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# MORPHO-PHYSIOLOGICAL INDICATORS FOR SELECTION OF HIGH YIELDING COTTON (*GOSSYPIUM HIRSUTUM* L.) CULTIVARS

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**Abstract**

The morpho-physiological selection and linkage between traits have been investigated. There were 20 cotton genotypes grown using RCBD with two replications at experimental area. ANOVA showed significant variation for all the traits. The GCV and PCV values of heritability and genetic advance were higher for the traits like bolls per plant, sympodial branches per plant and plant height, respectively. These traits were more under control of the genetic factors and additive gene action. There was high significant correlation between boll weight and seed cotton yield; transpiration rate and stomatal conductance. There would be yield breakthrough on considering the higher number of bolls per plant, high boll weight per plant and optimum net photosynthesis per plant as the basis of selection.

## Introduction

Cotton one of the most important economical crops belonging to Malveaceae includes more than 4000 species. Among them the most valued one is *Gossypium hirsutum* L. (upland cotton). It has sole position in world agriculture and economy. There are more than 1000 products which are manufactured and produced from it. Hence, cotton becomes an attractive commercial crop for the farming community around the world. Some important commercial products worth the name of upland cotton include proteins, oil and fiber (Campbell *et al.* 2016).

In Pakistan cotton contributes around 0.6 percent to GDP and 3.1 percent of the value added in agriculture (Government of Pakistan, Economic Survey of Pakistan 2020-21). Pakistan stands at $4^{th}$ position among the top cotton producing countries. There is no significant boost observed in the production due to poor knowledge of traits linkage.

The expressivity and physiology of plant traits can frequently be changed with changing environment, soil condition and genotypes genetic makeup (Broughton 2015). This is due to the genetic association of the traits. The information associated in between traits and with seed cotton yield is necessary to know and deal with the plant breeders. The correlation analysis shows the extent of association between traits on which selection for future breeding programs and variety development for improved seed cotton yield depend. The heritability study shows the extent of variability among the traits and their transferability to the next generations (Ahmad *et al.* 2016).

For the production of higher yield of cotton, it is necessary to know its morpho-physiological relationship between the traits. The cotton has a distinctive indeterminate growth nature and sympodial fruit branching that cause it to grow up in the four-dimensional occupation of space and

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time, that often resists the yield analysis (Jost and Cothren 2000). For a plant breeder there is need to study the processes going within plant so that a new breeding material developed must have strong genetic base to show efficient yield performance in different agro-ecological zones. The present study was designed to evaluate the physiological and morphological cotton growth pattern under the southern Punjab regime, for investigating the association of morphological and physiological traits and their influence on yield and to use the information for future utilization in breeding programs.

## Materials and Methods

The genetic materials comprising 20 genotypes, were collected from different cotton research stations/institutes working in Punjab and Sindh province (Table 1). The experimental study was conducted at the experimental area of the Cotton Research Institute, Multan during the year 2017.

**Table 1. Breeding material genotypes used for identification of physio-morphological indicators for selection of high yielding cotton.**

| Sr.No. | Genotypes | Sr.No. | Genotypes | Sr.No. | Genotypes | Sr.No. | Genotypes |
|---|---|---|---|---|---|---|---|
| 1 | CRIS-5A | 6 | IUB-13 | 11 | FH-342 | 16 | NIAB-2008 |
| 2 | CRIS-09 | 7 | IUB-222 | 12 | FH-LALAZAR | 17 | NIAB-777 |
| 3 | CRIS-121 | 8 | FDH-512 | 13 | CRIS-543 | 18 | NIBGE-2 |
| 4 | CIM-599 | 9 | FDH-512 | 14 | MNH-1016 | 19 | VH-305 |
| 5 | CIM-602 | 10 | FH-142 | 15 | MNH-886 | 20 | VH-327 |

Cotton genotypes were grown in RCBD with two replications keeping plant to plant distance of 30 cm and ridges apart at 75 cm at field and bed size was 20 feet long and 10 feet wide. The seeds were sown manually; three seeds per hole which were later thinned to one plant per hole after 20 days. All standard agronomic and management practices were carried out homogenously to all experimental units. At maturity picking was done.

The plants were tagged separately in each replication. The morphological data of plant height, bolls per plant, sympodial per plant was taken manually while boll weight and seed cotton yield were taken at crop maturity at final picking. The physiological data of net photosynthesis rate, transpiration rate, stomatal conductance were taken with help of portable IRGA. (Model no Cl-340, Photosynthetic System, CID, Inc., USA). Data were taken from 9:00 a.m. - 12:00 mid-day, the chlorophyll contents were measured by using SPAD.

The analysis of variance was performed for estimation of expected variances and genetic components. The statistical software used was ‘Agristat Packages’ developed by Dr. N. Manivannan. TNAU, Coimbatore-3 (Singh and Chaudhary 1979).

Heritability was estimated as: High heritability > 0.5, Medium heritability = 0.2 - 0.5, Low heritability < 0.2

Genetic advance was computed at 20% selection intensity with following formula (Panse and Sukhatme 1965):

$$GA = K \times \sqrt{\sigma^2_P} \times h^2$$

where, K = 1.47 for 20 % selection intensity, $h^2$= heritability coefficient, $\sqrt{\sigma^2_P}$ = Phenotypic standard deviation, GA = Genetic advance. The correlation was found by the Minitab 17 software.

## Results and Discussion

Data were subjected to the ANOVA and it showed highly significant differences at $p \leq 0.01$ and $p \leq 0.05$ among all genotypes for traits plant height (711**), bolls per plant (295.8**), seed cotton yield (221.7**), chlorophyll contents (97.8**), sympodial per plant (71.6**) and boll weight (0.4**). While the net photosynthetic rate, transpiration rate and stomatal conductance showed non-significant results (Table 2).

**Table 2. Mean squares values for morpho-physiological traits for selection of high yielding cotton.**

| | Traits | Replication | Genotypes | Error |
|---|---|---|---|---|
| Morphological Traits | D.F. | 1 | 19 | 19 |
| | PH | 384.4** | 711** | 5.2 |
| | BpP | 36.1** | 295.8** | 1.8 |
| | SBpP | 63** | 71.6** | 0.32 |
| | BW | 0.1** | 0.4** | 0.004 |
| | SCY | 39.9** | 221.7** | 0.6 |
| Physiological Traits | Pn | 1057.9* | 337.2 | 183.6 |
| | E | 0.02 | 3.7 | 2.5 |
| | C | 28.2 | 4279.2 | 2050.8 |
| | Cl | 0.2 | 97.8** | 2.7 |

* = Significant at 5 % probability level; ** = Significant at 1 % probability level. D.F.= Degree of freedom; PH = Plant height; BpP = bolls per plant; SBpP = Sympodial branches per plant; BW = Boll weight; SCY = Seed cotton yield; Pn = net photosynthesis rate; E = transpiration rate; C = Stomatal conductance; Cl = Chlorophyll content.

The phenotypic variance was higher than genotypic variance for all the traits. The GCV and PCV were low for all the traits except higher for bolls per plant (44.9) and net photosynthesis rate (21.2). The environmental coefficient of variance was higher in net photosynthesis rate (17.8) and transpiration rate (12.3). The heritability ranged from (19.7%) of transpiration rate to (99.5%) of seed cotton yield. The genetic advance ranged from (0.7) of transpiration rate to (40.8) of stomatal conductance. The coefficient of variation (CV) was lower for morphological traits including chlorophyll contents and higher was obtained in net photosynthesis rate (32.8), stomatal conductance (21.7) and transpiration rate (19.8) (Table 3).

Results presented in Table 4 showed highly significant positive correlation (r = 0.995**) followed by stomatal conductance and transpiration rate (r = 0.6872**) where the correlation was calculated for subjected traits, the boll weight and seed cotton yield. The significant positive correlation was seen in net photosynthesis rate with boll weight (r = 0.5261*) and seed cotton yield (r = 0.5285*) respectively. The negative significant correlation was seen in between transpiration rate and boll weight (r = -0.4847*) and seed cotton yield (r = -0.4867*).

In cotton, the variation and broad genetic based germplasm is prerequisite for enhancing seed cotton yield productivity and adaptability (Saleem *et al*. 2016). The analysis of variance showed higher significant differences among the genotypes for plant height, bolls per plant, seed cotton yield (Abdullah *et al.* 2016, Khan *et al.* 2018) and chlorophyll contents. This variation could be effectively exploited in improvement of these traits. The disparity was further explored by calculating variability parameters i.e. GCV, PCV and environmental coefficient of variance. In the present experiment the GCV and PCV were recorded for bolls per plant, sympodial branches per plant, plant height and net photosynthesis rate, respectively. The higher GCV showed that traits are under more influence of genes and environment roll is less. Such traits are of keen interest in breeding programs. The net photosynthesis rate, transpiration rate and stomatal conductance showed higher environmental coefficient of variation that depicts observed variation is less influenced by genetic factors but is higher effect of environment on these traits. In the present study it was observed that only transpiration rate had high ECV than GCV. The transpiration rate was one of the traits mostly influenced by environmental fluctuations. Here, the observation of high ECV might be due to dry and hot climatic condition in Multan regime (Pakistan) and high temperature range during the crop growth season was one of the limiting factors.

**Table 3. Variability parameters, heritability and genetic advance for identification of physio-morphological indicators for selection of high yielding cotton.**

| Components of variation | Morphological traits | | | | | Physiological traits | | | |
|---|---|---|---|---|---|---|---|---|---|
| | PH | BpP | SBpP | BW | SCY | Pn | E | C | Cl |
| GV | 352.9 | 147 | 35.6 | 0.18 | 110.6 | 76.8 | 0.6 | 1114.2 | 47.5 |
| PV | 358.1 | 148.7 | 36 | 0.19 | 111.1 | 260.3 | 3.1 | 3165 | 50.2 |
| EV | 5.2 | 1.7 | 0.4 | 0.01 | 0.5 | 183.5 | 2.5 | 2050.8 | 2.7 |
| GCV | 19 | 44.9 | 19 | 16 | 15.8 | 21.2 | 9.8 | 16 | 11.2 |
| PCV | 19.1 | 45.2 | 19.1 | 16.2 | 15.8 | 39 | 22.1 | 27 | 11.5 |
| ECV | 0.1 | 0.3 | 0.1 | 0.2 | 0 | 17.8 | 12.3 | 11 | 0.3 |
| Heritability (broad sense) h2 | 98.5 | 98.8 | 99.1 | 97.9 | 99.5 | 29.5 | 19.7 | 35.2 | 94.6 |
| Genetic advance | 38.8 | 24.8 | 12.2 | 0.9 | 21.2 | 9.8 | 0.7 | 40.8 | 13.8 |
| Genetic advance as percentage of mean (GA%) | 38.8 | 91.9 | 38.9 | 32.7 | 32.4 | 23.7 | 9 | 19.5 | 22.4 |
| CV(%) | 2.3 | 5 | 1.8 | 2.3 | 1.1 | 32.8 | 19.8 | 21.7 | 2.7 |
| Mean | 99 | 27 | 31.5 | 2.7 | 66.7 | 41. | 8 | 209 | 61.5 |
| Min. | 60 | 10.5 | 21.3 | 2.2 | 53.1 | 19.8 | 3.7 | 95.8 | 44.7 |
| Max. | 128.5 | 57.5 | 45 | 3.7 | 90.15 | 71.6 | 10 | 285.2 | 72.3 |

PH = Plant height; BpP = bolls per plant; SBpP = Sympodial branches per plant; BW = Boll weight; SCY = Seed cotton yield; Pn = net photosynthesis rate; E = transpiration rate; C = Stomatal conductance; Cl = Chlorophyll content.

Alone GCV and ECV are not reliable for the selection in the breeding programs. It is quite necessary to study the heritance and gene action, respectively. The heritability and genetic advance of traits were estimated. The bolls per plant, sympodial branches per plant, plant height and chlorophyll content showed higher broad sense heritability coupled with high genetic advance (Naik *et al.* 2016). The high heritability coupled with high genetic advance showed additive gene action in these traits. It would be valuable for the selection because these traits would not deteriorate in proceeding generations (Gnanasekaran *et al.* 2018).

**Table 4. Correlation coefficients of morphological and physiological traits in cotton (*Gossypium hirsutum*).**

| Traits | | Morphological Traits | | | | | Physiological Traits | | |
|---|---|---|---|---|---|---|---|---|---|
| | | PH | BpP | SBpP | BW | SCY | Pn | E | C |
| Morphological Traits | BpP | 0.4234 | | | | | | | |
| | SBpP | -0.2304 | -0.0311 | | | | | | |
| | BW | 0.195 | 0.3436 | 0.158 | | | | | |
| | SCY | 0.182 | 0.3256 | 0.1557 | 0.995** | | | | |
| Physiological Traits | Pn | 0.0625 | -0.1033 | 0.1579 | 0.5261* | 0.5285* | | | |
| | E | -0.0191 | 0.1396 | -0.008 | -0.4847* | -0.4867* | -0.172 | | |
| | C | -0.1944 | -0.1097 | 0.1322 | -0.1287 | -0.1149 | 0.1722 | 0.6872** | |
| | Cl | -0.1897 | -0.1025 | 0.0294 | -0.0226 | -0.0677 | 0.032 | 0.0419 | 0.1972 |

* = Significant at 5 % probability level; ** = Significant at 1 % probability level, D.F.= Degree of freedom; PH = Plant height; BpP = bolls per plant; SBpP = Sympodial branches per plant, BW = Boll weight; SCY = Seed cotton yield; Pn = net photosynthesis rate; E = transpiration rate; C = Stomatal conductance; Cl = Chlorophyll content.

However, it is observed that traits are mostly associated with each other in a crop plant. It is essential to know the intensity and nature of relationship between traits for their improvement. This mutual association results due to many reasons *i.e.* gene pleiotropic effects, chromosomal segmental linkage or due to environment cues, linkage of two genes by virtue of their existence on the same chromosome. The correlation analysis has been widely used for this purpose. In the present study correlation showed the significant positive higher correlation between seed cotton yield and boll weight. The seed cotton yield also showed significant positive correlation with net photosynthesis rate. The more production of glucose and growth molecules including sugars, enzymes and chlorophyll in photosynthesis process will increase alternatively the seed cotton yield (Munir *et al.* 2015). The boll weight and net photosynthesis rate have close genetic linkage with seed cotton yield. Hence, they both have a keen importance in determining the seed cotton yield. The emphasis should be given to high boll weight and net photosynthesis rate strains development in future breeding programs and association can be exploited in selection program leading towards the improvement of cotton varieties. The transpiration rate showed significant negative correlation with seed cotton yield. The water enters plant body through roots zone. The water contains dissolved nutrients that are excised along with water from leaves via high transpiration rate indirectly affecting the seed cotton yield (Blok *et al.* 2017). The boll weight showed significant positive correlation with net photosynthesis rate and significant negative correlation with transpiration rate. The boll weight directly affects the seed cotton yield. The stomatal conductance showed significant positive higher correlation with transpiration rate. The more stomatal opening causes more nutrient water loss and less carbon dioxide intake for net photosynthesis rate from leaves surface. Thus, less intake of carbon dioxide than $H_2O$ is due to the large size of $CO_2$ molecules, slow movement of molecules to the chloroplast of the plant and small

0.036% $CO_2$ gradient level in the atmosphere and hence affecting the seed cotton yield (Sterling 2005).

From present study, it is clear that with the higher number of bolls per plant, more boll weight and net photosynthesis rate breakthrough can be used as indicators for selection of high yielding cotton varieties.

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