (5.61 cm) was observed in P_5 (Table 4.13, Fig. 4.9). In case of hybrid, the highest mean leaf width (7.06 cm) was observed in cross combination $P_2 \times P_5$ which exceeded from it parental limits. Again the lowest mean leaf width (5.51 cm) was found in $P_4 \times P_2$, which was less than it's both parents (Table 12).

Among the parents two exhibited highly significant GCA effects with positive values (desirable effect), four had significant negative effects and the rest two had non-significant effect (Table 4.13). The positive and desired GCA effects were found in P_1 (0.106), and P_2 (0.096) which were considered as good general combiners for this trait. Another four parents possessed negative and significant GCA effects, and therefore, they are considered as poor general combiners. The parent P_5 showed positive but insignificant GCA effect and treated as average combiner.

The SCA effects ranged from -0.361 to 0.442 for leaf width. Seven crosses showed highly significant and one cross showed significant positive SCA effects and these eight cross combinations $P_2 \times P_5$, $P_1 \times P_2$, $P_2 \times P_3$, $P_2 \times P_7$, $P_3 \times P_4$, $P_4 \times P_5$, $P_4 \times P_8$ and $P_6 \times P_7$ were identified as good specific combiners for this trait. Another nine crosses showed positive but non-significant SCA effects, which could be considered as average combiners. Other crosses showed negative SCA effects and of them, these $P_2 \times P_4$, $P_1 \times P_4$, $P_2 \times P_6$, $P_5 \times P_6$ and $P_7 \times P_8$, showed highly significant SCA values. These cross combination, therefore, considered as the poor specific combiner (Table 4.14).

The reciprocal effects ranged from -0.310 to 0.467 for leaf width. Seven crosses showed highly significant and three crosses showed significant positive reciprocal effects and these ten cross combinations $P_4 \times P_2$, $P_5 \times P_2$, $P_5 \times P_4$, $P_6 \times P_3$, $P_6 \times P_4$, $P_7 \times P_1$, $P_7 \times P_3$, $P_8 \times P_2$, $P_8 \times P_7$ and $P_7 \times P_2$ were identified as good specific combiners for this trait. Another seven crosses showed positive but non-significant reciprocal values, which could be treated as average combiners. Other crosses showed negative reciprocal effects and the crosses were $P_3 \times P_1$, $P_5 \times P_1$, $P_6 \times P_1$ and $P_7 \times P_4$ showed highly significant reciprocal effects. These cross combinations, therefore, considered as the poorest specific combiners (Table 4.15).

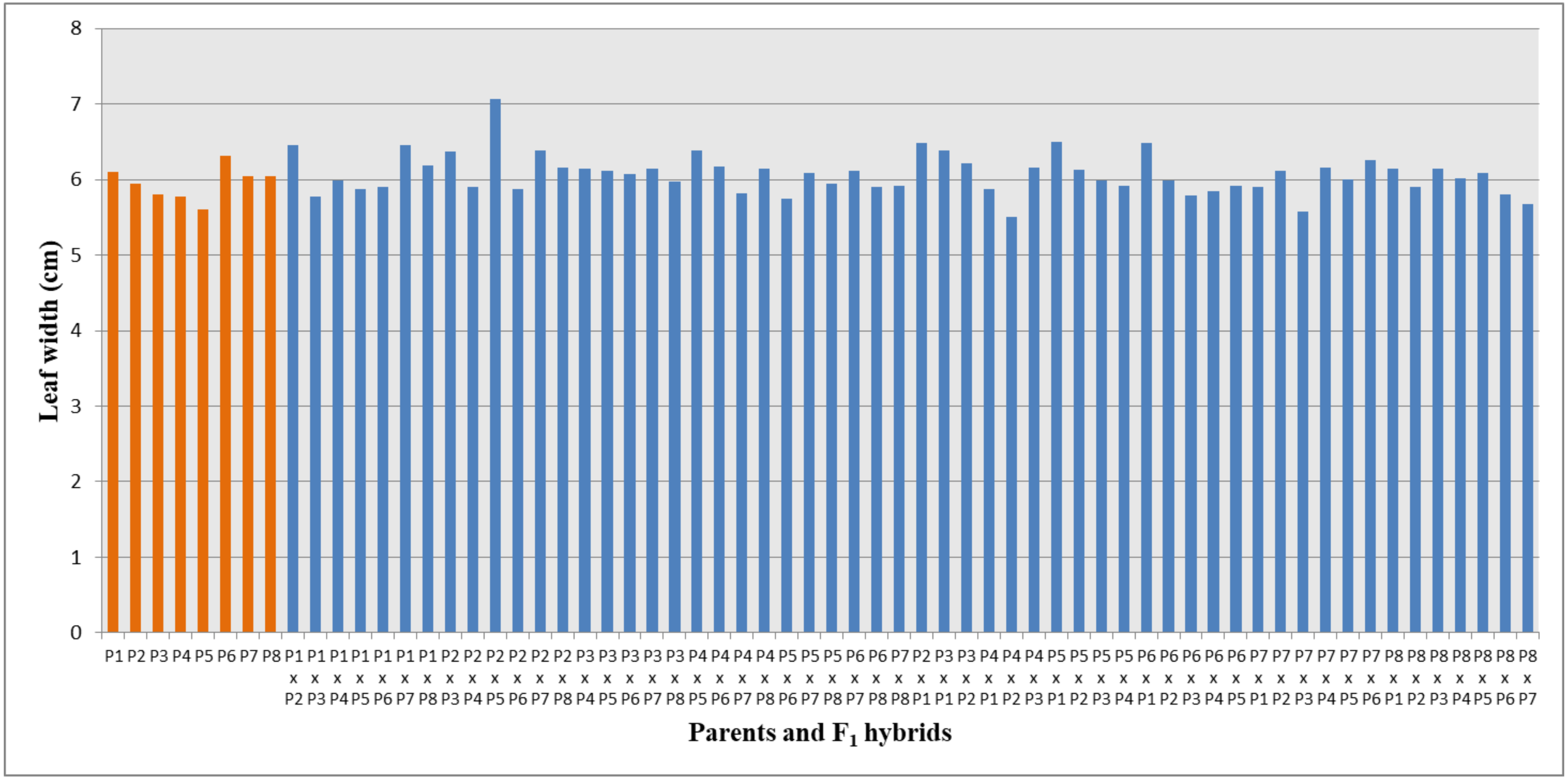

Fig. 4.9 Leaf width of parents and F_1 hybrids in Tossa jute

Table 4.14 Estimates of specific combining ability (SCA) effect for 11 agro-morphological characters of Tossa jute

Combinations	Plant height (m)		Base diameter (mm)		Green bark thickness (mm)		Leaf length (cm)		Leaf width (cm)		Leaf angle (dg)	
	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
$P_1 \times P_2$	3.46	0.003	17.07	0.229	1.63	0.075	14.58	-0.541**	6.45	0.205**	50.66	0.135
$P_1 \times P_3$	3.37	0.006	14.40	-1.196**	1.37	-0.018	14.62	0.040	5.78	-0.047	57.33	4.365**
$P_1 \times P_4$	3.46	-0.007	17.53	0.433*	1.75	0.005	14.98	0.043	5.98	-0.150**	54.66	2.281**
$P_1 \times P_5$	3.51	0.075	16.00	0.479*	1.50	-0.079	15.17	0.201	5.88	0.021	48.66	-1.823*
$P_1 \times P_6$	3.48	0.057	15.93	0.254	1.37	0.059	15.62	0.143	5.90	0.057	59.00	0.844
$P_1 \times P_7$	3.37	0.027	16.13	0.508*	1.37	-0.039	16.56	0.475**	6.46	0.030	53.33	1.073*
$P_1 \times P_8$	3.58	0.033	16.13	-0.671*	1.47	-0.126**	15.50	0.387**	6.18	0.050	48.33	-2.010**
$P_2 \times P_3$	3.47	0.060	15.13	2.166**	1.13	0.001	14.56	-0.121	6.37	0.167**	49.33	-0.469
$P_2 \times P_4$	3.38	-0.073	17.33	-0.471*	1.70	-0.060	14.91	-0.205	5.90	-0.362**	49.00	-0.219
$P_2 \times P_5$	3.58	0.001	16.93	-0.325	1.60	-0.027	16.97	0.521**	7.06	0.442**	54.00	2.677**
$P_2 \times P_6$	3.47	0.008	15.47	-0.684*	1.85	-0.006	14.32	-0.024	5.87	-0.196**	48.00	-1.156*
$P_2 \times P_7$	3.51	0.089	16.53	0.237	1.90	0.030	15.38	0.168	6.39	0.118*	42.00	-2.594**
$P_2 \times P_8$	3.79	0.077	18.47	-0.175	1.63	-0.008	15.84	0.360**	6.16	-0.070	49.66	-0.177
$P_3 \times P_4$	3.39	-0.036	19.47	-0.196	1.90	0.046	14.48	-0.314*	6.15	0.212**	46.33	-2.656**
$P_3 \times P_5$	3.43	0.157**	16.93	0.249	1.67	-0.054	15.90	0.373**	6.12	0.017	52.66	1.406*
$P_3 \times P_6$	3.48	0.062	15.13	-0.742*	1.10	-0.083	15.27	-0.077	6.07	-0.071	52.33	-0.760
$P_3 \times P_7$	3.33	0.009	16.07	0.679*	1.30	0.119**	15.59	0.171	6.14	-0.161*	48.66	0.635
$P_3 \times P_8$	3.33	-0.085	16.00	-0.267	1.30	-0.052	14.68	-0.250	5.97	0.085	48.33	0.552

*&** significant at 5% and 1%level, respectively

Table 4.14 Estimates of specific combining ability (SCA) effect for 11 agro-morphological characters of Tossa jute (Cont'd)

Combinations	Plant height (m)		Base diameter (mm)		Green bark thickness (mm)		Leaf length (cm)		Leaf width (cm)		Leaf angle (dg)	
	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
$P_4 \times P_5$	3.33	0.006	14.33	0.145	1.30	-0.031	15.44	0.217	6.38	0.175^{**}	45.66	-1.844^{*}
$P_4 \times P_6$	3.44	0.108^{*}	15.40	0.320	1.03	-0.077	15.56	0.269	6.17	0.060	49.00	0.990
$P_4 \times P_7$	3.39	-0.015	15.60	-0.225	1.37	-0.008	15.66	0.338^{**}	5.82	0.031	47.66	0.719
$P_4 \times P_8$	3.52	0.020	15.60	-0.505^{*}	1.27	-0.095	14.36	-0.270	6.14	0.153^{**}	45.66	-0.698
$P_5 \times P_6$	3.31	-0.059	20.07	0.699^{*}	1.95	0.073	16.38	0.281	5.74	-0.206^{**}	49.33	0.885
$P_5 \times P_7$	3.42	-0.049	14.67	-0.946^{*}	1.40	0.025	16.01	-0.517	6.08	-0.003	45.33	-0.219
$P_5 \times P_8$	3.36	-0.060	17.13	0.608^{*}	1.60	0.005	15.42	-0.025	5.94	0.006	46.33	0.031
$P_6 \times P_7$	3.19	-0.035	13.60	0.405	1.07	-0.154^{**}	14.29	-0.489^{*}	6.11	0.166^{**}	50.33	0.448
$P_6 \times P_8$	3.38	0.007	16.87	0.750^{*}	1.73	0.259^{**}	15.24	-0.137	5.90	-0.128^{*}	51.66	0.198
$P_7 \times P_8$	3.33	0.075	17.20	0.637^{*}	1.65	0.061	16.24	0.305^{*}	5.92	-0.194^{**}	51.66	1.927^{*}
SE (sij)	-	0.066	-	0.320	-	0.094	-	0.265	-	0.105	-	1.066
SE(sij- sik)	-	0.098	-	0.428	-	0.140	-	0.306	-	0.158	-	1.095
SE (sij-skl)	-	0.091	-	0.459	-	0.130	-	0.307	-	0.146	-	1.077

*&** significant at 5% and 1%level, respectively

Table 4.14 Estimates of specific combining ability (SCA) effect for 11 agro-morphological characters of Tossa jute (Cont'd)

Combinations	Petiole length (cm)		Green wt. with leaves (g)		Green wt. without leaves (g)		Fibre wt./plant (g)		Stick wt./plant (g)	
	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
$P_1 \times P_2$	5.12	-0.003	143.33	-12.719**	112.00	-9.708**	14.73	-1.212**	30.13	-3.271**
$P_1 \times P_3$	4.62	-0.146*	135.33	-4.156	106.33	-2.479	14.33	-0.249	28.86	-0.792
$P_1 \times P_4$	5.04	-0.029	225.00	13.490**	190.00	11.062**	20.93	1.586**	43.33	2.700**
$P_1 \times P_5$	4.47	0.145*	124.33	-2.906	97.33	-1.604	12.96	-0.181	26.86	-0.283
$P_1 \times P_6$	4.67	-0.150*	134.00	-0.427	104.66	-1.312	14.00	-0.112	28.26	-0.675
$P_1 \times P_7$	5.16	-0.016	153.00	0.781	120.00	-1.396	15.80	-0.268	32.93	-0.225
$P_1 \times P_8$	4.84	0.097	161.66	-0.969	126.66	-0.396	16.73	-0.210	34.80	0.021
$P_2 \times P_3$	5.34	0.173*	149.33	-2.948	117.00	-2.021	15.53	0.092	31.66	-1.254*
$P_2 \times P_4$	4.85	-0.173*	149.00	-7.802**	116.33	-5.646*	15.33	-1.039**	31.66	-1.829*
$P_2 \times P_5$	5.12	0.027	201.66	11.969**	157.66	9.521**	19.16	0.778	39.66	3.087**
$P_2 \times P_6$	5.52	-0.011	260.00	8.448**	225.00	5.312*	20.80	1.080**	43.00	0.996
$P_2 \times P_7$	5.17	0.033	250.00	26.823**	215.66	19.896**	20.46	3.007**	50.66	5.213**
$P_2 \times P_8$	5.30	0.020	233.33	6.240**	183.00	5.229*	16.06	0.898	42.53	1.592*
$P_3 \times P_4$	4.68	-0.122*	280.66	31.094**	240.33	24.750**	19.26	3.757**	50.33	7.950**
$P_3 \times P_5$	4.88	-0.039	250.00	15.031**	220.00	12.083**	19.46	1.690**	46.33	3.033**
$P_3 \times P_6$	5.21	-0.434**	215.00	10.510**	168.33	6.708*	17.00	0.759	36.66	2.275**
$P_3 \times P_7$	5.03	-0.066	161.33	-13.948**	126.33	-12.208**	15.80	-1.764**	35.00	-3.442**
$P_3 \times P_8$	5.50	0.320**	178.00	2.969	140.00	2.958	17.86	0.194	38.33	0.537

*&** significant at 5% and 1%level, respectively

Table 4.14 Estimates of specific combining ability (SCA) effect for 11 agro-morphological characters of Tossa jute (Cont'd)

Combinations	Petiole length (cm)		Green wt. with leaves (g)		Green wt. without leaves (g)		Fibre wt./plant (g)		Stick wt./plant (g)	
	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
$P_4 \times P_5$	5.62	0.242^{**}	161.33	5.844^{*}	125.33	4.792	15.33	0.742	35.00	0.958
$P_4 \times P_6$	5.63	0.053	205.00	3.156	160.00	1.083	19.93	-0.072	45.00	0.367
$P_4 \times P_7$	5.06	-0.019	160.33	-19.135^{**}	125.33	-15.500^{**}	15.66	-1.929^{**}	35.00	-4.317^{**}
$P_4 \times P_8$	5.15	-0.180^{*}	189.66	-5.052^{*}	148.00	-4.500	18.53	-0.570	41.00	-1.704^{*}
$P_5 \times P_6$	5.16	-0.293^{**}	280.00	8.427^{**}	250.00	5.750^{*}	21.40	1.078^{**}	54.66	1.117^{*}
$P_5 \times P_7$	5.02	-0.112^{*}	181.66	-2.365	142.00	-3.167	18.33	-0.145	38.66	-1.267^{*}
$P_5 \times P_8$	5.36	0.101^{*}	159.33	-18.615^{**}	125.66	-13.667^{**}	16.40	-1.454^{**}	34.53	-3.687^{**}
$P_6 \times P_7$	5.60	0.300^{**}	149.66	-4.719	117.33	6.792^{**}	14.66	0.907	32.66	1.975^{*}
$P_6 \times P_8$	5.86	-0.117^{*}	158.00	0.031	124.00	-1.208	15.93	0.032	34.66	-0.379
$P_7 \times P_8$	5.08	-0.127^{*}	230.00	15.240^{**}	19s0.66	10.542^{**}	20.93	1.509^{**}	43.66	2.571^{**}
SE (sij)	-	0.104	-	4.551	-	3.668	-	1.098	-	0.700
SE(sij- sik)	-	0.116	-	6.785	-	5.470	-	1.042	-	1.041
SE (sij-skl)	-	0.110	-	5.391	-	4.397	-	1.098	-	1.741

*&** significant at 5% and 1%level, respectively.

4.2.2.6 Leaf angle

It was found that the highest mean leaf angle (51.33°) for parents was found in P_2 and the lowest (46.33°) was observed in P_5 (Table 4.13, Fig. 4.10). In case of hybrid, the highest mean leaf angle (59.00°) was observed in cross combination $P_1 \times P_6$ which exceeded from it parental limits. Again the lowest mean leaf angle (42.00°) was found in $P_2 \times P_7$, which was less than it's both parents (Table 4.13).

All of the parents exhibited highly significant GCA effect in which four parents had positive values (desirable effect) and the rest four had negative effects (Table 4.13). Parent P_1 gave the highest positive GCA effect (1.344) while parent P_5 showed the lowest negative GCA effect (-1.198). So, they were considered as the best and the poorest general combiners, respectively. The parent P_3 showed positive and significant GCA effect and considered as good combiner.

The SCA effects ranged from -2.656 to 4.365 for leaf angle. Three crosses showed highly significant and three cross showed significant positive SCA effects and these six cross combinations $P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_5$, $P_1 \times P_7$, $P_3 \times P_5$, and $P_7 \times P_8$ were identified as good specific combiners for this trait. Another ten crosses showed positive but non-significant SCA values, which could be considered as average combiners. Other crosses showed negative SCA effects and of them, these $P_1 \times P_8$, $P_2 \times P_7$, and $P_3 \times P_4$, showed highly significant SCA values. These cross combinations, therefore, considered as the poorest specific combiners (Table 4.14).

The reciprocal effects ranged from -4.500 to 6.833 for leaf angle. Four crosses showed highly significant and three cross showed significant positive reciprocal effects and these seven cross combinations $P_4 \times P_1$, $P_5 \times P_2$, $P_6 \times P_1$, $P_6 \times P_3$, $P_8 \times P_6$, $P_7 \times P_1$ and $P_5 \times P_3$ were identified as good specific combiners for this trait. Another six crosses showed positive but non-significant reciprocal values, which could be considered as average combiners. Other crosses showed negative reciprocal effects and of them, these $P_7 \times P_2$, $P_7 \times P_3$, $P_8 \times P_3$, $P_8 \times P_4$, $P_8 \times P_5$ and $P_7 \times P_5$, showed highly significant reciprocal values. These cross combinations, therefore, considered as the poorest specific combiners (Table 4.15**).**

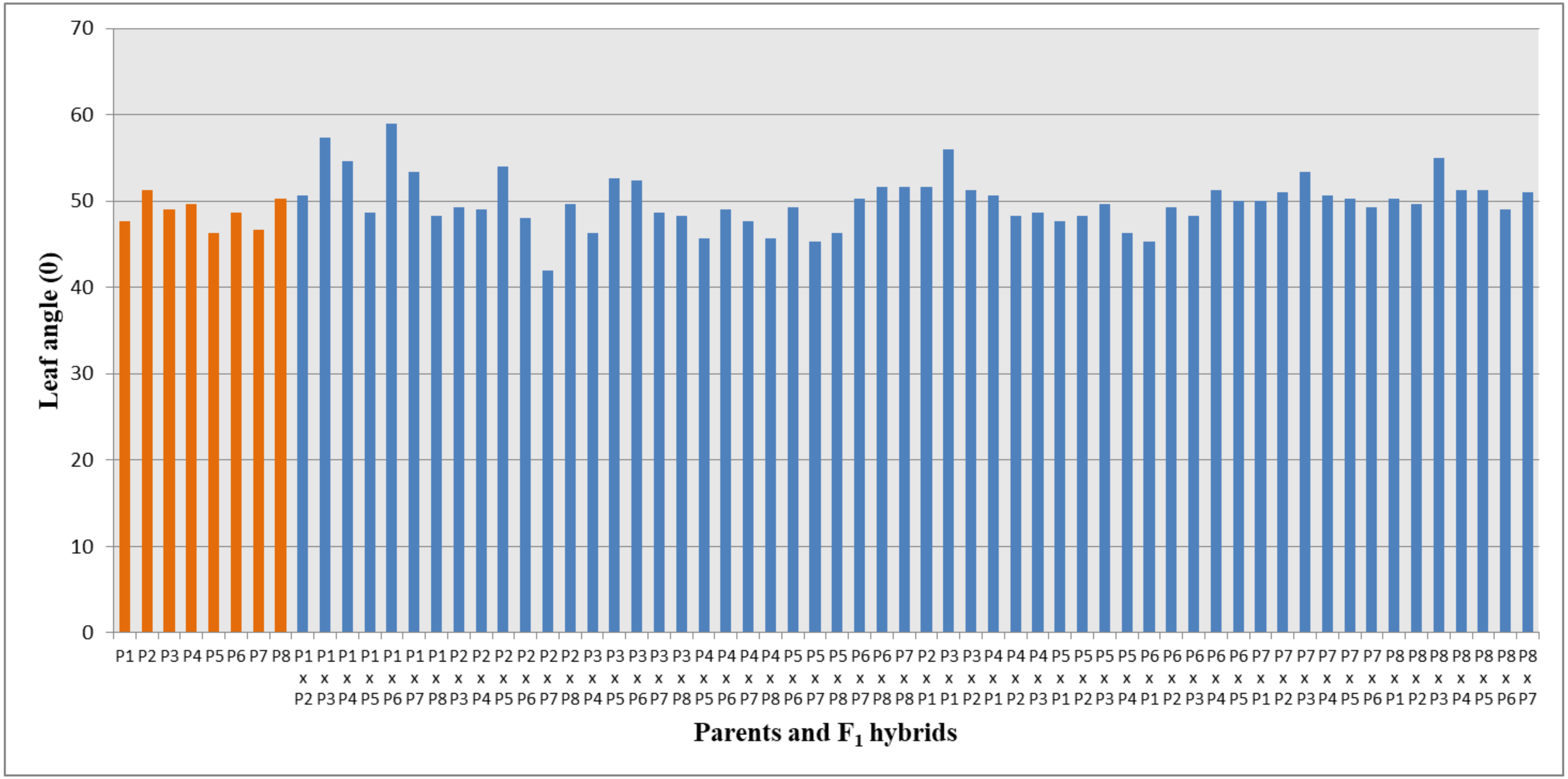

Fig. 4.10 Leaf angle of parents and F_1 hybrids in Tossa jute

4.2.2.7 Petiole length

It was observed that petiole length varied from 4.89 to 6.52 cm in parents and from 4.47 to 6.24 cm in hybrid (Table 4.13, Fig. 4.11). The cross combination $P_7 \times P_6$ produced highest (6.24 cm) petiole length which was much higher than its female parent and slightly lower than its pollen parent. On the other hand, the lowest mean (4.47 cm) was observed in $P_1 \times P_5$ that was less than both of its parents.

All of the parents exhibited significant GCA effect in which four parents had positive values (desirable effect) and the rest four had negative effects (Table 4.13). The parent P_6 gave the highest positive GCA effect (0.325) while parent P_1 showed the lowest negative GCA effect (-0.217). So, they were considered as the best and the poorest general combiners, respectively. The parent $P_{4,}$ P_7 and P_8 showed positive and significant GCA effect and considered as good combiners.

The SCA effects ranged from -0.434 to 0.320 for petiole length. Three crosses showed highly significant and three cross showed significant positive SCA effects and these six cross combinations $P_3 \times P_{8,}$ $P_6 \times P_{7,}$ $P_1 \times P_{5,}$ $P_4 \times P_{5,}$ $P_2 \times P_{3,}$ and $P_5 \times P_8$ were identified as good specific combiners for this trait. Another five crosses showed positive but non-significant SCA values, which could be considered as average combiners. Other crosses showed negative SCA effects and of them, these $P_3\times P_6$, and $P_5 \times P_6$, showed highly significant negative SCA values. These cross combinations, therefore, considered as the poorest specific combiners (Table 4.14).

The reciprocal effects ranged from -0.603 to 0.357 for petiole length. Three crosses showed highly significant and two crosses showed significant positive reciprocal effects and these five cross combinations $P_8 \times P_{6,}$ $P_5 \times P_{4,}$ $P_6 \times P_{3,}$ $P_1 \times P_5$ and $P_3 \times P_2$ were identified as good specific combiners for this trait. Another nine crosses showed positive but non-significant reciprocal values, which could be considered as average combiners. Other crosses showed negative reciprocal effects and of them, these $P_4 \times P_3$, $P_5 \times P_{1,}$ $P_6 \times P_{1,}$ $P_7 \times P_{4,}$ $P_7 \times P_6$ and $P_8 \times P_1$, showed highly significant reciprocal values. These cross combination, therefore, considered as the poorest specific combiners (Table 4.15).

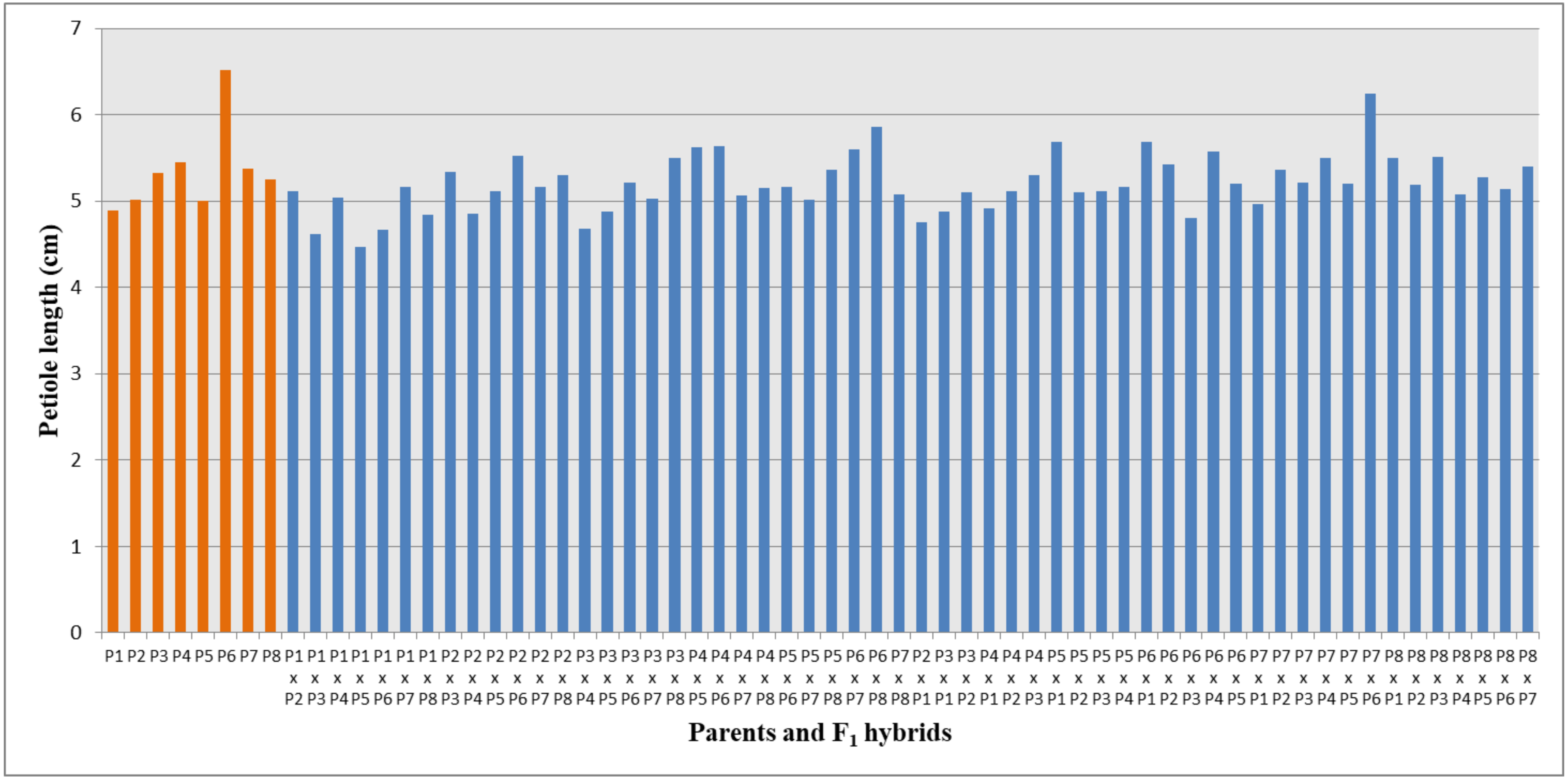

Fig. 4.11 Petiole length of parents and F_1 hybrids in Tossa jute

Table 4.15 Estimates of reciprocal effects for 11 agro-morphological characters of Tossa jute

Combinations	Plant height (m)		Base diameter (mm)		Green bark thickness (mm)		Leaf length (cm)		Leaf width (cm)		Leaf angle (dg)	
	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal
$P_2 \times P_1$	3.53	-0.033	16.60	0.233	1.53	0.050	15.10	-0.260	6.48	-0.013	51.66	-0.500
$P_3 \times P_1$	3.53	-0.075	15.80	-0.700*	1.50	-0.067	16.21	-0.797**	6.39	-0.303**	56.00	0.667
$P_3 x P_2$	3.69	-0.115**	22.80	-3.833**	1.57	-0.217**	15.52	-0.483**	6.21	0.080	51.33	-1.000*
$P_4 \times P_1$	3.38	0.038	16.47	0.033	1.73	-0.233**	15.65	-0.337*	5.88	0.048	50.66	2.000**
$P_4 \times P_2$	3.47	-0.045	14.87	1.233**	0.97	0.367**	14.78	0.063	5.51	0.197**	48.33	0.333
$P_4 \times P_3$	3.45	-0.027	15.67	0.400	1.33	0.050	14.97	-0.247	6.16	-0.008	48.66	-1.167*
$P_5 \times P_1$	3.31	0.103	16.20	-0.100	1.23	0.133**	16.80	-0.817**	6.50	-0.310**	47.66	0.500
$P_5 \times P_2$	3.30	0.165**	18.67	1.133**	1.83	0.283**	15.22	0.877**	6.13	0.467**	48.33	2.833**
$P_5 \times P_3$	3.62	-0.067	16.20	-0.133	1.00	0.233**	15.97	0.033	5.98	0.070	49.66	1.500*
$P_5 \times P_4$	3.38	-0.025	17.13	-1.400**	1.30	0.098	15.90	-0.227	5.92	0.233**	46.33	-0.333
$P_6 \times P_1$	3.29	0.098	15.93	0.035	1.77	-0.200**	15.28	0.170	6.48	-0.290**	45.33	6.833**
$P_6 \times P_2$	3.36	0.055	15.53	-0.033	1.33	0.067	15.81	-0.743**	5.99	-0.060	49.33	-0.667
$P_6 \times P_3$	3.37	0.055	16.13	0.398	1.75	-0.167**	14.74	0.267	5.79	0.140**	48.33	2.000**
$P_6 \times P_4$	3.45	0.076	19.53	-0.567*	1.95	-0.283**	14.92	0.323*	5.84	0.163**	51.33	-1.167*
$P_6 \times P_5$	3.08	0.117**	17.73	0.167	1.77	-0.050	15.17	0.603**	5.91	-0.083	50.00	-0.333
$P_7 \times P_1$	3.48	-0.053	16.13	0.400	1.43	-0.033	15.69	0.437**	5.90	0.277**	50.00	1.667*
$P_7 \times P_2$	3.61	-0.048	17.20	0.833*	1.43	-0.067	15.83	-0.223	6.12	0.133*	51.00	-4.500**
$P_7 \times P_3$	3.54	-0.103	16.93	-0.433*	1.50	-0.100	15.61	-0.010	5.57	0.283**	53.33	-2.333**
$P_7 \times P_4$	3.39	0.002	15.13	0.233	1.27	0.050	15.65	0.007	6.16	-0.173*	50.66	-1.500*
$P_7 \times P_5$	3.13	0.142**	16.73	0.467*	1.90	0.100	14.64	0.680**	6.00	0.040	50.33	-2.500**

*&** significant at 5% and 1%level, respectively.

Table 4.15 Estimates of reciprocal effects for 11 agro-morphological characters of Tossa jute (Cont'd)

Combinations	Plant height (m)		Base diameter (mm)		Green bark thickness (mm)		Leaf length (cm)		Leaf width (cm)		Leaf angle (dg)	
	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal
$P_7 \times P_6$	3.37	-0.088	16.00	-1.200**	1.30	-0.117**	15.45	-0.580**	6.26	-0.073	49.33	0.500
$P_8 \times P_1$	3.45	0.067	16.47	-0.166	1.60	-0.067	16.44	-0.470**	6.14	0.017	50.33	-1.000*
$P_8 \times P_2$	3.48	0.157**	16.13	1.167**	1.87	0.083	15.63	0.107	5.90	0.133*	49.66	0.643
$P_8 \times P_3$	3.52	-0.090	17.80	-0.900*	1.60	-0.150**	15.55	-0.437**	6.15	-0.090	55.00	-3.333**
$P_8 \times P_4$	3.51	0.005	17.27	-0.833*	1.63	-0.183**	15.60	-0.620**	6.01	0.063	51.33	-2.833**
$P_8 \times P_5$	3.33	0.015	17.07	0.033	1.40	0.100	16.08	-0.327*	6.08	-0.070	51.33	-2.500**
$P_8 \times P_6$	3.42	-0.022	17.73	-0.433*	1.90	-0.083	15.08	0.080	5.80	0.047	49.00	1.333*
$P_8 \times P_7$	3.75	-0.208**	17.07	0.067	1.53	0.017	15.66	0.290	5.68	0.120*	51.00	0.333
SE (Rij)	-	0.074	-	0.201	-	0.106	-	0.299	-	0.119	-	1.006
SE (Rij-Rkl)	-	0.105	-	0.392	-	0.110	-	0.424	-	0.129	-	1.005

*&** significant at 5% and 1%level, respectively.

Table 4.15 Estimates of reciprocal effects for 11 agro-morphological characters of Tossa jute (Cont'd)

Combinations	Petiole length (cm)		Green wt. with leaves (g)		Green wt. without leaves (g)		Fibre wt./plant (g)		Stick wt./plant (g)	
	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal
$P_2 \times P_1$	4.76	0.180*	152.66	-4.667	119.33	-3.667	15.40	-0.333	32.66	-1.267*
$P_3 \times P_1$	4.88	-0.133*	177.66	-21.167**	139.33	-16.500**	18.06	-1.867**	38.33	-4.733**
$P_3 x P_2$	5.10	0.117*	210.66	-30.667**	164.66	-23.833**	21.53	-3.000**	45.00	-6.667**
$P_4 \times P_1$	4.92	0.060	182.66	-13.833**	143.00	-11.000**	18.20	-1.067**	39.33	-3.000**
$P_4 \times P_2$	5.12	-0.133*	190.66	-20.833**	149.33	-16.500**	17.66	-1.167**	42.33	-5.333**
$P_4 \times P_3$	5.30	-0.307**	236.66	-28.000**	185.00	-21.833**	23.66	-2.200**	51.66	-5.167**
$P_5 \times P_1$	5.68	-0.603**	168.33	-22.000**	132.33	-17.500**	16.46	-1.750**	36.66	-4.900**
$P_5 \times P_2$	5.10	0.010	265.33	18.167**	219.33	14.167**	17.53	3.133**	47.66	2.667**
$P_5 \times P_3$	5.12	-0.120*	204.00	-17.500**	160.00	-14.000**	20.50	-1.750**	43.66	-3.667**
$P_5 \times P_4$	5.16	0.230**	182.66	-10.667**	143.33	-9.000**	18.46	-1.567**	39.33	-2.167**
$P_6 \times P_1$	5.69	-0.510**	169.00	-17.500**	133.33	-14.333**	17.00	-1.500**	36.66	-4.200**
$P_6 \times P_2$	5.42	0.053	181.33	1.333	142.33	0.833	15.60	0.483	39.00	0.333
$P_6 \times P_3$	4.80	0.207**	254.33	30.333**	225.66	23.833**	18.20	2.933**	44.00	6.333**
$P_6 \times P_4$	5.57	0.030	290.00	33.000**	254.00	25.500**	21.93	3.133**	50.33	7.333**
$P_6 \times P_5$	5.20	-0.020	264.33	36.833**	225.33	29.333**	19.40	4.100**	54.00	7.833**
$P_7 \times P_1$	4.97	0.093	164.66	-5.833*	126.33	-3.167	16.06	-0.133	35.00	-1.033
$P_7 \times P_2$	5.36	-0.093	215.33	-8.167**	168.33	-6.333**	13.66	-0.733	46.66	-2.067**
$P_7 \times P_3$	5.21	-0.090	171.33	-5.000	133.33	-3.500	13.20	-0.800	36.33	-0.667
$P_7 \times P_4$	5.50	-0.220**	151.33	4.500	119.00	3.167	15.40	0.133	33.06	0.967
$P_7 \times P_5$	5.20	-0.090	278.33	15.167**	236.00	12.000**	17.00	1.667*	49.33	3.167**

*&** significant at 5% and 1%level, respectively.

Table 4.15 Estimates of reciprocal effects for 11 agro-morphological characters of Tossa jute (Cont'd)

Combinations	Petiole length (cm)		Green wt. with leaves (g)		Green wt. without leaves (g)		Fibre wt./plant (g)		Stick wt./plant (g)	
	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal	Mean	Reciprocal
$P_7 \times P_6$	6.24	-0.317^{**}	184.00	-17.167^{**}	170.33	-26.500^{**}	22.20	-3.767^{**}	47.00	-7.167^{**}
$P_8 \times P_1$	5.50	-0.330^{**}	167.33	-2.833	130.66	-2.000	16.46	0.133	36.00	-0.600
$P_8 \times P_2$	5.19	0.057	254.66	39.333^{**}	220.66	31.167^{**}	20.46	4.233^{**}	43.66	8.500^{**}
$P_8 \times P_3$	5.51	0.057	203.33	-12.667^{**}	159.00	-9.500^{**}	16.46	-1.300^{*}	33.33	-2.500^{**}
$P_8 \times P_4$	5.08	0.037	295.00	12.333^{**}	255.33	10.333^{**}	20.53	1.033^{*}	50.66	3.167^{**}
$P_8 \times P_5$	5.28	0.040	156.00	1.667	122.33	1.667	15.53	0.433	34.00	0.267
$P_8 \times P_6$	5.14	0.357^{**}	200.00	-21.000^{**}	156.66	-16.333^{**}	20.40	-2.233^{**}	42.66	-4.000^{**}
$P_8 \times P_7$	5.40	-0.163^{*}	194.66	5.667^{*}	152.00	4.333	16.46	0.700	41.66	1.000
SE (Rij)	-	0.103	-	4.433	-	1.135	-	1.098	-	1.130
SE (Rij-Rkl)	-	0.130	-	5.411	-	4.747	-	1.119	-	1.426

*&** significant at 5% and 1%level, respectively.

4.2.2.8 Green weight with leaves

The heaviest 192.66 g and the lightest 140.00 g green weight with leaves were observed in parents P_8 and P_6 respectively. Similarly, in cross combination, $P_8 \times P_4$ possessed the highest green weight with leaves (295.00 g), which was markedly higher than both of its parents. On the other hand, the lowest green weight with leaves observed in $P_1 \times P_5$ (124.33 g) that was lower than its both parents (Table 4.13, Fig. 4.12).

Five parents were good general combiners, of them, P_8 was the best and showed highly significant positive GCA effect, and was followed by P_2, P_3, P_7 and P_4. Other three parents showed negative GCA effects and of them P_1 showed the highest significant value and was followed by P_5 and P_6 parents (Table 4.13).

Eleven crosses showed highly significant positive SCA effects, of which the best one was $P_3 \times P_4$ (31.094). This was followed by $P_2 \times P_7$ (26.823), $P_7 \times P_8$ (15.240), $P_3 \times P_5$ (15.031), $P_1 \times P_4$ (13.490), $P_2 \times P_5$ (11.969), $P_3 \times P_6$ (10.510), $P_2 \times P_6$ (8.448), $P_5 \times P_6$ (8.427), $P_2 \times P_8$ (6.240) and $P_4 \times P_5$ (5.844). Another four crosses showed positive but non-significant SCA effects and they could be treated as average specific combiners (Table 4.14).The rest crosses showed negative SCA effects and of them, six viz. $P_4 \times P_7$, $P_5 \times P_8$, $P_1 \times P_2$, $P_2 \times P_4$, $P_3 \times P_7$ and $P_4 \times P_8$ showed significant negative SCA values. So, they were considered as poor specific combiners for this trait.

Eight crosses showed highly significant positive reciprocal effects, of which the best one was $P_8 \times P_2$ (39.333). This was followed by $P_5 \times P_2$ (18.167), $P_6 \times P_3$ (30.333), $P_6 \times P_4$ (33.000), $P_6 \times P_5$ (36.833), $P_7 \times P_5$ (15.167), $P_8 \times P_4$ (12.333) and $P_8 \times P_7$ (5.667). Another three crosses showed positive but non-significant reciprocal effects and they could be treated as average specific combiners (Table 4.15).The rest crosses showed negative reciprocal effects and of them, fourteen crosses $P_3 \times P_1$, $P_3 \times P_2$, $P_4 \times P_1$, $P_4 \times P_2$, $P_4 \times P_3$, $P_5 \times P_1$, $P_5 \times P_3$, $P_5 \times P_4$, $P_6 \times P_1$, $P_7 \times P_1$, $P_7 \times P_2$, $P_7 \times P_6$, $P_8 \times P_3$ and $P_8 \times P_6$ showed significant negative reciprocal effects. So, these crosses were considered as poor specific combiners for this trait.

4.2.2.9 Green weight without leaves

The heaviest 151.33 g and the lightest 109.66 g green weight without leaves were observed in parent P_8 and P_6 respectively. Similarly in cross combination, the hybrid $P_8 \times P_4$ possessed the highest green weight without leaves (255.33 g), which was markedly higher than both of its parents. On the other hand, the lowest green weight without leaves observed in $P_1 \times P_5$ (97.33 g) that was lower than its both parents (Table 4.13, Fig. 4.13).

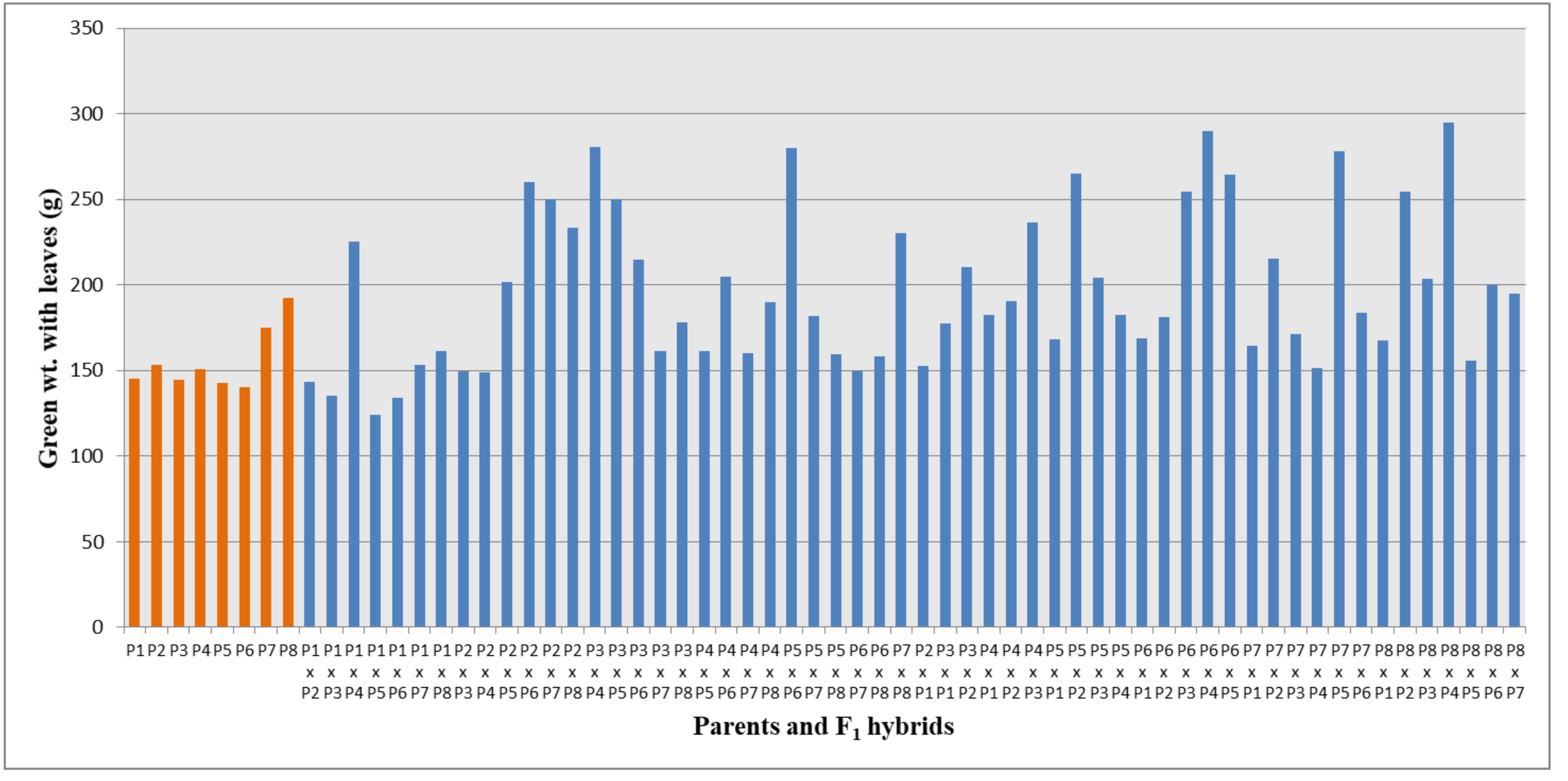

Fig. 4.12 Green wt. with leaves of parents and F_1 hybrids in Tossa jute

All of the parents exhibited highly significant GCA effects in which four parents had positive values (desirable effect) and the rest four had negative effects (Table 4.13). The parent P_8 gave the highest positive GCA effect (1.049), which was followed by P_2, P_3 and P_7. They were considered as the good general combiners. The parent P_1 showed the lowest negative GCA effect -13.396) which was considered as the poor general combiner.

Ten crosses showed significant positive SCA effects, of which the best one was $P_3 \times P_4$ (24.750). This was followed by $P_2 \times P_7$ (19.896), $P_3 \times P_5$ (12.083), $P_1 \times P_4$ (11.062), $P_7 \times P_8$ (10.542), $P_2 \times P_5$ (9.521), $P_6 \times P_7$ (6.792), $P_3 \times P_6$ (6.708) $P_5 \times P_6$ (5.750), and $P_2 \times P_8$ (5.229). Another three crosses showed positive but non-significant SCA effects and they could be treated as average specific combiners (Table 4.14). The rest crosses showed negative SCA effects and of them, six viz. $P_1 \times P_{2,}$ $P_3 \times P_{7,}$ $P_4 \times P_{7,}$ $P_5 \times P_{8,}$ and $P_2 \times P_4$ showed significant negative SCA values. So, they were considered as poor specific combiners for this trait.

Seven crosses showed significant positive reciprocal effects, of which the best one was $P_8 \times P_2$ (31.167). This was followed by $P_6 \times P_5$ (29.333), $P_6 \times P_4$ (25.500), $P_6 \times P_3$ (23.833), $P_5 \times P_2$ (14.167), $P_7 \times P_5$ (12.000), and $P_8 \times P_4$ (10.333). Another four crosses showed positive but non-significant reciprocal effects and they could be considered as average specific combiners (Table 4.15). The rest crosses showed negative reciprocal effects and of them, thirteen viz. $P_3 \times P_{1,}$ $P_3 \times P_{2,}$ $P_4 \times P_{1,}$ $P_4 \times P_{2,}$ $P_4 \times P_{3,}$ $P_5 \times P_{1,}$ $P_5 \times P_{3,}$ $P_5 \times P_{4,}$ $P_6 \times P_{1,}$ $P_7 \times P_{2,}$ $P_7 \times P_{6,}$ $P_8 \times P_{3,}$ and $P_8 \times P_6$ showed significant negative reciprocal effects. So, they were considered as poor specific combiners for this trait. Chavan and Nerkar (1994), suggested that at least one good general combiner is essential for getting a good hybrid combination.

4.2.2.10 Fibre weight per plant

Among the parental lines the highest mean fibre weight per plant (18.93 g) was produced by P_8 and the lowest by P_5 (13.00 g). Similarly in cross combination, $P_4 \times P_3$ possessed the highest fibre weight/plant (23.66 g), which was considerably higher than its both parents. Again the hybrid $P_1 \times P_5$ produced the lowest fibre weight/plant (12.96 g), which was almost same as its pollen parent (Table 4.13, Fig. 4.14).

All of the parents exhibited highly significant GCA effect in which four parents had positive values (desirable effect) and the rest four had negative effects (Table 4.13). The parent P_8 gave the highest positive GCA effect (1.050), which was followed by P_3, P_2 and P_7. They were considered as the good general combiners. The parent P_1 showed the lowest negative GCA effect (-1.473) which was considered as the poor general combiners.

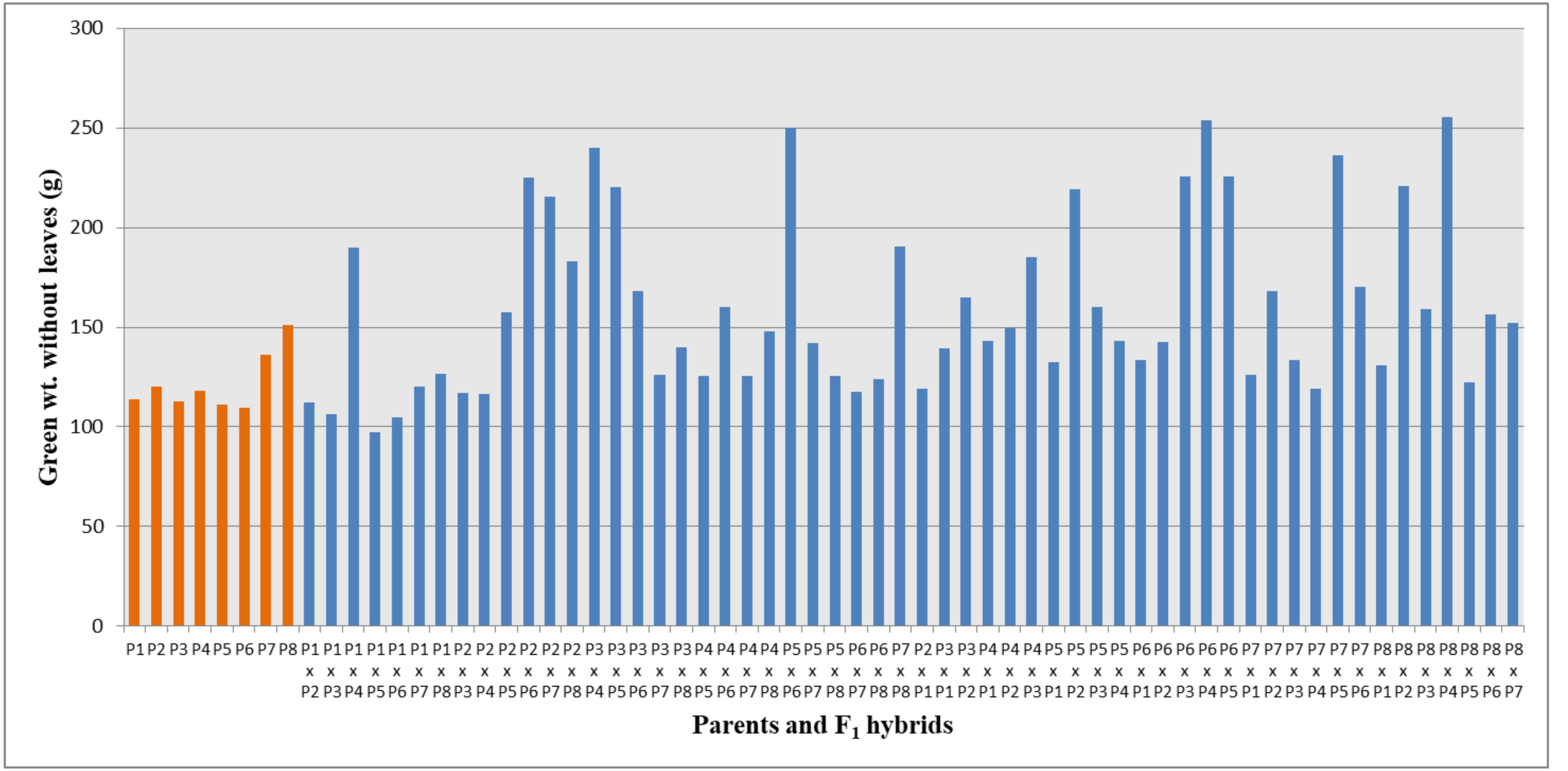

Fig. 4.13 Green wt. without leaves of parents and F_1 hybrids in Tossa jute

It is revealed that among twenty eight crosses, only seven showed significant positive SCA effects and eight showed positive but non-significant SCA effects for fibre weight per plant (Table 4.14). The highest significant positive SCA value produced by $P_3 \times P_4$ (3.757) followed by $P_2 \times P_7$ (3.007), $P_3 \times P_5$ (1.690), $P_1 \times P_4$ (1.586), $P_7 \times P_8$ (1.509) $P_2 \times P_6$ (1.080), and $P_5 \times P_6$ (1.078) indicating higher fibre yielding hybrids and considered as the best specific combiners for fibre weight per plant. On the other hand, thirteen hybrids showed negative SCA effects. Among them, five crosses viz $P_1 \times P_2$, $P_2 \times P_4$, $P_3 \times P_7$, $P_4 \times P_7$ and $P_5 \times P_8$ had significant negative values and considered as the poor specific combiners for the concerned trait. Other eight hybrids identified as poor combiners due to their negative SCA effects.

Seven crosses showed significant positive reciprocal effects, of which the best one was $P_8 \times P_2$ (4.233). This was followed by $P_6 \times P_5$ (4.100), $P_5 \times P_2$ (3.133), $P_6 \times P_4$ (3.133), $P_6 \times P_3$ (2.933), $P_7 \times P_5$ (1.667) and $P_8 \times P_4$ (1.033). Another five crosses showed positive but insignificant reciprocal effects and they could be considered as average specific combiners (Table 4.15). The rest crosses showed negative reciprocal effects and of them, twelve viz. $P_3 \times P_1$, $P_3 \times P_2$, $P_4 \times P_1$, $P_4 \times P_2$, $P_4 \times P_3$, $P_5 \times P_1$, $P_5 \times P_3$, $P_5 \times P_4$, $P_6 \times P_1$, $P_7 \times P_6$, $P_8 \times P_3$ and $P_8 \times P_6$ showed significant reciprocal effects. So, they were considered as poor specific combiners for this trait.

According to Sprague and Tatum (1942) the SCA is controlled by non-additive gene action and is an important criterion for the evaluation of hybrids. The SCA analysis revealed some useful cross combinations with significant positive SCA effects for fibre yield and its attributing traits.

4.2.2.11 Stick weight per plant

Stick weight per plant ranged from 31.00 to 42.33 g in parents and from 26.86 to 54.66 g in hybrids (Table 4.13, Fig. 4.15). The highest mean stick weight per plant was produced by $P_5 \times P_6$ (54.66 g), which was markedly greater than its both parents. Again the hybrid $P_1 \times P_5$ gave the lowest mean stick weight per plant (26.86 g), which was lower than both of its parents.

All of the parents exhibited significant GCA effect in which five parents had positive values (desirable effect) and the rest three had negative effects (Table 4.13). The parent P_8 gave the highest positive GCA effect (2.013), which was followed by P_2, P_3, P_7 and P_4. They were

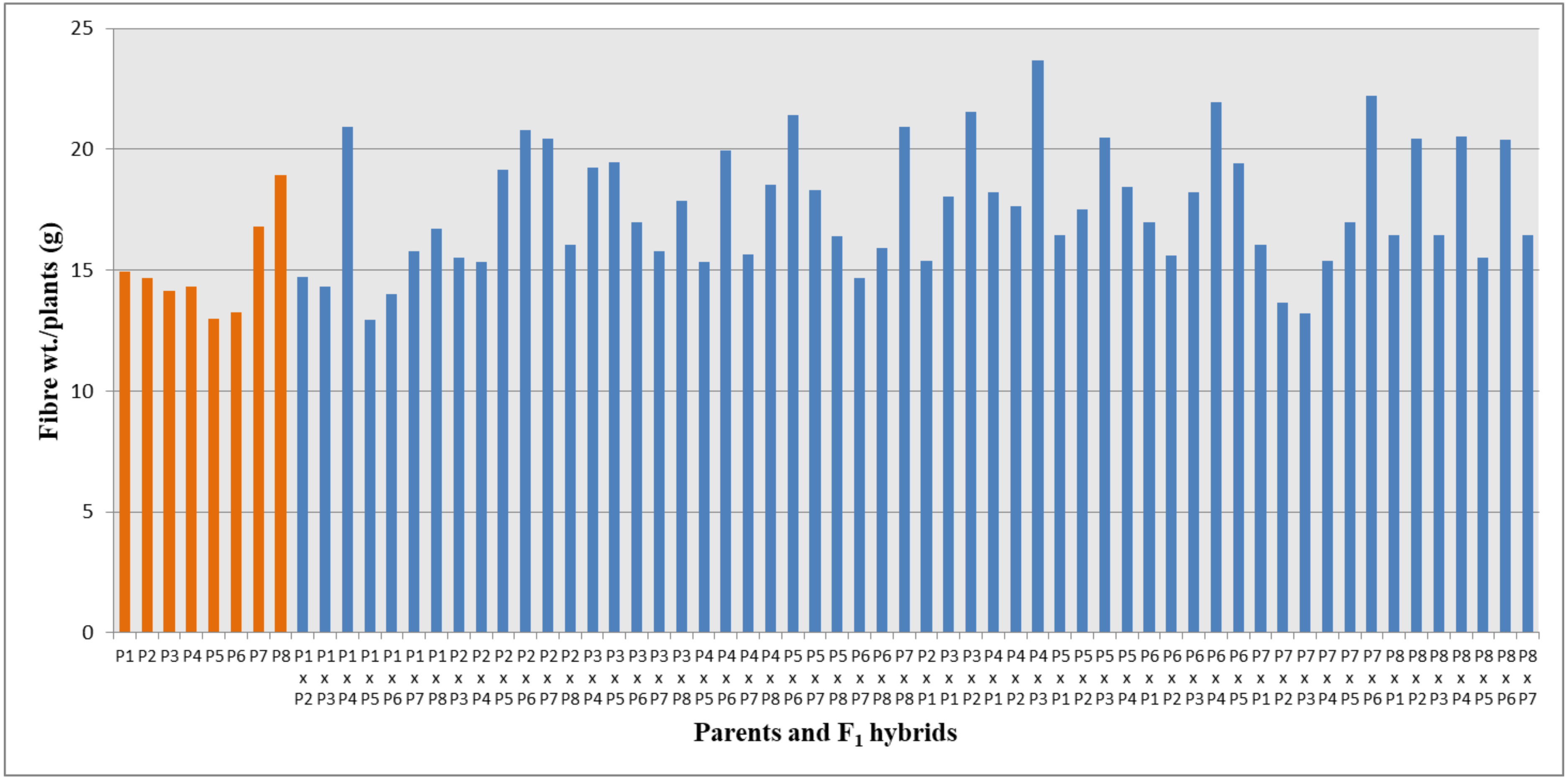

Fig. 4.14 Fibre weight/plant of parents and F_1 hybrids in Tossa jute

considered as the good general combiners. The parent P_1 showed the lowest negative GCA effect (-3.892) which was considered as the poor general combiners.

Out of twenty eight crosses, fifteen cross combination exhibited positive SCA effects, among them ten crosses showed significant positive SCA values for stick weight per plant indicating heterotic performance over the mean of their parents. On the other hand, thirteen hybrids showed negative SCA effects. Among them, eight crosses had significant negative value and treated as the poor specific combiners for the concerned trait. The cross $P_3 \times P_4$ (7.950) performed the highest significant positive SCA effect indicating best specific combiner for the trait. The highest significant negative SCA effect was obtained by $P_4 \times P_7$ (-4.317) and considered as the poor specific combiner (Table 4.14).

Seven crosses showed significant positive reciprocal effects, of which the best one was $P_8 \times P_2$ (8.500). This was followed by $P_6 \times P_5$ (7.833), $P_6 \times P_4$ (7.333), $P_6 \times P_3$ (6.333), $P_7 \times P_5$ (3.167), $P_8 \times P_4$ (3.167) and $P_5 \times P_2$ (2.667). Another four crosses showed positive but non-significant reciprocal effects and they could be treated as average specific combiners (Table 4.15). The rest crosses showed negative reciprocal effects and of them, fourteen crosses viz. $P_3 \times P_1$, $P_3 \times P_2$, $P_4 \times P_1$, $P_4 \times P_2$, $P_4 \times P_3$, $P_5 \times P_1$, $P_5 \times P_3$, $P_5 \times P_4$, $P_6 \times P_1$, $P_7 \times P_2$, $P_7 \times P_6$, $P_8 \times P_3$, $P_2 \times P_1$ and $P_8 \times P_6$ showed significant reciprocal effects. So, they were considered as poor specific combiners for this trait.

In this study, results showed that GCA effects of parents were not related to the SCA effects of their crosses which had highest significant positive magnitude. The high SCA effects of these crosses may be due to complementary type of gene effects. Moll and Stuber (1974) reported that any sort of combination among the parents might produce hybrid vigor over parents, which might be due to favorable dominant, over dominant or epistatic gene actions. It was already established that with significant GCA effects are considered to be good combiners and inclusion of such genotypes in breeding program can accelerate yield improvement process (Sengupta *et al*., 2005; Dar *et al*., 2016).

4.2.3 Estimates of cytoplasmic effect for 11 agro-morphological characters of Tossa jute

A total fifty six hybrids were produced in both direction crosses, therefore, twenty eight hybrids were the products of normal crosses and other 28 from reciprocal crosses. For nuclear contributions, male and female parents contribute same both in normal and reciprocal crosses but any deviation in the expression of a trait was due to cytoplasmic gene effects; apparently the mitochondria and chloroplast DNAs were the source of variation. However, the effects of cytoplasmic gene effects were assessed for 11 characters in Tossa jute. Most of the reciprocal crosses showed considerable cytoplasmic gene effects against 11 characters.

The character, green weight without leaves resulted in nineteen crosses significant and eighteen crosses in green weight with leaves showed significant effects in reciprocal as compared to corresponding normal crosses. The important characters like base diameter showed significant effects in twelve crosses ($P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_8$, $P_3 \times P_4$, $P_3 \times P_8$, $P_4 \times P_5$, $P_4 \times P_6$, $P_4 \times P_8$, $P_5 \times P_6$, $P_5 \times P_7$ and $P_6 \times P_7$). Green bark thickness showed significant effects in thirteen crosses ($P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_6$, $P_2 \times P_7$, $P_3 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$, $P_3 \times P_8$, $P_4 \times P_6$, $P_4 \times P_8$, and $P_5 \times P_7$). Green weight without leaves showed significant effects in nineteen crosses ($P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_2 \times P_7$, $P_2 \times P_8$, $P_3 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$, $P_4 \times P_6$, $P_4 \times P_8$, $P_5 \times P_7$, $P_6 \times P_7$, $P_6 \times P_8$ and $P_7 \times P_8$). Plant height showed significant effects in thirteen crosses ($P_1 \times P_3$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_5$, $P_2 \times P_8$, $P_3 \times P_5$, $P_3 \times P_7$, $P_3 \times P_8$, $P_5 \times P_6$, $P_5 \times P_7$, $P_6 \times P_7$ and $P_7 \times P_8$). Fibre weight showed significant effects in 10 crosses ($P_1 \times P_3$, $P_1 \times P_5$, $P_2 \times P_3$, $P_2 \times P_6$, $P_2 \times P_7$, $P_2 \times P_8$, $P_3 \times P_4$, $P_6 \times P_7$, $P_6 \times P_8$ and $P_7 \times P_8$). Therefore, results suggested that in Tossa jute not only nuclear genes but also the predominant cytoplasmic genes located in mitochondria and chloroplasts must be played vital role in obtaining desirables advanced lines after completion of the breeding approach suitable for both normal and reciprocal crosses derived hybrids.

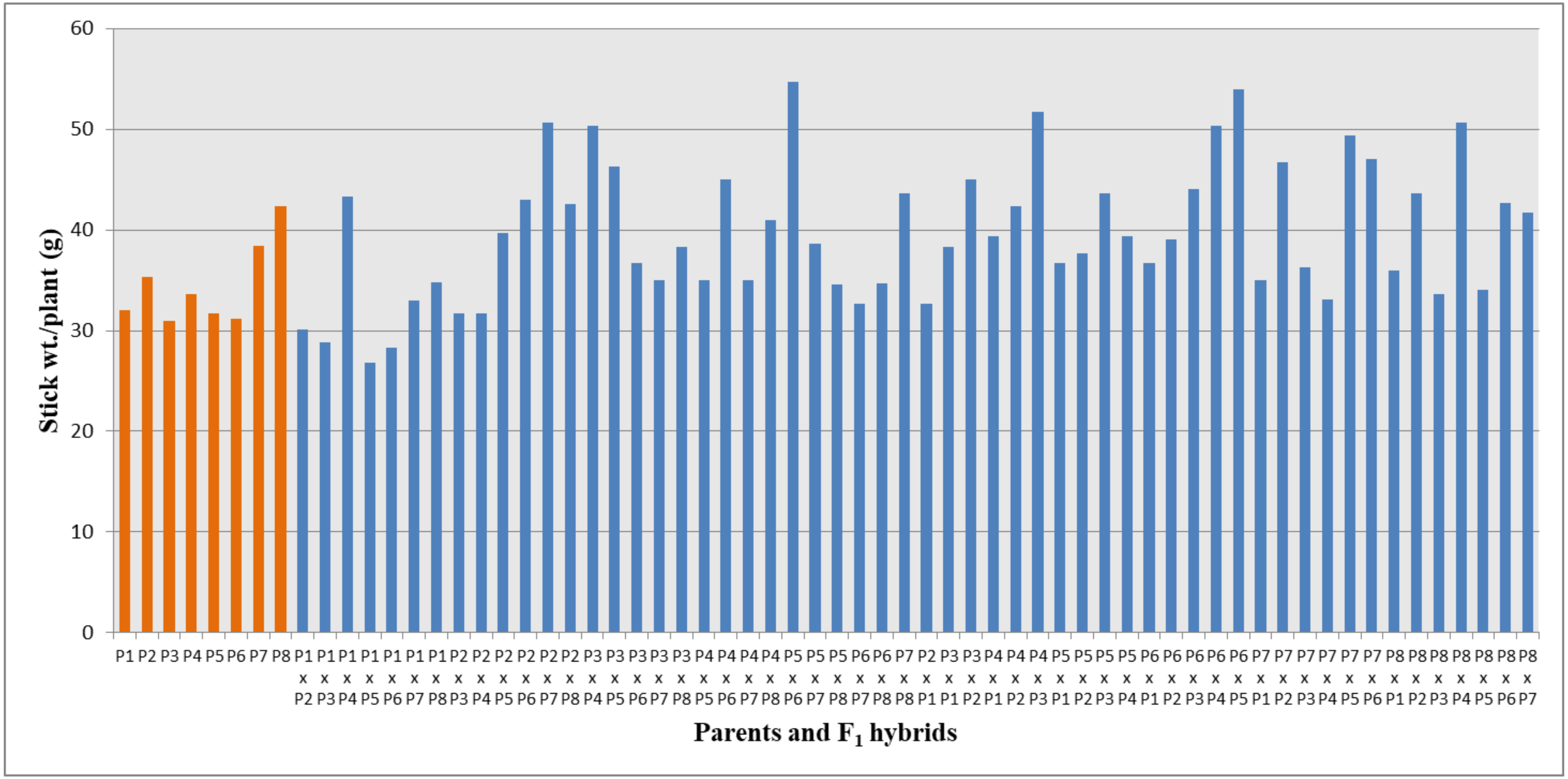

Fig. 4.15 Stick weight/plant of parents and F_1 hybrids in Tossa jute

Table 4.16 Estimates of cytoplasmic effects for eleven agro-morphological characters of Tossa jute

Combinations	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (g)	Green wt. without leaves (g)	Fibre wt./plant (g)	Stick wt./plant (g)
$P_1 \times P_2$	0.87	0.64	0.81	1.50	0.24	0.71	1.97	0.56	0.58	0.39	0.72
$P_1 \times P_3$	2.00*	1.73	1.04	4.59*	4.32*	0.95	1.42	2.58*	2.61*	2.20*	2.68*
$P_1 \times P_4$	1.00	1.31	0.16	1.93	0.70	2.87*	0.65	2.58*	3.72*	1.61	1.13
$P_1 \times P_5$	2.50*	0.24	2.17*	4.71*	4.39*	0.71	6.64*	2.68*	2.77*	2.06*	2.72*
$P_1 \times P_6$	2.28*	0.00	3.22*	0.98	4.11*	6.83*	5.50*	2.13*	2.26*	1.76	2.38*
$P_1 \times P_7$	1.32	0.00	0.48	2.51*	3.97*	2.39*	1.04	0.71	0.50	0.15	0.58
$P_1 \times P_8$	1.56	0.42	1.05	2.71*	0.28	1.43	3.62*	0.34	0.31	0.15	0.34
$P_2 \times P_3$	2.65*	6.49*	3.54*	2.77*	1.13	1.43	0.32	3.74*	3.77*	3.53*	3.78*
$P_2 \times P_4$	1.08	3.04*	5.88*	0.37	2.76*	0.48	1.48	2.54*	2.61*	1.37	3.02*
$P_2 \times P_5$	3.37*	2.15*	1.85	5.05*	6.59*	4.07*	0.10	3.88*	4.88*	0.96	2.26*
$P_2 \times P_6$	1.32	0.07	4.19*	4.30*	0.00	0.95	0.54	4.79*	6.54*	3.06*	1.13
$P_2 \times P_7$	1.20	0.82	3.79*	1.30	1.91	6.47*	1.04	2.11*	3.74*	4.01*	1.13
$P_2 \times P_8$	3.73*	2.89*	1.93	0.60	1.84	0.00	0.60	1.30	2.98*	2.59*	0.32
$P_3 \times P_4$	0.72	4.70*	4.59*	1.41	0.07	1.67	3.40*	2.68*	4.38*	2.59*	0.37
$P_3 \times P_5$	2.28*	0.90	5.40*	0.20	0.99	2.15*	1.31	2.80*	4.75*	0.61	0.75
$P_3 \times P_6$	1.32	1.23	5.24*	1.53	1.98*	2.87*	2.25*	2.39*	4.53*	0.70	2.08*
$P_3 \times P_7$	2.53*	1.06	1.61	0.05	4.04*	3.35*	0.98	0.61	0.55	1.53	0.37
$P_3 \times P_8$	2.28*	2.22*	2.41*	2.51*	1.29	4.79*	0.05	1.54	1.50	0.82	1.41
$P_4 \times P_5$	0.60	3.46*	0.00	1.32	3.26*	4.48*	2.52*	1.30	1.42	1.84	1.22
$P_4 \times P_6$	0.12	5.11*	7.41*	1.84	2.34*	1.67	2.36*	5.18*	7.44*	1.17	1.51
$P_4 \times P_7$	0.00	0.58	0.80	0.02	2.41*	2.15*	2.41*	0.54	0.50	0.15	0.55
$P_4 \times P_8$	0.12	2.06*	2.90*	3.58*	0.92	4.07*	0.38	6.42*	4.53*	1.17	2.73*

Table 4.16 Estimates of cytoplasmic effects for eleven agro-morphological characters of Tossa jute (Cont'd.)

Crosses	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Leaf length (cm)	Leaf width (cm)	Leaf angle (dg)	Petiole length (cm)	Green wt. with leaves (g)	Green wt. without leaves (g)	Fibre wt./plant (g)	Stick wt./plant (g)
$P_5 \times P_6$	2.77*	2.89*	1.45	3.49*	1.20	0.48	0.21	0.95	1.95	1.17	0.18
$P_5 \times P_7$	3.49*	2.54*	4.03*	3.95*	0.56	3.59*	0.98	5.89*	7.44*	0.78	3.02*
$P_5 \times P_8$	0.36	0.07	1.61	1.90	0.99	3.59*	0.43	0.20	0.26	0.51	0.15
$P_6 \times P_7$	2.16*	2.97*	1.85	3.35*	1.06	0.71	3.51*	2.09*	4.19*	4.44*	4.04*
$P_6 \times P_8$	0.48	1.06	1.37	0.46	0.70	1.91	3.95*	2.56*	2.58*	2.63*	2.26*
$P_7 \times P_8$	5.06*	0.16	0.96	1.67	1.74	0.47	1.75	2.15*	3.00*	2.63*	0.56
t = 1.98											

* Significant at 5% level

4.3 Experiment III. Selection in F_2 progenies to evolve desirable lines in advanced generation

4.3.1 Selection of superior cross combinations

Plant-breeding experiments concerning self-pollinated plants of Tossa jute have been traditionally performed with single crosses between two parents, followed by production of segregating population. This method generally results in a reasonable amount of genetic variability needed for selection and attainment of complete homozygosis. In self-pollinated crop like Tossa jute, superior parents with desirable combination sought to obtain the maximum expression of desirable agronomical traits. Selecting the best hybrid combinations is the initial breeding step which determines the degree of success achieved by the program because it is fundamental that genetic variability to be present in the initial population/progeny to obtain superior genotypes. Therefore, the selection of genotypes to serve as parents in crosses is the most important decision that a plant breeder has to face. Thus, each individual's high performance, wide adaptability, and yield potential have been the major features taken into account for choosing parental genotypes. Different statistical procedures such as, mean performances of the parental lines involved in both normal and reciprocal crosses, significant and positive GCAs of the parental lines along with SCAs for the specific crosses employed for selection of cross combinations from a swarm of 56 experimental hybrids that ultimately led to characterize on variability between and within the crosses, have become important auxiliary tools for the definition of the crosses. On the basis of above criteria ten crosses were selected to generate F_2 population. These crosses are $P_2 \times P_6$, $P_2 \times P_7$, $P_3 \times P_4$, $P_3 \times P_5$, $P_7 \times P_8$, $P_5 \times P_2$, $P_6 \times P_3$, $P_7 \times P_5$, $P_8 \times P_2$ and $P_8 \times P_4$.

Methods predicting the performance of cross combinations could be estimated on the basis of morphological (Cruz and Regazzi, 1997), molecular (Diniz Filho, 2000; Oliveira, 1998), or pedigree (Barbosa Neto *et al*., 1996; Cao *et al.*, 1997; Beuningen and Bush, 1997) evaluation. However, selecting parental lines based only on target traits is often insufficient to guarantee the presence of superior genotypes in the progeny because any genetic gain that occurs in progenies originating from the selected parents were due to their phenotypic attributes, and may be random and non-repeatable (Gandin, 1982). Thus, it is essential that the genotypes used in the crosses have a sufficient degree of combining ability to generate favorable recombinants at a high frequency. The best way to determine the combining ability of parents is the diallel analysis. This technique has its rationale based on the crossing of a pre-determined number of parents and the evaluation of the progenies in different degrees of relatedness, essential to the investigation of genetic properties of agronomically important traits. There are many methods for the evaluation of diallel crosses however; the most used is still Griffing's Method 1 (Lorencetti *et al*., 2005). This method enables one to estimate the general combining ability (GCA) and specific combining ability (SCA) which are related mainly to the additive gene effects and non-additive gene effects (dominance and epistasis), respectively. Despite its wide use, the diallel analysis (Javaid *et al*., 2001; Masood and Kronstad, 2000) has a disadvantage based on the fact that some hybrids may be difficult to obtain and the work load involved in the evaluations. However, current trends show a greater adoption of this technique by plant breeders (Balzarini *et al*., 2002) for predicting cross performance and choosing parental lines. In quantitative genetics statistical analyses have been used by numerous plant breeding programs (Balzarini *et al*., 2002; Flachenecker *et al.,* 2006; Lstiburek *et al.,* 2005; Milligan *et al.,* 2003; Perkins and Jinks, 1968; Piepho and Williams, 2006), to select parental combinations that would translate into major heterotic effects on their progenies, increasing the possibility of obtaining superior recombinants.

4.3.2 Pedigree records

The pedigree method was first described by H. H. Lowe in 1927. Pedigree: "A description of the ancestors of an individual and it generally goes back to some back to some distant ancestors in the past". Thus, a pedigree would describe the offspring's parents, grandparents, great grandparents and so on. The pedigree is helpful in finding out if two individuals are related by descent their ancestry, and therefore, are likely to have some genes in common.

In pedigree method, a detailed record of the relationships between the selected plants and their progenies are maintained. As a result, each progeny in every generation could be traced back to the F_2 plants from which it was originated such a record is known as pedigree-record.

The use of pedigree data as a criterion for studying relationship between genotypes is not new in plant breeding. Malecot's co-ancestry coefficient was the first measure used to evaluate relationship between genotypes (Malecot, 1949). This coefficient was defined as the probability that two given alleles would be identical by descent in a genotype product of a given cross. This method is described as an easy and affordable alternative to be used for the selection of parental genotypes and it has been largely employed in genetic distance estimates. The Malecot's co-ancestry coefficient has been reported in many studies: soybeans (Sneller, 1994), sunflower (Cheres and Knapp, 1998), sorghum (Ahnert, 1996), cotton (Van Esbroek *et* *al*. 1999), rye (Coarce *et al*., 1996), maize (Smith *et al*., 1990), and oats (Vieira *et al.*, 2005). In cereal, pedigree data are fairly abundant and favors co-ancestry coefficient estimates (Barbosa Neto *et al*., 1996; Bertan, 2005; Zeven and Schachl, 1989; Zeven and Hissink, 1976). Conversely, depending on the genotype pool, pedigree information is not publicly available and requires personal contact with breeders or germplasm curators. Therefore, pedigree records were maimtained for thirty visually selected plants against each of the selected ten crosses (Appendix II). However, the benefits from selection from 1st segregating generation (F_2) for important characters are briefly discussed below-

4.3.2.1 Plant height

The highest plant height was recorded from the cross, P_5 x P_2 (3.26 m), which was followed by the cross, P_3 x P_4 with 3.25 m. The range the character for the two crosses were 2.75-3.63 m and 2.22-3.60 m respectively (Table 4.17 and Fig. 4.16) When 30 plants were arbitrarily selected from 300 base plants, the plant height of the two crosses remarkably increased with 3.40 m and 3.34 m respectively (Table 4.18). The results suggest that desirable advanced line may be developed from the advanced progenies of the two crosses. Moreover, the variances of the two crosses slightly decreased in the selected populations, indicates rapid fixation of for the expression of the characters.

4.3.2.2 Base diameter

The physical strength of a jute plant is provided by the base diameter, it also indicates fiber and stick yields. The highest base diameters of original segregating populations and selected population are displayed in Table 4.17, Table 4.18 and Fig.4.17. The highest base diameter was derived from the cross, P_3 x P_4, followed by the cross, P_5 x P_2 both for base populations and selected populations. The range of the character in P_3 x P_4 was 13.80-23.40 mm and it was 11.60-23.40 mm in P_5 x P_2. Therefore, desirable advanced lines may derive at the end of continual selfing of the segregating plants. Moreover, from the Fig.4.17 it is apparent that mean values for the character was higher than the other values and individual mean values have showed a harmonial distribution in respect of tendency toward the grand mean.

4.3.2.3 Green bark thickness

Green bark thickness is an indicator of fibre yield in Tossa jute. The highest green bark thickness was recorded from the cross P_3 x P_4 with 1.78mm in the base population, whereas the character was the highest in cross P_6 x P_3 with 1.98 mm in the selected population. The changing of cross from base population to selected population suggests wide segregation in

Table 4.17 Mean, Variance and Range of based population (300 plants) for different characters in F_2 generation of Tossa jute

Combinations	Variability parameters	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Green wt. without leaves (g)	Fibre weight (g)	Stick weight (g)
$P_2 \times P_6$	Mean	2.89	14.98	1.82	222.00	17.00	40.95
	Variance	0.025	3.243	0.011	311.866	12.403	13.062
	Range	1.70 – 3.20	12.00 – 20.40	1.66 -2.10	192 - 252	11.00 -23.00	34.00 -47.00
$P_2 \times P_7$	Mean	2.99	15.95	1.86	209.86	17.00	49.98
	Variance	0.030	3.038	0.012	317.128	12.490	12.540
	Range	2.20 – 3.30	12.20 – 20.60	1.46 -1.99	160 -240	10.00 -24.00	44.00 – 56.00
$P_3 \times P_4$	Mean	3.25	18.92	1.87	235.96	18.60	49.46
	Variance	0.052	3.795	0.011	314.206	12.489	10.060
	Range	2.22 -3.60	13.80 -23.40	1.58 – 2.01	196 -266	11.60 -25.50	44.00 -55.90
$P_3 \times P_5$	Mean	2.98	16.32	1.58	214.00	17.80	43.40
	Variance	0.030	2.435	0.063	311.866	12.462	12.403
	Range	2.20 – 3.30	13.00 – 22.40	1.16 – 2.00	184 - 244	11.80 – 24.80	37.40 – 49.40
$P_7 \times P_8$	Mean	2.90	13.68	1.61	187.37	13.99	35.40
	Variance	0.021	2.308	0.047	392.622	12.496	12.446
	Range	2.65 – 3.20	11.00 – 17.20	1.26 – 1.96	155 - 220	8.00 – 22.00	29.40 – 42.40

Table 4.17 Mean, Variance and Range of based population (300 plants) for different characters in F_2 generation of Tossa jute (Cont'd)

Combinations	Variability parameters	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Green wt. without leaves (g)	Fibre weight (g)	Stick weight (g)
$P_5 \times P_2$	Mean	3.26	17.76	1.78	213.93	15.40	41.15
	Variance	0.041	5.463	0.021	317.079	12.504	13.223
	Range	2.75 – 3.65	11.60 – 23.40	1.54 – 2.02	165 - 244	9.20 – 23.40	34.00 – 48.00
$P_6 \times P_3$	Mean	3.04	16.06	1.74	221.94	15.40	45.39
	Variance	0.054	4.503	0.050	313.669	12.329	12.495
	Range	2.64 – 3.55	11.20 – 21.40	1.32 -2.12	192 - 252	9.40 -21.40	37.50 – 51.40
$P_7 \times P_5$	Mean	3.05	15.12	1.85	230.97	16.39	47.98
	Variance	0.059	7.288	0.011	311.383	12.404	12.532
	Range	2.27 – 3.55	10.20 -20.20	1.56 – 1.99	201 - 261	10.40 – 22.40	42.00 – 54.00
$P_8 \times P_2$	Mean	3.17	16.10	1.65	219.93	15.60	42.12
	Variance	0.034	4.423	0.059	317.212	12.489	15.316
	Range	2.70 – 3.55	12.20 – 21.60	1.25 – 2.05	170 - 250	9.40 – 22.40	30.80 – 50.00
$P_8 \times P_4$	Mean	2.74	14.15	1.60	250.04	20.39	47.98
	Variance	0.062	4.692	0.059	321.376	12.496	12.532
	Range	2.18 – 3.23	10.20 – 19.00	1.20 – 2.00	220 - 280	12.40 – 26.40	42.00 – 54.00

Table 4.18 Mean, Variance and Range of selected population (30 selected plants) for different characters in F_2 generation of Tossa jute

Combinations	Variability parameters	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Green wt. without leaves (g)	Fibre weight (g)	Stick weight (g)
$P_2 \times P_6$	Mean	2.97	16.03	1.86	232.26	19.46	43.23
	Variance	0.019	2.764	0.010	221.236	6.836	7.016
	Range	2.65 – 3.20	13.80 – 19.00	1.67 -2.00	199 - 252	14.70 -23.00	38.50 -47.00
$P_2 \times P_7$	Mean	3.07	17.47	1.92	225.37	20.56	53.20
	Variance	0.020	2.489	0.012	111.826	5.575	7.760
	Range	2.80 – 3.30	14.00 – 20.60	1.76 -1.99	200 -240	16.00 -24.00	44.90 – 56.00
$P_3 \times P_4$	Mean	3.34	20.16	1.93	246.70	21.34	51.91
	Variance	0.041	3.711	0.011	208.424	7.356	6.099
	Range	2.75 -3.60	15.00 -23.40	1.78 – 2.01	218 -266	16.80 -25.50	48.20 -55.90
$P_3 \times P_5$	Mean	3.12	17.94	1.90	226.40	20.63	46.04
	Variance	0.023	2.198	0.024	148.593	5.843	6.050
	Range	2.80 – 3.30	15.00 – 22.40	1.18 – 2.00	205 - 243	16.90 – 23.80	42.50 – 49.40
$P_7 \times P_8$	Mean	2.98	15.44	1.75	203.17	16.58	37.80
	Variance	0.029	1.626	0.038	156.351	5.200	5.726
	Range	2.70 – 3.20	12.40 – 17.20	1.26 – 1.96	178 - 219	13.20 – 22.00	31.80 – 41.40

Table 4.18 Mean, Variance and Range of selected population (30 selected plants) for different characters in F_2 generation of Tossa jute (Cont'd)

Combinations	Variability parameters	Plant height (m)	Base diameter (mm)	Green bark thickness (mm)	Green wt. without leaves (g)	Fibre weight (g)	Stick weight (g)
$P_5 \times P_2$	Mean	3.40	19.32	1.90	228.53	18.73	44.46
	Variance	0.021	6.782	0.010	153.292	6.140	5.425
	Range	3.15 – 3.65	14.80 – 23.40	1.54 – 2.02	205 - 244	14.50 – 23.40	40.10 – 47.60
$P_6 \times P_3$	Mean	3.27	18.38	1.98	235.20	18.11	48.39
	Variance	0.049	3.494	0.011	163.131	5.862	6.810
	Range	2.70 – 3.55	14.80 – 21.40	1.75 -2.12	212 - 252	14.40 -21.30	44.40 – 51.40
$P_7 \times P_5$	Mean	3.30	18.20	1.91	244.10	19.44	51.35
	Variance	0.029	2.241	0.011	172.024	7.038	7.107
	Range	3.00 – 3.55	15.40 -20.20	1.78 – 1.99	221 - 260	15.40 – 22.40	47.00 – 54.00
$P_8 \times P_2$	Mean	3.34	18.24	1.89	235.83	18.69	46.07
	Variance	0.026	5.452	0.012	171.178	6.884	7.475
	Range	2.90 – 3.55	14.00 – 21.60	1.60– 2.05	211 - 250	14.40 – 21.80	40.00 – 50.00
$P_8 \times P_4$	Mean	3.09	17.14	1.86	262.87	23.53	51.83
	Variance	0.016	2.089	0.012	237.085	8.488	9.221
	Range	2.74 – 3.23	14.00 – 19.00	1.55 – 2.00	229 - 279	17.70 – 26.40	42.30 – 54.00

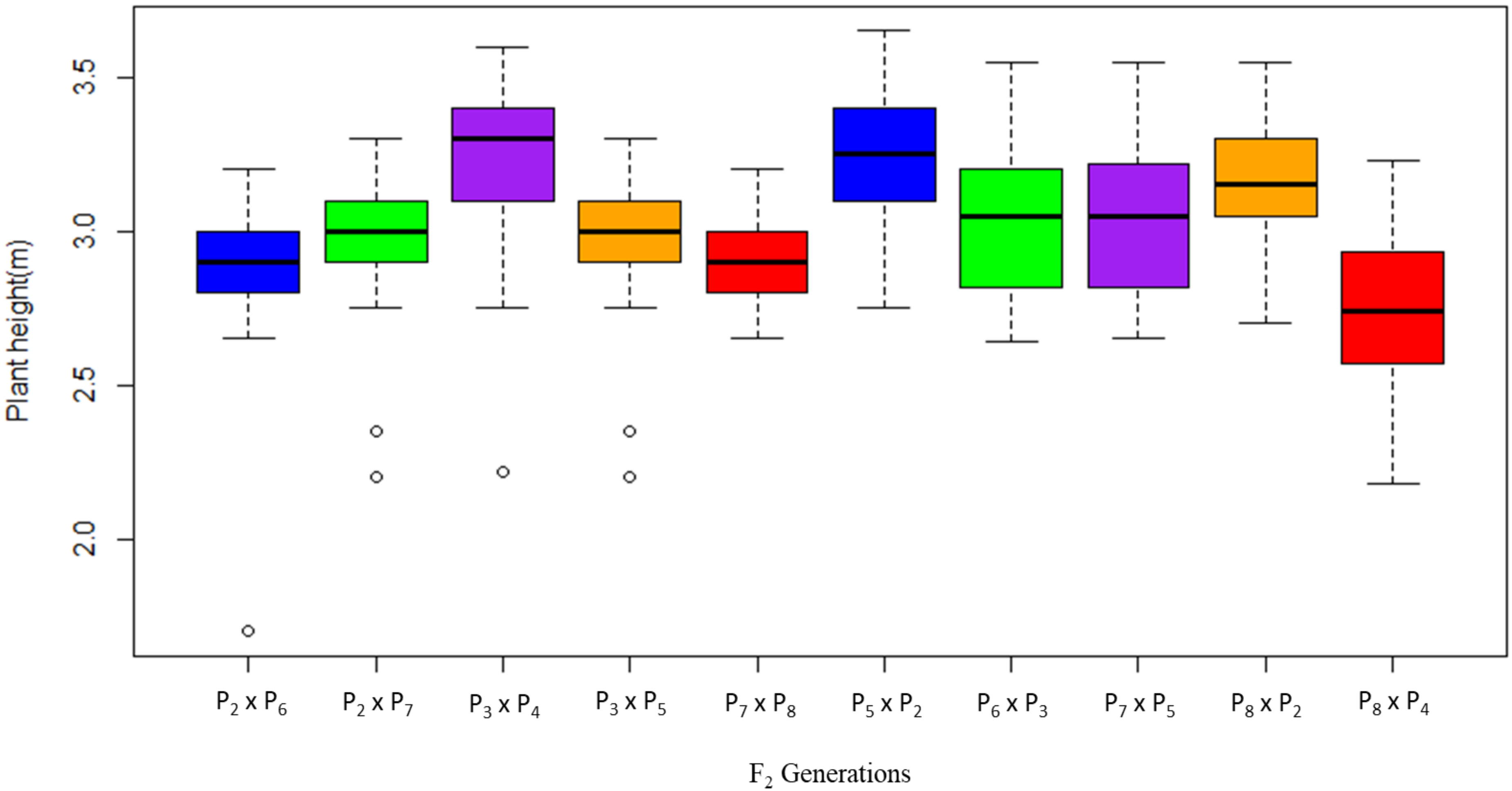

Fig. 4.16 Box plot showing Plant height of F_2 generations in Tossa jute (Based populations)

F_2 generation under each of the cross derivatives. From the Fig. 4.18 it is revealed that individual means of the selected plants were evenly distributed toward the grand mean for the character. Therefore, outstanding advanced lines may be derived if the lines advance in further breeding exercise. In our country new jute fiber retting method includes green bark, is an important character to the farmers to attain higher fiber yield after complete processing.

4.3.2.4 Green wt. without leaves

Green wt. without leaves is directly related to fiber and stick yields in Tossa jute. After harvesting of jute plants, leaves rapidly dropped off from the plants and it is better before setting the plants for retting. However, the highest green wt. without leaves was recorded 250.04 in the base population against the cross P_8 x P_4 and the character also the highest in the same cross with 262.87 in the selected population. The results suggest that the contributing alleles for the characters have shown gradual fixation, hence the character may be genetically homozygous at the end of segregation. The second ranked potential of the character was also recorded from the cross, P_3 x P_4 both in base population and selected populations with the values of 235.96 and 246.70g respectively. Besides, the ranges for the character were very close in each cross both in base and selected populations, also an indication of rapid fixation heterozygous alleles responsible for the expression of the character.

4.3.2.5 Fiber weight

The most important character, fiber weight was greatly varied in the segregating base and selected populations. The fiber weight was the maximum in the progenies of the cross, P_8 x P_4 (20.39g) for the base population, also it was the highest for the same cross with 23.53g in selected population. The magnitude of variance reduced from 12.496 to 5.200 when selectin was operated in base population to derive selected population. The results suggest rapid progressing of homozygous loci which might continue in next generations, eventually evolves pure lines. The Fig. 4.20 showed distributions of individual means in respect of grand mean, it is obviously noted that the selected plant under P_8 x P_4 cross proclaimed superior segregants as compared to others. It is also interestingly observed that distributions of individual plants under selection displayed harmonial patterns for each of the cross derivatives. For potential interest, another progenies produced from the cross P_3 x P_4 may also consider to identify supereon advanced lines as the means, range and the variances were acceptable both in base and selected populations

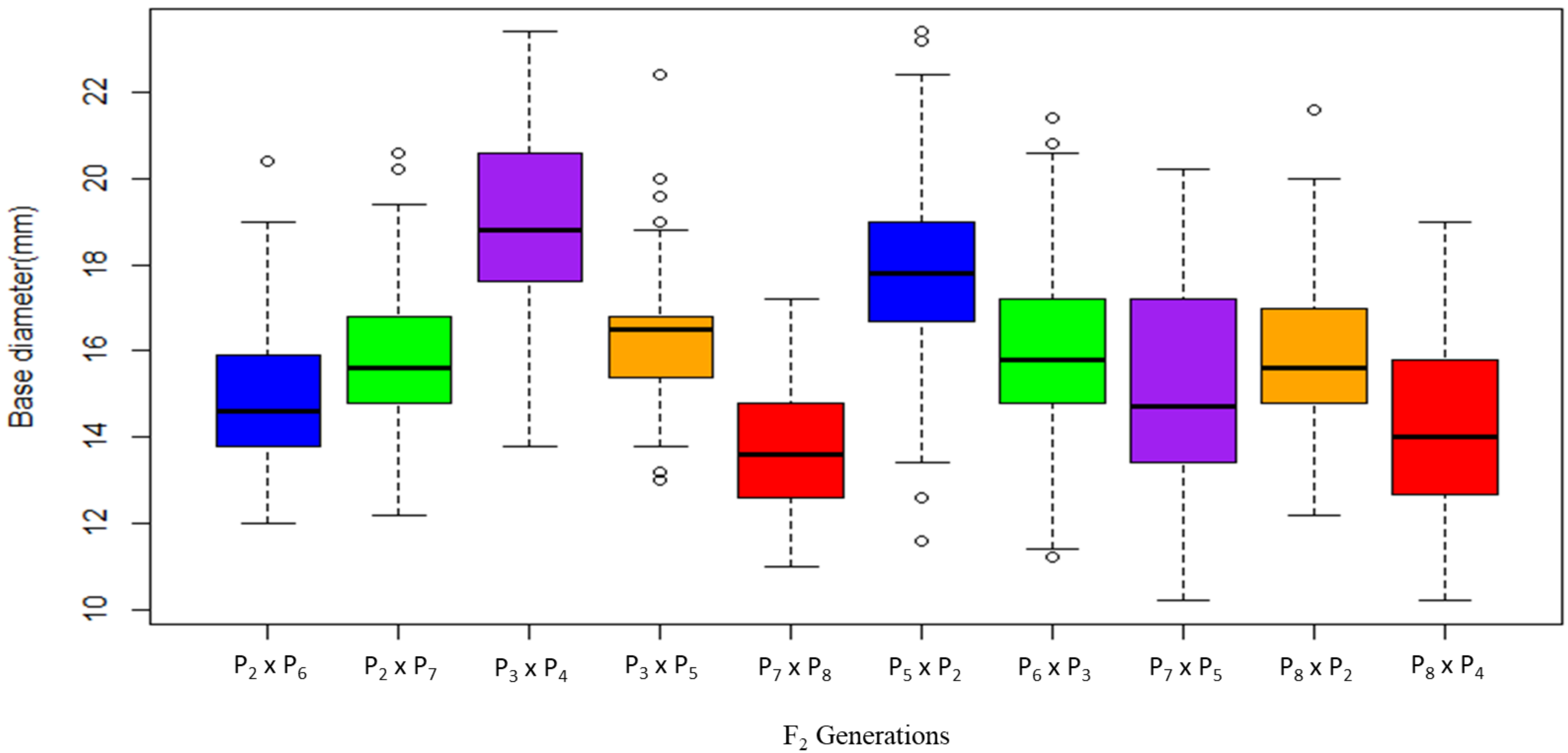

Fig. 4.17 Box plot showing Base diameter of F_2 generations in Tossa jute (Based populations)

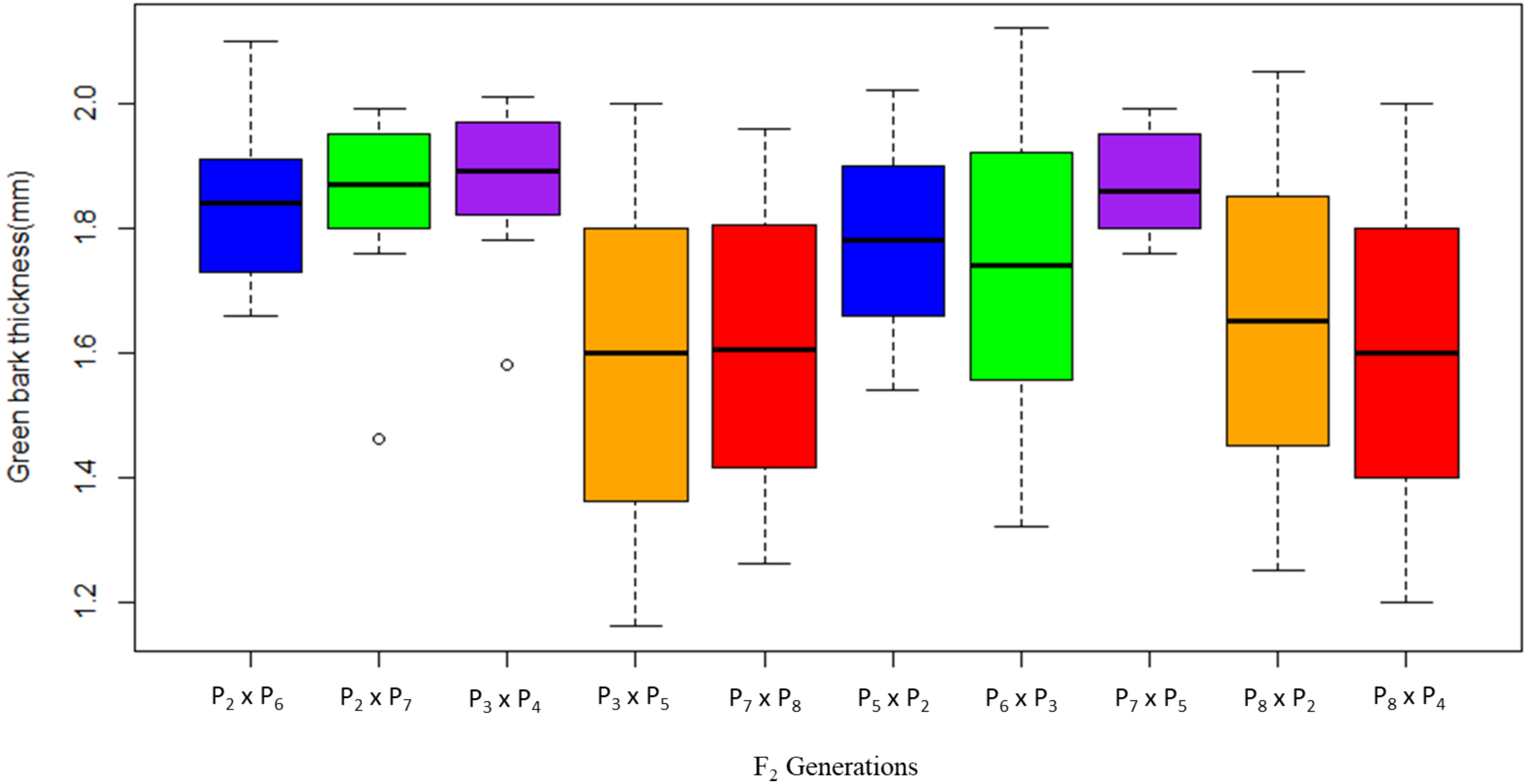

Fig. 4.18 Box plot showing Green bark thickness of F_2 generations in Tossa jute (Based populations)

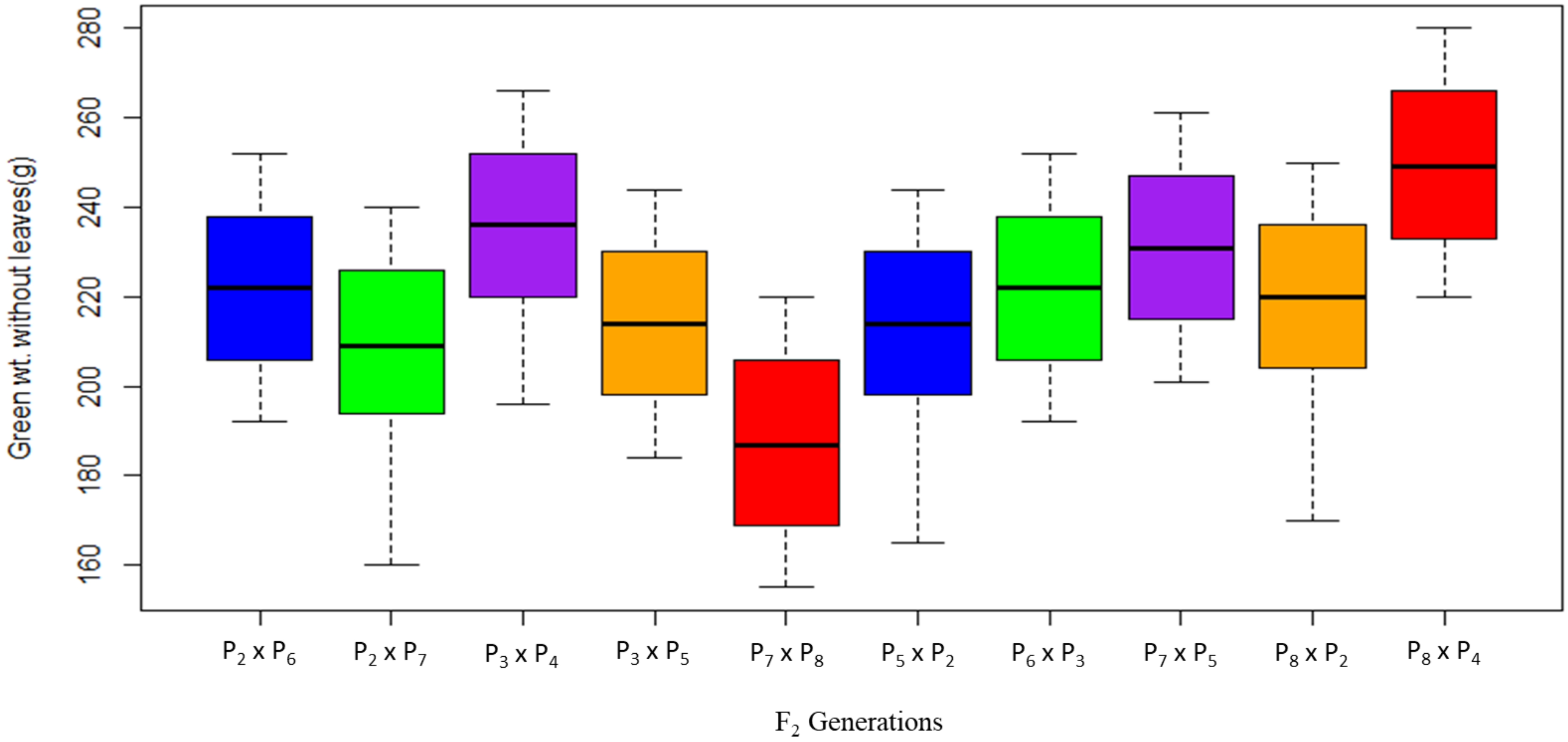

Fig. 4.19 Box plot showing Green wt. without leaves of F_2 generations in Tossa jute (Based populations)

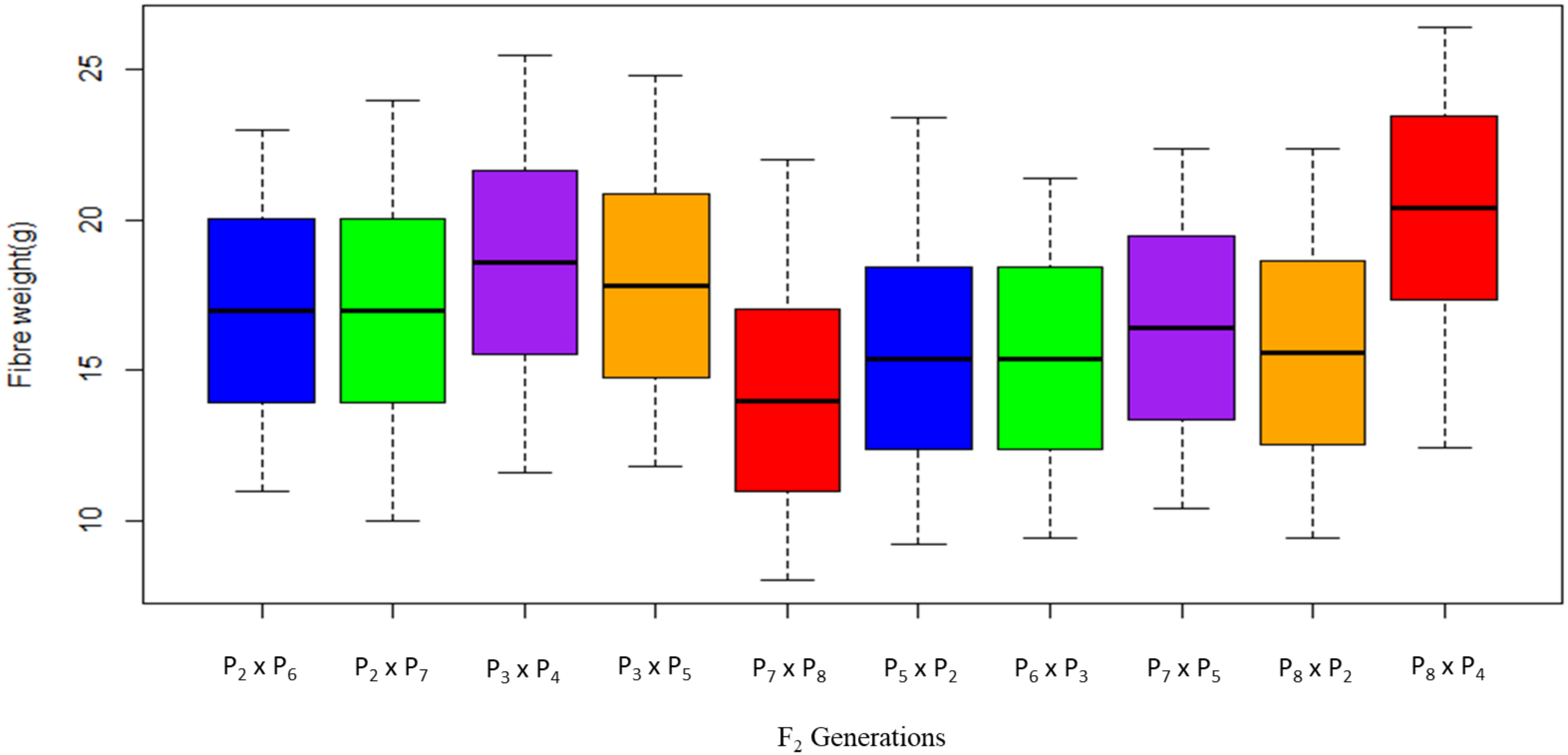

Fig. 4.20 Box plot showing Fibre weight of F_2 generations in Tossa jute (Based populations)

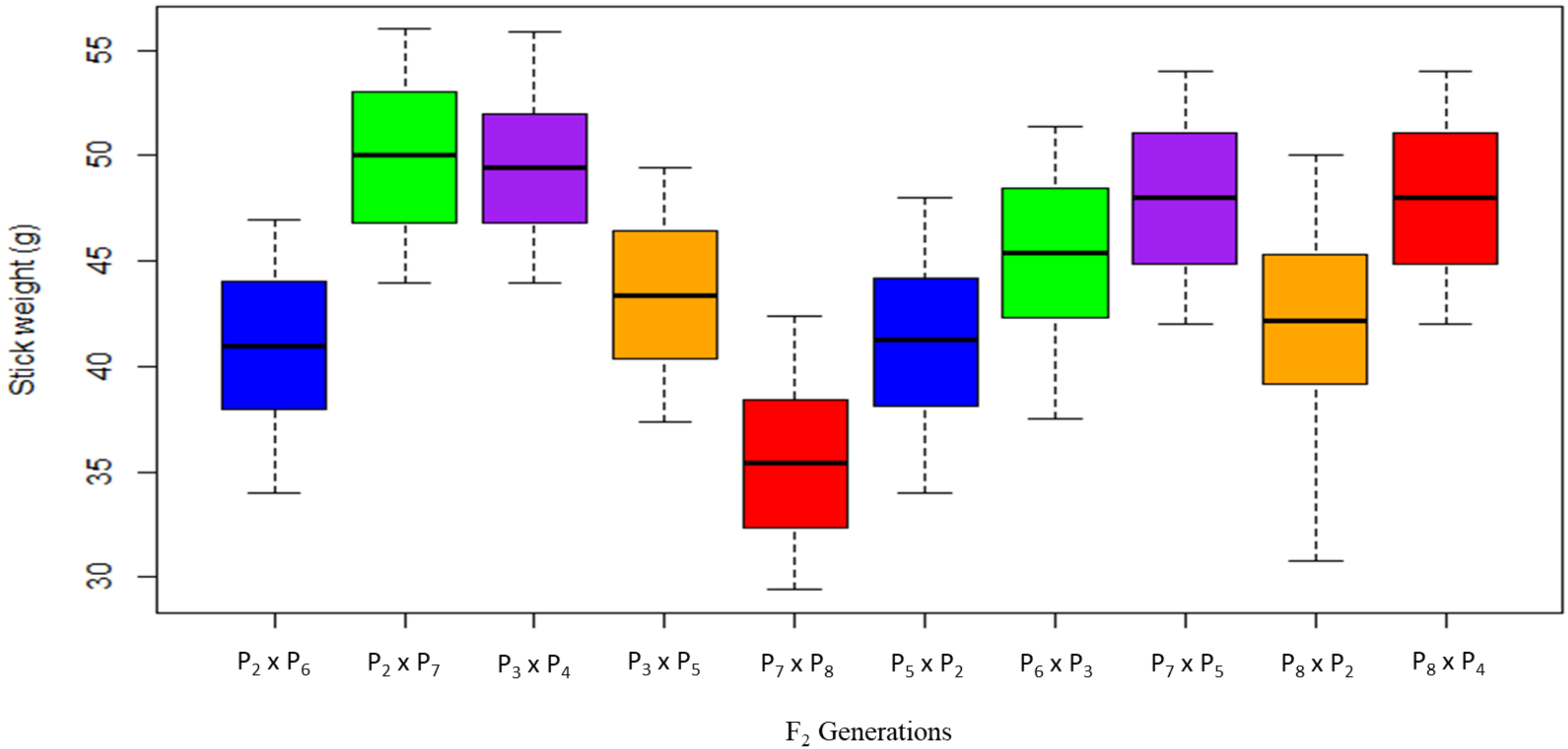

Fig. 4.21 Box plot showing Stick weight of F_2 generations in Tossa jute (Based populations)

Table 4.19 T-test between the base population and selected population for different characters in F_2 generation of Tossa jute

Parameters	Mean of base population	Mean of selected population	t- value	Pr > t
Plant height (m)	3.03	3.18	5.61**	0.0003
Base diameter (mm)	15.90	17.83	8.80**	0.0000
Green bark thickness (mm)	1.74	1.89	4.75**	0.0001
Green wt. without leaves (g)/plant	220.60	234.04	21.19**	0.0000
Fibre weight (g)/plant	16.76	19.71	27.08**	0.0000
Stick weight (g)/plant	44.38	47.43	16.17**	0.0001

** Significant at 1% level

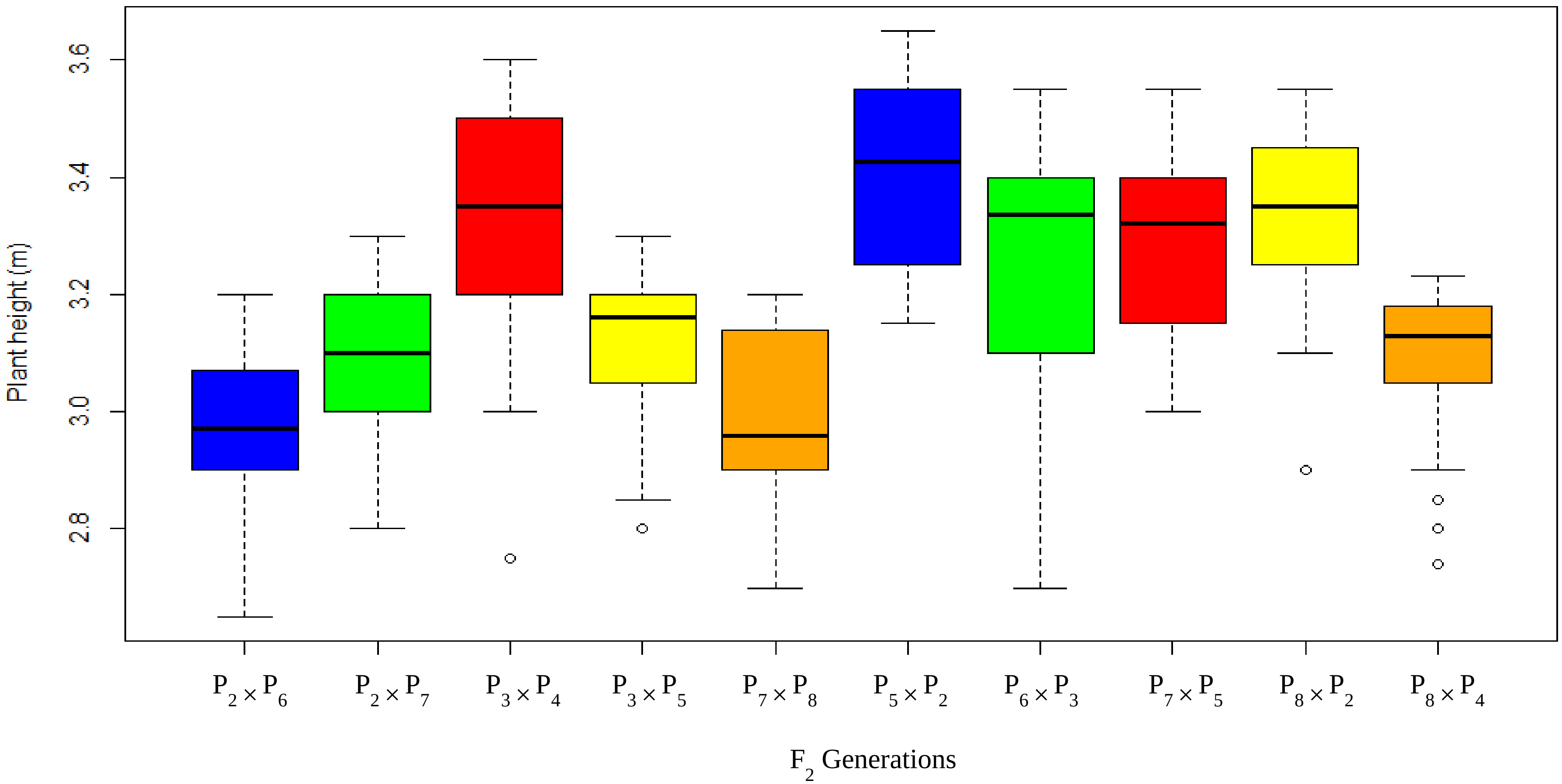

Fig. 4.22 Box plot showing Plant height of F_2 generations in Tossa jute (Selected populations)

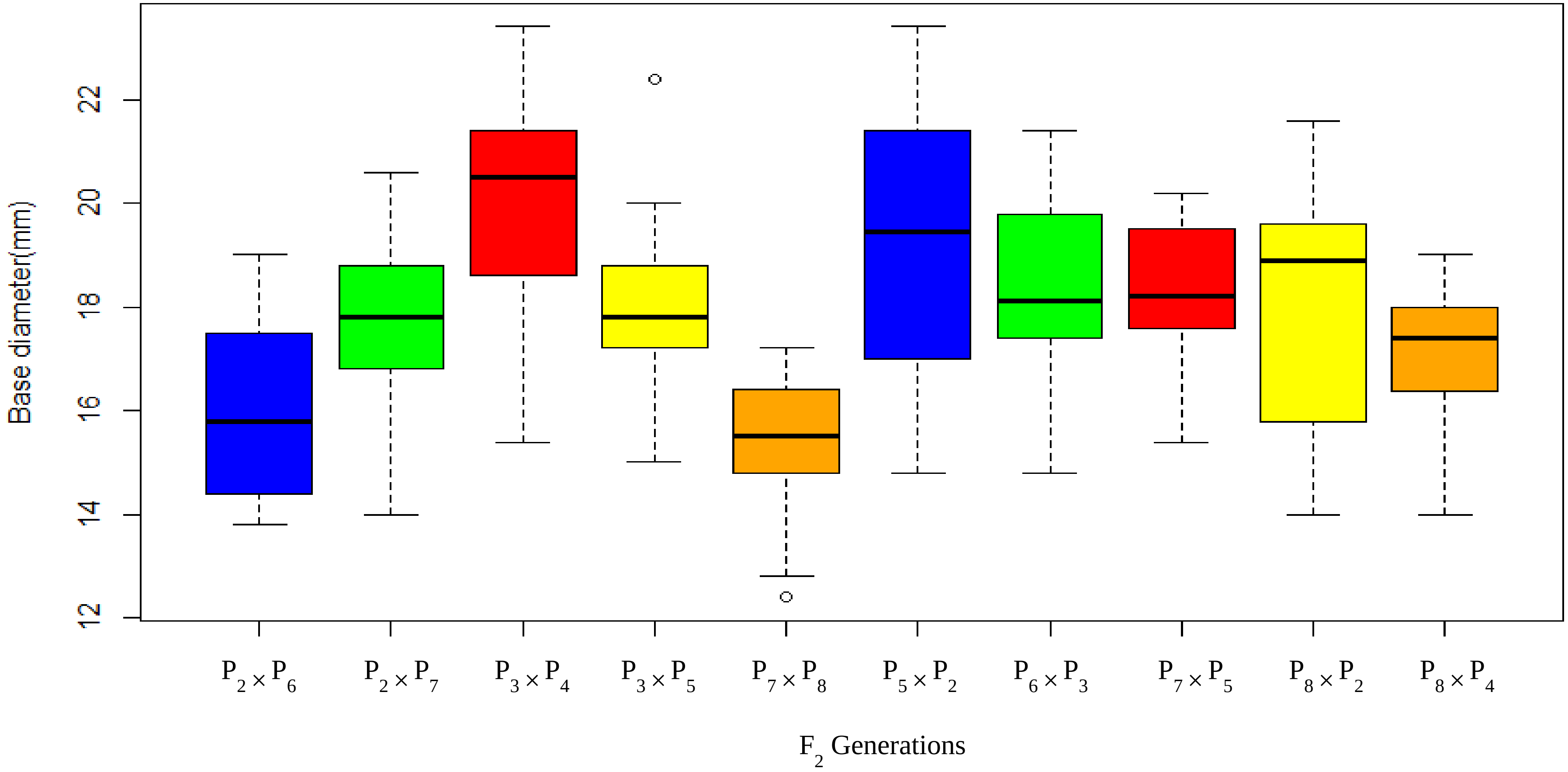

Fig. 4.23 Box plot showing Base diameter of F_2 generations in Tossa jute (Selected populations)

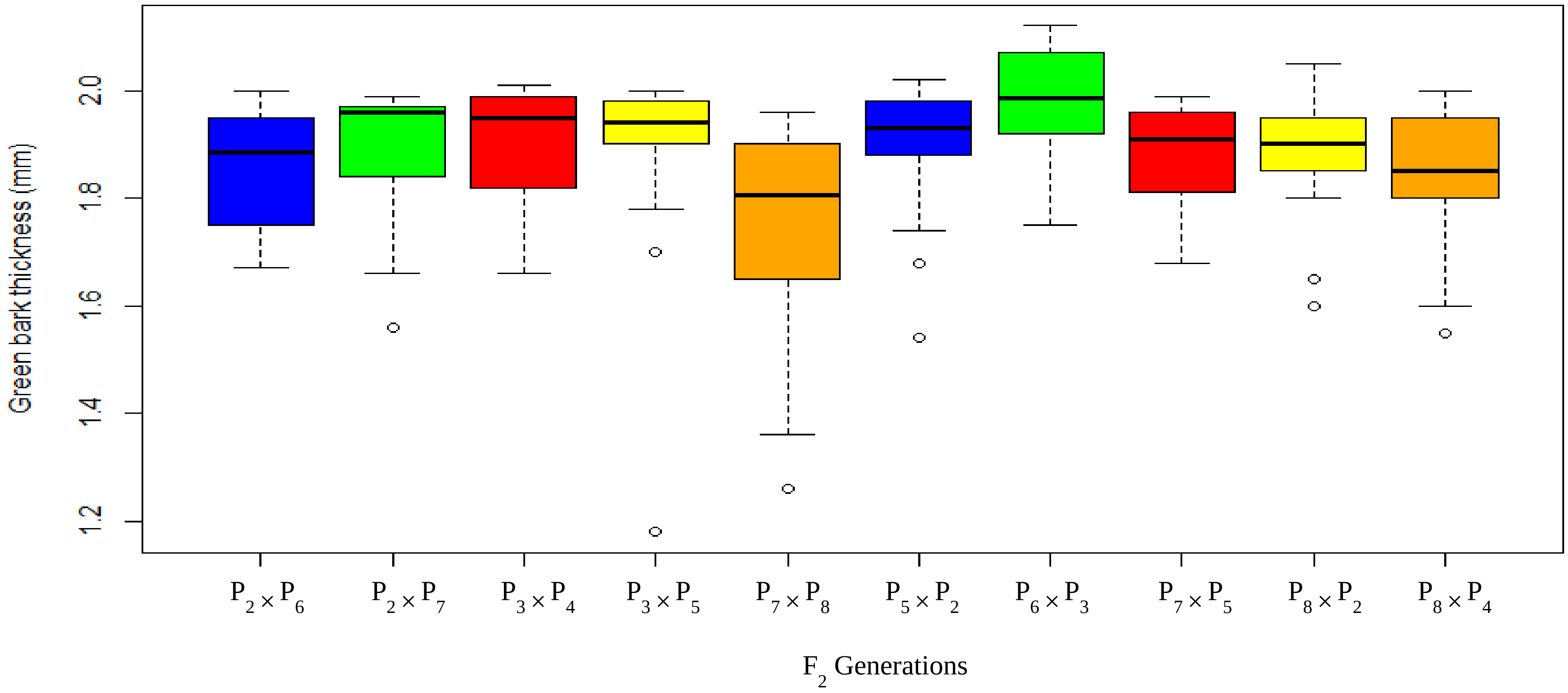

Fig. 4.24 Box plot showing Green bark thickness of F_2 generations in Tossa jute (Selected populations)

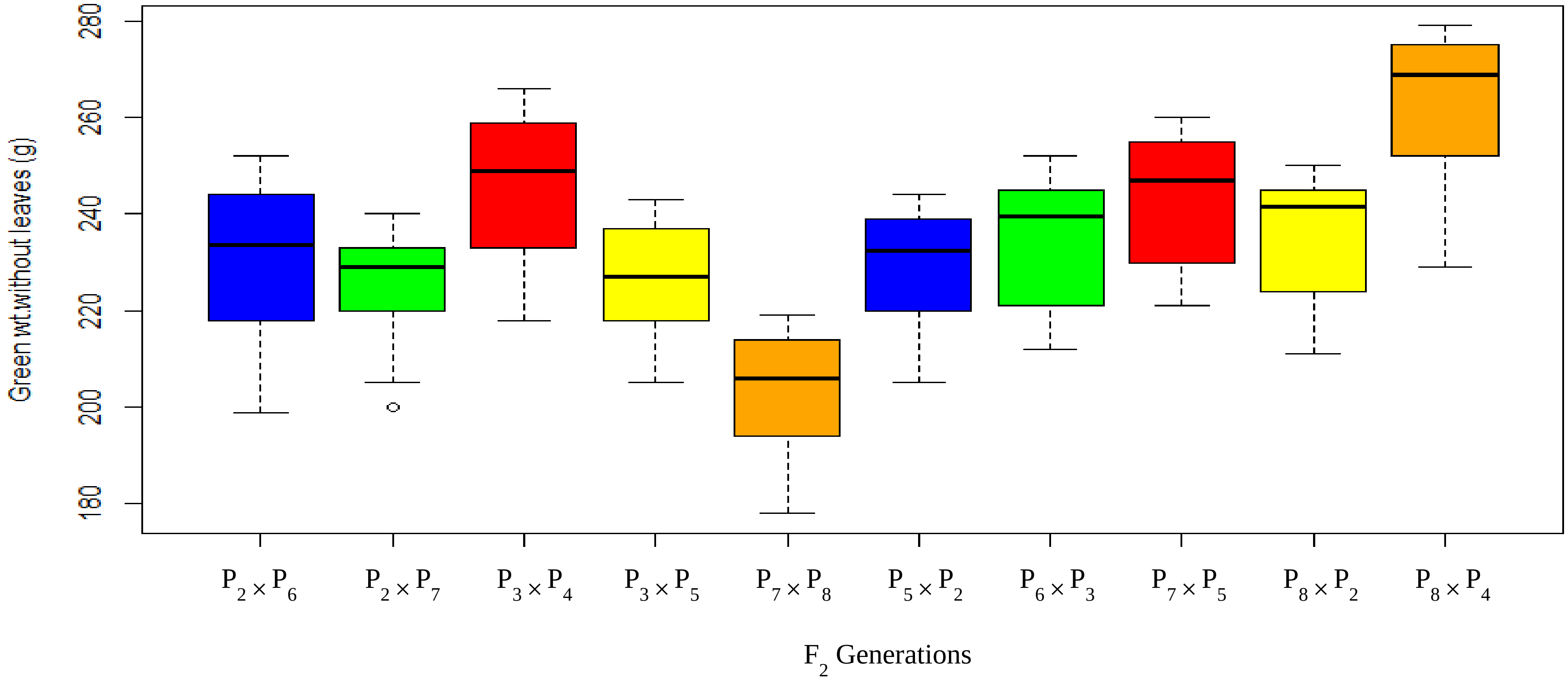

Fig. 4.25 Box plot showing Green wt. without leaves of F_2 generations in Tossa jute (Selected populations)

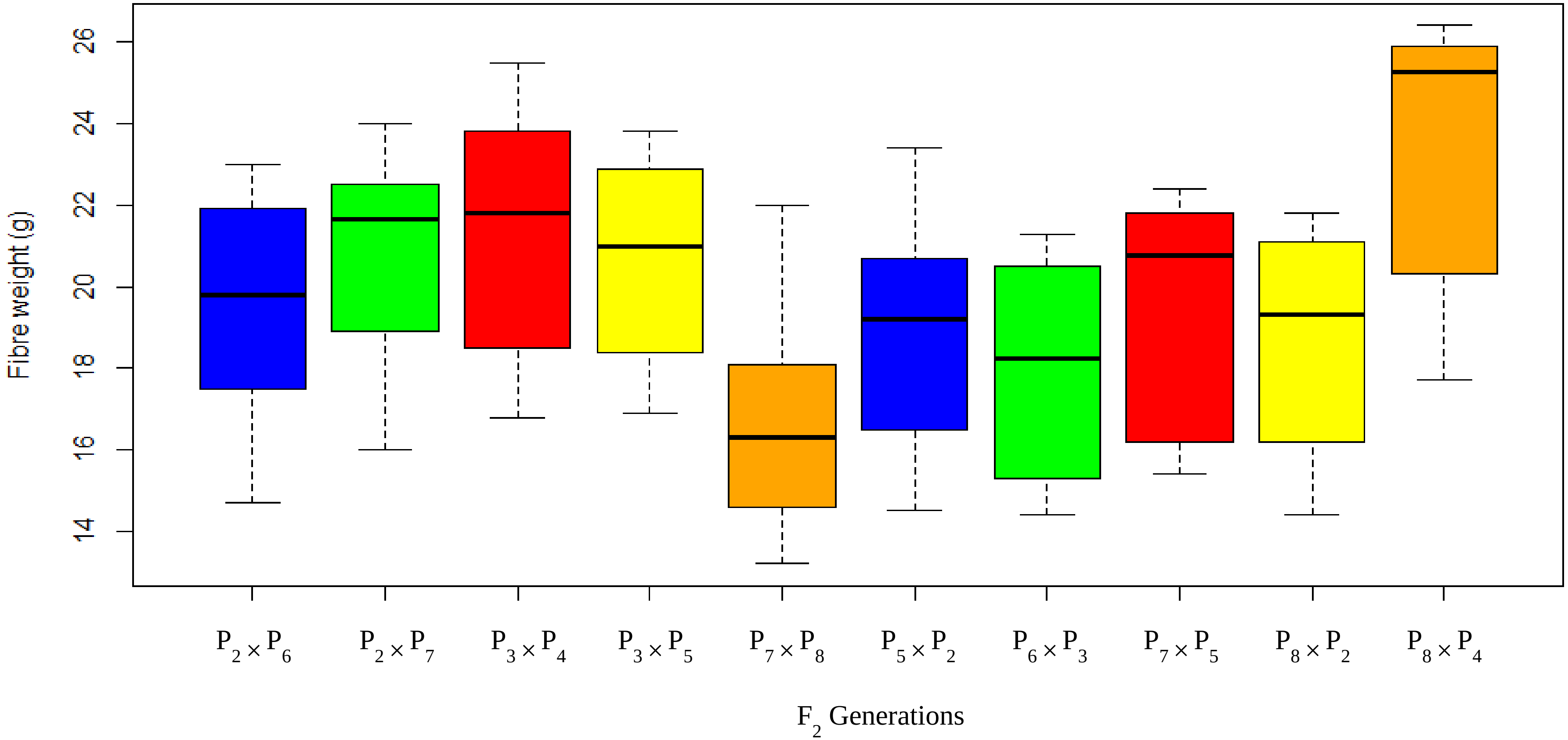

Fig. 4.26 Box plot showing Fibre weight of F_2 generations in Tossa jute (Selected populations)

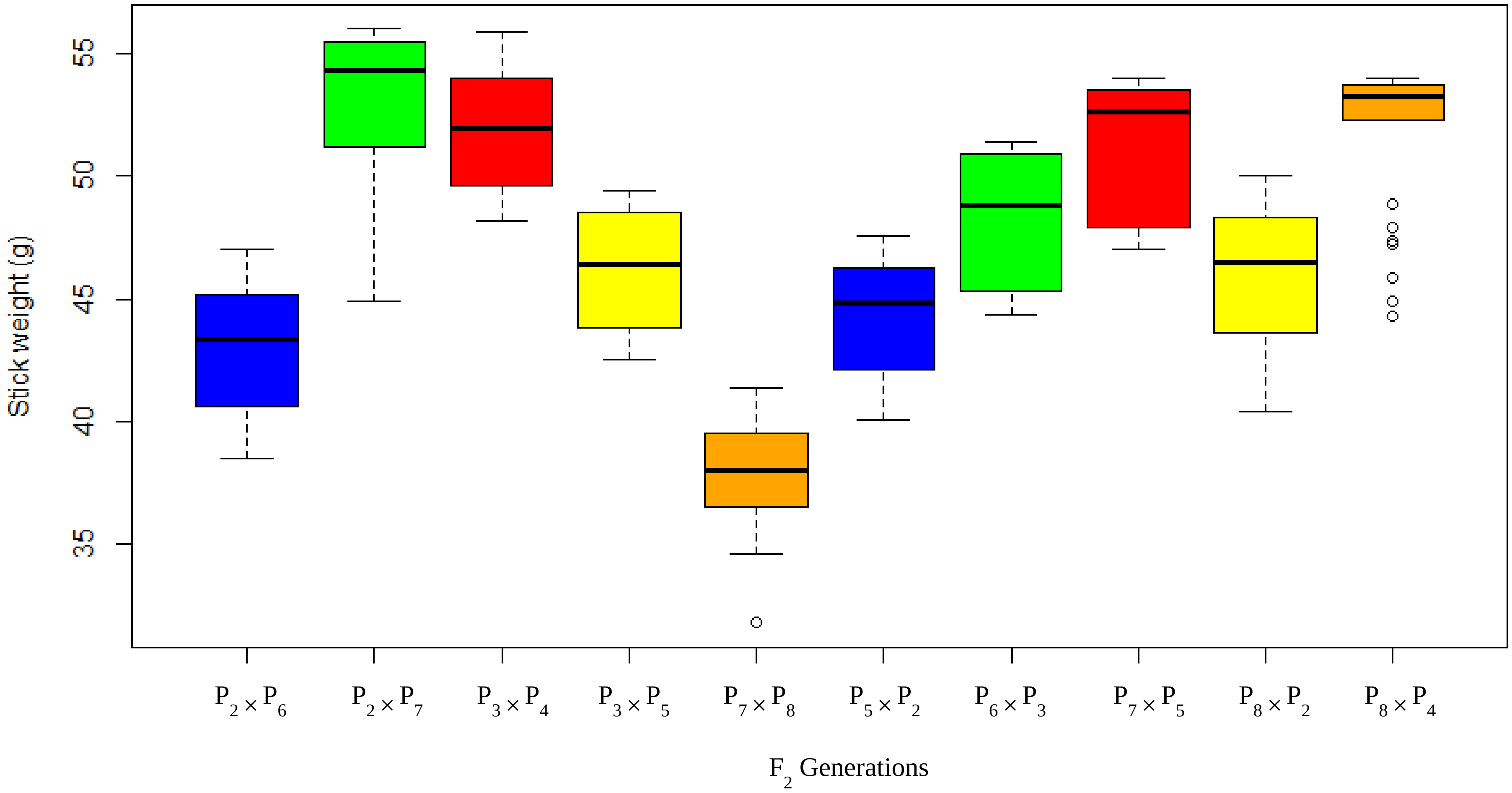

Fig. 4.27 Box plot showing Stick weight of F_2 generations in Tossa jute (Selected populations)

4.3.2.6 Stick weight

Stick weight of Tossa jute is important because of its multifarious use. The plants derived from the cross, P_2 x P_7 displayed outstanding potential for stick weight both in base and selected populations. Moreover, the mean for the character increased from base to selected populations but variance had decreased. From the Table 4.17 and Table 4.18 it is apparent that the highest stick weight was in general obtained from selected population corresponding to base populations. However the highest stick weight was obtained from the cross, P_2 x P_7 with 53.0 g in selected population, which was followed by the cross, P_3 x P_4 with 51.91g in selected population. Additionally it is observed that the plants had high base diameters and high plant heights, usually produced high stick weight. The distribution pattern on individuals means of 10 crosses are presented in Fig.4.27.

4.3.3 Authentication of results for different character

To assess the gain from arbitrary selection mean, mean differences, mean ranges and variances were estimated in ten crosses for the characters, plant height (m), base diameter (mm), green bark thickness (mm), green wt. without leaves (g), fiber weight (g) and stick weight (g). Based population and selected population were tested through t- test and showed significant gain after applying judicious selection (Table 4.19). All the characters showed significant differences from base to selected populations. Not only that the magnitudes of the characters significantly increased with 99% confidence level. If the characters should consider in advance generations, developed pure lines may be outstanding to incorporate in future breeding. Therefore, at the end of selfing (F_6 or F_7), a few pure lines may be exploited to release as new tossa jute varieties.