VARIABILITY IN MORPHOLOGICAL AND ANATOMICAL CHARACTERS AND THEIR ASSOCIATION IN WILD JUTE (*Corchorus* species)

ABUL KASHEM MD. SHAHADAT HOSSAIN

Registration No. 01506

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

IN

GENETICS AND PLANT BREEDING

SEMESTER: JULY-DECEMBER, 2005

Approved by:

(Dr. Shamsuddin Ahmad)
CSO and Head
Breeding Division
Bangladesh Jute Research Institute
Supervisor

(Dr. Md. Shahidur Rashid Bhuiyan)
Professor
Department of Genetics and Plant Breeding
Sher-e-Bangla Agricultural University
Co-supervisor

(Dr. Md. Sarowar Hossain)
Chairman
Examination committee

Government of the People's Republic of Bangladesh
Bangladesh Jute Research Institute
Manik Mia Avenue, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled, " **VARIABILITY IN MORPHOLOGICAL AND ANATOMICAL CHARACTERS AND THEIR ASSOCIATION IN WILD JUTE (*Corchorus* species)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements of the degree **MASTER OF SCIENCE** in **Genetics and Plant Breeding**, embodies the result of a piece of *bona fide* research work carried out by **ABUL KASHEM MD. SHAHADAT HOSSAIN**, Registration No. 01506 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by him.

Dated: December, 2005
Dhaka, Bangladesh

(Dr. Shamsuddin Ahmad)
CSO and Head
Breeding Division
Bangladesh Jute Research Institute
Supervisor

Dedicated

To

My Beloved Parents

SYMBOLS AND ABBREVIATIONS

Full Word	Abbreviation
Analysis of variance	ANOVA
Agro Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Bangladesh Jute Research institute	BJRI
Centimeter	cm
Coefficient of Variation	CV
Department of Agricultural Extension	DAE
environmental coefficient variation	ECV
And others(at elli)	*et al.*
Genetic Advance	GA
Genotypic Coefficient of Variation	GCV
Heritability in broad sense	h^2b
Meter	M
million hectare	M ha
Millimeter	mm
Mean Sum of Square	MS
Muriate of Potash	MP
Micro meter	μm
Haploid Chromosome Number	n
Diploid Chromosome Number	2n
Phenotypic coefficient of variation	PCV
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Triple Super Phosphate	TSP
Transverse Section	TS
Ultimate Fibre Cell Length	UFCL
Ultimate Fibre Cell Breadth	UFCB
Grand Mean	$\overline{x}$

ACKNOWLEDGEMENTS

Alhamdulillah, the author bows to the grace and mercy of almighty Allah, the supreme ruler of the universe without whose desire the author could not have materialized his dream to conclude this thesis.

It gives the author much pleasures to express his profound gratitude, respect and appreciation to his honourable research supervisor Dr. Shamsuddin Ahmad, CSO and Head, Breeding Division, Bangladesh Jute Research Institute (BJRI), Dhaka for the author's scholastic guidance, kind supervision, constant encouragement, timely instructions and affectionate inspirations throughout the entire period of the research work and in the preparation of this manuscript.

The author wishes to express his deepest gratitude and appreciation to his co-supervisor Dr. Md. Shahidur Rashid Bhuiyan, Professor, Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University for providing him with all possible help during the period of this thesis work and constructive suggestion.

The author expresses his heartfelt thanks and gratitude to his esteemed teachers professor Abu Akbar Mia, Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Associate Professor Dr. Md. Sarowar Hossain, Chairman, Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Assistant Professor Firoz Mahmud and Naheed Zeba, Lecturers, Md. Saiful Islam and Md. Jamilur Rahman, Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University for their constant co-operation, direct and indirect advice, encouragement and good wishes during the work.

The author also grateful to Professor Dr. A. M. Farooque, honourable Vice Chancellor, Sher-e-Bangla Agricultural University and professor Md. Shadat Ulla, Dean, postgraduate studies, Sher-e-Bangla Agricultural University for providing him with all possible help during studies.

The author is grateful to all his colleagues specially Mr. Shahidul Islam, Senior Scientific Officer, Breeding Division, BJRI, for his co-operation and encouragement.

Cordial thanks are due to Janab Ismail Hossain, Laboratory Assistant, Breeding Division, BJRI, Dhaka for his assistance in the anatomical studies.

The author thanks to his friends (Khairul, Main, Sanjit), room mates Ershad and Hasan for their help and inspiration in preparing his thesis.

The author expresses his sincere thanks to course mates Zahir, Asad and Saki for their help and inspiration.

The author remembers with happiness and joy that his wife Mrs. Hasina Akter and his son Monawar Hasnayan Ismum (Rhivu) have tolerated a lot of troubles during the study and encourage him to complete the thesis.

The author is grateful to the authority of Bangladesh Jute Research Institute (BJRI) for giving him permission for this study and also to use the laboratory and field facilities in which the present work was carried out.

Finally, the author would like to acknowledge his heartfelt indebtness to his beloved parents, brothers, sisters and relatives for their immensurable sacrifice, blessings and continuous inspiration throughout his academic life.

December, 2005 **The Author**

VARIABILITY IN MORPHOLOGICAL AND ANATOMICAL CHARACTERS AND THEIR ASSOCIATION IN WILD JUTE (*Corchorus* species)

BY

ABUL KASHEM MD. SHAHADAT HOSSAIN

ABSTRACT

Six wild *corchorus* species collected from different geographic origins were evaluated to study their variability, correlation and path coefficient analysis with 16 morphological and 8 anatomical characters at Bangladesh Jute Research Institute, Dhaka, during April to December, 2004. Significant variations were observed among the species tested. Considering genetic parameters, high GCV values were observed for plant height, internode length, leaf area, number of branch per plant, number of node per plant, green weight with leaves, green weight without leaves, dry fibre weight, dry stick weight, number of fruits per plant, number of seeds per fruit, root length and all anatomical characters. High heritability values with high genetic advance in percentage of means were observed for root length, plant height, inter node length, leaf area, number of branch per plant, number of node per plant, green weight with leaves, green weight without leaves, dry fibre weight, dry stick weight, number of fruits per plant, number of seeds per fruit and all anatomical characters. The fibre yield showed strong significant positive correlations with plant height, base diameter, middle diameter, number of node per plant, fresh weight with leaves, fresh weight without leaves, number of fruits per plant, dry stick weight, bark thickness,

number of fibre bundle per TS, number arc per layer, number of pyramid per TS, ultimate fibre cell length both at phenotypic and genotypic levels.

Path coefficient analysis indicated maximum direct contribution towards dry fibre weight through bark thickness followed by dry stick weight, plant height, ultimate fibre cell length, number of node per plant, root length, top diameter, middle diameter, L/B ratio, inter node length, number of fibre bundle per TS, branch per plant both at phenotypic and genotypic levels.

CONTENTS

CONTENTS (Contd.)

List of Table

List of Plate

List of Appendices

Chapter 1
Introduction

INTRODUCTION

The genus *Corchorus* has around 50-60 species, but over 170 *Corchorus* names are given in Index Kewensis (Edmonds 1990). These species are found throughout the tropics and subtropics. The genus is extremely variable and all species are highly fibrous. Out of these 50-60 species, two species are commercially cultivated namely- *Corchorus capsularis* L. its centre of origin is Bangladesh, India and Myanmer including South China (Sing, 1976) and *Corchorus olitorius* L. originated in North Africa (Kundu *et al*., 1959) are batter for their fibres, popularly known as jute.

The fibres are obtained from the bark of the stem. However, the entire bark is not composed of fibre. The fibres are arranged in bundles forming trapezoid. In between the bundles there are non-fibrous soft tissues. So, fibre yield is dependent on these internal characters viz. bark thickness, number and area of phloem wedges (trapezoid), number of fibre bundle in trapezoid, number of fibre bundle/layer (Anon.1996). Commercial jute fibre is not a single fibre, rather it is composed of many ultimate fibres. So, the quality of jute fibre depends upon the length and length/breadth ratio of these ultimate fibres, the more length/breadth ratio, the more quality of the fibre (Kundu, 1942, 1954).

Jute singly earns foreign exchange contributing approximately between 6-7% (BBS, 2004) to our national economy and provides livelihood to millions of rural and urban people. Jute is one of the most important bast fibre crops in Bangladesh context, because of its cheapness, high strength and non-elastic properties; it is used extensively in the manufacture of different types of packaging materials of various agricultural and industrial products. It is also used for the production of paper and pulp. Other diversified products from jute are novotex fabrics, carpet, shopping bags, knit wear, nursery sheet and pot, micro-crystal cellulose for photo stable dye etc.

In most of the jute producing countries, the number of recommended jute varieties is limited or inadequate in terms of meeting the requirements of the wide agro-ecological conditions. Most of these varieties are quite old and have narrow genetic base and susceptible to various biotic and abiotic stresses. All these factors combined with the increasing demand of new type of jute to meet various agro-industrial needs necessitate the development of varieties with desirable qualitative traits. To remove most of the short comings of the present day varieties and to meet the yield and quality objectives, the jute breeders have to look for appropriate genetic resources which may contribute the desired traits and finally combine them together to develop improved varieties.

Like most of the other major crops, crossing made the initial advances between the best available cultivars. Since the cultivated crop has arisen from a very narrow genetic base, much of the genetic variability is now exhausted, and breeders are increasingly turning to the wild species for the requisite variation.

Many wild jute species possess genes for resistance to pests and diseases, stressful environments and other important characters. Thus the wild jute gene pool is becoming an increasingly important source of genetic variation for desirable characters. The sap of *C. aestuans* and *C. trilocularis* was noted to be colourless and may provide germplasm for improved fibre quality sought by jute breeders.

There are many reports of the incorporation of characters from wild species to cultivated forms throughout the range of crop species, e.g. blight resistance was incorporated into the cultivated potato, *Solanum tuberosum* from wild *Solanum demustum* (Markes, 1960). Similarly, tobacco mosaic virus resistance was incorporated into *Nicotiana tabacum* from wild *Nicotiana glutinosa* (Gerstel, 1943).

In order to increase the frequency of desired genotypes in breeding progenies, superior parents with high breeding values are needed. Variability and genetic diversity are the fundamental laws of plant breeding which is a major tool being used in parent selection for efficient hybridization. When the variability in a population is largely genetic nature with least environmental effects, the probability of isolating genotypes is high. An understanding of genetic variability in any breeding program is essential because it provides not only a basis for selection but also some valuable information regarding selection of desired parents to be used in a hybridization program. The concept of relationship between phenotypic and genotypic values helps in the prediction of possible genetic advance through selection based on phenotypic values. The proper evaluation and careful selection provide scope for identifying desirable genes for exploitation, either in itself or through hybridization. The effectiveness of selection depends upon the genetic variability present in the population.

Therefore, the present research project was undertaken to study the variability of wild jute germplasm with the following objectives:

* To examine and assess the natural variation among populations paying particular attention to morphological and anatomical desirable traits.

* To select desirable parents for hybridization.

* To assess the character association and contribution of characters towards fibre yield in different wild species.

Chapter 2

Review of literature

REVIEW OF LITERATURE

Fibre yield of jute (*Corchorus* species) is a complex product. It is correlated with a number of characters such as root length, plant height, base diameter, middle diameter, top diameter, petiole length, internode length, number of node per plant, branch per plant, green weight with leaves, green weight without leaves, leaf area, dry stick weight, number of fruit per plant, number of seeds per fruit etc. Selection for yield may not be effective unless the associations between other yield components influencing it directly or indirectly are clearly known and taken into consideration. Selection should be based on yield components, which are least affect, by non-genetic factors (Chaudhury *et al.* 1981.)

Scientists are trying hard to improve the quality of this crop. Lot of genetic variability has already been reported but desired results so far as yield and quality aspect of this crop is eluding so far. The relevant literature available on *Corchorus* species has been reviewed and here under being presented.

2.1 Variability

Robinson *et al.* (1951) stressed the need to estimate genotypic and phenotypic variance of various characters for choosing individuals based on expression with an aim to identify superior genotype in corn.

According to Rao and Shaha (1961) long fibre cells were found to occur in the middle and top regions in jute plants. Middle and top regions containing long fibres gave higher quality and their length breadth ratio was high.

Arangzeb and Biswas (1964) studied the UFC length in different varieties of *C.capsularis*. They reported that the length of UFC'S was more towards the top position of the plant.

Increased fibre yield in jute is mainly based on two morphological characters namely plant height and base diameter (Eunus, 1968).

Plant height and basal diameter were found to have less genetic variability then stick weight and fibre weight respectively (Singh, 1970).

Begum *et al.* (1979) observed that the long fibre cells were found in top portion of jute stem (2746.90μ) and followed by middle (2505.16 μ) and bottom (2201.75 μ). The lowest mean breadth of fibre cells were found in top of the stem (14.68 μ) and followed by middle (16.39 μ) and bottom (17.50 μ).

Chaudhury *et al.* (1981) found that the estimated variance in *C. olitorius*. L. for the characters plant height, basal diameter, node number, internodal length and fibre yield was significant.

Khandaker *et al.* (1988) suggested that majority of the fibre is obtained from the basal region of the plant. In this study they maintained a specific length breadth ratio in the middle region but showed variability in basal region of the plant.

The genetic coefficient of variance was higher for fibre weight (33.01) whereas it was low for node number (12.55) and base diameter (11.75) in tossa jute (Ghosdastidar and Dus, 1984).

Maximum variability was marked for plant height, base diameter, top diameter, internodal length and fibre yield. Values of genotypic and phenotypic variance were very close in case of top diameter, internodal length and plant height (Chaudhury, 1984).

Ali and Haque (1984) conducted an experiment with *C. capsularis* L. and concluded that the highest mean length and lowest mean breadth of ultimate fibre cell were marked in the middle part of the stem.

Chaudhury *et al.* (1985) observed appreciable variability for plant height, basal diameter, top diameter, internodal length and fibre yield in tossa jute.

Sardana *et al.* (1990) observed higher phenotypic coefficient of variation than the corresponding genetic coefficient of variance value for plant height, basal diameter, number of node and fibre weight.

Begum and Sobhan (1991) observed that the fibre yield and some other morpho-agronomic characters, viz. plant height, base diameter, leaf angle, petiole length and internodal length showed high genotypic coefficient of variation (27.35, 12.53, 10.69, 14.63, 17.02 and 24.40).

Dahal (1991) observed the highest genotypic coefficient of variation for dry fibre weight (21.89) followed by dry stick weight (18.73), green weight (18.29), leaf area (11.11), petiole length (11.02), plant height (11.02) harvest index (7.90), base diameter (7.09), node number (5.44) and internodal length (3.28). He also observed that the phenotypic coefficient of variation was higher than corresponding genotypic coefficient of variation for all characters.

Ahmed *et al.* (1993) reported that phenotypic coefficient of variation was relatively higher that genotypic one for all characters. Both genotypic and phenotypic coefficients of variation were the highest for fibre yield followed by green weight and the lowest for base diameter. Wide and narrow differences between genotypic and phenotypic coefficients of variation were observed in stick weight and petiole length respectively.

Ali (1994) observed high values of genotypic and phenotypic coefficient of variation for fibre yield (24.8% and 35.4%) and bark thickness (11.2% and 15.7%).

Ahmed and Khatun (1997) observed the highest genetic and lowest environmental coefficient of variation in jute for number of trapezoid, area of trapezoid per section and bark thickness. They also found that the fibre yield had highly significant and positive correlation with number of trapezoid ($r = 0.975$) followed by area of trapezoid ($r = 0.882$) and bark thickness($r = 0.784$).

Islam *et al.* (2002) observed variability in tossa jute and revealed significant differences among them for all the characters with wide range of variability. The differences between PCV and GCV were little for all the characters.

Akter *et al.* (2003) reported significant variation in all the characters of jute. Area of trapezoid, bark thickness, number of trapezoid and bark diameter had high genotypic coefficient of variation.

Islam and Ahmad (2003) studied variability in jute genotypes and revealed significant differences for all the characters with wide range of variability. Considerable amount of genotypic variances were obtained for fibre weight per plant, stick weight per plant and plant height.

Akter *et al.* (2005) observed variability in jute. They reported that dry fibre weight, dry stick weight, fresh weight with leaves, fresh weight without leaves and node number had high genotypic coefficient of variation.

2.2 Heritability and genetic advance

Heritability is the degree in which variability of quantitative characters is transmitted from parents to offspring. So the estimation of heritability is of great interest to the plant breeders. A quantitative character having high heritability is transmitted from parents to offspring conveniently. Heritability value alone provides the indication of the amount of genetic progress that would result from selecting the best individual. Lush (1940, 1949) defined heritability in both broad and narrow sense. In broad sense, heritability is the ratio of genetic variance to the total variance expressed in percent. In narrow sense, it is only a portion of genetic variance, which is due to aditivity of genes. Robinson *et al.* (1949) defined heritability as the additive variance in percent of total variance in narrow sense. Later Robinson (1966) has been categorized the heritability values into low (below 10%) moderate (10-30%) and high (above 30%).

According to Johnson *et al.* (1955) heritability along with genetic advance would be more useful in predicting yield under phenotypic selection than heritability estimate alone.

Nei (1960) reported maximum heritability estimates for the characters of days to flowering, plant height, fibre weight basal diameter and internodal length.

The highest and the lowest heritability estimates were recorded for fibre weight and base diameter (Shukla and Singh, 1967).

Rahman, (1968) observed 25% heritability for fiber yield in jute. Dudley and Moll (1969) reported that the improvement of a crop mainly depends upon the magnitude of genetic variability and the degree to which the yield and its components are heritable.

Singh (1970) observed maximum heritability values for plant height (86.75%) followed by basal diameter (82.46%) and stick weight (68.04%). The highest genetic advance was observed in case of fibre weight (22.81%) followed by stick weight (19.31%), basal diameter (11.72% and plant height (8.20%).

Jana (1972) reported that the estimated heritability value tossa jute was 39 percent for plant height, 15 percent for basal diameter, and nearly 40 percent for fibre yield.

According to Katiyar *et al.* (1974) heritability value alone provides the indication of the amount of genetic progress that would result from selecting the best individual.

Sobhan (1982) reported the highest broadsense heritability in tossa jute for seed yield (78.38%) followed by bark weight (63.92%) fibre yield (49.48%) plant height (38.97%) and base diameter (15.03%).

Chaudhury (1984) observed that top diameter, internodal length and plant height had the highest heritability coupled with moderate genetic advances. Therefore, phenotypic selection for making genetic improvement is expected to be more effective for those three characters.

Ghosdastider and Das (1984) observed very high heritability (82.43%) and high genetic advance as percent of mean (39.09) for plant height but node number and base diameter showed low heritability (63.93% and 39.71%) and low genetic advances as percent of mean (20.68 and 15.25). Fibre yield also showed low heritability (53.93%) but high genetic advances as percent of mean (44.95).

Chaudhury *et al.* (1984) reported that high heritability value for plant height (64.85%) out of eight agronomic characters in tossa jute. They suggested that the phenotypic selection for these characters would be more effective to achieve high yield. High genetic advance was observed for fibre yield, plant height, base diameter, lamina breadth, petiole length and internodal length (39.90, 21.72, 15.60, 28.65, 26.43 and 27.99).

Talukder and Haque (1992) observed that the estimates of heritability (in broad sense) and genetic advance were greater in biomass yield. Heritability for branches / plant and 1000-seed weight was 2.74 and 3.15 times greater, respectively than that of seed yield /plant.

According to Ahmed *et al.* (1993) the highest genetic advance (35.5%) coupled with the highest heritability (52.9%) was observed for fibre yield. They also reported that high and low heritability values were observed for petiole length and base diameter. High and low value for genetic advance as percent of mean were obtained for fiber yield base diameter.

Ali (1994) observed that the broad sense heritability was high for plant height (50%), bark thickness (50%), area of phloem trapezoids (55%), number of fiber bundle area (47%), but these exhibited low genetic gains (7.1, 16.2, 8.8 and 11.1 respectively). The fibre yield had a high heritability value (49%) coupled with high genetic gain (35.9%).

Dahal (1991) observed that moderate heritability value with low genetic advance for the characters leaf area, petiole length, plant height, base diameter, dry stick weight, harvest index and dry fibre weight.High heritability (38%) along with the lowest genetic advance (9.3%) was observed for base diameter which might be due to non-additive gene action and this indicated epistasis and dominance. High genetic advance

(35.5%) coupled with the highest heritability (52.9%) was observed for dry fibre yield (Ahmed *et al.* 1993)

Islam *et al.* (2002) observed heritability and genetic advance in tossa jute and revealed that high heritability and high genetic advance were for area of pyramid and bark thickness. Number of pyramid, number of fibre bundle, number of fibre layer, length and breadth of fibre cells had high heritability and moderate genetic advance.

Akter *et al.* (2003) reported heritability coupled with high genetic advance in percentage of mean for bark thickness, area of trapezoid, number of trapezoid, number of fibre bundle/ trapezoid in jute.

Islam and Ahmad (2003) studied heritability in jute genotypes and revealed high heritability and genetic advance were for stick weight and fibre weight. Plant height had high heritability with moderate genetic advance, and green weight had moderate heritability and high genetic advance.

Akter *et al.* (2005) observed heritability in jute. They reported that heritability coupled with high genetic advance in percentage of mean for plant height, base diameter, fresh weight with leaves, fresh weight without leaves and dry stick weight.

2.3 Correlation

Roy (1965) found high positive correlation between basal diameter and fibre yield (0.929) and followed by plant height and fibre yield (0.889). Hence taller and thicker the plant the higher is its yield.

Ling (1972) reported that the length of fibre cells and their length: breadth ratios were positively correlated with breaking strength of the retted fibre.

Paul and Eunus (1976) studied on *Corchorus olitorius* L. and found that phenotypic and genotypic correlation for plant height, base diameter, node numbers, internodal length, fruit length, number of seeds per fruit, seed yield per plant, leaf area index, leaf angle and time of flowering were highly significant in a number of cases but environmental correlation coefficients were significant only a few cases. In this study they observed that partial and multiple correlation analysis indicated that fibre yield was dependent on base diameter, plant height and leaf angle. Environmental correlation was significant for plant height, base diameter, leaf area index and internodal length.

Sinhamahapatra and Rakshit (1977) observed that fibre yield per plant was positively correlated genotypically and phonetically with plant height, basal diameter, wood diameter, node number and internodal length in tossa jute.

The highly significant and positive correlation between green weight and fibre yield might be due to their strong positive direct effect on yield (Maiti *et al.*, 1977).

Khandaker *et al.* (1980) observed that growth rate was more or less uniform on base and very much uniform in the middle region of the plant, where the majority of the fibre are produced. They also found a negligible amount of fibre is obtained from the upper part (top region) of the plant.

Mandal *et al.* (1980) studied path coefficient analysis of 6 characters in *C. olitorius* L. and reported that plant height, basal diameter and node number had positive direct effects on fibre yield. The effect of plant height was found to be greatest.

Rahman and Hossain (1982) have also reported highly positive correlation between fibre yield with number of trapezoids and area of trapezoids.

Ali (1984) showed that fiber yield was strongly correlated with number of phloem wedges (r = 0.97), area of phloem wedges (r = 0.88), number of fiber bundle layers (r=0.92) and dry stick weight (r = 0.99), bark wood ratio (r = - 0.37) and fiber /stick ratio (r = 0.58) showed negative and insignificant association with fiber yield.

Zheng *et al.* (1985) found that plant height, thickness of stem, thickness of fresh weight of stem was positively correlated with fiber weight per plant.

Ali (1985) observed that correlation between length and length breadth ratio of fiber cells was positive and highly significant (r = 0.71 and (0.88) in both middle and bottom position of the stem respectively, it was negative and significant between breadth and length / breadth ratio (r = 0.51) in the bottom position.

Khandaker *et al.* (1988) observed that the best correlation was obtained between total plant dry matter production and bark weight followed by stick weight.

A negative insignificant correlation was observed between the number of layer and fibre yield per plant (Sarker, 1988).

Sardana *et al.* (1990) reported that plant height, base diameter and green weight had positive significant correlation and maximum direct effect on fibre yield in tossa jute.

Fibre yield was positively associated with lamina length lamina breadth canopy petiole length and internal length (Bagum and sobhan, 1991).

High genotypic and phenotypic coefficients of variation were observed for dry fibre yield, green weight, stick weight (Munjunathan and Sheriff, 1991).

Ali (1994) observed that the area of phloem trapezoids showed significant genetic correlation with plant height($r = 0.62$), basal diameter($r = 0.63$) and bark thickness($r = 0.99$). He also observed that there was significant genetic correlation of fibre yield with base diameter ($r = 0.86$), bark thickness ($r = 0.59$), number of phloem trapezoids ($r = 0.92$) and area of phloem trapezoids ($r = 0.58$).

Guo *et al.* (1994) reported negative correlation coefficient between fibre fineness and bark dry weight and positive correlation between fibre fineness and branching height.

Islam *et al.* (2002) showed correlation on anatomical characters in tossa jute. They reported that fibre yield per plant was significant positive association with bark thickness, number of pyramid, area of pyramid, number of fibre bundle at both levels.

Islam and Ahmad (2003) reported fibre weight showed significant positive association with all the characters at both phenotypic and genotypic levels. Genotypic correlations were higher than their corresponding phenotypic correlation coefficient in all the characters.

Akter *et al.* (2003) reported correlation on tossa jute and found that strong significant positive association with bark diameter, bark thickness, number of trapezoid and area of pyramid on fibre weight.

Islam *et al.* (2004) observed correlation on morphological characters in tossa jute and found that fibre yield per plant had significant positive genotypic correlation with plant height, base diameter, leaf area, node number, internodal length, fresh weight with leaves, fresh weight without leaves and dry stick weight.

Akter *et al.* (2005) reported correlation in jute and found that plant height, base diameter, fresh weight with leaves, fresh weight without leaves and dry stick weight showed significant positive association with dry fibre weight in jute.

2.4 Path analysis

The term path coefficient was coined by Wright (1921) to denote the direct influence of variable (cause) upon another variable (effect) as measured by the standard deviation remaining in the effect after the influence of all other possible paths are estimated expect that of cause. Niles (1954), Kempthorne (1957) and later elaborated by Li (1956) presented a detail account of both basic and applied aspect for path analysis. Path analysis helps to find out that the direct and indirect causes of association.

Green weight contributed maximum degree of positive direct effects towards fibre yield followed by plant height and time of flowering (Sukla *et al.*, 1967).

Chaudhury *et al.* (1981) showed that the indirect effect via green weight, which was positive and high, while time of flowering and plant height, and was negative.

Ghoshdastidar and Das (1984) reported that plant height and base diameter had high positive effect on fibre yield.

Biswas (1984) reported that node number and internodal length had negative direct effect on fibre yield.

Plant height had a high positive direct effect on fibre yield followed by basal diameter and leaf area. Rest of the trails such as petiole length, base diameter and node number had low and negative direct effect. The indirect effect of all the traits except petiole length via plant height was high and positive. The effect of basal diameter and leaf area was positive but low. The other via effects was mostly negative and low Das (1987).

Das and Rakshit (1988) observed that plant height had the highest positive effect on yield followed by basal diameter and leaf area. Rest of the characters had low as well as negative direct effect. The indirect effects of all characters expect in petiole length via plant height were all appreciably high.

Sardana *et al.* (1990) reported that plant height had the maximum direct effect on fibre yield followed by basal diameter in jute germplasm analysis. Moderate indirect effect was observed only in case of node number through plant height. The effect was negligible.

Thirthamallappa and Sheriff (1991) reported that plant height had maximum direct effect on fibre yield in jute.

Islam *et al.* (2002) showed path analysis on anatomical characters in tossa jute and reported that bark thickness had the highest positive direct effect on fibre yield per plant.

Akter *et al.* (2003) observed path analysis and revealed that the highest direct effect was for number of trapezoid on fibre weight in jute.

Islam *et al.* (2004) carried out an experiment on path analysis in tossa jute. They reported that fresh weight with leaves per plant had the highest positive direct effect on fibre weight.

Highest direct effect was obtained for fresh weight without leaves on fibre yield in jute (Akter *et al.*, 2005).

Chapter 3

Materials and method

MATERIALS AND METHOD

The experiment was carried out at the Bangladesh Jute research institute (BJRI), Dhaka, during the period of April-December, 2004.

3.1 Experimental site

The experimental site was situated in the madhupur tract (AEZ-28) at 8m above sea level.

3.2 Climate and soil

The experimental site was situated in the tropical climate zone, characterized by heavy rainfall during the April to July and scant rainfall during rest of the year. Mean monthly temperature and rainfall for the growing season are presented in Appendix1. The soil of the experimental field was silty clay in texture having a pH around 6.8. The land was medium high with uniform topography and almost homogenous with respect to soil fertility.

3.3 Experimental materials

The materials comprised of 6 wild *Corchorus* spp. Genetically pure and physically healthy seeds of these species were obtained from the Gene Bank of Bangladesh Jute Research Institute (BJRI), Dhaka. Name and distribution of the species are shown in

3.4 Design and Layout

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Each plot had a double row of 5m length. Space between rows was 0.30m, and block to block distance was 1m. The species were randomly distributed to each plot within each block.

3.5 Land preparation

The experimental plot was prepared by deep ploughing followed by harrowing and laddering. The recommended doses of fertilizers such as 100kg/ha Urea, 25kg/ha TSP and 45kg/ha MP were used. The whole amount of TSP and MP and half of the urea were applied during final land preparation. The remaining half of the urea was top dressed twice at the first and final weeding.

3.6 Sowing and intercultural operation

Seeds were sown on 29 April 2004. Thinning and weeding were done twice after 15 and 35 days of sowing to maintain uniform plant population. Insecticide was not applied but hand picking of insects was practiced to control the jute hairy caterpillar at larval stage.

3.7 Collection of data

The following data on morphological and anatomical characters were recorded from 10 randomly selected plants of each genotype from each replication at the time of harvest (120 days crop age).

Table 1. Name, ploidy level, chromosome number and distribution of the wild species studied

Name of the species	Ploidy number	Chromosome number	Distribution
Corchorus fascicularis	2n	14	Kenya, Angola, Cameroon, Central Africa Republic, Zambia, Zimbabwe, Tropical Australia, Srilanka, India, Pakistan, Myanmar.
Corchorus trilocularis	2n	14	India, Kenya, Afghanistan, Australia, Angola, Bhutan, Egypt, Ghana, Mozambopue, Paskistan.
Corchorus pseudo-olitorius	2n	14	Endewic to Pakistan Also found in Kenya, Somalia, Tanzania and India.
Corchorus tridens	2n	14	Angola, Australia, Benin, Cameroon, Egypt, Pakistan, Mauritania, Kenya.
Corchorus siliquosus	4n	28	India, Pakistan, Africa, Tanzania, Kenya.
Corchorus aestuans	2n	14	Bangladesh, Australia, Angoloa, Benin, Central African Republic, Ethopia, India, Myanmar, Srilanka, Nigeria, Pakistan.

3.7.1 Morphological characters

1. Root length: It was measured from the base of the plant to the tip of the main root in meter.

2. Plant height: It was measured from the base of the plant to the tip of the main shoot in meter.

3. Base diameter: Base diameter was measured at the base of the stem in mm using slide calipers.

4. Middle diameter: Middle diameter was measured at the middle of the stem in mm using slide calipers.

5. Top diameter: Top diameter was measured at the top of the stem in mm using slide calipers.

6. Petiole length: Five petioles per plant were taken and measured in cm from the base of the lamina to the point of the stem where the petiole joins.

7. Internodal length: Internodal length was measured from the middle portion of the plant; taking five different lengths between two nodes of each plant.

8. Leaf area: Length and breadth (at the middle portion of lamina) of five laminae per plant was measured in cm and leaf area was computed with the help of following formula as suggested by Gopal-Krishna and Sasmal, 1974.

Leaf area = K × Length × Maximum breadth

In this case the value of K was 0.6604.

9. Number of branch per plant: Number of branch was counted from the randomly selected 10 plants.

10. Number of node per plant: Number of node was counted from the base of stem to the apex of the shoot.

11. Fresh weight with leaves: Fresh weights of the plant with leaves were recorded.

12. Fresh weight without leaves: Fresh weights of the plant without leaves were recorded.

13. Dry fibre weight: Weight of fibre per plant after retting, extraction and drying was measured.

14. Dry stick weight: Weight of sun dried stick per plant was measured.

15. Number of fruits per plant: The number of fruits were counted from the randomly selected 10 plants.

16. **Number of seeds per fruit:** The number of seeds was counted from the randomly selected 10 fruits.

3.7.2 Anatomical Characters

For anatomical character, three cm long stem segment was collected from the middle part of each plant (previously selected plant) and preserved in Formalin Acetic Alcohol solution (10 ml of Formalin, 5ml of 85% glacial acetic acid and 85 ml of 70% alcohol). The preserved sample were taken out, washed and 20-25 μm thick transverse section (TS) were cut with microtome for preparing slides and studied under a compound microscope (4×10 magnification). TS of each stem were used for following anatomical characters.

1. **Bark thickness:** Eight equal distance of bark thickness were studied under microscope and their mean was expressed by mm.

2. **Number of pyramid per TS:** The number of pyramids was counted in each TS and their means were recorded.

3. **Number of fiber bundle per TS:** The number of fibre bundles in each pyramid was counted in each T S and their mean was calculated.

4. **Area of pyramid per TS:** The area of pyramid (sq. mm) in each TS was determined by using the formula, 1/2(AB+CD) ×EF × Total number of pyramid according to Shaikh *et al.* (1980). Where AB = upper parallel side pyramid, CD= lower parallel side of pyramid and EF= perpendicular distance between the two sides of a pyramid.

5. Number of arc per layer: The number of layer in each pyramid was counted in each TS and their mean were calculated.

6. Ultimate fibre cell length: The fibre cells were splitted by usual maceration technique suggested by Aziz (1964). Length and breadth of 20 fibre cells were studied under compound microscope (4 x 10 magnifications) and their mean was calculated.

7. Ultimate fibre cell breadth: The fibre cell was splitted by usual maceration technique suggested by Aziz (1964). Breadths of 20 fibre cells were studied under microscope (8 x10) magnification and there mean was calculated.

8. Length / breadth ratio: It is the ratio of length of fibre cell to the breadth of fiber cell and expressed in percentage.

3.8 Statistical analysis

All the collected data of the present study were statistically analyzed. For each character, analysis of variance was done individually by F test (Panse and Shukhatme, 1978) and mean values were separated by DMRT (Steel and Torrie, 1980). The mean square (MS) at error and phenotypic variances were estimated as per Johnson *et al.* (1955). The error MS was considered as error variance (σ^2_e). Genotypic varince (σ^2_g) were derived by subtracting error MS from the genotype MS and dividing by number of replications as shown below:

$$\sigma^2_g = \frac{(GMS-EMS)}{r}$$

Where,

GMS and EMS are the genotypic and error mean square and r is the number of replication.

The phenotypic variances (σ^2_p) were derived by adding genotypic variances (σ^2_g) with error variances (σ^2_e) as given by the following formula:

$\sigma^2_p = \sigma^2_g + \sigma^2_e$.

Estimation of genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficient of variation was calculated according to Burtin (1952).

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sigma_g}{x} \times 100$$

Where,
σ_g = Genotypic standard deviation,
x = Population mean

Similarly, the phenotypic coefficient of variation was calculated from the following formula:

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sigma_p}{x} \times 100$$

Where,
σ_p = Phenotypic standard deviation,
x = Population

Estimation of heritability

Broad sense heritability was estimated as per the formula suggested by Hanson *et al.* (1956).

$$H_b = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

Where,
H_b = Heritability in broad sense.
σ^2_g = Genotypic variance.
σ^2_p = Phenotypic variance.

Estimation of genetic advance

The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1949) and Johnson *et al.* (1955).

$$\text{Genetic advance (GA)} = \frac{\sigma^2_g}{\sigma^2_p} \times K \times \sigma_p$$

Where,
K = Selection differential, the value of which is 2.06 at 5% selection intensity
σ_p = Phenotypic standard deviation

Estimation of genetic advance in percentage of means (GA% means)

Comstock and Robinson (1952) calculated genetic advance in percentage of mean using the following formula:

$$\text{GA\% mean} = \frac{\text{Genetic advance}}{\text{Populations mean}} \times 100$$

Estimation of Genotypic and phenotypic correlation coefficient

Genotypic and phenotypic correlation coefficient for all possible combination were calculated using the following formula suggested by Miller *et al.* (1958), Johnson *et al.* (1955) and Hanson *et al.* (1956):

$$\text{Genotypic correlation } (r_{gxy}) = \frac{\sigma^2_{gxy}}{\sqrt{(\sigma^2_{gx} \times \sigma^2_{gy})}}$$

Where,
σ^2_{gxy} =Genotypic covariance between the trait x and y.
σ^2_{gx} = Genotypic variance of the trait x.
σ^2_{gy} = Genotypic variance of y.

$$\text{Phenotypic correlation } (r_{pxy}) = \frac{\sigma^2_{pxy}}{\sqrt{(\sigma^2_{px} \times \sigma^2_{py})}}$$

Where,
σ^2_{pxy} = Phenotypic covariance between the trait
σ^2_{px} = Phenotypic variance of trait x
σ^2_{py} = Phenotypic variance of trait y.

Estimation of path coefficient

Correlation coefficients were further partitioned into components of direct and indirect effects by path coefficient analysis originally developed by Wright (1921) and later described by Dewey and Lu (1959) using the following simultaneous equation:

$$r_{15} = p_{15} + r_{12}p_{25} + r_{13}p_{35} + r_{14}p_{45}$$

$$r_{25} = r_{12}p_{15} + p_{25} + r_{23}p_{35} + r_{24}p_{45}$$

$$r_{35} = r_{13}p_{15} + r_{23}p_{25} + p_{35} + r_{34}p_{45}$$

$$r_{45} = r_{14}p_{15} + r_{24}p_{25} + r_{24}p_{35} + p_{45}$$

Where,

r_{12} ,r_{13}, r_{14}, etc. are the estimates of simple correlation coefficients between variable x_1 and x_2, x_1 and x_3, x_1 and x_4 etc. respectively, and p_{15}, p_{25}, p_{35}, and p_{45} are the estimates of direct effects of variables x_1, x_2, x_3, and x_4, respectively on the dependent variable x_5 (effect)

Residual effect, $p^2 R_5 = \sqrt{\{1- (p_{15}r_{15} + p_{25}r_{25} + p_{35}r_{25} + p_{35}r_{45})\}}$

Path coefficient was estimated for 24 characters (16 morphological and 8 anatomical) related to fibre yield viz. root length, plant height, base diameter, middle diameter, top diameter, petiole length, internodal length, leaf area, number of branch per plant, number of node, green weight with leaves, green weight without leaves, dry fibre weight, dry stick weight, number of fruits per plant, number of seed per plant, bark thickness, number of pyramid per TS, number of fibre bundle per TS, area of pyramid, number of arc per layer, ultimate fibre cell length, ultimate fibre cell breadth and length/ breadth ratio.

Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

Jute (*Corchorus capsularis* L, and *C. olitorius* L.) constitutes a major world crop, of particular importance to the economics of Bangladesh, China, India and Nepal. Besides, the potential value of *Corchorus* species as a food source in the commercial jute-growing areas needs to be explored. A secondary but extensive use of some of the herbaceous annual *Corchous* species, particularly *C. olitorius*, is their cultivation as a local leaf spinach-type vegetables both in the jute (fibre) producing countries and also in hot moist low land tropical and sub-tropical areas worldwide. The early references to the jute plant upto the middle of the eighteenth century concerned with identifying the pot-herb. Indeed, *C. olitorius* is still grown as a leaf vegetables in Greece (Macedania and Crete) and it is probable that *C. trilocularis* (Plate 2) is the plant that theophrastus recordes as being used in ancient Greece. The species *C. aestuans* L (Plate 6), *C. depressus* L. C. christensen, *C. fascicularis* Lam., (Plate1) *C. tridens*. L (Plate 4) and *C. trilocularis* are examples of edible green. The leaves are used in sances, relishes green salads, soups and mucilaginous dishes either alone or mixed with other local leaf vegetables.

This chapter comprises the presentation and discussion of the findings obtained from the study. The data pertaining to sixteen morphological and eight anatomical characters were computed and statistically analyzed and the results thus obtained are discussed below section wise

Plate 1 Morphological view of *Corchorous fascicularis* and its fruits

Plate 2 Morphological view of *Corchorous trilocularis* and its fruits

Plate 3 Morphological view of *Corchorous pseudo-olitorius* and its fruits

Plate 4 Morphological view of *Corchorous tridens* and its fruits

Plate 5 Morphological view of *Corchorous siliquosus* and its fruits

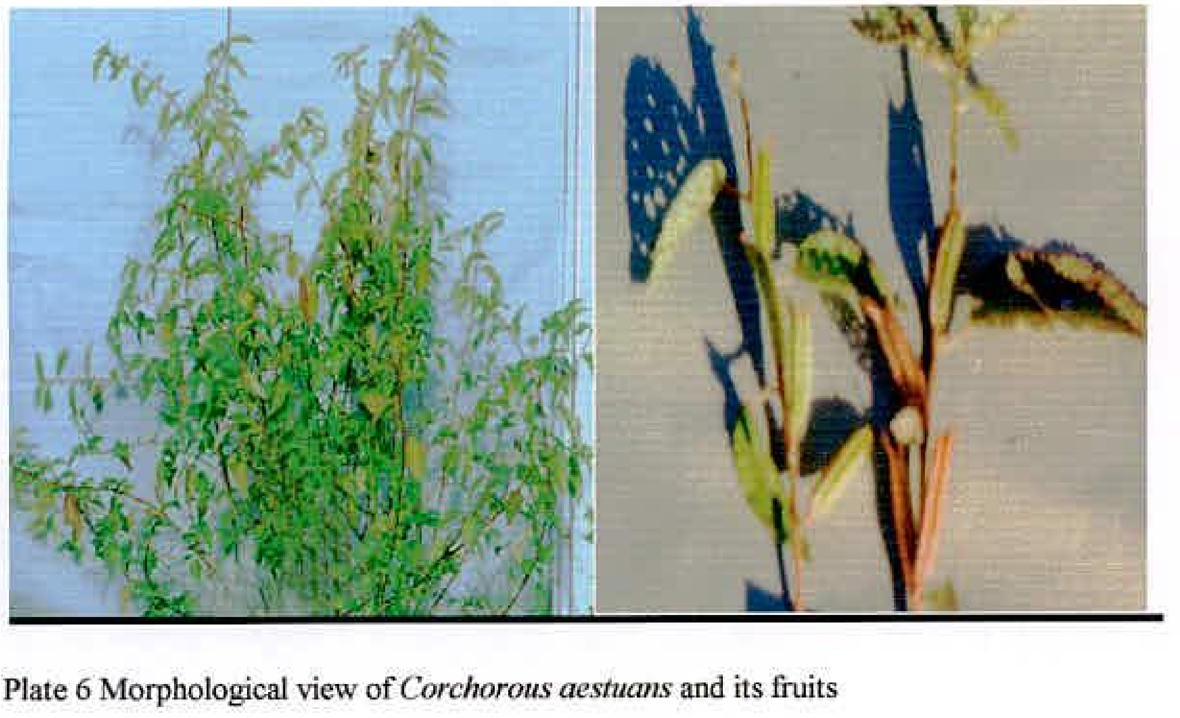

Plate 6 Morphological view of *Corchorous aestuans* and its fruits

Part1. Estimates of Genetic parameters for different morphological traits of wild *Corchorus* species.

Mean values, coefficient of variation, variance of genotypes and phenotypes, phenotypic, genotypic and environment coefficients of variation, heritability and genetic advance of the species in respect of 16 morphological characters are shown in Table 2 and 3.

4.1Variability

4.1.1 Root length

Root length of different species showed significant differences among the species, which ranged from 8.93cm to 20.38cm. *C. trilocularis* and *C. pseudo-olitorius* were statistically identical for root length (Table 2). Highest root length was found in *C. tridens*. Higher root length indicates this species may be drought tolerant. The wild East African species such as *C. aestuans*, *C. pseudo-olitorius*, *C. tridens*, *C. trilocularis* are found in a wide range of habitats (from very dry and near desert to swamps and flooded areas), and an a wide range of soil types. The incorporation of germplasm from such collections into controlled breeding programme should therefore broaden the genetic base of existing varieties and increase their adaptation to agro-ecological conditions, especially by increasing their drought, flood and problem-soil tolerance. Some of the *Corchorus* spp such as *C. fascicularis* have extremely woody tap-roots indicating their potentiality as drought resistance or problem-soil. Gomosta and Haque (1995) reported the association of greater rooting depth with drought tolerance in rice variety. The drought resistance or

Table 2. Mean performance of morphological characters of different wild *Corchorus* spp. under study

Parameters	*C. fascicularis*	*C. trilocularis*	*C. pseudo-olitorius*	*C. tridens*	*C. siliquosus*	*C.aestuans*	Mean	CV%	F-Test
RL	8.97d	11.63c	10.69c	20.38a	13.38b	8.93d	12.33	5.38	**
PH	1.30a	0.75b	1.318a	0.63c	0.57c	0.62c	0.86	2.85	**
BD	6.61b	4.64d	7.41a	5.99bc	5.66c	6.13bc	6.07	6.90	**
MD	5.16a	3.81c	4.58ab	3.84c	4.03bc	3.41c	4.14	8.54	**
TD	2.97a	2.25bc	2.16bc	1.74c	2.00bc	2.40b	2.25	12.49	**
PL	0.86b	0.71b	1.73a	1.25a	0.90b	0.82b	0.95	15.10	**
IL	2.60bc	5.47a	2.36bc	1.77c	3.07b	1.85c	2.85	17.58	**
LA	6.08bc	4.25cd	7.47b	3.33d	9.58a	4.26cd	5.83	18.72	**
BPP	8.33cd	4.67cd	3.67d	18.00b	10.33c	24.67a	11.61	27.40	**
NPP	53.33b	20.33e	60.00a	34.33c	28.00d	28.67d	37.44	6.79	**
FW	398.33a	132.33c	312.00b	103.67d	58.67e	51.33e	176.06	2.64	**
FWL	295.00a	201.33c	275.33b	92.33d	46.67e	39.00f	141.78	2.86	**
DFW	6.97a	1.34e	4.76b	4.21c	2.87d	1.89e	3.74	5.34	**
DSW	51.48a	15.03c	49.67b	13.17d	8.85e	10.39e	24.76	3.89	**
FPP	258.33a	114.33b	65.33bc	38.00c	98.67bc	65.67bc	106.72	34.13	**
SPF	15.00d	87.00a	78.00a	61.00b	61.67b	38.33c	56.83	13.60	**

* and ** Significant at 5% level and 1% level respectively

RL = Root length (cm), PH = Plant height (m), BD = Base diameter (mm), MD = Middle diameter (mm), TD = Top diameter (mm), PL = Petiole length (cm), IL = Internode length (cm), LA = Leaf area (cm^2), BPP = No. of branches per plant, NPP = No. of node per plant, FW = Fresh wt. with leaves (g), FWL = Fresh wt. without leaves (g), DFW = Dry fibre weight (g), DSW = Dry stick weight (g), FPP = No. of fruits per plant, SPF = No. of seed per fruit, upland varieties had higher root volume than the drought susceptible or lowland varieties (Ekanayake *et al.*, 1985 and zuno *et al.*, 1990).

From Table 3 it is revealed that the phenotypic coefficient of variation (35.03) and genotypic coefficient of variation (34.61) were close to each other indicating less environmental influence in the expression of this character. The greater heritability (97.64) together with high genetic advance (70.45) indicated a good scope of selection for improving this trait. .

4.1.2 Plant height

Significant differences were observed among the species for this character. Plant height ranged from 0.57m (*C. siliquosus*) to 1.31m (*C. pseudo-olitorius*). *C. tridens*, *C.siliquosus* and *C. aestuans* are statistically similar for plant height (Table 2). The maximum plant height was observed in species *C. fascicularis* & *C. pseudo-olitorius*. The results of this experiment support the findings of Sinha *et al.*, (2003). The little difference was observed in genotypic variance & phenotypic variance. The high heritability (99.18) coupled with high genetic advance in percentage of mean (82%) indicated that selection would be effective for this character (Table 3). The phenotypic coefficient of variation & genotypic coefficient of variation were close to each other, which indicated less environmental influence in expression of this character. Therefore, selection based upon phenotypic expression of this character would be effective for the improvement of this crop.

Table 3. Estimation of genetical parameters of morphological characters of different wild *Corchorus* spp.

Parameters	Mean	Range	σ^2_g	σ^2_p	σ^2_e	h^2 b	G.Ad. (5%)	G.Ad (% of Mean)	GCV	PCV	ECV
RL	12.33	8.93-20.38	18.221	18.662	0.441	97.64	8.687	70.457	34.61	35.03	5.38
PH	0.86	0.57-1.31	0.121	0.122	0.001	99.18	0.713	82.90	40.31	40.47	3.67
BD	6.07	4.64-7.41	0.805	0.979	0.175	82.22	1.675	27.594	14.77	16.29	6.89
MD	4.14	3.41-5.16	0.353	0.477	0.124	74.00	1.052	25.410	14.35	16.69	8.51
TD	2.25	1.74-2.97	0.149	0.228	0.079	65.35	0.642	28.564	17.12	21.18	12.47
PL	0.95	0.70-1.25	0.039	0.059	0.021	66.10	0.330	34.798	20.07	25.49	15.21
IL	2.85	1.77-5.46	1.636	1.888	0.252	86.65	2.452	86.058	44.82	48.14	17.59
LA	5.83	3.32-9.58	5.209	6.40	1.191	81.39	4.239	72.726	39.16	43.40	18.72
BPP	11.61	3.66-24.67	63.632	73.744	10.122	86.63	15.259	131.437	68.70	73.96	27.40
NPP	37.44	20.33-60.00	243.83	250.29	6.456	97.42	31.736	84.756	41.70	42.70	6.78
FW	176.06	51.33-398.3	20867.96	20889.59	21.622	99.89	297.30	168.864	82.05	82.09	2.64
FWL	141.78	39.00-295.0	12979.37	12995.76	16.389	99.87	234.495	165.394	80.35	80.41	2.85
DFW	3.74	1.73-6.96	3.958	3.998	0.040	98.99	4.076	109.010	53.32	53.48	5.35
DSW	24.76	8.84-51.48	404.32	405.25	0.928	99.77	41.638	167.079	81.12	81.13	3.89
FPP	106.72	38.00-258.3	5803.67	7130.72	1327.05	81.39	141.52	132.61	71.38	79.12	34.13
SPF	56.83	15.00-87.00	678.311	738.011	59.07	91.91	51.425	90.490	45.83	47.80	13.59

RL = Root length (cm), PH = Plant height (m), BD = Base diameter (mm), MD = Middle diameter (mm), TD = Top diameter (mm), PL = Petiole length (cm), IL = Internode length (cm), LA = Leaf area (cm^2), BPP = No. of branches per plant, NPP = No. of node per plant, FW = Fresh weight with leaves (g), FWL= Fresh weight without leaves (g), DFW = Dry fibre weight (g), DSW = Dry stick weight (g), FPP = No. of fruits per plant, SPF = No. of seed per fruit, σ^2_g = Genotypic variance, σ^2_p= Phenotypic variance, σ^2_e = Environmental variance, h^2 b = Heritability in broad sense, G.Ad. (5%) = Genetic advance, G. Ad (% of Mean) = Genetic advance in percent of mean, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, ECV = Environmental coefficient of variation.

4.1.3 Base diameter

Analysis of variance showed significant differences among the species for this character. The highest basal diameter was found in *C. Pseudo-olitorius* and it was closely followed by *C. fascicularis*, *C. aestuans*, *C. tridens* and *C. siliquosus*. The lowest basal diameter was observed in *C. trilocularis* (Table 2). This trait showed similar estimates of phenotypic coefficient of variation with the corresponding genotypic coefficient of variation (Table 3). The phenotypic variance (0.979) was higher than the corresponding genotypic variance (0.805). The high heritability (82.22) together with low genetic advance (27.59) indicated that selection for this character for breeding programme would not be effective. The results of this experiment support the findings of Dahal (1991) who found higher PCV than the corresponding GCV value and moderate heritability coupled with low genetic advance for basal diameter.

4.1.4 Middle diameter

The highest middle diameter was found in *C. fascicularis* (5.16mm) and it was closely followed by *C. pseudo-olitorius*, *C. siliquosus*. The middle diameter of *C. trilocularis*, *C.tridens* and *C. aestuans* were statistically identical (Table 2). The phenotypic coefficient of variation (16.69) and genotypic coefficient of variation (14.35) were close to each other, which indicated less environmental effect of this, character (Table 3). The high heritability (74.00) with lower genetic advance in percentage of mean (25.41) which indicate selection would not be effective for breeding program.

4.1.5 Top diameter

Significant difference was observed in the top diameter. The highest top diameter was observed in *C. fascicularis*, which was followed by *C. aestuans* (2.40mm). The top diameters of *C. trilocularis*, *C.pseudo-olitorius*, *C.siliquosus* were statistically similar (Table 2). The PCV (21.18) and GCV (17.12) were close to each other indicating less environmental effect on this character. The high heritablity (65.35) together with low genetic advance (28.56) indicate less scope of selection for the trait.

4.1.6 Petiole length

The highest petiole length was found in *C. pseudo-olitorius* (1.73 cm) and it was closely followed by *C. tridens* (1.25cm). The petiole length of *C. fascicularis*, *C. trilocularis*, *C. siliquosus*, *C. aestuans* were statistically identical (Table 2). The small differences were observed between PCV (25.49) & GCV (20.07). The high haritability (66.10) coupled with low genetic advance (34.74) indicated that selection on this trait would not be judicious.

4.1.7 Internode length

Significant difference was observed among the species for this character. The highest and the lowest internode length were observed in *C. trilocularis* (5.47 cm) and in *C. aestuans* (1.85cm) respectively. The phenotypic variance (1.888) was higher than the genotypic variance (1.636). Less difference between PCV (48.14) GCV (44.82) indicating effect of environmental was less. The high heritibility (86.65) together with high genetic advanced (86.05) indicates that selection for this character would be effective.

4.1.8 Leaf area

Analysis of variance showed significant differences among the species for leaf area. The maximum leaf area was found in *C. siliquosus* (9.58 cm^2) and it was closely followed by *C. pseudo-olitorius* (7.47cm^2) and *C. fascicularis* (6.08cm^2). The leaf area of *C.trilocularis* and *C. aestuans* (4.26 cm^2) were statistically similar. The lowest leaf area was observed in *C. tridens* (3.33 cm^2) (Table 2). The phenotypic variance (6.40) and genotypic variance (5.20) were close to each other indicating negligible environment influence on this trait. The difference between phenotypic coefficient of variation (43.14) and genotypic coefficient of variation (39.16) were also minimum (Table 3) indicating the genetic control of this trait. Estimated heritability (81.39) high and genetic advance (72.72%) also high. Higher estimates of heritability and genetic advance indicate a good scope of selection for improving this trait.

4.1.9 Number of branches per plant

Significant differences among the species were observed from the analysis of variance for this trait. The maximum number of branch was observed in *C. aestuans* (24.67) and it was followed by *C. tridens* (18.0). The minimum number of branch was observed in *C.pseudo-olitorius* (3.67), which was similar to *C. trilocularis*, & *C. fascicularis* but differed from other species (Table 2). The PCV (73.96) & GCV (68.70) were close to each other, which indicated less environmental effect in expression of this trait (Table 3). The estimated heritability was higher (86.63) and genetic advance in percentage of mean (131.43%) was also higher (Table 3). The high heritability coupled with high genetic advance indicates the selection for this character would be effective for breeding programme.

4.1.10 Number of nodes per plant

The mean value for number of nodes per plant showed significant differences among the species. The maximum node number was observed in *C. pseudo-olitorius* (60.00) and it was followed by *C. fascicularis* (53.33). The node number of *C. Siliquosus* and *C.aestuans* statistically identical and minimum node number were observed in *C.trilocularis* (20.33) (Table 2). The phenotypic varience (250.29) was close to genotypic variance (243.83) (Table 3). The environmental effect was observed less because PCV (42.70) & GCV (41.70) were close to each other. The heritability (97.42) & genetic advance (84.756) were very high which is indicating the scope of selection for the trait.

4.1.11 Green weight with leaves

The species differed significantly due to green weight with leaves. The green weight ranged from 51.33gm (*C. aestuans*) to 398.33gm (*C. fascicularis*) with a mean value of 176.06gm (Table 2). The PCV (82.09) & GCV (82.05) were identical which indicates less environmental influences of on this character (Table 3). The high heritability (99.89) together with high genetic advance (168.86%) indicates selection would be effective.

4.1.12 Green weight without leaves

The species varied significantly for green weight without leaves. The green weight without leaves ranged from 39.00gm (*C. aestuans*) to 295.00gm (*C. fascicularis*) with a mean value of 141.78 (Table 2). The phenotypic and genotypic variances were close to each other and PCV (80.41) & GCV (80.35) were also close to each other which indicating less environmental influences in this character. The estimated heritability (99.87) and genetic advance were high (165.39) (Table 3). The high heritability coupled with high genetic advance indicated that selection would be suitable for future breeding programme.

4.1.13 Dry stick weight

The species differed significantly for dry stick weight . The highest dry stick weight was observed in *C. fascicularis* (51.48gm) and it was followed by *C. pseudo-olitorius* (49.67gm). The lowest dry stick weight was also observed in *C. siliquosus* (8.85gm) (Table 2). The PCV and GCV were similar, which is indicating less environmental effect on this trait (Table 3). The high heritability (99.77) together with high genetic advance (167.07) indicated the scope of effective selection for this character.

4.1.14 Dry fibre weight

Significant differences were observed among the species for this character. The lowest fibre yield (1.34gm) was observed in *C. trilocularis* highest (6.97gm) in *C. fasciculars* (Table 2). The PCV (53.48) and GCV (53.32) were close to each other indicating the genetic control of this trait. The heritability was higher (98.99) and genetic advance (109.01%) was also higher (Table 3). The high heritability together with high genetic advance provided opportunity for selecting high valued species for dry fibre weight.

4.1.15 Number of fruits per plant

Significant differences were observed among the species from the analysis of variance for this trait. The maximum number of fruit was observed in *C. fascicularis* (258.33) and the minimum was observed in *C. tridens* (38.00). The number of fruits in *C. pseudo-olitorius, C. siliquosus* and *C. aestuans* were statistically identical with mean value of 106.72 (Table 2). Small differences were observed between PCV (79.12) and GCV (71.38). The high heritability (81.39) coupled with high genetic advance (132.61) indicated the scope of selection for this character.

4.1.16 Number of seeds per fruit

The highest number of seeds per fruit was found in *C. trilocularis* (87.00) and it was followed by *C. pseudo-olitorius* (78.00). The lowest number of seeds was observed in *C.fascicularis*. The number of seeds in *C. tridens* and *C. siliquosus* were ststistically identical (Table 2). The PCV (47.80) and GCV (45.83) were close to each other, indicating less environmental effect on this trait. The higher phenotypic variance (738.01), high heritability (91.91) with high genetic advance (90.49) indicated that this trait might be taken into consideration while selecting a suitable species for breeding programme.

4.2 Correlation coefficient

Phenotypic and genotypic coefficient for dry fibre weight and yield contributing agronomic characters are presented in Table 4 and Table 5.

4.2.1 Phenotypic correlation coefficient

Positive and highly significant correlation was observed between plant height and dry stick weight (0.995**) followed by fresh weight without leaves and dry stick weight (0.991**); fresh weight with leaves and fresh weight without leaves (0.989**); plant height and fresh weight without leaves (0.984**); fresh weight with leaves and dry stick weight (0.979**); plant height and fresh weight with leaves (0.970**); number of node per plant with dry stick weight (0.920**); plant height and number of node per plant (0.898**); number of node per plant and fresh weight without leaves (0.895**); base diameter and number of node per plant (0.879**); fresh weight with leaves and dry fibre weight (0.859**); middle diameter and fresh weight with leaves (0.856**); number of node per plant and fresh weight with leaves (0.855**); fresh weight without leaves and dry fibre weight (0.841**); top diameter and number of fruits per plant (0.836**); middle diameter and fresh weight without leaves (0.835**); number of node per plant and dry fibre weight (0.833**); middle diameter and dry fibre weight (0.827**); dry stick weight and dry fibre weight (0.826**); middle diameter and dry stick weight (0.824**); plant height and middle diameter (0.804**); plant height and dry fibre weight (0.773**); middle diameter and number of node per plant (0.751**); base diameter and dry stick weight (0.692**); plant height and base diameter (0.662*); middle diameter and number of fruits per plant (0.646*); fresh weight with leaves and number of fruits per plant (0.640*); base diameter and fresh weight without leaves (0.635*); base diameter and dry fibre weight (0.626*); internode length and number of seeds per fruits (0.617*); base

Table 4. Phenotypic correlation coefficients among different pairs of morphological characters of different wild *Corchorus* spp.

	PH	BD	MD	TD	PL	IL	LA	BPP	NPP	FW	FWL	FPP	SPF	DSW	DFW
RL	-0.461	-0.198	-0.253	-0.641*	0.577*	-0.155	-0.225	0.193	-0.237	-0.388	-0.345	-0.463	0.330		
PH		0.662*	0.804**	0.524*	0.158	-0.239	0.208	-0.566*	0.898**	0.970**	0.984**	0.512*	-0.647*	0.995**	0.773**
BD			0.581*	0.261	0.500	-0.668*	0.283	-0.020	0.879**	0.576*	0.635*	0.098	0.307	0.692**	0.626*
MD				0.475	0.265	-0.032	0.391	-0.467	0.751**	0.856**	0.835**	0.646*	-0.318	0.824**	0.827**
TD					-0.395	0.067	0.034	0.005	0.332	0.570*	0.493	0.836**	-0.554*	0.498	0.443
PL						-0.498	0.341	0.164	0.424	0.131	0.212	-0.352	0.152	0.201	0.395
IL							0.012	-0.524*	-0.446	-0.057	-0.089	0.228	0.617*	-0.148	-0.380
LA								-0.355	0.278	0.155	0.173	0.161	0.049	0.219	0.196
BPP									-0.332	-0.555*	-0.575*	-0.280	-0.379	-0.526*	-0.278
NPP										0.855**	0.895**	0.301	-0.276	0.920**	0.833**
FW											0.989**	0.640*	0.324	0.979**	0.859**
FWL												0.539*	-0.226	0.991**	0.841**
FPP													-0.546*	0.533*	0.581*
SPF														0.273	-0.508
DSW															0.826**

* and ** Significant at 5% level and 1%level

RL = Root length (cm), PH = Plant height (m), BD = Base diameter (mm), MAD = Middle diameter (mm), TD = Top diameter (mm), PL = Petiole length (cm), IL=Internode length (cm), LA = Leaf area (cm^2), BPP = No. of branches per plant, NPP = No. of node per plant, FW = Fresh weight with leaves (g) , FWL = Fresh weight without leaves (g), FPP = No. of fruits per plant, SPF = No. of seed per fruit, DSW = Dry stick weight (g), DFW = Dry fibre weight (g).

diameter and middle diameter (0.581*); number of fruits per plant and dry fibre weight (0.581*); petiole length and root length (0.577*); base diameter and fresh weight with leaves (0.576*); top diameter and fresh weight with leaves (0.570*); fresh weight without leaves and number of fruits per plant (0.539*); fruits per plant and dry stick weight (0.533*); plant height and top diameter (0.524*); plant height and number of fruits per plant (0.512*).

Negative correlation between base diameter and internode length (-0.668*); plant height and number of seeds per fruits (-0.647*); top diameter and root length (0.641*); branch per plant and fresh weight without leaves (-0.575*); plant height and branch per plant (0.566*); branch per plant and fresh weight with leaves (-0.555*); top diameter and number of seeds per fruits (-0.554*); number of fruits per plant and number of seed per fruits (-0.546*); branch per plant and dry stick weight (-0.526*); internode length and branch per plant (-0.524*) were recorded.

4.2.2 Genotypic correlation coefficient

Positive and highly significant correlation was observed between plant height and dry stick weight (0.996**) and it was followed by middle diameter and fresh weight with leaves (0.992**); fresh weight without leaves and dry stick weight (0.992**); fresh weight with leaves and fresh weight without leaves (0.990**); plant height and fresh weight without leaves (0.988**); fresh weight with leaves and dry stick weight (0.981**); plant height and fresh weight with leaves (0.974**); middle diameter and fresh weight without leaves (0.968**); middle diameter and dry fibre weight (0.965**); top diameter and number of fruits per plant (0.952**); middle diameter and dry stick weight (0.950**); base diameter and number of node per plant (0.941**); number of node per plant and dry stick weight (0.933**); plant height and middle diameter (0.917**); number of node per plant and fresh weight without leaves (0.908**); plant height and number of node per plant (0.907**); number of node per plant and fresh weight with leaves (0.866**); fresh weight without leaves and dry fibre weight (0.864**); fresh weight with leaves and dry fibre weight (0.864**); middle diameter and number of node per plant (0.852**); number of node per plant and dry fibre weight (0.847**); root length and dry fibre weight (0.829**); middle diameter and number of fruits per plant (0.821**); base diameter and dry stick weight (0.754**); plant height and dry fibre weight (0.753**); plant height and base diameter (0.717**); top diameter and fresh weight with leaves (0.701**); fresh weight with leaves and number of fruits per plant (0.701**); petiole length and root length (0.700**); base diameter and fresh weight without leaves (0.696**); base diameter and dry fibre weight (0.691**); base diameter and petiole length (0.669**); middle diameter and top diameter (0.660**); top diameter and dry stick weight (0.637*); plant height and top diameter (0.634*); base diameter and fresh weight with leaves (0.634*); number of fruits per plant and dry fiber weight (0.627*); top diameter and fresh weight without leaves (0.597*); internode length and

Table 5. Genotypic correlation coefficients among different pairs of morphological characters of different wild *Corchorus* spp.

	PH	BD	MD	TD	PL	IL	LA	BPP	NPP	FW	FWL	FPP	SPF	DSW	DFW
RL	-0.472	-0.224	-0.307	-0.852**	0.700**	-0.202	-0.282	0.205	-0.248	-0.395	-0.351	-0.541*	0.338		
PH		0.717**	0.917**	0.634*	0.186	-0.265	0.223	-0.610*	0.907**	0.974**	0.988**	0.568*	-0.618*	0.996**	0.753**
BD			0.548*	0.268	0.669*	-0.803**	0.287	-0.085	0.941**	0.634*	0.696**	0.033	0.343	0.754**	0.691**
MD				0.660*	0.222	-0.072	0.406	-0.704**	0.852**	0.992**	0.968**	0.821**	-0.423	0.950**	0.965**
TD					-0.632*	0.089	0.020	-0.127	0.403	0.701**	0.597*	0.952**	-0.748**	0.637*	0.465
PL						-0.714**	-0.042	0.102	0.545*	0.150	0.259	-0.544*	0.160	0.241	0.449
IL							0.002	-0.647*	-0.501	-0.063	-0.097	0.221	0.596*	-0.162	-0.427
LA								-0.470	0.305	0.172	0.190	0.183	0.040	0.239	0.190
BPP									-0.384	-0.598*	-0.621*	-0.418	-0.453	-0.575*	-0.362
NPP										0.866**	0.908**	0.336	-0.296	0.933**	0.847**
FW											0.990**	0.701**	0.335	0.981**	0.864**
FWL												0.591*	-0.237	0.992**	0.864**
FPP													-0.653*	0.577*	0.627*
SPF														0.282	-0.542*
DSW															0.829**

* and ** Significant at 5% level and 1%level respectively

RL = Root length (cm), PH = Plant height (m), BD = Base diameter (mm), MAD = Middle diameter (mm), TD = Top diameter (mm), PL = Petiole length (cm), IL=Internode length (cm), LA = Leaf area (cm^2), BPP = No. of branches per plant, NPP = No. of node per plant, FW = Fresh weight with leaves (g), FWL = Fresh weight without leaves (g), FPP = No. of fruits per plant, SPF = No. of seed per fruit, DSW = Dry stick weight (g), DFW = Dry fibre weight (g).

number of seed per fruits (0.596*); fresh weight without leaves and number of fruits per plant (0.591*); number of fruits per plant and dry stick weight (0.577*); plant height and number of fruits per plant (0.568*); base diameter and middle diameter (0.548*); petiole length and number of fruits per plant (0.545*).

Significant negative correlation was observed between top diameter and root length (0.852**) and it was followed by base diameter and internode length (-0.803**); top diameter and number of seed per plant (-0.748**); petiole length and internode length (0.714**); middle diameter and number of branch per plant (-0.704**); number of fruits per plant and number of seed per fruit (-0.653*); internode length and number of branch per plant (-0.647*); top diameter and petiole length (-0.632*); number of branch per plant and fresh weight without leaves (-0.621*); plant height and number of seeds per plant (0.618*); plant height and number of branch per plant (-0.610*); number of branch per plant and fresh weight with leaves (-0.598*); petiole length and number of fruits per plant (-0.544*); number of seed per fruits and dry fibre weight (0.542*); number of fruits per plant and root length (-0.541*).

From the study it is revealed that the genotypic correlation coefficient obtained between pairs of character in all possible combination were higher than their corresponding phenotypic correlation coefficient except between base diameter and middle, middle diameter and petiole length, leaf area and dry fibre weight, leaf area and green weight with leaves, leaf area and number of seed per fruits. This indicates fairly strong inherent association between yield and the characters studied.

4.3 Path coefficient

In order to find out a clear picture of the interrelationship between dry fibre weight and other morphological yield components, direct and indirect effects were worked out using path analysis. Dry fibre weight was considered as a resultant (dependent) variable and root length, plant height, base diameter, middle diameter, top diameter, petiole length, internode length, leaf area, number of branch per plant, number of node per plant, green weight with leaves, green weight without leaves, dry stick weight, number of fruits per plant, number of seed per fruit were independent variable. The association of characters for the fifteen causal variables with dry fibre weight related to phenotypic and genotypic path coefficient analysis have been presented in Table 6 and Table 7.

4.3.1 Root length

Root length had positive direct effect on dry fibre weight at phenotypic (1.791) and genotypic (0.472) level and it had negative correlation with fibre weight. At phenotypic level, the indirect positive effect of root length on fibre weight through fresh weight with leaves (1.284), fresh weight without leaves (1.989), base diameter (0.335) and number of fruits per plant (0.152). Other indirect effects were negligible. At genotypic level, the heights had indirect positive effect on dry fibre weight through green weight without leaves (2.375) which was followed by through fresh weight with leaves (2.274), base diameter (0.639) and petiole length (0.328).

Table 6. Path analysis of morphological characters of different wild *Corchorus* spp. at phenotypic level.

	RL	PH	BD	MD	TD	PL	IL	LA	BPP	NPP	FW	FWL	FPP	SPF	DSW	P. C. with DFW
RL	**1.791**	-0.979	0.335	-0.270	-0.799	-0.232	-0.058	0.014	0.047	-0.533	1.284	1.989	0.152	0.012	-2.866	-.043
PH	-0.825	**2.124**	-1.120	0.860	0.653	-0.063	-0.090	-0.013	-0.138	1.755	-3.211	-5.675	-0.168	-0.024	6.711	0.773**
BD	-0.354	1.406	**-1.692**	0.621	0.325	-0.201	-0.251	-0.017	-0.004	1.718	-1.907	-3.662	-0.032	0.011	4.667	0.626*
MD	-0.453	1.708	-0.983	**1.069**	0.592	-0.106	-0.011	0.024	-0.114	1.468	-2.834	-4.815	-0.212	-0.012	5.558	0.827**
TD	-1.148	1.113	-0.441	0.508	**1.246**	0.159	0.025	-0.021	0.001	0.649	-1.887	-2.843	-0.275	-0.021	3.359	0.443
PL	1.033	0.335	-0.846	0.283	-0.492	**-0.403**	-0.184	-0.021	0.040	0.828	-0.433	-1.222	0.115	0.005	1.355	0.395
IL	-0.277	-0.507	1.130	-0.034	0.083	0.197	**0.377**	-0.000	0.128	-0.871	0.188	0.513	-0.075	0.023	-0.998	-.380
LA	0.403	0.441	-0.479	0.418	0.042	-0.137	0.004	**-0.063**	-0.087	0.543	-0.513	-0.997	-0.052	0.001	1.477	0.196
BPP	0.345	-1.202	0.033	-0.499	0.006	-0.066	-0.197	0.022	**0.245**	-0.649	1.837	3.166	0.092	-0.014	-3.547	-.278
NPP	-0.424	1.907	-1.487	0.803	0.413	-0.170	-0.168	-0.017	-0.081	**1.954**	-2.830	-5.162	-0.099	-0.010	6.205	0.833**
FW	-0.694	2.060	-0.974	0.915	0.710	-0.052	-0.021	-0.009	-0.136	1.671	**-3.310**	-5.704	-0.210	0.012	6.603	0.895**
FWL	-0.617	2.090	-1.074	0.893	0.614	-0.085	-0.033	-0.010	-0.140	1.749	-3.274	**-5.767**	-0.177	-0.008	6.684	0.841**
FPP	-0.829	1.087	-0.165	0.691	1.042	0.141	0.085	-0.010	-0.068	0.588	-2.118	-3.108	**-0.328**	-0.020	3.595	0.581*
SPF	0.591	-1.374	-0.519	-0.340	-0.690	-0.061	0.232	-0.003	-0.092	-0.539	-1.072	1.303	0.179	**0.038**	1.841	-.508
DSW	-0.761	2.113	-1.171	0.881	0.620	-0.081	-0.055	-0.013	-0.128	1.798	-3.241	-5.715	-0.175	0.010	**6.745**	0.826**

Residual effect : 0.3812,

* and ** Significant at 5% level and 1%level respectively

RL = Root length (cm), PH = Plant height (m), BD = Base diameter (mm), MAD = Middle diameter (mm), TD = Top diameter (mm), PL = Petiole length (cm), IL=Internode length (cm), LA = Leaf area (cm^2), BPP = No. of branches per plant, NPP = No. of node per plant, FW = Fresh weight with leaves (g), FWL = Fresh weight without leaves (g), FPP = No. of fruits per plant, SPF = No. of seed per fruit, DSW = Dry stick weight (g), DFW = Dry fibre weight (g).

Table 7. Path analysis of morphological characters of different wild *Corchorus* spp. at genotypic level.

	RL	PH	BD	MD	TD	PL	IL	LA	BPP	NPP	FW	FWL	FPP	SPF	DSW	G. C. with DFW
RL	**0.472**	0.112	0.639	-0.409	-0.066	0.328	-0.041	0.259	0.004	-1.009	2.274	2.375	-0.589	-0.011	-4.387	-.048
PH	-0.223	**-0.238**	-2.047	1.222	0.049	0.087	-0.054	-0.204	-0.014	3.667	-5.607	-6.685	0.619	0.020	10.162	0.753**
BD	-0.105	-0.171	**-2.856**	0.730	0.020	0.314	-0.164	-0.263	-0.001	3.830	-3.650	-4.709	0.035	-0.011	7.693	0.691**
MD	-0.145	-0.219	-1.565	**1.333**	0.051	0.104	-0.014	-0.373	-0.016	3.468	-5.711	-6.550	0.895	0.014	9.693	0.965**
TD	-0.402	-0.151	-0.765	0.880	**0.077**	-0.297	0.018	-0.018	-0.002	1.640	-4.035	-4.039	1.037	0.025	6.499	0.465
PL	0.330	-0.044	-1.910	0.296	-0.049	**0.469**	-0.145	0.038	0.002	2.218	-0.863	-1.752	-0.593	-0.005	2.458	0.449
IL	-0.095	0.063	2.293	-0.096	0.006	-0.335	**0.204**	-0.001	-0.014	-2.039	0.362	0.656	0.240	-0.020	-1.652	-.427
LA	-0.133	-0.053	-0.819	0.541	0.001	-0.019	0.000	**-0.918**	-0.010	1.241	-0.990	-1.285	0.199	-0.001	2.438	0.190
BPP	0.096	0.145	0.198	-0.938	-0.009	0.047	-0.132	0.431	**0.023**	-1.563	3.442	4.202	-0.455	0.015	-5.866	-.362
NPP	-0.117	-0.216	-2.687	1.136	0.031	0.256	-0.102	-0.280	-0.008	**4.070**	-4.985	-6.144	0.366	0.010	9.519	0.847**
FW	-0.186	-0.232	-1.810	1.322	0.054	0.070	-0.012	-0.158	0.013	3.525	**-5.757**	-6.699	0.764	-0.011	10.009	0.864**
FWL	-0.165	-0.235	-1.987	1.290	0.046	0.121	-0.019	-0.174	-0.014	3.695	-5.699	**-6.767**	0.644	0.008	10.121	0.864**
FPP	-0.255	-0.135	-0.094	1.094	0.074	-0.255	0.045	-0.168	-0.009	1.367	-4.035	-3.999	**1.090**	0.022	5.887	0.627*
SPF	0.159	0.147	-0.979	-0.534	-0.058	0.075	0.121	-0.036	-0.010	-1.204	-1.928	1.603	-0.711	**-0.033**	2.877	-.542*
DSW	-0.203	-0.237	-2.153	1.266	0.049	0.113	-0.033	-0.219	-0.013	3.797	-5.647	-6.712	0.629	-0.009	**10.203**	0.829**

Residual effect : 0.4817,

* and ** Significant at 5% level and 1%level respectively

RL = Root length (cm), PH = Plant height (m), BD = Base diameter (mm), MAD = Middle diameter (mm), TD = Top diameter (mm), PL = Petiole length (cm), IL=Internode length (cm), LA = Leaf area (cm^2), BPP = No. of branches per plant, NPP = No. of node per plant, FW = Fresh weight with leaves (g), FWL = Fresh weight without leaves (g), FPP = No. of fruits per plant, SPF = No. of seed per fruit, DSW = Dry stick weight (g), DFW = Dry fibre weight (g).

4.3.2 Plant height

Plant height had positive direct effect on dry fibre weight at phenotypic level (2.124) and negative direct effect at genotypic level (-0.238) and it had also positive correlation with dry fibre weight. The indirect positive effect of plant height on fibre weight through dry stick weight, number of node per plant, middle diameter and top diameter were 6.711, 1.755, 0.860 and 0.653, respectively at phenotypic level. There was positive indirect effect of plant height through dry stick weight (10.162), number of node per plant (3.667), middle diameter (1.222) and number of fruits per plant (0.619) on dry fibre weight. The indirect negative effect may be nullified by positive indirect effect. Direct positive effect of plant height on dry fibre weight was reported by Islam *et al.*, (2004), Mondal *et al.,* (1980) and chaudhury *et al.*, (1981).

4.3.3 Base diameter

Base diameter had negative direct effect on dry fibre weight at phenotypic (-1.692) and genotypic (-2.856) level. But it was positive correlation with fibre weight at both levels. The base diameter contributed indirectly through dry stick weight (4.667), plant height (1.406), number of node per plant (1.718) and middle diameter (0.621) at phenotypic level on dry fibre weight. At genotypic level the indirect effect was through dry stick weight (7.693), number of node per plant (3.83) and middle diameter (0.730) on

dry fibre weight. Islam *et al.*, (2004) and chaudhury *et al.*, (1981) reported that the direct effect of base diameter was negative at geneotypic level which supported present findings.

4.3.4 Middle diameter

The direct effect of middle diameter on fibre weight was positive 1.069 and 1.333 at phenotypic and genotypic level, respectively. Middle diameter contributed indirectly through dry stick weight (5.558 and 9.693) & number of node per plant (1.468 and 3.468) at phenotypic and genotypic level, respectively. Other indirect effects were negligible. Fresh weights without leaves, fresh weight with leaves, base diameter and root length had negative indirect effect through middle diameter on dry fibre weight at both levels.

4.3.5 Top diameter

Positive direct effect was found in top diameter on dry fibre weight at phenotypic and genotypic level and it had positive correlation at both levels. Top diameter had positive indirect contribution through dry stick weight, plant height, number of node per plant, middle diameter at both phenotypic and genotypic levels.

4.3.6 Petiole length

Petiole length had negative direct effect (-0.403) on fibre weight at phenotypic level whereas at genotypic (0.469) level the effect was positive. These were also positive correlation with dry fibre weight at both levels. The indirect effect on dry fibre weight through dry stick weight (1.355), root length (1.033), number of node per plant (0.828) and plant height (0.335) were positive but negative indirect effect was observed through fresh weight without levels (-1.222), base diameter (-0.846) and top diameter (-0.492) on dry fibre weight.

4.3.7 Internode length

Positive direct effect of the trait was observed at phenotypic and genotypic levels, which were 0.377 and 0.204, respectively. The internode length contributed indirectly through base diameter (1.130), fresh weight without leaves (0.513) and fresh weight with leaves (0.188) on dry fibre weight at phenotypic level. Internode length contributed indirectly through base diameter (2.293), fresh weight without leaves (0.656) and fresh weight with leaves (0.362). On the other hand negative indirect effects of internode length through number of nodes per plant (-2.039), dry stick weight (-1.652) and petiole length (-0.335) at genotypic level on dry fibre weight were observed. The correlation was negative with fibre yield. It was suggested that during selection of wild *Corchorus* species the internode length to be minimized. Similar results were reported by Akter *et al*., (2005).

4.3.8 Leaf area

The direct effect of leaf area on fibre weight was negative which were -0.063 and -0.918 at phenotypic and genotypic level, respectively but it had positive correlation with dry fibre weight. Dry stick weight (2.438), number of node per plant (1.241) and middle diameter (0.451) contributed indirectly through leaf area on dry fibre weight at genotypic level. Similar result was observed by Islam *et al.*, (2004). He found that the direct effect of leaf area on fibre weight was negative.

4.3.9 Number of branches per plant

Number of branches per plant had small positive direct effect both at phenotypic and genotypic levels which were 0.245 and 0.023, respectively whereas it had negative correlation with dry fibre weight. Number of branches per plant contributed indirectly through fresh weight without leaves (3.166), fresh weight with leaves (1.837) and root length (0.345) at phenotypic level and fresh weight without leaves (4.202), fresh weight with leaves (3.442), leaf area (0.431), base diameter (0.198) and plant height (0.145) at genotypic level on dry fibre weight. The negative indirect effect was observed through dry stick weight (-3.547), plant height (-1.202), number of node per plant (-0.649), middle diameter (-0.499), internode length (-0.197) at phenotypic level and dry stick weight (-5.866), number of node per plant (-1.563), middle diameter (-0.938), number of fruits per plant (-0.455) at genotypic level.

4.3.10 Number of nodes per plant

The direct effect of nodes per plant on dry fibre weight was positive at both phenotypic and genotypic level. It had also positive correlation with dry fibre weight at both levels. The positive indirect effect of nodes per plant through dry stick weight (6.205), plant height (1.907) and middle diameter (0.803) at phenotypic level while the negative indirect effect was observed through fresh weight without leaves (-5.162), fresh weight with leaves (-2.830) and base diameter (-1.487) on dry fibre weight. Similar results were reported by Dahal (1991).

4.3.11 Fresh weight with leaves

Fresh weight with leaves had negative direct effect and it was -3.310 and -5.757 at phenotypic and genotypic level, respectively. It had positive correlation with dry fibre weight. Dry stick weight, plant height, number of node per plant and middle diameter had much indirect effects on fibre yield at both phenotypic and genotypic level. Dry stick weights, middle diameter, number of node per plant, number of fruits per plant had indirect positive effect on dry fibre weight at genotypic level. More or less similar result was observed by Akter *et al.*, (2005) and Islam *et al.*, (2004).

4.3.12 Fresh weight without leaves

Fresh weight without leaves had negative direct effect on dry fibre weight at both phenotypic and genotypic level. It had also positive correlation with dry fibre weight. Dry stick weight, plant height, middle diameter and number of node per plant had positive indirect effect whereas, fresh weight with leaves, base diameter and root length had fibre weight. Dry stick weight also contributed indirectly through plant height, number of node per plant, middle diameter and top diameter at phenotypic and genotypic level.

The phenotypic and genotypic residual effects of 0.3812 and 0.4817 respectivly indicated that there were other responsible traits for contribution to dry fibre weight but not taken into consideration in the present study.

Part 2. Genetic estimation of different anatomical characters of wild *Corchorus* species.

4.4 Analysis of variance and genetic parameters

The mean values, coefficient of variation (CV), genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance for 8 anatomical characters are shown in Table 8 & 9.

4.4.1 Bark thickness

Significant differences were observed among the species for this character. The heighest (1.010) bark thickness was observed in *C. tridens* and the lowest (0.2923) in *C.siliqusous*. The bark thickness of *C. fascicularis*, *C. trilocularis* and *C. pseudo-olitorius* were 0.3950, 0.3657 and 0.4243, respectively which was statistically similar

(Table 8). The less environmental influence in expression of this character because phenotypic coefficient of variation (58.493) and genotypic coefficient of variation (58.098) was identical (Table 9). High heritability (98.64) coupled with high genetic

Table 8. Mean performance of anatomical characters of different wild *Corchorus* spp.

Treatments	Bark thikness(mm)	No. of pyramid/TS	No. of fibre bundle/TS	Area of pyramid/TS	No.of arc/ layer	UFCL(μm)	UFCB (μm)	L/B ratio of UFC
Corchorus fascicularis	0.3950b	30.00c	29.67c	6.570c	4.667b	1803.70b	16.05a	112.38d
Corchorus trilocularis	0.3657b	23.33e	13.33e	4.857c	2.667c	1708.57c	14.92b	114.51d
Corchorus pseudo-olitorius	0.4243b	32.00b	27.33d	12.24ab	5.667b	1998.03a	15.00a	133.20b
Corchorus tridens	1.010a	42.67a	39.33a	14.18a	8.00a	1793.92c	14.50b	123.71c
Corchorus siliqusous	0.2923c	26.33d	30.00c	4.237c	4.000bc	1808.23b	12.98bc	139.30a
Corchorus aestuans	0.3070c	23.67e	32.33b	10.55b	3.667bc	1768.54c	13.78b	128.34c
Mean	0.466	29.667	28.667	8.773	4.611	1813.49	14.53	125.24
CV%	7.25	2.68	1.91	14.07	16.64	3.35	9.31	9.31
F-Test	**	**	**	**	**	**	**	**

* and ** Significant at 5% level and 1%level respectively

TS = Transverse section, UFCL = Ultimate fibre cell length, UFCLB = Ultimate fibre cell breadth.

advance (118.839) was observed for this character indicating a good scope of selection for this trait.

4.4.1 Number of Pyramids per TS

The mean value of number of Pyramids per TS showed significant differences among the species. The heighest number was observed in *C. tridens* (42.67) and lowest (23.33) in *C.trilocularis* (Table 8). The PCV (24.487) and GCV (24.340) were similar, which indicates less environmental influence in expression of this character (Table 9). The trait showed high heritability (98.80) and moderate genetic advance (49.839). The high heritatility together with moderate genetic abvance indicated that this trait might be taken into consideration while selection a suitable species

4.4.2 Number of fibre bundles per TS

The variance due to number of fibre bundles per TS showed that the species differed significantly. The maximum fibre bundle was found in *C. tridens* (39.33), which was followed by *C. aestuans* (32.33) and minimum in *C. trilocularis* (13.33). The number of fibre bundles per TS in *C. fascicularis* (29.67) and *C. siliqusous* (30.00) were statistically identical (Table 8). The PCV (29.92) and GCV (29.86) were same which indicated negligible environmental influence on this trait. The estimated heritability was very high (99.592) and genetic advance (61.386) also high. High heritability and genetic advance indicated a good scope of selection of traits for future breeding programme

Table 9. Estimation of statistical and genetic parameters of anatomical characters of different wild *corchorus* spp.

Parameters	Mean	Range	σ^2_g	σ^2_p	σ^2_e	h^2 b	G.Ad (5%)	G.Ad (%of Mean)	GCV	PCV	ECV
Bark thikness	0.466	0.29-1.01	0.073	0.74	0.001	98.64	0.553	118.839	58.098	58.493	6.786
No.of pyramid/TS	29.667	23.33-42.67	52.144	52.777	0.633	98.800	14.785	49.839	24.340	24.487	2.681
No. of fibre bundle/TS	28.667	13.33-39.33	73.277	73.577	0.300	99.592	17.597	61.386	29.860	29.921	1.910
Area of pyramid/TS	8.773	4.23-14.18	16.540	18.064	1.524	91.563	8.016	91.375	46.357	48.446	14.071
No. of arc/layer	4.611	2.66-8.00	3.111	3.7	0.589	84.081	3.331	72.254	38.252	41.716	16.644
UFCL(μm)	622.398	492.7-803.0	21452.263	21886.983	434.720	98.013	298.696	47.991	23.532	23.769	3.349
UFCB(μm)	11.084	7.55-13.37	5.811	6.876	1.065	84.511	4.565	41.997	21.748	23.657	9.310
Length breadth ratio of UFC	60.319	35.74-106.5	634.036	665.569	31.533	95.262	50.626	83.930	41.744	42.773	9.309
Dry fibre weight(gm)/plant	3.74	1.73-6.96	3.958	3.998	0.040	98.99	4.076	109.010	53.32	53.48	5.35

TS = Transverse section, UFCL = Ultimate fibre cell length, UFCLB = Ultimate fibre cell breadth.

σ^2_g = Genotypic variance, σ^2_p = Phenotypic variance, σ^2_e = Environmental variance, h^2 b = Heritability in broad sense, G.Ad. (5%) = Genetic advance, G. Ad (% of Mean) = Genetic advance in percent of mean, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, ECV = Environmental coefficient of variation.

4.4.3 Area of Pyramid per TS

Analysis of variance showed significant differences among the species for this trait. The maximum area of pyramid was found in *C. tridens* (14.18), which was followed by *C.pseudo-olitorius* (12.24) and the minimum in *C. siliqusous* (4.237), *C. trilocularis* (4.587) and *C. fascicularis* (6.570). The PCV (48. 446) and GCV (46. 357) were close to each other indicating less environmental effect on this trait (Table 9). High heritability (91.563) and high genetic abvance (91.375) estimated for this character indicated the scope of effective selection for this trait.

4.4.4 Number of Arc per layer

The variance due to number of arc per layer showed that the species differed significantly. The maximum arc per layer was found in *C. tridens* (8.00) and minimum in *C. trilocularis* (2.667). Estimated PCV (41.716) and GCV (38.252) were close to each other. This indicates that environmental influence was negligible for this trait (Table 9). The estimated heritability was high (84.081) and genetic advance in percentage of mean (72.254) also high. The high heritability and high genetic gain indicating selection would be suitable of this trait for future breeding programme.

4.4.5 Ultimate fibre cell length

The ultimate fibre cell length differed significantly among the species. The heights cell length was found in *C. pseudo-olitorius* (1998.03) and which *C. siliqusous* (1808.23) and *C. fascicularis* (1803.70) followed. The cell length of *C. trilocularis* (1708.57), *C. tridens* (1793.92) and *C. aestuans* (1768.54) were statistically identical (Table 8). The PCV

(23.769) and GCV (23.532) was same indicating the environmental influence was less. The high heritability (98.013) together with moderate genetic advance (47.991), indicating selection would be effective.

4.4.6 Ultimate fibre cell breadth

Significant differences were observed among the species. The heights cell breadth was found in *C. fasciularis* (16.05) which was followed by *C. pseudo-olitorius* (15.00), *C.trilocularis* (14.92). *C. tridens* (14.50), *C. aestuans* (13.78) and lowest in *C. siliqusous* (12.98). The difference between PCV (23.657) and GCV (21.748) was little, which indicates less environmental influence in expression of this character (Table 9). The trait showed high heritability (84.511) together with moderate genetic advance (41.997). High heritability with moderate genetic advance indicated that this trait might be taken into consideration while selecting a suitable line for breeding programme.

4.4.7 L/B ratio

The mean estimates of length breadth ratio varied significantly among the species. The ratio ranged from 112.38 (*C. fascicularis*) to 139.30 (*C. siliqusous*) with a mean value of 125.24 (Table 8). The estimated PCV (42.773) and GCV (41.744) close to each other indicating that the environmental control was negligible for this character (Table 9). High heritability (95.262) together with high genetic advance (83.93%) indicating selection would be suitable of trait for future hybridization programme.

4.5 Correlation Coefficient

Phenotypic and genotypic correlation for dry fibre weight and yield contributing anatomical characters are presented in Table 10.

4.5.1 Phenotypic correlation coefficient

Highly significant and positive correlation was observed between number of arc per layer and number of pyramid per TS (0.926**) and it was followed by bark thickness and number of pyramid per TS (0.924**); bark thickness and number of arc per layer (0.885**); area of pyramid per TS and dry fibre weight (0.858**); number of pyramid per TS and dry fiber weight (0.798**); number of arc per layer and dry fibre weight (0.792**); ultimate fibre cell length and length breadth ratio (0.784**); number of fiber bundle per TS and number of arc per layer (0.752**); bark thickness and dry fibre weight (0.723**); number of pyramid per TS and area of pyramid per TS (0.700**); number of arc per layer and area of pyramid per TS (0.687**); bark thickness and area of pyramid per TS (0.674**); number of fibre bundle per TS and number of pyramid per TS (0.664**); ultimate fibre cell length and dry fibre weight (0.638*); number of fibre bundle per TS and area of pyramid per TS (0.617*); bark thickness and number of fibre bundle per TS (0.558*); number of fibre bundle per TS and dry fibre weight (0.523*). Significant negative correlation was observed between ultimate fibre cell breadth and length breadth ratio (-0.663**).

Table 10. Correlation coefficient among different pairs of anatomical characters of different wild *Corchorus* spp.

Parameters		No. of fibre bundle/TS	No. of arc/ layer	No. of pyramid/TS	Area of pyramid/TS	Ultimate fibre Cell length	Ultimate fibre Cell breadth	Length breadth ratio	Dry fibre weight
Bark thickness	P	0.558*	0.885**	0.924**	0.674**	-0.299	0.342	-0.312	0.723**
	G	0.561*	0.951**	0.931**	0.695**	-0.309	0.355	-0.330	0.811**
No. of fibre bundle/TS	P		0.752**	0.664**	0.617*	0.085	-0.177	0.080	0.523*
	G		0.813**	0.667**	0.636*	0.081	-0.202	0.080	0.728**
No. of arc/layer	P			0.926**	0.687**	-0.062	0.134	-0.021	0.792**
	G			0.989**	0.742**	-0.093	0.075	-0.084	0.852**
No.of pyramid/TS	P				0.700**	-0.039	0.087	-0.019	0.798**
	G				0.724**	-0.041	0.087	-0.023	0.867**
Area of pyramid/TS	P					0.248	-0.082	0.285	0.858**
	G					0.239	-0.146	0.292	0.928**
Ultimate fibre Cell length	P						-0.357	0.784**	0.638*
	G						-0.392	0.808**	0.664**
Ultimate fibre Cell breadth	P							-0.663**	0.012
	G							-0.827**	0.003
Length breadth ratio	P								0.344
	G								0.354

* and ** Significant at 5% level and 1%level respectively

4.5.2 Genotypic correlation coefficient

Positive and highly significant correlation was observed between number of arc per layer and number of pyramid per TS (0.989**) and it was followed by bark thickness and number of arc per layer (0.951**); bark thickness and number of pyramid per TS (0.931**); area of pyramid per TS and dry fibre weight (0.928**); number of pyramid per TS and dry fibre weight (0.867**); number of arc per layer and dry fibre weight (0.852**); number of fibre bundle per TS and number of arc per layer (0.813**); bark thickness and dry fibre weight (0.811**); ultimate fibre cell length and length breadth ratio (0.808**); number of arc per layer and area of pyramid per TS (0.742**); number of fibre bundle per TS and dry fibre weight (0.728**); number of pyramid per TS and area of pyramid per TS (0.724**); bark thickness and area of pyramid per TS (0.695**); number of fibre bundle per TS and number of pyramid per TS (0.667**); ultimate fibre cell length and dry fibre weight (0.664**); number of fibre bundle per TS and area of pyramid per TS (0.636*); bark thickness and number of fibre bundle per TS (0.561*). Negative significant correlation was observed between ultimate fibre cell breadth and length breadth ratio (-0.827**).

4.6 Path coefficient

In order to find out a clear picture of the interrelationship between fibre weight and other anatomical yield components, direct and indirect effects were worked out using path analysis. Dry fibre weight was considered as a dependent variable and bark thickness, number of fibre bundle per TS, number of arc per layer, number of pyramid per TS, area of pyramid per TS, ultimate fibre cell length, ultimate fibre cell breadth, L/B ratio were independent variables.

The estimate of direct and indirect effects at both phenotypic and genotypic level has been presented in Table 11 and 12.

4.6.1 Bark thickness

The direct effect of bark thickness on dry fibre weight was high and positive at both phenotypic (7.0439) and genotypic (2.2403) level. It had also strong positive correlation with dry fibre weight. The indirect positive effect of bark thickness on dry fibre weight through number of fibre bundle per TS (0.1488) and number of arc per layer (1.8962) at both levels. Negative indirect effect was observed in number of pyramid per TS (4.0932), area of pyramid per TS (-1.0967), ultimate fibre cell length (-0.6340), ultimate fibre cell breadth (-o.3056), L/B ratio (-0.2004) at phenotypic level. The negative indirect effect via number of pyramid per TS (-2.6094), ultimate fibre cells length (-0.5524), area of pyramid per TS (-0.1959) and number of fibre bundle per TS was observed at genotypic level. The positive direct effects of bark thickness were reported by shao *et al.*, 1993.

4.6.2 Number of fibre bundle per TS

Number of fibre bundle per TS had positive direct effect (0.2667) on dry fibre weight at phenotypic level but it had negative direct effect (-0.1943) on dry fibre weight at genotypic level. The positive indirect effect through bark thickness (3.9305), ultimate fibre cell length (0.1802), ultimate fibre cell breath (0.1581) and negative indirect effect through number of pyramid per TS (-2.9414), area of pyramid per TS (-1.0039), number

Table 11. Path analysis of anatomical characters of different wild *corchorus* spp. at phenotypic level.

Par.	BT	NFB/TS	NAL	NP/TS	AP/TS	UFCL	UFCB	L/B,R	P. C. with DFW
BT	**7.0439**	0.1488	-0.1395	-4.0932	-1.0967	-0.6340	-0.3056	-0.2004	0.723**
NFB/TS	3.9305	**0.2667**	-0.1186	-2.9414	-1.0039	0.1802	0.1581	0.0514	0.523*
NAL	6.2338	0.2005	**-0.1577**	-4.1021	-1.1178	-0.1314	-0.1197	-0.0134	0.792**
NP/TS	6.5085	0.1771	-0.1460	**-4.4299**	-1.1390	-0.0827	-0.0777	-0.0122	0.798**
AP/TS	4.7476	0.1645	-0.1083	-3.1009	**-1.6271**	0.5259	0.0732	0.1831	0.858**
UFCL	-2.1061	0.0226	0.0097	0.1727	-0.4035	**2.1206**	0.3190	0.5038	0.638*
UFCB	2.4090	-0.0472	-0.0211	-0.3854	0.1334	-0.7570	**-0.8935**	-0.4260	0.012
L/B,R	-2.1977	0.0213	0.0033	0.0841	-0.4637	1.6625	0.5924	**0.6425**	0.344

Residual effect= 0.8618.

* and ** Significant at 5% level and 1%level respectively

BT = Bark thickness , NFB/TS = No. of fibre bundles/TS , NAL = No. of arc per layer , NP/TS = No. of pyramid/TS, AP = Area of pyramid/TS, UFCL = Ultimate fibre cell length , UFCB = Ultimate fibre cell breadth , L/B,R = Length/Breadth, Ratio, DFW = Dry fibre weight (g).

Table 12. Path analysis of anatomical characters of different wild *corchorus* spp. at genotypic level.

Par.	BT	NFB/TS	NAL	NP/TS	AP/TS	UFCL	UFCB	L/B,R	P. C. with DFW
BT	**2.2403**	-0.1090	1.8962	-2.6094	-0.1959	-0.5524	0.0523	0.0898'	0.811**
NFB/TS	1.2568	**-0.1943**	1.6211	-1.8695	-0.1793	0.1448	-0.0297	-0.0217	0.728**
NAL	2.1306	-0.1580	**1.9939**	-2.7720	-0.2092	-0.1662	0.0110	0.0228	0.852**
NP/TS	2.0858	-0.1296	1.9720	**-2.8028**	-0.2041	-0.0733	0.0128	0.0062	0.867**
AP/TS	1.5571	-0.1236	1.4795	-2.0293	**-0.2819**	0.4272	-0.0215	-0.0795	0.928**
UFCL	-0.6923	-0.0157	-0.1843	0.1149	-0.0673	**1.7877**	-0.0578	-0.2200	0.664**
UFCB	0.7965	0.0391	0.1494	-0.2438	0.0411	-0.7007	**0.1475**	-0.2253	0.003
L/B,R	-0.7393	-0.0155	-0.1675	0.0644	-0.0823	1.4445	0.1220	**-0.2722**	0.354

Residual effect = 0.8817,

* and ** Significant at 5% level and 1%level respectively

BT = Bark thickness, NFB/TS = No. of fibre bundles/TS, NAL = No. of arc per layer, NP/TS = No. of pyramid/TS, AP/TS = Area of pyramid/TS, UFCL = Ultimate fibre cell length , UFCB = Ultimate fibre cell breadth , L/B,R = Length/Breadth, Ratio, DFW = Dry fibre weight(g).

of arc per layer (-0.1186) at phenotypic level. At genotypic level positive indirect effect was observed through bark thickness (1.2568), number of arc per layer (1.6211) and negative effect was observed number of pyramid per TS (-1.8695), area of pyramid per TS (-0.1793).

4.6.3 Number of arc per layer

Number of arc per layer had negative direct effect at phenotypic level (-0.1577) and positive at genotypic level (1.9939) whereas it had positive correlation with dry fibre weight at both levels. At phenotypic level, the highest positive indirect effect through bark thickness (6.2338), number of fibre bundle per TS (0.2005) and negative effect through number of pyramid per TS (-4.1021), area of pyramid per TS (-1.1178), number of arc per layer (-0.1577), ultimate fibre cell length (-0.1314), ultimate fibre cell breadth (-0.1197). The negative indirect effect through number of pyramid per TS (-2.7720), area of pyramid per TS (-0.2092), ultimate fibre cell length (-0.1662), number of fibre bundle per TS (-0.1580) may be balanced by positive indirect effect through bark thickness (2.1306), L/B, ratio (0.0228) and ultimate fibre cell breadth (0.0110) at genotypic level.

4.6.4 Number of pyramid per TS

The direct effect of number of pyramid per TS on dry fibre weight was negative both phenotypic (-4.4299) and genotypic (-2.8028) level respectively. Number of pyramid per TS contributes indirectly through bark thickness (6.5085) and number of fibre bundle per TS (0.1771) at phenotypic level. At genotypic level it contributed indirectly through bark thickness (2.0858) and number of arc per layer (1.9720).

4.6.5 Area of pyramid per TS

Area of pyramid had negative direct effect on dry fibre weight both phenotypic (1.6271) and genotypic (-0.2819) level whereas it was positive correlation both phenotypic and genotypic level. At phenotypic level positive indirect effect was observed through bark thickness (4.7476), ultimate fibre cell length (0.5259), L/B ratio (0.1831), number of fibre bundle per TS (0.1645) and negative indirect effect was observed through number of pyramid per TS (-3.1009), number of arc per layer (-0.1083). At genotypic level, the high negative indirect effect via number of pyramid per TS (-2.0293) and number of fibre bundle per TS (-0.1236) may be balanced by positive indirect effect via bark thickness (1.5571), number of arc per layer (1.4795) and ultimate fibre cell length (0.4272).

4.6.6 Ultimate fibre cell length

Ultimate fibre cell length had high positive direct effect on dry fibre weight at phenotypic (2.1206) and genotypic (1.7877) level and it was also positive correlation with dry fibre weight at both levels. The negative indirect effect via bark thickness (2.1061) and area of pyramid per TS (-0.4035) may be nullified positive indirect effect via L/B ratio (0.5038), ultimate fibre cell length (0.3190) and number of pyramid per TS (0.1727) at phenotypic level. At genotypic level, negative indirect effect was observed through bark thickness (0.6923), L/B ratio (-0.2200), number of arc per layer (-0.1843) and positive effect via number of pyramid per TS (0.1149). Other indirect effect was negligible at both levels.

4.6.7 Ultimate fibre cell breadth

The direct effect of ultimate fibre cell breadth on dry fibre weight was negative at phenotypic level (-0.8935) and positive at genotypic (0.1475) level. The positive indirect effect via bark thickness (2.4090), area of pyramid per TS (0.1334) and negative indirect effect via ultimate fibre cell length (-07570), L/B ratio (-0.4260), number of layer per TS (-0.3854) were observed at phenotypic level. At genotypic level, negative indirect effect through ultimate fibre cell length (-0.7007), number of pyramid per TS (-0.2438), L/B ratio (-0.2253) may be balanced positive indirect effect through bark thickness (0.7965), number of arc per layer (0.1494) on dry fibre weight. Other indirect effect negligible on dry fibre weight.

4.6.8 L/B Ratio

L/B ratio had direct positive effect on dry fibre weight at phenotypic (0.6425) level but at genotypic level (-0.2722) it was negative. The indirect negative effect via bark thickness (-2.1977), area of pyramid per TS (-0.4637) may be nullified by positive indirect effect via ultimate fibre cell length (1.6625) and ultimate fibre cell breadth (0.5924) on dry fibre weight at phenotypic level. Negative indirect effect through bark thickness (-0.7393) and number of arc per layer (-0.1675) may be balanced by positive indirect effect via ultimate fibre cell length (1.4445) and ultimate fibre cell breath (0.1220) on dry fibre weight at genotypic level.

Phenotypic residual effect was (0.8618) and genotypic residual effect was (0.8817) which indicated that there were other responsible traits for contribution to dry fibre weight but not taken into consideration in the present study.

Chapter 5
Summary

SUMMARY

The present experiment was under taken to study the "genetic variability for morphological and anatomical traits viz. Root length, plant height, base diameter, middle diameter, top diameter, petiole length, internode length, leaf area, no.of branches per plant, no. of node per plant, fresh weight with leaves, fresh weight without leaves, no. of fruits per plant, no. of seed per fruits, dry fibre weight and dry stick weight in 6 *Corchorus* species.

All the species varied significantly for all the characters studied. Maximum and minimum root length was exhibited in *C. tridens* (20.38cm) and *C. aestuans* (8.93cm). The highest plant height was obtained in *C. pseudo-olitorius* (1.31m) and lowest in *C. Siliquosus* (0.57 m). The Base diameter ranged from 4.64mm (*C. trilocularis*) to 7.41mm (*C.pseudo-olitorius*). The highest middle diameter was obtained in *C. fascicularis* (5.16mm) and lowest in *C. aestuans* (3.41mm). The maximum and minimum top diameter was obtained in *C. fascicularis* (2.97mm) and *C. tridens* (1.74mm), respectively. The petiole length ranged from 0.82cm (*C.aestuans*) to 1.73cm (*C. pseudo-olitorius*). The highest internode length was obtained in *C. trilocularis* (5.47cm) and lowest in *C. tridens* (1.77cm). The maximum and minimum leaf area was obtained in *C. siliquosus* (9.58cm^2) and in *C.tridens* (3.33cm^2). The highest number of branches per plant was obtained in *C. aestuans* (24.67) and lowest in *C. pseudo-olitorius* (3.67). The ranged of number of node per plant was 20.33 to 60.00 (*C. trilocularis* and *C. pseudo-olitorius*). The highest green weight with leaves was obtained in *C. fascicularis* (398.33gm) and lowest in *C. aestuans* (51.33gm). The maximum and minimum green weight without leaves was

obtained in *C.fascicularis* (295.00gm) and *C. siliquosus* (46.67gm). The highest dry fibre weight was obtained in *C. fascicularis* (6.97gm) and lowest in *C. trilocularis* (1.34gm). The range of dry stick weight 8.85gm to 51.48gm (*C. siliquosus* and *C. fascicularis*). The maximum and minimum number of fruits per plant was obtained in *C. fascicularis* (258.33) and *C. tridens* (38.00). The highest number of seed per fruits was obtained in *C. trilocularis* (87.00) and lowest in *C. aestuans* (38.33). The maximum bark thickness was obtained in *C. tridens* (1.010 mm) and minimum in *C. siliquosus* (0.2923). The highest number of pyramids per TS was obtained in *C. tridens* (42.67) and lowest in *C. trilocularis* (23.33). The number of fibre bundle per TS ranged from 13.33 to 39.33 (*C. trilocularis* and *C. tridens*). The highest area of pyamid per TS was obtained in *C. tridens* (14.18) and lowest in *C. siliquosus* (4.237). The maximum and minimum number of arc per layer was obtained in *C. tridens* (8.00) and *C. trilocularis* (2.667). The ranged of ultimate fibre cell length 1708.57(µm) and1998.03 (µm) obtained in *C. trilocularis* and *C. pseudo-olitorius*. The highest ultimate fibre cell breadth was obtained in *C. fascicularis* (16.05µm) and lowest in *C. siliquosus* (12.98µm). The maximum and minimum L/B ratio of UFC was obtained in *C. siliquosus* (139.30) and *C. fascicularis* (112.38). In respect of morphological character *C. fascicularis* had the highest dry fibre weight (6.97gm) with highest plant height, middle diameter, top diameter, green weight with leaves, green weight without leaves and dry stick weight. The second highest dry fibre weight was obtained from *C. pseudo-olitorius* with the highest basal diameter, petiole length and number of node per plant. In the anatomical study *C. tridens* showed better performance for bark thickness, number of pyramids per TS, number of fibre bundles per TS, area of pyramids per TS and number of arc pre layer. So, *C. fascicularis* and *C. tridens* might be considered prospective parents in future breeding programme.

Both higher estimates of phenotypic and genotypic variances were observed in number of fruits per plant, green weight with leaves, green weight without leaves, number of seeds per fruit, dry stick weight, number of node per plant, ultimate fibre cell length, L/B ratio, number of fibre bundle per TS, number of pyramid per TS. Characters like plant height, internode length, leaf area, number of branch, green weight with leaves, green weight without leaves, dry fibre weight, dry stick weight, number of fruits per plant, number of seeds per fruit, bark thickness, area of pyramid per TS and dry fibre weight showed higher genotypic coefficient of variation value. Least differences between genotypic and phenotypic coefficient of variation were observed in plant height, green weight with leaves, green weight without leaves, dry fibre weight, dry stick weight, bark thickness, number of pyramid per TS, number of fibre bundles per TS, dry fibre weight indicated that there were less environmental influences for the expression of those traits. High heritability estimating were observed in all the characters studied. High heritability with high genetic advance in percentage of mean were also observed in all of the characters except base diameter, middle diameter, and top diameter and petiole length.

Correlation study revealed that the genotypic correlation coefficient were higher than phenotypic correlation coefficient. Dry fibre weight had significant and positive correlation with plant height, base diameter middle diameter, number of node per plant, green weight with leaves, green weight without leaves, dry stick weight, bark thickness, number of pyramid per TS, number of fibre bundle per TS, area of pyramid per TS, number of arc per layer and ultimate fibre cell length at both levels. So, selection on the basis of these characters should get preferences for further breeding programme.

The results of path coefficient analysis in morphological trait showed that dry stick weight had the highest (6.745) positive direct effect on dry fibre weight at both levels. The second highest positive direct effect was observed in plant height at phenotypic level and node per plant at genotypic level. The green weight with leaves, green weight without leaves and base diameter had negative direct effect on fibre weight at both levels. In anatomical traits bark thickness had the positives direct effect on fibre weight at phenotypic level which was followed by ultimate fibre cell length, number of fibre bundle per TS, while at genotypic level bark thickness also contributed the maximum direct positives effect on dry fibre weight which was followed by number of arc per layer and ultimate fibre cell length. Rest of the characters had contributed indirectly via other characters on dry fibre weight.

Chapter 6

Conclusion

CONCLUSION

Results of the present investigation indicated significant variation among the species for all the characters studied. The difference between the corresponding phenotypic and genotypic coefficient of variation was narrow for all the characters studied. The high heritability coupled with high genetic advance was observed for all the characters except base diameter, middle diameter and top diameter. The high heritability and moderate genetic advance was observed in number of pyramids per TS, ultimate fibre cell length and ultimate fibre cell breadth. These characters might be under genetic control and selection would be effective for future improvement.

Correlation studies showed positive and significant between fibre yield and its most components. The genotypic correlation coefficient was higher than their corresponding phenotypic correlation coefficient for most of the character pairs indicating less the environmental influence.

Path analysis showed highest positive direct effect of dry stick weight on dry fibre weight.

On the whole, the investigation revealed that no single morphological characters had major contribution to the fibre yield.

Chapter 7

Recommendation

RECOMMENDATION

1. Selection would be effective based on root length, plant height, internode length, leaf area, number of nodes per plant, green weight with leaves, green weight without leaves, bark thickness, number of fibres bundle per TS, area of pyramid per TS, number of arc per layer, length breadth ratio of ultimate fibre cell length.

2. Considering yield and other yield contributing characters, the species *C.fascicularis*, *C. pseudo-olitorius* and *C. tridens* showed better performance and can be included in the future hybridization programme.

3. Attention should be given on the anatomical characters of the stem for identification of high yielding species.

Chapter 8

References

REFERENCES

Akter, N., Ahmad, S., Islam, M. M., Islam, M. S. and Mian, M. A. K. (2003). Estimation of genetic variability, correlation and path analysis of anatomical traits in jute (*C. olitorius* L.). Bangladesh J. Pl. Breed. Genet., 16 (2): 31-36.

Akter, Nargis., Mian, M. A. K., Islam, M. M., Alim, M. A. and Islam, M. N. (2005). Estimation of genetic parameters, character association and path analysis in jute (*C. olitorius* L) germplasm. Bangladesh J. Pl. Breed. Genet., 18 (1): 35-38.

Aggarwal, V. D. (2000). Consultancy Report on Breeding Technique. Winrock International Institute for Agricultural Development 38, winrock Drive, Morrilton, Arkansas, USA.

Ahmed, S. S. and Khatun, R. (1997). Anatomical screening for selection of high yielding tossa jute (*C. olitorius* L.) Bangladesh J. P1. Breed. Genet. 10 (1&2): 9-12.

Ahmed, S. S., Muttalib, M. A. and Ahmed, A. (1993). Genetic variability, heritability and genetic advance of some quantitative characters in tossa jute, *C. olitorius* L. Bangladesh J. Jute Fib. Res. 18 (1-2): 103-108.

Alam, M. S., Ahmed, Q. N. and Ali, M. A. (1988). Correlation and path coefficient analysis for some anatomical characters in tomato. Bangladesh J. P1. Breed. Genet. 1 (1&2):42-46.

Ali, M. A. (1984). Correlation and regression studies between fibre yield and some anatomical characters in white jute. Bangladesh J. Jute Fib. Res. 9(1&2): 25-30.

Ali, M. A. (1986). Variability and correlation study of ultimate fibre in white jute. Bangladesh J. Jute Fib. Res. 11(1&2):1-5.

Ali, M. A. (1994). Genetic estimate of anatomical characters of white jute. Bangladesh J. Jute Fib. Res. 19(2):43-49.

Ali, M. A. and Haque, K. S. (1984). Length, breadth and length/breadth ratio of ultimate fibre cell of some land races of *C. capsularis* L. Bangladesh J. Jute Fib. Res. 9 (1&2): 65-70.

Al-Jibouri, H. A., Miller, P.A. and Robinson, H. F. (1958). Genotypic and environmental variances and covariance in an upland cotton cross of interspecific origin. Agron. J.50:633-636.

Anonymous, (1996). Technical Program, 1996, Bangladesh Jute Research Institute, Dhaka. PP. 101-105.

Anonymous, (2004). Weather Report, adjacent field, Bangladesh Jute Research Institute, Dhaka.

Arangzeb, S and Biswas, A. C. (1964). Comparative study of ulimate fibre cell-length of different varieties of *C. capsularis* L, Pakistan J. Sci.16:53:77.

Aziz, M.A. (1964). A new technique for maceration of fibre tissue. Pakistan J. Sci. Ind. Res. 7:76-77.

BBS, (2004). Year Book of Agriculture Statistics of Bangladesh for 2004. Bangladesh bureau of statistics, Planning Ministry, Dhaka.

Begum, H. A. and sobhan, M. A. (1991). Genetic variability, heritability and correlatin studies in *C. capsularis* L. Bangladesh J. Jute Fib. Res. 16(1&2):113-118.

Bhatt, G. M. (1973). Comparison of various methods of selecting parents for hybridization in common breed wheat (*Triticum aestivum*). Aus. J. Agric. Res. 24: 457-464.

Biswas, S. K. (1984). Genetic assessment of chemical mutagent population. Ph.D.Thesis, Bidhan Chandra Krishi Visawbidyalaya, Kalyani, West Bengal. India.

Burton, G. W. (1952). Qantative inheritance in grasses. Proc, sixth Int.Grassland Cong. 1: 277-283.

Chandra, S. (1977). Comparison of Mahalanobis's and Meteroglyph technique in the study of genetic divergence in *Linium usitatissium* L. Euphytica. 26: 141-148.

Chaudhury, R. (1998). Jute in Bangladesh. Bangladesh J. Jute Feb. Res. 25(1): 5-7.

Chaudhury, S.K., Sinha, M.K. and Singh, D.P. (1981). Path analysis in tossa jute. Indian J. Agric. Sci. 51(11): 772-775.

Chaudhury, S. K., Roy, M. K. G. and Sinha, M. K. (1985). Genetic variability and heritability studies in tossa jute germplasm. Jute Development J. 5(1): 36-37.

Chaudhury, S. K. (1984). Studies on the genetic variability in jute and its utilization for higher yield. Jute Agricultural Research Institute. Annnual Report-1984 JB 7, 20: 11.

Comstock, R. E. and Robinson, H. F. (1952). Genetic parameters, their estimation and significance. Proc.6th Intl. Grassland Cong. 1: 284-291.

Dahal, B. (1991). Genetic variability, correlation and path analysis studies on jute (*C. olitorius* L.). M.S. thesis. Rajendra Agricultural University, Bihar, Pusa, India.

Das, U. C. L. and Rakshit, S. C. (1988). Character association and path analysis in *C. olitorius* jute. Expt. Genet. 4(2): 48-52.

Das, U. C. L. (1987). Genetic evaluation of germplasm under indo-nepal Terai soil regions. Ph.D. thesis. Bidhan Chandra Krishi Viswabidyalaya, Kalyani,West Bengal. India.

Dewey, D. R. and Lu, K. H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51: 515-518.

Dixit, P. and Dubey, D. K. (1985). Heritability and genetic advance in induced mutant in Lentil. Indian J.Genet. 45(30): 520-524.

Dudley, J.W. and Moll, R. H. (1969). Heritability and genetic advances in plant Breeding Crop Sci. 9: 257-261.

Edmonds J. M. (1990). Systematic and ecogeographic studies on crop gene pools 4. Herbarium survey of African *Corchorus* L. species.

Ekanayake, I. J., O' Toole, J.C., Garrity, D. P. and Masajo, T.M. (1985). Inheritance of root characters and their relations to drought resistance in rice. Crop Sci. 25: 927-933.

FAO. (1997). Production Yearbook of Food and Agricultural Organization of the United Nations, Rome, Italy.

Gerstel, D. U. (1943). Inheritance in *Nicotiana tabacum*. x v п. Cytogenetical analysis of *Glutinosa* type resistance to mosaic disease. Genetics. 28: 533-536.

Gao, A. P., Gong, Y. C. and Chen, X. Q. (1994). Studies fibre fineness in Jute. Acta Agronomica Sinica 20(6):727-732.

Ghosdasitar, K. K. and Das, P. K. (1984). Selection breeding in *olitorius* jute. Prespective in Cytology and Genetic (ed .Manna, and U. Sinha) 4: 563-567.

Gomosta, A. R and Haque, M. Z. (1995). Leaf rolling and dessication tolerance in relation to rooting depth and leaf area in rice. International Rice Research Newsletter. 20(4): 7-8.

Hanson, C. H., Robinson, H. F. and Comstock, R. E. (1956). Biometrical studies of yield in segregation populations of korean Lespedza. Agron. J. 48: 268-272.

Islam, M. S., Mian, M. A. K., Ahmad, S., Hossain, T. and Hossain, M. A. (2002). Variability in anatomical characters in relation to fibre content and quality in tossa jute(*C. olitorius* L.). Bangladesh J. Pl. Breed. Genet. 15(2): 23-28.

Islam, M. S. and Ahmad, S. (2003). Genetic variability character association in *Corchorus olitorius* L. Bangladesh J. Life Sci. 15(2): 133-136.

Islam, M. S., Nasreen, A. Begum., S. and Haque, S. (2004). Correlated response and path analysis in tossa jute (*C. olitorius*. L.). Bangladesh J. Bot. 33 (2): 99-102.

IJO, (1994). Jute - Newsletter of International Jute Organization. 9(2):8

Islam, M. R. (1997). Genetic Divergence in *Corchorus olitorius* L. M. S. thesis, Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur.

Jana, M. K. (1972). Genetic analyasis of some quantative traits in jute. Ph.D. thesis. Bidhan Chandra Krishi Viswabidyalaya,West Bengal. India.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. (1995). Estimates of genetic and enviromental variability in Soybean. Agron. J. 47: 314-318.

Katiyar, R., Misra, P., Singh, S. N. and Chauhan, Y. S. (1974). Genetic variability, and heritability and genetic advance of yield and its components in Indian mustard. Indian J. Genet. Pl. Breed. 17: 318-328.

Kempthrone, O. (1957). An introduction to genetical statistics. John Wiley and Sons, Inc., New York. P. 545.

Khandakar, A. L., Begum, S. and Hossian, A. (1988). Correlation and distribution of assimilates to different sinks during growth of jute. Bangladesh J. Agric. (13): 61-64.

Khanna, K. K. and Chaudhury, R. C. (1974). The nature of gene action and combining ability for some vegetative characters in tomato. Euphytica. 23: 159-165.

Kundu, B. C. (1942). The anatomy of two Indian fibre plants, *Cannabinus* L. and *Corchorus* special reference of fibre distribution and development. J. Indian Bot. 21: 93-128.

Kundu, B. C., Basak, K. C. and Sarcar, P. B. (1959). In: Jute in India. ICJC, Calcutta. P.18.

Kundu, B. C. (1954). Jute-our wealth. The Indian Youth 6: 27-32.

Li, C. C. (1956). The concept of path coefficient and its impact on population genetics. Biometrics 12:190-210.

Ling, C. L. (1972). The correlation between the anatomy of the jute fibre cell and retted fibre quality. J.Taiwan Agric. Res. 21(2):103-117.

Lush, J. L. (1949). Heritability of quantative characters in farm animal's .proc.of. Intl. Cong, Genitica, Heriditas (Suppl.): 356-357.

Lush, J. L. (1940). Intrsire correlation and regression offspring in dams as a method of estimating heritability of characters. Proc. Amer. Soc. Animal prod. 33: 293-301.

Markes, G. E. (1960). Chromosome number in potato cultivars hypersensitive to late blight. Euphytica. 9: 254-257.

Maiti, S. N., Biswas, S. K. and Sen, S. (1977). A comparative study of selection indices in jute. Mysore J. Agril. 11(1):17-22.

Mandal, B. D., Chandra, N., Majumdar, M. K. and Banerjee, S. P. (1980). Pathway ti fibre yield in jute (*Corchorus olitorius* L.). Genitica Polonica. 21(4): 455-460.

Manjunatha, S and Sheriff, R. A. (1991). Variability, heritability correlation and divergence studies in Kenaf Golden Jubilee Symposium on genetic research and education.11:569.

Miller, P. J., Williams, J. C., Robinson, H. F. and Comstock, R. E. (1858). Estimates of genotypic and environmental variances and covariance in upland cotton and thier implications in selections. Agron. J. 50:126-131.

Nei, M. (1960). Studies on the application of biometrical genetics to plant breeding. Mem. Coll. Agric. Kyoto Univ. 82:1.

Pans, V. G. and Sukhatme, P. V. (1978). Statistical methods for agricultural workers. 3rd Edition. Indian Council of Agricultural Research. New Delhi. pp. 258-268.

Paul N. K. and Eunus. (1974). Correlation studies in jute (*C. olitorius* L.). Bangladesh J. Jute Fib. Res.1:8-15.

Rahman, A. and Hossian, M. (1982). Relationship between total yield of fibre and some anatomical characters of *C. capsularis* L, SABRAO. Journal. 14(1): 41-45.

Rahman, M. A. (1968). Inheritance of fibre yield in twelve parent diallel crosses of *Corchorus olitorius* L. Proc. PaK. Acad. Sci .5: 51-58.

Rao, N. S. and Saha, S. B. (1961). The dimensions of ultimate fibre and qulity of jute yarn. Indian Agri. 5: 108-110.

Robinson, H. F. (1966). Quantitative genetics in relation to breeding on centennial of Mendalism. Ind. J. Genet. 26:171-187.

Robinson, H. F., Comstock, R. E. and Harvey, P. H. (1949). Estimates of heritability and degree of Dominance in corn. Agron. J. 41: 353-359.

Robinson, H. F., Comstock, R. E. and Hervey, P. H. (1951). Geonotypic and phenotypic correlation in corn and their implications in selection. Agron .J.43:282-287.

Roy, B. (1965). Studies on correlation and means of yield components in relation to jute breeding. Indian Agri. 9(2): 107-111.

Sardana, S., Sasikumer, B. and Modak, D. (1990). Genetic variability, character associations and path analysis in jute germplasm. Bangladesh J. Bot. 19(1): 95-97.

Sarkar, G. (1988). Distribution of fibre on the stem of jute. J. Env. and Ecol. 6(3): 660-664.

Shaikh, M. A. Q., Ahmed, Z. U., Khan, A. I. and Majid, M. A. (1980). An anatomical screening approach to selection of high yielding mutants of jute. J. Env. and Exp. Bot. 20(3): 287-296.

Singh, D. P. (1976). Jute: Evolution of crop plants. In: N.W. Simonds (ed.), Longman publ. Co., London. PP. 290-291.

Singh, D. P. (1970). Estimates of correlation, heritability and discriminant function in jute (*C. olitorius* L.). Ind. J. Heredity. 2(1): 65-68.

Singh, D. P. (1976). Jute: Evolution of crop plants. In: N.W. Simonds (ed.), Longman Publ.Co., London. PP. 290-291.

Sinha, M. K., Roy, M. K. G. and Chaudhury, S. K. (1986). Correlation and path coefficient analysis in Mesta. Ind. J. Agril. Sci. 56(2): 83-85.

Sinhmahapatra, S. P. and Rakshit, S. C. (1977). Association of plant characters with fibre yield in *olitorius* jute. J. Soc. Expt. Agric. 2(1): 9-12.

Sobhan, M. A. (1982). Genetic Variability and correlation in tossa jute. Bangladesh J. Jute Fib. Res. 7(1&2): 97-101.

Steel, R.G. D. and Torrie, J. H. (1980). Principles and procedures of statistics. MeGrow- Hill Book co., Inc., New York.

Sukla, G. K., Das, D. and Bhattacharya, K. (1967). Correlation and regression studies on jute. Jute Bull. 30: 229-232.

Sukla, G. K. and Singh, D. P. (1967). Studies on heritability, correlation and discriminate function for selection in jute. Indian J.Genet and Pl. breed .27(2): 220-225.

Talukder, F. A. H. and Haque, M. M. (1992). Genotype x environmental interaction, heritability, genotypic variation and genetic advance in jute, *C. capsularis* L. Bangladesh J. Jute Fib. Res. 10(2): 211-215.

Thirthamallappa and Shariff, R. A. (1991). Genetic architecture of yield components in F2 generation of 10 x 10 diallel set of Roselle (*Hibiscus sabdariffa* L.). Golden Jubille Symposium on Genetic Research and Education. Vol. (11): 570.

Turkey, J. W. (1954). Causation, segregation and path analyasis of causal paths. Biometrics. 15: 236-258.

Willis, J. C. (1966). A dictionary of the flowering plants and ferns. Edited by Airy Show.H. K. Cambr. Univ. press, London.

Wright, S. (1921). Correlation and causation. J. Agric. Res. 20: 557-587.

Zheng, Y. Y., Lu, H. R., Wang, Y. J. and Qi, J. M. (1985). Correlation between the major economic traits of jute. Chian's Fibre Crops 3(5&6):41.

Zuno, C. C., Loresto, G. C., Osieno, M. and Chang, T. T. (1990). Root and shoot development of selected rice varieties as indices of drought avoidance. SABRAO J. 22(2): 131-142.

Appendix 1 Monthly summarized maximum temperature and minimum temperature and monthly rainfall during the cropping season at Bangladesh Jute Research Institute, Dhaka.

Month	Monthly rainfall (mm)	Mean daily temperature (°C max)	Mean daily temperature (°C min)
April 2004	167	34.5	25.2
May 2004	162	31.1	27.8
June 2004	460	32.1	25.8
July 2004	298	31.5	25.6
August 2004	167	31.7	27.0

Source: Physiology department, BJRI, Dhaka.

Appendix-II Area, production and yield of jute in Bangladesh

Year	Area in '000' ha.	Production in '000' tons	Yield kg/ha
1947-48	833.14	1221.41	1466.03
1948-49	759.44	978.02	1287.82
1949-50	631.65	594.91	941.83
1950-51	692.40	1072.32	1584.83
1951-52	719.86	1130.09	1569.87
1952-53	771.68	1217.86	1578.19
1953-54	390.88	644.34	1648.43
1954-55	503.11	832.23	1654.17
1955-56	661.47	998.22	1509.09
1956-57	497.88	984.24	1976.86
1957-58	632.18	1017.58	1609.64
1958-59	618.52	1071.15	1731.80
1959-60	556.52	957.32	1720.19
1960-61	614.25	1004.06	1634.61
1961-62	833.88	1243.90	1491.70
1962-63	697.31	1124.55	1612.70
1963-64	687.99	1048.69	1524.28
1964-65	671.80	951.09	1415.73
1965-66	889.50	1194.70	1343.11
1966-67	876.30	1142.40	1303.66
1967-68	946.07	1190.60	1258.47
1968-69	878.18	1027.14	1169.62
1969-70	997.46	1280.02	1283.28
1970-71	890.38	1190.60	1337.18
1971-72	678.09	748.49	1103.82
1972-73	896.28	1162.73	1297.28
1973-74	888.87	1071.00	1204.90
1974-75	573.26	1620.42	1082.27
1975-76	516.93	702.87	1359.70
1976-77	648.90	857.86	1322.02
1977-78	730.47	956.58	1309.54
1978-79	830.03	1150.08	1385059
1979-80	758.40	1064.40	1403.48
1980-81	634.91	882.33	1389.56
1981-82	571.43	829.31	1451.31
1982-83	668.15	1020.84	1527.86
1983-84	688.39	1025.84	1490.20
1984-85	676.24	912.31	1349.09
1985-86	924.32	1356.78	1467.87
1986-87	664.10	983.00	1480.00
1987-88	504.00	780.80	1549.00
1988-89	514.00	799.00	1554.00
1989-90	541.90	835.00	1541.00
1990-91	591.70	914.60	1546.00

1991-92	586.80	945.10	1611.00
1992-93	500.20	885.60	1771.00
1993-94	521.30	782.30	1500.00
1994-95	567.80	929.50	1640.00
1995-96	500.00	738.00	1480.00
1996-97	507.29	883.00	1740.62
1997-98	577.73	1057.00	1829.57
1998-99	478.13	812.00	1698.28
1999-2000	408.09	711.00	1742.26
2000-01	448.17	821.00	1831.89
2001-02	456.68	854.00	1880.09
2002-03	438.40	854.00	1947.99
2003-04	443.20	460.00	1940.43

Source: BBS and DAE, 2005