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Correlation and Path Coefficient Analysis of Earliness and Agronomic Characters of Upland Cotton in Multan

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Abstract: The present study was conducted on correlation and path coefficient analysis of earliness an agronomic characters of upland cotton. The results showed that node of first fruiting branch, number of monopodial and sympodial branches plant^{-1}, number of flowers and number of bolls per plant^{-1}, boll weight, fiber fineness (micronaire) value and fiber strength were positively and significantly correlated with yield in present material. Similarly path coefficient analysis revealed that number of sympodial branches and number of flowers plant^{-1}, number of bolls plant^{-1} and boll weight had maximum direct positive effect on yield of seed cotton. Whereas, the traits number of monopodial branches plant^{-1}, ginning out turn percentage (GOT%) and staple length had the direct negative effects on seed cotton yield plant^{-1}. The results indicated that for evolving a superior genotype possessing all the three basic characteristics i.e. earliness, high yield and improved fiber quality of international standard, the breeder had to use the reciprocal recurrent selection method or modified back cross or three way cross within genetic material under study.

Key words: Cotton, correlation, path coefficient, earliness, seed cotton yield

Introduction

Correlation coefficient analysis measures the magnitude of relationship between various plant characters and determines the component character on which selection can be based for improvement in seed cotton yield, earliness and fiber quality. Genotypic correlation is the inherent association between two variables (Fonseca and Patterson, 1968). It may be either due to pleiotropic action of genes or linkage. If the correlation between seed cotton yield and a character is due to the direct effect of the character, it reflected a true relationship between them and selection can be practiced for such a character in order to improve yield. But if the correlation is mainly due to indirect effect of the character through another component trait, the breeder has to select for the trait through which the indirect effect is expected (Fonseca and Patterson, 1968). A great yield response is obtained when the character for which indirect selection is practiced has a high heritability and a positive correlation with yield. Tyagi ***et al.*** (1988) reported that boll number, boll weight and plant height contributed directly towards seed cotton yield. Direct and indirect effect of fiber traits via yield components were negligible on seed cotton yield. Tariq ***et al.*** (1992) found highly positive and significant correlation of boll number and bolls weight with seed cotton yield and showed that boll number and boll weight had positive direct effects on seed cotton yield. Baloch ***et al.*** (1992) stated that phenotypic correlation coefficients between boll number and seed cotton yield were strong and positive and the values of correlation coefficient between sympodial branches per plant and boll weight was 0.78. Path coefficient analysis revealed that the trail boll number had major and direct effect on seed cotton yield: whereas, other variables, sympodial branches per plant and boll weight had very minor or negligible effects on seed cotton yield. Weijun (1998) showed that earliness is very significantly and positively correlated with the height of first sympodial node and earliness is negatively correlated with plant height. It was concluded that height of first sympodial node could be used to select for earliness in cotton. Godoy and Palomo (1999) reported that the least determinate and slowest maturing genotype had the highest lin yield. Yields generally decreased as determinacy increased and rate of maturity accelerated. But days taken to first boll open, showed no association with seed cotton yield. Babar ***et al.*** (2002) stated that the main stem node number of first sympodial branch and days taken to first flower are reliable and efficient methods for predicting the earliness of any variety in cotton.

Materials and Methods

Six selected varieties viz., Reshmi, MNH-439, S-14, NIAB-78, DPL-54 and MNH-93 were crossed in all possible combinations. F_1 generation of each cross was raised during 1999 and F_2 of these crosses was grown in subsequent year at Cotton Research Station Multan. The F_2 populations of each cross occupied 18 rows of 3.3 m long keeping plant to plant distance 30 cm and row to row 75 cm. The data was recorded for node for node of first fruiting branch, number of monopodial branches and sympodial branches plant^{-1}, days taken to first flower, days taken to open first boll, number of flowers, number of bolls plant^{-1}, average boll weight, total yield plant^{-1}, percent first pick, ginning out turn percentage (GOT%), staple length, fiber fineness and fiber strength. The interrelationships among these plant traits were analysed by computing simple correlation coefficient by using the computer programme excel-98. The correlations were further analyzed by the path coefficient method following by Dewey and Lu (1959).

Results and Discussion

Genotypic correlation

The simple correlation coefficient were determined for all the possible character combinations with the objective to derive information about the nature and intensity of the relationship among different character combinations (Table 1).

Table 1: Genotypic and phenotypic correlation among various plant characters

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Node of first fruiting branch		0.43**	-0.66**	0.81**	0.49**	-0.32	-0.30	0.14	0.34**	-0.68**	-0.03	0.21	-0.17	0.15
Monopodial branches per Pl			-0.61**	0.63**	0.34*	0.50**	0.34*	-0.45**	0.49**	-0.39*	-0.32	0.59**	-0.39*	0.13
Sympodial branches per Pl				-0.39*	0.33	0.50**	0.50**	0.18	0.72**	0.21	-0.45*	0.45*	-0.26	-0.25
Days taken to first flower					0.75	-0.57**	-0.16	0.10	-0.04	-0.67**	0.45**	-0.10	0.19	0.35*
Days taken to open first boll						0.24	0.03	0.04	0.10	-0.72**	-0.27	0.23	0.29	0.31
No. of flowers per plant							0.56**	0.14	0.47*	0.12	-0.68**	0.10	0.21	0.02
No. of bolls per plant								-0.61**	0.98**	0.23	-0.24	0.09	-0.04	0.03
Boll weight									0.43*	0.17	0.25	-0.09	0.11	0.06
Total yield per plant										0.31	0.25	-0.39*	0.48**	0.52**
Percent first pick											-0.25	0.15	0.16	0.10
GOT												-0.43*	-0.18	-0.19
Staple length													-0.67**	-0.15
Fibre fineness														0.70**

*:P≤ 0.05; **: P≤ 0.01

1= Node of first fruiting branch, 2= Monopodial branches per Piant, 3= Sympodial branches per Piant,
4= Days taken to first flower, 5= Days taken to open first boll, 6= No. of flowers per plant,
7= No. of bolls per plant, 8= Boll weight, 9= Total yield per plant,
10= Percent first pick, 11= GOT, 12= Staple length,
13= Fibre fineness, 14= Fiber strength

Pak. J. Agron., 2 (3): 160-168, 2003

Table 2: Path coefficient of factors influencing yield of seed cotton in a six parent diallel in upland cotton

Pathway of association	Direct effect path coefficient	Indirect effect	Correlation coefficient
Yield of seed cotton vs. number of monopodial branches plant $^{-1}$			
Direct effect	-0.01		
Indirect effect via number of sympodial branches plant^{-1}		-0.06	
Indirect effect via number of flowers plant^{-1}		0.20	
Indirect effect via number of bolls plant^{-1}		0.40	
Indirect effect via boll weight		-0.07	
Indirect effect via GOT (%)		0.06	
Indirect effect via Staple length		-0.11	
Total			0.49
Yield of seed cotton vs. number of symbpodial branches plant $^{-1}$			
Direct effect	0.17		
Indirect effect via number of monopodial branches plant^{-1}		0.01	
Indirect effect via number of flowers plant^{-1}		0.28	
Indirect effect via number of bolls plant^{-1}		0.52	
Indirect effect via boll weight		-0.18	
Indirect effect via GOT (%)		0.01	
Indirect effect via Staple length		-0.09	
Total			0.72
Yield of seed cotton vs. number of flowers per plant $^{-1}$			
Direct effect	0.41		
Indirect effect via number of monopodial branches plant^{-1}		0.05	
Indirect effect via number of sympodial branches plant^{-1}		0.05	
Indirect effect via number of bolls plant^{-1}		0.52	
Indirect effect via boll weight		-0.12	
Indirect effect via GOT (%)		-0.14	
Indirect effect via Staple length		-0.20	
Total			0.47
Yield of seed cotton vs. number of bolls plant $^{-1}$			
Direct effect	1.30		
Indirect effect via number of monopodial branches plant^{-1}		-0.02	
Indirect effect via number of sympodial branches plant^{-1}		0.04	
Indirect effect via number of flower plant^{-1}		0.25	
Indirect effect via boll weight		-0.61	
Indirect effect via G.O.T (%)		0.04	
Indirect effect via Staple length		-0.03	
Total			0.98

Node of the first fruiting branch was positively and significantly correlated with the number of monopodial branches plant^{-1}, days taken to first flower, days taken to open first boll, seed cotton yield plant^{-1}, while it was negatively correlated with the number of sympodial

Table 2: Continue

Yield of seed cotton vs. boll weight			
Direct effect	1.01		
Indirect effect via number of monopodial branches plant^{-1}		-0.001	
Indirect effect via number of sympodial branches plant^{-1}		0.02	
Indirect effect via number of bolls plant^{-1}		0.06	
Indirect effect via boll weight		-0.65	
Indirect effect via G.O.T (%)		-0.03	
Indirect effect via Staple length		0.02	
Total			0.43
Yield of seed cotton vs. G.O.T. (%)			
Direct effect	-0.20		
Indirect effect via number of monopodial branches plant^{-1}		0.01	
Indirect effect via number of sympodial branches plant^{-1}		-0.01	
Indirect effect via number of flowers plant^{-1}		0.27	
Indirect effect via number of boll plant^{-1}		0.11	
Indirect effect via boll weight		0.13	
Indirect effect via Staple length		0.15	
Total			0.25
Yield of seed cotton vs. Staple length			
Direct effect	-0.54		
Indirect effect via number of monopodial branches plant^{-1}		-0.006	
Indirect effect via number of sympodial branches plant^{-1}		0.10	
Indirect effect via number of flower plant^{-1}		0.04	
Indirect effect via number of bolls plant^{-1}		0.01	
Indirect effect via boll weight		0.11	
Indirect effect via GOT (%)		-0.10	
Total			-0.39

branches plant^{-1} and percent first pick (Table 1). Weijun (1998) working on upland cotton also found similar relationships.

High significant positive correlation of the number of monopodial branches plant^{-1} with the days taken to first flower, days taken to open first boll, number of flowers plant^{-1}, number of bolls plant^{-1}, seed cotton yield plant^{-1} and staple length, was observed while negative association was found with number of sympodial branches plant^{-1}, fiber fineness and percent first pick (Table 1). Correlation of the number of sympodial branches plant^{-1} with the number of flowers plant^{-1}, number of bolls plant^{-1}, seed cotton yield plant^{-1} and staple length was positive and significant, while found negative with hays taken first flower and ginning out turn (Table 1). The high significant positive correlation of the days taken to first flower with the days taken to open first boll, ginning out turn (percentage and fiber strength was observed while negative correlation was observed for the days taken to first flower with the number of flowers plant^{-1} and percent first pick (Table 1). These results were in conformity with those reported by Godoy and Palomo (1999). High negative correlation of the days taken to open first boll and percent first pick was observed and with other traits the values of correlation coefficient were non significant (Table 1). Similar findings were also reported by Godoy and Palomo (1999).

Correlation of the number of flowers plant^{-1} with the number of bolls plant^{-1} and seed cotton yield plant^{-1} was significantly positive and was significantly negative correlated with ginning out turn percentage (Table 1). The highly significant and positive correlation of the number of bolls plant^{-1} with the seed cotton yield, whereas significantly negative correlation with the boll weight was recorded (Table 1). The relationship of the number of bolls plant^{-1} with the remaining characters combinations were not significant. Similar correlation was reported by Waldia ***et al.*** (1979).

Genotype correlation of the boll weight with the seed cotton yield was highly significant and positive. The magnitude and direction of associations was similar to some extent as given in previous findings by Waldia ***et al.*** (1979). The character seed cotton yield plant^{-1} displayed positive significant correlation with the fiber fineness and fiber strength while, it showed significantly negative association with the staple length (Table 1).

The significantly negative correlation between the ginning out turn percentage and staple length was observed in present study and the correlation of staple length with the fiber fineness was negative and significant.

The traits relating to maturity are node of first fruiting branch, number of monopodial branches plant^{-1}, days taken to first flower, days taken to open first boll and present first pick (product quality measure). Percent first pick was negatively and significantly correlated with node of first fruiting branch, number of monopodial branches plant^{-1}, days taken to first flower, days taken to open first boll (Table 1). These results indicated that the genotypes involved in this study, when entered earlier in reproductive phase, the first fruiting branch was developed at a lower node on the main stem which triggered the development of its fruiting parts relatively earlier by impeding the growth and development of monopodial branches being vegetative in nature. Since the reproductive phase started earlier, the first flower and first boll took less number of days to open and resultantly the proportion of seed cotton yield in first pick became higher in early maturing genotypes. This study therefore leads to the conclusion that probably, the earliness of crop maturation is affected more by the position of first fruiting branch than by other morphological traits. Significant genotypic correlations were found among all these morphological traits, but node of first fruiting branch appears to be the most appropriate one for earliness investigations, as this method is so elementary and simple in nature that to use it one needs only to be able to recognize first fruiting branch and to count main stem nodes. The node number of first fruiting branch measure is adaptable to any problem or program that requires the quanitification of genetic earliness. It will also give reliable estimates of earliness, when it is impossible or impractical to collect data on the time and rate of fruiting or boll maturation. Other measures such as the days taken to open first boll proved to have an important place in estimating earliness of the crop maturity but not practicable in large populations of segregating generations and for common grower.

All these traits related to earliness are correlated with quality traits of fiber, which indicated that as early maturing genotypes will develop, the staple length will decrease, fineness will reduce and fiber strength will increase. Due to this association breeder has to study a large population and look for combination (as a result of crossing over) that fit for quality traits with earliness.

Path coefficient analysis

An early application of path coefficient analysis in the field of plant breeding was made by Dewey and Lu (1959) in the study of crested wheat grass.

Number of Monopodial branches plant^{-1} vs. yield of seed cotton plant^{-1}

The correlation of number of monopodial branches plant^{-1} with yield of seed cotton plant^{-1} (Table 2) was positive (r=0.49) but their direct effect on yield of see cotton plant^{-1} was observed to be negative (-0.01). The positive indirect effects were contributed through number of flowers plant^{-1} (0.20), number of bolls per plant (0.48), GOT % (0.06). The negative indirect effect were produced via number of sympodial branches plant^{-1} (-0.06), average boll weight (-0.07). The direct effect of the number of monopodial branches plant^{-1} on seed cotton yield was negligible. The indirect effect via other traits were small, either negative or positive except for number of flowers plant^{-1} and number of bolls plant^{-1}, which had relatively larger positive indirect effects. Therefore, Positive indirect effects of total number of flowers plant^{-1} and number of bolls plant^{-1} showed that these traits can be helpful in indirect selection for improvement of seed cotton yield.

Number of sympodial branches vs. yield of seed cotton plant^{-1}

Although the correlation of number of the sympodial branches plant^{-1} with the seed cotton yield plant^{-1} was significantly positive (0.72) but its direct effect on seed cotton yield plant^{-1} was very small (0.17). It was further observed that positive indirect effects contributed by number of flowers plant^{-1} (0.28) and number of bolls plant^{-1} (0.5) were most important , The contribution of other indirect effects by GOT% (0.01) and number of monopodial branches plant^{-1} (0.10) was negligible (Table 2). The negative indirect effects were produced via average boll weight (-0.18), Staple length (-0.09). The positive direct effect of number of sympodial branches plant^{-1} reflected its effectiveness in a selection procedure. Selection can be made directly on the basis of more number of sympodial branches plant^{-1} in the present plant material. On the other hand negative indirect effect of average boll weight and staple length showed that these characters may not be useful in selection of genotypes with improved seed cotton yield per plant from present segregating material.

Number of flowers vs yield of seed cotton plant^{-1}

Correlation of total number of flowers plant^{-1} with yield of cotton plant^{-1} was positive (0.47). The direct effect of total number of flowers was positive (0.41). The positive indirect effects were contributed through number of sympodial branches plant^{-1} (0.05), total number of bolls plant^{-1} (0.52) . The negative indirect effects were produced via number of monopodial branches plant^{-1} (0.05), average boll weight (-0.12), GOT% (-0.14) and staple length (-0.20). The effects of total number of flower plant^{-1} on yield of seed cotton plant^{-1} suggested that direct selection for more number of flowers to improved yield of seed cotton would be effective up to some extent in breeding material under study.

Number of bolls per plant vs. yield of seed cotton

An examination of Table 2 exhibited that correlation of number of bolls plant^{-1} with yield of seed cotton plant^{-1} was positive (r= 0.98). The direct effect of number of bolls plant^{-1} was positive (1.30). The positive indirect effects were contributed through number of sympodial branches plant^{-1} (0.04) . The negative indirect effects were produced via number of monopodial branches plant^{-1} (-0.02), average boll weight (-0.61) and staple length (-0.03). The high positive genotypic correlation (0.98) of number of bolls plant^{-1} with seed cotton yield plant^{-1} and the value of its direct effect on seed cotton yield (1.30) indicated true picture of association between these two traits. Therefore, the positive direct effect of number of bolls plant^{-1} on seed cotton yield reflected that selection for more number of bolls plant^{-1} is effective for the improvement of seed cotton yield in material under study.

Boll weight vs yield of seed cotton plant^{-1}

The correlation of average boll weight with seed cotton yield (Table 2) was positive (0.43). The direct effect of boll weight was also positive (1.01). The positive direct effects were contributed through number of sympodial branches plant^{-1} (0.02), total number of flowers plant^{-1} (0.06) and staple length (0.02). The negative indirect effects were produced via number of monopodial branches plant^{-1} (-0.001), total number of bolls plant^{-1} (-0.65) and GOT% (-0.03). The positive direct effect of average boll weight reflected its effectiveness in a selection procedure. Selection can be made directly on the basis of greater boll size in the present research material.

Ginning out turn percentage (GOT%) vs. yield of seed cotton plant^{-1}

The correlation of GOT% with yield of seed cotton plant^{-1} was positive but not significant (r= 0.25) and its direct effect on yield of seed cotton was negligible (-0.20). The positive indirect effects produced through number of monopodial branches plant^{-1} (0.01), total number of flowers plant^{-1} (0.27), average boll weight (0.13) and staple length (0.15) were very small. Negative indirect effects were produced through number of sympodial branches plant^{-1} (-0.01) and total number of bolls plant^{-1} (0.11) were negligible (Table 2). These results showed that the GOT% contributed by and large through total number of flower plant^{-1} and boll weight. On the basis of GOT%, direct selection in the segregating material use in present studies will not be useful. Selection can be done indirectly on the basis of total number of flowers plant^{-1} and total number of bolls plant^{-1}. It was further concluded that seed cotton, yield cotton plant^{-1} and GOT% would not effect each other and either trait could be considered separately in breeding material under study. The results suggested that genotypes could be selected in which high GOT could be considered with a number of economic traits such as seed cotton yield and fiber quality characters.

Staple length vs yield of seed cotton plant^{-1}

A critical view of revealed that the simple correlation of staple length with seed cotton yield (Table 2) was significant and negative (r= -0.39). The direct effect of staple length on seed cotton yield was negative (Path coefficient = -0.54). The indirect effect via number of monopodial branches plant^{-1} (-0.006) was negligible. The staple length had its major influence via negative indirect effect of GOT% (-0.10). A positive indirect effect via number of sympodial branches plant^{-1} (0.10) and boll weight (0.11) was observed. The total correlation between staple length and seed cotton yield was negative (-0.39). Its direct effect in seed cotton yield was also in negative which indicated true relationship between them and direct selection through this trait will effect the seed cotton yield negatively. Three basic seed cotton yield components viz., number of flowers plant^{-1}, boll weight contributed directly towards seed cotton yield as they had direct and positive effects on it. Whereas, the staple length being fourth important component of seed cotton yield had direct negative effect on the seed cotton yield plant^{-1}. Whereas, characters such as monopodial branches plant^{-1}, sympodial branches plant^{-1} and GOT% had only small proportion of direct effect on seed cotton yield plant^{-1}.

The progress in breeding by selection for components of seed cotton yield plant^{-1} rather seed cotton yield ***Per se***, may be limited due to the strong negative correlation between number of bolls plant^{-1} and boll weight. In its simplest interpretation, this means that as the plant develops additional bolls, they will be progressively smaller in size.

It can further be concluded that the increase in seed cotton yield can be achieved mainly through breaking the negative correlation between number of bolls plant^{-1} and boll weight. Obviously this would mean manipulation of physiological production potential of the plant through changing the genetic architecture of the plant.

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