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# GERMPLASM POTENTIAL FOR DIFFERENT ADVANCE LINES OF *GOSSYPIUM HIRSUTUM* FOR WITHIN BOLL YIELD COMPONENTS

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**Abstract:** *Cotton production per hectare is low in Pakistan due to many biotic and abiotic factors. As boll is the basic determinant for yield in cotton crop, a study on within boll yield parameters was carried out using 24 cotton bulk and 2 check varieties to check their variability for within boll yield components. The experiment was performed in the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The genotypes were seeded in two replications following a randomized complete block design. Data were subjected to analysis of variance to check significance among different genotypes. Genotypes were significantly different. The genotype PB-132 performed best for most parameters including GOT, lint index, lint mass per seed, and seed density. Correlation analysis was applied to find out the association of these parameters. Seed cotton yield was positively associated with the GOT, boll weight and number of seeds per boll while it negatively correlated with fiber fineness, seed volume, and seed surface area. The first principal component showed 26.37%, the second component showed 17.93%, the third component showed 14.88%, and the fourth component showed 14.40% of total variation. PCA analysis showed the genetic diversity among cotton genotypes. The current study's findings revealed the potential of different bulks of cotton for developing high-yielding varieties. This information may be used to develop breeding strategies to enhance cotton production and variety.*

**Keywords:** Cotton, PCA, Correlation, Within boll yield, High yielding

## Introduction

The most basic factors affecting cotton seed cotton and lint yield are within-boll components (*Gossypium hirsutum* L.). Boll serves as the foundation for seed cotton production, therefore within-boll yield components may be the most fundamental factors affecting cotton productivity on a per-unit-land-area (Zhi et al., 2016). Studying the genetic process behind the inheritance of any characteristic is necessary before attempting to improve it. Seed cotton yield, seeds per boll, lint mass per boll, and GOT% directly affect cotton yield (Imran et al., 2012).

The correlation analysis forecasts the change that occurs in one attribute by the change in the other (Hampannavar et al., 2020). Correlation analysis is an effective tool to identify the association between the yield-related attributes in genetically diverse populations that will be used in the future breeding program for crop improvement (Komala et al., 2018). All yield contributing traits are correlated with one another. Therefore, it is important to have information about their association for the selection of suitable breeding. To start any breeding program information about genotypic and phenotypic correlation is helpful. If the correlation between two different traits of a plant is positive, then it means by improving one trait other traits will have significant positive results, while if the correlation is negative then it means by increasing or improving one character another trait will show negative or non-significant results. Magnitude and direction of correlation among yield and yield-related attributes must be considered for selecting the superior genotypes for the highly diverse genetic breeding program (Abbas et al., 2015).

Utilization of available diversity regarding morphological features is required to initiate a well-planned breeding program (Mugheri et al., 2017). Boll weight, seed cotton yield, and lint yield are positively correlated; an increase in boll weight enhances seed cotton yield and lint production. The most important trait and the ultimate goal of the breeder for any crop is the yield. Yield is a quantitative trait which means multiple genes control it. Cotton yield is an inclusive trait, factors such as lint yield, lint percentage, lint index, seed index, seed yield, boll number, boll size, and weight affect the total yield (Constable et al., 2015). Considering the importance of population in the cotton breeding program, the research was designed to study correlation analysis to set selection criteria in the different advance lines of cotton. This study may be helpful for the selection of other plants in the bulk populations.

**Objectives**

- To evaluate the best-performing lines based on within boll yield components.

**MATERIALS AND METHODS**

The material comprised 24 advanced cotton lines (table 1) developed by cotton research group, department of Plant Breeding and Genetics. The research was conducted in the cotton field area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the regular cotton planting season in 2021. Twenty-six genotypes were sown in a randomized complete block design with two replications. At the time of sowing, the recommended row-to-row distance (75cm) and plant-to-plant distance (30cm) were maintained. Proper agronomic practices were applied from sowing to picking, like weeding, thinning, hoeing, proper irrigation, and plant protection by using different pesticides as recommendations.

Ten plants of each genotype from each replication were chosen at random for data collection for the following traits.

**Attributes**

1. Seed cotton yield (g)
2. Boll weight (g)
3. Seed index (g)
4. Lint index (g)
5. Seed number per boll
6. Seed mass per boll (g)
7. Seed volume per 100 seeds
8. Seed density (g/cm$^3$)
9. Seed surface area (cm$^2$)
10. GOT (%)
11. Lint mass per boll (g)
12. Fiber fineness (µg/inch)
13. Fiber strength (g/tex)
14. Fiber length (mm)

**Table 1: Genotypes Name**

| | |
|---|---|
| 1. PB-106 | 2. PB-99 |
| 3. FLD-490 | 4. PB-100 |
| 5. PB-114 | 6. PB-136 |
| 7. PB-95 | 8. PB-116 |
| 9. PB-97 | 10. PB-131 |
| 11. PB-101 | 12. LALAZAR |
| 13. PB-94 | 14. PB-130 |
| 15. PB-129 | 16. PB-126 |
| 17. PB-134 | 18. PB-135 |
| 19. NOOR-21 | 20. PB-96 |
| 21. PB-93 | 22. PB-137 |
| 23. PB-123 | 24. PB-132 |
| 25. PB-133 | 26. PB-128 |

**Traits Evaluation**

At the time of maturity 20 plants were selected from two replications. Ten from replication one and 10 from replication two. Ten effective bolls were picked from axial, terminal, and middle part of the plant to study seed and lint-related traits. Data were recorded from selected plants individually for the following parameters.

**Statistical analysis**

The collected data was exposed to the analysis of variance and correlation by using Statistix 8.1. PCA determined diversity among genotypes with the help of XLSTAT.

**Results and discussion**

**Analysis of Variance**

Analysis of variance manifested that the bulk population exhibited significant variation for all the attributes like boll weight, lint index, seed index, ginning outturn (%), seeds boll$^{-1}$, fiber length, fiber length, fiber strength, fiber fineness, seed volume, seed density and seed surface area while seed cotton yield was highly significant (Table 2).

**Table 2. Analysis of variance of cotton genotypes for various traits under study**

| Source | DF | SCY | S/B | BW | GOT | SM/B | LM/B | SI | LI | FS | FF | FL | SV | SSA | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Replication** | 1 | 84.992 | 24.923 | 1.13723 | 1.72463 | 0.28062 | 0.04043 | 1.05023 | 0.99139 | 2.08 | 0.013 | 0.00085 | 0.30769 | 0.00007 | 0.0055 |
| **Genotypes** | 25 | 834.394** | 25.15** | 0.143** | 3.880* | 0.045* | 0.023** | 0.30** | 0.276* | 8.97** | 0.135* | 1.090** | 4.390** | 0.015** | 0.042** |
| **Error** | 25 | 59.526 | 1.9231 | 0.00622 | 1.5278 | 0.01191 | 0.00623 | 0.0715 | 0.11157 | 0.8488 | 0.03718 | 0.19588 | 0.34769 | 0.0028 | 0.00064 |
| **Total** | 51 | | | | | | | | | | | | | | |

*Significant Values = * Highly Significant Values = ** SCY= seed cotton yield, S/B= seed per boll, BW= boll weight, GOT%= ginning out turn percentage, SM/B= seed mass per boll, LM/B= lint mass per boll, FF=fiber fineness, FL = fiber length, FS= fiber strength, SI= seed index, SV= seed volume, LI= lint index, SD= seed density, SSA= seed surface area*

[Citation Shafique, M.T., Bano, M., Khalid, M.N., Raza, A., Shahid, M., Hussnain, H., Iqbal, M., Hussain, M., Abbas, Q., Iqbal, M.M., Ahmad, H.R., Aqeel, M. (2023). Germplasm potential for different advance lines of *Gossypium hirsutum* for within boll yield components. *Biol. Clin. Sci. Res. J.*, **2023**: *297*. doi: https://doi.org/10.54112/bcsrj.v2023i1.297]

**Correlation**

Correlation analysis studied the magnitude and type of association among the attributes under study and which attribute should be selected to increase the seed cotton yield. It determined traits that may be able to increase the value of the crop. A correlation study is an important factor in developing a selection strategy for the breeding program. The information of association among characters is crucial for the selection procedure. This association may be due to genetic or environmental factors (Hampannavar et al., 2020). Correlation is usually studied to find out the association between different traits. The correlation values lie between -1.0 to +1.0 if the value is 0 to 1.0 then the trait is positively correlated, and if the values of the results are between -1.0 to 0 then the trait is negatively correlated. The results of correlation analysis of the current study are presented in table 3.

**Seed Per Boll**

Seeds per boll positively correlated with seed cotton yield per plant and boll weight. It showed significant positive correlation with GOT%. Seeds per boll showed a negative association with seed volume, seed surface area, lint index, and seed index and highly significant negative association with lint index. Positive correlation of seeds per boll with seed cotton yield per plant was observed (Malik, 2018). A highly significant correlation was observed between numbers of seeds per boll, lint yield and cotton yield per plant.

Positive association was observed between the number of seeds per boll and boll weight observed by Desalegn *et al*. (2009). Seeds per boll positively correlated with lint percentage and cotton yield per plant (Batool *et al.,* 2010). Positive association of seeds per boll with seed cotton yield, fiber strength and fiber length by Bibi *et al.* (2011). Seeds per boll positively associated with seed cotton yield per plant by Tang and Xio. (2014).

**Boll Weight**

Boll weight per plant positively associated with seeds per boll and seed cotton yield per plant and seed index. It showed highly significant positive correlation with seed mass per boll and lint mass per boll. Boll weight per plant showed negative association with lint percentage and seed volume. Boll weight per plant positively associated with lint percentage reported by Azhar *et al*. (2004). Significant results of boll weight with seed cotton yield per plant were reported by Afiah and Ghoneim (2000). Hussain et al. (2010) reported the same results according to our research work. Positive linkage between boll weight and seed index was studied by Killi*et al.* (2005). Different cotton varieties were assessed for a positive association between boll weight and seed cotton yield. Boll weight per plant showed positive correlation with seed cotton yield per plant. Positive association between boll weight and seed cotton yield was observed by Ahmad *et al*. (2008). Boll weight per plant positively associated with seed cotton yield per plant Abbas *et al.* (2008). Positive correlation between boll weight and number of seeds per boll was stated by Karademir *et al.* (2009). Boll weight per plant positively associated with seed cotton yield per plant Desalegn *et al.,* (2009). Boll weight per plant positively correlated with 62 seed cotton yields per plant (Bibi *et al*., 2011; Alkuddsi *et al*., 2013). Boll weight per plant positively correlated with seed cotton yield per plant (Erande *et al.*, 2014; Ahsan *et al.*, 2015).

**GOT%**

Ginning out turn showed a significant positive association with seeds per boll. It showed a highly positive correlation between lint index and seed density. Ginning out turn, showed a significant negative association with seed volume and a highly significant negative association with seed surface area. Positive and significant association of ginning out turn with seed index was investigated by Yaqoob *et al.* (2016). Negative association between GOT and seed mass per boll was studied by Zeng *et al.* (2009). A positive association of plant GOT% was observed with seed cotton yield per plant and the Lint index (Djaboutou *et al.,* 2005). Positive correlation of ginning out turn with a yield of seed cotton and fiber fineness while studying $F_2$ population of upland cotton (Yaqoob *et al.*, 2016).

**Seed Mass per Boll**

Seed mass per boll depicted a highly significant positive correlation with boll weight per plant and lint mass per boll. It showed a negative association with fiber fineness. It showed a significant positive association with seeds per boll and seed cotton yield per plant. Seed mass per boll showed a positive association with boll weight. Seed mass/boll positively and significantly associated with seeds/boll. Within boll seed yield components per boll depicted positive and significant results i.e., seed mass per boll and number of seeds depicted positive association Tang and Xiao (2013).

**Lint Mass Per Boll**

The amount of lint per boll was found to be highly significant positive association with boll weight, seed mass per boll. The negative association was observed with GOT% which means that if we increase lint percentage then GOT% decrease which is not desirable for us. A significant negative correlation was detected for fiber fineness.

Positive association of lint weight with plant height was reported by Kumar *et al.* (2017). The findings align with Zeng *et al.* (2009) and Tang and Xiao (2013) who revealed a positive significant association between lint mass per boll and seed mass per boll.

**Lint index**

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Lint index depicted a highly significant positive association with seed cotton yield and GOT%. It showed a positive association with lint mass per boll and lint percentage. It showed a negative association with seeds per boll and seed mass per boll. It showed a significant negative correlation with seed per boll and seed index. A significant correlation of lint index with boll weight was observed by Ahmad *et al.* (2019).

**Seed index**

Seed index showed a highly significant and negative correlation with lint index. Seed index showed a positive correlation with seeds per boll, seed cotton yield per plant, boll weight per plant, seed mass per boll and. Seed index showed negative association with fiber fineness and significant and positive association with fiber strength. Results are following Kale *et al*. (2007) that seed index is positively associated with boll weight. Seed index is positively correlated with number of bolls per plant Do Thi *et al*. (2008). Hinza et al. (2011) stated a negative correlation between lint index and seed index in a diallel mating system of seven parents. Positive correlation between seed index and the number of sympodial branches per plant was reported by Kumar *et al.* (2017). Seed index positively associated with boll weight (Deshmukh *et al*., 2019).

**Seed Volume**

Seed volume highly significant and positively correlated with seed surface area. It showed a highly significant but negative correlation between seed density and GOT%. A negative correlation was found with seed cotton yield and seed per boll.

**Seed Density**

Seed density showed a significant and positive correlation with seed index. A positive correlation was found with seed cotton yield, seed per boll and seed mass per boll. Seed density showed a highly significant negative association with seed volume and seed surface area. Its mean that seed density is inversely proportional to seed volume and seed surface area. If seed density increases seed surface area of cotton seed will decrease.

**Seed Surface Area**

Seed surface area was found positively correlate with seed volume and showed a significantly negative association with seed cotton yield, seed per boll and boll weight. A positive correlation was found with seed index while having a negative association with seed density.

If the seed index will be high seed surface area also increase as compared to seed density because it showed a negative correlation with each other.

**Fiber Fineness**

Fiber Fineness is positively associated with GOT%, fiber length, seed volume, and lint index. While fiber fineness shows a highly significant and negative association with boll weight and seed density. Fiber fineness positively correlated with fiber length (Hussain *et al*., 2010).

**Fiber Length**

Fiber length showed a highly significant positive association with fiber strength and a negative association with Boll weight and GOT%. Mei *et al*. (2013) and Imran *et al*. (2012) found that Fiber length is positively associated with fiber fineness and uniformity. Dinakaran *et al*. (2012), Ahuja *et al*. (2006), Nateera *et al*. (2012) and Rasheed *et al*. (2009) also revealed that fiber length directly affected seed cotton yield.

**Fiber Strength**

Fiber strength showed a positive association with seed cotton yield, seed per boll, seed mass per boll, lint mass per boll and showed a negative association boll weight and GOT% and fiber fineness. Fiber strength is positively linked with seed per boll for the overall population. Karademir *et al.* (2010) also indicated that fiber strength is positively linked with seed per boll.

**Seed Cotton Yield**

Seed cotton yield per plant showed a positive, important, and strong positive association with seed per boll, boll weight, GOT%, fiber length, fiber strength, lint index and seed density while having a negative association with seed mass per boll, lint mass per boll, fiber fineness, seed index, seed volume and seed surface area. Seed cotton yield positively associated with seed traits (Afiah and Ghoneim, 2000). Positive association of seed cotton yield per plant was observed with plant GOT% and Lint index. (Djaboutou *et al*., 2005). Khan et al. (2010) observed a positive correlation with the number of seeds per boll. Seed cotton yield positively correlated with lint percentage (Salhuddin *et al.*, 2010). Positive association of seed cotton yield with number of seeds per boll was observed by Raza *et al.* (2016). Seed cotton yield positively correlated with fiber length and fineness (Hussain *et al.*, 2010). Positive association of seed cotton yield with boll weight was observed by Ahsan *et al*. (2015). Positive association of seed cotton yield with the boll weight was reported by Baloch *et al.* (2015).

***Table 3: Correlation matrix among yield related traits of upland cotton***

| | S/B | BW | GOT% | SM/B | LM/B | FF | FL | FS | SI | SV | LI | SD | SSA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BW | 0.239 | | | | | | | | | | | | |

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOT% | *0.288 | -0.071 | | | | | | | | | | | |
| SM/B | 0.222 | **0.425 | 0.176 | | | | | | | | | | |
| LM/B | -0.226 | **0.471 | -0.072 | **0.658 | | | | | | | | | |
| FF | -0.069 | **-0.366 | 0.143 | -0.152 | *-0.343 | | | | | | | | |
| FL | 0.081 | -0.013 | -0.197 | 0.023 | 0.139 | *0.289 | | | | | | | |
| FS | 0.112 | -0.023 | -0.128 | 0.062 | 0.065 | -0.093 | **0.508 | | | | | | |
| SI | 0.151 | 0.181 | 0.057 | 0.218 | *-0.276 | -0.165 | 0.251 | **0.358 | | | | | |
| SV | -0.188 | -0.076 | *-0.329 | -0.041 | 0.119 | 0.25 | 0.012 | -0.065 | 0.181 | | | | |
| LI | **-0.371 | 0.117 | **0.438 | -0.024 | 0.018 | 0.029 | 0.08 | 0.181 | **-0.61 | 0.009 | | | |
| SD | 0.216 | 0.162 | **0.366 | 0.136 | 0.015 | *-0.29 | 0.088 | 0.134 | 0.207 | **-0.903 | 0.249 | | |
| SSA | -0.16 | -0.098 | *-0.343 | -0.146 | 0.106 | 0.186 | 0.092 | -0.024 | 0.196 | **0.908 | 0.067 | **-0.789 | |
| SCY/P | 0.173 | 0.068 | 0.101 | 0.045 | 0.211 | *-0.355 | 0.249 | 0.003 | -0.113 | *-0.286 | 0.015 | 0.269 | *-0.277 |

*Significant Values = *        Highly Significant Values = ***

*SCY= seed cotton yield, S/B= seed per boll, BW= boll weight, GOT%= ginning out turn percentage, SM/B= seed mass per boll, LM/B= lint mass per boll, FF=fiber fineness, FL = fiber length, FS= fiber strength, SI= seed index, SV= seed volume, LI= lint index, SD= seed density, SSA= seed surface area*

**Principal component analysis**

Principal component analysis is most frequently used statistical technique in environmental studies (Yongming *et al*., 2006). Principal component analysis is a multivariate statistical technique used to describe the data set and extract important information from data set (Tokalioglu and Kartal, 2006). Principal component analysis was performed on 14 characters of 26 genotypes to check Eigen value, proportion of variation and cumulative variation among all genotypes and their studied traits. Fourteen yield contributing traits were studied i.e., Seed cotton yield, boll weight, seed index, lint index, seed number per bolls Seed mass per boll, seed volume, seed density, seed surface area, GOT (%), lint mass per boll, fiber fineness, fiber strength and fiber length. Out of 14 principal components 5 components showed Eigen value of greater than I (Eigen value > 1), which represents significant results (table 4). The first principal component contributed 26.37 % to the total variation, mainly due to lint mass per boll, seed mass per boll, seed index, and boll weight, seed cotton yield and lint index. The second principal component showed 17.93 % of total variation due to bool weight, seed mass per boll, lint mass per boll, fiber length, seed volume and seed surface area (Table 5). Third component represented 14.88 % variability to the total variation attributed by seeds per boll GOT percentage, boll weight per plant, lint mass, seed mass and fiber strength. 4th principal component showed 14.40 % of total variation which is depicted by seed cotton yield, GOT%, seeds per boll, seed index. Fifth principle component showed 7.211% of total variation due to seed mass per boll, lint mass per boll, fiber fineness, fiber strength and seed density.

First component showed 26.37 % cumulative variation, second 44.31 %, third showed 59.19%, 4$^{th}$ component represented 73.60 % and 5$^{th}$ components represented 80.81% cumulative variation (Table 6). These attributes should be emphasized for improving cotton genotypes for future breeding program. Results of these aspects have shown their contribution towards cumulative variability and cotton programs for future (Latif *et al*., 2015; kaleri *et al*., 2015).

Genotypes PB-106, G.FLD-490, PB-114, PB-95, PB-97, PB-101, PB-94, PB-129, PB-134, NOOR, PB-93, PB-123, PB-133, PB-99, PB-100, PB-136, PB-116, PB-131, LALAZAR, PB-130, PB-126, PB-135, PB-96, PB-137, PB-132 and PB-128. Score plot scattered the genotypes based on variation (Rana *et al*., 2013).

Distance from plot origin has depicted the level of variation among genotypes. Greater the distance from origin greater will be variation Greater distance from origin among genotypes had displayed greater variation (Rana *et al*., 2013) principal component analysis and cluster analysis were used to group winter genotypes of wheat (Salihu *et al*., 2006). Present research results were in great accordance with Latif *et al*. (2015). Therefore, the present study was carried out to access PCA to find the association among various yield-contributing traits in upland cotton genotypes. Present results were in favor of the findings of Saeed *et al.* (2014). Kaleri *et al*. (2015) and Gunasegaram (2019) Maximum yield components were observed in principal component 1 (Jarwar *et al*., 2019). Maximum contribution of yield and sympodial branches per plant was observed in principal component 1. Results favor Farooq *et al*. (2017), who accounted maximum contributions of ginning out turn percentage and boils per plant in principal component II.

**Table 4: Principle Components Analysis**

| | Eigenvalue | Variability (%) | Cumulative (%) |
|---|---|---|---|
| | 3.6920 | 26.3716 | 26.3716 |
| II. | 2.5115 | 17.9391 | 44.3107 |
| III. | 2.0837 | 14.8835 | 59.1942 |

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| | | | |
|---|---|---|---|
| IV. | 2.0170 | 14.4073 | 73.6015 |
| V. | 1.0096 | 7.2117 | 80.8131 |
| VI. | 0.7921 | 5.6576 | 86.4707 |
| VII. | 0.6143 | 4.3882 | 90.8589 |
| VIII. | 0.5275 | 3.7680 | 94.6269 |
| IX. | 0.3429 | 2.4496 | 97.0765 |
| X. | 0.2158 | 1.5418 | 98.6183 |
| XI. | 0.1665 | 1.1891 | 99.8073 |
| XII. | 0.0189 | 0.1350 | 99.9424 |
| XIII. | 0.0077 | 0.0547 | 99.9971 |
| XIV. | 0.0004 | 0.0029 | 100.000 |

**Table. 5: Principal Component Analysis for 14 characters in 26 genotypes of upland Cotton.**

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 |
|---|---|---|---|---|---|---|---|---|---|---|
| SYC/P | 0.206 | -0.082 | -0.270 | 0.244 | -0.518 | 0.473 | -0.205 | 0.196 | -0.343 | -0.091 |
| S/B | 0.212 | -0.050 | 0.296 | 0.277 | -0.312 | -0.099 | 0.767 | -0.031 | 0.075 | -0.282 |
| B/W | 0.110 | 0.244 | -0.368 | -0.252 | -0.117 | -0.274 | 0.130 | 0.751 | 0.170 | -0.052 |
| GOT% | 0.319 | -0.10 | 0.339 | -0.296 | -0.218 | 0.244 | 0.028 | 0.081 | 0.015 | 0.567 |
| SM/B | 0.128 | 0.313 | -0.071 | -0.431 | 0.0724 | 0.506 | 0.136 | -0.191 | -0.153 | -0.423 |
| LM/B | 0.022 | 0.471 | -0.190 | -0.325 | 0.0024 | -0.039 | 0.243 | -0.300 | 0.037 | 0.221 |
| FF | -0.188 | -0.214 | 0.399 | -0.226 | 0.305 | 0.317 | -0.023 | 0.3651 | 0.212 | -0.315 |
| FL | 0.079 | 0.320 | -0.130 | 0.446 | 0.053 | 0.320 | -0.121 | -0.064 | 0.73 | -0.001 |
| FS | 0.094 | 0.257 | 0.053 | 0.372 | 0.551 | 0.227 | 0.260 | 0.290 | -0.406 | 0.322 |
| SI | 0.165 | 0.431 | 0.332 | 0.138 | -0.0018 | -0.288 | -0.319 | 0.039 | -0.160 | -0.325 |
| SV | -0.444 | 0.226 | 0.168 | 0.014 | -0.237 | 0.087 | -0.008 | 0.134 | 0.0154 | -0.004 |
| LI | 0.325 | 0.235 | 0.4335 | -0.080 | -0.135 | -0.049 | -0.228 | 0.084 | -0.0024 | 0.109 |
| SD | 0.485 | -0.071 | -0.053 | 0.003 | 0.184 | -0.154 | -0.178 | -0.112 | 0.0128 | -0.157 |
| SSA | -0.404 | 0.2944 | 0.190 | 0.074 | -0.239 | -0.004 | -0.058 | -0.037 | -0.129 | 0.112 |

**Table 6: Contribution of genotypes in PC1 and PC2**

| **Sr. no** | **Genotypes** | **PC1** | **PC2** |
|---|---|---|---|
| 1 | PB-106 | 1.3077 | 2.1071 |
| 2 | G.FLD-490 | 0.1818 | 4.1700 |
| 3 | PB-114 | -1.7446 | 0.0832 |
| 4 | PB-95 | -2.1729 | 1.3899 |
| 5 | PB-97 | 1.1582 | -1.8490 |
| 6 | PB-101 | 0.1900 | 0.9965 |
| 7 | PB-94 | 0.1292 | -1.8917 |
| 8 | PB-129 | -0.6043 | -1.6655 |
| 9 | PB-134 | -4.0385 | -0.6939 |
| 10 | NOOR | -0.1305 | 0.5912 |
| 11 | PB-93 | -0.4882 | -1.0044 |
| 12 | PB-123 | -2.3018 | 0.9489 |
| 13 | PB-133 | 0.8000 | -0.4388 |
| 14 | PB-99 | 0.9908 | 2.8764 |
| 15 | PB-100 | 0.8967 | -0.9358 |
| 16 | PB-136 | -1.0050 | -0.5344 |
| 17 | PB-116 | -0.4044 | 1.2611 |
| 18 | PB-131 | -2.3347 | -1.0162 |
| 19 | LALAZAR | -0.6948 | 1.5807 |
| 20 | PB-130 | 0.0253 | -1.9708 |
| 21 | PB-126 | 2.0711 | -2.6400 |
| 22 | PB-135 | -1.2202 | -0.6257 |
| 23 | PB-96 | -1.6476 | -0.6710 |
| 24 | PB-137 | 2.6588 | 0.5779 |
| 25 | PB-132 | 5.3448 | 0.3980 |
| 26 | PB-128 | 3.0331 | -1.0438 |

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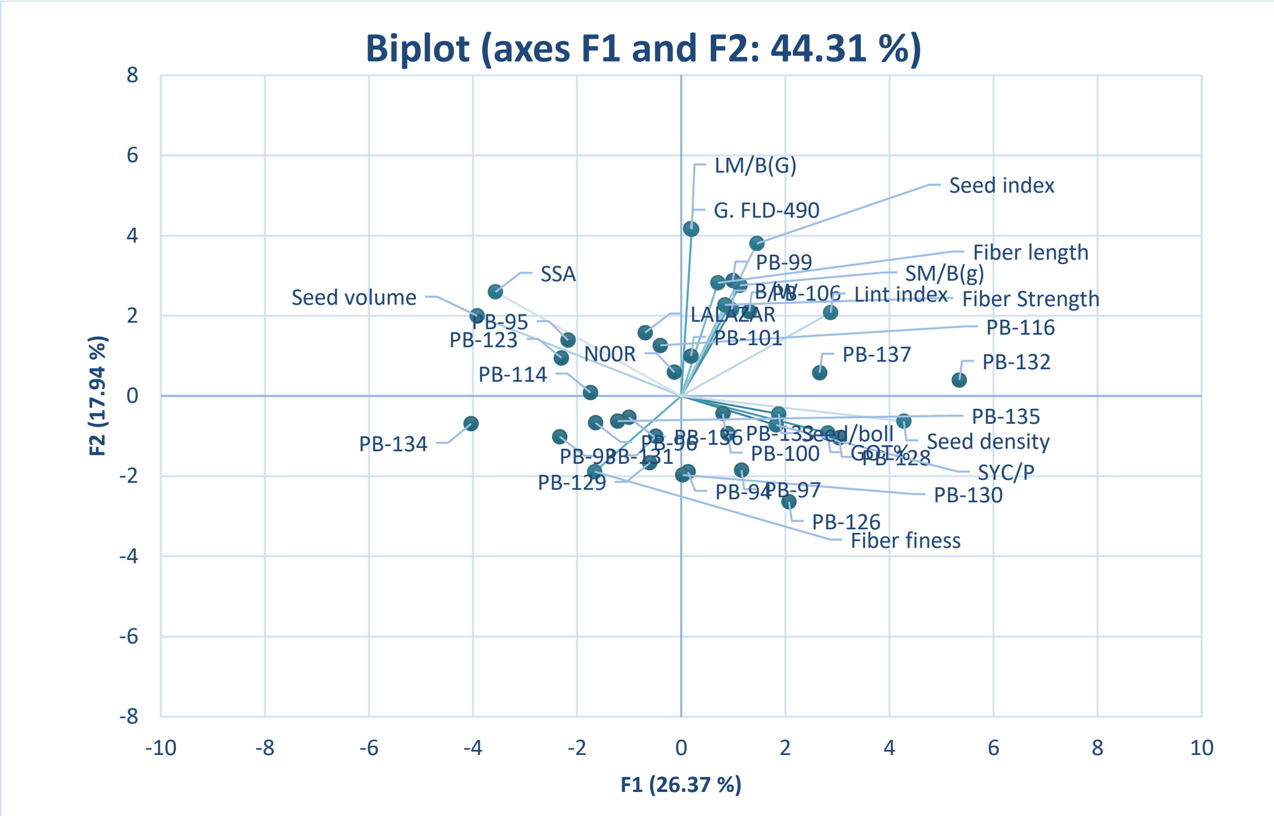


**Figure 1: Biplot orientation of 26 genotypes on principal components axis 1 and 2**

Figure 1 showed Biplot between 1st and 2nd component which displays contribution of yield contributing traits of cotton genotypes concerning variation. Traits represented with vectors and genotypes as dots. Distance of traits for first and second components depicted the contribution of genotypes and their traits in variation. Genotype PB-106 showed high potential for boll weight, seed mass per boll and fiber length. Genotypes G.FLD-490 represented high yielding cultivar for lint mass per boll, PB-99 illustrated seed index, PB-130 represented high yielding cultivar for seed cotton yield.

## Conclusion

All lines performed well in different traits, but bulk PB-132 performed well for most traits like GOT%, Lint index, and lint mass per boll. It showed good seed cotton yield value as compared to other lines. In short, PB-132 showed good results, and can contribute to the next breeding programs.

## Conflict of interest

Authors have no conflict of interest.

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