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# Development of Lime Fruit (*Citrus aurantifolia*) in Northern Gezira State, Sudan

***Elsadig Hassan Elsadig (Prof. Dr.)[1] and Amel Sir-Elkhatim Suleiman (Ms.)[2]**

[1]College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Sudan.
[2]Horticultural Sector Administration, Ministry of Agriculture and Irrigation, Khartoum, Sudan.

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**An experiment was carried out to investigate lime (*Citrus aurantifolia*, Sswingle) fruit development by recording the rate of the increase of size of the fruits during the season of the study. The experiment was conducted in a randomized complete design with 4 trees and four replicates (12 trees). On each tree the selected fruits are labeled. The diameter of each one was measured each week and for nine consecutive weeks. This was done to determine the rate of fruit development under the prevailing conditions. The results of the experiment showed that the highest values of development of fruits of lime and the highest mean size of the fruit occurred during the period of development from the first week to the ninth week. The statistical comparison for development of the fruits from the first week through the ninth week showed that there was a significant increase in size of fruits in the first weeks and a non-significant increase in the following weeks.**

**Keywords:** Lime, citrus, fruit development, gazira, aurantifolia.

## INTRODUCTION

Citrus is a common term and genus of the flowering plants in the family Rutaceae. It is a perennial plant. The most commonly cultivated species in this genus are the sweet orange, the mandarin, the grapefruit, the lemon and the lime .The citrus originates in the wet tropics in South East Asia but large scale commercial production is found in the sub tropics under irrigation [1].

The citrus fruits take second place among the fruits of the world. Physiologically, citrus fruit is a non- climacteric fruit. A fruit harvested near their horticultural maturity shows a gradual decline in rate of respiration and produces no ethylene [2].

The lime is a very important fruit and because of its characteristic bouquet and flavor, it is ideal for serving as a garnish, the juice is used for cold drinks, and the powdered dried peel is used in industry processing. The oil is used in the perfume industry. In tropical Africa limes twigs are popularly used as chewing sticks. The lime juice dispels the irritation and swelling of mosquito bites [3]. Lime, like all citrus fruits, is a good source of vitamin C and it is known as an effective antioxidant when eaten and when applied topically [4]. The green limes are common food ingredients in parts of Asia and Central America. Mostly, the fruit juice is used to impart a sour and refreshing fragrance to cold and warm dishes and drinks [5].

Fruit development is considered to start after anthesis, with the initial event being pollination followed by fertilization, growth, maturation and ripening. However, some aspects of fruit development even though not obvious to the observer start soon after flower induction. These earlier cellular level events are significant developmental pattern of the fruit. All stages of fruit development are associated with changes on the cellular and metabolic levels. These changes include cell division and enlargement. Activities of growth substances such as gibberellins and cytokines are major translocation materials to developing fruit [6].

No plant organs show growth at the same uniform rate even when conditions of food supply, temperature and light remain unchanged. The plant organs generally show three phases; the initial phase is the one of slow growth

*Corresponding Author's E-mail: elsadig_hassan2000@hotmail.com; Tel.: +249 912391278, +249 123101046.

**Table 1.** Mean development of fruits /week (cm).

| Week 9 | Week 8 | Week 7 | Week 6 | Week 5 | Week 4 | Week 3 | Week 2 | Week 1 | trees |
|---|---|---|---|---|---|---|---|---|---|
| 2.829 | 2.867 | 2.790 | 2.645 | 2.455 | 2.264 | 1.982 | 1.780 | 1.467 | 1 |
| 2.900 | 2.922 | 2.827 | 2.717 | 2.567 | 2.417 | 2.125 | 2.017 | 1.717 | 2 |
| 2.857 | 2.800 | 2.700 | 2.578 | 2.508 | 2.408 | 2.217 | 2.133 | 1.892 | 3 |
| 2.600 | 2.533 | 2.657 | 2.680 | 2.609 | 2.483 | 2.317 | 2.170 | 1.792 | 4 |

followed by a period of fast growth and finally during the third phase growth again slow down till it ceases. If a curve is plotted to indicate the growth in size of a plant organ at intervals, the shape of the curve shows these three phases of growth mentioned above which comprise the grand period of growth [7]. Waynick [8] measured the growth in diameter of Valencia oranges from September until the following summer. Maximum growth occurred between September 1 and about December 1, after which the rate of increase in fruit diameter fell off. He also found that the size on December 1 was proportional to fruit size at picking time and therefore useful in forecasting fruit size. Bain [9] found that oranges tend to accumulate soluble solids mostly in the final stage of fruit development when the increase in size was slowly taking place.

Most of the farmers harvest the fruits before maturation and this decreases the value in the market especially for the foreign market, because certain characteristics are desirable (full maturation). The importance of harvest in lime fruit must be clearly understood, it is necessary to know the period from pollination to harvest to determine the suitable time for harvest.

The objective of this study is to know the period of maturation of the lime fruit, from flower set until it reaches the maturation stage in the north El Gazira State. This determination of maturation period indicates the suitable time for harvest and hence leads to regulation of harvesting and marketing the produce.

## MATERIALS AND METHODS

The experimental area was located within a private orchard in Gazira State at Elbagear, about 40 kilometers, south of Khartoum State. It lies between the latitudes 13-32 north from the south and 15-30 north from the north, longitudes 22-32 east from the east and 20-34 east from the west. The total of area of this State is about 23,373 kilometers. The soil is mostly clay; the climate is dry in winter and with summer rains from July – September [10]. The rains increase towards the south of the State. The average rainfall per year is about 272 mm. The humidity between 70-80% in the rainy season and it is low in the dry season, between 18-32% .The mean maximum temperature throughout the year is about 36°C and the mean minimum temperature is about 20.6°C [10]. The Balady type lime trees (*Citrus aurantifolia*) were planted in this farm in 1990 at 4x4 meter spacing. The study continued for one season, July-September. The trees received regular irrigation throughout the experimental period. At the start of the study, healthy trees were selected randomly, and 12 small fruits of about equal size (1.7 Cm in diameter) were selected randomly on each tree and labeled. Each fruit was indicated by a number. The materials used in the study were, paper, meter, ruler, needle, string, polyethylene sheets and a Vernier caliper. The data collection was every week. The diameter of each fruit was determined at each reading using a Vernier caliper. The diameters were measured in centimeters. At the end of the study period the data collected showing the increase in the size of fruit were tabulated and graphed.

The experiment was conducted in randomized complete design with 4 trees four replications (12 trees). Collected data were analyzed using SPSS (statistical package in social science version 11-5) computer program.

## RESULTS AND DISCUSSION

Development of fruits of lime (*Citrus aurantifolia*) and the mean increase in size during the period of fruit development from the first week to the ninth week for the four trees are shown in table 1 and figures (1-4). The data in table 1 and figures 1 and 2 showed that the size of the fruit in the first tree and the second tree increased with time. In the first week the size of the fruit increased with increasing rate of growth. This growth pattern coincides with the growth stages, stage 1 and stage 2, according to the findings of Salunkhe [11] who stated that the growth and development of citrus trees take place in three stages.

Fruit size and weight increase is due to both fresh and dry weight increase of the fruit. As shown in table 1 and figure 3, the size of lime fruit increased with increasing rate from the first week to the ninth week. This result is also in agreement with the stages of growth according to Salunkhe [11].

The rate of size development increased in the first weeks at an increasing rate, while the size increased at a

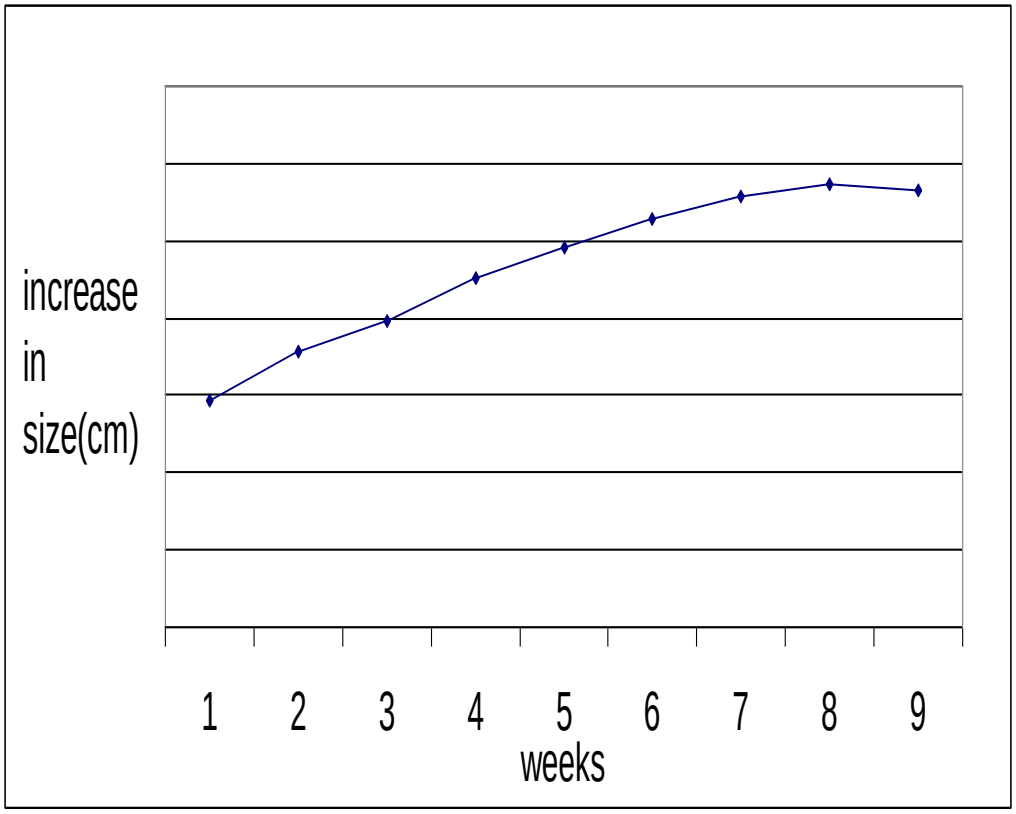


**Figure 1.** Mean development of fruits for tree (1).

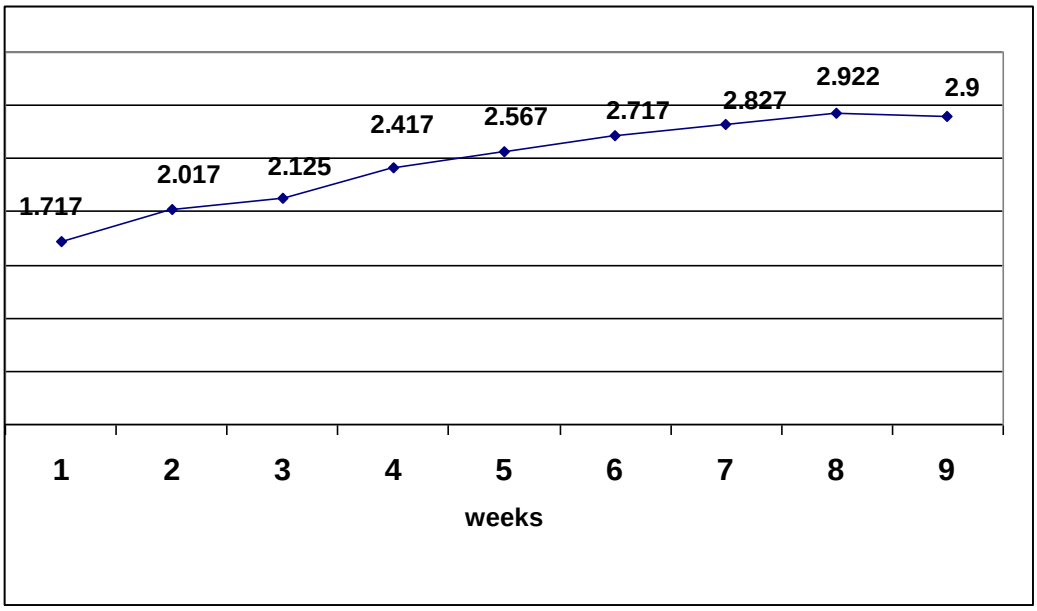


**Figure 2.** Mean development of fruits for tree (2).

decreasing rate during the ninth week of growth until it ceased (table 1 and figure 4). This fast increase in size is in agreement with the second stage of growth according to the Salunkhe [11]. The slow growth in the seventh week through the ninth week coincided with stage (3) according to the above definition and this result is in

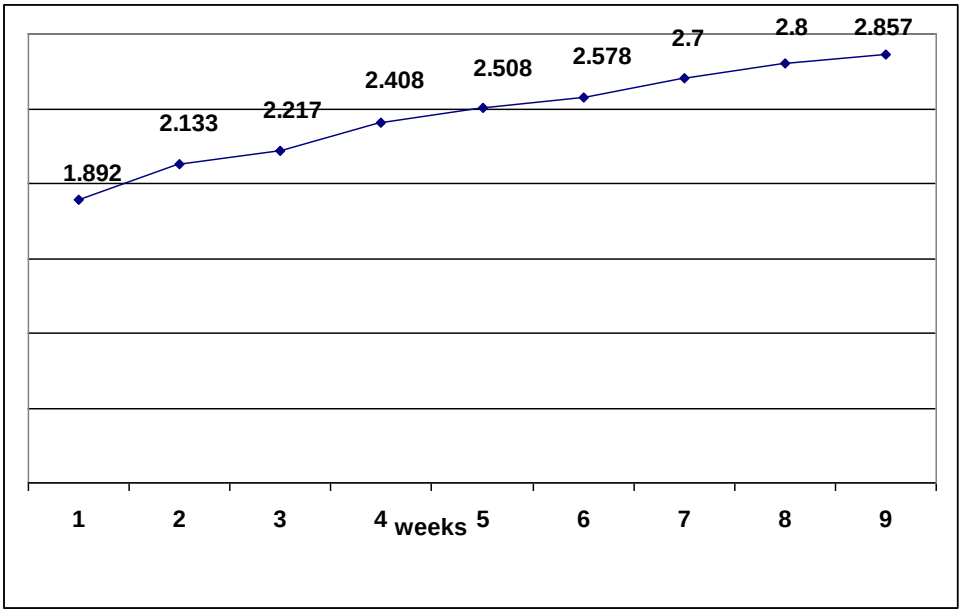


**Figure 3.** Mean development of fruit for tree (3).

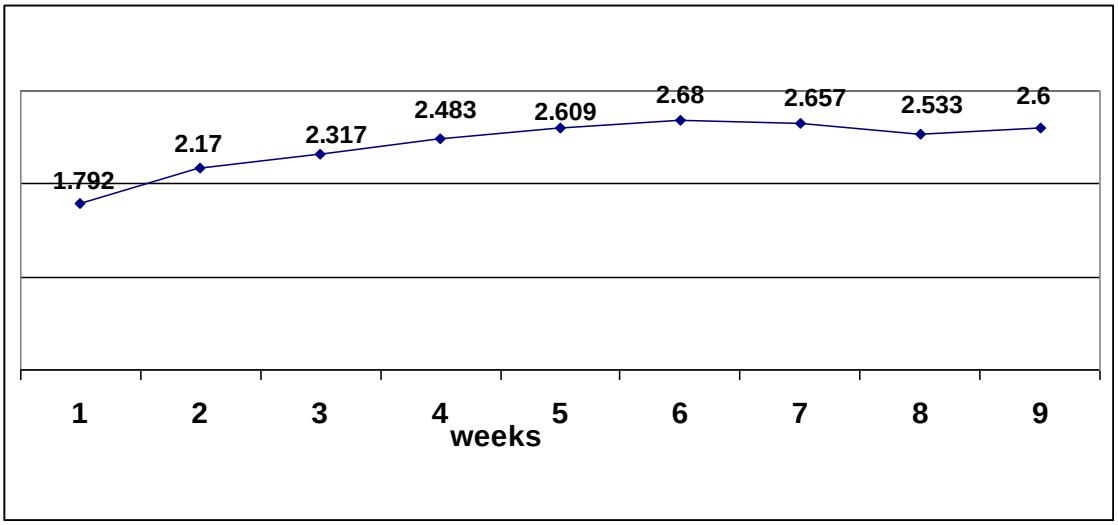


**Figure 4.** Mean development of fruit for tree (4).

agreement with Waynick [8] who measured the growth of diameter of Valencia orange fruit from September 1 until the following summer and found that the maximum growth occurred between September 1 and about December 1, after which the rate of increase in fruit diameter declined. He also found that fruit size on December 1 was proportional to fruit size at picking time and therefore useful in forecasting fruit harvesting time.

The statistically comparisons LSD for development of fruit of (*Citrus aurantifolia*) from the first week through the ninth week for the four trees are shown in table 2. There was significant increase in size of fruit in the first weeks and in-significant increase (at the .05 level) in the sixth week up to the ninth week. In the second tree there was significant increase in size between the first and second week and between the third and fourth week and there was in-significant increase in size between the second and third week and the fourth week up to the ninth week. Likewise the third tree showed an increase in the first weeks and this increase in size is significant at .05 level. The previous result is in agreement with identification of Salunkhe [11] stage (1), which is distinguished as the period of cell division. Also there was a significant increase in size of the fruits in the second and third trees. The insignificant increase in the size of the fruits coincides with stage (3) which is the stage of change in

**Table 2.** Multiple Comparisons of fruit development per week on each tree.

| Tree | (i) week | (j) week | Mean Difference (I-J) |
|---|---|---|---|
| 1 | 1 | 2 | -.313(*) |
| | 2 | 3 | -.202(*) |
| | 3 | 4 | -.282(*) |
| | 4 | 5 | -.191(*) |
| | 5 | 6 | .191(*) |
| | 6 | 7 | -.145 |
| | 7 | 8 | -.077 |
| | 8 | 9 | -.038 |
| 2 | 1 | 2 | -.300(*) |
| | 2 | 3 | -.108 |
| | 3 | 4 | -.292(*) |
| | 4 | 5 | -.150 |
| | 5 | 6 | -.150 |
| | 6 | 7 | -.111 |
| | 7 | 8 | -.095 |
| | 8 | 9 | .022 |
| 3 | 1 | 2 | -.242(*) |
| | 2 | 3 | -.083 |
| | 3 | 4 | -.192(*) |
| | 4 | 5 | -.100 |
| | 5 | 6 | .069 |
| | 6 | 7 | -.122 |
| | 7 | 8 | -.100 |
| | 8 | 9 | -.057 |

* The mean difference is significant at the .05 level.

**Table 3.** Multiple comparisons of mean fruit development /week.

| Sig. | Mean Difference (I-J) | (J) weeks | (I) weeks |
|---|---|---|---|
| .000 | -.313(*) | 2 | 1 |
| .003 | -.134(*) | 3 | 2 |
| .000 | -.232(*) | 4 | 3 |
| .002 | -.139(*) | 5 | 4 |
| .007 | -.125(*) | 6 | 5 |
| .052 | -.095 | 7 | 6 |
| .151 | -.076 | 8 | 7 |
| .710 | -.022 | 9 | 8 |

The difference is significant at the .05 level mean.

the chemical constituents of the fruit.

Multiple comparisons of means of size of the fruits of lime (*Citrus aurantifolia*) development for the ninth week for all trees are shown in table 3.There was a significant increase in growth in the first week and in-significant in the seventh up to ninth week .This result is in agreement with the explanation given by Salunkhe [11] for growth stages. The increase in size with increasing rate from the first week up to the seventh week corresponds with stage (2). Stage (1) is a stage of slow growth and it may have been occurred before the study began. The increase in size between the seventh week and the ninth week

**Table 4.** Mean fruit development of all trees (cm).

| Week | No of fruit | Mean |
|---|---|---|
| 1 | 48 | 1.72 |
| 2 | 44 | 3.03 |
| 3 | 47 | 2.16 |
| 4 | 47 | 2.39 |
| 5 | 46 | 2.53 |
| 6 | 42 | 2.66 |
| 7 | 37 | 2.75 |
| 8 | 30 | 2.83 |
| 9 | 23 | 2.85 |

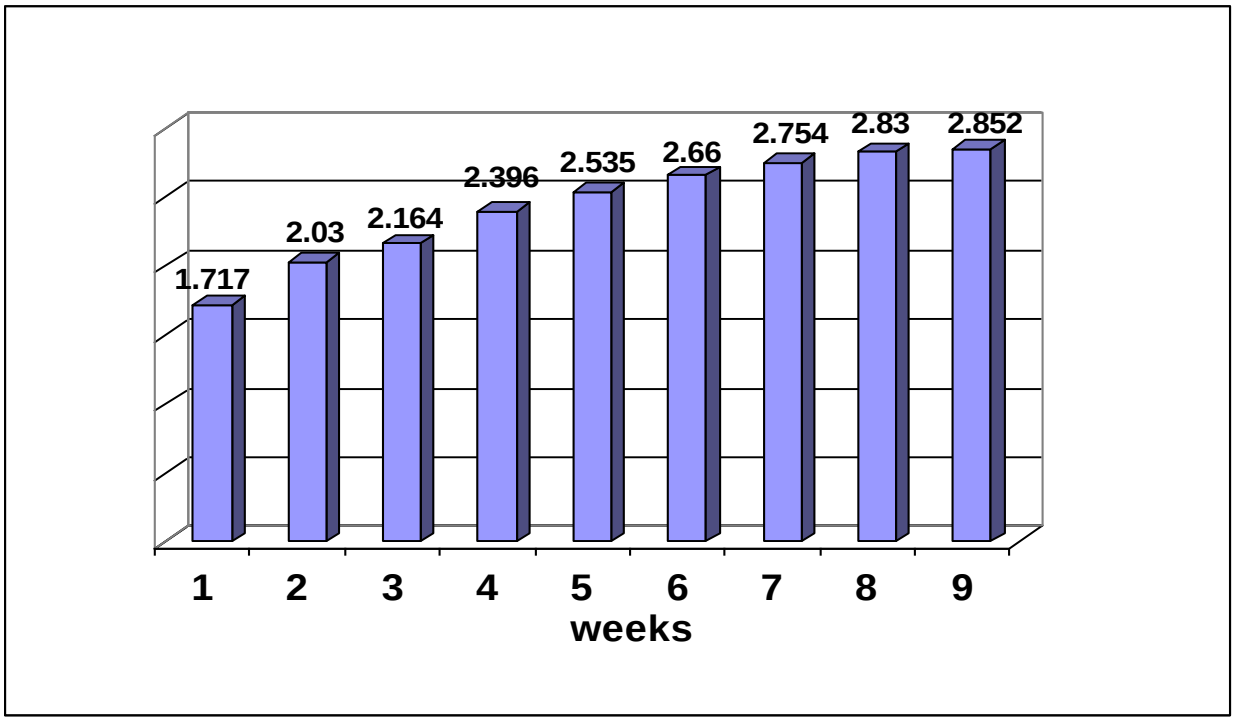


**Figure 5.** Fruit development.

corresponds with stage (3) according to the explanation given above.

The increase in size in lime fruit in all trees for the nine weeks are shown in table 4 and figure (5).There were increases in means between the first week up to the ninth week. This result is in agreement with the identification given by Salunkhe [11] for the sages of growth of citrus fruit.

## Conclusion

Lime fruit is important in nutrition as a source of vitamin C and an antioxidant, as well as its uses in medicine. Since the fruit growth is affected by the environment and since the tree flowers throughout the year, this study was conducted to study the growth rate of the fruit in this region. It revealed that the size of the fruit increased at an increasing rate up to the seventh week and subsequently at a decreasing rate. This is an important step in determining harvesting index and hence the suitable time for harvest. Further studies are recommended to determine fruit constituents at different stages of development and consequently set the harvesting index.

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