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Genetic Parameters, Character Association and Path Analysis for Fruit Yield and its Component Characters in Mango (*Mangifera indica* L.)

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The nature and genetic parameters were assessed to select superior genotypes of mango (*Mangifera indica* L.) for sub-mountain region of Punjab (India). The moderate estimates (>7.0%) of genotypic co-efficient of variation (GCV) recorded for fruit yield/plant (11.70), fruit weight (7.18), pulp weight (8.73) and peel weight (9.69) signified the presence of adequate variation among the genotypes. Physical fruit attributes *viz.* fruit yield/tree, fruit weight, pulp weight and peel weight had substantially higher heritability estimates coupled with high genetic advance and confirmed that these traits are under the control of additive gene action hence phenotypic selection for their improvement may be effective. Estimates of correlation co-efficient showed positive significant association of fruit yield/plant with fruit breadth (0.72) and fruit weight (0.66), while it was negatively associated with acidity (-0.076). Path analysis revealed that fruit weight (1.60) and fruit breadth (0.41) had moderately higher direct effects on fruit yield. Fruit weight showed indirect contribution via all the traits except fruit juice acid content signifying that fruit weight is the major contributor towards fruit yield/plant. The scope of further improvement of mango cultivars under Punjab conditions has been discussed.

Key Words: GCV, Genetic advance, Heritability, *Mangifera*, Mango, Path analysis, PCV

Introduction

The mango (*Mangifera indica* L.), commonly called as the 'King of fruits' in India is acclaimed an important tropical and sub-tropical fruit in the world due to its excellent flavour, delicious taste, attractive colour and nutraceutical properties (Nayak *et al*., 2013, Rathore *et al*., 2007). In India, primarily thirty mango cultivars are commercially cultivated; and also seedlings originated from seeds as well as indigenous strains/genotypes are grown on an area of 2516 thousand hactares with an annual production of 18431 thousand million tonnes (NHB, 2014). A wide variability in fruit shape, size, skin colour, time of maturity, stone size, pulp content and its quality attributes has been observed in the naturally growing population of seedling mangoes (Singh *et al*., 2012). The choice of a suitable cultivar is of paramount importance for its successful cultivation. The knowledge of genetic parameters such as heritability and correlation among characters under selection is very useful for predicting genetic progress in breeding programme and developing efficient breeding strategies (Falconer and Mackay, 1996). Knowledge of the magnitude of genetic variation among fruit characters and their heritability is utmost important particularly in highly out crossing species like mango (Rajan *et al*., 2009). The breeding strategy for the genetic improvement of fruit yield and its components depends upon the genetic diversity for different traits. The assessment of genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance is a pre-requisite for making effective selection and improvement in the base population. Path analysis based on phenotypic correlation coefficients further unravels the contributions of different traits towards fruit yield. Hence, the present investigation was carried out to assess the nature and magnitude of genetic parameters and their utilization for the development of superior genotypes of mango suitable for sub mountain regions of Punjab.

Materials and Methods

The studies were conducted at PAU-Fruit Research Station, Gangian (Hoshiarpur), Punjab, on 35-year-old indigenous genotypes/promising cultivars of north India during 2010-13. The experimental material comprised of GN_1 (Gurmail da Amb), GN_2 (Samrali), GN_3 (Kukian de Chhalli), GN_4 (Bijrore de Bud), GN_5 (Hariana Kanghi), GN_6 (Punjab Beauty), GN_7 (Mallian de Chhalli), GN_{12} (Bijrore de Chhalli), GN_{19} (Chhauni Kalan de Chhalli),

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Langra, Dushehari, SB Rampur, SB Chausa, Alphonso, Mallika, Fazri, Malda, Amrapalli and Kishan Bhog planted at 9m × 9m spacing and all the recommended package of practices like fertilizers, irrigation and plant protection measures were followed (Anonymous, 2014). The region is situated in the sub montane and undulated tract of 31.82° North latitude and 75.66° East longitudes in district Hoshiarpur (Punjab) in North western part of India. The average elevation is about 239 meters from the mean sea level. The annual rainfall is around 800-1000 mm, where 75 per cent of the total rainfall is received during months of July to September and 15 per cent in the winter months from December to February. Fruit yield was recorded from the whole fruit weight per tree. Data was recorded from randomly selected ten fruits per genotype per replication at physiological maturity ('*Tapka* stage' having specific gravity > 1.0) and analyzed for various fruit physico-chemical quality attributes viz. fruit weight (g), fruit size (cm), pulp weight (g), peel weight (g), stone weight (g), total soluble solids, fruit juice acid content and reducing sugars. Fruit juice was extracted from the pulp by straining through a muslin cloth for determining various bio-chemical characteristics. Total soluble solids were noted with Bausch and Lamb hand refractometer and values were corrected at 20°C. Fruit juice acid content and reducing sugars were determined with standard methods (AOAC, 1980). The pooled data recorded was subjected to biometrical analysis. The genotypic and phenotypic co-efficients of variation and heritability were calculated according to Singh and Choudhary (1985), while phenotypic correlation co-coefficients and genetic advance were estimated as per the procedure described by Johnson *et al*. (1955). The path analysis was carried out according to the method suggested by Dewey and Lu (1959).

Results and Discussion

The analysis of variance showed significant differences among the cultivars for all the traits. The moderate estimates (>7.0%) of genotypic co-efficient of variation (GCV) (Table 1) recorded for fruit yield/plant, fruit weight, pulp weight and peel weight indicated the presence of adequate genetic variation among different genotypes which showed that these attributes may be improved through selection procedure. The data revealed that high phenotypic co-efficient of variation (PCV) along with high genotypic co-efficient of variation (GCV) were recorded for fruit yield, fruit weight, peel weight and pulp weight and medium to low for other traits. The magnitude of PCV was higher than GCV for all the traits indicating that they are highly influenced by environmental components. Rai *et al*. (2001) found high range of variation for peel, pulp and stone weight in mango. GCV alone is not sufficient to determine the extent of heritable variation. Hence, heritability in broad sense was estimated for all the traits.

The heritability estimates were high for all the traits except total soluble solids (Table 1). As characters like fruit yield per plant, fruit weight, pulp weight and peel weight showed high heritability estimates coupled with high genetic advances, indicating that these traits are under the control of additive gene action. Rajan *et al*. (2009) also reported high heritability estimate accompanied with greater genetic advance on the basis of per cent mean for fruit yield/plant, fruit weight, pulp and peel weight indicating that these characters are additive gene action effect and, therefore, have more role in proficient selection. In present study high genetic advance was found for fruit yield and peel weight. Relatively moderate genetic advance was observed for pulp weight and fruit weight, while extremely low genetic advance was recorded for total soluble salts. The result pertaining to genetic advance coupled with h^2 clearly depicted that environmental effects might not be contributing much to the total phenotypic variation for fruit yield and pulp weight and could have moderate to high influence on fruit and pulp weight. Relationship of heritability and genetic advance also give an idea about the type of gene action. According to Johnson *et al.* (1955), an estimated heritability associated with genetic advance is more reliable than heritability alone for prognosticating the impact of selection. High heritability accompanied with high genetic advance is mainly referred to the action of additive genes (Panse, 1957). A low genetic advance implies that heritability of a particular trait in a specific environment was mainly due to non-additive gene action, whereas, if the heritability was due to additive gene effect, it would be associated with high genetic advance (Shadakshari *et al.,* 1995). So, it can be concluded that different characters specially fruit yield/plant and pulp weight under study can be improved through phenotypic selection.

The estimates of correlation coefficients showed significant positive association of fruit yield per plant with all the traits except total soluble solids and acidity (Table 2). Among the other components fruit weight was positively correlated with the quantitative traits.

Table 1. Estimation of genetic parameters for fruit yield and its components in mango

Character	GCV	PCV	Heritability (h^2)	Genetic advance	GA (%)	Mean	CV (%)
Fruit yield/plant (kg)	11.70	12.15	96.31	9.59	11.27	58.05	19.63
Fruit weight (g)	7.18	7.73	92.81	12.24	6.66	183.78	17.28
Fruit length (cm)	4.98	5.34	93.19	0.43	4.64	9.28	11.63
Fruit breadth (cm)	3.92	4.29	91.30	0.24	3.58	6.67	10.51
Stone weight (g)	5.18	5.74	90.27	1.61	4.68	34.37	14.82
Pulp weight (g)	8.73	8.86	98.6	10.29	8.61	119.57	9.01
Peel weight (g)	9.69	9.94	97.48	2.97	9.45	31.48	13.31
Total soluble solids (%)	1.76	2.86	61.46	0.19	1.08	17.87	13.54
Acidity (%)	6.75	7.27	92.85	0.02	6.26	0.395	16.18
Reducing sugars (%)	4.63	5.26	88.05	0.18	4.08	4.50	14.96

However, qualitative characters had no association with yield attributing traits. Among the quality traits, there was no inter-relationship but stone weight showed positive association with juice acidity and negative with pulp weight. Chadha *et al*. (1993) and Pareek and Dhaka (2003) also observed that fruit length, fruit breadth, fruit weight and pulp weight had significant positive association with fruit yield in mango and ber, respectively. Significant association among fruit yield components indicated that correlated response to selection for these traits will increase improvement of fruit yield.

Path analysis carried out to estimate the direct and indirect contributions of various component traits for recommending a reliable selection criterion revealed that fruit weight (1.6026) followed by fruit breadth (0.4052) and peel weight (0.3555) had direct effect on fruit yield (Table 3). Highest direct effect of fruit length towards fruit yield was also reported by Prasad (1987) and Pareek and Dhaka (2003) in mango and ber, respectively. Though pulp weight is more desirable trait in mango but its contribution directly and indirectly to the productivity is negative, likewise stone weight had also negative contribution towards fruit yield. It is desirable to give due consideration to stone weight and pulp weight while selecting mango cultivars for higher productivity. Higher pulp: stone ratio is desirable while selecting mango cultivars for pickle purposes (Singh *et al*., 2012). Among the quality traits *viz.* total soluble

Table 2 Phenotypic correlation coefficients of fruit yield and component characters in mango

Character	Fruit weight	Fruit length	Fruit breadth	Pulp weight	Peel weight	Stone weight	TSS (%)	Acidity (%)	Reducing sugars	Fruit yield/ plant
Fruit weight	1.0000									
Fruit length	0.8681**	1.0000								
Fruit breadth	0.8035**	0.5688**	1.0000							
Pulp weight	0.9365**	0.7754**	0.7682**	1.0000						
Peel weight	0.9171**	0.7989**	0.7162**	0.8027**	1.0000					
Stone weight	0.6031**	0.5889**	0.4104**	0.3284*	0.7172**	1.0000				
Total soluble solids (%)	0.1533*	0.2747	0.0048	-0.0482	0.0366	0.2781*	1.0000			
Acidity (%)	-0.0548	-0.0077	-0.0053	-0.3292*	0.1036*	0.5732**	0.2832	1.0000		
Reducing sugars	0.3718**	0.3700*	0.4067**	0.3903**	0.1456*	-0.0308	0.2991	-0.2565	1.0000	
Fruit yield/ plant	0.6593**	0.5153**	0.7210**	0.6181**	0.6217**	0.3094*	0.0149	-0.0758	0.4264**	1.0000

* Significant at 5% level of probability
** Significant at 1% level of probability

Table 3. Path coefficient analysis of fruit yield versus component characters in mango

Character	Fruit weight	Fruit length	Fruit breadth	Pulp weight	Peel weight	Stone weight	TSS (%)	Acidity (%)	Reducing sugars	PCC*with fruit yield/plant
Fruit weight	**1.6026**	-0.0187	0.3255	-1.3509	0.3260	-0.2749	-0.0317	0.0069	0.0745	0.6593
Fruit length	1.3911	**-0.0215**	0.2305	-1.1186	0.2840	-0.2685	-0.0568	0.0010	0.0741	0.5153
Fruit breadth	1.2876	-0.0122	**0.4052**	-1.1082	0.2546	-0.1871	-0.0010	0.0007	0.0815	0.7210
Pulp weight	1.5007	-0.0167	0.3113	**-1.4426**	0.2853	-0.1497	0.0099	0.0416	0.0782	0.6181
Peel weight	1.4696	-0.0172	0.2902	-1.1579	**0.3555**	-0.3269	-0.0076	-0.0131	0.0292	0.6217
Stone weight	0.9665	-0.0127	0.1663	-0.4737	0.2549	**-0.4558**	-0.0575	-0.0724	-0.0062	0.3094
Total soluble solids (%)	0.2457	-0.0059	0.0020	0.0695	0.0130	-0.1268	**-0.2066**	-0.0358	0.0599	0.0149
Acidity (%)	-0.0879	0.0002	-0.0022	0.4749	0.0368	-0.2613	-0.0585	**-0.1264**	-0.0514	-0.0758
Reducing sugars	0.5959	-0.0080	0.1648	-0.5631	0.0518	0.0140	-0.0618	0.0324	**0.2003**	0.4264

Residual effect: 0.3823 * PCC stands for phenotypic correlation coefficient
Bold figures are direct effects

solids, acidity and reducing sugars are the desirable attributes for fruit flavour and taste but these do not affect the production. Mango cultivars having excellent flavour and taste may be selected without compromising total productivity of the crop.

It is concluded that fruit weight, fruit breadth and peel weight are the major yield contributing characters and hence during selection, weightage should be given to these characters for the development of high yielding cultivars of mango for sub-mountain region of Punjab.

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