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Growth, fructification and plastochron index of different branches in the crown of the husk tomato (*Physalis ixocarpa* Brot.)

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ABSTRACT

The husk tomato (*Physalis ixocarpa* Brot.) is commonly cultivated in Central Mexico for its fruits. The plants of cv. 'Rendidora' show sympodial growth after forming 3-5 internodes in the main axis. From there on, each internode is terminated with a node having one flower bud, one leaf and 2 branches (dichasium type of branching). With the exclusion of the first 3 bifurcations which initiate 4 equal apparent main branches of the plant, each subsequent bifurcation has unequal ramifications: a stronger one which prolongs the apparent main branch, and a weaker one which serves as the origin of an apparent lateral branch. The apparent lateral branches form smaller internodes but these internodes require more time for their growth which is the reason that the plastochron lasts longer in the apparent lateral branches. By forming a smaller number of internodes in the same period of time, the apparent lateral branches reach a lower value of the plastochron index. All apparent lateral branches of a plant produce a greater total number of fruits, but a large proportion of them abscise. Due to this, the harvested fruits come principally from the apparent main branches. The phenology of the husk tomato plant is described. Its short period of development makes possible its cultivation in regions with a limited vegetative period.

Key words: branching type, dichasium, morphology

INTRODUCTION

The husk tomato (*Physalis ixocarpa* Brot.) is an important vegetable crop in Central Mexico. Its fruit is very similar to that of the red

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tomato (*Lycopersicon esculentum* Mill.) but is green to yellow, sometimes with dark violet shade, and has more parenchymatous tissue inside. It is used to prepare traditional Mexican dishes like sauces (moles) with hot pepper etc. The plant is commonly cultivated in Mexico from the time of the Aztec empire (Saray 1977, 1982).

There are no detailed descriptions of the development of this plant (Saray 1977, 1982), however, such a description is necessary for the planning of agricultural practices and in research. This work was done to describe some details of the vegetative and generative development of the husk tomato plant and to provide the scheme of its phenology taking as an exemple cv. 'Rendidora' which is commonly cultivated in the State of Morelos in Mexico due to its fertility and due to the larger size of its fruits (Saray and Loya 1978, Cardenas 1981).

We understand development as a concept which comprises both growth and differentiation (Loomis 1953, Listowski 1970, Wareing and Phillips 1970, 1981) and even senescence, abscission and death of plant parts or of the whole plant (Listowski 1970, Jankiewicz 1979).

We have expressed the chronological age of the plant in weeks after emergence and "developmental age" of the apparent branches as plastochron index (PI), (Erickson and Michelini 1957, Michelini 1958, see also Maksymowych and Erickson 1973, and Jankiewicz 1979). The concept of PI is used more and more often in recent scientific works (Lamoreaux et al. 1978, Sinclair 1984). As a PI unit (plastochron) for measuring the physiological age of a plant one can use any structure which appears rhythmicly during plant growth (Esau 1965). Normally the lapse of time between the moment when a leaf reaches a certain size (for instance 1 cm) up to the moment when the next one attains the same size is considered a plastochron. In our experiment we have taken as "one plastochron" the lapse of time between the moment when one internode attains 1 cm, up to the time when the next one reaches the same size. The internodes of the husk tomato attain up to 13 cm in length, therefore it is almost certain that when they reach 1 cm in length, they are in the period of exponential growth.

MATERIAL AND METHODS

The experiment during which the present description was done was set up in the Campo Agricola Experimental in Zacatepec, Morelos, México, during the dry period of the year (October 31 th to February 14 th, 1982/83) when the average weekly temperature was 17-22°. Cultivar 'Rendidora' (Saray et al. 1978) was used. The seeds were obtained from the Productora Nacional de Semillas. The plants were growing in deep loamy soil with a large proportion of clay. The field was furrow irrigated weekly. The distance between furrows was 100 cm and between pairs of plants 50 cm (two plants were left in each place).

The plants of the cv. 'Rendidora' are not homogenous genetically and show 2 types of growth: prostrated and erect, with some per cent of intermediate forms. In the case of fructification we considered these 2 forms jointly. The experimental field was divided into 8 plots and the plants used for the present description represented in most cases all 8 plots (one plant per plot for the erect and one for the prostrated form). The development of the plants was registered in the form of diagrams, some of which are presented (Figs. 1 and 2). Some other results of this experiment are presented in the papers of Cartujano et al. (1985).

Data for fructification (Figs. 6 and 7) were presented as the averages of the numbers of fruits and as the models of regression based on these averages. The equations used were of the 3 rd and 4 th grade. The method of minimum quadrates was used. The Statistical Analysis System version 822/IBM 370 was applied.

RESULTS

The husk tomato plant initially forms a single main axis with about 3-5 internodes above the cotyledons (Fig. 1). The last internode terminates with a node which bears one flower bud, one leaf and 2 lateral ramifications. Each of these ramifications forms only one internode whose terminal node has the same set of appendages: one flower bud one leaf and 2 ramifications. This module is continuously repeated until the death of the plant (Figs. 1 and 2). The only modification, which occurs howerver, is that a node has 2 leaves and one ramification, meaning that at this point no bifurcation appears. Therefore it can be stated that starting with the 3-5 internode of of which are presented (Figs. 1 and 2). Some other results of this experiment are presented in the papers of Cartujano et al. (1985). typical dichasium occurs in plants with decussate leaf arrangement (Denffer et al. 1971) the type of dichasium which occurs in husk tomato seems especially interesting.

The first 3 bifurcations have both ramifications of similar vigor which leads to the formation of 4 egual apparent main branches of the plant. All of the bifurcations which are produced afterwards form unequal ramifications: one of them is almost always longer than the other. The longer one contributes to the extension of the apparent main branch and the shorter one serves as the origin of the apparent lateral branch which may ramify further forming apparent sublateral branches and very rarely branches of a still higher order (Figs. 2 and 3).

The typical characteristic of the apparent main branches is that their internodes attain a different length in different zones. The largest ones occur in the central part of the branch whereas the basal, subterminal and terminal ones are shorter (Fig. 3, Table 1).

Table 1

Internode length (cm) in different zones of husk tomato apparent main branches (compare Fig. 3)

The zone	Prostrated plants	Erect plants
Basal	9.0	8.5
Middle	11.0	10.0
Subterminal	6.4	7.1
Terminal	3.25	3.3

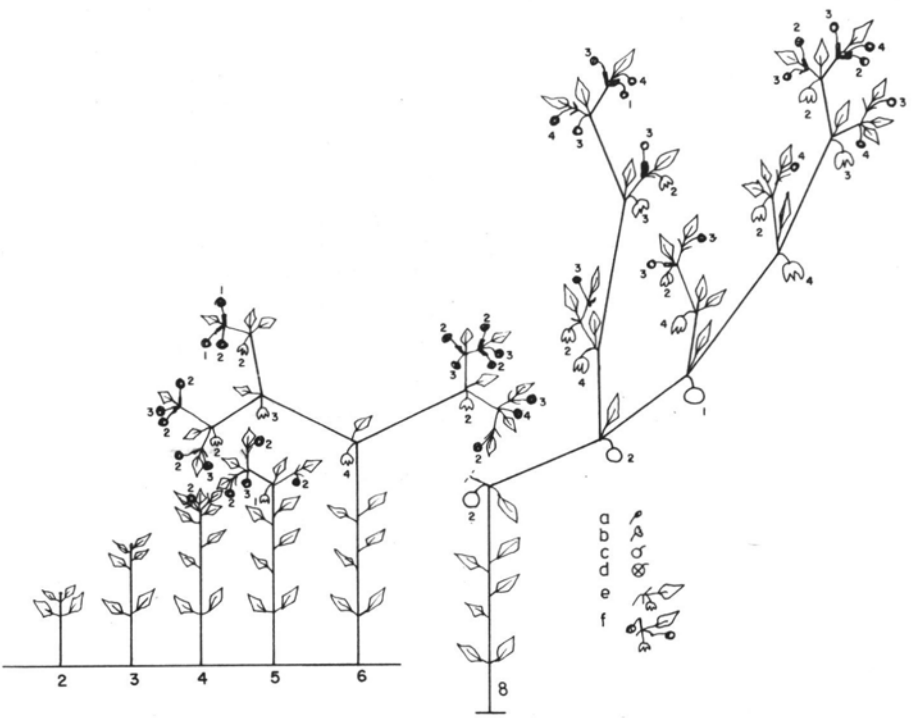

Fig. 1. Development of the husk tomato plant from the 2nd to the 8th week after emergence (see numbers at the bottom of the picture). a — flower bud, b — flower, c — fruit, d — fruit harvested previously, e — apical node with leaf, flower and 2 ramifications (marked with strokes) which are very young, with internodes less than 1 cm in length, f — apical node with a leaf, flower and 2 ramifications less than 1 cm which have, however, a well visible flower bud. The numbers below the flower buds, flowers and fruits in the picture indicate the stage of development in a scale 1-4 what for the fruits means: 1 — fruit 0-2 cm in diameter, 2 — 2-3 cm, 3 — 3-4 cm and 4 — more than 4 cm in diameter

In the same period of time the apparent lateral branch forms a smaller number of internodes than the apparent main branch (in connection with this it must be mentioned that in the husk tomato the apparent main, as well as the lateral branches, grow continuously up to the senescence of the plant). This means that the apparent lateral branch reaches lower value of PI than the main one in the same time (Table 2). This also means that the apparent lateral branch needs more time to produce one internode and due to this its plastochron lasts longer.

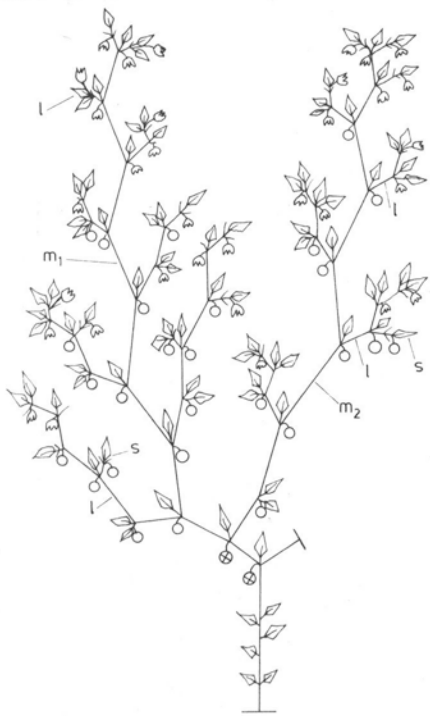

Fig. 2. Husk tomato plant 10 weeks after emergence. The legend to the symbols the same as in Fig. 1. Only two of the four apparent main branches are shown (m_1 and m_2), l — some of the apparent lateral branches, s — apparent sublateral branches

In spite of growing for longer time, the internodes of the apparent lateral branches are shorter. This was checked comparing in each bifurcation first and second internode of the apparent main branch with those of the apparent lateral one (Fig. 3, Table 2) and also the average length of the internodes of the apparent main branch and in the lateral one which initiate from the same bifurcation (Fig. 3, Table 2).

Fructification. The total number of fruits (existing on a plant in each date of checking) increased gradually up to its maximum at the 12 th week after emergence, and thereafter it abruptly decreased (Fig. 4). During the entire life cycle of the plant, fruits 0-2 cm in diameter constituted the major part of the total fruits (Fig. 4). This may reflect the phenomenon that the fruits need more time to reach the diameter of 2 cm than to pass from 2 cm to 3 cm and more. On the other hand, many fruits of the size 0-2 cm and some of the 2-3 cm abscise and never reach a larger diameter.

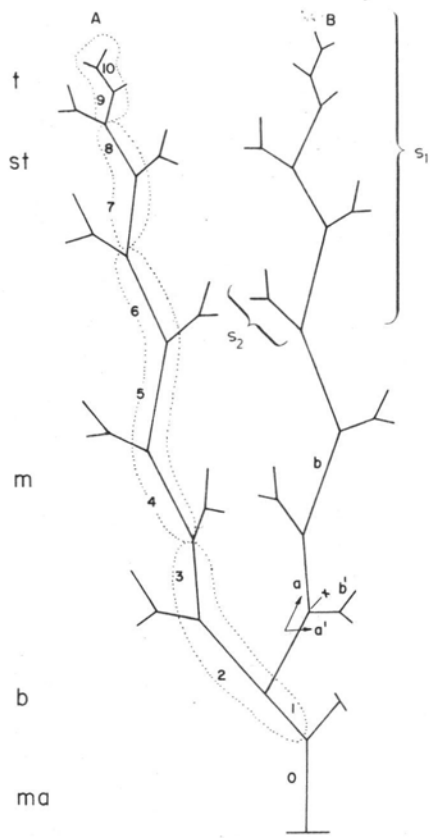

Fig. 3. Diagram of the husk tomato plant. A — one of the four apparent main branches (2 of which are shown) indicating zones (dotted) in which internodes were of different length: b, m, st and t — basal, middle, subterminal and terminal zones, respectively (see Table 2); ma — main axis temporarily non-ramified. B — the first (a, a') and the second (b, b') internodes compared in the main and lateral apparent branches departing from the bifurcation x (see Table 2), s_1 and s_2 — the entire main and lateral apparent branches departing from each node also compared

It also seement interesting to know which types of apparent branches are more productive. As already mentioned each node of the apparent main, lateral and sublateral branches produce a flowe bud. However, not

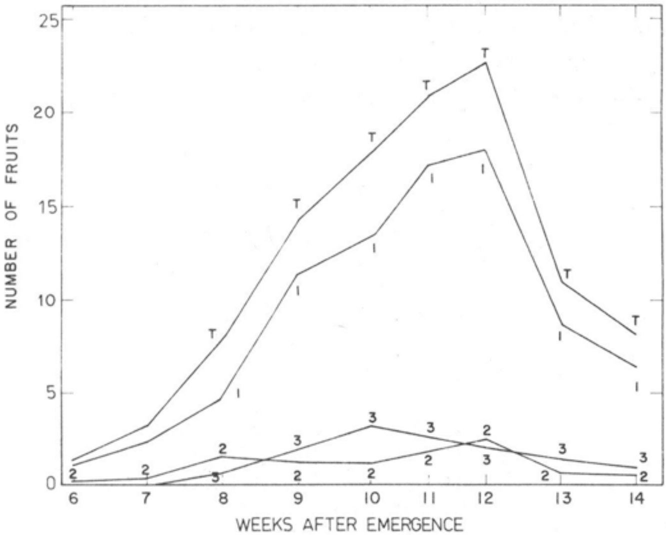

Fig. 4. Number of fruits found at a given time on the prostrated and erect plants considered jointly: T — total number, 1 — fruits 0-2 cm in diameter, 2 — fruits 2-3 cm in diameter, 3 — fruits larger than 3 cm

Table 2

Comparision of some characteristics of the apparent main and apparent lateral branches in each bifurcation in husk tomato plants (*Physalis ixocarpa* Brot.). (Joint means for prostrated and erect plants. In parentheses the actual data, in cm)

Apparent branches	Plastochron index, %	Length of the branches, %	Length of the 1st internode*, %	Length of the 2nd internode*, %	Mean length of all internodes, %
Main	100 (8.0)	100 (32.2)	100 (7.3)	100 (7.1)	100 (5.2)
Lateral	52.5	38.0	59.6	60.9	67.4

* Compare Fig. 3B.

all flower buds produce a fruit. As shown in Fig. 5, the nodes of the apparent main branch bear fruits more frequently than those of the lateral and sublateral ones. This means that the flower buds, flowers and possibly small fruits abscise less from the apparent main branches. However, due to the greater total number of nodes on the apparent lateral branches in the whole plant, they produce in total more fruits of the size 0-2 cm than the main ones, at least during the later part of the plant life (Fig. 6). The apparent sublateral branches also produce in total a substantial number of fruits of the size 0-2 cm, especially during the last period of the plant life. This is in contrast to the distribution of fruits larger or equal to 3 cm (Fig. 7): such fruits occur mainly on the apparent main branches, much less on the lateral ones and not at all on the apparent sublaterals.

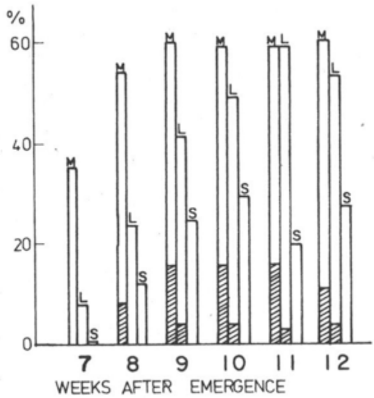

Fig. 5. Per cent of nodes which had a fruit at a given date in the apparent main (M), lateral (L) and sublateral (S) branches. White colimns — fruits of all sizes, stripped columns — fruits equal or larger than 3 cm

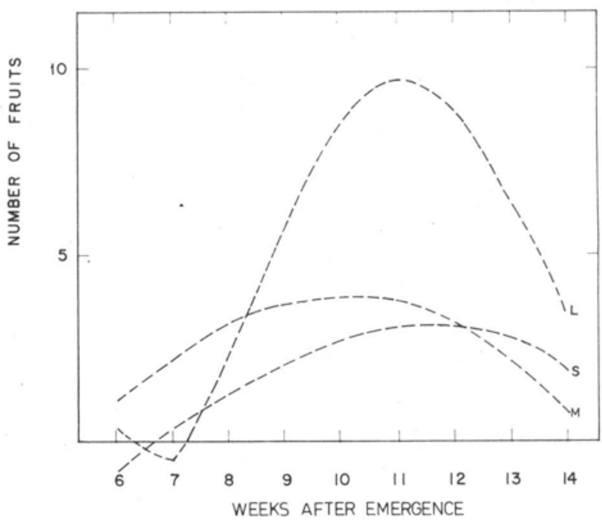

Fig. 6. Number of 0-2 cm fruits in the apparent branches: main (M), lateral (L) and sublateral (S). The fitted curves based on the regression equations: $M = -9.887 + 1.899\ F — 0.006\ F^3$, $L = 305.50 - 132.136\ F + 20.287\ F^2 - 1.303\ F^3 + 0.029\ F^4$, $S = -8.613 - 1.341\ F - -0.00021\ F^4$, where F = time in weeks

Sometimes the branches also appear on the initially nonramified main axis of the plant. They are not included in the presented figures and tables since they appear very irregularly. In some plants they are almost

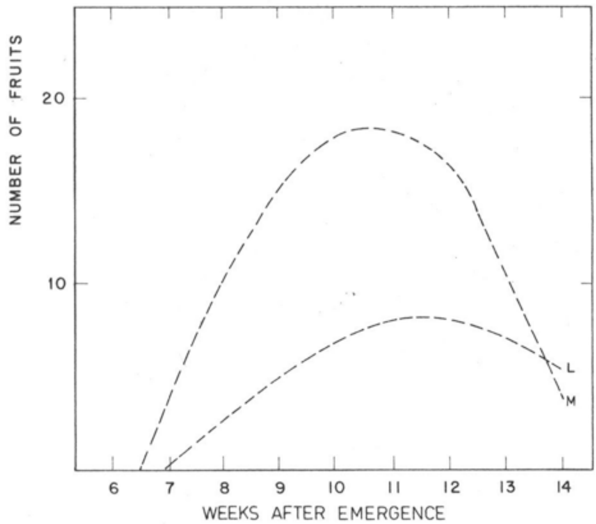

Fig. 7. Number of fruits equal or larger than 3 cm in diameter found on the plant in the given date. Other details as in Fig. 6. The apparent sublateral branches did not produce fruits. Regression equations: $M = -7.302 + 1.282\,F - 0.00037\,F^4$, $L = -2.179 + 0.366\,F - 0.0000051\,F^4$

absent, while in others they are very large. They appear late on the plants and in our experiment did not produce fruits large enough for harvesting.

Phenology. Germination lasted about 1 week (Fig. 8), elongation of the primary axis lasted up to the 4 th week after emergence (AE) and thereafter the plant grew sympodially. The vegetative growth continued in all apparent

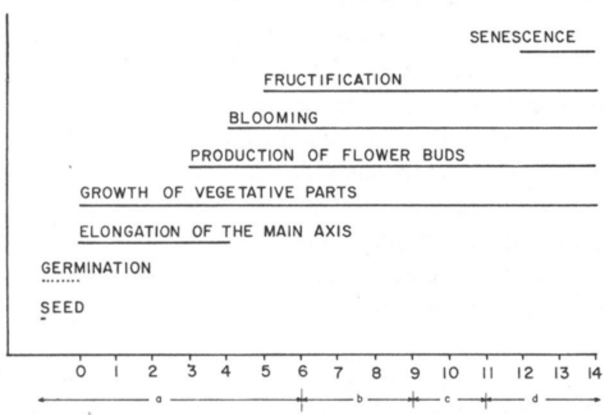

Fig. 8. Development of husk tomato plant in Zacatepec, Morelos, México. Abscissa: weeks after emergence. The letters a-d the phases of leaf area development: a — exponential growth, b — rectilinear maximum increments, c — decreasing increments, d — decrease of the leaf area (see Cartujano et al. 1985)

main and lateral branches of the plant up to the end of its life. The first visible flower bud was formed before the elongation of the main axis had terminated (3 rd week AE). Since that time the production of flower buds continued up to the end of the plant life. The first flowers appeared on the 4 th week AE, and the first fruits appeared on the 5 th week AE, reaching more than 3 cm in size on the 8 th week AE. The symptoms of senescence were already well visible on the 12 th week AE, and the death of the plant usually occurred on about the 14 th-15 th week AE. These data show that the life of the husk tomato plant is very short, so that it can be cultivated in a wide range of climatic conditions.

DISCUSSION

The diagram of the *Physalis ixocarpa* Brot. plant that we have presented is similar to that of Menzel (1951) for one of the interspecific hybrids of *Physalis*. As was mentioned the cv. 'Rendidora' of husk tomato has 2 types of growth: prostrated and erect which are described in detail in another of our papers (Cartujano et al. 1985). In respect to the characteristics described in this paper, the behaviour of the plants of both forms was similar.

The phenomenon of different length of internodes in different zones of husk tomato apparent main branches is analogous to which was found in poplar shoots (Maini 1966). This author found the internodes of maximum length in the middle part of the stem. The best nutritional and hormonal conditions for internodal elongation probably exist during the maximum growth of the plant (compare Fig. 8).

Concerning the differential growth of the apparent main and lateral branches it was interesting to find that the internodes of the apparent lateral branch had not only shorter internodes but these internodes were also growing more slowly. This in turn means that an average plastochron for an apparent lateral branch lasts longer than for the main one and that the lateral branch reaches lower PI. We have not found data in literature which describe a similar phenomenon. The husk tomato seems to be a good model to detect such differences because the main and the lateral apparent branches show continuous growth up to the death of the plant.

Fructification on the apparent branches of differnt types has not been investigated in the husk tomato by other authors. From the point of view of breeding, it seems interesting that the nodes of the apparent main branches are more fertile than those of the lateral ones, and that the abscission of fruits from the apparent lateral branches is greater than from the main ones. As was shown, the apparent sublateral branches do not produce at all fruits suitable for harvesting. Possibly the nodal parts of the apparent main branches show a greater competitive ability in comparision to those of the apparent lateral and sublateral ones, thus producing better conditions for fruit development.

The phenology of the husk tomato plant was described partially by Saray (1977). In general our phenological data are retarded by one week in relation to what he found (differentiation of flower buds 17-20 days after sawing, the first flowers 28-30 days, fruit set 35 days and maturation 55-57 days after sawing — Saray 1977). The short period of husk tomato growth makes its cultivation possible in countries with a shorter vegetative period than in Mexico, as shown by the successful trials made in Poland (Borkowski, personal comm.).

Acknowledgments

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Wzrost, owocowanie i wskaźnik plastochronowy różnych rodzajów gałęzi w koronie miechunki skórzastej (Physalis ixocarpa Brot.)

Streszczenie

Miechunka skórzasta odmiany 'Rendidora' jest powszechnie uprawiana w Centralnym Meksyku. Początkowo rośnie monopodialnie aż do wytworzenia 3-5 międzywęźli w osi głównej. Potem każde międzywęźle jest zakończone węzłem z kwiatem, na którym znajduje się także jeden liść i 2 boczne rozgałęzienia (typ rozgałęziania się "distachium"). Te boczne odgałęzienia rosną jednakowo tylko w pierwszych trzech wytworzonych rozwidleniach, dając początek czterem głównym, pozornym gałęziom rośliny. Każde później wytworzone rozwidlenie ma nierówne ramiona: większe z nich daje przedłużenie pozornej gałęzi głównej, natomiast mniejsze daje początek pozornej gałęzi bocznej (lateralnej). Pozorne gałęzie boczne mają mniejsze międzywęźla, które jednak wymagają więcej czasu do wzrostu. To powoduje, że w tym samym czasie pozorne boczne gałęzie wytwarzają mniej międzywęźli niż główne, a przez to ich wskaźnik plastochronowy jest mniejszy. Owoców jest w sumie więcej na pozornych gałęziach bocznych niż na głównych, jednak większość z nich przedwcześnie opada. Owoce nadające się do zbioru pochodzą przede wszystkim z gałęzi pozornych, głównych. Gałęzie pozorne, boczne drugiego rzędu (sublateralne) nie wytworzyły w ogóle owoców nadających się do zbioru. Opisano także fenologię miechunki skórzastej — dzięki krótkiemu cyklowi rozwojowemu nadaje się ona do uprawy w krajach o krótkim okresie wegetacji, np. w Europie środkowej.