Growth and development of grenadilla plants
I. Morphology during the first phases of the growth cycle

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Abstract

Introduction. The initial phases of the grenadilla growth cycle were analysed to understand how this plant grows, for potential improvement and cropping purposes. **Materials and methods.** Plantlets grown from seed in a shaded nursery were transplanted into plastic bags filled with a suitable substrate; some were kept under shelters, and the rest were placed in shaded conditions. The appearance, shape, number and location of rootlets, leaves, tendrils, buds, aerial branches and flowers were monitored. Internode lengths and leaf surface were measured on the first four foliar helices on the main plant axis. **Results and discussion.** During its growth and development, the plant goes through embryonic, juvenile and transition phases before reaching the adult phase. Germination and emergence occur 10.5 and 15.5 d after planting. Germination is phanero-cotyledonary and epigeal. The juvenile phase lasts 80 ± 10 d, when the plant grows its first two foliar helices, and the phase ends when it bears 10 leaves. During the transition phase, from the third to the seventh foliar helix, several morphological changes occur: leaf size and shape, internode elongation, appearance of tendrils and the beginning of branching–the plant also takes on a creeping habit. The adult phase begins when the main axis begins flowering, ie, when the plant is about 195 d old and eight foliar helices have formed.

Keywords

Passiflora edulis, plant, life cycle.

Croissance et développement du plant de grenadille. I. Morphologie des premières phases du cycle.

Résumé

Introduction. Pour mieux comprendre la croissance du plant de grenadille afin d'améliorer, ensuite, sa culture, les premières phases de son cycle de développement ont été analysées. **Matériel et méthodes.** Les plantules, issues de la germination des graines sous ombrière, ont été repiquées en sacs de polyéthylène remplis d'un substrat approprié ; une partie d'entre elles a été placée sous abri, l'autre partie a été laissée sous ombrage. L'apparition, la forme, le nombre et la localisation des radicelles, des feuilles, des vrilles, des bourgeons, des ramifications et des fleurs ont été observés. La longueur des entre-nœuds et la surface foliaire ont été mesurées sur les quatre premières hélices foliaires de l'axe principal du plant. **Résultats et discussion.** Au cours de sa croissance et de son développement, le plant passe par les phases embryonnaire, juvénile et de transition avant d'atteindre sa phase adulte. Germination et émergence interviennent respectivement 10,5 et 15,5 j après semis. La germination est de type phanéro-cotylédonnaire et épigé. La phase juvénile dure 80 ± 10 j, temps nécessaire au plant pour former ses deux premières hélices foliaires ; elle se termine lorsque dix feuilles sont formées. Pendant la phase de transition, de la troisième à la septième hélice foliaire, plusieurs changements morphologiques interviennent : taille et forme des feuilles, élongation des entre-nœuds, apparition des vrilles et début de ramification ; par ailleurs, le plant acquiert le port grimpant. La phase adulte débute lorsque l'axe principal commence à fleurir ; le plant a alors environ 195 j et a déjà formé huit hélices foliaires.

Mots-clés

Passiflora edulis, plante, cycle de développement.

introduction

The *Passiflora* genus, the largest of the Passifloraceae, has most of its species originating from the new world (VANDERPLANK, 1991). It consists of 350 or 500 species (FOUQUÉ, 1972; HUTCHINSON, 1967). The passion fruit vine, *Passiflora edulis* f *flavicarpa*, is a perennial climbing by tendrils and it has foliar dimorphism with oblong young leaves and trilobate adult leaves (LEON, 1968; MORTON, 1967). The oblong leaves are often intercalated at intervals in the median and terminal portion of the vine axis (MORALES and MULLER, 1972). Its stem is monopodial, semihard woody and cylindrical.

The plants go through embryonic, juvenile and adult phases during the life cycle (KESTER, 1983; HARTMANN et al, 1990). The juvenile phase could be easily differentiated from the adult phase because of morphological and physiological characteristics (ZIMMERMANN, 1971). During the juvenile phase, of which duration varies according to genetic and environmental factors (HACKETT, 1983), no floral induction occurs. The plant becomes adult when it acquires the ability to flower and may respond to floral induction factors.

A set of progressive morphological and physiological changes takes place from the juvenile to the adult phase by the action of several mechanisms of which effects are added in a chain of complex events (HACKETT, 1985). The morphological and physiological changes have been seen to keep close in relation with the ontogeny between the plant structure and the behaviour of the apical meristem (HACKETT, 1985).

Some general aspects about the morphological growth habit of passion fruit vine have been known (MORTON, 1967; LEON, 1968; MORALES and MULLER, 1972) though the features of each developmental phase had not been considered. This paper aims to describe and analyze the growth and development of the first phases of the passion fruit vine.

materials and methods

This study was conducted in the Postgrado de Horticultura, Universidad Centroccidental Lisandro Alvarado, Barquisimeto, Venezuela (10 05' N, 69 16' W; 510 masl).

procedure

The developmental morphology was described by macroscopic observations from the beginning, when the first structure and the characteristic organs had appeared. The observations were taken through the different phases of the ontogeny.

biological material

The seedlings were obtained from seeds of ripe fruits which were put on a tray filled with a mixture of soil, sand and rice shells in portion 1:1:1 by volume, for emergence. The emergence took place under a shade house with 80% of solar light restriction, average day temperature of 26 ± 2 °C and 65 ± 15% of relative humidity. The seeds were sowed at 10 mm depth and watered every day. Sowings were done several times at different dates.

Seedlings with one true leaf at least were transplanted to polyethylene bags filled with the same substrate used for germination. One part of seedlings was placed under a roof built by sheets of translucent fibre glass; another group of seedlings was left under above mentioned shade conditions. In both cases, the seedlings were watered, fertilised and trained vertically: each group was formed by 36 or more seedlings.

observed variables

The initiation and appearance of structures and organs such as radicles, leaves, tendrils, buds, lateral branches and flowers were chronological determined on the epicotylar axis. Also, shape, number and location of structures and organs were watched. The internodal length and the foliar area of the first four phyllotactic turns were established on the main axis of the vines.

results and discussion

The cycle of life of *P edulis* f *flavicarpa* started as an embryo that resulted from an ovule fecundation by cross pollination (RUGGIERO

and ANDRADE, 1989). During its growth and development, the vine went through embryonary, juvenile, transition and adult phases, verifying the sexual cycle characteristic of a perennial plant, according to the criteria of KESTER (1983) and HARTMANN et al (1990). Along its life cycle, the vine showed features inherent to each phase.

embryonic phase

The embryonic phase is variable in time since it includes the embryo stage and the process of germination and emergence. The seed consists of an embryonal axis (hypocotyl-radicle), two laminar cotyledons, a yellowish endosperm and a hard episperm that is evaginated inward and invaginated outward (fig 1). The embryo holds only a small portion of the seed.

During the germination, the radicle protruded through the hard coat (the episperm) by opening longitudinally the suture line at the portion where the radicle was located (fig 2a). When the radicle was about 5 mm long, the hypocotyl began to elongate forming an eventual curvature like a hook (fig 2b) until reaching a upright position, leaving with it the leaflike cotyledons. After emergence, the cotyledons became functionally as photosynthetic structures, making the seedling independent from its reserves.

DUKE (1969) showed that *Passifloraceae* presented two types of germination that he defined as phanerocotylar and cryptocotylar. The passion fruit seed might correspond to the phanerocotylar type. However, according to a later classification by NG (1978), the germination of passion fruit seed would correspond to the epigeal type.

When the seedling had became upright, it showed the leaflike cotyledons, the cotyledonary node, the hypocotyl, the collar (transition zone between hypocotyl and root) and the root. The epicotyl, even not visible, became macrovisible later on.

The foliaceous cotyledons increased in size after they had became perpendicular to the seedling axis. At maturity, the cotyledonary leaves became oblong with palmated venation and retused apex. The petiole grew

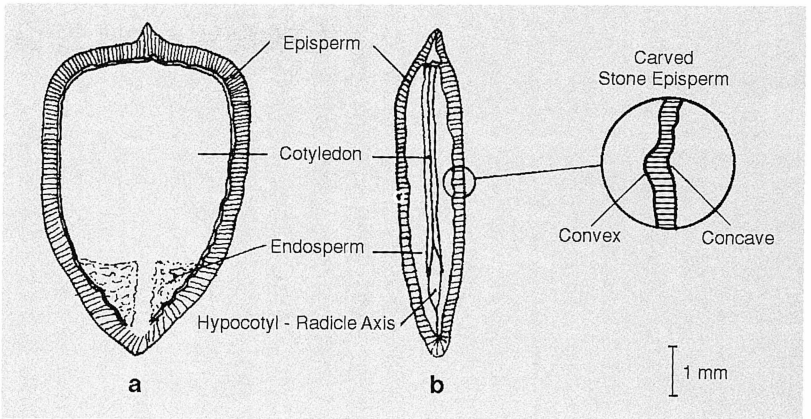

Figure 1
Seed part diagram of Passiflora edulis *f* flavicarpa.

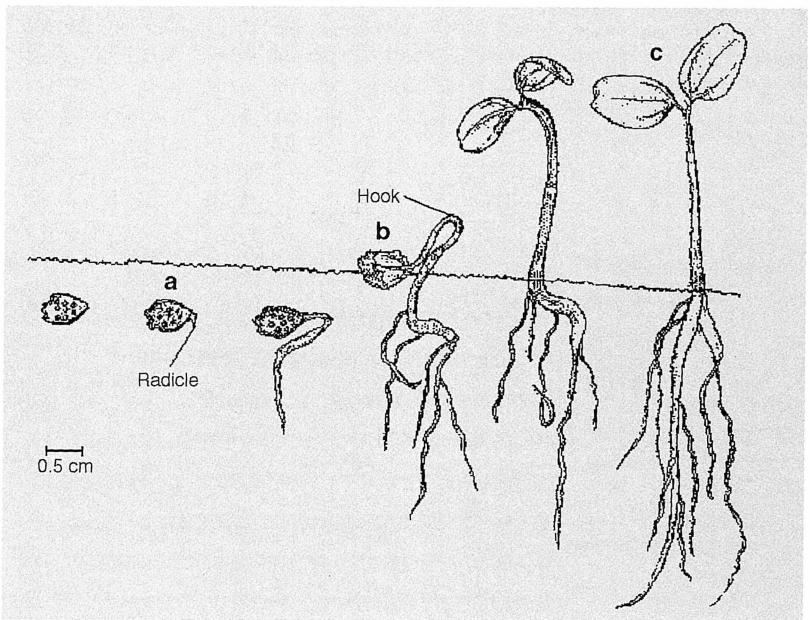

Figure 2
Germination evolution and emergence of Passiflora edulis *f* flavicarpa *seedlings.*

adaxially. The abscission of cotyledons had normally occurred about 70 days after emergence.

The radicle started to emerge at 4 d after sowing and the 50% germination (T_G 50) was reached at 10 or 11 d according to lab experiments (fig 3). The emergence seedlings started at 12 days and 50% of total emergence (T_E 50) was observed at 15 or 16 d under shade house conditions. The curves of germination and emergence showed similar tendency, though they presented a displacement in time. The seedling

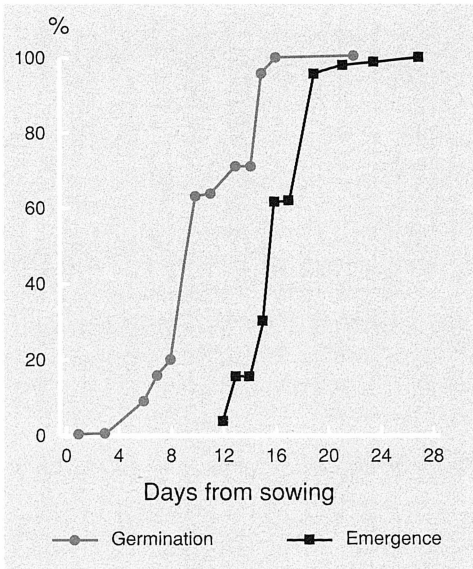

Figure 3
Germination and emergence of Passiflora edulis *f* flavicarpa *expressed as percentage from the total.*

emergence was noticed to start at 5.2 d after the germination process had taken place. It was remarkable that 50% of total emergence was reached when the germination had been 90%.

Sometimes, during the emergence process, it might occur that cotyledons remained wrapped by the endosperm giving to the seedling the appearance of a match. This might be due to lack of humidity in the substrate and/or a shallow sowing of seeds.

juvenile phase

The first leaf showed a decussate arrangement with cotyledons. It attained complete exposure at 7 d after seedling emergence. The leaves formed during this phase were simple, oval shaped, with acuminate apex and cuneate base. The venation was palmated with three veins emerging from the same point. The main vein branched alternatively and the leaves showed conduplicate vernation.

The petiole showed a pair of opposite and sessile glands in its distal portion. The petiole also presented a pair of linear stipules beside the basal insertion to the stem. At the beginning, the couple of stipules were more developed than the primordial leaf and formed a protective cupule to the growing apex and the younger primordial leaves. Each leaf presented a vegetative bud at the axil.

The internodal length remained constant along nodes belonging to the first phyllotactic turn (from first to fifth nodes). The internodes had showed a noticeable increase in length at the starting of the second phyllotactic turn until the 10th or 12th node. At this point the internodes reached the characteristic length of the adult plant (fig 4).

Under shade house conditions, it was observed that internodal length belonging to the first phyllotactic turn was higher than those under rain shelter, but it became higher under rain shelter than in shade house during and after the second phyllotactic turn had been formed (fig 4).

The leaf area increased slowly until the first two phyllotactic turns had been completed

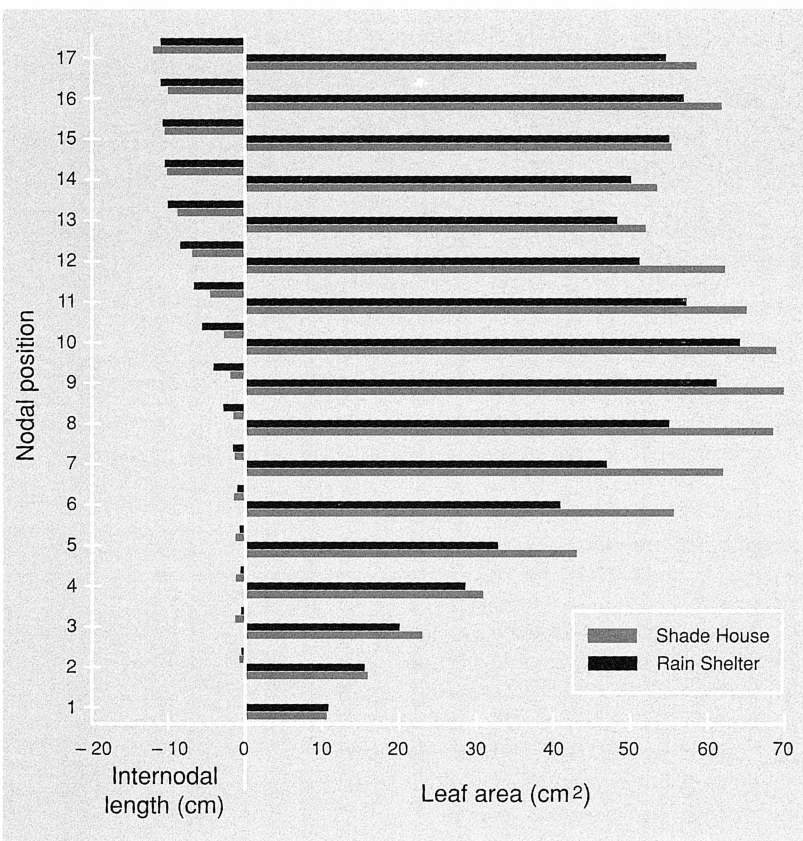

Figure 4
Leaf area and internodal length retated to nodal position on passion fruit seedlings.

(fig 4). Leaves from 11th to 15th nodal positions presented a slight decrease in foliar area, probably due to a sudden appearance of multiple growing points such as tendrils and root branches. Generally, the seedlings growing under rain shelter showed greater foliar area increments than those in shade house (fig 4).

The juvenile phase required at least 10 leaves, the equivalent of two phyllotactic turns, with 12 to 15 cm height, and 80 (± 10) days from its beginning to the characteristic changes of the following phase (fig 5). Abscission of the cotyledonary leaves occurred from 45 to 90 d after emergence. In general, the cotyledons had already abscised when the first two phyllotactic turns had been fulfilled.

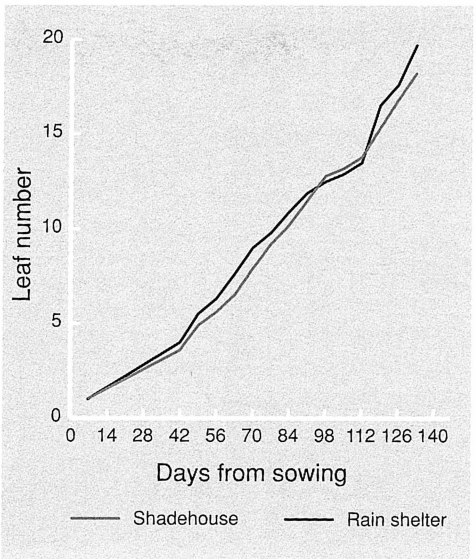

Figure 5
Leaf number of Passiflora edulis *f* flavicorpa *according to seedling age (n=60).*

transition phase

Changes in internodal lengths, leaf shape, tendril appearance and starting of lateral branching were morphological and physiological expressions that characterised the transition among juvenile and adult phases. The transition changes took place during the development of five phyllotactic turns (from third to seventh) after which the main axis had reached about 250 cm in length.

The passion fruit seedling became a liana by the internodal enlargement and, subsequently, it underwent decumbent position if supports were not provided. If the vine grew in decumbent position, the branching was early induced especially at the orthotropic position of the axis, corresponding to the portion formed during juvenile phase. If the vine was trained upright, the branching would take place later in the season. It seems that the branching might depend earlier on the orientation of the main axis and later on the attainment of a given grade or level of ontogenetic maturity of the vine.

The tendrils appeared continuously at the leaf base beside the axillary bud of the main axis. They were filiform, developed simultaneously to the leaves and might reach 18 cm in length. The first tendril frequently appeared at the eleventh node, as soon as the first two phyllotactic turns had been already complete (fig 6).

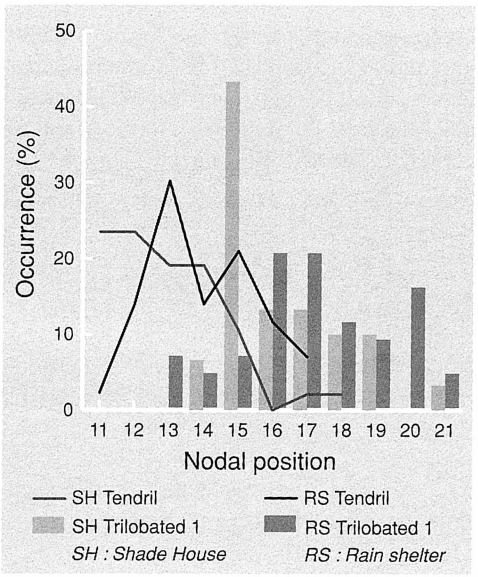

Figure 6
Tendril and trilobate leaf first appearance on passion fruit seedlings under shade house and rain shelter.

Both light intensity and day length seemed to influence the nodal position of the first tendril. The appearance of the first tendril occurred at a high nodal position in vines growing in days with photoperiods less than 12 h (November–February) and low light intensity (shade house) (fig 7). Generally, the first tendril appeared in the third or fourth phyllotactic turn, from 11th to 20th nodal position.

During the transition period some morphological changes occurred in the leaves. Those changes took place from a single

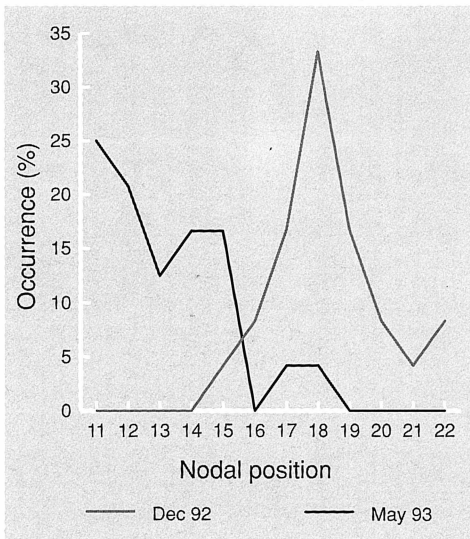

Figure 7
Tendril first appearance on passion fruit under shade house according to two different seasons (n=24).

complete blade to trilobate ones; MORALES and MULLER (1972) called the former juvenile leaves and the latter adult leaves. Occasionally, bilobate leaves were formed among complete blade and trilobate leaves. The three palmated veins at the base of a unlobate leaf gave rise to the middle vein in each lobe of a trilobate leaf.

The lobed leaves frequently appeared in nodes above the first tendril; however, occasionally they might occur at the same node (fig 6). It was noticeable that, during the transition phase from 11th to 15th nodal position, the internodal length became stable and the foliar area decreased at the same time as the tendrils and trilobate leaves appeared (figs 4, 6).

adult phase

The main feature of the adult phase was the appearance of flowers; the first one observed once the 8th phyllotactic turn of the main axis had been completed. This usually occurred at 195 d after the seedling emergency. The first flower appearance also coincided with, or above, the 25th nodal position after the first tendril.

The flowers emerged at the right and at the same level as the tendril on each axile along the axis. As soon as the adult phase had been initiated, a noticeable branching was observed. All the shoots presented a continuously lateral flowering despite the branching order.

note

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Crecimiento y desarrollo de la planta de pasionaria
I. Morfología de las primeras fases del ciclo.

RESUMEN

INTRODUCCIÓN. Para mejor comprender el crecimiento de la planta de pasionaria a fin de mejorar después su cultivo, se analizaron las primeras fases de su ciclo de desarrollo. **MATERIAL Y MÉTODOS.** Las plántulas, resultantes de la germinación de las semillas bajo umbral, se transplantaron en bolsas de polietilena llenas de un substrato apropiado ; una parte de ellas fue colocada bajo cobertizo la otra parte fue dejada bajo umbría. La aparición, la forma, el número y la localización de las raicillas, de las hojas, de los zarcillos, de los brotes, de las ramificaciones y de las flores fueron observados. La longitud de los entre-nudos y la superficie foliar fueron medidos sobre las cuatro primeras hélices foliares del eje principal de la planta. **RESULTADOS Y DISCUSIÓN.** Durante su crecimiento y su desarrollo, la planta pasa por las fases embrionaria, juvenil y de transición antes de alcanzar su fase adulta. Germinación y emergencia intervienen respectivamente 10,5 y 15,5 días después de las semillas. La germinación es de tipo fanero-cotiledoneal y epigea. La fase juvenil dura 80 Å 10 días, tiempo necesario a la planta para formar sus dos primeras hélices foliares ; esta se termina cuando 10 hojas son formadas. Durante la fase de transición, de la tercera a la sétima hélice foliar, varios cambios morfológicos intervienen : talla y forma de las hojas, elongación de los entre-nudos, aparición de las tijeretas y principio de ramificación ; por otro lado la planta se vuelve trepadora. La fase adulta empieza cuando el eje principal comienza a florecer ; la planta tiene entonces unos 195 días y ha formado ya ocho hélices foliaires.

PALABRAS CLAVES

Passiflora edulis, plantas, ciclo vital.