GROWTH, DEVELOPMENT AND MATURATION OF THE PURPLE (*PASSIFLORA EDULIS*, SIMS.) THE WHOLE FRUIT[1]

ILDO ELIEZER LEDERMAN[2] and SHMUEL GAZIT[3]

ABSTRACT - The growth rate pattern of purple passion fruit was studied in the southern part of the coastal plain of Israel. It has a very rapid sigmoid growth pattern and the attainment of its final size takes place in about three weeks - The relative fruitlet growth rate reaches a high outstanding peak of 210% per day, 4-7 days after fruit set. Passion fruits do not increase their dimensions after the short period of very fast growth. They keep their size and weight almost unchanged for more than two months, until they attain full ripening and abscission (aprox. 85 days after anthesis).

Index terms: growth rate, fruit ripening.

CRESCIMENTO, DESENVOLVIMENTO E MATURAÇÃO DO FRUTO DO MARACUJÁ-ROXO (*PASSIFLORA EDULIS* SIMS.)

RESUMO - A taxa de crescimento do fruto do maracujá-roxo foi estudada no sudeste da planície costeira de Israel. O fruto apresenta um modelo de crescimento sigmóide muito rápido, alcançando o seu tamanho final em cerca de 3 semanas. A taxa de crescimento relativo do frutilho alcança o destacável pico de 210% ao dia, aos 4-7 dias após a fertilização. O fruto não aumenta mais as suas dimensões depois do curto período de rápido crescimento. Seu tamanho e peso ficam quase que imutável por mais de dois meses, até que atinja a maturação plena e caia (aprox. 85 dias após a antese).

Termos para indexação: taxa de crescimento, amadurecimento do fruto.

INTRODUCTION

Passion fruit is a globose or ovoid berry with a non-edible hard pericarp (colored exocarp, greenish mesocarp and white endocarp), with many seeds attached to funiculi on the ovary wall, enclosed by yellowish aromatic pulpy juicy aril (Purseglove 1969).

Data on fruit growth and development of the purple passion fruit are meager. At Thika, Kenya, Gachanja & Gurnah (1981) reported that fruits attained their maximum size and full muturity 24 and 84 days, respectively, after anthesis, with the most rapid growth occurring during the first 13 days. Several studies have been conducted on yellow passion fruit growth. At Waimanalo, in Hawaii, the width and length of young fruitlets increased very rapidly up to the 11th day after pollination (Akamine & Girolami 1959). From then on, growth rate dropped rapidly on the 18th and 20th day when the maximum size was attained (Akamine & Girolami 1959, Gilmartin, 1958). They found that the time required from pollination to fruit maturity varied from 61 to 80 day, in different yellow passion fruit genotypes. Araújo et al. (1974) reported from Brazil that mean weight of the yellow passion fruit, increased upt to 39th day after anthesis, remained steady until the 53th day and then dropped during the later stages of fruit maturation, about 70 days after anthesis.

The growth and development of purple passion fruit grown in the southern part of the coastal plain of Israel with particular reference to the whole fruit, was studied.

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MATERIALS AND METHODS

Plant material

This research was carried out with five year old purple passion fruit vines grown in a loess-sandy soil, at the Habsor Regional Agricultural Research Station, located in the southern part of the coastal plain of Israel. Plants were regularly irrigated and fertilized during the dry season (April to November).

Pollination and fruit set

Flowers were hand-pollinated with pollen collected from freshly dehisced anthers. All data presented herein represent growth pattern of fruits, whose flowers were pollinated in a single day (May 5, 1982). Fruits were sampled at various time intervals; initially twice a week, later on, at weekly and 15-day intervals. Sampling of the pea-like ovary started at anthesis (0 (zero) day old fruits). Each sample consisted of 10 tagged fruits, collected randomly. The following physical and chemical analysis were carried out:

Fruit dimensions and fresh weight

The length and width of detached fruits were determined using a 1/20 mm precision caliber, and afterwards freshly weighed. Fruit volume was calculated by the formula $V = 1/6\ \Pi\ ab^2$; in which V = volume, a = fruit length and b = fruit width.

Chemical analysis of juice

Soluble solids (T.S.S.) percentage was determined with a hand refractometer. Acidity (as % of citric acid) was established by titrating 5 ml of juice with 0.1N of NaOH solution.

Temperature and relative humidity

Daily records of temperature and relative humidity were registered with a thermohygrograph placed close to the experimental plot. Fig. 1 shows the daily maximum and minimum temperatures and relative humidities recorded during fruit development studies.

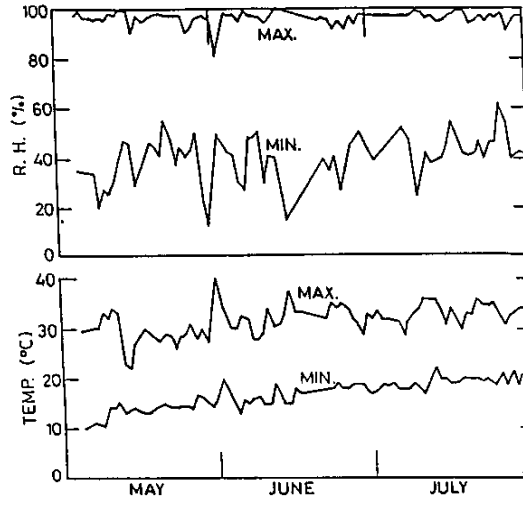

FIG. 1. Daily maximum and minimum temperatures (°C) and relative humidity (R.H.%) recorded during the period of fruit growth studies at the "Habsor Agricultural Experimental Station"; in 1982.

RESULTS AND DISCUSSION

Fruit growth pattern

The cumulative increase in fruit dimensions, calculated volume and fresh weight is depicted in Fig. 2. Immediately after anthesis fruitlets grew at a very fast rate, in their dimensions as well as on fresh weight basis. At about the 11th day, growth started to taper off. Fruits reached their maximum size and weight on the 23rd day. No significant changes in fruit dimensions and weight occurred during the following 62 days. Fruit ripened and were on the verge of abscission, at the age of 85 days. The slight decrease in fruit weight toward maturation was found to be non-significant.

The cumulative growth curves (weight and calculated volume) of purple passion fruit have the characteristic pattern of a sigmoid growth as plotted on a logarithmic scale (Fig. 2). A similar pattern of growth for purple passion fruit was reported by Gachanja & Gurnah (1981) in Kenya.

Passion fruit is distinguished for its relatively short period of fruit growth (Akamine & Girolami 1959), Araújo et al. 1974, Gachanja & Gurnah 1981). Our data show likewise that the fruit reaches its maximum weight and volume 23 days after anthesis (Fig. 2).

Afterwards, during 62 days in which the fruit attained full ripeness, no significant changes occurred in these values (Fig. 2).

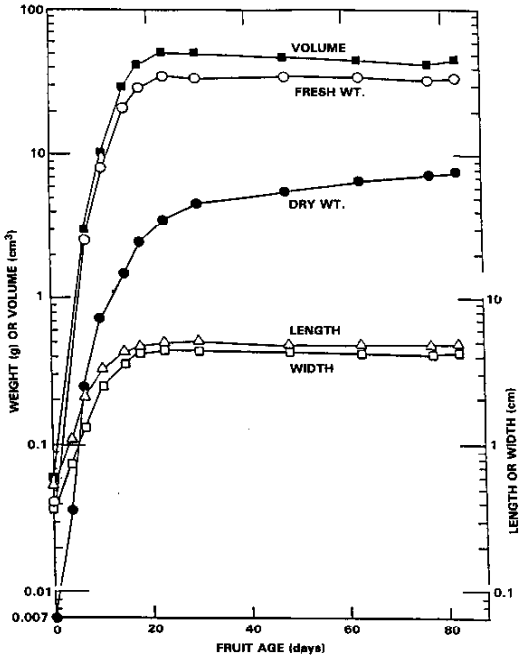

FIG. 2. Cumulative increase in fruit dimensions, volume (calculated), fresh and dry weight of purple passion fruit during fruit ontogeny.

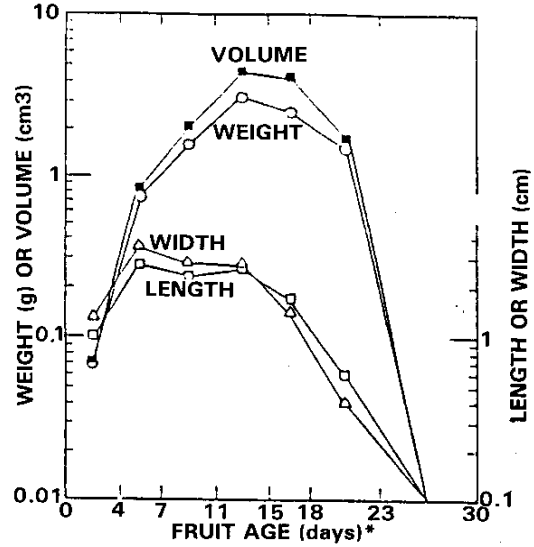

FIG. 3. Daily increment in fruit dimensions, weight and volume (calculated), during the period of purple passion fruit growth.

***Numbers from 4 to 30 on the abscissa indicate days at which fruits were sampled.**

Similar growth patterns were reported by Gachanja & Gurnah (1981) in the purple passion fruit as well as in the yellow-fruited variety (Araújo et al. 1974).

The daily increase in fruit dimensions, weight and calculated volume is depicted in Fig. 3. The rate of increase in fruit dimensions reached a peak when the fruit was 4-7 days old, but continued to be high up to the period of 11-15 days. The increase in fruit weight was very similar to the calculated increase in its volume. Both parameters reached a peak at the period of 11-15 days and remained high up to the age of 18-23 days. After fruit reached the age of 23 days, no significant changes in fruit dimensions or fresh weight occurred.

The relative daily growth rate of the fruit was calculated and is presented in Fig. 4. Fruit weight increased at a fast rate, 130% per day, during the first 4 days, and then, for the following 3 days, reached a peak of 210% per day. Afterwards, the relative growth rate decreased markedly.

The rather short period of time (23 days) in which passion fruit reached its maximum size, point to a very fast growth rate. Indeed, the relative fruit growth rate reached a very high value of ca. 210% per day between the 4th and 7th day (Fig. 3). This growth rate is much higher than those found in citrus (Monselise 1986), avocado (Blumenfeld & Gazit 1974) and tomato fruits (Varga & Bruinsma 1986). During the first 4 days after fruit set, relative growth rate was lower, Ca. 150% per day (Fig. 3). A pronounced peak is evident 4-7 days after fruit set. A similar relative growth pattern for the period immediately after fruit set was reported by Varga & Bruinsma (1986) in tomato and by Monselise (1986) in citrus fruits. The fact that 3 different and unrelated fruit species, have a similar pattern in growth rate immediately after fruit set, suggests that it may be a wide-spread phenomenon. The reason it has not

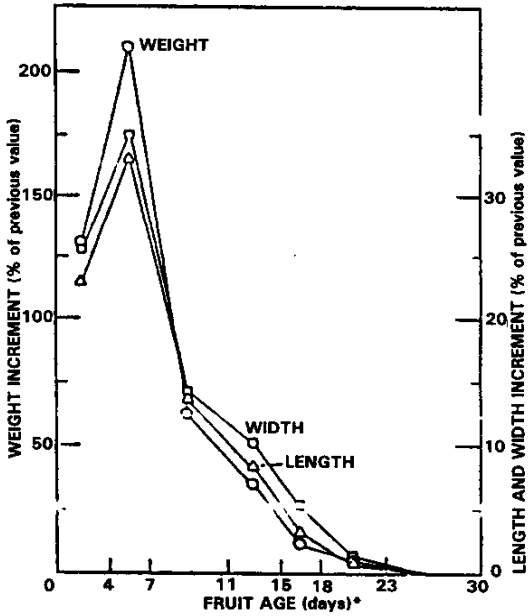

FIG. 4. Relative rate of daily increment in fruit dimensions and weight, during the period of purple passion fruit growth.

*Numbers from 4 to 30 on the abscissa indicate days at which fruits were sampled.

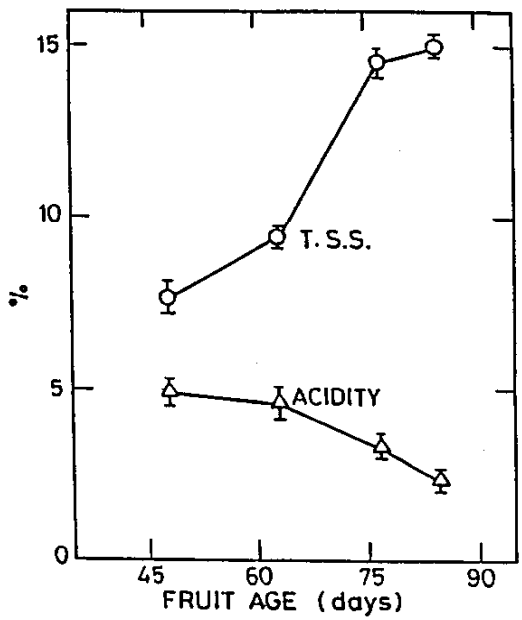

FIG. 5. Changes in total soluble solids (T.S.S.) and acid content (calculated as citric acid) in juice of the purple passion fruit, during fruit maturation and ripening.
Data (± SE) represent means of 10 replicates.

been reported so far in other fruit species may be due to technical difficulties in following growth in tiny fruitlets at the very first days of development.

Our data enabled us to determine ultimate fruit growth for the purple passion fruit; the increase was ca. 670 fold in weight and ca. 1250 times in volume (Figs. 2 and 4). This expansion factor is much less than those reported for avocado (Blumenfeld & Gazit 1974) and water melon (Coombe 1976) and higher than that found in "Corinth" grapes (Coombe 1976).

Chemical analysis of juice

Juice was first extracted when fruit was 30 days - old. At this time it had a pale-yellow color with a low content of total sugars and high acidity. As fruit approached ripening, juice color turned deep--yellow to orange, sugar content increased and acidity decreased (Fig. 5).

CONCLUSIONS

1. Purple passion fruit has a very rapid sigmoid growth pattern and the attainment of its final size takes place in about three weeks.

2. The relative fruitlet growth rate reach a high outstanding peak of 210% per day, 4-7 days after fruit set.

3. The highest daily increment in fruit weight and volume was reached at the age of 11-15 days.

4. Passion fruits do not increase their dimensions after the short period of very rapid growth. They keep their size and weight almost unchanged for more than two months, until they attain full ripening and abscission (aprox. 85 days after anthesis).

REFERENCES

AKAMINE, E.K.; GIROLAMI, G. **Pollination and**

fruit set in yellow passion fruit. [S.l.:s.n.], 1959. 44p. (Tech. Bull. Hawaii Agric. Exp. Sta., 39).

ARAÚJO, C.M.; GAVA, A.J.; ROBBS, P.G.; NEVES, J.F.; MAIA, P.C.B. Características industriais do maracujá (*P. edulis* var. *Flavicarpa*) e maturação do fruto. **Pesquisa Agropecuária Brasileira,** Brasília, v.9, n.9, p.65-69, 1974.

BLUMENFELD, A.; GAZIT, S. Development of seeded and seedless avocado fruits. **Journal of the American, Society for Horticultural Science,** v.99, n.5, p.442-448, 1974.

COOMBE, B.G. The development of fleshy fruits. **Annual Review of Plant Physiology,** v.27, p.507-528, 1976.

GACHANJA, S.P.; GURNAH, A.M. Flowering and fruiting of purple passion fruit at Thika. **East African Agricultural and Forestry Journal,** v.44, n.1, p.47-51, 1981.

GILMARTIN, A.J. Post fertilization and ovary development in *Passiflora edulis* Sims. **Tropical Agriculture,** Trinidad, v.35, p.41-58, 1958.

MONSELISE, S.P. Citrus. In: MONSELISE, S.P. (Ed.). **Handbook of fruit set and development.** Florida: CRC Press, Inc., 1986. p.87-108.

PURSEGLOVE, J.W. Passifloraceae. In: TROPICAL Crops. Dciotyledons. [S.l.]: Longmans Green & Co. Ltd., 1969. v.2, p.420-422.

VARGA, A.; BRUINSMA, J. Tomato. In: MONSELISE, S.P. (Ed.). **Handbook of Fruit set and Development.** Florida: CRC Press. Inc. 1986. p.461-481.