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GROWTH PATTERN AND BIOCHEMICAL DYNAMICS OF ACID LIME CV. KAGZI IN JHALAWAR DISTRICT

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ABSTRACT : Acid lime fruits are a matter of research because of its importance to agriculture and human diet. It is highly valued for its medicinal value. Acid lime (*Citrus aurantifolia* Swingle.) is one of the most important commercial citrus cultivars al and nutritive value irrespective of its economic significance in its daily use as well as in pickle industry. Acid lime fruit growth follows smooth sigmoidal type during fruit development. The patterns of fruit growth and changes in biochemical quality parameters were assessed at 15 days interval from fruit set to maturity. The fruits attained maturity in 120 days after fruit set when skin colour changed from green to yellowish green. There was a continuous increase in fruit size throughout the growth phase. At maturity, fruit weight reaches a peak of 97.85g and fruit juice recovery was 57.91%. The peel thickness and peel % decreased with progressive increase till it reaches full maturity; while pulp% and pulp to peel ratio showed an ascending trend with maturity. The value of specific gravity at peak maturity was 0.98. Based on the characteristics of different indexes, TSS and TSS/TA ratio revealed advancing trend with advancing maturity and reached the steady status during 105-120 days after fruit set.

Keywords : *Kagzi lime, fruit weight, pulp, total soluble solids, total acidity,*

Acid lime (*Citrus aurantifolia* Swingle.) is one of the most important commercial citrus cultivars grown in many parts of the Rajasthan state. Acid lime fruits are a matter of research because of its importance to agriculture and human diet. It is highly valued for its medicinal and nutritive value irrespective of its economic significance in its daily use as well as in pickle industry. It bears fruits almost round the year with peak period during July-August. There is always a great demand of acid lime for table purpose, mouth freshing cold drinks, production of canned juice and increasing importance of frozen juice rising significantly all over the world. Growth studies have been done in many other fruit crops vis a vis physico-chemical changes in fruits during various growth phases by Neog and Mohan (6).

So far information with respect to changes in various fruit quality indices during the growth and development of acid lime cv. Kagzi is still lacking under Vertisols of Jhalawar district. The present studies were undertaken at Kagzi lime orchard at Fruit Instructional Farm of College of Horticulture and Forestry, Jhalawar to ascertain the various aspects of physical and biochemical changes in acid lime cv. Kagzi fruits during growth and development in order to standardize right stage of maturity for harvesting.

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MATERIALS AND METHODS

Experimental Site : The present investigations were conducted during 2014 at the Fruit Instructional Farm of College of Horticulture and Forestry, Jhalawar at Kagzi lime orchard utilizing 7 years old, uniform, healthy bearing plants of acid lime cv. Kagzi.

Data Collection and Determination : The flowers on the similar age basis at the time of anthesis (13 February, 2014) were tagged to obtain physiologically mature uniform fruits. Criteria of eight fruits comprising one unit at single stage of harvesting was used under the study. Sixteen fruits were harvested selectively for random sampling at an interval of fifteen days from fruit setting (01 March, 2014) onwards till the harvest maturity in order to assess various morphometric and bio-chemical changes of acid lime fruits at different stages. Fruit weight was measured on electronic weighing balance of Sartorious make. Horizontal diameter and peel thickness were measured using Vernier Callipers. Total soluble solids content was estimated using hand refractometer by making temperature corrections. Specific gravity on wt. /volume basis as well as the thickness of different components of lime fruit (pulp, peel etc.) was also measured. The ascorbic acid content, total sugars and reducing sugars percentage was determined by following the standard procedures of A.O.A.C.(1).

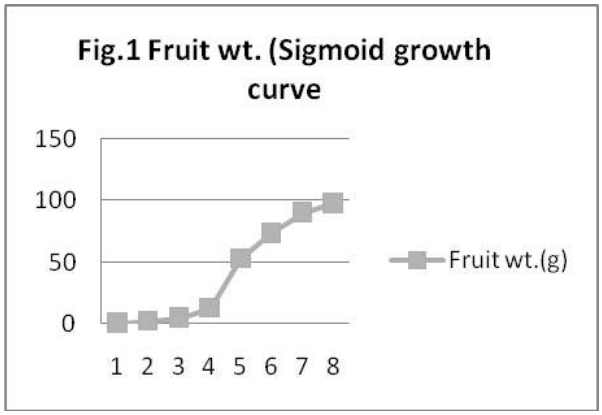
Statistical analysis: The experiment was investigated and performed using completely randomized block design and data were analyzed using Indostat Software.

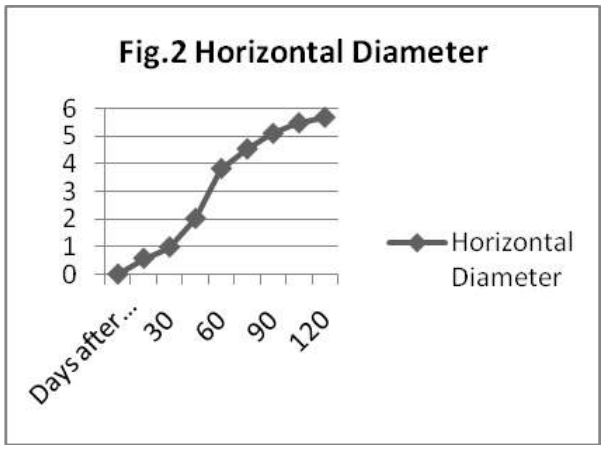
RESULTS AND DISCUSSION

The results are discussed in consonance to physical and chemical changes taking place during the various progressive growth and developmental stages of Kagzi lime fruit.

Morphometric changes

Fruit weight was 0.29g only at 15 days after fruit set (DAF) which reaches maximum (97.85g) at harvest. The trend in Fig.1 depicts sigmoidal curve of corresponding increase in fruit weight. Horizontal diameter of fruit increased rapidly from 45 DAF and it continued up to full maturity (Fig.2). The peel thickness however showed a declining trend with the advancement of fruit maturity. The peel thickness was 4.30 mm, when it was possible to be separated i.e at 60 DAF and the value was 2.25 mm at harvest maturity. There was a gradual decrease in peel percent however the pulp percent and pulp to peel ratio increased continuously towards harvest maturity. The pulp percent value was 55.02 at 60 DAF, which subsequently increased to 68.20 at harvest maturity with respective values for pulp to peel ratio of 1.13 and 2.15, correspondingly (Table 1).





The pulp which could be managed to be separated from 60 DAF measured a juice content of 18.45% and subsequently increased up to 57.91% at harvest maturity. The specific gravity of acid lime fruits was 0.97 at 15 DAF that further increased to a value of 1.03 at 90 DAF. The value of specific gravity at peak maturity was 0.97.

Biochemical changes

The total soluble solids content was high (7.300 brix) in early stages of growth, which later decreased with the increasing maturity till 45 DAF (Table 2) and subsequently increased thereafter from 60 DAF with the increasing maturity at 120 DAF. The total soluble solids content was 9.20° brix recorded at harvest maturity. The pulp could be separated from 60 DAF and revealed a TSS value of 7.10° brix, subsequently increased up to 9.20 at harvest maturity (120 DAF). The analysis study of whole fruit at 15 DAF recorded 4.10% total sugars while the content of pulp at harvest maturity showed 1.60% total sugars (Table 2).

The total acidity percentage in whole fruit as well as in the pulp revealed a progressive increasing trend with static increase towards harvest maturity (Table 2). The total acidity measured at 60 DAF was 5.80 % which further increased to 6.50% at maturity. The ascorbic acid content ranged from 75.24 mg to 70.02 mg for whole fruit and for the pulp it varied between 63.58 mg and 48.96 mg/100g. in litchi. The acid lime fruits reached physiological harvest maturity at 120 days after fruit set. At the harvesting maturity, value of fruit weight was 97.85g and it contained 57.91% juice, 9.20°brix TSS, 1.60 % total sugars, 6.50% total acidity, TSS-acid ratio of 1.35 and 48.96 mg/100g ascorbic acid.

Morphometric changes

The increase in fruit weight registered a phenomenal increase with the progressive development of fruits. The growth in terms of increase in size of fruit continued till the physiological maturity was attained. The growth manifestation in terms of increase in size and fruit weight was chiefly ascertained to increase in size of cell, subsequent cell division and progressive accumulation of photosynthates within the intercellular spaces in the compartments of fruit as corroborated by Bollard (3). There was a progressive increase in the juice content with the concomitant fruit development till the fruits reached its physiological maturity stage. The higher fruit juice

Table 1 : Changes in physical characters of acid lime cv. Kagzi lime fruit during growth and development (2014).

Days after fruit set (DAF)	Fruit weight (g)	Horizontal diameter (cm)	Peel thickness (mm)	Peel (%)	Pulp (%)	Pulp-peel ratio	Specific gravity	Juice content (fruit pulp) %	Peel colour
15	0.29	0.57	-	-	-		0.97	-	Dark green
30	2.00	0.98	-	-	-		1.00	-	Dark green
45	4.77	2.01	-	-	-		1.00	-	Dark green
60	12.48	3.82	4.30	48.69	55.02	1.13	1.01	18.45	Dark green
75	52.78	4.53	3.85	45.00	55.28	1.22	1.02	23.90	Dark green
90	73.36	5.09	3.10	39.60	59.48	1.50	1.03	40.50	Dark green
105	89.95	5.47	2.80	34.34	64.67	1.88	0.98	55.65	Light green
120	97.85	5.67	2.25	31.69	68.20	2.15	0.97	57.91	Yellowish green
CD (P=0.05)	1.50	0.06	0.63	6.57	4.42	0.06	0.04	4.68	

Table 2 : Bio-chemical changes in the developing Kagzi lime fruit (2014).

Days after fruit set (DAF)	TSS (°Brix)		Total sugar (% fresh weight)		Total Acidity (%)		Ascorbic acid (mg/100g)		TSS-acid ratio	
	Whole fruit	Pulp	Whole fruit	Pulp	Whole fruit	Pulp	Whole fruit	Pulp	Whole fruit	Pulp
15	7.30	-	4.10	-	1.98	-	75.24	-	3.68	-
30	6.90	-	3.80	-	2.79	-	71.56	-	2.47	-
45	6.10	-	3.21	-	4.50	-	70.02	-	1.35	-
60	-	7.10	-	3.05	-	5.80	-	63.58	-	1.22
75	-	7.20	-	2.72	-	5.90	-	58.74	-	1.22
90	-	8.20	-	2.39	-	6.20	-	51.55	-	1.32
105	-	8.80	-	2.08	-	6.40	-	46.85	-	1.37
120	-	9.20	-	1.60	-	6.50	-	48.96	-	1.35
CD (P=0.05)	0.28	0.29	0.36	0.07	0.05	0.06	2.15	6.09	0.12	0.03

content could be attributed to rise in pulp percent and decrease in peel thickness. The results of present studies are supported by the findings of Vij (10) on Kinnow mandarin.

Biochemical changes

There is an accumulation of CO_2 in the presence of light in the immature green fruits containing chlorophyll which accounts for higher TSS during the early stages of development of fruits. The probable reason for again high TSS is due to dormant period of vegetative growth during summers in lime trees and this reduces the competition for resources and results in fruits with increased TSS supported by the findings of Mongi (8). The TSS in mature acid lime fruits is due to citric acid, amino acids and other organic compounds. The intense sun's rays the fruit receives can influence total soluble solids as reported by Carolina *et al.*(4). The higher values of ascorbic acid content during the early stages might be attributed to the adequate supply of hexose sugars via photosynthetic activity as reported by Mapson (7). However the decrease in ascorbic acid content at the later stages of development could be ascertained to enzymic loss of ascorbic acid through oxidation as supported by Soni and Randhawa (9). Similar findings were reported by Gaur and Bajpai (5). The increase in total acidity percentage towards the physiological maturity is due to excess production of organic acids such as citric acid, oxalic acid in the fruits. The results are supported by observations reported by Bartholomew and Sinclair (2) in lemon fruits.

Conclusion

Acid lime fruit growth follows smooth sigmoidal type during fruit development. Peel thickness and peel percentage decreased till it reaches full maturity. Fruit quality parameters *viz.* acidity percentage, juice content and total soluble solids content are gradually increased with fruit development. Harvesting of ambe bahar (flowering time February) acid lime fruits during month of May fetches remunerative returns to growers under North Indian conditions with quality production of acid lime fruits.

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