BANGLADESH JOURNAL OF PROGRESSIVE SCIENCE & TECHNOLOGY BJPST

BJPST: 15(2): 031-038 [July, 2017] ISSN: 2305-1809 (Online version)

Available online at *http:/www.bjpst.net*

DEVELOPMENT OF INTERSPECIFIC HYBRIDS BETWEEN AMERICAN COTTON (*Gossypium hirsutum*) AND EGYPTIAN COTTON (*Gossypium barbadense*) FOR NEW GENETIC RECOMBINATIONS

Joha MRK[1], Biswas BK[2], Kabir A[3], Turin MTS[1] and Sultana S[1]

Hajee Mohammad Danesh Science and Technology University, Dinajpur

[1]MS in Genetics & Plant Breeding, [2]Professor, Dept. Genetics & Plant Breeding and [3]Upazilla Agriculture Officer, Khetlal Upazilla, Joypurhat

ABSTRACT

An investigation was carried out on eight genotypes of cotton where four genotypes were under the species *Gossypium hirsutum* and another four species from *Gossypium barbadense.* Since the fiber quality of *Gossypium barbadense* (Egyptian cotton) is superior to *Gossypium hirsutum* (American cotton), so an attempted was undertaken to produce interspecific hybrids with a view to incorporate desirable traits from both the species. Before going to operate hybridization program, the parental lines were evaluated for different morpho-physiological characters. The mean values of seed cotton yield were higher in American cotton than that of Egyptian cotton. The mean squares (ms) were significant for all the selected characters, indicated ample variation among the eight genotypes for the selected characters. The highest CV (%) against plant height at harvest suggested that plant height in cotton was highly sensitive to environmental conditions. Among the four genotypes under American cotton (*Gosypium hirsutum*) JA-08/E produced the highest seed cotton yield (116.2 g/plant) whereas, among the four genotypes under Egyptian cotton (*Gossypium barbadense*) JA-10/202 produced the highest seed cotton yield of 81.37 g plant^{-1}. Hence, the yield potential of American cotton is higher than that of Egyptian cotton in our country, Different genetic parameters were estimated on 12 characters, where the highest heritability was measured for days to 50% flowering (95.02%) but none of the characters showed high heritability coupled with high genetic gain as percentage of mean. High heritability along with high genetic advanced provide better response selection expected in next generation. A set of 28 experimental hybrids were produced in a half diallel fashion from 8x7 cross combinations. Number of fruit set was lower as compared to number of bud emasculated followed by pollination because of environmental and physiological causes. The crossability estimated 100% for the cross. JA-08/A x JA-12/203. The segregants derive from this cross might result super quality cotton varieties suitable for our country. Since the requirement raw cotton is high but area under production is little, desirable hybrids or inbred varieties must be needed to fulfill the demand of the farmers of the country.

INTRODUCTION

Cotton is a major fibre crop of global importance and has high commercial value over the world. It is grown commercially in the temperate and tropical regions of more than 70 countries (Biology of *Gossypium* spp., 2011). The word 'cotton' refers to species in the genus *Gossypium* (Malvaceae) namely *G. hirsutum* L., *G. barbadense* L., *G. arboretum* L. and *G. herbaceum* L. were domesticated independently as source of textile fibre (Brubaker *et al*., 1999). The place of origin of the genus *Gossypium* is not known, however the primary centers of diversity are west-central and southern Mexico (18 species), north-east Africa and Arabia (14 species) and Australia (17 species). DNA sequence data from the existing *Gossypium*s pp*.* suggested that the genus arose about 10-20 million years ago (Wendel and Albert, 1992 and Seelanan *et al*., 1997).

Bangladesh has a glorious historical reference in growing superfine quality of cotton. The advent of the industrial revolution provided a great boost to cotton manufacture, as textiles emerged leading export in Bangladesh. It is the second most important cash crop in Bangladesh after jute. Under normal conditions, it can only meet 3% of the country's demand for raw cotton that is used for yarn and textiles. Bangladesh cotton production was 153280 (1bales=400lb) bales in 2015-16, over 1.54% from previous year. Area harvested was 42,800 hectares in 2016 as compared to 42,700 hectares in 2015 (BTMA, 2017). The area increased 2.5% was attributed to implementation of Bangladesh Cotton Development Board. 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, 2017). 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 (2014-2015) and 0.27 percent (2015-2016) of the total cropped area, respectively (BBS, 2017).

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. Heritability indicates the extent of transmissibility of a character into future generations. Moreover, knowledge of heritability is also essential for selection of component traits for yield improvement. Genetic advance measures the difference between the mean genotypic values of selected population and the original population from which these were selected. Heritability estimates along with genetic advance is normally more helpful in predicting the genetic gain under selection than heritability estimates alone. Heritability is the ratio of genotypic variance to total or phenotypic variance (Broad sense). Genetic advance is the improvement in mean genotypic value of selected plants over the parental population. Regression is the association between any two variables which measures contribution of various independent variables on the dependent variable (Dewey and Lu, 1959.). Crossability helps to understand the extent of success of hybridization between two species. Regression analysis is majorly used for prediction purposes as it provides predicted entity as a function of the dependent entities. In certain cases, it gives the relationship between independent and dependent variables (Alan, 1993). The present study was undertaken; (i) to evaluate seed cotton yield potential along with yield enhancing traits in American and Egyptian cotton lines; (ii) to estimate crossability of two cotton species, and (iii) to combine the quantitative and qualitative characteristics from two different species with a view to evolve high quality hybrid cotton varieties or inbred cotton varieties.

MATERIALS AND METHODS

A field experiment was conducted in the Plant Breeding Research Field under the Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, during the period from July, 2016 to February, 2017. 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 plot of each block. The individual plot size was 12.8m x 6m. Each replication contained 48 lines. Each line contained 15 plants. The source all of the genotypes used in this experiment was collected from Bangladesh Cotton Development Board. The genotypes of four American cotton (JA-08/A, JA-08/BJA-08/D andJA-08/E) and four Egyptian cotton (JA-10/201, JA-10/202,JA-12/203 and JA-12/204) were used. Depending on variable maturity time harvesting continued for about one month because balls of different genotypes matured progressively at different dates. The balls per genotypes were collected three different times 1st Jan 17, 15th Jan and 1st Feb 17. Data on different yield and yield contributing characters were recorded on plot and plant basis as per experimental requirement. Data were recorded on vegetative branches plant^{-1}, number of fruiting branches plant^{-1}, primary fruiting branches plant^{-1}, secondary fruiting branches plant^{-1}, days to (50%) flowering, days to (50%) bolls splitting, numbers of bolls plant^{-1}, un-burst bolls plant^{-1}, single boll weight (g), plant height at harvest (cm),seeds boll^{-1}, seed cotton yield (g plant^{-1}).The data on various growth and quality traits were recorded by using standard procedure. The data collected were analyzed statistically using analysis of variance (ANOVA) test. The analyses of variances for the characters under consideration were performed by F variance test. The significance of difference among the means was evaluated by least significant difference (DMRT) test for interpretation of results (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Analysis of variance for different yield contributing characters

The analysis of variance for 12 quantitative characters viz. vegetative branches plant^{-1}, node number of first fruiting branches plant^{-1}, primary fruiting branches plant$^{-1,}$ secondary fruiting branches plant^{-1}, days to (50%) flowering, days to (50%) boll splitting, number of bolls plant^{-1}, un-burst bolls plant^{-1}, single boll weight, plant height at harvest, number of seeds boll^{-1} and seed cotton yield was accomplished to assess the variability pertained for a particular character among the eight cotton cultivars. The mean sum squares and the co-efficient of variation for the studied characters from the analysis of variance are summarized in the Table 1. It is observed that mean sum of squares of the varieties of all the characters were significant indicating significant variation present in all the tests. There was no significant variation found among the three replications in all the characters. Coefficient of variation in all the characters was equal to or less than 10.83 except Un-burst bolls plant^{-1} (12.28), Boll weight (11.35) and Plant height at harvest (15.78). The results of analysis of variance (Table 1) 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 for hybridization.

Table 1. Analysis of variance (MS) on different characters in cotton

SI. No.	Characteristics	Sources of variation with mean sum of squares			
		Replication (2df)	Genotype (7df)	Error (14df)	CV%
1.	Vegetative branches plant $^{-1}$	0.3	1.92**	0.14	10.58
2.	Node number of first fruiting branches (NFB) plant $^{-1}$	0.63	5.774**	0.85	9.19
3.	Primary fruiting branches plant $^{-1}$	2.02	20.64**	1.3	8.64
4.	Secondary fruiting branches plant $^{-1}$	0.56	5.73**	0.7	5.08
5.	Days to (50%) flowering	4.50	29.14**	0.5	9.63
6.	Days to (50%) boll splitting	0.87	92.94**	1.018	3.78
7.	Number of Bolls plant^{-1}	7.12	205.60**	19.15	5.51
8.	Un-burst bolls plant^{-1}	0.5	0.923**	0.065	12.28
9.	Single boll weight (g)	0.9	2.108**	0.26	11.35
10.	Plant height at harvest	1.87	207.98**	4.7	15.78
11.	Number of Seeds boll^{-1}	0.13	2.48**	0.15	7.22
12.	Seed cotton yield ((g/plant))	0.03	267.02**	2.87	10.83

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

Table 2. Mean performance of different characters

Genotypes	VBP	NFBP	PFBP	SFBP	DFF	DBS	BPP	UBPP	SBW	PH	SPB	SCY
JA-08/A	2.74b	7.27a	15.18c	8.17c	55b	110e	28.14g	1.56h	5.5b	124.2c	27.3d	110.4c
JA-08/B	2.64b	6.3c	12.38f	8.62b	54bc	112de	29.54e	1.93e	5.46b	126b	28.5b	112.1b
JA-08/D	1.98c	5.87d	16.23b	9.28a	54bc	115c	27.03h	1.84f	5.13c	127.8a	26.35g	109.3d
JA-08/E	3.14a	6.9b	17.4a	9.31a	52c	113cd	28.81f	1.66g	6.23a	120.9d	26.81f	116.2a
JA-10/201	1.35e	4.17f	14.82d	6.58e	60a	120b	70.03a	2.7b	4.12f	105.6h	27.11e	77.3f
JA-10/202	1.5d	3.42g	13.17e	6.76d	59a	125a	68.77b	3.12a	4.42d	111.5f	28.3c	81.37e
JA-12/203	1.24f	5.48e	12.17g	5.92g	58a	118b	65.95d	2.59c	3.87g	113e	28.85a	65.85h
JA-12/204	1g	4.26f	9.18h	6.3f	60a	124a	67.15c	2.28d	4.17e	110.4g	26.9f	68.21g

VBP=Vegetative branches plant $^{-1}$, PEBP=Primary fruiting branches plant $^{-1}$, DFF=Days to (50%) flowering, BPP=Bolls plant^{-1}, SBW=Single boll weight, SPB=Seeds boll^{-1}, NFBP=Node number of first fruiting branches plant -1, SFBP=Secondary fruiting branches plant $^{-1}$ DBS=Days to (50%) boll splitting, UBPP=Un-burst bolls plant^{-1}, PH=Plant height at harvest and SCY=Seed cotton yield

Table 3. Genetic parameters for different characteristics in cotton

Characters	$б^2$g	$б^2$p	GCV%	PCV%	H^2b	GA	GAM
VBP	0.59	0.73	39.70	44.14	80.90	1.42	73.57
NFBP	1.64	2.49	23.50	28.96	65.88	2.14	39.30
PEBP	6.44	7.74	18.38	20.15	83.21	4.77	34.55
SFBP	1.67	2.37	17.01	20.25	70.54	2.24	29.44
DFF	9.54	10.04	5.46	5.60	95.02	6.20	10.98
DBS	30.64	31.65	4.72	4.80	96.78	11.21	9.57
BPP	62.15	81.3	16.36	18.71	76.44	14.19	29.47
UBPP	0.286	0.351	24.19	26.80	81.48	0.99	44.99
SBW	0.616	0.876	16.14	19.25	70.31	1.35	27.89
PH	67.76	72.46	7.01	7.24	93.51	16.39	13.96
SPB	0.77	0.926	3.20	3.49	83.81	1.66	6.04
SCY	88.05	90.92	10.13	10.29	96.84	19.02	20.54

Table 4.Crossability of parental genotypes in experimental hybrid seed production

Crosses	NBE	NBP	DBS	SBW	SPB	TS	Crossability (%)
JA-08/A X JA-08/B	15	12	120	4.92	21.36	256.32	80.00
JA-08/A X JA-08/D	16	13	112	5.00	22.18	288.08	81.25
JA-08/A X JA-08/E	12	10	118	4.37	25.37	253.70	83.33
JA-08/A X JA-10/201	17	16	124	2.84	18.80	300.60	94.12
JA-08/A X JA-10/202	20	18	125	3.49	22.64	407.52	90.00
JA-08/A X JA-12/203	18	18	117	4.72	23.18	417.24	100
JA-08/A X JA-12/204	17	12	115	5.02	24.49	293.88	70.06
JA-08/B X JA-08/D	12	10	121	4.98	24.00	240.00	83.33
JA-08/B X JA-08/E	10	8	121	3.71	19.41	155.28	80.00
JA-08/B X JA-10/201	13	10	119	4.00	18.73	187.30	76.69
JA-08/B X JA-10/202	15	11	122	4.56	20.38	224.18	73.33
JA-08/B X JA-12/203	18	12	125	4.14	22.46	269.52	66.67
JA-08/B X JA-12/204	20	15	110	4.22	24.11	361.65	75.00
JA-08/D X JA-08/E	19	17	116	4.79	18.39	312.63	89.47
JA-08/D X JA-10/201	17	14	110	3.98	25.07	350.98	82.35
JA-08/D X JA-10/202	15	13	121	3.32	18.99	246.87	86.67
JA-08/D X JA-12/203	14	12	123	4.49	21.58	58.96	85.71
JA-08/D X JA-12/204	13	10	123	5.15	24.01	240.10	76.92
JA-08/E X JA-10/201	10	7	125	4.28	19.25	134.75	70.00
JA-08/E X JA-10/202	20	18	120	3.56	17.90	322.20	90.00
JA-08/E X JA-12/203	17	14	118	3.77	22.38	313.32	82.35
JA-08/E X JA-12/204	15	12	117	4.11	17.15	205.80	80.00
JA-10/201 X JA-10/202	14	10	111	4.16	18.10	181.10	71.14
JA-10/201X JA-12/203	16	12	113	3.99	15.89	190.68	75.00
JA-10/201X JA-12/204	17	15	122	3.56	21.32	319.80	88.24
JA-10/202X JA-12/203	18	13	119	4.18	24.58	319.54	72.22
JA-10/202X JA-12/204	15	12	123	4.73	16.66	199.92	80.00
JA-12/203X JA-12/204	14	10	118	3.89	19.09	190.90	71.43

NBE= Number of boll emasculated, DBS= Days to ball splitting, SPB= Seeds per boll, NBP= Number of ball pollinated, NBP= Number of ball pollinated, SBW=Single boll weight

Mean performances of different yield contributing characters

Mean performances of different parameters are presented in Table 2. The number of vegetative branches was significantly varied from 1.00 to 3.14. The maximum number of vegetative branches (3.14) was recorded in JA-08/E line and the minimum (1.00) was recorded in JA12/204 line. This was also reported by Altaher *et al.* (2003), Long *et al.* (2010). The number of first fruiting branches (NFB) plant^{-1} was significantly varied from 3.42 to 7.27. The maximum number of first fruiting branches (NFB) plant^{-1} (7.27) was recorded in JA08/A and the minimum (3.42) was recorded in JA-10/202 line. Similar result was observed by Senthil *et al.* (2010). Among the different cotton lines the maximum number (17.4) of primary fruiting branches was recorded in JA-08/E line and the minimum (9.18) was recorded in JA12/204 line. The number of secondary fruiting branches was significantly varied from 5.92 to 9.31. The maximum number (9.31) of secondary fruiting branches was recorded in JA-08/E line which was statistically similar with (9.28) from JA-08/D and the minimum (5.92) was recorded in JA12/203 line. Days to (50%) flowering was significantly varied from 52 to 60 days. The highest value (60) was found in JA-10/201 and JA12/204 line which was statistically similar with JA-10/202(59) and JA12/204(58) and the lowest value (52) was found in JA-08/E line. This was happened due to their genetical characteristics. The number of days required for ball splitting is presented in Table 2**.** Days to ball splitting were significantly differed ranging from 110 to 125 days. The lowest days (110) was needed for ball splitting in JA08/A line, and the highest days (125) was required in JA10/202 line which was statistically similar with (124) from JA-12/204. Management practices and environment can slightly interfere on ball splitting but in the experimental field all cotton inbred lines were grown in similar management practices and environmental condition. The number of balls which contributed to seed cotton yield was significantly varied from 27.03 to 70.03 (Table 2.). The highest balls per plant (70.03) were found in JA-10/201 line and the lowest number of balls plant^{-1} (27.03) was found in JA-08/D line. Number of balls plant^{-1} varied in different lines but the management practice was similar for 8 cotton inbred lines. The Un-burst bolls plant^{-1} was significantly varied from 1.56 to 3.12 (Table 2). The highest number of Un-burst bolls plant^{-1} (3.12) was found in JA-10/202 line and the lowest was (1.56) found in JA08/A line. The ball weight was significantly varied from 3.87 to 6.23g (Table 2). The highest ball weight (6.23) was found in JA-08/E line followed by JA08/A andJA08/B line (5.50 and 5.46) respectively and the lowest ball weight (3.87) was found in JA-12/203 line. This was happened due to their genetically controlled characters. The plant height was significantly varied from 105.6 to 127.8 cm. The tallest plant height (127.8) was recorded in JA-08/D line where the shortest plant height (105.6) was recorded from JA-10/201 line. Management practice can interfere plant height but in the experimental field management was same in 20 cotton inbred lines. The Seeds boll^{-1} was significantly varied from 26.35 to 28.85g. The highest Seeds boll^{-1} (28.85g) was recorded in JA-12/203 line where the lowest Seeds boll^{-1} (26.35g) was recorded from JA-08/D line. This was in agreement with Naqib *et al.* (2010). The seed cotton yield was significantly varied from 65.85 to 116.2 g plant^{-1} (Table 2). The highest seed cotton yield (116.2) found in JA-08/E line and the lowest seed cotton yield (65.85) found in JA-12/203 line. This was happened due to their inherent 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. Similar result was observed by Senthil *et al.* (2010), Zhang *et al.* (2016).

Genetic parameters on the selected characters in cotton

In cotton, the variability has been evaluated for seed cotton yield and yield components (Mathapati *et al.,* 1978) Different parameters such as genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), genetic advance (GA) and genetic advance as percent of mean (GAM) of 12 characters were estimated to observe the variability exited among the characters. The results are presented in (Table 3) revealed that very close relation was observed between each of the pairs of parameters against each of the selected characters.

High genotypic and phenotypic variances were recorded with Seed cotton yield (88.05 and 90.92), plant height (67.76 and 72.46) and bolls plant^{-1} (62.15 and 81.3) respectively. The low values of genotypic and phenotypic variances were observed with the characters Un-burst bolls plant^{-1} (0.286 and 0.351), vegetative branches plant^{-1} (0.59 and 0.73), single boll weight (0.616 and 0.876), respectively. In general, the phenotypic variances were higher than genotypic variances for all the characters These findings were in accordance with those of Neelam *et al.* (2002), Altaher and Singh (2003), Narisireddy and Ratnakumari (2004), Karunakar Raju (2005), Kaushik and Kapoor (2006), Leela Pratap (2006), Vijayalaxmi (2007), Neelima *et al*. (2008), Sarada *et al.* (2010), Rajanna (2010) and Kulkarni *et al*. (2011). The phenotypic coefficients of variance (PCV) were ranged from 3.49% for seeds per ball to 44.14% for vegetative branches plant^{-1}, whereas, genotypic coefficients of variance (GCV) were ranged from 3.20% for seeds ball^{-1} to 39.70% for vegetative branches plant^{-1}. The highest heritability value (h^2b=96.84%) was estimated for seed cotton yield and the lowest heritability value (h^2b=65.88%) was estimated for number of first fruiting branches (NFB) plant^{-1}, the magnitude of heritability for yield (g plant^{-1}) was high 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. Most of the characters showed high heritability couple with low genetic advance. Moderate genetic advance was recorded for seed cotton yield (19.02), plant height (16.39), bolls plant^{-1} (14.19) and days to boll splitting (11.21). These findings were in supportive of Kale *et al.* (2007), Ravikesavan *et al.* (2008), Krishna Mohan (2011), Kulkarni *et al*. (2011), Krishna Kishore *et al.* (2011), Kumar *et al.* (2017) and Meena and Meena (2017). The present study revealed high heritability accompanied with high genetic advance as percent of the mean for vegetative branches plant^{-1}, node number of first fruiting branches plant^{-1}, primary fruiting branches plant^{-1}, secondary fruiting branches plant $^{-1}$, bolls plant^{-1}, un-burst bolls plant^{-1}, single boll weight, seed cotton yield and moderate genetic advance as percent of the mean for days to (50%) flowering, days to 50% flowering, plant height at harvest. These results could be explained by additive gene action and their selection may be done in early generations. Similar findings have been reported by Ashokkumar and Ravikesavan (2010) and Farooq *et al.* (2014). The results of the present study on variability, heritability and genetic advance indicated scope for improvement of seed cotton yield through selection, using parameters like the genetic coefficient of variation, heritability and GAM and are of great importance when developing an efficient breeding programfor cotton, because when there is sufficient genetic variation, breeders can exploit additive gene effects, transgressive segregation, and heterosis to improve yield.

Cross ability of parental genotypes in experimental hybrid seed production

The genotypes under American cotton and Egyptian cotton were crossable. The cross ability in interspecific hybrids varied from 66.67 to 100%. The produced 28 interspecific hybrids successfully gave enough hybrid seeds to conduct the experiment for evaluation of hybrids. The genotype, JA-08/D showed the best performance in hybridization with four genotypes of Egyptian cotton. After evaluation of 28 interspecific hybrids, a few outstanding hybrids might prove to superior to others that may fulfill the demand of super quality hybrid cotton. The flower buds were selected before anthesis. The flower buds manually emasculated early in the morning every day. Number of emasculated buds varied from cross to cross. The highest number of flower buds was emasculated in the crosses JA-08/A x JA-10/202, JA-08/B x JA-12/204 and JA-08/E x JA-10/202, where 20 flower buds were emasculated, whereas the lowest number of flower buds were emasculated in JA-08/B x JA-08/E and JA-08/E x JA-10/201, where only 10 buds were emasculated in each genotype. Number of pollinated flower buds was lower than the corresponding emasculated buds because rapid dryness of stigma after emasculation might be resulted unsuccessful pollination. However, the highest number of buds pollinated in JA-08/A x JA-10/202, JA-08/A x JA-12/203 and JA-08/E x JA-10/202; each with 18 pollinated buds. The lowest number of buds pollinated in the crosses, JA-08/B x JA-08/E and JA-08/E x JA-10/201. The pollinated buds were immediately covered by brown paper bags with tags. The tags carried necessary information, so that hybrid seeds might harvest properly. The required for 1st boll splitting was counted in the crosses, JA-08/A x JA-10/202, JA-08/B x JA-12/203 and JA-08/E x JA-10/201 and it was 125 days. The bolls were split very early in the crosses, JA-08/B x JA-12/204and JA-08/D x JA-10/201 and value was 110 days. Usually earlier split bolls produce low seed cotton yield due to insufficient translocation of starch into bolls. The range of single boll weighs varied from 2.84 (cross, JA-08/A x JA-10/201) to 5.15 g (cross, JA-08/D x JA-12/204). Single boll weight is a direct reflection seed cotton yield, since the character is positively related with yield potential of cotton genotypes. Usually the hybrid bolls had lower boll weight as compared to the respective parental lines. The highest seed boll^{-1} was obtained from the crosses, JA-08/A x JA-08/E and JA-08/B x JA-12/204. The lowest number of seeds was obtained from the cross, JA-10/201 x JA-12/203 with average 15.89 seed per boll. Since there are two kinds of fibers, such as fuzz and lint are associated with seed, the seeds boll^{-1} was reliable indicator to obtain more seed cotton yield. Total number of seeds varied from cross to cross. The success of hybridization depended on the seeds obtained from each of the crosses. The range of hybrid seeds produced 28 experimental crosses was 58.71 to 417.24. The number of hybrid seeds was obtained from the cross, JA-08/A x JA-12/203, which was followed by the cross, JA-08/A x JA-10/202 (407.52). Since hybrid seed production is appreciable in cotton, hybrid variety development program might launch at least in smaller to supply hybrids to the cotton grower of the country. The success of hybridization programs depends upon crossability of the concerned parental lines. Even two superior may show lower crossability, which determines the quantity of hybrid seed would produce either manual or CMS system. Whatsoever, crossability range was 66.67 to 100%. The highest crossability was counted from the cross, JA-08/A x JA-12/203, suggested that what may be potential of the segregants derived from the cross, maximum amount of hybrids may be produced in the cross even in hand pollination. Self-incompatibility is observed in many crop species that is barrier of interspecific hybridization.

Regression analysis in hybrid cotton seed production

Regression analysis is a common statistical tool for the investigation of relationships between two groups of variables. The fitted model can be used to describe the relationship between dependent and independent variables, or also to predict new values. he types of relationship between independent variables (selected parameters) and dependent variables (yarn properties) were checked by using curve estimation and correlation analysis. Statistical analysis demonstrated that there was a nearly linear relationship between number of balls emasculated and number of balls pollinated vs total seed obtained from hybridization. Because of this, the linear multiple regression analysis method was chosen for this study. The regression equations were developed which helped to predict effects number of balls emasculated and number of balls pollinated on total seed obtained. The scatter plot and the corresponding regression line and regression equation for the relationship between the dependent variable total seed (TS) and the independent variable number of bolls emasculated (NBE) and number of bolls pollinated (NBP) was depicted in fig. 4.4 and fig. 4.5 respectively. The coefficient of determinations were 0.5924 and 0.5102, respectively and indicated more than 50% effects were exerted by number of balls emasculated and number of balls pollinated on seed production in cotton. This implied that successful hybridization depended upon the initial activities like emasculation followed by pollination to obtain maximum hybrid seeds in cotton. Similar results were reported by Pole *et al. (*2008) and Naqib *et al.* (2009). For the number of bolls emasculated the regression coefficient of 22.76 means that total seed was increased by 22.76 with each additional number of bolls emasculated. Similarly, for the number of bolls pollinated the regression coefficient of 22 means that total seed was increased by 22 with each additional number of bolls pollinated.

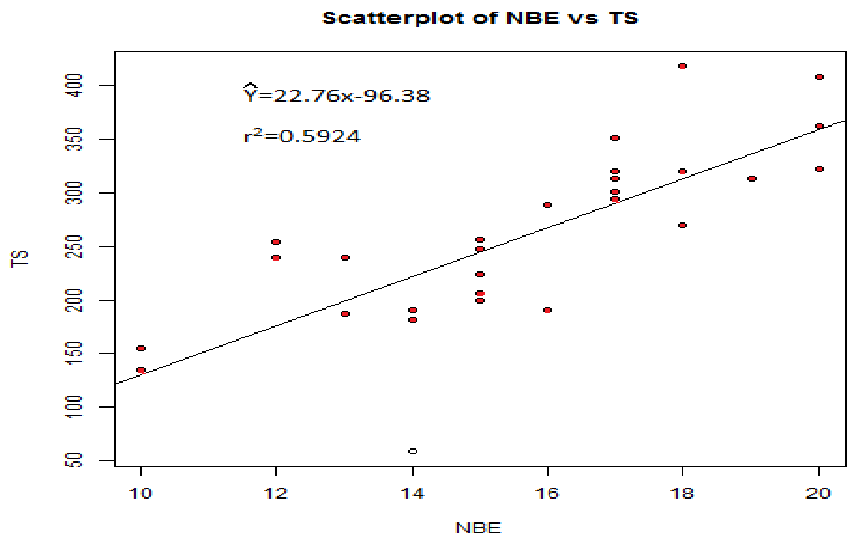

Fig.1 Confidence interval of total seed (TS) with number of bolls emasculated (NBE)

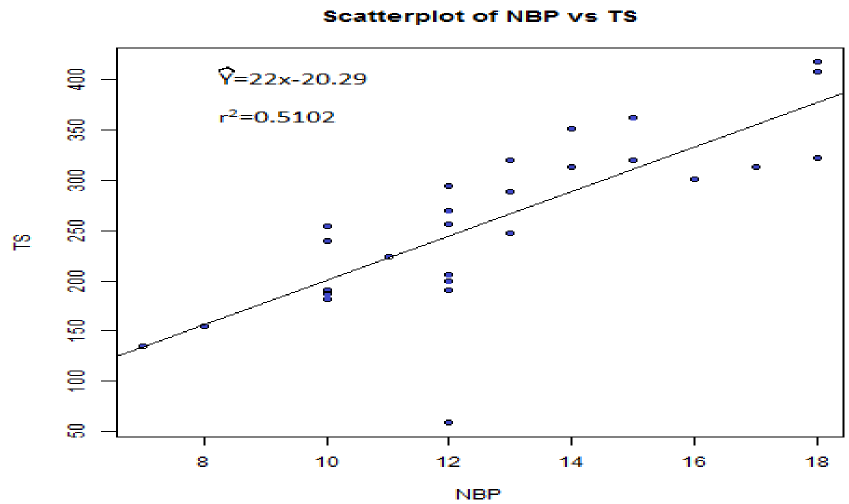

Fig 2. Confidence interval of total seed (TS) with number of bolls pollinated (NBP)

Results of the present studies indicated significant variation among the genotypes for all the characters studied. The highest heritability was observed for all traits. High heritability coupled with moderate genetic advance was estimated against days to 50% boll splitting, bolls plant^{-1}, plant height and seed cotton yield. Therefor selection would be effective with these characters. Cross JA-08/A x JA-12/203 with highest total seed and cross ability might advance for further evaluation with a view to develop high yielding cotton variety.

REFERENCES

Alan OS. 1993. An introduction to regression analysis.Master thesis, University of Chicago law school, Chicago, Illinois.

Altaher AF and Singh RP. 2003. Yield component analysis in upland cotton (*GossypiumhirsutumL.).* J. Indian Soc. Cotton Improv. 28 (3): 151-157.

Ashokkumar K and Ravikesavan R. 2010. Genetic variation and heterotic effects for seed oil, seed protein and yield attributing traits in upland cotton (*Gossypium. hirsutum*L.). African J. Biotech. 12(33):5183-5191.

BBS. 2017. Bangladesh Bureau of Statistics. All Crops Summary 2016-2017.

Biology of *Gossypium spp.* 2011. Ministry of Environment and Forest, Government of India.

Brubaker CL, Seelanan T, Stewart JM, Craven LA and Wendel JF. 1999. Molecular systematics of Australian Gossypium section Grandi calyx (Malvaceae). Syst. Bot. 24: 183-208.

BTMA. 2017. Bangladesh Textile Mills Association. Bangladesh Cotton and Products Annual Reports. pp.2-3.

Dewey JR and Lu KH. 1959. A correlation and path co-efficient analysis of components of crested wheat seed production. Agron. J. 51:515-518

Elfawal MA, Bishr MA and Hassoub EK. 1976. Natural cross pollination in Egyptian cotton (*Gossypium barbadense* L.). J. Agricl. Sci. 86: 205- 209.

Farooq MA, Farooq RZ and Ilahi F. 2014. Correlation and path coefficient analysis of earliness, fiber quality and yield contributing traits in cotton. J. Animal and Plant Sci. 24 (3): 781 – 790.

Gomez and Gomez, 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York.

Kale UR, Kalpande S, Annapurve SN and Gite VK. 2007. Yield components analysis in American cotton (*Gossypium hirsutum* L.). Madras Agril. J. 94 (7-12): 156-161.

Karunakar Raju GB. 2005. Character association and genetic divergence in cotton (*Gossypium hirsutum*. L.). *M.Sc. (Ag) Thesis.* Acharya N G Ranga Agricultural University, Hyderabad, India.

Kaushik SK and Kapoor CJ. 2006. Genetic variability and association study for yield and its component traits in upland cotton (*Gossypium hirsutum* L.). J. Cotton Res. Dev. 20 (2): 185-190.

Krishna Kishore D, Gopinath M, Satyanarayana Rao V and Srinivasa Rao V. 2011. Genetic variability studies in upland cotton. Andhrapradesh Agril. J. 58 (1): 17-21.

Krishna Mohan M. 2011. Combining ability analysis for fibre quality in interspecific hybrids of cotton. M.Sc. (Ag) Thesis. Acharya N G Ranga Agricultural University, Hyderabad, India.

Kulkarni AA, Nanda HC and Patil SG. 2011. Study of genetic parameters on yield, yield contributing and fibre quality characters in upland cotton (*Gossypium hirsutum* L.). J. Cotton Res. Dev. 25 (1): 22-24.

Kumar NVM and Katageri IS. 2017. Genetic variability and heritability study in f2 population of *Gossypium barbadense* cotton for yield and its components. Int. J. Cur. Microbiol. Appl. Sci. 6 (6):975-983.

Leela Pratap K. 2006. Combining ability and heterosis in cotton (*Gossypium hirsutum* L.). M. Sc. (Ag) Thesis. Acharya N G Ranga Agricultural University, Hyderabad, India.

Long R, Bange MP, Gordon SG, Sluijs MHJ, Naylor GRS and Constable GA. 2010. Fiber quality and textile performance of some Australian cotton genotypes. Crop Sci. 50(4): 1509-1518.

Mathapati SN, Hiremath KG, Kadapa SN and Goud JV. 1978. Genetic variability and correlation between economic characters in Egyptian cotton. Indian J. Agril. Sci. 48: 156-158.

Meena PKP and Meena H. 2017. Genetic variability and character association in intra-hirsutum hybrids. Int. J. Pure Appl. Biosci. 5(3): 403-406.

Naqib UK, Marwat KB, Hassan G, Farhatullah, Kumbhar MB, Parveen A and Umm-E-Aiman. 2009. Diallel analysis of some quantitative traits in *Gossypium hirsutum* L. Pakistan J. Bot. 41 (6): 3009 -3022.

Narisireddy A and Ratnakumari S. 2004. Genetic components of variation of physiological attributes for drought screening of genotypes in American cotton (*Gossypium hirsutum* L.). Ann. Agril. Res*.* 25 (3): 412-414.

Neelam GD, Potdukhe NR and Patil VT. 2002. Heterosis for seed cotton yield and morphological characters in *Gossypium hirsutum* L. J. Cotton Res. Dev. 16 (2): 161-164.

Neelima S, Chenga R and Narisireddy A. 2008. Genetic parameters of yield and fibre quality traits in American cotton (*Gossypium hirsutum* L.). Indian J.Agril. Res.42 (1): 67-70.

Pole SP, Kamble SK, Madrap IA and Saranga DH. 2008. Diallel analysis for combining ability of seed cotton yield and its components in upland cotton (*Gossypium hirsutum* L.). J. Cotton Res. Dev. 22 (1): 19-22.

Rajanna B. 2010. Combining ability studies involving new hirsutum lines in upland cotton (*Gossypium hirsutum* L.). M.Sc. (Ag) Thesis. Acharya N G Ranga Agricultural University, Hyderabad, India.

Ravikesavan R, ThiHaan and Iyanar, K. 2008. Genetic advance and heritability as a selection index for improvement of yield and quality in cotton. J. Cotton Res. Dev. 22 (1): 14-18.

Sarada B, Lal Ahamed M, Satyanarayana Rao V and Sreekanth B. 2010. Genetic variability, character association and path coefficient analysis in *Gossypium hirsutum*. Andhrapradesh Agril. J. 57 (4): 352-356.

Seelanan T, Schnabel A and Wendel JF. 1997. Congruence and consensus in the cotton tribe (Malvaceae). Syst. Bot. 22: 259-290.

Senthilkumar R, Ravikesavan R, Punitha D and Rajarathinam S. 2010. Genetic analysis in cotton. Elec. J. Plant Breed. 1 (4): 846-851.

Vijayalaxmi G. 2007. Genetic divergence in cotton (*Gossypium hirsutum* L.). M.Sc. (Ag) Thesis. Acharya N G Ranga Agricultural University, Hyderabad, India.

Wendel JF and Albert VA. 1992. Phylogenetics of the cotton genus (*Gossypium*): character-state weighted parsimony analysis of chloroplast DNA restriction site data and its systematic and biogeographic implications. Syst. Bot. 17: 115-143.

Zhang J, Wu M, Yu J, Li X and Pei W. 2016. Breeding potential of introgression lines developed from interspecific crossing between upland cotton (*Gossypium hirsutum*) and (*Gossypium barbadense*). Cotton Res. J. 5(2) 111-131.