Annals of Plant and Soil Research 16(1): 35-40 (2014)

INTER-RELATIONSHIP AND PATH COEFFICIENT ANALYSIS FOR DIFFERENT PHYSIOLOGICAL AND YIELD CONTRIBUTING TRAITS IN MAIZE

DIPIKA, SHAILESH MARKER*, SRIKANT VERMA AND GIDEON J. SYNREM

Department of Genetics and Plant Breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Formerly Allahabad Agricultural Institute) Deemed-to-be-University, Allahabad-211007, Uttar Pradesh, India

Received: August, 2013, Revised accepted: January, 2014

ABSTRACT

The present investigation was carried out with twenty five maize genotypes grown in Kharif 2012 following randomized block design at Allahabad (U.P.). Analysis of variance revealed the presence of considerable genetic variability in the maize germplasm for all quantitative and physiological characters. Per se *performance for physiological parameters depicted that genotype POP 318211 was found most promising followed by EC-598475, TEMP X TROP QPM, and JP25W95. High to moderate estimates of GCV and PCV were recorded for leaf area and for other characters, the difference between these two was low, indicating little influence of environment. High to moderate estimates of heritability and genetic advance were found for chlorophyll content, leaf area, cob height, plant height, cob length and seed index. Positive significant correlation of leaf area, leaf relative water content and chlorophyll content with seed yield reflect the importance of these traits. Therefore, these traits can be used as selection indices for indirect selection for the improvement of maize productivity.*

Keywords: Genetic variability, inter-relationship, physiological traits, maize

INTRODUCTION

Maize (*Zea mays L.*) is the third most important cereal after rice and wheat. It occupies 7.27 million hectares area with production of 15.86 million tonnes and productivity of 2.1 tonnes per hectare where as in Uttar Pradesh it occupies 9.63 lakhs hectare with production of 11.24 lakh tonnes and productivity of 1126 kg/hectare (Agricultural statistics at a glance, 2012), Physiological approach to assess the causes of variation in grain yield is the basic attempt towards increasing the crop productivity. Growth analysis is a physiological probe into the development of crop in chronological sequence to elucidate and account for the causes for the difference in yield through the events that have occurred earlier in growth. The technique of growth analysis involves estimating the photo synthetically active area and its efficiency, the chlorophyll content, its leaf relative water content in the leaf area. Variability refers to the difference among the individuals in a plant population. Variability results due to difference either in genetic constitution of the individuals in a population or in the environment they are grown. Genetic improvement in traits of economic importance along with maintaining sufficient amount of variability is always the desired objective in maize breeding programs**.** Naushad *et al,* (2007) observed considerable genotypic variability among various maize genotypes for different traits. Hence, broader the genetic variability more effective could be the selection. The information about phenotypic and genotypic interaction of various morpho-physiological traits is of immense importance to a plant breeder for selection and breeding of different varieties of maize with increased yield potential, correlation between various characters is of great value as it indicates the degree to which various characters of a plant are associated with the economic productivity (Paterniani, 1990)**.** Genetic correlation analysis is a handy technique which elaborates the degree of association among important quantitative traits. The studies on correlation are quite old and extensive but, unfortunately there is hardly any rule set on how much a character contributes towards the expression of other character(s) in a plant population. A path coefficient analysis permits the separation of correlation coefficient into direct and indirect effects (effects exerted through other variables) and effectively measuring the relative importance of causal factors. Such information provides realistic basic for allocation of appropriate weightage to various yield components. Hence, the investigation was initiated using maize genotypes.

Corresponding author: Email:marker_sn@yahoo.com

MATERIALS AND METHODS

The experimental materials consisted of 25 diverse maize genotypes including two checks, obtained from the Department of Genetics and Plant Breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad (U.P.). Field trial was laid out during kharif season of 2012 in a randomized block design with three replications in the spacing of 60 cm x 20 cm in 370 m^2 plot at the field experimentation center of the Department of Genetics and Plant Breeding, and the recommended culture practices were followed. Five plants from the middle row of each entry in each replications were randomly taken for recording observations on 14 traits namely, days to 50% silking, days to 50 % tasseling, anthesis silking interval, plant height, number of cobs per plant, ear length, ear girth, 100 grain weight, grain yield per plant, leaf area, leaf relative water content and chlorophyll content. The data were analyzed by using ANOVA and genetic parameters such as PCV and GCV were calculated by the formula given by Burton (1952), heritability in broad sense (h^2) by Lush (1949), genetic advance in percent of mean (genetic gain) were work out as suggested by Johnson *et al.* (1955), correlation coefficient by Al-jibouri *et al*. (1958) and Path coefficient analysis by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences for all yield attributing characters studied. An estimate of genetic variability in respect to 14 traits studied is presented in table (Table 1). In general, phenotypic coefficient of variation (PCV) values were higher than genotypic coefficient of variation (GCV) values, which indicated the effect of environment on the expression of characters. A perusal of variability parameters revealed that wide range of genotypic variability was observed for leaf area (cm^2) (345.29) followed by plant height (324.59), grain yield per plant (152.92), chlorophyll content (78.56) and cob height (72.60). The rest of the characters showed low estimates of genotypic variance, which indicates the influence of environment. The results were well supported by similar findings by Saikia *et al.* (2000) and Singh *et al*. (2003) for grain yield and ear length.

Table 1: Estimation of genetic variability parameters for 14 different traits in maize

S No.	Characters	Genetic Variance (σ^2g)	Phenotypic Variance (σ^2p)	GCV (%)	PCV (%)	Heritability (h^2 %) (bs)	Genetic advance	GA as % mean
1	Days to 50% tasseling	1.22	5.26	2.20	4.56	23.00	1.10	2.18
2	Days to 50% silking	1.17	5.38	2.05	4.39	22.30	1.04	1.97
3	ASI	0.09	0.24	11.98	19.08	39.00	0.40	15.49
4	Plant height	324.59	351.90	12.19	12.70	42.50	35.64	24.13
5	Cob height	72.60	72.81	11.52	11.55	63.00	17.50	23.70
6	Cobs/plant	0.17	0.14	16.59	24.05	52.50	0.39	25.30
7	Cob length	6.22	6.92	19.62	20.70	91.00	34.92	38.75
8	Cob girth	0.47	1.09	7.04	10.72	73.50	30.93	39.53
9	Grain rows/cob	0.43	1.10	5.52	8.80	39.00	10.85	17.12
10	Seed index	8.04	9.65	14.80	16.28	83.00	35.33	27.94
11	Chlorophyll content	78.56	78.68	22.08	22.10	58.50	28.24	45.46
12	Leaf area	345.29	145.07	32.80	33.20	61.20	28.20	68.38
13	LRWC	19.88	20.94	8.65	8.87	72.00	18.95	27.35
14	Grain yield/plant	152.92	155.94	19.49	19.68	53.50	25.23	39.75

Where ASI= Anthesis Silking Interval, LRWC= Leaf relative water content

The phenotypic coefficient of variation (PCV) was estimated highest for leaf area (33.20) followed by number of cobs per plant (24.05), chlorophyll content (22.10) and cob length (20.70). The genotypic coefficient of variation (GCV) also showed a similar trend in all the traits studied and was observed highest for leaf area (33.20) followed by chlorophyll content (22.08), cob length (19.62) and grain yield per plant (19.49). The coefficient of variation doesn't offer the full scope of heritable variation. It can be found out with great accuracy when heritability is conjunction with genetic advance study. The estimation of heritability along with high genetic advance is more helpful in predicting the gain under selection than heritability alone (Panse, 1957). The heritability estimates were found to be high (more than 60 %) for chlorophyll content (100 %), leaf area (100 %) and cob height (99 %), whereas, moderate (> 30 but < 60 %) for number of cobs per plant (52 %) and cob girth (43 %). High heritability coupled with high genetic

Table 2: Genotypic (rg) and Phenotypic (rp) correlation coefficients for quantitative and physiological characters in Maize (*Zea mays* L)

Characters		**Days to 50% silking**	**Anthesis silking interval**	**Plant height**	**Cob height**	**Number of Cobs/Plant**	**Cob length**	**Cob girth**	**Number of grain rows/ cob**	**Seed index**	**Chlorophyll content**	**Leaf area**	**Leaf relative water content**	**Grain yield /plant**
Days to 50% tasseling	r p	0.97**	-0.03	-0.08	0.06	0.006	-0.08	0.05	0.005	-0.15	0.06	0.01	-0.17	0.10
	r g	0.97	-0.21	-0.13	-0.015	-0.27	-0.13	0.16	0.20	-0.20	0.14	-0.04	-0.28	0.26
Days to 50% silking	r p		0.16	-0.08	-0.01	-0.02	-0.11	0.06	-0.01	-0.17	0.03	0.01	-0.18	0.06
	r g		0.03	-0.14	-0.04	-0.25	-0.21	0.23	0.10	-0.23	0.10	0.02	-0.34	0.17
Anthesissilking interval	r p			-0.09	-0.16	0.15	-0.04	0.10	-0.02	-0.03	-0.13	0.08	-0.06	-0.10
	r g			-0.14	-0.24	0.04	-0.08	0.21	-0.24	0.02	-0.21	0.13	-0.19	-0.20
Plant height	r p				0.90 **	0.16	-0.01	0.10	-0.09	-0.39**	0.21	-0.24*	-0.09	-0.29**
	r g				0.94	0.28	-0.03	0.13	-0.03	-0.36	0.22	-0.25	-0.11	-0.31
Cob height	r p					0.21	0.03	0.06	0.04	-0.23*	0.29**	-0.25 *	-0.04	-0.34**
	r g					0.29	0.04	0.10	0.05	-0.24	0.30	-0.26	-0.04	-0.34
Cobs/plant	r p						-0.01	0.13	0.16	0.11	0.08	-0.48 **	-0.31 **	-0.10
	r g						-0.02	0.40	0.28	0.11	0.15	-0.13	-0.70	-0.45
Cob length	r p							0.28 *	0.49 **	0.34**	0.23 *	0.15	0.05	0.51 **
	r g							0.41	0.84	0.38	0.24	0.16	0.04	0.54**
Cob girth	r p								0.32 **	0.01	-0.18	0.01	-0.23 *	0.22
	r g								0.66	-0.01	-0.27	0.03	-0.39	0.34
Grain rows/cob	r p									0.24 *	0.17	-0.12	-0.11	0.44**
	r g									0.33	0.27	-0.19	-0.21	0.32**
Seed index	r p										-0.02	0.10	0.10	0.28*
	r g										-0.02	0.11	0.10	0.30*
Chlorophyll content	r p											-0.18	-0.33 **	-0.06
	r g											-0.18	-0.34	-0.06
Leaf area	r p												0.32 **	0.29**
	r g												0.33	0.30**
Leaf relative water content	r p													0.16
	r g													0.15

**Significant at 5 % and **Significant at 1% level of probability respectively.*
rp= phenotypic level, rg= genotypic level

advance as percent of mean was maximum for leaf area (100 %, 68.38 %), followed by chlorophyll content (100 %, 45.46%), grain yield per plant (98 %, 39.75 %), and cob length (91%, 38.32 %), indicating additive gene action for gene expression. Similar findings for high heritability coupled with high genetic advance in maize for different quantitative characters were also reported by Singhal *et al.* (2006) for grain yield per plant. The results were also well supported by findings of Muhammad *et al.* (2008) for grain yield per plant. Leaf relative water content (95 %, 17.35 %), plant height (92 %, 24.13 %) and seed index (83 %, 27.94 %) exhibit high heritability with moderate genetic advance indicating both additive and dominant gene action might be involved in controlling these traits.

An overview of the Table 2 revealed that, genotypic correlation was at a higher magnitude than phenotypic correlation in most of the cases indicating a high degree of association among the characters. Therefore, selection based on phenotypic traits would be effective in achieving genetic gain. Phenotypic correlation coefficient analysis (rp) revealed that cob length (0.51**), number of grain rows per cob (0.44**), leaf area (0.29**) and seed index (0.28**) showed significant positive correlation with grain yield per plant. This was well supported by similar findings of Saleem *et al.* (2007) where cob height and leaf area were positive significantly correlated with grain yield. Similar results were also earlier reported by Shinde *et al.* (2009). Brar *et al.* (2008) also reported that plant height, ear height, ear length, ear girth and number of ears per plot, had significant positive genotypic and phenotypic correlations with yield. The characters cob height and plant height however, showed negative significance with grain yield per plant (-0.34**) and (-0.29**) respectively at the phenotypic level. Plant height showed significant and positive correlation with cob height (0.905 **), and negative and significant one with seed index (-0.33**) and leaf area (-0.24*). The above results were well supported by the findings of Suresh (2004). Cob height showed positive and significant correlation with chlorophyll content (0.299**), however it showed negative but significant correlation with leaf area (-0.255*) at the phenotypic level. Cob length showed positive and significant correlation with cob girth (0.288*), number of grain rows/cob (0.491**), seed index (0.347**) and chlorophyll content (0.234*). Cob girth showed significant and positive correlation with number of grain rows per cob (0.328**). Leaf area showed significant and positive correlation with leaf relative water content (0.326**) which shows that these physiological traits are interrelated.

Path analysis reveals the direct and indirect effects of characters on grain yield (Table 3) From the study, it revealed that the characters days to 50 % silking (P=0.051, G=6.864), plant height (P=0.524, G=1.211), cob girth (P=0.067, G=2.240), number of grain rows per cob (P=0.317, G=0.182), seed index (P=0.047, G=1.111), chlorophyll content (P=0.016, G=1.334) and leaf relative water content (P=0.204, G=0.768) showed positive direct effect on grain yield at both the phenotypic (P) and genotypic (G) levels. The results clearly show that there is an inter-relationship of quantitative and also physiological traits that they directly and positively affect the grain yield. Muhammad *et al.* (2008) also reported that cobs per plant, plant height, cob height, days to 50 percent tasseling, days to 50 percent silking exerted positive direct effect on grain yield per plant. The present study revealed that there was significant amount of variability for number of cobs per plant, cob length, seed index, Chlorophyll content and leaf area. In order to develop high yielding varieties, the characters cob girth, number of grain rows per cob, seed index, chlorophyll content and leaf relative water content should be taken into consideration for the selection of these traits as they showed positive significant association with grain yield.

It is concluded from the present study that the genotypes viz: POP 318211, TEMP X TROP QPM and EC-598475 were recorded as promising genotypes for seed yield. The maize germplasm showed significant differences for all the characters under study depicting the presence of substantial amount of genetic variability. Characters which showed strong and direct positive effect on the grain yield were male and female flowering, plant height, number of cobs per plant , 100 grain weight, cob girth, number of grain rows per cob and seed index, chlorophyll content and leaf relative water content. Any increase in one of these or all of these characters will results in overall increase in the yield.

Table 3: Direct (diagonal) and indirect (off diagonal) effect of quantitative and physiological characters to yield in maize (*Zea mays* L.)

Characters	Level	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Cob height	Cobs /plant	Cob length	Cob girth	Grain rows/ Cob	Seed index	Chlorophyll content	Leaf area	Leaf relative water content	Grain yield/ plant
Days to 50% tasseling	P	**0.15**	0.15	-0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.02	0.01	0.00	-0.02	0.10
	G	**-7.57**	-7.34	1.63	1.04	0.11	2.10	1.05	-1.25	-1.55	1.57	-1.13	0.03	2.18	
Days to 50% silking	P	0.05	**0.051**	0.00	-0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	0.00	0.00	-0.00	0.06
	G	6.66	**6.86**	0.21	-1.01	-0.32	-1.77	-1.45	1.61	0.70	-1.63	0.68	0.18	-2.38	
Anthesissilking interval	P	0.00	-0.03	**-0.19**	0.01	0.03	-0.03	0.00	-0.02	0.00	0.00	0.02	-0.01	0.01	-0.10
	G	0.47	-0.07	**-2.21**	0.31	0.54	-0.09	0.18	-0.48	0.53	-0.05	0.46	-0.29	0.42	
Plant height	P	-0.04	-0.04	-0.05	**0.52**	0.47	0.08	-0.00	0.05	-0.00	-0.17	0.11	-0.12	-0.05	-0.29
	G	-0.16	-0.17	-0.17	**1.21**	1.14	0.34	-0.03	0.16	-0.03	-0.43	0.26	-0.30	-0.13	
Cob height	P	-0.00	0.00	0.13	-0.76	**-0.84**	-0.18	-0.02	-0.05	-0.03	0.19	-0.25	0.21	0.03	-0.34
	G	0.02	0.08	0.45	-1.73	**-1.84**	-0.54	-0.07	-0.18	-0.10	0.45	-0.55	0.47	0.07	
Cobs/plant	P	0.00	0.00	0.01	0.02	0.02	**0.12**	-0.00	0.01	0.02	0.01	0.01	-0.06	-0.04	-0.09
	G	0.55	0.51	-0.08	-0.56	-0.58	**-2.00**	0.05	-0.81	-0.57	-0.31	-0.27	1.40	0.92	
Cob length	P	-0.02	-0.03	-0.01	-0.00	0.01	-0.00	**0.32**	0.09	0.15	0.11	0.07	0.04	0.01	0.51
	G	0.11	0.18	0.07	0.02	-0.03	0.02	**-0.85**	-0.35	-0.72	-0.32	-0.21	-0.13	-0.03	
Cob girth	P	0.00	0.00	0.00	0.00	0.00	0.00	0.01	**0.06**	0.02	0.00	-0.01	0.00	-0.01	0.22
	G	0.37	0.52	0.49	0.30	0.22	0.91	0.92	**2.24**	1.49	-0.02	-0.62	0.03	-0.88	
Grain rows/ Cob	P	0.00	-0.00	-0.00	-0.00	0.01	0.05	0.15	0.10	**0.31**	0.07	0.054	-0.03	-0.03	0.44
	G	0.03	0.01	-0.04	-0.00	0.01	0.05	0.15	0.12	**0.18**	0.06	0.050	-0.03	-0.03	
Seed index	P	-0.00	-0.00	-0.00	-0.01	-0.01	0.00	0.01	0.00	0.01	**0.04**	-0.00	0.00	0.00	0.28
	G	-0.23	-0.26	0.02	-0.40	-0.27	0.17	0.42	-0.01	0.36	**1.11**	-0.03	0.12	0.11	
Chlorophyll content	P	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	0.00	-0.00	**0.01**	0.00	-0.00	-0.06
	G	0.19	0.13	-0.28	0.29	0.40	0.18	0.33	-0.36	0.36	-0.03	**1.33**	-0.24	-0.45	
Leaf area	P	0.00	0.00	0.01	-0.04	-0.05	-0.09	0.03	0.00	-0.02	0.02	-0.03	**0.20**	0.06	0.29
	G	0.00	-0.03	-0.15	0.30	0.31	0.85	-0.19	-0.01	0.23	-0.14	0.21	**-1.21**	-0.40	
LRWC	P	-0.03	-0.03	-0.01	-0.01	-0.00	-0.06	0.01	-0.04	-0.02	0.02	-0.06	0.06	**0.20**	0.16
	G	-0.22	-0.26	-0.14	-0.08	-0.03	-0.35	0.03	-0.30	-0.16	0.08	-0.26	0.25	**0.76**	
Partial R^2	P	0.01	0.00	0.02	-0.15	0.29	-0.01	0.16	0.01	0.14	0.01	-0.00	0.06	0.03	
	G	-1.99	1.17	0.45	-0.38	0.64	0.26	-0.46	0.77	0.13	0.33	-0.08	-0.36	0.12	

Where LRWC= Leaf relative water content, P= Phenotypic level and G= Genotypic level ,Genotypic path (R^2 = 0.6044, Residual effect = 0.6289) and Phenotypic path (R^2 = 0.5958, Residual effect = 0.6358)

REFERENCES

Agricultural Statistics at a glance (2012) Directorate of economic and statistics, Ministry of agriculture Government of India.

Burton, F.W. (1952) Quantitative inheritance in grasses. *Proceedings of 6th International Grassland Congress* 1; 227-283.

Brar, S.P.S., Chawla, J.S. and Pritpal, S. (2008) Studies on different selection indices and path analysis in maize (*Zea mays* L.). *Crop Improvement* 35: 16-19.

Dewey, D.R. and Lu, K.H. (1959) Correlation and path-coefficient analysis of crested wheat grass seed production. *Agronomy Journal* 51: 515-518.

Johnson, H.W., Robinson, H.F., and Comstock, R.E. (1955) Genotypic and phenotypic correlations in soyabean and their implication in selection. *Agronomy Journal* 47: 477-483.

Lush, J.L. (1949) Intra- site, correlation and regression of offspring on dams as a method of estimating heritability of characters. *Proceedings American Society of Animal Production* 33:293-301.

Muhammad Akbar, Shakoor, M.S., Amber Hussain and Muhammad Sarwar (2008) Evaluation of maize 3 way cross through genetic variability broad sense heritability, character association and path analysis. *Journal of Agriculture Research Lahore* 46: 399-415.

Naushad Ali Turi, Salim Shah, Sajid Ali, Rahman, Tahir Ali and Muhammad Sajjad (2007) Genetic variability for yield parameters in maize (Z*ea mays* L.) Genotypes Journal of Agricultural and Biological Science., 2:(4-5)

Patemiani, E. (1990) Maize breeding in the-tropics. CRC *Critical Revolution Plant Sciences 9:* 52-54.

Panse, V.G. (1957**)** Genetics of quantitative traits in relation to plant breeding. *Indian Journal of Genetics* 15:318-328.

Saikia, R.B. and Gargi Sharma (2000) Variability studies in some exotic maize genotypes. *Indian Journal of Hill Farming* 13:106-107.

Saleem, A.U.R., Saleem, U. and Subhani, G.M. (2007) Correlation and path analysis in maize. *Journal of Agriculture Research Lahore* 45: 177-183.

Shinde, S.A., Shelki, D.K. and Sawargaonkar, G.L. (2009) Intercharacter associations and path analysis of yield components in *rabi* maize. *International Journal Plant Sciences* 4: 49-51.

Singh, P., Das, S., Kumar, Y. and Yagya Dutt (2003) Variability studies for grain yield and component traits in maize (*Zea mays* L.). *Annals of Agriculture and Biology Research* 8:29-31.

Singhal, N., Verma, S. S., Baskheti, D.C. and Ali Kumar (2006) Heritability, genetic advance, correlation and path coefficient estimation in high quality protein maize (*Zea mays* L.). *Asian Journal of Biological Sciences* 6: 54-56.

Suresh (2004) Genetic analysis of protein and grain yield parameters in selected maize (*Zea mays.* L) genotypes. Ph. D thesis submitted to ANGRAU, Hyderabad.