DOI : 10.5958/0974-0112.2016.00100.6
Indian J. Hort. 73(4), December 2016: 465-469

Genetic variability, character association and path analysis for yield and yield contributing traits in peach

S. Lal[*], N. Ahmed, M.K. Verma[**], O.C. Sharma and J.I. Mir
ICAR-Central Institute of Temperate Horticulture, Old Airport P.O., Rangreth, Srinagar 190 007, Jammu & Kashmir

ABSTRACT

Genetic variability, correlation and path coefficient analysis for yield and yield contributing traits were studied on 24 peach (*Prunus persica* L.) genotypes. Maximum variability recorded for TSS/ acid ratio and fruit weight, however, low differences between the phenotypic and genotypic coefficients of variation indicated low environmental influence on the expression of these traits. High heritability coupled with high genetic advance was obtained with acidity, TSS/ acid ratio, fruit weight and yield per plant. Fruit weight (r = 0.797), fruit length (r = 0.481), fruit diameter (r = 0.559), fruit pulp thickness (r = 0.630) and stone diameter (r = 0.352) were the most important traits, which possessed significant positive association with fruit yield per plant. Path coefficient analysis revealed that among the different yield contributing traits, fruit weight (0.9786) followed by TSS (0.299), fruit pulp thickness (0.211), stone diameter (0.1933) and ascorbic acid (0.0028) influenced fruit yield per plant directly. The direct effects of these traits on fruit yield were found positive and considerably high. Moreover, fruit length, fruit diameter had positive and higher indirect effect on fruit yield through fruit weight. Selection for fruit yield in peach through these traits will be effective and helpful in future improvement programmes.

Key words: Character association, genetic variability, path analysis, *Prunus persica*, yield.

INTRODUCTION

Peach (*Prunus persica* L. Batsch) belongs to the Rosaceae family. It includes different types of varieties: downy skin with freestone or clingstone (peach), smooth skin with freestone or clingstone (nectarine) (Bretaudeau and Faure, 3). Peach and nectarine are the third most important temperate fruit crops of India having an area of (36.40 thousand ha), production (2.43 lakh tonnes) and productivity (6.67 t/ha) (FAOSTAT, 7). It is favorite table fruit and is highly valued for its taste and attractive colour. The fruits are rich source of sugars, vitamins and minerals and malic acid (1.2%). Among temperate fruit crops, the peach breeding industry is one of the most dynamic and all peach cultivars grown across the world today come as the result of breeding, whose intensity has led to reduced genetic variability within this species (Byrne, 3; Sansavini *et al*., 12). Genetic variability is the prerequisite for any plant breeding programme (Khush, 8). Studies of genetic variability, heritability and correlation between traits can show the extent to which certain traits are genetically determined and which of them have the greatest importance in the selection for favourable traits. In addition to determining the components of variability and the coefficient of heritability, it is also very important in peach breeding to know the relationships existing between horticultural traits. Under the impact of selection, a change in the correlated inter-dependent traits occur, therefore, the testing of values of correlation coefficients must be done all the time. The aim of the present investigation was to determine the components of variability and the coefficients of heritability for yield and yield attributing traits and to observe the inter-relations of such traits.

MATERIALS AND METHODS

The present study was conducted during 2010 to 2012 on 24 peach genotypes (Table 1) grown at the research farm of ICAR-CITH, Srinagar, J&K. The site is situated at latitude of 34°05 N and longitude of 74^{0}°50 E at an altitude of 1,640 m above the msl. Recommended package of practices uniformly followed for growth and health of the trees. The average maximum temperature 19.63°C, minimum 6.52°C, rainfall 160.72 cm and relative humidity 58.35%, evaporation 2.45/ day and soil characteristics, *viz*., pH (6.81), EC (0.36 dS m^{-1}) were recorded during growing seasons.

The primary selection criterion was based on fruits and yield attributes of the genotypes. Individual genotypes were marked in the field. The data were recorded at the time of fruit maturity during summer (June-August) seasons of the each year, *i.e*., 2010, 2011 & 2012 and data was pooled for analysis. Twenty fruits from each genotype were randomly collected and observations on fruit length (mm), fruit weight (g), fruit diameter (mm), pulp thickness (mm), stone diameter (mm), stone weight (g), TSS (^{o}Brix), acidity

*Corresponding author's E-mail: shivcith@gmail.com
**Division of Fruits and Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Table 1. Origin of peach genotypes used in the study.

Genotype	Origin
Fantasia	USA
Crest Heaven	USA
Red Globe	USA
Gloheaven	USA
Nimla	India
K-209014	USA
Fertilia	USA
Elberta	USA
Flemish Beauty	USA
Peshawari	Pakistan
Kanto-5	USA
Snow Queen	USA
Summerglo	USA
Quetta	Pakistan
Early Red June	USA
July Elberta	USA
CITH-P-1	India
Paradelux	USA
Snow Crest	USA
Shan-e-Punjab	India
Vance Marble	USA
CITH-P-2	India
CITH-P-3	India
CITH-OAF-P-1	India

(%), TSS/acid ratio and fruit yield (kg/ plant) were recorded. The length and diameter of the fruit was measured with the help of digital Vernier calipers. The stones were manually separated from the fruits and stone weight and stone diameter were measured. Total soluble solids (TSS), titratable acidity and total soluble sugars were determined as per the standard procedures (AOAC, 2). The experiment was conducted under randomized block design replicated three times and pooled data of three years were analyzed (Gomez and Gomez, 6).

The genotypic and phenotypic coefficients of variation were calculated (Burton and De Vane, 6). Heritability and genetic advance were calculated as suggested by Allard (1) and genetic gain was estimated using the method suggested by Johanson *et al*. (12). Genotypic and phenotypic correlations were calculated as per the procedures given by Al-Jibouri *et al*. (1). The direct and indirect paths were obtained according to the method of given by Dewey and Lu (4).

RESULTS AND DISCUSSION

The extent of variability in respect of range, mean, phenotypic and genotypic coefficients of variation, heritability and genetic advance are given in Table 2. Maximum variability recorded in TSS/ acid ratio followed by fruit weight, fruit length, fruit diameter, yield per plant, stone diameter, TSS, fruit pulp thickness, ascorbic acid, stone weight and lowest in titratable acidity. Considerable variability was observed for all the traits studied indicating the diversity of germplasm and their amenability to selection. Similar kind of variability among pomological traits and yield were also reported by Rakonjac (11), Perz (16), Ogasanovic *et al*. (10), Milatovic *et al*. (9) and Bhat (4) in *Prunus* species.

Phenotypic coefficients of variation was more than genotypic coefficient of variation for all the characters. Maximum PCV and GCV were estimated for yield per plant followed by TSS/ acid ratio, titratable acidity and fruit weight and lowest in fruit length. Fruit yield per plant, titrable acidity, TSS/ acid ratio, fruit length and fruit weight traits exhibited high heritability. Highest genetic advance estimated for TSS/acid ratio followed by fruit weight, yield per plant, fruit diameter, fruit length, stone diameter, TSS, fruit pulp thickness, ascorbic acid, stone weight and lowest in titratable acidity, whereas, genetic advance as percent of mean recorded maximum in yield per plant followed by TSS/ acid ratio, titratable acidity and fruit weight and minimum in fruit length. High GCV, PCV, heritability and genetic advance per cent of mean for yield per plant followed by TSS, titratable acidity and fruit weight suggested that these two traits could be transmitted to the hybrid progeny and phenotypic selection based on these would be effective. Although high heritability estimates have been found to be effective in the selection of superior genotypes on the basis of phenotypic performance. Johnson *et al*. (12) suggested that heritability estimates along with genetic advance will be more useful in predicting the effect for selecting the best individual suggested that genotypic coefficient of variation along with heritability estimates would give better idea about the efficiency of selection. The high heritability estimates along with low genetic advance indicates that non-additive type of gene action and genotype-environment interaction plays a significant role in expression of the traits as observed in stone weight, stone diameter and TSS in the present study. Yield per plant followed by TSS/ acid ratio, titratable acidity, fruit weight traits were less influenced by environment demonstrating either these were simply inherited traits governed by a few major genes or additive gene effect even if, they were under polygenic control. Therefore, selection of these traits would be more effective for yield improvement (Johnson *et al*.,12).

Table 2. Genetic parameters of different yield and yield contributing traits in peach genotypes.

Trait	Range	Mean ± SE (m)	GCV	PCV	Heritability % (broad sense)	Genetic advance (%)	Genetic advance (% of mean)
Fruit weight (g)	28.63-91.63	57.54 ±0.92	31.10	31.16	99.61	36.79	63.95
Fruit length (mm)	35.3-59.66	50.17 ± 0.76	12.00	12.14	97.67	12.25	24.42
Fruit dia. (mm)	33.35-57.47	47.31 ± 0.72	12.88	13.02	97.98	12.43	26.27
Fruit pulp thickness (mm)	7.66-16.17	11.37 ± 0.21	19.74	19.87	98.65	4.59	40.39
TSS (°B)	8.6-21.10	12.65 ± 0.23	18.95	19.09	98.60	4.90	38.77
Titratable acidity (%)	0.13-0.78	0.31 ± 0.01	41.56	41.61	99.74	0.26	85.49
TSS/ acid ratio	14.61-99.23	46.97 ± 0.92	41.84	41.91	99.67	40.41	86.04
Ascorbic acid (mg/100 g)	6.00-12.36	8.22 ± 0.14	19.42	19.53	98.87	3.27	39.78
Stone weight (g)	2.6-6.8	4.95 ± 0.09	21.64	21.74	99.07	2.20	44.37
Stone dia. (mm)	19.01-37.22	24.66 ± 0.42	20.28	20.39	98.95	10.25	41.56
Yield (kg)/plant	0.86-24.21	7.22 ± 0.14	95.10	95.13	99.94	14.14	195.85

Mutual relationship between fruit yield and its contributing traits (Table 3) revealed that in most of the cases the genotypic correlation coefficient were higher than the corresponding phenotypic correlation coefficient indicating strong inherent relation between the traits but suppressing effect of the environment, which modified the phenotypic expression of these characters by reducing phenotypic coefficient values. Fruit length is genotypically and phenotypically significantly positively associated with fruit weight and similarly fruit diameter is exhibited significant positively associated with fruit weight and fruit length. Fruit pulp thickness showed positive significant link to fruit weight and fruit diameter, however positive non-significant relation with fruit length. Stone weight revealed positive significant association with fruit weight, whereas stone diameter exhibited positive significant association with fruit weight, fruit length, ascorbic acid and stone weight. Yield per plant showed positive significant asscoiation with fruit weight, fruit length, fruit diameter, fruit pulp thickness and stone diameter, however, non-significant association with rest of the traits. Significant correlations of yield contributing traits suggested the scope of direct and indirect effective selections for further improvement. These findings were also supported by Saran (13) on peach, Saran *et al*. (14) on Indian jujube and Sofi *et al*. (15) on apricot.

Relationship between yield and yield contributing traits were studied in detail through path coefficient analysis (Table 4). It was revealed that considerably high positive direct effect on fruit yield was exhibited by fruit weight (0.9786) followed by TSS (0.299), fruit pulp thickness (0.211), stone diameter (0.1933) and ascorbic acid (0.0028), however, negative direct effect exhibited by fruit length (-0.3484), fruit diameter (-0.0043), fruit titratable acidity (-0.0547), TSS/ acid ratio (-0.1393) and stone weight (-0.2136). Among these fruit weight, fruit pulp thickness and stone diameter were highly correlated with fruit yield per plant at genotypic level. The direct effects of these traits on fruit yield could be considered as cause of such high correlation. TSS exhibited high and positive direct effects on fruit yield but their correlations with yield per plant was non-significant. High positive indirect effect of fruit length through fruit weight increased the correlation of the character with fruit yield per plant to be significant. Similarly, high and positive indirect effect of fruit diameter through fruit weight caused the significant correlation of the character with fruit yield per plant. The character fruit length had negative direct effect on fruit yield, which suggests that the selection for higher fruit length types with high yield is possible. Similar reports are available in apricot (Sofi *et al*., 15) and in *ber* (Saran *et al*., 14) who observed significant positive correlation for these traits with fruit yield due to fruit weight.

REFERENCES

1. Allard, R.W. 1960. *Principles of Plant Breeding*, John Wiley and Sons, New York.

2. A.O.A.C. 1994. *Official Methods of Analysis, Association of Official Analytical Chemists* (16th Edn.), 111 North 19th street, Suite 20, Ed. 16th, Arlington, Virginia, USA, 2209 p.

3. Bretaudeau, J. and Faure, Y. 1991. *Atlas d'Arboriculture Fruitiere*. Tec & Doc Lavoisier, Paris, Vol. 3, 224 p.

Table 3. Genotypic and phenotypic correlations among yield and yield contributing traits in peach.

Trait	Fruit weight (g)	Fruit length (mm)	Fruit dia. (mm)	Fruit pulp thickness (mm)	TSS (°B)	Titratable acidity (%)	TSS/ acid ratio	Ascorbic acid (mg/100g)	Stone weight (g)	Stone dia. (mm)	Yield/ plant (kg)
Fruit weight (g)	1.000										
Fruit length (mm)	G 0.673** P 0.662**	1.000									
Fruit dia. (mm)	G 0.764** P 0.753**	G 0.582** P 0.571**	1.000								
Fruit pulp thickness (mm)	G 0.601** P 0. 597**	G0.195^{NS} P0.187^{NS}	G 0.432** P 0.424**	1.000							
TSS (°B)	G-0.257* P -0.252*	G0.297* P0.294*	G-0.224^{NS} P-0.221^{NS}	G-0.360** P-0.366**	1.000						
Titrable acidity (%)	G0.108^{NS} P0.107 ^{NS}	G-0.016^{NS} P-0.0.15^{NS}	G0.183^{NS} P0.180^{NS}	G-0.027^{NS} P-0.026^{NS}	G-0.205^{NS} P-0.203^{NS}	1.000					
TSS/ acid ratio	G-0.122^{NS} P-0.121^{NS}	G0.189^{NS} P0.186^{NS}	G-0.130^{NS} P-0.127^{NS}	G-0.217^{NS} P-0.214^{NS}	G0.568** P0.564**	G-0.755** P-0.753**	1.000				
Ascorbic acid (mg/100 g)	G-0.196^{NS} P-0.195^{NS}	G-0.111^{NS} P-0.113^{NS}	G-0.051^{NS} P-0.050^{NS}	G-0.084^{NS} P-0.080^{NS}	G0.197^{NS} P0.197^{NS}	G0.061^{NS} P0.059^{NS}	G-0.013^{NS} P-0.012^{NS}	1.000			
Stone weight (g)	G0.321** P0.320**	G-0.050^{NS} P-0.046^{NS}	G0.169^{NS} P0.165^{NS}	G0.156^{NS} P0.154^{NS}	G-0.185^{NS} P-0.182^{NS}	G0.128^{NS} P0.126^{NS}	G0.004^{NS} P0.003^{NS}	G0.168^{NS} P0.166^{NS}	1.000		
Stone dia. (mm)	G0.331** P0.330**	G0.302** P0.300**	G0.114^{NS} P0.112 ^{NS}	G0.051^{NS} P0.050^{NS}	G0.225^{NS} P0.223^{NS}	G0.291* P0.290	G0.108^{NS} P0.106^{NS}	G0.340** P0.338**	G0.505** P0.502**	1.000	
Yield/ plant (kg)	G0.797** P0.793**	G0.481** P0.480**	G0.559** P0.557**	G0.630** P0.626**	G-0.114^{NS} P-0.112^{NS}	G0.123^{NS} P0.121^{NS}	G-0.138^{NS} P-0.135^{NS}	G-0.080^{NS} P-0.080^{NS}	G0.185^{NS} P0.184^{NS}	G0.352** P0.346**	1.000

*, **Significant at 5 & 1% levels respectively, NS = non significant.

Table 4. Direct (bold) and indirect effects of different yield attributes on fruit yield of peach.

Trait	Fruit weight (g)	Fruit length (mm)	Fruit dia. (mm)	Fruit pulp thickness (mm)	TSS (°B)	Titratable acidity (%)	TSS/ acid ratio	Ascorbic acid (mg/100 g)	Stone weight (g)	Stone dia. (mm)	Genotypic correlation with fruit yield (kg/plant)
Fruit weight (g)	**0.9786**	-0.2344	-0.0033	0.1270	-0.0770	-0.0059	0.0170	-0.0006	-0.0685	0.0640	0.797**
Fruit length (mm)	0.6584	**-0.3484**	-0.0025	0.0412	0.0890	0.0009	-0.0263	-0.0003	0.0106	0.0585	0.481**
Fruit dia. (mm)	0.7473	-0.2028	**-0.0043**	0.0915	-0.0671	-0.0100	0.0182	-0.0001	-0.0360	0.0220	0.559**
Fruit pulp thickness (mm)	0.5877	-0.0678	-0.0019	**0.2115**	-0.1079	0.0015	0.0302	-0.0002	-0.0333	0.0099	0.630**
TSS (°B)	-0.2513	-0.1034	0.0010	-0.0761	**0.2999**	0.0112	-0.0791	0.0006	0.0395	0.0436	0.114^{NS}
Titratable acidity (%)	0.1062	0.0056	-0.0008	-0.0057	-0.0614	**-0.0547**	0.1051	0.0002	-0.0273	0.0563	0.123^{NS}
TSS/ acid ratio	-0.1191	-0.0658	0.0006	-0.0459	0.1703	0.0413	**-0.1393**	0.0000	-0.0008	0.0209	0.138^{NS}
Ascorbic acid (mg/100 g)	-0.1921	0.0387	0.0002	-0.0177	0.0592	-0.0033	0.0018	**0.0028**	-0.0358	0.0658	0.080^{NS}
Stone weight (g)	0.3138	0.0173	-0.0007	0.0329	-0.0555	-0.0070	-0.0005	0.0005	**-0.2136**	0.0977	0.185^{NS}
Stone dia. (mm)	0.3241	-0.1053	-0.0005	0.0109	0.0676	-0.0159	-0.0151	0.0010	-0.1079	**0.1933**	0.352**

Residual value = 0.250

4. Byrne, D.H., Nikolic, A.N. and Burns, E.E. 1991. Variability in sugars, acids, firmness, and color characteristics of 480 peach genotypes. *J. American Soc. Hort. Sci*. **116**: 1004-06.

5. Dewey, J.R. and Lu, K.H. 1959. A correlation and path analysis of components of crested wheat-grass seed production. *Agron. J*. **51**: 515-18.

6. Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2nd Edn.), John Wiley and Sons Inc., New York.

7. FAOSTAT. 2011.http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor.

8. Khush, G.S. 2002. Molecular genetics-plant breeder's perspective, **In**: *Molecular Techniques in Crop Improvement*. S.M. Jain, D.S. Brar and B.S. Ahloowalia (Eds.), Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 1-8.

9. Milatovic, D., Nikolic, D. and Durovic, D. 2012. Variability, heritability and correlations of some factors affecting productivity in peach. *Hort. Sci*. (*Prague*), **37**: 79-87.

10. Ogasanovic, D., Plazinic, R., Rankovic, M., Stamenkovic, S. and Milinkovic, V. 2007. Pomological characteristics of new plum cultivars developed in Cacak. *Acta Hort*. **734**: 165-68.

11. Rakonjac, V. 2005. Geneticki parametri vaznijih pomoloskih osobina breskve (Genetic parameters of the major pomological properties of peach). *Vocarstvo*, **39**: 3-12.

12. Sansavini, S., Gamberini, A. and Bassi, D. 2006. Peach breeding, genetics and new cultivar trends. *Acta Hort*. **713**: 23-48.

13. Saran, P.L. 2007. Association analysis in peach (*Prunus persica* L.) genotypes. *Prog. Hort*. **39**: 49-53.

14. Saran, P.L., Godara, A.K., Lal, G. and Yadav, I.S. 2007. Correlation and path coefficient analysis in *ber* (*Ziziphus mauritiana* Lamk) genotypes for yield and yield contributing traits. *Indian J. Hort*. **64**: 172-75.

15. Sofi, A.A., Zaffar, G. and Mir, M.S. 2001. Genetic variability and association of component characters for fruit weight in apricot (*Prunus armeniaca* L.) cultivars of Kargil (Ladakh). *Indian J. Hort*. **58**: 239-43.

Received : January, 2014; Revised : October, 2016; Accepted : November, 2016