Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 647-650
Received: 19-05-2020
Accepted: 23-06-2020

K Usha Rani
Department of Fruit Science, College of Horticulture, University of Horticultural Sciences, Bangalore, Karnataka, India

MK Honnabyraiah
Department of Fruit Science, College of Horticulture, University of Horticultural Sciences, Bangalore, Karnataka, India

T Sakthivel
Division of Fruit Crops, ICAR-IIHR, Bengaluru 89, Karnataka, India

J Dinakara Adiga
Principal Scientist (Hort-FS), ICAR-Directorate of cashew Research, Puttur, Karnataka, India

Ashok S Alur
Special officer, Regional Office, COH, Bengaluru-65, Karnataka, India

GK Halesh
Assistant Professor, Department of Biotechnology, COH, Bengaluru-65, Karnataka, India

Corresponding Author:
K Usha Rani
Department of Fruit Science, College of Horticulture, University of Horticultural Sciences, Bangalore, Karnataka, India

Studies on correlation among vegetative parameters, yield parameters, fruit quality parameters, soil and leaf nutrient status of mango (*Mangifera indica* L.) *cv.* Alphonso

K Usha Rani, MK Honnabyraiah, T Sakthivel, J Dinakara Adiga, Ashok S Alur and GK Halesh

Abstract
Correlation studies were carried out in Alphonso mango with different physical and chemical parameters during 2017-19 at College of Horticulture, Bangalore. The data on correlation coefficient of yield and its component characters reveals that yield per tree was significantly and positively correlated with number of fruits per panicle (0.94*), soil nutrients and leaf nutrients, while negative significant correlation with days to maturity (-0.72*). TSS showed negative significant correlation with acidity (-0.96**) and spongy tissue (-0.96**) while positive significant correlation with total sugars (0.93**), reducing sugars (0.88**), shelf life (0.96**) and leaf nutrients. Acidity showed negative significant correlation with total sugars (- 0.97**), reducing sugars (-0.79**), non-reducing sugars (-0.53), shelf life (-0.97**) and leaf nutrients, while positive significant correlation with spongy tissue (0.98*). Reducing sugars showed significant positive correlation with shelf life (0.84**) and non-significant positive relation with non-reducing sugars (0.08) and leaf nutrients.

Keywords: Correlation, Number of fruits per panicle, Yield, Fruit quality and Alphonso

Introduction
Mango (*Mangifera indica* L.) is called„ the King of fruits‟ due to its wide adaptability, delicious taste, excellent flavor, attractive appearance and richness in phytochemical and nutrient [9]. India has traditionally been the world's largest producer of mangoes, having area under cultivation of 22.5 lakh hectares with production 21.82 million tonnes with a productivity of 8.7 tonnes/ha [1]. Among the mango cultivers, *cv.* Alphonso tops the list and is used as one of the choicest and prime varieties of India. It is nutritionally accepted because of its characteristic sugar-acid blend, attractive colour and shape, pleasant aroma, superior fragrance, highly appreciable flavour, delicious taste and long keeping quality. In spite of these, „Alphonso‟ is handicapped by its serious inherited physiological disorders like alternate bearing and occurrence of spongy tissue, which makes the variety a poorer yielder (2.5-3 tonnes/ha) compared to an average Indian productivity of 8.7 tonnes/ha. The number of fruits harvested per tree (yield) depends on parameters like number of fruits per panicle, days to fruit maturity and spongy tissue incidence and also soil and leaf nutrient status. Hence correlation studies among vegetative parameters, yield parameters, fruit quality parameters, soil and leaf nutrient status of mango were carried out during 2017-19 at College of horticulture, Bangalore, Karnataka.

Material and Methods
The experiment was carried out on an uniform trees (7 years) of cultivar Alphonso during 2017-18 and 2018-19 which are maintained at 5 X 5 m spacing at Fruit Science block, College of Horticulture, Bengaluru.

Tre atment details of the experiment
T1 = control (No pruning and only 100% RDF); T2 = Shoot pruning at 10cm length + 100% RDF; T3 = Shoot pruning at 10cm length + PBZ @ 0.75g a.i./ m canopy diameter + 75% of RDF + 5kg vermicompost +20g of AMC + Mango special(spray); T4 = Shoot pruning at 10cm length + PBZ @ 0.75g a.i./ m canopy diameter + 75% of RDF + 10kg vermicompost + 2 g of AMC + Mango special(spray); T5 = Shoot pruning at 10cm length + PBZ @ 1.25g a.i./ m canopy diameter + 75% of RDF + 5kg vermicompost +20g of AMC + Mango special(spray); T6 = Shoot pruning at 10cm length + PBZ @ 1.25g a.i./ m canopy diameter + 75% of RDF +

10kg vermicompost + 20g of AMC + Mango special(spray); T7 = Shoot pruning at 20cm length + 100% RDF; T8 = Shoot pruning at 20cm length + PBZ @ 0.75g a.i./ m canopy diameter + 75% of RDF + 5kg vermicompost + 20g of AMC + Mango special(spray); T9 = Shoot pruning at 20cm length + PBZ @ 0.75g a.i./ m canopy diameter + 75% of RDF + 10kg vermicompost + 20g of AMC + Mango special(spray); T10 = Shoot pruning at 20cm length + PBZ @ 1.25g a.i./ m canopy diameter + 75% of RDF + 5kg vermicompost + 20g of AMC + Mango special(spray); T11 = Shoot pruning at 20cm length + PBZ @ 1.25g a.i./ m canopy diameter + 75% of RDF + 10kg vermicompost + 20g of AMC + Mango special(spray).

Treatment Imposition for experiment

This investigation was laid out in randomized complete block design (RCBD) with three replications. Two years data was statistically analyzed and pooled data is interpreted here. Pruning was carried out in 3rd week of July of year 2017 and 2018, application of paclobutrazol in the last week of September of year 2017 and 2018 and fertilizer application in 2 split doses (first half dose in July of year 2017 and 2018 along with FYM and AMC, second half dose in October of year 2017 and 2018), mango special 3 sprays (before flowering, after flowering, during fruit setting) in year 2017 and 2018. The samples were collected from three trees for each treatment. For quality parameters, ten fruits from each replication were randomly selected and used for analysis. The content of total soluble solids (TSS) was determined with the help of digital hand refractometer (Atago®; pocket refractometer) and expressed as degree brix (0Brix).

The total titratable acidity and total sugars of mango fruits sample was determined by titrating the fruit sample against 0.1N NaOH using phenolphthalein as an indicator [10]. Shelf life of five fruits was decided based on the appearance and marketability of the fruits. When the fruits attained beyond edible ripe stage and shrivelled, then those fruits were considered to have reached the end of their shelf life [15]. Recently matured leaves (5th leaf from top) from mid position of 4 to 5 months old shoots were collected at the beginning of experiment and at the time of harvest, likewise, 30 leaves per tree were collected and oven dried at 65oC for 48 hours. The dried samples were powdered, stored in air tight plastic container and utilized for analysis.

Similarly soil samples were collected before initiation of experiment and at the time of harvest.

Results and Discussion

Studies on correlation among vegetative parameters, yield parameters, soil and leaf nutrient status of mango *cv.* Alphonso

Simple correlation was worked out among the vegetative parameters, number of fruits per panicle, days to maturity, yield, soil and leaf nutrient status during the year 2017-18 and 2018- 19. The results given in Table 1 revealed that tree volume was positive and significantly correlated (0.772**) with canopy height. Days to maturity is positive and non-significantly correlated with tree volume (0.277) and tree height (0.531) and showed negative significant correlation with fruit yield (-0.724*), soil nutrients *viz.,* nitrogen (-0.641*), phosphorus (- 0.783**), potassium (-0.81**), calcium (-0.80**), magnesium (-0.841*) and sulphur (-0.519) and leaf nutrients *viz.,* nitrogen (-0.718*), phosphorus (-0.758**), potassium (-0.811**), calcium (-0.686*), magnesium (-0.787**) and sulphur (-0.740**). Number of fruits per panicle showed positive non-significant correlation with tree height (0.058) and tree volume (0.314) while negative significant correlation with days to maturity (–0.699*) and showed positive significant correlation with soil nutrients *viz.,* nitrogen (0.785**), phosphorus (0.839**), potassium (0.637*), calcium (0.830**), magnesium (0.939**) and sulphur (0.668*) and leaf nutrients *viz.,* nitrogen (0.932**), phosphorus (0.914**), potassium (0.947**), calcium (0.807**), magnesium (0.931**) and sulphur (0.811**) Correlation studies of fruit yield showed positive non-significant correlation with tree height (0.004) and tree volume (0.201), positive significant correlation with number of fruits per panicle (0.946*), soil nutrients *viz.,* nitrogen (0.814**), phosphorus (0.934**), potassium (0.712**), calcium (0.869**), magnesium (0.950**) and sulphur (0.762**) and leaf nutrients nitrogen (0.964**), phosphorus (0.893**), potassium (0.953**), calcium (0.886**), magnesium (0.924**) and sulphur (0.873**) while negative significant correlation with days to maturity (- 0.724*). Soil nutrients and leaf nutrients showed positive significant correlations with each other.

Data on correlation co-efficient between morphological characters and fruit yield indicated that fruit yield was significantly and positively correlated with number of fruits per panicle and soil nutrients and leaf nutrients While, it had negative relationship with days to maturity. From this, it is inferred that the fruit yield is more dependent on number of fruits per panicle, soil and leaf nutrients. The similar conformational results were recorded in mango *cv.* Himsagar [12], Amrapali [7, 13] and Banganapalli [4].

Studies on correlation among fruit quality parameters and leaf nutrient status of mango *cv.* Alphonso.

A glance on Table 2 depicted about the correlation studies among physiochemical parameters and leaf nutrient status during two years (2017-18 and 2018-19) of the experiment. The pooled mean data of two years revealed that fruit weight was positive and significantly correlated with acidity (0.860**) and spongy tissue (0.818**) while negative significant correlation with TSS (-0.88**), total sugars (-0.84**), reducing sugars (-0.75**), non-reducing sugars (-0.615*) and shelf life (-0.86**). Fruit length and fruit width was positive and significantly correlated with acidity and spongy tissue while negative significant correlation with TSS, total sugars, reducing sugars, non-reducing sugars and shelf life. Fruit weight, fruit length and fruit width showed positive and significant correlation with each other.

TSS showed negative significant correlation with acidity (-0.96**) and spongy tissue (-0.96**) while positive significant correlation with total sugars (0.93**), reducing sugars (0.88**), shelf life (0.96**) and leaf nutrients *viz.,* nitrogen (0.671*), phosphorus (0.729*), potassium (0.758**), calcium (0.660*), magnesium (0.733*) and sulphur (0.750**). Acidity showed negative significant correlation with total sugars (-0.97**), reducing sugars (-0.79**), non-reducing sugars (-0.533), shelf life (-0.97**) and leaf nutrients *viz.,* nitrogen (-0.75**), phosphorus (-0.80**), potassium (-0.83**), calcium (-0.734*), magnesium (-0.78**) and sulphur (-0.79**), while positive significant correlation with spongy tissue (0.982*). Reducing sugars showed significant positive correlation with shelf life (0.844**) and non-significant positive relation with non-reducing sugars (0.080) and leaf nutrients *viz.,* nitrogen (0.537), phosphorus (0.595), potassium (0.579) and magnesium (0.581) while significant positive correlation with calcium (0.634*) and sulphur (0.693*).

Correlation studies on spongy tissue shows that it correlate positively and significant with acidity (0.982*) and shows negative significant correlation with total sugars (-0.96**), reducing sugars (-0.856*), TSS (-0.96**), shelf life (-0.989*) and leaf nutrients *viz.*, nitrogen (-0.799*), phosphorus(-0.84**), potassium (-0.858*), calcium (-0.81**), magnesium (-0.822*) and Sulphur (- 0.84**). Shelf life showed negative significant correlation with fruit weight (-0.86**), fruit length(-0.89**), fruitwidth (-0.90**), acidity (-0.97**) and spongy tissue (-0.989*) while positive significant correlation with TSS (0.844**), total sugars (0.981**), reducing sugars (0.96**) and leaf nutrients *viz.*, nitrogen (0.746**), phosphorus (0.819**), potassium (0.815*), calcium (0.770**), magnesium (0.796*) and sulphur (0.797**).

The chemical character such as TSS, total sugars, reducing sugars was found to have significant positive correlation with shelf life and negatively with spongy tissue. While, acidity was found to be negatively correlated with shelf life and positively with spongy tissue. Leaf nutrients positively correlated with shelf life and negatively with spongy tissue. Among the number of factors investigated for establishing their correlation with the occurrence of spongy tissue disorder in Alphonso mango, Ca deficiency in spongy tissue affected fruits have shown strong association with the occurrence of spongy tissue [5, 6, 14]. The results obtained with the application of paclobutrazol in the present investigation supports the above finding and lower incidence of spongy tissue in paclobutrazol treated trees could be attributed to higher uptake of Ca and its relocation to fruits as rate of leaf transpiration is significantly reduced, thus could favour the supply of Ca towards the fruit. Moreover, significant increase in Ca uptake of Alphonso mango trees under paclobutrazol application has been reported [2, 3, 8, 9].

Table 1: Studies on correlation among vegetative parameters, yield parameters, soil and leaf nutrient status of mango *cv.* Alphonso

Variables	Tree Volume	No. of fruits/ panicle	Days to maturity	Fruit yield	Soil N	Soil P	Soil K	Soil Ca	Soil Mg	Soil S	Leaf N	Leaf P	Leaf K	Leaf Ca	Leaf Mg	Leaf S
Plant height(m)	0.772**	0.058	0.531	0.004	0.100	0.183	0.541	0.212	0.157	0.203	0.014	0.110	0.145	0.008	0.153	0.110
Tree Volume (m3)		0.314	0.277	0.201	0.041	0.054	0.469	0.145	0.077	0.265	0.108	0.096	0.039	0.026	0.060	0.023
No. of fruits /panicle			-0.699*	0.946*	0.785**	0.839**	0.637*	0.830**	0.939**	0.668*	0.932**	0.914**	0.947**	0.807**	0.931**	0.811**
Days to maturity				-0.724*	-0.641*	-0.783**	-0.81**	-0.80**	-0.841*	-0.519	-0.718*	-0.758**	-0.811**	-0.686*	-0.787**	-0.740**
Fruit yield (kg/tre e)					0.814**	0.934**	0.712**	0.869**	0.950**	0.762**	0.964**	0.893**	0.953**	0.886**	0.924**	0.873**
Soil N						0.904*	0.854**	0.834**	0.876**	0.810**	0.885**	0.886**	0.883**	0.855**	0.841**	0.919**
Soil P							0.878**	0.940**	0.950**	0.794**	0.951**	0.915**	0.947**	0.919**	0.913**	0.912**
Soil K								0.877**	0.815**	0.537	0.782**	0.797**	0.836**	0.748**	0.811**	0.809**
Soil Ca									0.926**	0.627*	0.941**	0.903**	0.945**	0.870**	0.903**	0.834**
Soil Mg										0.760**	0.958**	0.944**	0.985**	0.885**	0.936	0.904**
Soil S											0.759**	0.722*	0.704*	0.837**	0.633*	0.859**
Leaf N												0.924**	0.979**	0.903**	0.939**	0.899**
Leaf P													0.942**	0.895**	0.952**	0.881**
Leaf K														0.869**	0.964**	0.897**
Leaf Ca															0.810**	0.937**
Leaf Mg																0.833**

Table 2: Studie s on corre lation among fruit quality parame te rs and le af nutrie nt status of mango *cv.* Alphonso.

Variables	Fruit length	Fruit width	TSS	Acidity	Total sugars	Reducing sugars	Non R. sugars	Shelf life	Spongy tissue	Leaf N	Leaf P	Leaf K	Leaf Ca	Leaf Mg	Leaf S
Fruit weight	0.983**	0.930**	-0.88**	0.860**	-0.84**	-0.75**	-0.615*	-0.86**	0.818**	0.406	0.487	0.506	0.407	0.497	0.506
Fruit length		0.948**	-0.90**	0.890**	-0.89**	-0.80**	-0.545	-0.89**	0.855**	0.430	0.538	0.536	0.481	0.527	0.550
Fruit width			-0.88**	0.876**	-0.92**	-0.81**	-0.538	-0.90**	0.855*	0.493	0.542	0.578	0.547	0.563	0.621*
TSS				-0.96**	0.93**	0.88**	0.486	0.96**	-0.96**	0.671*	0.729*	0.758**	0.660*	0.733*	0.750**
Acidity					-0.97**	-0.79**	-0.533	-0.97**	0.982*	-0.75**	-0.80**	-0.83**	-0.734*	-0.78**	-0.79**
Total sugars						0.80**	0.483	0.981**	-0.96*	0.736**	0.78**	0.815*	0.755**	0.782**	0.782**
Reducing sugars							0.080	0.844**	-0.856*	0.537	0.595	0.579	0.634*	0.581	0.693*
Non R. sugars								0.468	-0.410	0.169	0.209	0.286	0.055	0.220	0.165
Shelf life									-0.989*	0.746**	0.819**	0.815*	0.770**	0.796*	0.797**
Spongy tissue										-0.799*	-0.84**	-0.858*	-0.81**	-0.822*	-0.84**
Leaf N											0.924*	0.979**	0.903**	0.939**	0.899**
Leaf P												0.942**	0.895**	0.952*	0.881**
Leaf K													0.869**	0.964**	0.897**
Leaf Ca														0.810**	0.937**
Leaf Mg															0.833*

Conclusion

Correlation studies revealed that fruit yield positively and significantly correlated with number of fruits per panicle, soil nutrients and leaf nutrients. Spongy tissue is positively correlated with acidity and negatively correlated with TSS, reducing sugars, non-reducing sugars, total sugars and leaf nutrients. Shelf life positively correlated with TSS, total sugars, reducing sugars, non-reducing sugars and leaf nutrients, while negatively correlated with acidity and spongy tissue.

Acknowledgements

The authors are thankful to the Dean, College of Horticulture, Bengaluru for providing necessary facilities for smooth conduction and completion of research work.

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