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PHYSICO-CHEMICAL STUDIES ON DEFORMATION OF PONKANTANGERINE FRUITS

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Abstract

Mandarin fruit trees undergo cycles of heavy fruit load (ON-Year) in one year, followed by low fruit load (OFF-Year) the following year, a phenomenon known as alternate bearing. Roughing disorder is animportant quality barrier in citrus fruit, prevalent on easy-peeling mandarins; it appears on trees that carry a light load of fruits. That phenomenon in fruits can be distinguished morphology by large fruit size with excessively thick and rough peel. This study focuses on the knowledge of this phenomenon in the mandarin fruits (smooth and curly) which focused on the fruit external shape and its relation to physical and chemical properties of fruit and nutritional status of trees (leaves, fruits and seeds) as well as hormonal situation of those fruits to find out the causes of this phenomenon. Thisstudy was performed during 2016 and 2017 seasons on eight years old mandarin Ponkan trees grafted on Volkamer lemon rootstock, grown in sandy soil conditions under drip irrigation system, of a private orchard located at El-Beheira Governorate Egypt. The results indicated that the concentrations of potassium, magnesium, sodium and copper were higher in the leaves and fruits (peel and pulp) in affected fruits more than in healthy fruits. Also, results showed that there increases of all growth regulators in leaves of smooth fruits except the Zeatin was the highest in curly fruits. It can be concluded that, the morphological shape change of citrus fruits can be attributed to yield production fruit/tree; there was problems of feeding trees or hormonal status of trees.

Key Words: Citrus Ponkan tangerine fruits, physical and chemical properties, nutritionaland hormonal status.

Introduction

Citrus fruits and juices are an important source of bioactive compounds including antioxidants such as ascorbic acid, flavonoids, phenolic compounds and pectin that are important to human nutritionGhasemi *et al.,* (2009), Stuetz *et al.,* (2010), Abad-Garcia *et al.,* (2012), Zhang *et al.,* (2014). Mandarin (*Citrus reticulata* Blanco) is a group name for a class of oranges with thin, loose peel; include a diverse group of citrus fruits that are characterized by bright colored peel and pulp, excellent flavor, easy-to-peel rind and segments that separate easily. It is considered as one of the most importantand popular citrus fruit in the world and in Egypt. It is cultivated widely in the tropical/subtropical regions 35^0N to 35^0S of equator as well as temperate regions. In recent times, with changing environmental conditions (climate - soil – irrigation – fertilization- rootstock) has led to a noticeable change in the familiar shape of mandarin fruits which was focused in wrinkle in the outer rind in addition to thickened rinds, which threat of production, consumption and exportValiente andAlbrigo (2004), because it leads to instability of fruit quality, fruit supply and price Knauer *et al.,* (2011), Goldschmidt (2013). Curly peel (CP) is a serious barrier in citrus fruit quality, spread in easy-peeling mandarins, characterized by excessively thick, rough peel and large fruit size Monselise and Goldschmidt (1982), Liu *et al.,* (1988), Kubo and Hiratsuka (1998, 1999). This characteristic appears on trees that carry a light load of fruit where curly peel fruits are predominant, it could be commonly observed during Satsuma mandarin fruit development, occurs through a complicated process and is influenced by hormones, soil, air humidity and rootstockErner *et al.,* (1975,1976).

Shalom *et al.,* (2014) who said two main factors often lead to roughing disorder (RD) in Satsuma mandarin plants. The first one is low fruit load. Hormones are another important factor behind Roughing disorder in

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Satsuma mandarin. Fruit on mandarin trees tending to have RD had higher GA content than sideward fruit with smooth peel. Thus, increased gibberellin signal transduction likely promotes fruit let development and drives starch hydrolysis in RD peel. RD occurrence on the peel was influenced significantly by GA, especially abundant GA before July. These changes may mean a significant alteration in excessive thick of RD peel.Liu (2012), Lu *et al.,* (2017) reported that the primary metabolites of sugars, organic acids and amino acids are dramatically changed in RD peel. The RD peel was always characterized by higher magnesium content during development. Gene set enrichment analysis suggested that RD significantly altered starch and GA metabolism in peel. Higher starch content and hydrolysed chain status were found in RD peel at cell division stage. This is probably associated with gibberellin signal activity in RD peel, which is an important accelerator for starch hydrolysis.

So, the target of this studywas investigating the physical and chemical characteristicsas well as nutritional status and hormonal situation of Citrus Ponkan Tangerine in both fruits (smooth and curly) as a comparison.

Materials and Methods

Citrus Orchard

Mandarin oranges (*Citrus reticulata* Blanco) trees on eight years old grafted on Volkamer lemon (*Citrus volkameriana*) rootstock, which spaced at 4×3 m, distance (830 trees ha.$^{-1}$), grown in sandy soil conditions under drip irrigation system, of a private orchard, located atEl-Beheira Governorate Egypt.

The Trees Received theHorticultural Practices as The Following:

Fertilization

Fertilizer applications were used as following: Farmyard manure 42 m^3 ha^{-1} during December – January. NPK rates were 240 Kg N/ha^{-1} as ammonium nitrate (33.5% N) and calcium nitrate (15.5% N), 70 Kg P_2O_5 / ha^{-1}, as a super phosphate (15% P_2O_5) and phosphoric acid (60% P_2O_5) and 240 Kg K_2O ha^{-1} as potassium sulfate (48-52%) were using as fertigation and divided along the growing season, combinations of magnesium, iron, manganese, zinc sulphate and boron were sprayed at three times, February, June and September.

Irrigation

The irrigation of orchard was depending on season growth and environmental conditions. Drip irrigation system was divided to three regimes, during flowering and set fruiting (start from mid-March to mid-June) at1.5–2.0 hours/day (three time/week), during fruit growth (start from mid-June to end-October) at 3 hours/day (three times/week) and duringfruit ripening (start from November to January) at 0.5–1.0 hour, once/week. In addition to, gives two times heavy irrigations for the orchard, the first when entering December month and the second one when out of February month. Volume of water spray used was (1400 L ha^{-1}).

Water Samples: Were taken up after 0.50 h from beginningthe pump.

Soil Analysis: Soil samples were tested for texture, pH and electric conductivity (EC) using water extract (1:2.5) method, total calcium carbonate ($CaCO_3$%) determined with calcimeter method and for organic matter (O.M%) was determined using potassium dichromate Chapman and Pratt (1978). Phosphorus was extracted using sodium bicarbonate, Olsen *et al.*(1954). Potassium (K), calcium (Ca) magnesium (Mg) and sodium (Na) were extracted using ammonium acetate Jackson (1973). Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were extracted using DTPA, Lindsay and Norvell (1978).

Soil Samples: Were collected before experiment initiated from the root zone tips of the tree at the end of the canopy (60 cm depth) table 2.

The results of soil analysis was indicated that physical properties such as soil texture is a sandy soil, as well as high pH and EC and very low calcium carbonate and organic matter in both sites. Chemical properties were

Table 1: Water physico-chemical properties of the experimental site.

pH	EC(mS/m)	SAR	CO_3+HCO_3	Cl	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
8.44	3.72	9.14	1115	290	14.4	126.5	41.0	462.5	0.026	Traces		

Table 2: Soil physico-chemical properties of the experimental site.

Sample Type	Mechanical analysis %			Tex.	Physical properties				Macronutrients (mg/ 100 g)					Micronutrients (mg/ Kg)			
	Sand	Silt	Clay	Sandy	pH	EC (mS/m)	$CaCO_3$ (%)	O.M (%)	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Smooth	87.2	6.0	6.8		8.12	1.05	0.44	0.22	1.50	7.2	250	16.1	96.1	4.9	5.2	2.4	6
Curly	89.2	6.0	4.8		8.15	2.25	0.88	0.15	1.75	8.0	250	17.2	154.0	4.8	4.6	3.5	4

explained the available phosphorus and calcium is moderate level and the very low of potassium, magnesium, iron and manganese in both sites according with Ankerman and Large (1974).

The location of curly fruit tree showed that pH, electrical conductivity, calcium carbonate and most elements except manganese and copper were increased for than the sitesmooth fruit tree.

Nutrition Status: Nutrient element compositions in the leaves, fruits (rind and flesh) and seeds of healthy and affected fruit were analyzed. All samples washed, dried at 70^{o} C till constant weight, then grind and digested to determinethe macro nutrients (N, P, K and Mg) and micronutrient (Fe, Zn and Mn) according to Rebbeca (2004).

Leaf Samples: Were collected around the tree from the fully mature leaves at October month (4 to 5 from the shoot top) to determine the nutrient contents.

Fruit Samples: Were taken at harvest time "mid-November" in the two seasons; three fruits from four sides of each tree"three replicates, tree/replicate" were picked up randomly and used for determination fruit quality assessments in both types of fruits.

Fruit Quality Estimation

Physical Characteristics

Fruit fresh and dry weights (g), fruit length "L" (cm), fruit diameter "D" (cm), index (L/D) ratio, crust thickness (cm), fruit weight (g), pulp weight (g), crust weight (g), ratio of both crust and pulp to fruit, ratio of crust to pulp, number of seeds and lobes and average weight of 100 seeds (g).

Chemical Characteristics

Chemical characteristics of fruitjuice, *i.e.,* total soluble solids percentage (TSS%) by using hand refractometer, total acidity (TA%) was estimated as percentages of Citric acid and vitamin C "Ascorbic acid" were analyzed as described by AOAC (2000).

Growth Regulators

Extraction, Separation and Estimation of Plant Hormones

The frozen plant material (leaves, peels and fruits) were extraction according to the method of Shindy and Smith (1975) and described by Hashem (2006). To estimate the amounts of acidic hormones (IAA, IBA, ABA and GA), the plant hormone fractions and standard ones were methylated according to Vogel (1975) to be ready for GC analysis. On the other hand JA was determined according to Kramell (1996). Peak identification was performed by comparing the relative retention time of each peak with those of IAA, GA, ABA and JA standards.

Cytokinins fractions (Zeatin and Benzyl Adenine) were extracted as previously mentioned for the acidic hormones and were detected by HPLC analyzer, standards of Cytokinin, Zeatin and Benzyl Adenine were used and the peak area of the standard was also used in identification and detection of Zeatin and Benzyl Adenine in each sample Muller and Hilgenberg (1986).

Statistical Analysis

Experimental design Randomized Complete Block Design (RCBD) with three replicates was adopted. The results were submitted to analysis of variance Snedecor and Cochran (1980), Differences among treatment means were determined by using the LSD test at a significance level at 0.05 of probability Waller and Duncan (1969).

Results and Discussion

Nutrition Status

Nutrient concentrations in leaves, fruit parts and seeds in the two shapes of citrus Ponkan Tangerine fruits: The nutritional status of the tree "macronutrient concentrations and micronutrients" plays a very important role in the growth, productivity of trees and fruits nutritive quality. Data in Fig. 1 refer to there is a difference in nutrient concentrations for different parts of trees, such as leaves, fruit rind, fruit flesh and seeds and also influenced by trees type, curled or healthy. From the first glance of the Figure nutrient concentrations were highest in healthy trees parts than affected trees parts. It worth mentioned, the results indicated that the highest significant nutrient contents of nitrogen, phosphorus, calcium, iron, manganese and zinc were obtained by leaves, fruits (rind & flesh) and seeds of smooth fruits. Other vise, the curly fruits had the highest statistical concentrations of potassium, magnesium, sodium and copper in leaves and fruits parts more than in healthy fruits. It may be due to high nutrient contents of P, K, Mg and Na in the soil which grow of curled fruits tree except P element in leaves and fruit parts. Also, the high phosphorus concentrations in smooth fruit tree parts can be the result of increased root propagation, increased pH, or increased salt concentration in the soil. Meanwhile, the high nitrogen concentration may be the result of increased concentration of organic matter in the soil for smooth trees. Despite the high concentration of calcium carbonate in the soil of the crumpled fruit trees, which reached twice as much as the calcium concentration in the soil of the two type's fruit trees, the concentration of calcium in the parts of the tree (leaves, fruits and seeds) was lower than smooth

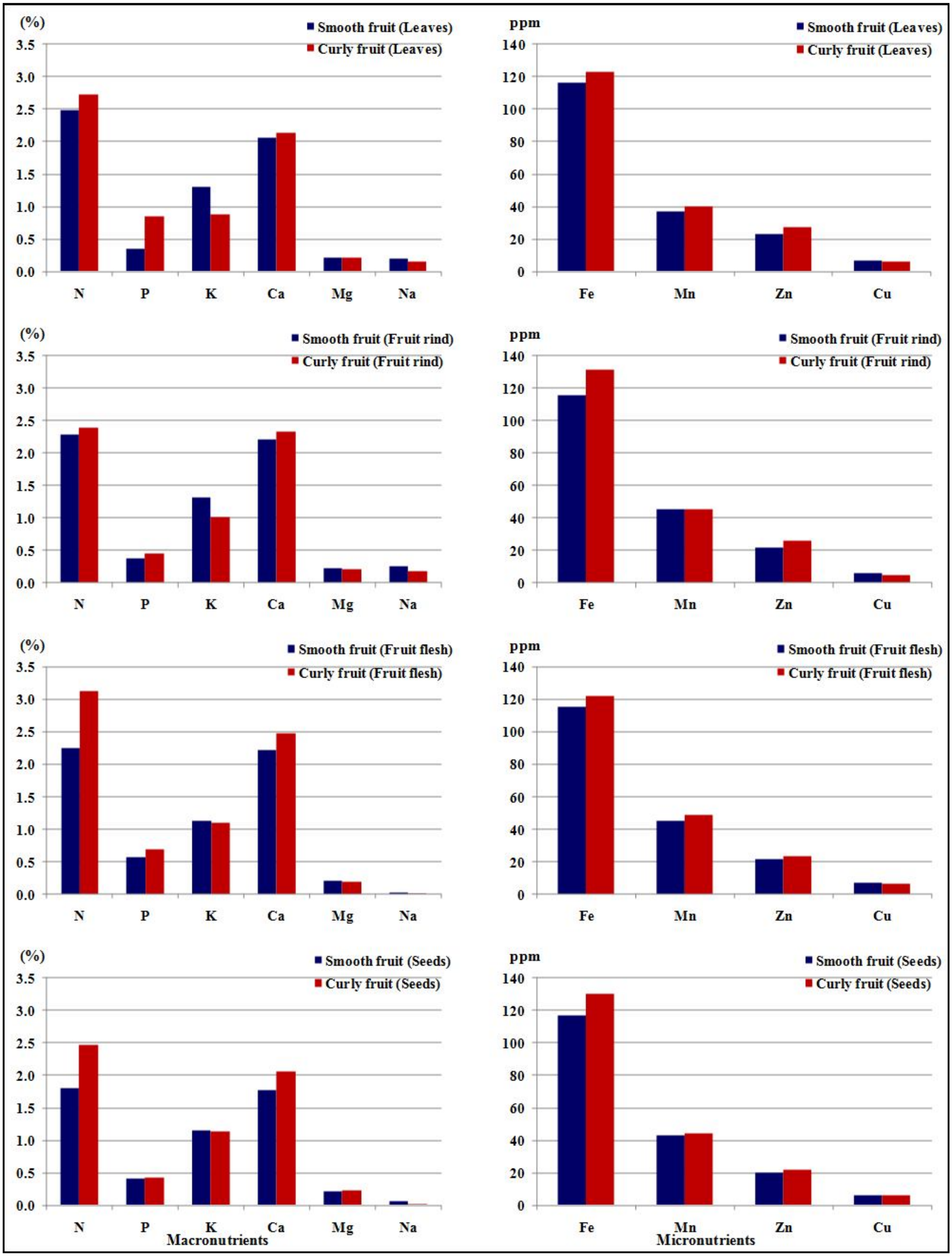

Fig. 1: The nutrient concentrations in leaves, fruit parts and seeds of Citrus Ponkan Tangerine Fruits.

trees.

These results agreed with Camara *et al.,* (2003) who stated that Volkamer lemon was clearly leaf mineral composition and, to some degree, tolerance to environmental stress. Curly fruits analyses revealed that higher Mg and Cu levels occurred in mature peel Liu *et al.,* (1988, Kubo and Hiratsuka (2000), Mahouachi *et al.,* (2009). The higher Mg content might contribute to the chlorophyll biosynthesis, carbohydrate accumulation and delayed degreening in roughing disorder peel Lu *et al.,* (2017).

Fruit Quality Estimation

Physical Characteristics

From visual observations, appear that the shape and size of the fruit varies depending on the degree of bearing. The smooth fruit trees were high in yield and smaller fruits size when compared to the crumpled fruit trees Fig. 2.

The data presented in table 3 showed that all physical properties of Citrus Tangerine fruits were dependent on the type of fruit. Moreover, significant progress has been made in curly fruits in most physiological measurements than soft fruits. These measurements such as the average of fruit diameter, length, crust thickness, fruit weight, pulp weight, crust weight and weight of 100 seeds superior increased than smooth fruits by about 0.12, 0.16, 0.5, 0.58, 0.57, 0.60 and 0.03% respectively. In contrast the delicate fruits were progressed in juice volume around 0.01% than creased fruits. Meanwhile, no significant differ among them in the other parameters such as fruit index (L/D ratio), crust ratio to fruit, pulp ratio to fruit, ratio of crust to pulp, number of seeds and lobes.

Table 3: Physical properties of Citrus Ponkan Tangerine Fruits.

Physical characteristics	Curly fruit	Smooth fruit	$LSD_{0.05}$
Fruit length "L" (cm)	7.89	7.05	0.41
Fruit diameter "D" (cm)	8.89	7.67	0.48
Index (L/D ratio)	0.89	0.92	NS
Crust thickness (cm)	0.72	0.48	0.09
Fruit weight (g)	253.22	160.19	54.1
Pulp weight (g)	170.91	108.70	38.0
Crust weight (g)	82.31	51.49	26.9
Crust ratio to fruit	0.32	0.32	NS
Pulp ratio to fruit	0.68	0.68	NS
Ratio of crust to pulp	0.49	0.47	NS
Number of seeds	14.78	13.33	NS
Number of lobes	13.67	9.67	NS
Average weight of 100 seeds (g)	12.20	11.80	0.16
Juice volume (cm)	68.33	68.89	0.09

NS: Non Significant.

There are several reports that indicated a Volkamer lemon rootstock effect on the quality of citrus fruit, yield and tree growth and tree size Economides (1976, 1977), Wutscher (1988), Hafez-Omaima (2006), also trees grafted on it were highly productive and with large fruits Ali-Akbar & Ali Al Irezanezhad (2005). Our results are in harmony with those findings Monselise and Goldschmidt (1982), Liu *et al.,* (1988), Kubo and Hiratsuka (1998, 1999), Goldschmidt (2013) they said that citrus trees produce in one year heavy fruit load (ON-Year), which inhibits return bloom and vegetative growth the next year, the second year produce few fruit, most of which are curly fruits and predominant.It is characterized by excessively thick, rough peel and large fruit size Erner *et al.,* (1976), Kubo and Hiratsuka (1998), Mohamed-Karima and Hafez-Omaima (2004), Liu (2012), Shalom *et al.,* (2014).

Chemical Characteristics

The results in the table 4 indicated that the chemical properties of fruits such as pH, total soluble solids% (TSS), total acidity% (TA) and ascorbic acid (VCmg/100ml juice) are affected by smooth and wrinkled Citrus Tangerine fruits.

The results also, referred that all chemical measurement characters that were the mentioned above were significant increase in fruits smooth than the other one. It may be because of curly fruits that are high in fiber. These results of chemical properties of Citrus Ponkan Tangerine Fruitare in agreement with those obtained by Kaplankiran *et al.,* (2005), El-Sayed *et al.,* (2007), Demirkeser *et al.,* (2009), El-Nagdi, *et al.,* (2010), Hifny *et al.,* (2012, 2013), Incesu *et al.,* (2013), Khalifa and Hamdy (2015), Hafez-Omaima *et al.,* (2017).

Hormonal Status

From the first look in table 5 below, the results showed differences in the hormonal status in the leaves and fruit parts in both smooth and curly fruits.

Generally, results indicated that the curly shape had increment in GA, ABA, BA and JA in flesh and peel fruits than in leaves. But, in contrast the previous growth regulators in the smooth shape in this regard.

Concerning the Zeatin, data showed higher content

Table 4: Physical properties of Citrus Ponkan Tangerine Fruit.

Fruit types	Chemical characteristics			
	Juice pH	TSS (%)	TA (%)	VC (mg/ 100ml juice)
Curly	4.13	10.33	1.32	7.13
Smooth	4.14	11.67	1.38	7.70
$LSD_{0.05}$	0.003	0.01	0.04	0.06

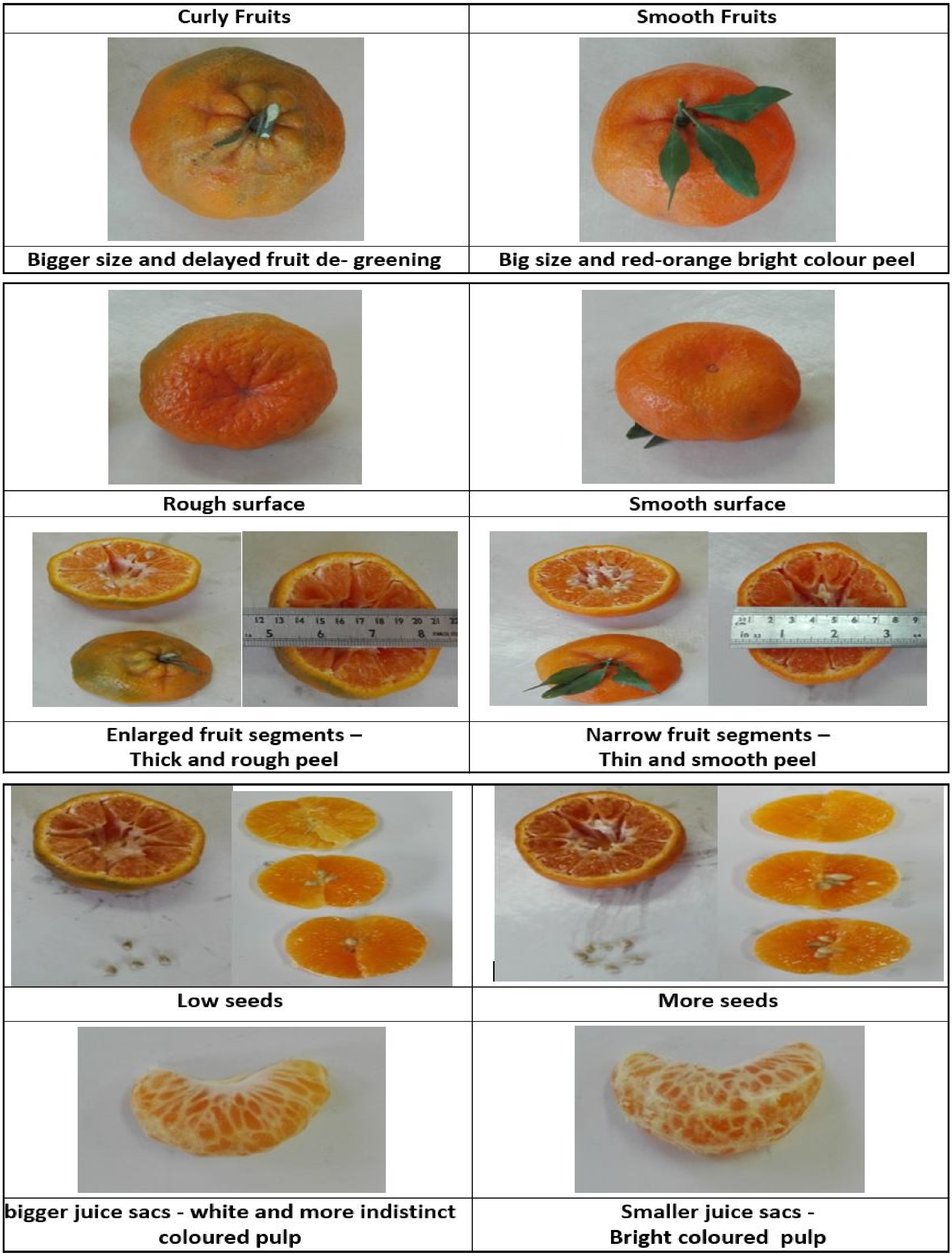

Fig. 2: External characteristics of Citrus Ponkan Tangerine Fruits in both shapes.

Table 5: Plant hormones contains of leaves and fruits (flesh & peel) of Citrus Ponkan Tangerine.

Plant hormones (ppm)	Leaves		Fruit (Flesh)		Peel	
	Smooth	**Curly**	**Smooth**	**Curly**	**Smooth**	**Curly**
Gibberellic Acid (GA)	5029.33	4744.06	182.241	420.278	669.474	1267.33
Zeatin	49.8254	85.7843	3.28854	3.5782	19.0721	27.334
IndoleAcetic Acid (IAA)	311.805	247.961	10.2794	7.26482	59.9818	95.2265
Abscisic Acid (ABA)	13.3478	9.02871	0.71851	2.86475	2.79332	15.2865
Benzyl Adenine (BA)	26.2445	19.4134	0.7975	4.05162	14.017	20.4555
Indole Butyric Acid (IBA)	141.064	Absent	5.87951	Absent	43.4175	62.0844
Jasmonic Acid (JA)	882.16	628.192	36.4613	193.196	109.69	597.927

in all aspects estimated (leaves and fruit parts) in curly shape in compared the smooth shape.

As for IAA and IBA, it can be noticed in the two growth hormones were increased in leaves and flesh fruits in smooth shape and also in peel curly shape. On the contrary, IAA and IBA were decreased in peel of smooth fruits as well as in leaves & flesh fruits in curly shape in case IAA only in this respect. Meanwhile, IBA was absent in leaves and flesh curly shape.

From the above results we can say trees produce a variety of hormones, like auxins, gibberellins and cytokinins that are called stimulators. Auxins promote cell enlargement, the main factor controlling fruit size during the rapid growth phase Iglesias *et al.,* (2007), like indole acetic acid (IAA) and Indole-3-butyric acid (IBA) play a key role in regulating growth and development of different plant parts Popko *et al.,* (2010). IAA regulation is by affecting the transcriptional factors Hayashi (2012). Gibberellins increase cell enlargement, thus enhancing fruit growth in certain species such as citrus Eman *et al.,* (2007). Gibberellins also, induce seeds to sprout, have a role in flowers development and reduction of physiological drop Ullah *et al.,* (2014). Cytokinins such as Zeatinand benzyl adenine are active in all stages of germination to regulate seed germination Riefler *et al.,* (2006), affect the activities of meristemic cells in shoots and roots, as well as leaf senescence Santner *et al.,* (2009), Hafez-Omaima *et al.,* (2013).

Cytokinins promote carbohydrate metabolism and increased sink strength, fruit size by increasing number of cell layers and fruit dry matter at harvest Monthes and Engelbrecht (1961), Emomogor (1995). Jasmonic acid (JA) and its derivatives have essential roles in plant development from germination to senescence, included number of physiological processes like vegetative growth, cell cycle regulation, senescence and fruit ripening Wasternack and Hause (2002), Yoshida *et al.,* (2009). Abscisic acid is known as growth inhibitors; it positively affects stomatal activity, seed dormancy, causes the leaves to break off and fall in autumn and plant activities under stresses Popko *et al.,* (2010).

Our results were nearly in the same line with obtained by Liu (2012) said that hormones are another important factor behind roughing disorder in Satsuma mandarin. Fruit on "Okitsu wase" mandarin (*C. unshiu* Marc.) trees tending to have RD had higher GA content than sideward fruit with smooth peel Shalom *et al.,* (2014).

CONCLUSION

From the above results it can be say the morphological shape change of citrus fruits with changing environmental conditions such as rootstock - soil - fertilization - irrigation -climate and it depended on a light load of fruit has led to a noticeable change in the familiar shape of mandarin fruits. Thus, it can be concluded that, the morphological shape change of citrus fruits can be attributed to tree productivity (number of fruits/tree); there was problems of feeding trees and also hormonal status of trees.

References

AbAbad-Garcia, B., S. Garmon-Lobato, L.A. Berrueta, B. Gallo and F. Vicente (2012). On line characterization of58 phenolic compounds in *citrus* fruit juices from Spanishcultivars by high-performanceliquid chromatographywith photodiode-array detectioncoupled to electrospray ionization triple quadrupolemassspectrometry. *Talanta,* **99:** 213-224.

Ali-Akbar Ramin and Ali Al Irezanezhad (2005). Effects of citrus rootstocks on fruit yield and quality of Ruby Red and Marsh grapefruit. *Fruits,* **60(5):** 311–317. DOI: 10.1051/fruits: 2005037.

Ankerman, D. and L. Large (1974). Soil and Plant Analysis, Agricultural Laboratories Inc., New York, USA.pp: 82.

AOAC (2000). Official Methods of Analysis, Association of Official Agricultural Chemists. 17th Ed, Washington DC. USA.

Camara, J.M., F. Garcia-Sanchez, M. Nieves and A. Cerda (2003). Effect of interstock ('*Salustiano' orange*) on growth, leaf mineral composition and water relations of one year old citrus under saline conditions, *J. Horti. Sci. Biotech.,* **78(2):** 161–167.

Chapman, H.D. and P.E. Pratt (1978). Method of analysis for soil plant and water.University of California, Dep. Agric. Sci. USA, pp. 1-309.

Demirkeser, T.H., M. Kaplankiran, C. Toplu and E. Yildiz (2009). Yield and fruit quality performance of Nova and Robinson mandarins on three rootstocks in Eastern Mediterranean. *African J. Agric. Res.,* **4(4):** pp. 262-268.

Economides, C.V. (1976). Performance of Marsh seedless grapefruit on six rootstocks in Cyprus. *J. Horti. Sci.,* **51:** 393–400.

Economides, C.V. (1977). The influence of rootstocks on tree growth, yield and fruit quality of Valencia oranges in Cyprus. *J. Horti. Sci.,* **52:** 29–36.

El-Nagdi, W.M.A., M.M.A. Youssef and O.M. Hafez (2010). Effects of commercial formulations of *Bacillus thuringiensis* and Streptomyces avermitilis on *Tylenchulussemipenetrans* and on Nnutritionstatus, yield and fruit quality of mandarin. *Nematol. Medit.,* **38:** 147-157.

El-Sayed, S.A., S.A. El-Saiada and H.A. Ennab (2007). Yield and fruit quality of Washington navel orange as affected by sour orange and Volkamer lemon rootstocks. *J. Agric. Sci. Mansoura Univ.,* **32(11):** 9051-9060.

Eman, A.A., E.M. Abd, E.M.O. Abid and M.M. Ismail (2007). GA_3 and zinc sprays for improving yield and fruit quality of Washington navel orange trees grown under sandy soil conditions. *Research Journal of Agriculture and Biological Sciences,* **3(5):** 498-503.

Emongor, V.E. (1995). Thinning activity of benzyladenine on empire apples application timing and fruit storage. Ph.D. Thesis, University of Guelph, pp: 78-98.

Erner, Y., R. Goren and S.P. Monselise (1976). The rough fruit condition of the Shamouti orange-connections with the endogenous hormonal balance. *J. Hortic. Sci.,* **51:** 367.

Erner, Y., S.P. Monselise and R. Goren (1975). Rough fruit condition of the Shamouti orange: occurrence and patterns of development. *Physiol. Vége.,* **13:** 435–443.

Ghasemi, K., Y. Ghasemi and M.A. Ebrah1mzadeh (2009). Antioxidantactivity, phenol and flavonoid contents of 13 citrus speciespeels and tissues. *Pakistan J. Pharma Sci.,* **22:** 277-281.

Goldschmidt, E.E. (2013). The evolution of fruit tree productivity: a review. *Economic Botany,* **67:** 51–62.

Hafez-Omaima, M. (2006). Evaluation of growth characteristics of some citrusrootstocks using protein finger print technique. *American-Eurasian J. Agric. and Environ. Sci.,* **1(3):** 243-248.

Hafez-Omaima, M., Malaka A. Saleh and Safaa R. El-Lethy (2013). Response ofsomeseedlingsolive cultivarstofoliar spray of yeast and garlicextractswithorwithout Vascular Arbuscular Mycorrhizalfungi. *World Appli. Sci. J.,* **24(9):** 1119-1129.

Hafez-Omaima, M., Maha Sultan, Saber Ibrahim and Malaka A. Saleh (2017). Enhancement yield and fruit quality of Washington Navel orange by application of spraying potassium microencapsulated biodegradable polylacticacid. AgricEngInt: CIGR Journal, Open access at http://www.cigrjournal.org. Special issue: 101-110.

Hashem, H.A. (2006). Physiological and molecular actions of jasmonic acid on soybean plant. Ph.D Thesis, Fac. of Sci., Ain Shams Univ., Cairo, Egypt.

Hayashi, K. (2012). The Interaction and integration of auxin signaling components. *Plant Cell Physiol.,* **53:** 965–975.

Hifny, H.A., M.A. Fahmy, G.A. Bagdady, G.A. Abdrabboh and A.E. Hamdy (2013). Effect of nitrogen fertilization added at various phenological stages on growth, yield and fruit quality of Valencia orange trees. *Nature and Sci.,* **11:** 12.

Hifny, H.A., A.M. Abd Elrazik, G.A. Abdrabboh and M.Z. Sultan (2012). Effect of some citrus rootstocks on fruit quality and storability of Washington Navel orange under cold storage conditions. *American-Eurasian J. Agric. and Environ. Sci.,* **12(10):** 1266- 1273.

Iglesias, D.J., M. Cercós, J.M. Colmenero-Flores, M.A. Naranjo, G. Ríos, E. Carrera, O. Ruiz-Rivero, I. Lliso, R. Morillon and M. Talon (2007). Physiology of citrus fruiting. *Braz. J. Plant Physiol.,* **19(4):** 333-362.

Incesu, M., B. Çimen, T. Yesiloglu and B. Yilmaz (2013). Rootstock effects on yield, fruit quality, rind and juice color of blood orange. *J. Food, Agric. and Environ.,* **11(3&4):** 867 - 871.

Jackson, M.I. (1973). Soil chemical analysis Prentice Hal Inc. N. J, USA.

Kaplankiran, M., T.H. Demirkeser and E. Yeldiz (2005). The effects of some citrus rootstocks on fruit yield and quality for Okitsu Satsuma during the juvenility period in Dortyol (Hatay, Turkey) conditions. In: 7th International Society of Citrus Nurserymen Congress.Cairo, Egypt, Sept., 17-21.

Khalifa, S.M. and A.E. Hamdy (2015). Effect of some citrus rootstocks on yield and fruit quality of two mandarin varieties. 6th Inter. Sci. Agric. Sympo., Agrosym. Pp. 182-190.

Knauer, T., M. Dummer, F. Landgraf and C. Forreiter (2011). A negative effector of blue light-induced and gravitropic bending in Arabidopsis. *Plant Physiol.,* **156:** 439–447.

Kramell, R. (1996). HPLC separation of jasmonic acid methyl ester enantiomers. *Phytochemi. Analy.,* **7:** 738-743.

Kubo, T. and S. Hiratsuka (1998). Effect of bearing angle of Satsuma mandarin fruit on rind roughness, pigmentation and sugar and organic acid concentrations in the Juice. *J. Jpn. Soc. Horti. Sci.,* **67:** 51–58.

Kubo, T. and S. Hiratsuka (1999). Histological study on rind roughness of Satsuma mandarin fruit. *Engei. Gakkai. Zasshi.,* **68:** 101–107.

Kubo, T. and S. Hiratsuka (2000). Relationship between rind roughness and gibberellins in Satsuma mandarin fruit. *Engei. Gakkai. Zasshi.,* **69:** 718–723.

Lindsay, W.L. and W.A. Norvell (1978). Development of DTPA micronutrient soil tests for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.,* **42:** 421-428.

Liu, F. (2012). Study on the anatomical morphology and quality changes of rough of Satsuma.Dissertation, Huazhong Agric. Univ., Wuhan.

Liu, J., C. Huang and D. Chen (1988). Effects of plant growth regulators on the development of flavedo and its relationship with peel roughness in Citrus reticulata *Cv.* Tankan. *Acta Horti. Sci.,* **15:** 165–168.

Lu Xiao-Peng, Fei-Fei Li, Jiang Xiong, Xiong-Jun Cao, Xiao-Chuan Ma, Zi-Mu Zhang, Shang-Yin Cao and Shen-Xi Xie (2017). Transcriptome and metabolomeanalyses provide insights into the occurrence of peel roughing disorder on Satsuma mandarin (*Citrus unshiu* Marc.) fruit. *Front Plant Sci.,* **8:** 1907. doi: 10.3389/fpls.2017.01907.

Mahouachi, J., D.J. Iglesias, M. Agustí and M. Talon (2009). Delay of early fruitlet abscission by branch girdling in citrus coincides with previous increases in carbohydrate and gibberellin concentrations. *Plant Growth Regul.,* **58(10):** 15–23.

Mohamed-Karima, A.H. and Omaima M. Hafez (2004). Effect of foliar spraying of some yeast mutants on Valencia orange trees (*Citrus sinensis*). *J. Agric. Sci. Mansoura Univ.,* **29(4):** 1995-2012.

Monselise, S.P. and E.E. Goldschmidt (1982). Alternate bearing in fruit trees. *Horti. Revi.,* **4:** 128–173.

Monthes, K. and L. Engelbrecht (1961). Kinetin-induced directed transport of substances in excised leaves in the dark. *Phytochemi.,* **1:** 58-62.

Muller, P. and W. Hilgenberg (1986). Isomers of zeatin and zeatinriboside in club root tissue: evidencefor trans-zeatin biosynthesis by *Plasmodiophora brassica*. *Physiol. Plant,* **66:** 245-250.

Olsen, S.R., C.W. Cole, S.S. Watnable and L.A. Dean (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. Washington: USDA Dep. *Agric. Circular,* **939:** 1-19.

Popko, J., R. Hänsch, R. Mendel, A. Polle and T. Teichmann (2010). The role of abscisic acid and auxin in the response of poplar to abiotic stress. *Plant Biol.,* **12:** 242–258.

Rebbeca, B. (2004). Soil survey laboratory methods manual.Soil Survey Investigation Report. 42 Natural Resources Conservation Services.

Riefler, M., O. Novak, M. Strnad and T. Schmulling (2006). Arabidopsis cytokinin receptor mutants reveal functions in shoot growth, leaf senescence, seed Size, germination, root development and cytokinin metabolism. *Plant Cell,* **18:** 40–54.

Santner, A., L. Calderon-Villalobos and M. Estelle (2009). Plant hormones are versatile chemical regulators of plant growth. *Nature Chem. Biol.,* **5:** 301–307.

Shalom, L., S. Samuels, N. Zur, L. Shlizerman, A. Doron-Faigenboim and E. Blumwald (2014). Fruit load induces changes in global gene expression and in abscisic acid (ABA) and indole acetic acid (IAA) homeostasis in citrus buds. *J. Exp. Bot.,* **65:** 3029.

Shindy, W.W. and O. Smith (1975). Identification of plant hormones from cotton ovules. *Plant Physiol.,* **55:** 550-554.

Snedecor, G.W. and W.G. Cochran (1980). In "Statistical Methods" 7th Ed., Iowa State Univ. Press, Ames, U.S.A.

Stuetz, W., T. Prapamontol, S. Hongsibsong and H.K. Biesalski (2010). Polymethoxylated flavones, flavanone glycosides, carotenoids and antioxidants in different cultivation types of tangerines (*Citrus reticulata* Blanco *cv.* Sainampueng) from NorthernThailand *J. Agric. Food Chem.,* **58:** 6069-6074.

Ullah, R., M. Sajid, H. Ahmed, M. Luqman, M. Razaq, G. Nabi, S. Fahad and A. Rab (2014). Association of Gibberellic acid (GA_3) with fruit set and fruit drop of Sweet orange and farming system in the middle. *Res. J. Biolo. Agric. and Health,* **4:**.

Valiente, J.I. and L.G. Albrigo (2004). Flower bud induction of sweet orange trees (*Citrus sinensis* L. Osbeck): effect of low temperatures, crop load and bud age. *J. Ameri. Soc. Horti. Sci.,* **129:** 158–164.

Vogel, A.J. (1975). A text book of practical organic chemistry, 3rd ed., English Language Book Societyand Longman Group Ltd., pp: 843-845.

Waller, R.A. and D.B. Duncan (1969). A bays rule for the symmetric multiple comparisons problem. *Am Stat. Assoc. J.,* **64:** 1484-1499.

Wasternack, C. and B. Hause (2002). Jasmonates and octadecanoids: signals in plant stress responses and development. *Prog. Nucleic Acid Res. Mol. Biol.,* **72:** 165–221. 10.1016/S0079-6603(02)72070-9.

Wutscher, H.K. (1988). Performance of Hamlin orange on 30 citrus rootstocks in southern Florida. *J. Am. Soc. Horti. Sci.,* **113:** 493–497.

Yoshida, Y., R. Sano, T. Wada, J. Takabayashi and K. Okada (2009). Jasmonic acid control of GLABRA3 links inducible defense and trichome patterning in Arabidopsis. *Develop.,* **136:** 1039–1048. 10.1242/dev.030585.

Zhang, Y., Y. Sun, W. Xi, Y. Shen, L. Qiao, L. Zhong, X. Ye and Z. Zhou (2014). Phenolic compositions and antioxidant capacities of Chinesewild mandarin (*Citrus reticulata* Blanco). *Food Chem.,* **145:** 674-680.