STUDY ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS OF COTTON (*Gossypium hirsutum*)

A THESIS

BY

JOYANTA KUMAR ROY

STUDENT NO.: 1305021

SESSION: 2013-2014

MASTER OF SCIENCE (MS)
IN
GENETICS AND PLANT BREEDING

DEPARTMENT OF GENETICS AND PLANT BREEDING
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
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DEDICATED
TO MY
BELOVED PARENTS

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Author

STUDY ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS OF COTTON (*Gossypium hirsutum*)

ABSTRACT

A field experiment was conducted in Randomized Complete Block Design (RCBD) with three replications in the experimental field of Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during July 2013 to March 2014 to study the yield and yield contributing characters of 20 cotton inbred lines T_1....T_{20} . Different yield and yield contributing characters such as number of vegetative branch, number of primary fruiting branch, number of secondary fruiting branch, node number of fruiting branch days to 50% flowering, days to 50% ball splitting. ball number per plant, plant height, ball weight and yield were studied.The number of vegetative branch was significantly varied from 3.633 to 4.5. Among the lines the maximum number of vegetative branch (4.5) was recorded in T_6 line and the minimum number of vegetative branch (3.633) was recorded in T_3 line.The maximum number of primary fruiting branch number (13.63) was recorded in T_{13} and T_{20} line and the minimum number (11,03) was in T_2 line.The maximum number of secondary branch numbers (12.37) were in T_{17} line and the minimum secondary branch number (9.3) were recorded in T_{10} line. The highest number of node for fruiting branch (7.37) found in T_{20} line and the lowest number of node of fruiting branch (5.12) found in T_3 line. Days to ball splitting were significantly different ranging from 101.3 to 118.1 days. The number of days required for ball splitting is significantly varied ranging from 45.87 to 57.10 days. The highest balls per plant (25.23) was found in T_{12} line followed by T_{16} and T_{19} line (24.9 and 26.83) respectively and the lowest balls per plant (18.00) was found in T_1 line followed by T_2 inbred lines (19.33) respectively. The ball weight was significantly varied from 4.333 to 6.35 g. The seed cotton yield was significantly varied from 1812 to 2977 kg/ha. The highest seed cotton yield (2977) found in T19 line and the lowest seed cotton yield (1812) in T_2 line.

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

SYMBOLES AND ABBREVIATIONS

σ^2e	: Environmental Variance
σ^2g	: Genotypic Variance
σ^2ph	: Phenotypic Variance
ANOVA	: Analysis of Variance
BBS	: Bangladesh Bureau of Statistics
cm	: Centimeter
CV	: Coefficient of Variance
df	: Degree of freedom
g	: Gram
GA	: Genetic Advance
GCV	: Genotype Coefficient of Variance
J	: Journal
MS	: Mean Sum of Square
MSE	: Error Mean Square
PCV	: Phenotypic Coefficient of Variance
Pi	: Phenotypic Index
RCBD	: Randomize Complete Block Design
S^2di	: Deviation from Regression
S^2e	: Pooled Variance
SE	: Standard Error

CHAPTER 1

INTRODUCTION

Bangladesh has a glorious historical reference of growing cotton of superfine quality cotton and it is one of the important cash crops. Cotton, being the king of fibers in preparing human apparel plays a key role in the Development of civilization. Due to its importance in agriculture as well as industrial economy, it is also known as "white gold". It is mainly used in textile industries. There are more than 140 spinning mills, over 280 weaving and over 60 dying and finishing mills in the country, which consume 2.5 million bales of cotton (BTMA, 2010). Cotton is an important fibre crop of global importance, which is grown in tropical and subtropical regions of more than 80 countriestheworld over. It provides livelihood to about sixty million people and is an important agricultural commodity providing remunerative income to millions of farmers both in developed and developing countries. Cotton provides raw material for various agro based industries like ginning factories, oil mills, textiles industries which also provide employment to thousands of people (Soomro, 2000).Generally, hybrid varieties exhibit high yield performance over HYV. Xu and Fok (2007) reported that average seed cotton yield of hybrid varieties was 3360 kg/ha and non-hybrid varieties was 3225 kg/ha. Begum *et al.* (2005) found that, higher average weight of seed cotton/boll increased the highest seed cotton yield. Boll size, boll wt. and fiber properties were positively correlated with flowering date and boll retention (Fan *et al.,* 1989).

1.1 Global production scenario of cotton

Cotton is the most widely used plant fibre and also the most important raw material for the textile industry, grown in tropical and subtropical regions in more than 80 countries all over the world. World consumption of cotton fibre is approximately 115 million bales per year. Pima cotton or Egyptian cotton, *Gossypium barbadense* is known for its better fibre properties being cultivated in less than 2% in the world (Chen *et al.*, 2007).Cotton is an important commercial crop providing lint as a raw material to the textile industry. It is an important natural fibre crop of global importance and widely referred as 'King of fibre crops'. The hybrid cotton occupies about 45 per cent of the total area and contributes about 55 per cent to the total production (Dongre and Parkhi, 2005). Globally, India ranks first in cotton area but occupies second position in production, next to China. Lower productivity in India is mainly due to cultivation of more than 75 per cent of cotton under rainfed conditions besides non-adoption of quality seeds, nutrient management and plant protection measures.

Cotton (*Gossypium hirsutum* L.) is an essential fibre as well as edible oil crop. It plays an important role in the economy of the country and has remained the central theme of self sufficiency program. In Pakistan, cotton is grown on area of about 2.98 m ha among which, Sindh shares 0.63 m ha (Laghari *et al.*, 2003). It enjoys prominent position in the between the various factors contributing to seed cotton economic perspective of Pakistan for its value and lint yield. Cotton is cultivated cover 2.820 mha .The increase yield of 713kg/ha, which contributed about 1.6 % value in ginning percentage may result in the reduction of staple added in GDP of Pakistan (Economic Survey, 2008-09).In India, in spite of severe competition from synthetic fibres in recent years, it is occupying the premiere position with 70 per cent share in the textile industry. There have been many factors which affect the cotton yield, like other cash crops. With regard to plant breeding studies, it is important that locations where plants are grown and determination of some traits which effect morphological and physiological characters of plants. Therefore, determination of direct and indirect relations among the traits is important in order to determine aspect of plant selection criteria.

1.2 Cotton cultivation in Bangladesh

In Bangladesh, cotton is generally grown as a rain fed crop. Two types of cotton are grown in Bangladesh namely- i) upland cotton (*Gossypium hirsutum*) and ii) hill cotton (*Gossypium arboreum*). American cotton that is upland is cultivated in the south western region, northern region and central region covering more than 32 districts out of 61 plain districts. Annual requirement of raw cotton for textile industry of Bangladesh is estimated around 2.5 million bales. However, local production is only about 0.1 million bales which meets up around 4-5% of the national requirement. The remaining 95-96% is fulfilled by importing raw cotton from United States of America (40%), Commonwealth of Independent States (35%), Australia, Pakistan, South Africa and other cotton producing countries (25%) (BTMA, 2010). Though cotton is an important cash crop and is an important raw material, the relative weight age of cotton within the cropping systems scenario is rather marginal. The area under cotton cultivation ranges only between 0.08 (2007-2008) and 0.27 percent (2008-2009) of the total cropped area, respectively (BBS, 2009). The current production of cotton in the country hardly meets up 4-5 percent of the requirement (CDB, 2009). Therefore, with a total land area suitable for cotton cultivation estimated 2.42 lakh hectares cotton production is taking place in 35 districts out of 64 districts in Bangladesh. After functioning of CDB (Cotton Development Board) the crop year 1997-98 saw the area devoted to cotton production peaked at a total of 54,429 hectares, or a utilization rate of 22.5% as a result of gradual expansion of coverage over the past 25 years. During the following crop year 1998-99, however, cotton areas shrank by 17.6% (42,640 ha) due to floods, low price, degeneration of yield capacity of existing varieties and lack of modern technologies. In crop year 2001-02 nevertheless, cotton areas reportedly started to increase again. American cotton hectarage, for instance, rose from 29,120 ha to 37,950 ha or an increase of 8,830 ha and ultimately reached at 41975 ha in the crop year 2006-07, an overall increase of 4,025 ha. One of the reasons for the limited increase in hectarage is the shift of farmers from cotton production to other crops. This is because of the declining economic prospect in cotton compared to the profits derived from growing vegetables, spices, tobacco, flowers, banana and other crops.

1.3 Importance of cotton in textile sector of Bangladesh

Bangladesh has a glorious history in textile production. The finest cotton fabric," Moslin" once produced in medieval Bengal was famous throughout the world. However, the production and trading of Moslin gradually declined during the British rule ultimately resulting to closure of the industry by early nineteenth century. During Pakistan era, there had been limited effort to introduce cotton in this part (East Pakistan) with little support for research and development of the crop and as a consequence cotton remained confined to laboratory until early seventies. Importance of producing cotton domestically strongly soon after the liberation of the country in 1971 when the supply of raw cotton was suspended from Pakistan.

Cotton is the main raw materials of textile industry. In Bangladesh garments industries contribute 27% of GDP (Gross Domestic Product), due to low labor costs and quota free export to the European markets. The garments industries have been flourishing in Bangladesh; ready-made garments (RMG) accounts for about 75% of the total export earning, but cotton production did not increase as expected due to several constrains. The highest domestic cotton production was 93,000 bales in 1997-98 against the total requirement of 1,20,000 bales for the year 2001-2002 (CDB, 2002 and BTMA, 2002). Cotton Development Board was targeted 50000 ha cultivation and expected production of 94000 bales lint in the year of 2007-08. This amount of domestic production of the total could cater only negligible proportion of the total requirement of the country's textile industry. The textile industry therefore, predominantly depends on imported cotton.

1.4 Scientific basis and statistical inference of the investigation

In order to increase the yield potential of cotton varieties, an understanding of the relationship among different plant character is of more importance, besides, knowledge about the direct contribution of different characters to seed cotton yield would be highly important for formulating a selection program (Thiyagu *et al.*, 2010). Crop yield is a complex character, its genetic analysis is rather difficult; seed cotton yield is the resultant product of component characters which are not under direct control of any gene. An improvement of yield and its components leads in the improvement of yield and its components. Knowledge of mechanism of association, cause-effect relationship and direct and indirect effects of the components/characters provide a basis in formulating suitable selection methods on the basis of yield components. The correlation analysis provides a good index to predict the corresponding change which occurs in one trait at the expanse of the proportionate change in the other (Khan *et al.*, 2007; Ahmad et al., 2008). Genetic variation and positive correlation in cotton between yield and its components was reported by (Iqbal *et al.*, 2003; Wang *et al.*, 2004). Suinaga *et al.* (2006), Taohua and Haipeng (2006), Khan *et al.* (2007) and Meena *et al.* (2007) studied the stability and adaptability of *Gossypium hirsutum* cultivars and observed varied values for different agronomic, morphological and yield related traits. Finlay and Wilkinson (1963) suggested that the mean yield and regression coefficient (b) of yield of genotypes over environments provides information for selecting cultivars with broad adaptability. Eberhart and Russell (1966) described that a desirable cultivar is one, which has high mean yield, a regression coefficient (b) close to unity and a small (close to zero) variance due to deviation from regression (S^2d). Selection of cultivar and interpretation of findings from the evaluation trials can be difficult, if there is significant interaction between genotype and environment. However, differential response of cotton varieties to different environments had led plant breeders to determine the phenotypic stability among genotypes (Baloch, 2001).

1.5 Aims and objectives of the investigation

However, this study was undertaken with the following objectives.

- To evaluate different yield and yield contributing characters in cotton genotypes.
- To select the appropriate genotypes for cultivation in Bangladesh.
- To find out the suitable characters responsible for further improvement.

CHAPTER 2

REVIEW OF LITERATURE

For yield improvement in Cotton, it requires information on materials for variation of yield and yield contributing characters and relationship between them. The research program was conducted to study the characteristics which have a direct or indirect influence on yield, the relationship between yield and yield attributing characters, genetic advance and divergence. Many researcher has conducted different works on different aspects for the improvement of this crop.In the present, study distinct experiment has been done to identify suitable genotypes responsible for higher yield. Most of the works related to the present study are reviewed here.

2.1 Analysis of genetic parameters of different characters in cotton

Ali*et al.* (2014)conducted an experiment to investigate the effects ofdifferent regimes of irrigation schedule onvarious vegetative and reproductive stagesof cotton crop. The results showed that irrigation effect was non-significant fornumber of plants m-2, while I_4 treatmentproduced maximum number of monopodial branches 2.18, but statistically it was at parwith I_3, I_5. I_4 treatment showed maximum number of sympodial branches (20.43) followed by I_3 (18.63). F.H-900 showed statistically higher sympodial branches(18.34) than the F.H-901 (17.08). Maximumnumber of flowers per plant was formed inthe I_4 treatment (101.00), followed by I_3 (96.31) and 15 (92.23). Significantly highernumber of flowers and boll drops were recorded in treatment I_1, followed by I_2.Flowers and boll drop per plant decrease with increase in irrigations applied to crop.Minimum number of flowers (60.45) and bolls (16.98) dropped per plant were in I_4 and 1_3 (65.0 and 22.72, respectively)

Gul *et al.* (2014) mentioned that Legacy of seed cotton yield and other quantitative traits is highly persuaded by environmental aspects, therefore, phenotypic response of a genotype is ascertained by genetic and environmental factors upon it, although occurrence of a third effect, of no less importance i.e. genotype-by-environment interaction (GEI). Studies were conducted in 2010 and 2011 evaluating G × E interactions and correlation in upland cotton using randomized complete block design at the University of Agriculture, Peshawar, Pakistan. The contribution to the total sums of squares, regardless of trait, revealed that genotypes and genotype × environment play principal role followed by environments, while replications (experimental error) share was minimal. The environment accounts for 61.86%, 26.99% and 18.64% of total variation for bolls plant-1, seed cotton yield and sympodia plant-1, respectively, considering the larger effects of environment in combination with genotypes on plant growth and morphology. Seed cotton yield has significant ($p \leq 0.01$) positive correlation with boll number, and positive with morphological traits. Based on two-year studies, CIM-496 exhibited the best performance followed by CIM-554 and SLH-284 for improvement in seed cotton and lint yields.

Ashok kumar *et al.* (2013) stated that Cotton fiber length, strength and fineness properties have vital influence textile industry. The developing high fiber length and strength cultivars or hybrids are essential to current modernized spinning mills. Therefore, the present study was carried out to assess the expression of *per se* performance and heterotic effect for fibre quality traits from 28 hybrids involving four adapted varieties as lines and the seven accessions as testers in Line x Tester analysis. Significant range of variability was observed all the traits in parents and their 28 hybrids. Fiber length in parents and their hybrids ranged from 23 to 32.9 mm and 25.40 to 33.3 mm, respectively. The hybrid MCU 12 x SOCC 17 and SVPR 2 x TCH 1641 for fiber elongation exhibited significant positive heterotic effects. Eleven hybrids showed significant negative heterotic effects for fiber fineness and hybrid MCU 5 × SOCC 17 displayed greater negative heterosis. Mean performance of bundle strength in parents and hybrids was 20.6 and 21.9 (g/tex), respectively.

Tamilselvam *et al.* (2013) stated that thirty-seven genotypes of American cotton were selected and Randomized block design was followed with two replicates.

Significant positive association was observed for number of bolls per plant, sympodial branches per plant, plant height and monopodium branches per plant with seed cotton yield per plant. Besides, these components had positive inter–relationships among themselves. Path-Coefficient analysis at genotypic level revealed that sympodia per plant, monopodia per plant and boll weight (g) had positive direct effect on seed cotton yield. Selection based on these characters may contribute considerably to improvement in seed yield.

Vineela *et al.* (2013) stated that the present investigation was conducted to elicit information on extent of genetic variability, heritability and genetic advance for twenty-one characters in 84 intra hirsutum cotton hybrids (*Gossypium hirsutum* L.) plus two checks which were derived by involving twelve lines and seven testers in line X tester fashion. These lines were developed from new heteroticgene pools. These 84 intrahirsutum cotton hybrids along with two checks were evaluated during kharif 2010-11. Wide variability was observed in case of number of sympodia, specific leaf weight, crop growth rate at peak flowering stage, crop growth rate at boll formation stage, crop growth rate at maturity stage. High heritability accompanied by high genetic advance was observed in case of plant height, number of monopodia, number of sympodia, relative water content, specific leaf weight, crop growth rate at peak flowering stage, crop growth rate at boll formation stage, crop growth rate at maturity stage, boll weight, seed index and lint index indicating the role of additive gene action in the inheritance of these traits and directional selection could be profitably applied on these traits in the genetically diverse material.

Kannan *et al.* (2013) studied Gene effects for 12 characters in three crosses of *Gossypium hirsutum* by six generation mean model to determine the potential for improvement of yield components and fiber quality in upland cotton. Additive genetic variance (gene action) was predominantly operating in the inheritance of boll weight, single plant yield, and lint index. In the presence of epistasis dominance and additive × additive gene effects were observed for boll weight, single plant yield, lint index, ginning outturn, 2.5 percent span length, bundle strength fineness and uniformity ratio. Boll weight, lint index, seed index, ginning outturn, fineness, bundle strength and uniformity ratio were predominantly under the control of dominance and dominance × dominance gene action. Duplicate type epistasis was noticed for all the studied characters and the possible breeding strategies for improvement of lint yield and quality traits were discussed.

Ali *et al.* (2012) conducted an experiment at the Regional Cotton Research Farm, Jagadishpur, Jessore during 2009-10 to evaluate six cotton varieties. Among them, four were hybrid cotton varieties and another two were inbreeds taken as control. Significant differences were found among the varieties for all traits except number of plants/ha and plant height at harvest. Hybrid variety SSC-3 performed well in terms of seed cotton yield (3570.33 kg/ha), lint yield (1404 kg/ha) and ginning out turn (GOT) percentage (43.83%).

Hossain *et al.* (2012) evaluated that Cotton yield, fiber quality and seed germination especially depend on cultivated variety, production technology and pest management techniques. In this study seeds of CB-3 and CB-9 cotton cultivars were treated with different dosages of Gaucho 70 WS and investigations were done to know their effect on seed germination and quality of crops. Results indicated that Gaucho 70 WS as seed dresser did not affect germination over a period of four weeks for both CB-3 and CB-9 cultivars. On the contrary, seed treatments showed significant effect on ginning out tern, seed index, lint index, fiber length and micronaire value of these two cultivars. Gaucho 70 WS as seed dresser revealed quality crops with proper seed germination indicated that this insecticide was suitable for CB3 and CB9 cultivars.

Khan *et al.* (2011) studied the nature and magnitude of genetic effects on morpho-yield traits in a 6×6 F1 and F2 diallel cross in upland cotton. An additive-dominance model was adequate for most of the traits except plant height and seed cotton yield, where the model was partially adequate. Genetic parameters were estimated following Hayman's and Mather's model. Additive effects controlled lint percentage and monopodia in both generations, and plant height and sympodia in F2. Non-additive inheritance with over-dominance controlled yield in both generations, and plant height and sympodia in F1. Most traits presented an unequal proportion of positive (U) and negative (V) alleles in the loci (H2<H1) and an asymmetrical distribution of genes in the parents (H2/4H1 < 0.25 and F different to zero). The value of H2/4H1 was lower than maximum value (0.25) for all of traits, which arises when U=V = 0.5 over all loci. Dominance effects (h2) for most of the traits suggested that substantial contribution of dominance was not due to heterogeneity of loci in these parameters. Broad and narrow sense heritabilities were high for most of the traits. Correlation coefficient between the Wr+Vr and mid parental (y) indicated that dominant genes were responsible for increased sympodia, lint % and yield, and recessive genes increased monopodia and plant height. Genetic gain was encouraging for most traits. Cultivar CIM-1100 was identified by genetic advancement as a promising parental cultivar to cross combinations.

Méndez-Natera *et al.*(2012)carried out an experiment to assess the general combining ability (GCA)and specific combining ability (SCA) of six important commercial cultivars of *Gossypium hirsutum* L. of Venezuela, viz., 'Deltapine 16', 'Tamcot-SP-21', 'Cabuyare', 'Stoneville','Ospino' and 'Acala 90-1' and their 15 *F1* hybrids, respectively. The data were analyzed using Griffing's Model I Method II. Significant differences were found for all traitsevaluated, except for seeds per boll and bolls per plant. Combining ability analysis ofvariance revealed significant differences for GCA and SCA effects among the parents andhybrids for almost all traits except for seed cotton yield ha-1 and fiber % for GCA andboll set, seed yield, and fiber % for SCA. The results suggested the presence of additiveand non-additive gene action for almost all of the traits. The ratio GCA/SCA ranged from0.59 for fiber fineness to 5.14 for plant height. Cultivars with the best (desired) GCAeffects were *cv.* Cabuy are for blooming initiation, seed yield, and fiber fineness; Stonevillefor plant height, stem diameter, number of fruit branches, number of set flowers, and bollweight; Tamcot-SP-21 for boll set and fiber fineness; Deltapine 16 for plant height, 100-seed weight and fiber length; Ospino for fiber strength. Also, the results revealed thatStoneville was the best general combiner for most of the traits. Finally, the correlationsamong GCA effects of the parents showed negative and significant associations of boll setwith plant height and positive and significant associations of fruit branches with plantheight, boll weight, and number of set flowers; of set flowers with plant height and bollweight; and of plant height with stem diameter.

Khan *et al.* (2011) studied that Upland cotton dominates the world's cotton fiber production accounting for approximately 90% of the total production. Fiber from various species within this genus had been used for several thousand years for clothing and other textiles in India, Nile valley and Peru.

Dhamayanathi *et al.* (2010) carried out a study during kharif 2006-07 with twenty five genotypes of cotton (*Gossypium barbadense* L.) to obtain information on genetic variability, heritability and genetic advance for seed cotton yield and its yield attributes. Significant differences were observed for characters among genotypes. High genetic differences were recorded for nodes/plant, sympodia, bolls as well as fruiting points per plant, seed cotton yield, lint index indicating ample scope for genetic improvement of these characters through selection. Results also revealed high heritability coupled with high genetic advance for yield and most of the yield components as well as fibre quality traits. Sympodia/plant, fruiting point /plant, number of nodes/plant, number of bolls per plant, and lint index were positively correlated with seed cotton yield per plant and appeared to be interrelated with each other. It is suggested that these characters could be considered as selection criteria in improving the seed cotton yield.

Soomro (2010) stated that Heritability, genetic advance, phenotypic and genotypic variancefor different quantitative traits is important in determining the effectiveness of selection. In this study the potential effectiveness of selection in parents and their F2 and F3 progenies of *Gossypium hirsutum* for plant height, sympodia/ plant, bolls/plant, boll weight, seed index and seed cotton yield/plant was determined. It was found that all the populations along with parents differed significantly ($P < 0.01$) and exhibited genetic variability among the genotypes for all the traits except sympodia / plant. Genetic parameters computed through variance components method show that all the traits were highly heritable in F2 and F3 generations except sympodia /plant, indicating quantitative pattern of inheritance, offering better chances of selection for these traits in F2 and F3 generations. The traits namely plant height, bolls/plant and seed cotton yield/plant displayed high heritability (72.97 - 75.55%) with remarkable genetic advance (112.46 - 357.01%) indicating that these traits were predominantly governed by additive gene effects and direct selection may be effective. Boll weight and seed index exhibited low genetic advances irrespective to their high heritability estimates, probably due to non-additive gene effects, developing transgressive segregants through hybridization is suggested. However, hybridization system, which exploits both fixable and non-fixable components, simultaneously, could be useful in the genetic improvement of yield and yield components in upland cotton.

Hasan *et al.* (2010)conducted an experiment at 4 (four) cotton research farms, located in Rangpur, Dinajpur, Jessore and Gazipur district during the season 2007-08 to evaluate the yield contributing parameters and yield of ten cotton variety. The experiment was set up in Randomized Complete Block Design (RCBD) with 3 replications. Cotton varieties were encoded as BC-040, BC -044, BC-0405, BC-0406, BC-037, BC0303 and SR-12 and two crossed materials of CDB encoded JA/2000/054 and JA/2000/526. CB-9 was taken as local control. Significant difference was found among the treatments for different agronomic and yield contributing parameters at different locations. Combination of four location's data showed that seed cotton yield as well as yield contributing parameters like number of vegetative branches per plant, node number of first sympodia, number of primary fruiting branches per plant, number of secondary fruiting branches per plant, days to first boll split, plant height at harvest, number of bolls per plant, single boll weight were affected by different treatments. The highest amount of seed cotton was produced by BC-0406 (2342kg/ha) followed by JA/2000/526 (2121kg/ha) and BC-0303 (2023kg/ha).These three line performed well in all location which indicates their wide adaptability and moderately high GOT%.

Ahmad *et al.* (2009) carried out in District Toba Tek Singh to evaluate the effect of plant spacing on growth, yield and quality of cotton variety BH-160 (*Gossypium* *hirsutum* L.). The treatments comprised of four plant spacing's viz. 15 cm, 22.5 cm, 30 cm and 37.5 cm. The experiment was laid out in randomized complete block design (RCBD) by using four replications. The data exhibited that plant spacing significantly influenced number of sympodial branches per plant, plant height (cm), number of bolls per plant, average boll weight (g), seed cotton yield per plant (g) and seed cotton yield (kg ha-1) while number of monopodial branches per plant, ginning out turn (%), fibre length (mm) and fibre fineness (µg inch-1) were affected non significantly by plant spacing. It is suggested that for the purpose of getting higher seed cotton yield per hectare the farmers should adopt the practice of growing cotton crop in general and particularly the variety BH-160 at plant spacing of 22.5 cm x 75 cm.

Karademir *et al.* (2009) carried out an experiment at the Southeastern Anatolia Agricultural Research Institute during 2006 and 2007 cotton growing season to facilitate the selection in cotton breeding program and estimate the general combining ability (GCA) of the parents and specific combining ability (SCA) of hybrids considered for the development of high yielding and better fiber quality in early generations.. Seven cotton lines (which are known as high quality) and three testers (which are known as well adapted and high yielding) were crossed in a line x tester mating design in 2006. Ten genotypes and 21 F1 hybrids were planted in the randomized complete block design with three replications at the same experimental area in 2007. The variance due to GCA and SCA were highly significant for all the traits studied. This indicated that both additive and non-additive gene effects were responsible for the investigated characters. From the trial it was found that in the population, fiber length, fiber fineness and fiber elongation were influenced by additive gene effects while seed cotton yield, fiber yield, ginning percentage, fiber strength and fiber uniformity were influenced by non-additive gene effects. Among the parents Fiber Max 832, Teks, Stoneville 453 and Maraş 92 for seed cotton yield and fiber yield; Aşkabat 71 and Giza 45 for fiber length and fiber strength; Askabat 71 for fiber fineness and fiber uniformity were detected with higher general combining ability. Most of the parents except Aşkabat 71, Giza 45 and Maraş 92 exhibited GCA for ginning percentage. SCA was significant for Fiber Max 832 x Stoneville 453, Tam 94 L 25 x Maraş 92 and Teks x Stoneville 453 hybrid combinations for yield with acceptable fiber quality.

Ten F2 intraspecific cross combinations derived from genetically diverse genotypes cotton (*Gossypium hirsutum* L.) were estimated for genetic selection parameters (Soomro *et al.*, 2008). All the F2 populations along with their respective parents were laid out in three replications in a randomized complete block (RCB) design at Agriculture Research Institute, Tandojam Sindh, Pakistan during 2004. The mean values of all the genotypes differed significantly ($P<0.01$) for all the characters understudy viz; number of sympodial branches per plant, boll weight, number of bolls per plant and seed cotton yield per plant. The results indicated that the hybrid FH-901 x Cedix produced significantly higher seed cotton yield per plant with maximum number of bolls per plant and higher boll weight followed by NIAB-78 x Cedix. The progeny NIAB-78 x Cedix performed better for number of bolls per plant and seed cotton yield per plant. It is concluded that a good prospects exist for selecting FH-901 x Cedix and NIAB-78 x Cedix hybrids for further synthesis and development of new cotton genotypes.

Ehsan *et al.* (2008) mentioned that varied values of plant height and other yield contributing traits could be attributed to diverse base of cotton genotypes. Significant differences were noted among cotton cultivars, environments, cultivar × environment interactions about plant height and other yield traits which may be due to distinct cotton genotypes grownunder diverse environmental conditions.

Hussain *et al* .(2007) stated that *Gossypium hirsutum* L. cultivars viz. CIM-446, NIAB-999, NIAB-111, and CIM-473 & RH-511 at the farmer's field under Toba Tek Singh, Pakistan conditions. The experiment was laid out in randomized complete block design(RCBD) and was replicated four times. The net plot size was 7.0 m x 4.5 m. The data on various crop growth, yield and quality attributes was recorded using standard procedures. Significant differences in respect of plant height at maturity (cm), monopodial branches plant-1, sympodial branches plant-1, number of bolls plant-1, mature boll weight (g), total seed cotton yield (kg ha-1), fiber strength (g tax-1), fiber fineness (mic.), staple length (mm) and ginning out turn (%) were observed among all the cultivars except plant population which showed non-significant results. Statistically the maximum seed cotton yield (2917 kg ha-1) was produced by cultivar NIAB-111 while the minimum seed cotton yield of 1315 kg ha-1 was produced by cultivar RH-511. It was revealed from the results that variety NIAB-111 proved to be best among all the five varieties particularly in respect of almost all the agro-qualitative characters under Toba Tek Singh conditions.

Khan *et al.* (2007) stated that Cotton is regarded as multipurpose agricultural product and used in the manufacturing of more than 1000 major products. Not only its fiber is important, but also thecotton seed is of economic importance and is used as an oilseed. After soybean, cotton is the second most important oilseed crop in the world. However, in Pakistan it contributes 65-70% to the local edible oil industry.

Manjunath *et al.* (2007) carried out investigations to study the varietal characterization of two inter specific (DCH-32 and DHB-105) and one intra specific cotton hybrid (DHH-11) and their parents for various morphological characters and showedvariation for leaf characters viz., leaf size, leaf shape, leaf color, leaf incision and leaf hairiness. Whereas based on plant characters such as growth habit, stem pigmentation, stem hairiness and plant height (cm) and flower characters such as days to 50 per cent flowering, petal color, petal spot, anther color, position of stigma, boll shape, bract type and number of serrations on bract thus can be differentiated from each genotype.

Joshi *et al.* (2006) assessed the extent of variability, heritability and genetic advance per cent in 36 hybrids revealed that the GCV, heritability in broad sense and genetic advance as per cent of mean values were comparatively high for lint yield, seed cotton yield, number of sympodia per plant and plant height indicating the operation of additive gene action for these four traits. The correlation analysis indicated that lint yield and plant height had positive and significant correlation with seed cotton yield, while days to first flowering and days to 50% boll opening had negative and significant association with seed cotton yield. Path coefficient analysis revealed that among all the characters studied, lint yield should receive greater emphasis in cotton improvement programs as it contributes maximum direct effect and higher indirect effect through other characters.

Zakaria *et al* . (2006) Researched to delineate nitrogen, potassium, and mepiquat chloride (MC) effects on cotton performance has been primarily conducted with upland cotton (*Gossypium hirsutum* L). A field study was conducted at the Agricultural Research Center, Giza, Egypt, to evaluate N, K, and MC effects on yield, yield components, and fiber properties of Egyptian cotton (*Gossypium barbadense* L). The experimental treatmentswere N rates of 95 or 143 kg ha-1, foliar K at 0.0,319, 638, or 957 g ha-1 applied 70 and 95 daysafter planting, and MC applied 75 days afterplanting at 0.0 or 48 g ha-1, and 90 days afterplanting at 0.0 and 24 g ha-1. Number of openedbolls per plant, boll weight, seed index, lint index,seed cotton yield per plant, and seed cotton and lint yield per hectare increased with the higher N rate and with foliar application of K and MC. There were no interactions among N, K, and MC on yield, and applications increased average lint yield 125 kg ha-1. Effect on earliness of harvest was inconsistent, and harvest maturity increased from 69% to 72% with application of K and MC in the second season. Nitrogen, K, and MC effects on fiber properties were small and inconsistent. The combination of the three inputs increased length 0.3 mm, micronaire 0.1 units, and strength 0.39 cN tex-1 (0.4 g tex-1). Under the conditions of this study, applying N at 143 kg ha-1 combined with foliar application of K at 319 g ha-1 and MC at 48 + 24 g ha-1 improved growth and yield of Egyptian cotton.

Saeed *et al.* (2006) studied Combining Ability Analysis in Upland Cotton (*Gossypium hirsutum* L.) Combining ability analysis for seed cotton yield and other related traits were studied in a set of diallel crosses involving five cotton genotypes of upland cotton. Both additive and non-additive gene effects were important in the inheritance of most ofthe traits. The parent CIM- 473, NIAB- 999 and ACALA1517/C showed high GCA while cross CIM- 473 x NIAB- 999 exhibited high SCA. Aforementioned parents and cross could be utilized for further selection of high yield.

Rauf *et al.* (2004) mentioned that Seed cotton yield was highly affected directly and indirectly by boll number and boll weight in upland cotton.

Mandloi *et al.* (1996) carried out Genotype-environment interaction, correlation and direct effects on seed cotton yield on 20 genotypes of upland cotton grown under three environments. The mean squares of genotype-environment interaction revealed significant differences for plant height, followed by monopodial branches/ plant, ginning percentage and bolls/plant in cotton. Mechanism of character association, cause-effect relationship via provide a basis for formulating suitable selection procedure

Krishnadoss and Kadambavanasundaram (1993) studied twelve genotypes of American cotton (*Gossypium hirsutum* L.) and 14 Egyptian cotton (*G. barbadense* L.) genotypes for genetic variability, heritability and genetic advance for seed cotton yield, halo length, ginning outturn, lint index, seed index, bolls per plant and boll weight. In *G. hirsutum* cotton, LRA 5166 and TKH 4–3 were superior for seed cotton yield, MCU 5, MCU 9 and MCU 11 were superior for halo length and RKR 4145 and HLS 321729 were superior for ginning outtum. In *G. barbadense* cotton, BCS 9–95 and TCB 87-6 were superior for seed cotton yield; IMS 0721, IMS 2722 and Suvin were superior for halo length and TCB 87-6, BCS 23-18-7 and RBS 85 were superior for ginning outturn. These genotypes could be exploited by inter-varietal hybridization within the species (pedigree breeding) for evolving a superior variety or by interspecies hybridization between the species (heterosis breeding) for developing a superior interspecific hybrid combining high yield and good fibre quality.

Singh and Gill (1986) studied 16 varieties grown at 4 sites in the Punjab and 2 in Haryana, genotypic variance predominated for number of sympodia, plant height, halo length, boll size, ginning outturn and seed index. They observed that genotype × environment interaction was important for number of bolls, boll size, seed index, halo length and yield indicating that these traits should be evaluated in a large number of environments such spacing sowing date etc.

2.2 Review of literature on Correlation analysis

Ahmad *et al.* (2014) stated that Correlation of the qualitative traits like flower shape, boll color and boll shape was analyzed with the yield and fiber quality traits. Ten varieties were crossed. Parents along with hybrids were sown in field in the research area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Studies revealed that tubular flower shape showed negative association with green boll color and ovate boll shape. Green boll color had negative correlation with ovate boll shape. The qualitative traits like flower shape, boll shape and boll color also act as markers for selection of polygenic traits like fiber quality and boll characteristics. Dark green boll color showed positive association with plant height, number of bolls per plant, boll weight, number of locales and fiber strength. Green boll color negatively correlated with tubular flower shape. Round boll shape had positive correlation with number of sympodial branches and boll weight. Ovate boll shape had negative association with fibre fineness and fibre strength. Tubular flower shape had negative association with plant height, number of sympodial branches, number of monopodial branches, number of bolls per plant, boll weight, and number of locules, GOT%, fiber fineness and fiber strength. Bell shape of flower had positive association with staple length. The association of quality with yield contributing traits may be helpful in future for the development of varieties.

Frasat *et al.* (2014) experimented that Cotton leaf curl virus disease (CLCuD) is one of the major factors limiting cotton production in Pakistan. For the assessment of genetic diversity one hundred cotton genotypes was evaluated for CLCuD tolerance, fiber quality, yield and some yield related traits. For evaluation of these traits cluster, principle components (PC) and correlation analysis were employed to obtain suitable parents that can be further exploited in a breeding program. CLCuD exhibited negative and significant association with seed cotton yield (-0.317**) while with other traits it showed non-significant correlation. The ginning out turn had a significant positive correlation (0.367**) with fiber fineness but negative and significant association (-0.273**) with fiber length. For staple length only positive and significant association was found with sympodia per plant (0.210**). Plant height showed positive association (0.661**) with sympodia per plant and seed cotton yield (0.233*) while sympodia per plant showed positive and significant association with seed cotton yield (0.271**). Principal component (PC) analysis showed first 5 PCs having eigen value >1 explaining 71.3% of the total variation with plant height, sympodia per plant and seed cotton yield being the most important characters in PC1. Cluster analysis classified 100 accessions into four divergent groups. In cluster 3 and 4 included genotypes with higher tolerance of CLCuD and better fiber quality along with higher yield potential were included. Scatter plot and tree diagrams demonstrated sufficient diversity among the cotton accession for various traits and some extent of association between different clusters. The results concluded that the diversity among the genotypes could be utilized for the development of CLCuD resistant varieties with higher lint yield and germ plasm conservation programs aimed at improving CLCuD tolerance with better fiber quality.

Jehanzeb (2013) carried an experiment to find out genotypic, phenotypic correlation coefficients and path analysis at the genotypic level between seed cotton yield, earliness, fiber and yield contributing traits in 31 cotton cultivars under CLCuV intensive conditions. The material was sown on 15th of June to observe their tolerance ability against Cotton leaf curl virus and influence of late sown conditions on association among fiber, earliness and yield related traits. Heritability was estimated to determine the selection criteria under virus intensive conditions for the studied traits. Phenotypic coefficient of variation (PCV%) was higher in magnitude than the genotypic coefficient of variation (GCV%) for all the traits. Heritability (broad sense) revealed higher estimates of fiber strength (97%), CLCuV% (97%), fiber fineness (91%), yield kg/ha (91%), boll weight (90%), plant height (87%), bolls per plant (86%), days taken to 1st flower (84%), Days taken to 1st bud (82%) while for nodes to 1st fruiting branch (56%), staple length (46%), monopodia per plant (42%) moderate but for GOT% (32%) and sympodia per plant (28%) low estimates were found. Regarding correlation studies seed cotton yield had only positive genotypic association with bolls per plant, plant height and sympodia per plant. Path coefficient analysis results revealed that all the traits indirectly influenced seed cotton yield. The traits like plant height, bolls per plant and sympodia per plant may be considered for selection in virus intensive conditions as they showed higher estimates of broad sense heritability along with positive and significant genotypic correlation with seed cotton yield.

Samia et al. (2013) carried out a study at Cotton Research Institute, AARI, Faisalabad, Pakistan during the year 2013 to determine the cause and effect of some morphological traits viz. number of leaves per plant, number of sympodial branches per plant, number of bolls per plant and plant height on seed yield per plant in upland cotton. Seventy two cotton genotypes at F5 generation were sown in a RCBD with three replications. The results indicated that number of leaves (0.2334), sympodial branches (0.4859) and number of bolls per plant (0.3722) had exerted positive and significant to highly significant correlation at genotypic level with seed cotton yield per plant. The data also revealed that number of leaves showed positive and highly significant correlation with sympodial branches (0.3427**) plant height (0.6924**) and bolls per plant (0.4238**). Number of leaves, bolls per plant and sympodial branches showed positive direct effect on seed-cotton yield per plant. Direct effect of sympodial branches on cotton yield was very high and positive. However, number of leaves showed positive indirect effect via sympodial branches, bolls per plant and plant height. Similarly sympodial branches had shown positive indirect effect on seed yield per plant via number of leaves and bolls per plant. Direct effect of number of leaves on seed-cotton yield per plant was low while indirect effect via number of bolls per plant was positive. The number of bolls per plant also showed positive indirect effect via number of leaves, sympodial branches and plant height but effect of plant height on cotton yield was negative via number of bolls and sympodial branches. The results conclude that sympodial branches per plant influenced the cotton yield per plant to greater extent. Hence selection based on this trait may lead to development of genotypes having high seed cotton yield potential.

Acharya *et al.* (2013) stated that Correlation and path coefficient analysis were carried on 28 interspecific hybrids and 8 parents of *hirsutum* cotton. Genotypic correlation studies revealed that number of bolls per plant, boll weight, number of monopodia per plant, number of sympodia per plant, seed index, lint index and plant height have significant association with seed cotton yield per plant. Path coefficient analysis showed that number of bolls per plant exhibited maximum direct effect on seed cotton yield per plant followed by boll weight, number of sympodia per plant and lint index. The maximum positive indirect effect on seed cotton yield per plant was observed through number of bolls per plant. Thus due emphasis should be given to number of bolls per plant, boll weight and lint index for improvement in seed cotton yield.

Khan *et al.* (2011) studied that the positive association was observed between sympodia and seed cotton yield. Significant differences were noted among cotton genotypes for sympodial branches, and their positive association with yield also revealed their affirmative impact on yield in upland cotton.

Saravanan *et al.* (2011) studied on correlation and indicated that intensive selection on the positive side for plant height, sympodia per plant, seed index, lint index, 2.5 per cent span length and bolls per plant since these characters showed positive correlation with seed cotton yield and also positive correlation among themselves. Days to flower initiation, micronaire value and elongation per cent showed negative correlation with seed cotton yield and hence a compromise towards selection is required in this case. Path coefficient analysis further revealed that bolls per plant played a major role in determining the seed cotton yield.

Salahuddin *et al.* (2010) reported on phenotypic correlation and path coefficient analysis have been worked out for some important characters in fifteen genotypes (six parents, nine crosses) of American upland cotton (*Gossypium hirsutum* L.) Sympodial branches, bolls per plant, boll weight, G.O.T (%) and lint index were found to be positively correlated with yield per plant in all the genotypes at 1.0% level of probability. Further partitioning of correlation coefficients into direct and indirect path ways of influences showed that the characters having most influence on seed cotton yield were bolls per plant and boll weight, which should be taken care of while selecting for higher yields in further breeding program.

Thiyagu *et al.* (2010) revealed that plant height, number of sympodial branches per plant, number of bolls per plant along with 2.5% span length, bundle strength and elongation percentage showed significant positive association with seed cotton yield per plant at genotypic level indicating that these characters can be improve simultaneously. The direct and indirect effect of path analysis revealed that the number of bolls per plant, boll weight, number of sympodial branches per plant, plant height, 2.5% span length, bundle strength, elongation percentage, lint index and seed index are the major yield contributing traits in interspecific crosses and should be considered for improving yield under wide hybridization in cotton. The correlation and path coefficient analysis revealed that simultaneous selection based on plant height, number of bolls per plant, number of sympodial branches per plant, 2.5% span length, bundle strength and elongation percentage may be promising in improving the seed cotton yield per plant.

Makhdoom *et al.* (2010) reported negative association between the plant height and boll number/seed cotton yield which may be due to lodging of cotton plants in worse environmental conditions.

Salahuddin *et al.* (2010) stated that Correlation and regression studies of cultivars of *Gossypium hirsutum* L. were analyzed for quantitative characters. Results revealed that highly significant positive correlation (r=0.567) was displayed by sympodial branches with seed cotton yield, which showed that seed cotton yield was greatly influenced by sympodial branches. The coefficient of determination (r2=0.321) revealed32.1% variation in the seed cotton yield per plant, due to its relationship with sympodial branches per plant. Regression coefficient (b=5.66) showed that a unit increase in sympodial branches per plant resulted into a proportional increase of 5.66 gms in seed cotton yield per plant, whereas bolls per plant exhibited strong positive association with seed cotton yield (r=0.959). The coefficient of determination (r2=0.92) revealed 92% of the total variation in seed cotton yield attributable to the variation in number of bolls per plant. The regression coefficient (b=3.37) indicated that for a unit increase in bolls per plant, there would be a proportional increase of 3.37 gms in seed cotton yield per plant. Boll weight displayed a highly significant positive correlation (r=0.597) with seed cotton yield per plant. The coefficient of determination (r2=0.356) determined that boll weight was responsible for 35.6% variation in seed cotton yield per plant. The regression coefficient (b=53.479) indicated that a unit increase in boll weight resulted into corresponding increase of 53.48 gms in seed cotton yield per plant. However, the plant height and monopodial branches per plant showed non significant association with the yield per plant.

Salahuddin *et al.* (2010) reported thatPhenotypic correlation and path coefficient analysis have been worked out for some important characters in fifteen genotypes (six parents, nine crosses) of American upland cotton (*Gossypium hirsutum* L.) Sympodial branches, bolls per plant, boll weight, G.O.T (%) and lint index were found to be positively correlated with yield per plant in all the genotypes at 1.0 percent level of probability. Further partitioning of correlation coefficients into direct and indirect path ways of influences showed that the characters having most influence on seed cotton yield were bolls per plant and boll weight, which should be taken care of while selecting for higher yields in further breeding program.

Ekinci *et al.*(2010) carried a study out to determine direct and indirect effects of some characters (single leaf area, leaf SPAD value, number of nods, number of sympodial branches, number of monopodial branches, single boll weight, number of bolls) on seed cotton yield. The experiment was carried out with four cotton varieties, two of which okra-leaf (Adana 98, Siokra 1/4) and two of which normal-leaf (Teks Stoneville 453) cotton (*Gossypium hirsutum* L.) and was conducted the randomized block design with 4 replications. In order to increase seed cotton yield in the studies of breeding program and selection orderly leaf SPAD value, number of sympodial branches, single boll weight, number of monopodial branches and number of bolls characters determined that must be high. Results showed that in order to increase seed cotton yield in the studies of breeding program and selection the highness of leaf SPAD value, number of sympodial branches, single boll weight, number of monopodial branches and number of bolls characters should be considered important.

Karademir *et al.* (2009)carried an experimenton Twenty cotton genotypes which were evaluated in terms of leaf chlorophyll content, number of boll per plant, boll weight, seed cotton weight per boll, number of monopodial branches, number of sympodial branches, 100 seed weight, plant height, ginning out turn and seed cotton yield. According to results of analysis of variance there were significant differences among the genotypes in terms of leaf chlorophyll content, seed cotton weight per boll, 100 seed weight, plant height and ginning out turn. There were significant correlations between leaf chlorophyll content, seed cotton yield (r= 0.231*) and ginning out turn (r= 0.320**), however positive but non- significant correlations were observed among leaf chlorophyll content and other investigated characteristics except for plant height and 100 seed weight. Phenotypic correlations were also partitioned into path coefficients, keeping seed cotton yield as the resultant variable and other components as causals. Path analysis revealed that leaf chlorophyll content, plant height, number of monopodial branches, ginning out turn and 100 seed weight had direct effect on seed cotton yield under drought stress conditions. Partitioning through path coefficient analysis revealed that leaf chlorophyll content may be one of the indicators in the improvement of seed cotton yield in cotton under drought stress conditions.

Khan *et al.* (2009) stated that comprising of genetic variability, heritability and correlation study for seed cotton yield and its components in cotton (*Gossypium hirsutum* L.) cultivars was carried out during 2005 at the NWFP Agricultural University Peshawar, Pakistan. Cultivars mean values manifested highly significant differences for all the traits except locules boll-1. Genetic potential of cultivars for different parameters revealed plant height (137.30 to 155.30 cm), bolls sympodia-1 (2.28 to 3.31), bolls plant-1 (14.00 to 25.95), boll weight (3.07 to 4.16 g), locules boll-1 (4.30 to 4.48) and seed cotton yield (1200 to 2450 kg ha-1). Genetic variances were found almost greater than the environmental variances for all the traits except bolls sympodia-1 and locules boll-1. High broad sense heritability (h^2b) and genetic gain were recorded for plant height (0.94, 9.41 cm), bolls sympodia-1 (0.81, 0.44), bolls plant-1 (0.96, 6.63), boll weight (0.96, 0.64 g) and seed cotton yield (0.98, 643.16 kg), respectively. Correlation of seed cotton yield with other different traits was found significantly positive for majority of traits i.e., plant height (r = 0.560), bolls sympodia-1 (r = 0.158), bolls plant-1 (r = 0.820) and boll weight (r = 0.476). This type of correlation is desirable by cotton breeders and little genetic gain in bolls per plant, boll weight and bolls per sympodia is a great accomplishment. Cultivars CIM-499 CIM-473, CIM-496 and CIM-506 have larger genetic potential and room for enhancement of seed cotton yield and its attributes under the prevailing environmental conditions of Peshawar, Pakistan.

Killi *et al.* (2005) observed positive association between plant height and seed cotton yield, revealed that there was no lodging in cotton plants. In cotton crop, the plant height has imperative role by having close association with bolls setting and has ultimate positive impact on the seed cotton yield. In previous studies, positive association was also observed between yield and plant height in *G. hirsutum* L.

Rauf *et al.* (2004) observed that Positive correlation between sympodia and seed cotton yield is mainly due to boll number, however, the sympodial branches could not be regarded as a reliable source of getting high yields in cotton.

2.3 Path co-efficient analysis

Tamimselvam *et al.* (2013) investigated on thirty-seven selected genotypes of American cotton and Randomized block design was followed with two replicates. Significant positive association was observed for number of bolls per plant, sympodial branches per plant, plant height and monopodium branches per plant with seed cotton yield per plant. Besides, these components had positive inter – relationships among themselves. Path-Coefficient analysis at genotypic level revealed that sympodia per plant, monopodia per plant and boll weight (g) had positive direct effect on seed cotton yield. Selection based on these characters may contribute considerably to improvement in seed yield.

Irum *et al.* (2011) studied the genetic variability, broad sense heritability, genetic advance and correlation among the six seedling traits and their direct and indirect effects on cotton yield by using path coefficient analysis. Thirty cotton genotypes were studied in green house using randomized complete block design with 3 replications at Cotton Research Station Multan, Pakistan. The genotypes exhibited a wide range of variability for all the traits except shoot length. Moderate to high heritability estimates were found for all traits. All the seedling traits showed positive and significant correlation with cotton yield both at genotypic and phenotypic level. Path coefficient analysis showed that root length had the highest and positive direct effect on cotton yield. Positive direct effects were produced by shoot length, root length, shoot/root length ratio, shoot weight and root weight, while shoot/root weight ratio had negative direct effects. The information obtained from the current studies will be utilized in successful cotton breeding program.

Girase and Mehetre (2002) reported association and direct contribution of different characters towards the seed cotton yield in cotton reviewed critically. From the earlier literature it appeared that boll number, boll weight, plant height, sympodia number, seed index, lint index and total dry matter exhibited significant positive association with seed cotton yield. There traits also found to be directly positive contributors towards the seed cotton yield. Selection made through these traits will automatically brought an improvement in seed cotton yield.

Rauf *et al.* (2004) computed path coefficients to estimate the contribution of individual characters to yield in cotton. The calculated correlations indicate that boll number per plant, sympodial branches had positive and significant correlation with seed cotton yield at genotypic level. Internodal length had negative but significant genotypic correlation. Number of bolls per plant had maximum positive direct effect on seed cotton yield per plant followed by boll weight; whereas, internodal length had maximum negative direct effect on seed cotton yield.

CHAPTER 3

MATERIALS AND METHOD

The field experiment was carried out at the Experimental field of the Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during July 2013 to March 2014 to study the yield and yield contributing characters of cotton.

3.1 Geographical Location of the Experiment

The research work was conducted at the experimental plot of the department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh from July 2013 to March 2014during the Kharif season.

Geographically the location is situated at 25^0 41′ North latitude and $88^0$39′ East latitude with an elevation of 37m from the sea level.

3.2 Soil and Climatic Condition

The experimental field was medium high land. The soil belongs to the old Himalayan Piedmont Plain agro-ecological zone (AEZ-1), textured by sandy loam with pH of around 6.2 during the growing period of the crop total rainfall and mean temperature for the month of July 2013 to March 2014 were recorded.

3.3 Layout of the Experiment

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the genotypes into the every line of each block. There were total of 60 lines, each line measuring of 3 m. each of block measuring 18 m x 3 m. The distance maintained between two lines was 0.90m.

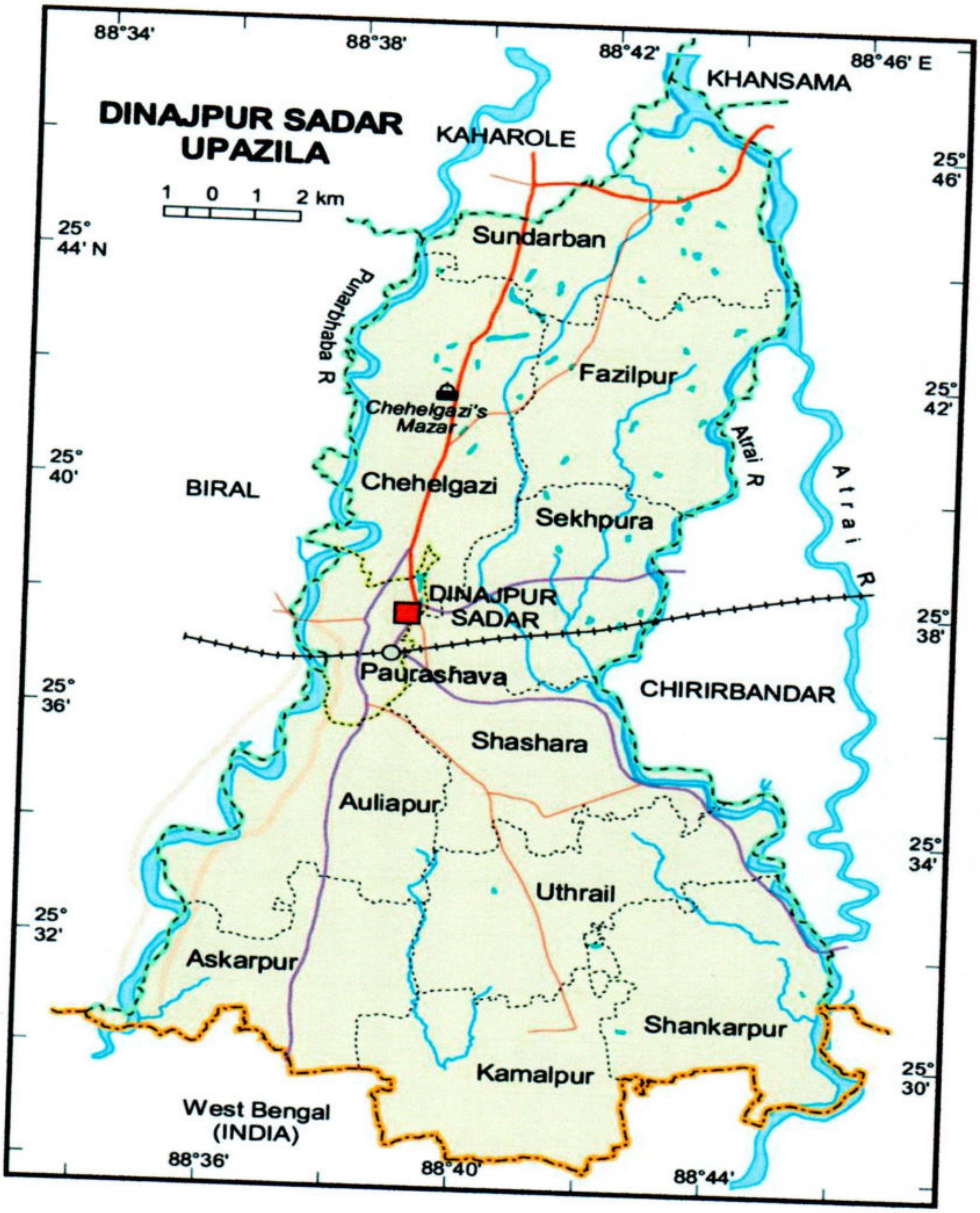

Fig. 1: Map of Dinajpur district showing experimental site

3.4 Experimental Material

Twenty cotton genotypes were used for this research work. All the genotypes are collected from GPB experimental plot, HSTU presented in Table 1.

Table 1. The name of the genotypes used in this study is listed below:

Treatment	Genotype
T_1	JA0541
T_2	JA054
T_3	CB10
T_4	BC088
T_5	BC051
T_6	JA08/9
T_7	BC0406
T_8	BC0303
T_9	BC0342
T_{10}	CB9
T_{11}	JA08/E
T_{12}	JA0526
T_{13}	JA08/D
T_{14}	JAO8/A
T_{15}	JA08/B
T_{16}	JA0510
T_{17}	BC073
T_{18}	BC0188
T_{19}	JA08/C
T_{20}	CB11

3.5 Preparation of the Main Field

The plot selected for the experiment was opened at the second week of June, 2013 with power tiller and was the exposed to the sun for a week, after one week the land was harrowed, ploughed and crossed-ploughed several times followed by laddering to obtain a good tilth. Weed and stables were removed and finally obtained a desirable tilth of soil for planting of cotton seed. The experimental plot was partitioned into the unit plots in accordance with experiment design mentioned in 3.4. The recommended doses of well rotten cow dung as manure and chemical fertilizers as indicated in 3.6 were mixed with the soil of each unit plot.

3.6 Application of Manures and Fertilizers

Green manure and decomposed organic matter were used at the rate of 6.0 ton/ hector before final land preparation. The chemical fertilizer such as Urea, TSP, MOP, Gypsum, boric acid and zinc sulphate were applied in the plot at the rate of 40, 180, 35, 25 and 10 kg/ha respectively as basal doze. The rest 120 kg urea was applied in three equal splits (i.e. 40 kg/splits) at 25, 60 and 120 days after planting as side dressing, 3-5 cm away from the plat and the furrow of the fertilizer are hilled up immediately, At the same time third dressing of Urea , rest 35 kg of MOP was used. The doses and method of application of fertilizer are shown below-

Table 2. Dose and method of application of fertilizers and manures in cotton field

Manures and fertilizers	Doze/ha	Application (kg)			
		Basal	25 DAP	45DAP	60 DAP
Cow dung	06 tons	06 tons	--	--	--
Urea	160 kg	40 kg	40 kg	40 kg	40 kg
TSP	180 kg	180 kg	--	--	--
MOP	70 kg	35 kg	--	--	35 kg
Gypsum	25 kg	25 kg	--	--	--
Zinc Sulphate	10 kg	10 kg	--	--	--
Magnesium	10kg	10kg	--	--	--
Boric acid	10 kg	10 kg	--	--	--

Source of recommendation : CDB

3.7 Planting of seeds in the Field

The cotton seed were soaked and planted in a line to lines of 0.90m on 16 July, 2013 which were germinated on 20 July, 2013.

Fig. 2: Overall view of the cotton field

Fig. 3: A plant with several splitting cotton bolls

Fig. 4: A plant with several productive branches

Fig. 5: Close view of a cotton boll

3.8 Intercultural Operations

When the seedlings were started to emerge in the beds, they were always kept under careful observation. After the emergence of seedling, various inter-culture operations were accomplished for better growth and development of the cotton seedling.

3.9 Irrigation

Irrigation was provided at knee stage, pre-flowering stage and milking stage at 25, 60, and 120 days after planting (DAP) for three times for proper growth and development of the plants.

3.10 Weeding and Mulching

Weeding and mulching were done to keep the plots free from weeds, easy aeration of soil and to conserve soil moisture, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of cotton seedling as and when necessary. Breaking of crust of the soil, when needed was done through mulching.

3.11 Plant Protection

After 50 days of planting, first spray of chloropyriphose was done against sucking pest such as jussid and aphid.

3.12 Harvesting

The crops were harvested when the ball was burst and come out white cotton

3.13 Data Collection

Data on the following morphological parameters were recorded on the basis of descriptors for cotton.

3.13.1 Vegetative branch

Total no. of vegetative branch of each plant was counted

3.13.2 Number of primary fruiting branch per plant

The number of branches on main stem which were lateral and axillary in position with vertical growth in acropetal succession was counted at maturity stage, avoiding small sprouts.

3.13.3 Number of secondary fruiting branch per plant

Branches which are extra-axillary in position and normally horizontal with zig-zag pattern of fruiting points were taken as secondary branch. The numbers of such secondary branch on main stem were counted at maturity stage.

3.13.4 Number of node per main branch

Total no. of node in the main stem was counted.

3.13.5 Days to 50% ball splitting

The number of days recorded from the date of planting to splitting 50% balls of plant in the plot.

3.13.6 Days to 50% flowering

The days taken to 50% flowering of the total plants in the each progeny from data of sowing was recorded for each genotypes.

3.13.7 Number of balls per plant

The number of bolls which contributed to seed cotton yield were recorded at the time of harvest.

3.13.8 Ball weight (gm)

Seed cotton obtained from a random sample of 20 bolls collected from each progeny was used to determine the boll weight in grams.

3.13.9 Plant height (cm)

Plant height was expressed in centimeters by measuring the plant stalk from the ground level to the base of the last leaf sheath of the plant.

3.13.10 Seed cotton yield (kg/ha)

It is the mean seed cotton yield harvested till final picking from the net plot area and expressed in kg/ha.

3.14 Statistical Analysis

3.14.1 Analysis of variance

The data on various growth and quality traits viz, number of plants m-2 at harvest, plant height at maturity (cm), number of monopodial branches plant-1, number of sympodial branches plant-1, number of bolls plant-1, mature boll weight (g), total seed cotton yield (kg ha-1), staple length (mm), fiber strength (g tax-1), fiber finness (micronair), ginning outturn (%) were recorded by using standard procedure. The data collected were analyzed statistically using analysis of variance (ANOVA) test.

The analyses of variances for most of the characters under consideration were performed by F variance test. The significance of difference among the means was evaluated by least significant difference (LSD) test for interpretation of results (Gomez and Gomez, 1984).

The structure of ANOVA

Source of variation	d.f.	M.S.S.	Expected values of M.S.S.
Replication(r)	r-1	M1	-
Genotypes (g)	g-1	M2	$\sigma e^2 + r\sigma g^2$
Error	(r-1) (g-1)	M3	σe^2
Total	(rg-1)	M1 + M2 + M3	_

Where, r = number of replications

g = number of genotypes

3.14.2 Component of variance

According to Johnson *et at.* (1955) the genotypic and phenotypic variances were calculated by using the following formula:

$$\delta^2 g = \frac{VMS - EMS}{r}$$

Where, VMS and EMS are the varietal and error mean squares and r is the number of replications.

The phenotypic variance (δ^2ph) was derived by the following formula:

$$\delta^2 ph = \delta^2 g + \delta^2 e$$

Where,

δ^2g is the genotypic variance and δ^2e is the efficient error mean square.

According to the Burton (1952) the genotypic and phenotypic co-efficient of variation were calculated by the following formula:

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\delta\, g \times 100}{\bar{x}}$$

Where,

δg = Square root of genotypic variance and $\bar{x}$ = Population mean.

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\delta\, ph \times 100}{\bar{x}}$$

Where,

δph = Square root of phenotypic variance and $\bar{x}$ = Population mean.

3.14.3 Estimation of heritability

Broad sense heritability of all characters was estimated by the formula

$$\text{Heritability (\%) (Broad sense)} = \frac{\sigma_g^2 \times 100}{\sigma_p^2}$$

Where,

σ_g^2 = genotypic variance σ_p^2 = phenotypic variance

3.14.4 Estimation of genetic advance

The expected genetic advance for different characters under selection was estimated by the formula

$$\text{GA} = \frac{\sigma_g^2}{\sigma_p^2} \times K.\sigma_p$$

The value of K was taken as 2.06 assuming 5% selection intensity.

3.14.5 Genotypic and Phenotypic correlation coefficients

The genotypic and phenotypic correlation coefficients of yield and its different contributing characters were estimated by the following formulae given by Singh and Chaudhury (2010).

Genotypic correlation coefficient: $r_{g1.2} = \frac{Cov._{g1.2}}{\sqrt{\sigma^2 g_1 \times \sigma^2 g_2}}$

where

$Cov.g_{1.2}$ = genotypic covariance between the variables x_1 and x_2.

$\sigma^2 g_1$ = genotypic variance of the variable x_1

$\sigma^2 g_2$ = genotypic variance of the variable x_2

Similarly,

Phenotypic correlation of coefficient: $r_{p1.2} = \frac{Cov._{ph1.2}}{\sqrt{\sigma^2 ph_1 \times \sigma^2 ph_2}}$

Where,

$Cov.ph_{1.2}$ = phenotypic covariance between the variable x_1 and x_2

$\sigma^2 ph_1$ = phenotypic variance of the variable x_1

$\sigma^2 ph_2$ = phenotypic variance of the variable x_2

3.14.6 Estimation of path co-efficient

Path coefficient analysis was carried out according to the procedure employed by Dewey and Lu (1959) using simple correlation values. In path analysis, correlation co-efficient is divided into direct and indirect effects of independent variable on the dependent variable.

To estimate the direct and indirect effects of the correlated characters, i.e. X_1, X_2 and X_3 with yield Y, a set of simultaneous equations (three equations in this example) are required to be formulated as given below:

$$ryx_1 = Pyx_1 + Pyx_2rx_1x_2 + Pyx_3rx_1x_3$$

$$ryx_2 = Pyx_1rx_1x_2 + Pyx_2 + Pyx_3rx_2x_3$$

$ryx_3 = Pyx_1rx_1x_3 + Pyx_2rx_2x_3 + Pyx_3$

Where,

r's denotes simple correlation co-efficient and P's denotes path co-efficient. Arranging them in matrix form may conveniently solve P's in the above equations.

Total correlation, say between X_1 and y is thus partitioned as follows-

Pyx_1 = the direct effect of x_1 only

$Pyx_1rx_1x_2$ = indirect effect of x_1 via x_2 only.

$Pyx_1rx_1x_3$ = indirect effect of x_1 via x_3 only.

After calculating the direct and indirect effects of the characters, residual effect (R) was calculated by using the formula given below(Singh and Chaudhury, 1985)

$P^2RY = 1\text{-}\Sigma p_iy.\ r_iy$

Where,

$P^2RY = (R^2)$; and hence residual effect,

$R = (P2RY)^{\frac{1}{2}}$

p_iy = Direct effect of the characters on yield.

r_iy = Correlation of the character with yield.

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to analyze the yield and yield contributing characters of the inbred lines in respect to different morphological characters. A total number of 20 cotton inbred lines were used for the experiment. Mean performance and other analyses were done on yield contributing characters viz. days to flowering, days to ball splitting, plant height, number of primary fruiting branch, number of secondary fruiting branch, ball weight, ball number, number of vegetative branch and yield/ha. The results have been presented and discussed under following heading.

4.1 Mean performances of different yield contributing characters

Significant variation was observed in yield and yield contributing characters for different cotton inbred lines. Analysis of variance (ANOVA) of the data of different parameters are presented in Table 2.

4.1.1 Vegetative branch

The number of vegetative branch was significantly varied from 3.63 to 4.5 (Table 3). The maximum vegetative branch number (4.5) was recorded in T_6 line and the minimum vegetative branch number (3.633) was recorded in T3 line.

4.1.2 Number of primary fruiting branch per plant

The present experiment among the different cotton inbreeds line the maximum branch number (13.63) was recorded in T_{13} and T_{20} line which was statistically similar (13.47,13.27 and 13.20) from T_6, T_{12} and T_8 inbred line respectively and the minimum branch number (11.03) was recorded in T_2 line which was statistically similar ((11.10 and 11.83) from T_1, T_4 and inbred line respectively.

Anjum (2003) reported non-significant effect of plant spacing on number of monopodial branches per plant.

4.1.3 Number of secondary branch per plant

The number of secondary branch was significantly varied from 9.3 to 12.37. The maximum secondary branch numbers (12.37) were recorded in T17 line and the minimum secondary branch number (9.3) were recorded in T10 line. Hussain *et al.* (2000) reported more number of sympodial branches per plant in wider plant spacing.

4.1.4 No. of Node / main stem

The number of node of fruiting branch was significantly varied from 5.12 to 7.37 (Table 3).The highest number of node of fruiting branch (7.37) found in T_{20} line and the lowest number of node of fruiting branch (5.12) found in T_3 line. This was happened due to their genetical characters.

4.1.5 Days to ball splitting

The number of days required for ball splitting is presented in Table 3. Days to ball splitting were significantly different ranging from 101.3 to 118.1 days. The lowest days (101.3) was needed for ball splitting in T_{19} line, and the highest days (118.1) was required in T_{12} line. Management practice and environment can slightly interfere on ball splitting but in the experiment field all cotton inbred lines were grown in similar management practices and environmental condition.

4.1.6 Number of days to 50% flowering

The number of days required for ball splitting is significantly varied ranging from 45.87 to 57.10 days. The lowest days (45.87) were required for Flowering in T_{19} line and the highest days (57.10) was required in T_9 line. Environment condition such as temperature slightly influence days to flowering.

4.1.7 Number of effective balls per plant

The number of effective balls were significantly varied from 18 to 25.23 (Table 3). The highest balls per plant (25.23) found in T_{12} line followed by T_{16} and T_{19} line (24.9 and 26.83) respectively and the lowest balls per plant (18.00) found in T_1 line followed by T_2 inbred lines (19.33) respectively. Cob length varied in different inbred line but the management practice was similar for 20 cotton inbred lines. Palomo *et al.* (2000) and Siddiqui *et al.* (2007) reported that the number of bolls per plant decreased with increase in plant density.

4.1.8 Fiber weight (gm)

The fiber weight was significantly varied from 3.807 to 4.84 Table 3. The highest fiber weight (6.35) was found in T_{19} line and the lowest ball weight (3.807) found in T_6 line.

4.1.9 Ball weight (gm)

The ball weight was significantly varied from 4.333 to 6.35 Table 3. The highest ball weight (6.35) found in T_{20} line followed by T_{18} and T_6 line (6.11 gm and 6.047 gm) respectively and the lowest ball weight (4.087) found in T_7 line followed by T_4 and T_3 inbred lines(4.37 and 4.41) respectively. This may be happened due to their genetical variations.

Table. 3 Components of ANOVA for 20 cotton inbred lines.

Characters	Minimum	Maximum	Mean	CV%	F Value
Vegetative branch	3.633	4.5	4.010	10.78	0.8456*
Node no of fruiting branch	7.377	5.12	6.324	8.19	4.8902**
Primary fruiting branch	13.63	11.03	12.348	6.94	2.9490**
Secondary fruiting branch	12.37	9.3	10.559	6.08	4.5841**
Days of flowering	45.87	57.10	52.945	4.13	6.53**
Days of ball splitting	101.3	118.1	111.23	3.51	3.65**
Balls per plant	18	25.23	22.810	5.77	4.80**
Balls weight(gm)	4.333	6.35	5.152	10.93	3.52**
Plant height(cm)	77.90	124.1	100.438	10.35	3.57**
Yield(kg/ha)	1812	2977	2390.590	10.73	4.65**

Here, ** indicates significant at 1% level of probability and * indicates 5 % level of probability

4.1.10 Plant height (cm)

The plant height was showed significantly varied from 77.90 to 124.1 cm. The tallest plant height (124.1) was recorded in T_6 line which was statistically similar (134.4 days and 126.067 days) from T_3 and T_2 inbred line respectively where the shortest plant height (77.90) was recorded from T_2 line. All other inbred lines were found medium plant height. Different inbred line produce different plant height because it is a genetical characters. Management practice can interfere plant height but in the experimental field management was same in 20 cotton inbred lines.

4.1.11 Seed cotton yield (kg/ha)

The seed cotton yield was significantly varied from 1812 to 2977 kg/ha.(Table 3).The highest seed cotton yield (2977) found in T_{19} line and the lowest seed cotton yield (1812) found in T_2 line. This was happened due to their genetical characters. Yield contributing characters varied from different line which greatly influenced yield of cotton. Management practice can interfere on yield contributing characters but 20 inbreed line were cultivated in similar management practice. Palomo *et al.* (2000) and Alfaqeih *et al.* (2002) stated that yield per plant increases with decreasing plant density.

Table- 4: Mean performance of different characters of the lines

Lines	Vegetative branch/ plant	Primary fruiting branch/plant	Secondary fruiting branch /plant	Number of node /main stem	Day to 50% flowering	Day to 50% ball splitting	No. of ball/pla nt	Fiber weight (g)	Ball weight (g)	Plant height (cm)	Yield (Kg)	No. of seed/ball
1	3.93 ^{ab}	11.10 ^{d}	9.66 $^{f-h}$	5.190 ^{hi}	49.23 $^{d-g}$	110.2^{b-e}	18.00^{g}	4.183^{a-d}	4.930 ^{cde}	80.07 ^{d}	1882 ^{g}	24.90 $^{a-e}$
2	3.833 ^{ab}	11.03 ^{d}	10.77 $^{b-g}$	5.120 ^{i}	48.93^{efg}	112.3 $^{a-e}$	19.33 ^{fg}	3.893 ^{bcd}	4.600 $^{c-e}$	77.90 ^{d}	1812 ^{g}	23.80 $^{d-f}$
3	3.633 ^{b}	12.07 $^{a-d}$	10.47 $^{c-h}$	5.397 ^{ghi}	54.07^{abc}	108.0 $^{c-f}$	20.00^{efg}	3.940 ^{bcd}	4.410 ^{de}	101.3 ^{bc}	1970^{fg}	18.87 ^{gh}
4	4.167 ^{ab}	11.83 ^{bcd}	9.9 $^{e-h}$	5.77 $^{f-i}$	55.90 ^{abc}	113.2 $^{a-e}$	21.37^{def}	3.833 ^{cd}	4.377 ^{de}	102.0 ^{bc}	2049^{fg}	21.83^{c-h}
5	3.7 ^{ab}	12.13 $^{a-d}$	10.27 $^{d-h}$	6.153^{c-h}	54.57 ^{abc}	106.4^{def}	21.97^{b-e}	4.08 ^{bcd}	4.927 ^{cde}	101.6 ^{bc}	2239^{efg}	18.27 ^{h}
6	4.5 ^{a}	13.47 ^{ab}	9.533 ^{gh}	5.750 $^{f-i}$	54.57 ^{abc}	108.2 $^{c-f}$	23.03^{a-d}	3.807 ^{d}	4.653 ^{cde}	124.1 ^{a}	2200^{efg}	21.07 ^{eh}
7	3.767 ^{ab}	11.90 ^{bcd}	9.933 $^{e-h}$	6.233 $^{b-g}$	53.07 $^{a-d}$	112.0 $^{a-e}$	23.53^{a-d}	3.843 ^{cd}	4.087 ^{e}	107.2 ^{abc}	2274^{c-g}	18.07 ^{h}
8	4.0 ^{ab}	13.20 ^{abc}	9.907 $^{e-h}$	5.890 $^{e-i}$	56.67 ^{ab}	110.9 $^{a-e}$	24.03^{abc}	4.260 $^{a-d}$	5.140 $^{b-e}$	103.1 ^{bc}	2560^{a-e}	19.53^{fgh}
9	4.1 ^{ab}	11.90 ^{bcd}	10.77 $^{b-g}$	6.037 $^{d-i}$	57.10 ^{a}	116.4 ^{ab}	24.47 ^{ab}	3.947 ^{bcd}	4.827 ^{cde}	94.20 ^{cd}	2418^{b-f}	21.73^{c-h}
10	4.233 ^{ab}	11.07 ^{d}	9.3 ^{h}	6.553 $^{a-f}$	55.30 ^{abc}	116.6 ^{ab}	21.60 $^{c-f}$	4.527 $^{a-d}$	5.157 $^{b-e}$	100.2 ^{bc}	2567^{a-e}	21.30^{e-h}
11	3.967 ^{ab}	12.40 $^{a-d}$	10.10 $^{d-h}$	6.333 $^{b-g}$	54.67 ^{abc}	112.9 $^{a-e}$	22.17^{b-e}	4.113 ^{bcd}	4.850 ^{cde}	117.1 ^{ab}	2280^{c-g}	21.53^{d-h}

Table- 4: Mean performance of different characters of the lines (continued)

Lines	Vegetative branch/ plant	Primary fruiting branch/plant	Secondary fruiting branch /plant	Number of node /main stem	Day to 50% flowering	Day to 50% ball splitting	No. of ball/plant	Fiber weight (g)	Ball weight (g)	Plant height(cm)	Yield (Kg)	No. of seed/ball
12	4.300^{ab}	13.27^{abc}	10.43^{c-h}	6.530^{a-f}	54.57^{abc}	118.1^{a}	25.23^{a}	4.08^{bcd}	5.053^{b-e}	107.3^{abc}	2570^{a-e}	21.10^{e-h}
13	3.967^{ab}	13.63^{a}	10.87^{b-f}	6.963^{a-d}	55.80^{abc}	114.9^{abc}	22.17^{b-e}	4.060^{bcd}	5.250^{bcd}	119.0^{ab}	2249^{d-g}	22.93^{c-g}
14	4.267^{ab}	12.07^{a_d}	10.97^{b-e}	7.207^{ab}	54.00^{abc}	113.8^{a-d}	21.53^{c-f}	4.527^{a-d}	5.380^{a-d}	96.53^{cd}	2434^{b-f}	22.97^{c-g}
15	4.033^{ab}	11.60^{cd}	10.57^{c-g}	6.530^{a-f}	54.23^{abc}	116.5^{ab}	24.47^{ab}	4.510^{a-d}	5.483^{a-d}	92.46^{cd}	2756^{abc}	28.37^{a}
16	3.867^{ab}	12.43^{a-d}	11.87^{ab}	6.867^{a-e}	52.50^{b-e}	110.9^{a-e}	24.90^{a}	4.557^{abc}	6.047^{ab}	96.00^{cd}	2835^{ab}	27.70^{ab}
17	3.833^{ab}	13.17^{abc}	12.37^{a}	6.520^{a-f}	51.70^{c-f}	108.3^{c-f}	23.20^{a-d}	4.10^{bcd}	5.69^{abc}	99.97^{bc}	2379^{b-f}	24.50^{a-e}
18	3.900^{ab}	12.03^{a-d}	10.60^{c-g}	6.947^{a-d}	47.97^{fg}	108.3^{c-f}	24.47^{ab}	4.313^{a-d}	6.117^{ab}	101.5^{bc}	2615^{a-e}	26.30^{abc}
19	4.333^{ab}	13.03^{abc}	11.33^{a-d}	7.110^{abc}	45.87^{g}	101.3^{f}	24.83^{a}	4.840^{a}	5.703^{abc}	92.16^{cd}	2977^{a}	26.13^{a-d}
20	3.867^{ab}	13.63^{a}	11.57^{abc}	7.377^{a}	48.20^{fg}	105.6^{ef}	24.07^{abc}	4.587^{ab}	6.350^{a}	95.03^{cd}	$2747.^{a-d}$	25.30^{a-e}
LSD at 5% level	0.7148	1.417	1.060	0.8557	3.611	6.445	2.168	0.6118	0.9306	17.19	424.0	3.953
CV %	10.78	6.94	6.08	8.19	4.13	3.51	5.77	8.80	10.93	10.35	10.73	10.48

4.2 Analysis of variance for different yield contributing characters

The analysis of variance for 12 quantitative characters was accomplished to assess the variability pertained for a particular character among the twenty five fine rice cultivars. The source of variation included genotype, replication and error (Table.3).The mean squares against three replications found non-significant for all the characters studied, visualized justification of blocking in the field. Coefficient of variation in all the characters was equal to or less than 10.73 except Vegetative branch / plant(10.78) andBoll weight (10.93) due to segregating performance of F_1. Breeders could drive the breeding methods either selection or hybridization for the improvement of present yield status of the collected cotton cultivars. The results of analysis of variance (Table-3) showed that the genotypes had significant differences among them for all the characters indicating the existing genetic variance and there is a scope and chance for the selection of a high quality cotton variety.

Table 5. Analysis of variance (MS) on different characters in cotton

Sl.no.	Characters	Different sources of variation			
		Replication	Genotype(19df)	Error (38df)	CV (%)
1	Vegetative branch / plant	0.488	0.158**	0.107	10.78
2	Primary fruiting branch/plant	1.607ns	2.168**	0.735	6.94
3	Secondary fruiting branch/plant	0.245	1.886**	0.411	6.08
4	No. of node/ main stem	0.535	1.311**	0.268	8.19
5	Days to first flowering	4.239	31.178**	4.772	4.13
6	Days to 50% boll splitting	27.046	55.570**	15.204	3.51
7	No. of boll /plant	36.504	12.006**	1.721	5.77
8	Fiber weight (gm)	0.595	0.272**	0.137	8.80
9	Boll weight (gm)	5.423	1.118**	0.317	10.93
10	Plant height(cm)	276.93	386.286**	108.167	10.35
11	Yield(t/ha)**	368.286	306.311**	65.795	10.73
12	No. of seed/ boll	4.177	27.453**	5.719	10.48

Here, ** indicates significant at 1% level of probability and d.f. indicates degrees of freedom

4.3 Genetic parameters on the selected characters in cotton

Different parameters such as mean range, genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), genetic advance (GA) of 12 characters were estimated to observe the variability exited among the characters. The results are presented in Table 4.revealed that very close relation was observed between each of the pairs of parameters against each of the selected characters. Most of the characters showed high heritability couple with low genetic advance. The highest heritability value (h^2b=94.72%) was estimated for Fiber weight (g) and the lowest heritability value (h^2b=55.91%) was estimated for No. of seed/boll.Nonetheless, the magnitude of heritability for yield (t/ha) was also high ((h^2b=97.05%).But direct selection on yield alone would not be effective for improving yield potential; others approaches of plant breeding need to be applied for sustainable improvement of cotton.

Table 6. Estimation of variability of different characters in cotton

Parameters	Genotypic variance α^2_g	Phenotypic variance	GCV (%)	PCV (%)	Heritability in broad sense(h^2b)%	Standard deviation	GA
Vegetative branch/plant	0.017	0.124	3.25	8.78	56.45	0.35	0.99
Primary fruiting branch/plant	0.48	1.21	5.59	8.90	79.42	1.1	0.89
Secondary fruiting branch/plant	0.491	0.902	6.64	8.99	64.43	0.95	1.06
No. of node/ main stem	0.347	0.615	9.31	12.40	56.42	0.78	0.91
Days to first flowering	8.80	13.57	5.60	6.95	84.84	3.68	4.91
Days to 50% boll splitting	13.455	28.66	3.29	4.81	86.95	5.35	5.17
No. of boll /plant	3.42	5.15	8.14	9.9	66.42	2.27	3.10
Fiber weight	0.045	0.182	5.05	10.15	94.72	0.43	0.22
Boll weight	0.267	0.584	10.02	14.83	75.72	0.764	0.72
Plant height	92.70	200.87	9.58	14.11	76.19	14.17	13.47
Yield(t/ha)	80.17	14.59	11.84	15.98	74.92	0.38	.43
No. of seed/ boll	7.24	12.95	11.79	15.77	55.91	3.60	4.14

4.4 Correlated response of different characters

Correlation provides information on the nature and extent of relationship among the characters. Selection for yield will be effective when it is based on its contributing component traits rather than relying on yield alone. When the selection pressure is applied for a trait, the population being improved for a trait also gets improved in respect to all traits associated with it. Thus correlation study facilitates simultaneous improvement of two or more characters. Knowledge of the relationship among yield components is essential for formulation of breeding program aimed at achieving the desired combination of various components of yield. The estimates of correlation coefficients was worked out among 12 yield and fibre quality related characters with seed cotton yield per plant (Table-5 and Table-6).Of total traits eight traits namely number of bolls per plant, boll weight, number of monopodia per plant, number of sympodia per plant, node/main stem fibre weight, boll weight, no. of seed/boll and plant height had a significant positive association with seed cotton yield per plant but no. of vegetative branch, days to first flowering and days to 50% boll splitting showed negative association with seed cotton yield per plant. Hence selection for these traits will help in selecting genotypes with higher seed cotton yield per plant. Similar results of positive association between yield and fibre quality traits was reported by Aguado *et al.* (2008), Mahantesh (2009), Ashok kumar and Ravi Kesavan (2010).

Correlated response all possible paired combinations of characters were estimated to gain better response during indirect selection of different characters. In every case, the values of genotypic correlation were greater than those of phenotypic correlation. In case of genotypic correlation, the highest and negative correlated response (-0.674)was paid by Days to 50% boll splitting. In addition, No. of node/ main stem(.698)and Fiber weight (0.675)developed strong positive response to selection when yield is considered to be increased. Efficiency of indirect selection depended on the magnitude of correlations between yield and target yield components. Similar types of result were found in case of phenotypic correlation also but the their relationship with yield is non-significant.

Table.7 Genotypic correlation among different characters

	VBP	PFBP	SFBP	NNMS	DFF	DBS	NB	FW	BW	PH	NSB	Yield
VBP	1	0.744**	-0.484*	0.372	0.256	0.414*	0.41*	3.62	0.098	0.452*	0.227	-0.210
PFBP		1	0.503**	0.605**	0.034	-0.421*	0.685**	-0.054	0.427	0.802**	-0.029	0.367
SFBP			1	0.620**	-0.463*	-0.385	0.425	0.421*	0.718**	-0.313	0.658**	0.504**
NNMS				1	-0.225	-0.116	0.742**	0.789**	0.910**	0.256	0.492*	0.698**
DFF					1	0.787**	0.035	-0.539**	-0.554**	0.624**	-0.654**	-0.324
DBS						1	-0.014	-0.129	-0.307	0.133	-0.136	-0.674**
NB							1	0.489*	0.583**	0.361	0.271	0.63**
FW								1	1.34	-0.4	0.946*	0.675**
BW									1	-0.26	0.945**	0.612**
PH										1	-0.55**	0.064
NSB											1	0.483*
Yield												1

Here, VBP= Vegetative branch per plant, PFBP =Primary fruiting branch/plant, SFBP= Secondary fruiting branch/plant, NNMS= No. of node/ main stem, DFF= Days to first flowering, DBS= Days to 50% boll splitting, NB= No. of boll /plant, FW= Fiber weight, BW= Boll weight, PH= Plant height, NSB=No. of seed/ boll

Table. 8 Phenotypic correlation among different characters

	VBP	PFBP	SFBP	NNMS	DFF	DBS	NB	FW	BW	PH	NSB	Yield
VBP	1	0.505**	-0.132	0.103	0.076	0.105	0.123	0.665**	-0.025	0.036	0.019	-0.018
PFBP		1	0.233	0.29	0.017	0.181	0.351	.017	0.182	0.343	-0.014	0.171
SFBP			1	0.344	-0.275	-0.195	0.256	0.155	0.358	-0.157	0.363	0.275
NNMS				1	-0.136	-0.059	0.454*	0.377	0.462*	0.130	0.276	0.388
DFF					1	0.434*	0.023	-0.216	-0.302	0.341	-0.393	-0.193
DBS						1	-0.083	-0.043	-0.142	0.062	-0.069	-0.342
NB							1	0.198	0.321	0.199	0.165	0.381
FW								1	0.451*	-0.135	0.351	0.249
BW									1	-0.119	0.478*	0.306
PH										1	-0.279	0.032
NSB											1	0.268
Yield												1

Here, VBP= Vegetative branch per plant, PFBP =Primary fruiting branch/plant, SFBP= Secondary fruiting branch/plant, NNMS= No. of node/ main stem, DFF= Days to first flowering, DBS= Days to 50% boll splitting, NB= No. of boll /plant, FW= Fiber weight, BW= Boll weight, PH= Plant height, NSB=No. of seed/ boll

4.5 Path coefficient Analysis

The effect of independent character on the dependent is known as direct effect, where as effect of an independent character on the dependent one on other independent traits is known as indirect effect. The study of path coefficients enable breeder to concentrate on the variable which show high direct effect on seed cotton yield. The genotypic correlation coefficient of seed cotton yield with other yield contributing and fiber quality traits were further partitioned into direct and indirect effects (Table-7 and Table-8). Among the traits studied number of bolls per plant exerted maximum direct effect on seed cotton yield per plant followed boll weight(2.20),plant height (0.7480) and uniformity ratio also had positive direct effect in genotypic path coefficient Analysis. In case of Phenotypic path analysis, all the characters showed positive direct effect except days to first flowering. On the other hand, no. of vegetative branch and days to first flowering showed highly negative effect with yield in both genotypic and phenotypic level.. The results are in accordance with the findings of Do-Tha-Ha-An *et al.* (2008) and Venkatesh warlu *et al.* (2010). Maximum indirect positive effect on seed cotton yield per plant was recorded for number of sympodia per plant and plant height through number of bolls per plant. Similar types of result were found in case of phenotypic path co-efficient.Seed index and lint index through boll weight. (Khan *et al.*, 2009).Each and every character had both positive and negative indirect effects but through which these effect were exerted should be considered.The direct and indirect effects of yield characters number of bolls per plant, boll weight, plant height recorded major yield contributing traits and should be considered for yield improvement. Based on correlate ion and path analysis it is suggested due emphasis should be given to number of bolls per plant, boll weight, plant height, fiber weight and days to first flowering for increasing seed cotton yield per plant for the red soil situation.

Table.9 Genotypic path analysis showing direct and indirect effects for yield contributing characters in cotton

	VBP	SFBP	NNMS	DFF	DBS	NB	BW	PH	FW	Yield
VBP	-0.677	0.272	-0.426	0.009	-0.079	0.199	0.215	0.338	-0.062	-0.21
SFBP	0.327	-0.562	-0.689	-0.0178	0.074	0.206	1.580	-0.234	-0.181	0.504
NNMS	-0.252	-0.338	-1.145	-0.008	0.022	0.360	2.003	0.191	-0.135	0.698
DFF	-0.173	0.260	0.257	0.0385	-0.151	0.0170	-1.219	0.467	0.179	-0.324
DBS	-0.280	0.216	0.132	-0.004	-0.192	-0.006	-0.675	0.099	0.037	-0.674
NB	-0.277	-0.239	-0.849	0.0286	0.002	0.486	1.283	0.270	-0.074	0.630
BW	-0.066	-0.404	-1.042	0.0350	0.059	0.283	2.20	-0.194	-0.259	0.612
PH	-0.306	0.176	-0.293	0.009	-0.025	0.175	-0.572	0.748	0.151	0.064
FW	-0.153	-0.370	-0.563	0.0189	0.026	0.131	2.080	-0.411	0.274	0.483

Here, VBP= Vegetative branch per plant,PFBP =Primary fruiting branch/plant, SFBP= Secondary fruiting branch/plant, NNMS= No. of node/ main stem, DFF= Days to first flowering, DBS= Days to 50% boll splitting, NB= No. of boll /plant,FW= Fiber weight, BW= Boll weight, PH= Plant height, NSB=No. of seed/ boll

Table.10 Phenotypic path analysis showing direct and indirect effects for yield contributing characters in cotton

	VBP	SFBP	NNMS	DFF	DBS	NB	BW	PH	FW	Yield
VBP	-0.036	-0.004	0.022	0.002	-0.031	0.027	-0.0005	0.0006	0.002	-0.018
SFBP	0.004	0.031	0.0737	-0.009	0.059	0.055	0.008	-0.003	0.053	0.275
NNMS	-0.0037	0.010751	0.214	-0.004	0.017	0.099	0.010	0.002	0.041	0.388
DFF	-0.002	-0.008	-0.029	0.033	-0.131	0.005	-0.006	0.006	-0.058	-0.193
DBS	-0.0038	-0.006	-0.012	0.0143	-0.303	-0.018	-0.003	0.001	-0.01	-0.342
NB	-0.004	0.008	0.097	0.0007	0.025	0.218	0.007	0.003	0.024	0.381
BW	0.0009	0.011	0.099	-0.009	0.043	0.070	0.022	-0.002	0.07	0.306
PH	-0.0013	-0.005	0.027	0.011	-0.018	0.0435	-0.002	0.018	-0.04	0.032
FW	-0.0007	0.011	0.059	-0.012	0.021	0.036	0.011	-0.005	0.148	0.268

Here, VBP= Vegetative branch per plant, PFBP =Primary fruiting branch/plant, SFBP= Secondary fruiting branch/plant, NNMS= No. of node/ main stem, DFF= Days to first flowering, DBS= Days to 50% boll splitting, NB= No. of boll /plant, FW= Fiber weight, BW= Boll weight, PH= Plant height, NSB=No. of seed/boll

CHAPTER 5

SUMMARY AND CONCLUSION

The field investigation/experiment was carried out at the Experimental Plot of Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during July 2013 to March 2014 to study different of yield contributing characters in cotton. The purity and germination percentage were leveled as around 95.

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the genotypes into the every line of each block. There were total of 60 lines, each line measuring of 3 m. each of block measuring 18 m x 3 m. The distance maintained between two lines was 0.90m.

The experiment was conducted to study yield and yield contributing characters of the inbred lines in respect to different morphological characters. A total number of 20 cotton inbred lines were used for the experiment. Mean performance and divergence analyze were done on yield contributing characters viz. days to flowering, days to ball splitting, plant height, number of primary fruiting branch, number of secondary fruiting branch, ball weight, ball number, number of vegetative branch and yield/ha.

Mean performances of different characters

The number of vegetative branch was significantly varied from 3.633 to 4.5. The maximum vegetative branch number (4.5) was recorded in T_6 line and the minimum vegetative branch number (3.633) was recorded in T_3 line.The present experiment among the different cotton inbreeds line the maximum branch number (13.63) was recorded in T_{13} and T_{20} line which was statistically similar (13.47,13.27 and 13.20) from T_6, T_{12} and T_8 inbred line respectively and the minimum branch number (11,03) was recorded in T_2 line which was statistically similar ((11.10 and 11.83) from T_1, T_4 and inbred line respectively.The number of secondary branch was significantly varied from 12.37 to 9.3. The maximum secondary branch numbers (12.37) were recorded in T_{17} line and the minimum secondary branch number (9.3) were recorded in T_{10} line.The number of node of fruiting branch was significantly varied from 5.12 to 7.37 Table3. The highest number of node of fruiting branch (7.37) found in T_{20} line and the lowest number of node of fruiting branch (5.12) found in T3 line. This was happened due to their genetical characters. The number of days required for ball splitting is presented in Table 3. Days to ball splitting were significantly different ranging from 101.3 to 118.1 days. The lowest days (101.3) was needed for ball splitting in T_{19} line, and the highest days (118.1) was required in T_{12} line. Management practice and environment can slightly interfere on ball splitting but in the experiment field all cotton inbred lines were grown in similar management practices and environmental condition. The number of days required for ball splitting is significantly varied ranging from 45.87 to 57.10 days. The lowest days (45.87) were required for Flowering in T19 line and the highest days (57.10) was required in T_9 line. Environment condition such as temperature slightly influence days to flowering. The plant height was showed significantly varied from 77.90 to124.1 cm. The tallest plant height (124.1) was recorded in T_6 line which was statistically similar (134.4 days and 126.067 days) from T_3 and T_2 inbred line respectively where the shortest plant height (77.90) was recorded from T2 line. All other inbred lines were found medium plant height. Different inbred line produce different plant height because it is a genetical characters. Management practice can interfere plant height but in the experimental field management was same in 20 cotton inbred lines.

The number of balls which contributed to seed cotton yield were significantly varied from 18 to 25.23 Table 3. The highest balls per plant (25.23) found in T12 line followed by T16 and T19 line (24.9 and 26.83) respectively and the lowest balls per plant (18.00) found in T1 line followed by T2 inbred lines (19.33) respectively. Cob length varied in different inbred line but the management practice was similar for 20 cotton inbred lines. Palomo *et al.* (2000) and Siddiqui *et al.* (2007) who reported that the number of bolls per plant decreased with increase in plant density.The ball weight was significantly varied from 4.333 to 6.35 (Table 3). The highest ball weight (6.35) found in T_{20} line followed by T_{18} and T_6 line (6.11 gm and 6.047 gm) respectively and the lowest ball weight (4.087) found in T_7 line followed by T4 and T3 inbred lines (4.37 and 4.41) respectively. This was happened due to their genetical characters. The seed cotton yield was significantly varied from 1812 to 2977 kg/ha. Table 3.The highest seed cotton yield (2977) found in T_{19} line and the lowest seed cotton yield (1812) found in T_2 line. This was happened due to their genetical characters. Yield contributing characters varied from different line which greatly influenced yield of cotton. Management practice can interfere on Yield contributing characters but 20 inbreed line were cultivated in similar management practice. Palomo *et al.* (2000) and Alfaqeih *et al* .(2002) who stated that yield per plant increases with decreasing plant density.

Correlated response of different characters

Correlation provides information on the nature and extent of relationship among the characters. Selection for yield will be effective when it is based on its contributing component traits rather than relying on yield alone. When the selection pressure is applied for a trait, the population being improved for a trait also gets improved in respect to all traits associated with it. Thus correlation study facilitates simultaneous improvement of two or more characters. Knowledge of the relationship among yield components is essential for formulation of breeding program aimed at achieving the desired combination of various components of yield. The estimates of correlation coefficients was worked out among 12 yield and fibre quality related characters with seed cotton yield per plant (Table-5 and Table-6). Of total traits eight traits namely number of bolls per plant, boll weight, number of monopodia per plant, number of sympodia per plant, node/main stem fibre weight, boll weight, no. of seed/boll and plant height had a significant positive association with seed cotton yield per plant but no. of vegetative branch, days to first flowering and days to 50% boll splitting showed negative association with seed cotton yield per plant. Hence selection for these traits will help in selecting genotypes with higher seed cotton yield per plant. Similar results of positive association between yield and fibre quality traits was reported by Aguado *et al.* (2008), Mahantesh (2009), Ashok kumar and Ravi Kesavan (2010).

Correlated response all possible paired combinations of characters were estimated to gain better response during indirect selection of different characters. In every case, the values of genotypic correlation were greater than those of phenotypic correlation. In case of genotypic correlation, the highest and negative correlated response (-0.674) was paid by Days to 50% boll splitting. In addition, No. of node/ main stem(.698) and Fiber weight (0.675) developed strong positive response to selection when yield is considered to be increased. Efficiency of indirect selection depended on the magnitude of correlations between yield and target yield components. Similar types of result were found in case of phenotypic correlation also but the their relationship with yield is non-significant

Path coefficient Analysis:

The study of path coefficients enable breeder to concentrate on the variable which show high direct effect on seed cotton yield. The genotypic correlation coefficient of seed cotton yield with other yield contributing and fibre quality traits were further partitioned into direct and indirect effects. Among the traits studied number of bolls per plant exerted maximum direct effect on seed cotton yield per plant followed boll weight (2.20), plant height (0.7480) and uniformity ratio also had positive direct effect in genotypic path coefficient Analysis. In case of Phenotypic path analysis, all the characters showed positive direct effect except days to first flowering. On the other hand, no. of vegetative branch and days to first flowering showed highly negative effect with yield in both genotypic and phenotypic level. Maximum indirect positive effect on seed cotton yield per plant was recorded for number of sympodia per plant and plant height through number of bolls per plant. Similar types of result were found in case of phenotypic path co-efficient. Seed index and lint index through boll weight. (Khan *et al.*,2009) . Each and every character had both positive and negative indirect effects but through which these effect were exerted should be considered.The direct and indirect effects of yield characters number of bolls per plant, boll weight, plant height recorded major yield contributing traits and should be considered for yield improvement. Based on correlate ion and path analysis it is suggested due emphasis should be given to number of bolls per plant, boll weight, plant height, fiber weight and days to first flowering for increasing seed cotton yield per plant for the red soil situation.

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