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Assessment of correlation for yield and its contributing traits in papaya cv. Red Lady Taiwan under South Gujarat conditions

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Abstract

A study was carried out to identify the correlation between vegetative traits, floral characters and yield related attributes with fruit yield and weather parameters in papaya cv. Red Lady Taiwan under South Gujarat conditions at Navsari Agricultural University, Navsari during 2018-19. Results revealed that plant height; stem girth and leaf area had a highly significant and positive correlation with fruit yield in hermaphrodite and pistillate forms of papaya. Yield also expressed a highly significant and positive correlation with insertion height of first fruit in both *viz.*, pistillate and hermaphrodite plants. Further, yield attributing characters like number of fruits per plant, fruit weight, fruit diameter and fruit length showed positive and highly significant correlation with yield in both type of plants. With regard to traits like weather parameters, plant height, stem girth and leaf area showed significantly positive correlation with maximum temperature in both the types of plants. Pistillate flowers showed highly significant positive correlation with minimum temperature and barren flowers exhibited highly significant positive correlation with sunshine hours while, misshapen hermaphrodite fruits had a positive and highly significant correlation with maximum temperature. The trait fruit yield showed highly significant positive correlation with minimum temperature and sunshine hours in pistillate and hermaphrodite plants of papaya cv. Red Lady Taiwan.

Keywords: Correlation, temperature, relative humidity, sunshine hours, vegetative traits, floral characters, fruit yield

1. Introduction

Papaya (*Carica papaya* L.) is a quick growing, high yielding delicious fruit crop belonging to family Caricaceae. Christopher Columbus an Italian explorer gave it the name "Fruit of the Angels". It is native to Tropical America and was introduced to India in 16th century. Presently, papaya is grown extensively in countries like Australia, Hawaii, India, Brazil, Sri Lanka, Malaya, Myanmar, South Africa and Kenya. About 6.10 million metric tonnes of papaya are produced from an area of 1.36 lakh hectares with a productivity of 44.9 MT/ha in India. In Gujarat, the area under papaya is 0.02 million hectares with the production of 1.24 million metric tonnes and productivity of 61.54 MT/ha (NHB, 2017) [2].

Papaya is low in calories, rich in nutrients (Vitamin A, Vitamin C, Potassium and Calcium) and the best food for those on diet. The proteolytic enzyme papain obtained from unripe fruits traditionally used for meat tenderizing also finds application in protein analysis, as a clarifying and cleansing agent. Ease in cultivation, quick returns, high productivity, adaptability to diverse soil and climatic conditions are some of the reasons which have contributed to its popularity. It is a highly remunerative crop providing more income on per hectare basis, next only to banana.

In South Gujarat, Red Lady Taiwan is the commercially cultivated variety due to its orange red colored pulp and excellent quality with high yielding potential. It has replaced papaya variety Madhu Bindu in Gujarat because of its high productivity, flesh colour and gynodioecious nature. Plants begin to bear fruits at 60-80 cm height and bear about 30 fruits per plant. Fruits are short oblong in shape on female plants and rather long shaped on bisexual plants weighing about 1.5-2.0 kg.

Fruit yield of papaya is a polygenic trait, so direct selection for yield alone is usually not very effective. Fruit yield is also a function of several component characters and their interaction with environment. Hence, selection based on its contributing traits could be more efficient and reliable.

Association of plant characters that is determined by correlation coefficient is although useful in determining the relative influence of various fruit associated characters on fruit yield. With the above background, it was felt necessary to identify the correlation between different characters with fruit yield and weather parameters in papaya (*Carica papaya* L.) cv. Red Lady Taiwan.

2. Materials and Methods

This experiment was carried out at Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during 2018-19 to study the correlation among fruit yield and weather parameters with other phenological characters in papaya cv. Red Lady Taiwan. The experiment was laid out in non-replicated trial by random selection of 200 plants. Seven weeks old papaya seedlings were transplanted in the month of May at 2 m x 2 m spacing and applied with 200:200:250 g NPK per plant at 2, 4, 6 and 8 months after transplanting. Uniform cultural practices as recommended by NAU were adopted for the cultivation of papaya crop. Various vegetative parameters like plant height (cm), stem girth (cm), leaf area (cm²), number of leaves per plant were observed from 2nd

month after planting at monthly intervals. Floral characters such as days taken for first flower initiation, number of flowers, insertion height of first fruit (cm), days taken from fruit set to harvesting, number of fruits per plant, fruit weight (kg), fruit diameter (cm) and fruit length (cm) were observed and correlated with fruit yield per plant (kg) and weather parameters like maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, sunshine hours and wind velocity using Pearson Correlation (r) method. Statistical analysis was done at the Agricultural Statistics Department, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat).

3. Results and Discussion

3.1. Correlation of fruit yield with vegetative traits

It is evident from Table 1 that in case of pistillate plants, fruit yield was significantly and positively correlated with plant height and stem girth from 4 MAP to 12 MAP whereas, leaf area was highly and positively correlated from 7th to 9th MAP. Moreover, number of leaves from flowering to harvesting in pistillate plants was significantly correlated in 9th and 10th MAP.

Table 1: Correlation coefficient (r) of vegetative traits with yield of papaya cv. Red Lady Taiwan

Observation periods	Plant height		Stem girth		Leaf area		Number of leaves (Flowering to harvesting)	
	Pistillate plants	Hermaphrodite plants	Pistillate plants	Hermaphrodite plants	Pistillate plants	Hermaphrodite plants	Pistillate plants	Hermaphrodite plants
(2nd MAP)	0.040	0.040	0.095	0.068	0.062	0.017	-	-
(3rd MAP)	0.072	0.107	0.103	0.116	0.075	0.028	-	-
(4th MAP)	0.195*	0.169*	0.159*	0.137	0.098	0.086	0.032	0.020
(5th MAP)	0.197*	0.170*	0.192*	0.187*	0.109	0.108	0.055	0.032
(6th MAP)	0.236**	0.182*	0.351**	0.221**	0.135	0.171*	0.061	0.040
(7th MAP)	0.235**	0.200**	0.363**	0.207**	0.225**	0.202**	0.087	0.046
(8th MAP)	0.329**	0.218**	0.334**	0.218**	0.287**	0.276**	0.102	0.065
(9th MAP)	0.433**	0.248**	0.468**	0.223*	0.211**	0.221**	0.159*	0.112
(10th MAP)	0.302**	0.215**	0.476**	0.298**	0.171*	0.136	0.268**	0.232**
(11th MAP)	0.242**	0.156*	0.264**	0.108	0.135	0.119	0.094	0.087
(12th MAP)	0.344**	0.153*	0.207**	0.047	0.128	0.108	0.071	0.072

In hermaphrodite plants, positive correlation of fruit yield was observed with plant height from 4th to 12th MAP, stem girth from 5th to 10th MAP, leaf area from 6th to 9th MAP and number of leaves per plant in 10th MAP. According to Francisco *et al.* (2007) [4], stem diameter was found highly and positively correlated with yield per plant in case of papaya. Kumar *et al.* (2015) [8] and Kumar *et al.* (2018) [7] reported a significant positive association of fruit yield with plant height and number of leaves at flowering in papaya.

3.2. Correlation of fruit yield with floral characters

Data presented in Table 2 indicated that fruit yield was significantly and positively correlated with number of pistillate flower (0.153) and number of hermaphrodite elongate flowers (0.187). Positive and highly significant correlation was also obtained with insertion of first fruit in hermaphrodite (0.329) and pistillate plants (0.384). Whereas, number of hermaphrodite barren flowers (-0.022) exhibited non-significant and negative correlation with fruit yield.

Table 2: Correlation coefficient (r) of floral characters with fruit yield in papaya cv. Red Lady Taiwan

Days taken for first flower initiation in hermaphrodite plants	0.127
Days taken for first flower initiation in pistillate plants	0.124
Number of pistillate flower	0.153*
Number of hermaphrodite elongate flower	0.187*
Number of hermaphrodite barren flower	-0.022
Insertion height of first fruit in hermaphrodite plants	0.329**
Insertion height of first fruit in pistillate plants	0.384**

3.3. Correlation of fruit yield with yield related attributes

Fruit yield had positive and highly significant correlation with number of fruits per plant (0.247 and 0.252), fruit diameter (0.415 and 0.249), fruit weight (0.221 and 0.210) and fruit

length (0.225 and 0.289) in pistillate and hermaphrodite plants, respectively Table 3). Whereas, number of misshapen fruits (-0.002) in hermaphrodite plants was found negatively correlated with fruit yield in papaya.

Table 3: Correlation coefficient (r) of yield related attributes with fruit yield in papaya cv. Red Lady Taiwan

Yield related attributes	Pistillate plants	Hermaphrodite plants
Days taken for fruit set to harvesting	0.022	0.094
Number fruits per plant	0.247**	0.252**
Number of mis-shapen fruits	-	-0.002
Fruit weight	0.221**	0.210**
Fruit diameter of pistillate fruits	0.415**	0.249**
Fruit length	0.225**	0.289**

Jambhale *et al.* (2014) [5] also reported that fruit yield per plant in papaya exhibited a significant and positive correlation with plant height, number fruits per plants, average fruit weight, fruit diameter and fruit length. Selection based on these parameters would indirectly favour higher yield. Kumar *et al.* (2015) [8] observed that fruit yield per plant had significantly positive association with fruit length, fruit girth and number of fruits per plants in papaya. A highly significant and positive correlation of fruit yield per plant with fruits per plants, fruit girth and fruit weight was identified by Kumar *et al.* (2018) [7] in papaya.

3.4. Correlation of vegetative traits with weather parameters

Table 4 reflected that plant height had positive and significant correlation with maximum temperature (0.670 and 0.656) and maximum relative humidity (0.700 and 0.681). It also had non-significant positive correlation with minimum temperature (0.190 and 0.149), minimum relative humidity (0.608 and 0.595), sunshine hours (0.506 and 0.574) and wind velocity (0.498 and 0.486) in pistillate and hermaphrodite plants, respectively.

Table 4: Correlation coefficient (r) of vegetative characters with weather parameters of papaya cv. Red Lady Taiwan

Weather Parameters	Plant height		Stem girth		Leaf area		Number of leaves (Flowering to harvesting)	
	Pistillate plants	Hermaphrodite plants	Pistillate plants	Hermaphrodite plants	Pistillate plants	Hermaphrodite plants	Pistillate plants	Hermaphrodite plants
Maximum temperature	0.670*	0.656*	0.686*	0.646*	0.680*	0.664*	0.319	0.334
Minimum temperature	0.190	0.149	0.126	0.146	0.019	0.021	0.240	0.265
Maximum relative humidity	0.700*	0.681*	0.691*	0.650*	0.593	0.495	-0.043	-0.075
Minimum relative humidity	0.608	0.595	0.586	0.491	0.498	0.510	0.512	0.497
Sunshine hours	0.506	0.574	0.551	0.587	0.934**	0.938**	0.425	0.461
Wind velocity	0.498	0.486	0.486	0.493	0.421	0.514	0.397	0.457

Stem girth had positive and significant correlation with maximum temperature (0.686 and 0.646) and maximum relative humidity (0.691 and 0.650). Non-significant and positive correlation was exhibited with minimum temperature (0.126 and 0.146), minimum relative humidity (0.586 and 0.491), sunshine hours (0.551 and 0.587) and wind velocity (0.486 and 0.493) in pistillate and hermaphrodite plants, respectively.

Leaf area showed significantly positive correlation with maximum temperature (0.680 and 0.664) and highly significant positive correlation with sunshine hours (0.934 and 0.938). Further, it exhibited non-significant positive correlation with minimum temperature (0.019 and 0.021), maximum relative humidity (0.498 and 0.510) and wind velocity (0.421 and 0.514) in both pistillate and hermaphrodite plants, respectively.

Allan *et al.* (1987) [1] had earlier observed rapid plant growth in papaya under high temperature regime. As per Kore *et al.*

(2017) [6] the vegetative and reproductive responses of papaya are influenced by agro climatic conditions of a particular region.

3.5. Correlation of floral parameters with weather parameters

Papaya is regarded as a thermo-sensitive crop and several workers have reported the influence of weather on flowering and fruiting in papaya. In the present study, it was clear from Table 5 that, days taken for first flower initiation (0.510) in pistillate plants showed significant positive correlation with maximum relative humidity. Number of pistillate flowers (0.729) had positive and highly significant correlation with minimum temperature whereas; hermaphrodite barren flowers had positive and significant correlation with sunshine hours (0.712) and maximum temperature (0.619).

Table 5: Correlation coefficient of weather parameters with floral characters of papaya cv. Red Lady Taiwan

Weather Parameters	Days taken for first flower initiation in hermaphrodite plants	Days taken for first flower initiation in pistillate plants	Number of pistillate flowers	Number of hermaphrodite elongate flowers	Number of hermaphrodite barren flowers
Maximum temperature	-0.564*	-0.543*	0.587	0.519	0.619*
Minimum temperature	-0.656*	-0.589*	0.729**	0.601	0.563
Maximum relative humidity	0.432	0.510*	0.162	-0.218	-0.210
Minimum relative humidity	0.208	0.204	0.050	-0.265	-0.461
Sunshine hours	0.342	0.312	-0.425	-0.310	0.712**
Wind velocity	0.218	0.238	0.513	0.419	0.441

Malo and Campbell (1986) ^[9] reported that high temperature tended to induce more maleness or barren flowers in papaya plants. According to Storey (1958) ^[12], the pistillate plant was stable, while staminate and andromonoecious plants may be either phenotypically stable or phenotypically ambivalent going through seasonal sex reversals during which they produce varying proportions of staminate, perfect and pistillate flowers. It seems, therefore, that the change in flora types is closely associated with one or more seasonal factors the most likely of these are day length and temperature.

Table 6: Correlation coefficient of weather parameters with fruit yield and related attributes in papaya cv. Red Lady Taiwan

Weather Parameters	Days taken from fruit set to harvesting in hermaphrodite plants	Days taken from fruit set to harvesting in pistillate plants	Number of mis-shapen hermaphrodite fruits	Fruit yield per hermaphrodite plant	Fruit yield per pistillate plant
Maximum temperature	-0.654*	-0.598*	0.758**	0.668*	0.736*
Minimum temperature	-0.619*	-0.610*	-0.830**	0.743**	0.798**
Maximum relative humidity	0.486	0.043	0.554	0.632	0.618
Minimum relative humidity	0.235	0.305	0.512	0.528	0.638
Sunshine hours	-0.284	-0.425	0.591	0.780**	0.784**
Wind velocity	0.348	0.378	0.611	-0.860**	-0.496

Further, fruit yield per plant exhibited positively significant correlation with maximum temperature (0.668 and 0.736) whereas, positive and highly significant correlation with minimum temperature (0.743 and 0.798) and sunshine hours (0.780 and 0.784) in pistillate and hermaphrodite types, respectively. As per Ong and Kwok (1983) ^[10], monthly harvests were found to be positively correlated with monthly maximum temperature and there was negative correlation between monthly harvest and monthly changes in minimum temperature. Allan *et al.* (1987) ^[11] opined that under hot environment fruit development was quicker and even the smaller fruits matured early.

4. Conclusion

It can be thus concluded from the present investigation that plant height, plant girth, number of pistillate or hermaphrodite elongate flowers, insertion height of first fruit, number of fruits, fruit weight, fruit diameter and fruit length should be prioritized in papaya breeding programs for identification of high yielding types, as these characters have a significant and positive effect on fruit yield in papaya. Vegetative parameters like plant height and stem girth had a positive and significant correlation with maximum temperature and maximum relative humidity. Leaf area had a highly significant and positive correlation with sunshine hours whereas; production of hermaphrodite barren flowers and misshapen fruits had a positive and significant correlation with maximum temperature. Further, fruit yield showed highly significant positive correlation with minimum temperature and sunshine hours in pistillate and hermaphrodite plants of papaya cv. Red Lady Taiwan when grown under South Gujarat conditions.

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3.6. Correlation of fruit yield with weather parameters

It is evident from Table 6 that misshapen fruits showed positive and highly significant correlation with maximum temperature (0.758). Awad (1958) ^[3] had earlier reported that hermaphroditic plants bear distorted flowers in the month of April and May; due to high temperature. Singh and Dahiya (1982) ^[11] observed that the occurrence of low temperature and frost restricted papaya growth and production in Northern India.

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