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Correlation Studies on Fruit Traits of Some Mandarin Genotypes Grown Under Sub-Tropical Conditions of India

Gurteg Singh[1], Pushpinder Singh Aulakh[2] and Harinder Singh Rattanpal[3]

Department of Fruit Science
Punjab Agricultural University, Ludhiana 141 004 (Punjab)

ABSTRACT

The relationships between fruit traits of some indigenous and exotic mandarin cultivars were studied during the year 2015-16.The study revealed highly significant positive correlation (r = +0.801) between fruit weight and fruit juice weight followed by fruit weight and segment length (r = +0.761); fruit weight and fruit juice percentage (r = + 0.731); fruit weight and rind weight (r = +0.634) and fruit weight and fruit diameter (r = +0.634). Highly significant and positive correlations were also observed between fruit diameter and fruit rind weight (r = +0.505): fruit rind weight and segment length (r = +0.785); fruit rind weight and fruit juice weight (r = +0.626). Significant and positive correlations were also observed between fruit rind weight and vesicle length (r = +0.538), fruit rind weight and fruit juice percentage (r = +0.491), fruit rind weight and number of segments per fruit (r = +0.481). However, negative and significant correlation (r = -0.534) was observed between diameter of fruit axis and fruit juice weight followed by non- significant negative correlation between diameter of fruit axis and total soluble solids (r = -0.386). Total soluble solids showed positive correlations with fruit juice weight (r = +0.444) and fruit juice percentage (r = +0.443) and negative correlation (r = -0.227) with fruit acidity. These correlations among different fruit traits help to understand the relationship between different mandarin genotypes and must be considered before targeting the desired traits in improvement programme.

Key Words: Correlation, Genotypes, Mandarin, Traits.

INTRODUCTION

Mandarin is a most popular fruit in subtropical zone of India. The agro-ecological conditions of Punjab are best suited for the production of Kinnow mandarin. Presently, ctrus is being grown in Punjab over 52,836 with annual production of 10, 49,977. Kinnow mandarin occupies an area of 49,356 ha (93.4 %) with annual production of 10,21,719 (97.3%) (Anonymous, 2016).

No doubt, the fruit characters are generally used for the selection of best genotypes of citrus trees but the farmers pay more attention to the fruit quality than to its size and yield (Paudyal *et al*, 2008). The quality of citrus fruits depends on several factors including the amount of juice, its content of total soluble solids (TSS), the acidity level and the proportion of vitamin C. Besides introduction of new cultivars, the scope of citrus cultivation, therefore, exists for further expansion of citrus industry through release of early and late varieties. It is very important to select the desired fruit trait in the parentage and more importantly the relationship studies between the important traits must not be ignored.

Only a few varieties of mandarins are available for commercial cultivation under Indian sub tropical conditions. Secondly, information about the genotypic variability, correlation studies among important physioco-chemical traits is lacking in mandarin. The study on correlation coefficient may

*Corresponding Author's Email: gurteg-hort@pau.edu

[1]Assistant Horticulturist, [2]Director of Horticulture, Govt. of Punjab,

[3]Senior Horticulturist, Department of Fruit Science, Punjab Agricultural University, Ludhiana 141 004, India

not only provide the exact insight effect on yield but also indicate the influence of one character on other character. Thus, the present study was undertaken to focus on the correlation studies among different fruit traits in nineteen mandarin genotypes grown under sub-tropical conditions of India.

MATERIALS AND METHODS

The present investigation was carried out on 19 mandarin genotypes at Punjab Agricultural University, Ludhiana (Punjab) during the year 2015-16. The university is at latitude 30° 54' N and longitude 75° 48' E with subtropical climatic conditions. The height above mean sea level is 247 m. The maximum air temperature of area in summer rose up to 41°C whereas minimum temperature in winter went down to 5°C during the period under research. The annual average rainfall and evaporation in research area was about 769 mm and 1564 mm during the period of investigation, respectively.

Nineteen mandarin genotypes grafted on rough lemon rootstock planted at a spacing of 6 x 3 m were used in the research work. Observations were recorded during the years 2015 and 2016 on trees for different morphological characters at various growth and development stages. All the trees received recommended doses of fertilizers and other cultural practices during the course of these investigations. Data were recorded on mature vegetative parts. Reproductive and fruit characters were recorded before the harvesting of fruits. Correlations among fruit physiochemical characters of different mandarin genotypes were carried out with partial correlation method and test of significance was considered at 5 and 1 per cent level of probability ($P<0.05$) and $P<0.01$).

RESULTS AND DISCUSSION

Fruit weight

The data in Table 1 show that there was a highly significant positive correlation (r = +0.801) between fruit weight and fruit juice weight which was followed by fruit weight and segment length (r = +0.761); fruit weight and fruit juice percentage (r = + 0.731); fruit weight and rind weight (r = +0.634) and fruit weight and fruit diameter (r = +0.634).The correlations between fruit weight and fruit length (r = + 0.524), and fruit weight and segment length (r = +0.465) were positive and significant. Non-significant and negative correlations were observed in fruit weight with fruit rind thickness, diameter of fruit axis and fruit acidity.

The data show that fruit weight influence fruit segment length and breadth, and fruit juice content, however, fruit weight has no effect on fruit rind thickness and fruit acidity. The results were contrary to the findings of Gill *et al* (2002) who reported negative correlations among fruit size and juice content in Kinnow mandarin. Zhang and Gu (2003) also found negative correlation between fruit size and soluble solids.

Fruit diameter and length

Highly significant and positive correlations were also observed between fruit diameter and fruit epicarp width (r = +1.000) followed by significant positive correlations in fuit diameter and fruit rind weight (r = +0.505) and fruit diameter and vesicle length (r = + 0.488). Other traits like fruit length, segments per fruit, segment length, segment breadth, vesicle thickness, total soluble solids, fruit juice weight and fruit juice percentage showed positive correlation with fruit diameter but were non-significant ($P<0.05$). Non- significant and negative correlations were found in fruit diameter with fruit rind thickness, diameter of fruit axis and fruit acidity.

The correlations were highly significant and positive between fruit length and fruit rind weight (r = +0.641) and between fruit length and segment length (r= +0.635). Fruit traits like fruit epicarp width, areola diameter, segment per fruit, diameter of fruit axis, vesicle length, vesicle thickness, fruit juice weight and fruit juice percentage also showed positive correlations with fruit length but were non-significant. Negative correlations were observed between fruit length and total soluble solids and between fruit length and fruit acidity.

Fruit epicarp width

Epicarp width showed significant and positive correlations with fruit rind weight (r = +0.505) and vesicle length (r = + 0.488). Negative non-significant correlations were found in fruit epicarp width with fruit rind thickness, diameter of fruit axis and fruit acidity.

Fruit rind thickness and weight

Fruit rind thickness showed positive correlation with areola diameter, segment length, diameter of fruit axis, vesicle length, and vesicle thickness and fruit acidity while negative correlations were observed with other traits like fruit rind weight, number of segment per fruit, segment breadth, total soluble solids, fruit juice weight and fruit juice percentage.

The maximum positive correlation (r = +0.785) was observed between fruit rind weight and segment length, followed by fruit rind weight and fruit juice weight (r = +0.626) and these correlations were highly significant. Significant and positive correlations were also observed between fruit rind weight and vesicle length (r = +0.538), fruit rind weight and fruit juice percentage (r = +0.491), fruit rind weight and number of segments per fruit (r = +0.481). However, non-significant and negative correlations were found in rind weight with diameter of fruit axis and fruit acidity.

Areola diameter

Areola diameter showed significant positive correlation with diameter of fruit axis (r = +0.459), however negative correlations were observed with number of segments per fruit, total soluble solids, fruit acidity, fruit juice weight and fruit juice percentage.

Segment length and breadth

Segment length was positively correlated with fruit juice weight, fruit juice percentage, vesicle length, vesicle thickness and segment breadth. However, the correlations between segment length and fruit juice weight (r = +0.579); and between segment length and fruit juice percentage (r = +0.536) were significant only. Segment length was non-significantly and negatively correlated with fruit acidity. Segment breadth was positively correlated with fruit juice weight, fruit juice percentage, vesicle thickness, total soluble solids and fruit acidity. However, the correlations between segment breadth and fruit juice weight (r = +0.471) was significant only. Segment length was non-significantly and negatively correlated with vesicle length.

Fruit axis diameter

Maximum negative and significant correlation (r = -0.534) was observed between diameter of fruit axis and fruit juice weight followed by non-significant negative correlation between diameter of fruit axis and total soluble solids (r = -0.386). However, significant and positive and correlation (r = +0.465) was observed between diameter of fruit axis and vesicle thickness. Negative correlation was also reported by Kumar *et al* (2015) in fruit weight and fruit axis diameter (hollowness) in mandarin.

Vesicle length and thickness

Vesicle length showed positive correlation with vesicle thickness (r = +0.210), total soluble solids (r = +0.338), fruit juice weight (r = +0.222) and fruit juice percentage (r = +0.120) except fruit acidity which showed negative correlation (r = -0.342) with vesicle length. However, all these correlations were non–significant. Positive but non-significant correlations in vesicle thickness were found with total soluble solids (r = +0.220), fruit juice weight (r = +0.039), fruit juice percentage (r = +0.072). However, fruit acidity showed negative correlation (r = -0.387) with vesicle thickness.

Total soluble solids and acidity

Total soluble solids showed positive correlations with fruit juice weight (r = +0.444) and fruit juice percentage (r = +0.443) and negative correlation (r = -0.227) with fruit acidity. Non-significant negative correlations were observed between fruit

Table 1. Correlation matrix among mandarin genotypes based on fruit characteristics

Traits	FW	FD	FL	EW	RT	RW	AD	SPF	SL	SB	DFA	VL	VT	TSS	TA	FJW
FD	0.634**															
FL	0.524*	0.433														
EW	0.634**	1.000**	0.433													
RT	-0.194	-0.214	0.003	-0.214												
RW	0.718**	0.505*	0.641**	0.505*	-0.031											
AD	0.179	0.141	0.330	0.141	0.203	0.010										
SPF	0.272	0.410	0.145	0.410	-0.158	0.481*	-0.029									
SL	0.761**	0.389	0.635**	0.389	0.145	0.785**	0.227	0.236								
SB	0.465*	0.051	0.006	0.051	-0.367	0.037	0.291	-0.113	0.343							
DFA	-0.225	-0.125	0.308	-0.125	0.341	-0.006	0.459*	-0.117	0.007	0.063						
VL	0.350	0.488*	0.162	0.488*	0.324	0.538*	0.306	0.233	0.352	-0.201	0.056					
VT	0.234	0.014	0.062	0.014	0.076	0.290	0.278	0.105	0.256	0.403	0.465*	0.210				
TSS	0.432	0.398	-0.122	0.398	-0.118	0.351	-0.101	0.244	0.320	0.267	-0.386	0.338	0.220			
TA	-0.428	-0.393	-0.220	-0.393	0.065	-0.362	-0.212	-0.131	-0.212	0.106	0.097	-0.342	-0.387	-0.227		
FJW	0.801**	0.359	0.280	0.359	-0.322	0.626**	-0.244	0.019	0.579**	0.316	-0.534*	0.222	0.039	0.444	-0.368	
FJP	0.732**	0.332	0.248	0.332	-0.343	0.491*	-0.103	-0.160	0.536*	0.471*	-0.341	0.120	0.072	0.443	-0.371	0.885**

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed)

Legend:-FW: Fruit Weight, FD: Fruit Diameter, FL: Fruit Length, EW: Epicarp Width, RT: Rind Thickness, RW: Rind Weight, AD: Areola Diameter, SPF: Segment Per Fruit, SL: Segment Length, SB: Segment Breadth, DFA: Diameter of Fruit Axis, VL: Vesicle Length, VT: Vesicle Thickness, TSS: Total Soluble Solids, TA: Titratable Acidity, FJW: Fruit Juice Weight, FJP: Fruit Juice Per cent acidity and fruit juice weight, and acidity and fruit juice percentage.

The positive and significant correlations were found among different characters like fruit weight and juice; fruit weight and diameter; fruit weight and segment length; fruit diameter and fruit epicarp width; fruit diameter and rind weight; vesicle length and vesicle thickness; total soluble solids and fruit juice weight; areola diameter and fruit axis diameter. However, negative correlations were observed between fruit length and total soluble solids; fruit length and fruit acidity; diameter of fruit axis and fruit juice weight. The results were supported more or less by the finding of Khandavi (2012) who reported highly significant and positive correlations of fruit weight with fruit length and fruit breadth in sweet oranges selections and Kagzi lime. Number of seeds positively correlated with length and rind thickness of the fruit in Kagzi lime (Pingle, 2011). Tilekar (2011) reported highly significant and positive correlation with each and negative but highly significant correlation with the fruit acidity. However, negative correlation in acidity and TSS was reported by Pingle (2011). Significant and negative correlation was found in fruit weight, fruit diameter, juice percent and seed number, however significantly positive correlation in fruit pulp, and ascorbic acid, but no significant effect was observed in fruit peel, TSS and acidity in acid lime selections (Shrestha *et al*, 2012).

No doubt, the fruit characters are generally used for the selection of best genotypes of citrus trees but the farmers pay more attention to the fruit quality than to its size and yield (Paudya *et al*, 2008). The quality of citrus fruits depends on several factors including the amount of juice, its content of total soluble solids (TSS), the acidity level and the proportion of vitamin C. Marcilla *et al* (2009) reported that fruit juice yield was independent and poorly correlated with almost all fruit sensory parameters in 'Clemenules' mandarins. Rehman *et al* (1983) also supported our findings of positive correlation between fruit weight and juice content and TSS in sweet oranges. However, their findings were contrary to our finding where they reported negative correlation between juice content and acidity.

CONCLUSIONS

The study concluded that there was a strong positive and negative association between different important fruit traits in mandarin genotypes and hence breeding programme should be planned in accordance with the desired trait association.

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