Heritability and correlation analysis of morphological and yield traits in genetically modified cotton

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Research

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Abstract

Background

Cotton is known for its fiber and it is grown in tropical and sub-tropical areas of the world. It has a significant role in GDP of Pakistan. Therefore, present two years research was conducted to estimate heritability and association among various yield contributing parameters of cotton. The selected genotypes of cotton were hybridized in green house of the department. The F 0 cotton seed along with parents were planted in the field conditions during May, 2018. The sowing of this experiment was completed in three replications followed by RCBD. The data was recorded at maturity for various agronomic traits including plant height, number of bolls per plant, number of sympodial branches per plant, seed cotton yield, boll weight, seed index, ginning out turn, fiber length, fiber strength, and fiber fineness. Level of significance of data was computed by ANOVA to assess the difference among cotton genotypes which was used for estimation of heritability and correlation analysis among the related traits.

Results

Association analysis revealed that seed cotton yield had significant positive relationship with plant height, number of bolls per plant, number of sympodial branches per plant, ginning out turn, staple length and fiber strength. Staple length and fiber strength were negatively linked with each other. Estimates of heritability were high for all observed traits except number of sympodial branches per plant and boll weight.

Conclusion

The parent IUB-222 was found best for plant height, number of bolls per plant, boll weight, ginning out turn, seed cotton yield and seed index. NIAB-414 and VH-367 were identified best parents for fiber length, strength and fineness. Among crosses NIAB-414 × IUB-222 was best for number of bolls per plant, seed index, seed cotton yield and fiber fineness. Whereas, cross NIAB-414 × CIM-632 was good for plant height. The combination of A555 × CIM-632 was best for number of sympodial branches per plant, boll weight, fiber length and strength. VH-367 × CIM-632 proved best for ginning out turn. The correlation results from this study would be helpful to breed cotton cultivars with good yield and quality characters. Broad sense heritability was high for all of parameters which provides the strong evidence that selection in early generations can improve the performance of these traits.

Introduction

Cotton is also known as white gold due to its white and soft fiber. The cotton plant grown like shrub in nature and its fiber is pure cellulose. Cotton is cultivated all over the world which is mainly considered for fiber production. Its fiber is usually used to spin into yarn which is further used for making socks, curtains and towels etc. Its fiber also consumed in textile industry for cloth making (Stewart and Rossi 2010). Significant amount of oil (16–27%) is extracted from cotton seed and seed cake is used in livestock industry, and oil extracted from cotton seed is used as vegetable oil for making fries, excite etc. because taste of cottonseed oil is similar to coconut oil. In addition, it is an important source of vitamins, fat and antioxidants (Dowd et al., 2010). During 2018–2019 survey, cotton was cultivated on an area of 2,373 thousand hectares with

9.861 million bales production. It shares 0.8% in GDP and 4.5% in value addition (Govt. of Pakistan, 2018-19).

The world population is increasing day by day therefore it is necessary to increase the productivity of crop to meet the requirement of cotton. Utilization of breeding tools is the only method to meet the demand of textile industry (Farooq et al., 2014). Understanding the genetic basis of important yield contributing traits is the pre-requisite and information about their relationship must be available to cotton breeder. All the yield related traits are correlated with each other in such a way, increase or decrease in one trait directly effects on other traits. So, estimation of genotypic and phenotypic correlations among these traits are helpful for initiating breeding programs. The knowledge about association among different plant characters is useful in the selection of appropriate breeding method. Phenotypic correlation shows visual observation while genotypic correlation estimates the inheritance of characters (Desalegn et al., 2009). It is indicated that boll number and sympodial branches per plant were positively linked with each other. Weight of boll had negative relationship with bolls per plant. Seed cotton yield and number of bolls were also positively correlated with each other. Heritability values were also high for these traits (Shar et al., 2017). Investigations revealed that association and inheritance for various quantitative and fiber related parameters of American cotton (Haq et al., 2017). Furthermore, yield of seed cotton was positively linked with plant height, sympodial branches, monopodial branches and bolls per plant whereas negatively correlated with days to 1st flowering. Broad sense heritability was high for all characters. While seed cotton yield had positive correlation with 100-seed weight, number of bolls per plant, plant height and boll weight (Memon et al., 2017; Mukoyi et al., 2018). Lint index, number of bolls per plant, boll weight, sympodial branches/plant and GOT exhibited positive linkage with yield of seed cotton per plant. Heritability was high for number of bolls/plant, monopodial branches/plant, internode distance and sympodial branches/plant (Monisha et al., 2018). High heritability and positive correlation were reported for fiber fineness, monopodia/plant, number of bolls/plant and yield of seed cotton (Khokhar et al., 2017; Komala et al., 2018). Positive correlation and high heritability were observed for plant height, sympodial branches, boll weight, number of bolls, seed cotton yield, fiber fineness and shoot length. Hence, concluded that these traits may be considered as selection criteria for improvement in seed cotton yield (Jarwar et al., 2018; Rathinavel et al., 2017). The present research was planned to determine correlation among various yield contributing traits due to increased demand of cotton in the country. In addition, heritability of these parameters was also computed which could be used for the selection of suitable traits from certain parents for the development of new germplasm of upland cotton.

Materials And Methods

The experiment was performed at two places, first in glasshouse and then at cotton research area of the Department of Plant Breeding and Genetics, University of Agriculture, (latitude 31°25′N, longitude 73°09′E and altitude 184.4 m from sea level) Faisalabad. Experimental material was collected from Cotton Research Group of the department. Five genotypes namely, A-555, IUB-222, VH-367, NIAB- 414 and CIM-632 were grown in earthen pots during November 2017. The humidity, temperature and light conditions for germination and growth was controlled. At two leaf stage one healthy seedling per pot was kept while others were thinned. These five parents were crossed to make all possible combinations in full diallel at the appearance of buds. Some of the buds from parents were selfed. Later on, cotton seed from 20 crosses along with their parents

was picked, ginned and sown at cotton farm during second week of May 2018. The parents alongwith F_1 population planted in three replications followed by randomized complete block design (RCBD). Row to row and plant to plant distance was 75 cm and 30 cm respectively. All agronomic practices were followed from sowing to harvesting to get good plant population. Following plant parameters of cotton plant were noted at various time intervals, the protocol of each trait is discussed in the following paragraphs.

Plant Height (cm)

Plant height was measured in cm with the help of measuring rod. The height was measured from the first cotyledonary node to the apical bud at maturity. Average height of seven guarded plants was calculated in each family.

Number Of Bolls Per Plant

Number of matured bolls of all pickings were counted and record for each family was maintained for each picking. Average number of bolls were calculated for each parent/cross for data analysis.

Number Of Sympodial Branches Per Plant

Sympodial branches are direct fruit bearing branches, these are generally short appearing towards the top of the stem. At maturity, number of sympodial branches of seven guarded plants was counted manually in each replication and then average values were calculated for each parent/cross.

Seed Cotton Yield (g)

Seed cotton was picked from mature opened bolls from seven guarded plants. Seed cotton picked during all of pickings was cumulatively weighed in grams by using electronic balance. Average seed cotton yield was calculated for each parent/cross for use in analysis.

Boll Weight (g)

Boll weight was obtained by dividing weight of seed cotton yield from each plant by the number of bolls per plant. Average boll weight was calculated for each genotype for biometrical analysis.

Seed Index (g)

Seed index determined from 100 seed weight from each plant. Cotton seeds were separated from each plant by using single roller ginning machine. A random sample of 100 seeds was obtained from each plant and

weighed by using electronic balance to determine the seed index. Mean seed index was calculated for each parent/cross in all of replications.

Ginning Out Turn (%)

First seed cotton yield was weighed then ginned with a single roller electrical gin machine. The lint obtained from each sample was weighed separately. Ginning percentage was calculated by using following formula:

$$\text{GOT (\%)} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

Fiber length (mm), Fiber strength (g/tex) and Fiber fineness (µg/inch)

Fiber traits were measured by high using high volume instrument (HVI-900) system and means for each parent/cross were calculated.

Statistical Approaches

The data collected were subjected to analysis of variance following the method of Steel and Dickey (1997) in order to determine the significant differences in plant characters of upland cotton. Genotypic and phenotypic correlation among traits were analyzed by a statistical technique that is known as correlation analysis (Kwon and Torrie, 1964). Furthermore, significance was assessed according to Steel and Dickey (1997). Whereas, Heritability in broad sense was estimated according to Burton and Devane (1953). Heritability were divided in three classes i.e. Low heritability < 0.2, Medium heritability = 0.2–0.5 and High heritability > 0.5.

Results

The analysis of variance (ANOVA) exhibited significant differences and confirm the presence of variations among genotypes for traits namely plant height, number of bolls per plant, number of sympodial branches per plant, boll weight, yield of seed cotton, seed index, fiber length, fiber strength and fiber fineness (Table 1). Actually, these genotypes are significantly different from each other and significant differences allow the breeder to proceed for further analysis useful for selection of suitable candidate parental lines. In later stage this data was used for correlation and heritability analysis.

Table 1
Analysis of variance of various quantitative traits for F_1 population and parents in upland cotton

SOV	DF	PH	NB	SB	BW	GOT	SI	SCY	FL	FS	FF
Rep.	2	2.21^{ns}	2.88^{ns}	4.39^{*}	4.77^{*}	5.88^{ns}	0.29^{ns}	4.63^{ns}	4.65^{*}	5.68^{*}	0.35^{ns}
Gen.	24	3.92^{**}	2.17^{*}	1.93^{*}	1.86^{*}	10.70^{**}	2.15^{*}	16.21^{**}	2.13^{*}	2.48^{**}	3.37^{**}
Err.	48	-	-	-	-	-	-	-	-	-	-
** = Highly significant $p \leq 0.01$, *= Significant $p \leq 0.05$											
Where, PH (plant height), BP (bolls per plant), SB (number of sympodial branches per plant), BW (boll weight), GOT (ginning out turn), SI (seed index), SCY (seed cotton yield), FL (fiber length), FS (fiber strength) and FF (fiber fineness).											

Correlation Coefficient Analysis

Correlation coefficient analysis measures the relationship between various plant characters. The estimation of genotypic and phenotypic correlations among these traits are helpful for initiating breeding programs. If correlation between two traits is positive and it is significant then improvement in one trait will exert significant impact on other trait. In this way selection for one character will also improve the other associated traits. Plant height had positive and significant linkage with number of bolls/plant, number of sympodial branches per plant, ginning out turn, seed cotton yield, fiber length and fiber fineness (Table 2). It had positive but non-significant association with boll weight. However, plant height had negative and non-significant relationship with fiber strength. Number of bolls per plant had positive and significant association with plant height, number of sympodial branches per plant, boll weight, seed index, seed cotton yield and fiber strength whereas had positive but non-significant relationship with ginning out turn and fiber fineness. It had negative but non-significant correlation with fiber length. Number of sympodial branches per plant had positive and significant relationship with all of traits except seed index and staple length. Boll weight had positive and significant correlation with number of bolls per plant, number of sympodial branches per plant, 100 seed weight, staple length and fiber fineness whereas rest had positive but non-significant association whilst negative and non-significant relationship with ginning out turn. Ginning out turn had positive and significant linkage with plant height, seed cotton yield, number of sympodial branches per plant and fiber length. It had positive but non-significant association with number of bolls per plant. However, ginning out turn had negative and non-significant correlation with boll weight, 100 seed weight and fiber strength and fineness. Seed index had positive and significant linkage with number of bolls per plant, boll weight and fiber length while had positive but non-significant correlation with plant height, number of sympodial branches/plant, yield of seed cotton and fiber fineness. It had negative and non-significant relationship with ginning out turn and fiber strength.

Table 2
Correlation among various traits of Upland cotton grown in filed conditions

Traits	PH	BP	SB	BW	GOT	SI	SCY	FL	FS
BP	0.16*								
SB	0.63**	0.17*							
BW	0.05	0.21**	0.07*						
GOT	0.34**	0.02	0.22*	-0.04					
SI	0.08	0.25*	0.09	0.51**	-0.02				
SCY	0.29**	0.54**	0.39**	0.18	0.28**	0.02			
FL	0.20*	-0.04	0.06	0.20*	0.19*	0.17*	0.03*		
FS	-0.16	0.19*	0.27*	0.12	-0.06	-0.05	0.33**	-0.02*	
FF	0.08*	0.04	0.17*	0.27*	-0.14	0.26	-0.06	0.11*	-0.05

Where, PH (plant height), BP (bolls per plant), SB (number of sympodial branches per plant), BW (boll weight), GOT (ginning out turn), SI (seed index), SCY (seed cotton yield), FL (fiber length), FS (fiber strength) and FF (fiber fineness).

Seed cotton yield had positive and significant association with plant height, number of bolls per plant, number of sympodial branches per plant, ginning out turn, staple length and fiber strength. It had positive but non-significant correlation with boll weight, seed index and fiber fineness whereas had negative and non-significant association with fiber strength. Fiber length had positive and significant linkage with plant height, boll weight, ginning out turn, seed index, fiber fineness and seed cotton yield while had positive but non-significant correlation with number of sympodial branches per plant. Staple length had negative and significant association with fiber strength while had negative and non-significant relationship with number of bolls/plant and fiber fineness. Fiber strength had positive and significant association with number of bolls per plant, number of sympodial branches per plant, and seed cotton yield whereas had positive and non-significant correlation with boll weight. It had negative and significant linkage with fiber length while had negative and non-significant relationship with plant height, ginning out turn and seed index. Fiber fineness had positive and significant correlation with plant height, number of sympodial branches per plant, boll weight, and staple length whereas had positive and non-significant association with number of bolls per plant and seed index. It had negative and non-significant linkage with ginning out turn, yield of seed cotton and fiber strength.

Estimates Of Heritability

Heritability (B.S) were ranged from medium to high for various yield and fiber related traits (Table 3). Among these traits plant height, number of bolls per plant, GOT, seed index, seed cotton yield, fiber length, strength and fineness showed high heritability estimates i.e. 74.48, 53.87, 90.65, 53.42, 54.56, 52.95, 59.66 and 70.42

respectively. While the traits sympodial branches per plant and boll weight exhibited medium estimates of heritability i.e. 48.06 and 46.66. The process of selection could be useful for characters with high heritability values.

Table 3
Range of heritability of various traits of cotton grown in field conditions

Traits	Heritability (%)	Status
Plant height	74.48	High
Sympodial branches/plant	48.06	Medium
Number of bolls/plant	53.87	High
Boll weight	46.66	Medium
Ginning out turn	90.65	High
Seed index	53.42	High
Seed cotton yield	54.56	High
Fiber length	52.95	High
Fiber strength	59.66	High
Fiber fineness	70.42	High
High > 0.5, Medium 0.2–0.5, Low < 0.2		

Mean Comparison For Certain Traits

Among parents the mean values for the character plant height, the genotype A555 had lowest mean value 99.93 cm, while CIM-632 exposed maximum mean value 124.73 cm (Fig. 1-A). Whereas, hybrid IUB-222 × NIAB-414 exhibited minimum mean value 88.07 cm, whereas NIAB-414 × CIM-632 showed highest mean value 127.2 cm. Mean data number of bolls per plant showed that genotypes VH-367 exposed minimum number of bolls per plant with lowest mean value 16.26 whereas IUB-222 showed maximum value 32.13 followed by CIM-632, NIAB-414 and A555 having mean values i.e. 26.53, 23.26, 23.13 correspondingly (Fig. 1-B). Crosses, VH-367 × CIM-632 indicated highest mean value 32.93 which is greater than NIAB-414 × IUB222, NIAB-414 × CIM-632 and A555 × IUB-222, having mean values i.e. 32.53, 31, 30.4 and 28.2 respectively. Number of sympodial branches per plant, VH-367 showed highest mean value 23.13 which is greater than A555, NIAB-414 and IUB-222 having mean values i.e. 22.66, 20.93 and 20.86 respectively (Fig. 1-C). Among the hybrids, A555 × IUB-222 had minimum mean value 18.86 for this trait, whereas VH-367 × NIAB-414 indicated maximum number of sympodial branches 25.73. Genotype, CIM-632 had minimum mean value for boll weight 1.83 g whereas VH-367 exposed maximum mean value 2.46 g (Fig. 1-D). Hybrids, IUB-222 × VH-367 revealed lowest mean value but VH-367 × NIAB-414 showed maximum boll weight. NIAB-414 had

minimum mean value for ginning out turn 38.03% while IUB-222 had maximum ginning out turn 42.32% (Fig. 1-E). NIAB × IUB-222 showed minimum mean value 35.46% whilst hybrid VH-367 × CIM-632 revealed maximum ginning out turn 46.33% followed by CIM-632 × VH-367, CIM-632 × A555 and A555 × NIAB-414 with estimates of i.e. 45.62, 44.33 and 43.22%.

Furthermore, NIAB-414 and A555 exhibited the minimum and maximum mean estimates 5.07 and 5.64 g respectively for 100 seed weight (Fig. 1-F). Hybrid CIM-632 × VH-367 had minimum seed index 4.62 g whereas CIM-632 × A555 exhibited maximum mean value 5.70 g. While studying the seed cotton yield it was observed that among parents, the genotype IUB-222 had maximum mean value 74.81 g (Fig. 1-G). Crosses of IUB-222 × A555 had minimum seed cotton yield 42.39 g but the hybrid VH-367 × CIM-632 revealed highest mean value 80.17 g as compare to A555 × IUB-222 and NIAB-414 × IUB-222 with mean values i.e. 73.95 and 72.84. CIM-632 indicated lowest mean value 24.71 mm for fiber length, while NIAB-414 had maximum fiber length 26.86 mm (Fig. 1-H). Among the hybrids, A555 × VH-376 had minimum fiber length 24.29 mm, while highest mean value 28.33 mm was shown by CIM-632 × NIAB-414. In case of fiber strength, parent IUB-222 showed minimum mean value 25.42 g/tex whereas VH-367 indicated maximum mean value 29.83 g/tex followed by A555, NIAB-414 and CIM-632 having mean values i.e. 26.35 g/tex, 26.28 g/tex and 25.47 g/tex respectively (Fig. 1-I). Furthermore, CIM-632 × IUB-222 had minimum fiber strength 23.29 g/tex, while VH-367 × NIAB-414 revealed highest value 27.96 g/tex. IUB-222 had lowest mean value 3.31 µg/inch for fiber fineness, while NIAB-414 had highest mean value 5.06 µg/inch (Fig. 1-J). While among the hybrids IUB-222 × NIAB-414 exposed minimum mean value 3.23 µg/inch, but NIAB-414 × IUB-222 had highest mean value 5.44 µg/inch followed by IUB-222 × A555, NIAB-414 × A555 and CIM-632 × IUB-222 with estimates of 5.40, 5.23 and 5.14.

Discussion

Plant height was positively linked with sympodial branches per plant, number of bolls per plant, ginning out turn, seed cotton yield, staple length and fiber fineness (Table 2). Azhar and Ajmal (1999), Rao and Gopinath (2013) and Shahzad et al.(2015) also had similar findings and reported a positive relationship of plant height with number of bolls per plant, seed cotton yield and sympodial branches per plant. Tulasi et al. (2012) also observed positive association with GOT, fiber length and fineness. Heritability (B.S) for plant height was 74.48% (Table 3). Kapoor and Kaushik (2003), Ahmad et al. (2011) and Baloch et al. (2015) also found high heritability 94%, 81% and 96.4% for this character. High heritability estimates indicated that selection for plant height can be effective. Bolls per plant had positive association with plant height, boll weight, sympodial branches per plant, seed index, seed cotton yield and fiber strength. Ahmad and Azhar (2000), Djaboutou et al. (2005), Gul et al. (2014), Magadum et al. (2012), Alkuddsi et al. (2013) and Farooq et al. (2014), also found same results. Heritability value for this character was 53.87% (Table 3). Desalegn et al. (2009), Ahmad et al. (2011), Baloch et al. (2015) and Rathinavel et al. (2017) estimated 59%, 88%, 93% and 60.21% high broad sense heritability for bolls per plant. High estimates of heritability revealed that successful and effective selection can be helpful in the improvement of this trait.

Sympodial branches per plant had positive relationship with plant height, number of bolls per plant, boll weight, seed cotton yield, ginning out turn, fiber strength and fiber fineness (Table 2). Pujer et al. (2014), Joshi

et al. (2006), Anandan (2009) indicated that sympodial branches/plant positively correlated with seed cotton yield, plant height, GOT and boll weight. Killi et al. (2005) found that sympodial branches per plant were positively linked with fiber strength. Rauf et al. (2004) also observed that sympodial branches per plant had positive relationship with number of bolls per plant and fiber fineness. Moderate heritability for this trait was observed 48.06% (Table 3). Ahmed et al. (2006), Mustafa et al. (2007), Neelima and Reddy (2008) and Kulkarni et al. (2011) also observed medium heritability 50.72%, 59%, 61.30% and 43% for sympodial branches per plant. Boll weight was positively linked with bolls per plant, sympodial branches per plant, 100 seed weight, staple length and fiber fineness (Table 2). Jatt et al. (2007) revealed that boll weight had positive association with yield of seed cotton. Abdullah et al. (2016) and Shaheen and Yaseen et al. (2014) observed that boll weight was positively correlated with fiber length, fiber fineness and sympodial branches per plant. Do Thi et al. (2008) and Kale et al. (2007) reported that boll weight positively linked with seed index and number of bolls per plant. Whilst heritability value was moderate 46.66% for this trait (Table 3). Huangjun and Myers (2011), Naveed et al. (2004) and Ahmed et al. (2006) estimated 57%, 22% and 50.0% medium heritability for boll weight.

Ginning out turn had positive relationship with plant height, seed cotton yield, sympodial branches per plant and fiber length (Table 2). Monicashree and Balu (2018), Pujer et al., 2014) and Chattha et al. (2013) observed that ginning out turn had positive linkage with plant height and sympodial branches per plant and yield of seed cotton. Shahzad et al. (2015) observed that GOT had positive association with staple length. Heritability for ginning out turn was 90.65% (Table 3). Devidas et al. (2017), Shahzad et al. (2015), Kumar and Katageri (2017) and Jarwar et al. (2018) found high heritability values 72.5%, 80.73%, 90.0% and 85.46% for this trait. Seed index had positive linkage with bolls per plant, boll weight and fiber length (Table 2). Patil (2010), Komala et al. (2018), Memon et al. (2017), Isong et al. (2017), Ashokkumar and Ravikesavan (2010), Shabbir et al. (2016) and Méndez et al. (2012) depicted that 100 seed weight positively correlated with boll weight, number of bolls per plant and fiber length. Heritability (B.S) for this trait was 53.42% (Table 3). Dhivya et al. (2014), Kaleri et al. (2016), Kumar and Katageri (2017) and Rajamani et al. (2015) estimated 60.01%, 72.24%, 51.63% and 66.72% heritability for seed index. Significant progress is possible through selection for this character.

Seed cotton yield had positive association with plant height, number of bolls per plant, sympodial branches per plant, ginning out turn, fiber length and fiber strength (Table 2). Majeedano et al. (2014), Joshi et al. (2006), Gite et al. (2006) and Latif et al. (2015) indicated that seed cotton yield was positively linked with plant height, sympodial branches per plant and number of bolls/plant. Thiyagu et al. (2010) reported that yield of seed cotton positively correlated with plant height and staple length. Monisha et al. (2018) determined positive correlation among GOT, fiber strength and seed cotton yield. Heritability value for seed cotton yield was 54.56% (Table 3). Desalegn et al. (2009), Reddy and Reddy (2007), Hussain et al. (2010), Ullah et al. (2015) and Ahmad et al. (2011) estimated 61%, 80%, 50%, 98% and 76% heritability for this trait. This trait could be improved through selection process. Fiber length was positively linked with plant height, boll weight, ginning out turn, seed index, fiber fineness and seed cotton yield. Fiber length had negative correlation with fiber strength (Table 2). Ali and Awan (2009) and Echekwu (2001) indicated that staple length was negatively associated with fiber strength. Bechere et al. (2014) indicated that fiber length had positive linkage with ginning out turn. Killi et al. (2005) determined positive association among fiber length,

plant height and seed cotton yield. Abbas et al. (2013) observed that staple length was positively associated with fiber fineness. Shabbir et al. (2016) observed that fiber length had positive association with seed index. Khan and Azhar (2000) found that fiber length had positive relationship with boll weight. Heritability in broad sense for fiber length was 52.95% (Table 3). Killi et al. (2005), Abbas et al. (2013), Khan and Azhar (2000) and Ahmed et al. (2006) found 94%, 52%, 96% and 56% heritability estimates for this trait. It is concluded from results that selection can be useful for fiber length. Fiber strength had positive association with bolls per plant, sympodial branches per plant, and seed cotton yield whereas had negative linkage with fiber length (Table 2). Ahmad and Azhar (2000), Thiyagu et al. (2010) and Farooq et al. (2014) found that fiber strength was positively correlated with yield of seed cotton and number of bolls per plant. Ali and Awan (2009) revealed that fiber strength was negatively linked with fiber length. For this trait heritability value was 59.66% (Table 3). Desalegn et al. (2009), Killi et al. (2005), Shahzad et al. (2015), Rasheed et al. (2009) and Khokhar et al. (2017) determined 33%, 73%, 62%, 70% and 68% heritability for this character. Fiber fineness was positively correlated with plant height, sympodial branches per plant, boll weight, and staple length (Table 2). Ali and Awan (2009), Zeng and Meredith (2009), Tang and Xiao (2014) and Yaqoob et al. (2016) found positive linkage between fiber fineness and staple length. Abbas et al. (2013) and Altaher and Singh (2003) revealed that fiber fineness had positive linkage with plant height, sympodial branches per plant. Abdullah et al. (2016) reported that fiber fineness was positively correlated with boll weight. Heritability value for fiber fineness was 70.42% (Table 3). Hendawi et al. (1999) and Lu et al. (2002) estimated 67% and 73% and heritability for fiber fineness.

Conclusion

The parent IUB-222 was found best for plant height, number of bolls per plant, boll weight, ginning out turn, seed cotton yield and seed index. NIAB-414 and VH-367 were identified best parents for fiber length, strength and fineness. Among crosses NIAB-414 × IUB-222 was best for number of bolls per plant, seed index, seed cotton yield and fiber fineness. Whereas, cross NIAB-414 × CIM-632 was good for plant height. The combination of A555 × CIM-632 was best for number of sympodial branches per plant, boll weight, fiber length and strength. VH-367 × CIM-632 proved best for ginning out turn. The correlation results from this study would be helpful to breed cotton cultivars with good yield and quality characters. Broad sense heritability was high for all of parameters which provides the strong evidence that selection in early generations can improve the performance of these traits.

Declarations

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Availability of data and material

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Conflict of interest

Authors declare that they have no conflict of interest for the publication of the manuscript.

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Authors' contributions

NM and AR conducted experiment and wrote the initial draft of the manuscript. MTA played role in designing and statistics of the experiment, in addition MTA supervised NM for her master studies. DX proof read the manuscript before submission to JCR.

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Figures

Figure 1

Mean comparison for plant height of parents and crosses of upland cotton where, A for PH (plant height), B- BP (bolls per plant), C- SB (number of sympodial branches per plant), D- BW (boll weight), E- GOT (ginning out turn), F- SI (seed index), G- SCY (seed cotton yield), H- FL (fiber length), I- FS (fiber strength) and J- FF (fiber fineness).