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Correlation Studies on pummelo genotypes of West Bengal

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Abstract
Pummelo (*Citrus grandis* Osbeck.) is one of the major monoembryonic species of citrus with good source of vitamin C and calories can easily grow in inferior, marginal and backyard orchard. For Commercial exploitation and crop improvement it demands the survey, identification of elite germplasm and its subsequent utilization through proper plant characterization and comprehensive variability study. The present investigation was carried out by using one twenty four genotypes from fourteen district of West Bengal and bio chemical analysis was done in the laboratory of Department of fruits and orchard management, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the year 2016-17 considering seventeen quantitative characters as well as twenty four qualitative characters. For quantitative data Pearson technique of correlation co-efficient and for qualitative data Spearman technique of correlation co-efficient was followed. Yield is one of the important characters which is directly correlated with other characters and produce variability among the germplasms. From this present experiment it can be concluded that Yield character of pummelo is positively correlated with different yield attributing characters like fruit weight, fruit diameter, fruit length, seed length and seed width at 1% level of significance and with segment number and seed weight at 5% level of significance. Similarly, fruit weight had a positive correlation with fruit diameter, fruit length, rind thickness, segment number and seed characters like seed weight, seed length and seed width. Fruit apex and fruit base were positively correlated with fruit surface texture. Nature of oil glands was positively correlated with pulp firmness and vesicle length. So, it revealed that fruit weight, fruit size and number of fruits per plant had a direct impact on fruit yield. Beside this it also revealed that growth of plant had some positive correlation between plant height and canopy spreading.

Keywords: Pummelo, Yield, correlation, genotypes, variability

Introduction
Citrus is one of the world's most important fruit crops due to its wide distribution throughout the tropical and subtropical regions and large scale production. After grape, citrus is now the second most widely cultivated crop in the world (Mukhopadhyay, 2004) [1]. Pummelo, a tropical fruit plant species, is originated from South East Asia and considered as the giant among the citrus fruits and is well known as the ancestor of grapefruit. Pummelo is considered as an easily recognized species due to a number of notable morphological characteristics, such as huge leaves borne on broadly winged petioles, very large and fragrance flowers and big fruits with a single embryo, while most of other citrus species are polyembryonic (Uzun and Yesiloglu, 2012) [2]. It is considered as an excellent tree for waste land development in arid and semi-arid region. Pummelo fruit is a fat, sodium and cholesterol free. This makes pummelo a very good source for dieters. It is a good source of vitamin C and calories. Besides its use as a table fruit, the fruit and other parts of pummelo plant can also be exploited for different

purposes. The extracted juice is an excellent beverage. Now its several therapeutic properties have also been established particularly for its pectin and flavonoids. Hesperidina, naringin, tangeretin and nobiletin have anti-inflammatory and anti-allergic activities. These flavonoids also improve circulatory system. Its therapeutic and nutritive values along with its taste and flavour have placed it in the regular dietary list of the people living in advanced countries (Mukhopadhyay, 2004) [1]. There is a potentiality for the development of this pummelo fruit as an export crop because its thick rind makes it easy to handle and suitable for long distance transport. It has played an important role as a parent of many citrus fruits, such as lemon, oranges and grapefruits. An urgent need for pummelo conservation is necessary as there is a tendency of declining varietal diversity due to loss of natural habitat. Therefore, the problem of decreasing variability in pummelo needs a particular attention in preventing further loss of plant species that has not been fully uncovered (Wen *et al.*, 2010) [3].

However, the diverse eco-geographical distribution in India and the occurrence of spontaneous mutation and natural hybridization have given rise to a wide range of variability in citrus. In West Bengal, diverse populations of pummelo also exist in the different agro-ecological zones with a lot of variations in plant and fruit characters. There is direct need for conservation of crop. Genetic resources as their value is immense and indispensable considering diversified new technological option available and human requirements in future. To select a superior germplasm, investigation on variability of fruit characters is considered important.

Keeping this in view, one twenty four genotypes of pummelo were collected from fourteen districts of West Bengal. For continued improvement of pummelo through breeding to overcome threats from diseases, insect pests or biotic stresses and to evolve varieties according to consumer preferences, a diverse gene pool is essential. An accurate knowledge about the availability of the genetic diversity and the origin of cultivars would assist in the selection of parents in a hybridization programme. So, study on correlation among the different quantitative and qualitative characters are useful for crop improvement programmes to select the desirable types.

Materials and methods

One hundred twenty four genotypes were selected covering fourteen districts (North 24 Parganas, Nadia, Burdwan, Purulia, Hooghly, Bankura, South 24 Parganas, Birbhum, Howrah, Murshidabad, Malda, Paschim Medinipur, Uttar Dinajpur and Cooachbihar) for studying correlation of pummelo. All the plants were more or less uniform age and vigour. The pummelo collections were named on the basis of code used for different districts. The experiment was carried out during 2016-17. The analytical works were conducted in the laboratory of Fruits Science of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. Individual plant was selected based on assessment of traits provided by the farmers (fruit bearing frequency, maturity, fruit yield) as well as in-situ observation of trees (general health) and fruits (fruit shape, fruit size, peel thickness, pulp colour etc.). Seventeen quantitative characters (leaf length, leaf width, petiole length, yield, fruit weight, fruit diameter, fruit length, rind thickness, segment number, juice content, seed length, acidity, TSS, ascorbic acid etc.) and twenty four qualitative characters (tree shape, tree growth, density of branches, spine density, leaf lamina shape, leaf lamina margin, leaf apex, petiole wing shape, petiole wing width, secondary flowering, fruiting season, fruit base, fruit apex, pulp colour, fruit axis, seed number etc.) from 'citrus descriptor' (cited by IPGRI, Rome, Italy) were considered for this study. Three fully mature, healthy and disease free fruits from each replication were collected randomly from different direction for recording different observations. Data obtained from this experiment were statistically analysed to study correlation coefficient of different pairs of characters (Johnson *et al*., 1955b and Jibouri *et al*., 1958) [4, 5]. For quantitative data Pearson technique of correlation co-efficient and for qualitative data Spearman technique of correlation co-efficient was followed.

Result and Discussion

Correlation studies of quantitative characters of pummelo (table1) revealed that yield character had a positively significant correlation with different yield attributing characters like fruit weight (r=0.498), fruit diameter (r=0.387), fruit length (r=0.356), seed length (r=0.267) and seed width (r=0.249). Fruit weight had a highly significant positive correlation with fruit diameter (r=0.761), fruit length (r=0.697. Fruit weight also exhibited significant positive correlation with rind thickness, segment number and seed characters like seed weight, seed length and seed width. This clearly indicated that during selection of any genotype based on fruit and yield character, the breeder should give emphasis on those genotypes having more fruit weight and fruit size. This statement supported by Hazarika *et al.,* (2016) [6] who stated that genotypes having more pulp and fruit weight might be used in breeding programme. The findings of present investigation of correlation are in agreement with the earlier findings of Alam *et al.* (2016) [7] who also obtained highly significant correlation between fruit yield and fruit weight (r=0.55) and fruit weight and fruit breadth (r=0.8). Titratable acid content of fruit was positively correlated with ascorbic acid at 5% level of significance.

Correlation coefficient of qualitative characters (table2) exhibited that tree shape had a significant positive correlation with tree growth (r=0.641) and branch density (0.316). Beside this tree shape was positively correlated with green colour of the leaf and green colour of leaf was positively correlated with petiole width. Leaf margin was positively correlated with wing shape as well as wing shape was positively correlated with seed shape. Nature of oil glands was positively correlated with pulp firmness and vesicle length A significant positive correlation was also found between tree growth and branch density (r=0.310), fruit shape and fruit apex (r=0.237) and surface texture and nature of oil glands (r=0.442). Alam *et al.* (2016) [7] also found growth related significant positive correlation between plant height and canopy spreading (r=0.51).

Table 1: Correlation coefficient of quantitative characters of pummelo genotypes

Characters	Leaf length	Leaf width	Petiole length	Yield	Fruit weight	Fruit diameter	Fruit length	Rind thickness	Segment number	Juice	Seed weight	Seed length	Seed width	Acidity	Ph	TSS	Ascorbic acid
Leaf length	1.00																
Leaf width	.752**	1.00															
Petiole length	.635**	.511**	1.00														
Yield	.399**	.201*	.224*	1.00													
Fruit weight	.230*	0.14	0.07	.498**	1.00												
Fruit diameter	.192*	0.12	0.14	.387**	.761**	1.00											
Fruit length	0.16	0.08	0.08	.356**	.697**	.648**	1.00										
Rind thickness	0.03	-0.01	0.05	0.11	.288**	.502**	.422**	1.00									
Segment number	0.17	0.05	0.10	.206*	.285**	.194*	0.00	0.02	1.00								
Juice	-0.08	-0.10	-0.01	-.196*	-.322**	-.268**	-.199*	-.271**	-0.14	1.00							
Seed weight	0.04	-0.07	0.01	.188*	.270**	0.08	0.12	-.180*	0.13	-0.02	1.00						
Seed length	0.13	0.05	0.01	.267**	.278**	0.11	0.07	-.244**	.185*	0.00	.796**	1.00					
Seed width	0.15	0.05	0.04	.249**	.246**	0.10	0.10	-.226*	0.15	0.07	.792**	.933**	1.00				
Acidity	0.11	0.08	0.01	0.09	0.08	0.14	0.06	0.09	0.02	-0.13	-0.01	0.04	0.02	1.00			
Ph	0.02	0.10	0.12	0.06	0.02	-0.07	0.04	-.206*	0.03	-0.01	0.17	0.16	0.13	-.346**	1.00		
TSS	0.05	-0.02	0.04	0.01	-0.12	-0.16	0.00	-0.05	-.218*	0.03	-0.01	-0.02	-0.03	0.04	-.063	1.00	
Vit C	0.02	-0.04	-0.03	0.08	0.09	0.06	-0.04	0.10	0.13	-.249**	-0.06	-0.08	-0.13	.207*	-.159	-0.08	1.00

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

Table 2: Correlation coefficient of qualitative characters of pummelo genotypes

Characters	Tree shape	Tree growth	Branch density	Spine density	Green colour	Leaf shape	Leaf Margin	Leaf Apex	Wing shape	Petiole width	Secondary flowering	Fruit season	Fruit shape	Fruit base	Fruit apex	Surface texture	Nature of oil glands	Density of oil glands	Fruit axis	Pulp colour	Pulp firmness	Vesicle length	Seed number	Seed shape
Tree shape	1.000																							
Tree growth	.641**	1.000																						
Branch density	.316**	.310**	1.000																					
Spine density	.048	.004	.098	1.000																				
Green colour	.203*	.270**	.133	.028	1.000																			
Leaf shape	.032	-.042	-.108	-.097	-.061	1.000																		
Leaf Margin	-.082	-.041	-.014	.039	-.052	.056	1.000																	
Leaf Apex	-.040	-.080	.048	.117	-.187*	.331**	.123	1.000																
Wing shape	-.183*	-.094	-.139	-.002	-.213*	.069	.204*	.168	1.000															
Petiole width	-.043	.078	.053	.015	.205*	-.206*	-.254**	-.354**	-.371**	1.000														
Secondary flowering	-.034	.041	-.105	-.018	-.152	.012	-.103	-.185*	.054	.070	1.000													
Fruit season	-.007	-.076	-.105	.222*	.100	-.062	-.066	.051	.138	-.076	-.155	1.000												
Fruit shape	.027	.039	-.045	-.007	-.115	.023	-.125	.061	.112	-.054	-.036	.016	1.000											
Fruit base	.046	.094	.165	.029	-.143	-.054	.151	-.173	.081	.096	.067	-.045	.060	1.000										
Fruit apex	.125	.072	.200*	.049	.086	.156	.157	-.192*	.114	-.108	-.020	.081	.237**	.237**	1.000									
Surface texture	-.053	-.102	.174	.005	-.008	.024	.178*	-.138	.051	-.017	-.050	.070	.107	.272**	.315**	1.000								
Nature of oil glands	.008	-.120	.155	.062	.069	-.128	-.081	-.239**	.034	-.070	.006	-.080	.132	.178*	.163	.442**	1.000							
Density of oil glands	.005	.073	-.122	.022	-.169	.104	.043	.182*	.038	-.031	-.193*	.025	.164	-.180	.044	-.121	-.175	1.000						
Fruit axis	.023	-.008	-.026	.124	-.020	-.065	.078	.025	.113	.064	-.001	.113	-.009	.100	.049	.040	.073	-.104	1.000					
Pulp colour	-.069	-.041	-.052	-.019	-.168	-.036	-.074	.041	.022	.032	-.199*	-.003	.185*	.022	.061	-.156	-.075	.230*	.066	1.000				
Pulp firmness	-.019	-.089	-.035	.066	-.123	.013	.129	-.170	.056	-.101	.015	-.054	.014	.200*	.079	.092	.195*	.043	.128	.151	1.000			
Vesicle length	.054	.010	.058	-.024	.101	-.036	-.124	-.134	-.006	.098	.056	-.057	-.003	.103	.036	.054	.225*	-.027	-.065	.019	.024	1.000		
Seed number	.022	.091	.172	-.194*	-.005	.183*	.128	-.027	.035	-.053	-.107	-.311**	-.134	.113	.039	.020	-.071	.099	-.275**	-.005	-.014	.167	1.000	
Seed shape	.128	.161	.059	-.074	-.033	-.016	.058	-.030	.206*	-.019	-.190*	-.098	.012	-.031	-.086	-.030	.056	.075	-.036	.109	.034	.156	.483**	1.000

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

Conclusion

From this present experiment it can be concluded that Yield character of pummelo is positively correlated with different yield attributing characters like fruit weight, fruit diameter, fruit length, seed length and seed width. Similarly, fruit weight had a positive correlation with fruit diameter, fruit length, rind thickness, segment number and seed characters like seed weight, seed length and seed width. The tree shape was positively correlated with tree growth and branch density. Leaf margin was positively correlated with wing shape. Surface texture was positively correlated with nature of oil glands. These correlation studies indicated the relationship between characters. Present investigation revealed that fruit weight, fruit size and number of fruits per plant had a direct impact on fruit yield. Beside this it can also be stated that the branch density, petiole width and green colour of leaves had a direct impact on tree growth as well as tree shape. Fruit shape was directly correlated with fruit apex, fruit base, pulp firmness, surface texture, nature of oil glands and density of oil glands.

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