Fruit formation dynamics in parthenocarpic cucumber (*Cucumis sativus* L.) in spring forcing

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Summary: 20% of the cucumber crop of the world belongs to the parthenocarp type. Parthenocarp cucumber forcing has a great importance in Hungary, too. In our country the whole area of parthenocarp cucumber forcing was approximately 500 ha of the last years (2000–2002) and 75–85000 tons of yield has been harvested (MGYSZT, 2003). It means 15 – 17 kg/m^2 as an average yield. In European forcing systems, parthenocarp cucumber is usually planted in January or February and it is harvested in spring or early summer. In Hungary cucumber forcing is the most profitable in two separate periods: spring and autumn, the reason for it is the changes of the average prices of fresh market cucumber, but spring forcing is still the most profitable. Forced cucumber cultivars are mostly parthenocarp; non-parthenocarp cultivars are grown in summer preferably. Cucumber cultivars, forced in our country, are hybrids, and 90% of them are offered by foreign seed companies (Kristófné, 1998.). The productivity of these hybrids is high and the productive period is quite short. All the mentioned details give the reason why it is important to know everything about the productivity, the dynamics of growth, and the possibilities of timing of parthenocarp cultivars, and it is also important to learn how to control all these parameters. Our spring cucumber-forcing experiment aimed to characterize of those parameters mentioned.

Key words: Parthenocarp cucumber; Forcing; Fruit growth

Introduction

Parthenocarp cucumber cultivars grown in Hungary are cultivated only on supporting systems in wide span greenhouses. Continuous growth, fruit set, and fruit formation need continuous and intense plant nutrition (*Saigusa* et al., 2001; *Nemeskéri & Nagy*, 2003) and irrigation.

The parthenocarp cultivars have female flower, for fruit set and fruit formation; pollination is not necessary (*Rudich* et al., 1977.). Parthenocarpy is not an exclusive feature of gynoic cultivars; it is expressed to the ratio of female flowers (*Rudich* et al., 1977 & *Kim* et al., 1992.). Low temperature and short-day conditions reinforce this character of cucumber cultivars (*Dean & Baker*, 1983.).

Fruit growth is influenced by the environmental parameters and the other parts of the plant (*Marcelis & Hofman-Eijer*, 1993.). From environmental parameters the most decisive are: temperature, irradiance and CO_2-level. Fruit growth reaches its maximum at 25 °C, the optimal interval is between 18 °C and 24 °C. In the case of higher temperature first fruits are harvested earlier but the stem elongates, the growth period is reduced and the total yield decreases (*Drews et al., & Liebig*, 1980.). When temperature is optimal, increase irradiance raises productivity. Under winter conditions, the productivity is the highest at 21 °C, higher temperature has no positive effect (*Marcelis & Hofman-Eijer*, 1993.). During the growth period, under concrete irradiance and optimal temperature, 700–1000 ?/l CO_2 concentration increases yield with rate of 20–43% (*Hand*, 1984; *Kimball*, 1986; *Tuba* et.; 1998a). The more fruits a plant develop at the same time, the slower their growth. (*Marcelis & Hofman-Eijer*, 1993.).

Growth of fruit has three phases. The first phase starts with the formation of flower initials and it ends with flowering, it is called cell-division phase. The second phase, called cell-elongation and the last phase is saturation (Wien, 1977.). However, the whole process of fruit formation and growth of a plant is not fully cleared yet. We set our experiment for the sake of this process to be explored more clearly.

Material and method

In 2001 we set a experiment of cucumber forcing in order to characterize the fruit formation and fruit growth of parthenocarp cucumber. Our experiment was carried out at the experimental and educational farm of the Department of Horticultural Technology of Szent István University, Gödöllő. We tested four cucumber hybrids: Bellissima F_1, Bronco F_1, Mustang F_1, and Nicola F_1.

The seeds were sown at 8th of January, into pots of 10 cm diameter. The seedlings were transplanted in the greenhouse at 20th of February. The average plant density was 2 plants m^{-2}. 15 kg m^{-2} manure was applied to the soil before transplanting. A randomised complete block design was followed and each hybrid was replicated 5 times (40 plants/hybrid). Once a week we pruned the plants, we cut all initial fruits and side-shoots until the plants reached the height of 60 cm. After reaching the mentioned height we cut all the axillary's shoots but we cut fruits only from every third nodes.

During the experiment, we recorded the start of flowering, the fruit length and diameter of the pistil during flowering, later on, we recorded the weight, the length and the diameter of marketable fruits, and the harvest date. Length and diameter of the growing fruit were recorded continuously, at harvest, the final size and number as well as weight of fruits. Data were recorded twice a week. Harvest period lasted from 10th April to 30th May. We used 20 plants for our observations, five plants per cultivar, they were chosen randomly.

Results

The weight of the total yield and the length of the harvest period are usually used to describe the performance of the cultivars. These parameters depend on the average yield of the cultivar, the length of productive period, the forcing season, and the cultivation technology. In our experiment the observed yield results differed slightly, the difference was only 13%. In comparison of the proportion of the early yield, which means the whole weight of the yield from the first six harvests (the first three weeks of the harvest period), the difference is less than 10% (see *Figure 1.*)

As it is shown in Figure 1 in the middle part of the productive period, we harvested 1 kg m^{-2} yield as an average. The average volume of the productive period was 20 kg m^{-2}; the proportion of the early yield was 25%. Fruits do not develop individually, development of fruit overlaps another fruit's developing time and so on, these intervals are continuously overlapped during the season. We found, that during the intensive fruit-developing period, usually 8–11 fruits were developing on the same plant plant. The required time a fruit needs to develop was between 14 and 25 days. *(Figure 2).*

At the beginning of the productive period, when the number of fruits is small on a plant, the growth of the first cucumbers is more intensive. Later, when there are more fruits on the plants, the time required to grow a fruit becomes longer. The length and diameter of the fruit primordium of the flower up to its full size and weight obtained at harvest was recorded, continuously, so the growth dynamics of each fruit could be reproduced.

Fruit growth has been divided into two phases. The first phase is cell-elongation when the fruit becomes longer but its weight does not increase much. The saturation follows this, it is the second phase, in which the diameter of the fruit grows and that is why its weight increases significantly. These two phases are correctly described with a polynomial curve. The data, from which we got the individual degrees of fruit growth, we got from our records, what we recorded twice a week on the 20 examined plants. The average time of fruit developing was 19.3 days; we calculated it from the start of flowering. In description of the average yield, the time of the two mentioned phases during fruit growth can be divided into 50–50% *(Figure 3).*

In the first phase of fruit growth (cell-elongation; cca.10 days; Wien, 1977) the growth of weight is small, related to the average weight of a harvested fruit it is only 27%, (95 grams, with a polynomial curve) as it can be seen in Figure 3. In the saturation phase (from the 10th until 20th day) the fruit weight grows by 73%. Using the whole yield's weight development data and the data of the overlapping of individual fruit developing times, we can get the total weight of fruits, in variable growing phases, developed in the same time by the plants.

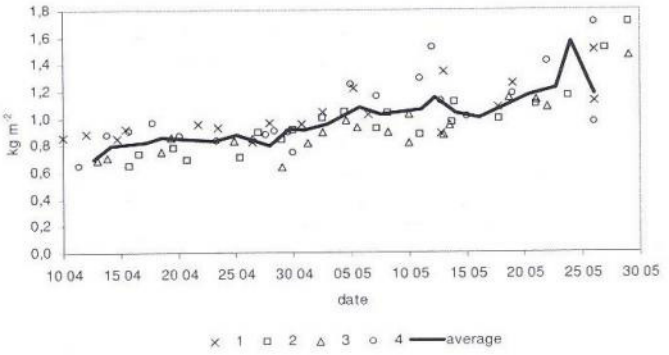

Figure 1 The dynamics of average volume during the harvesting period (1–4: varieties; -average yield kg m^{-2})

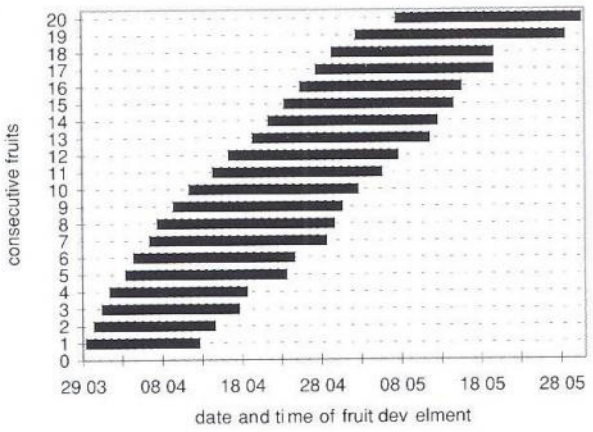

Figure 2 The required time of development and overlap of consecutive fruits in average

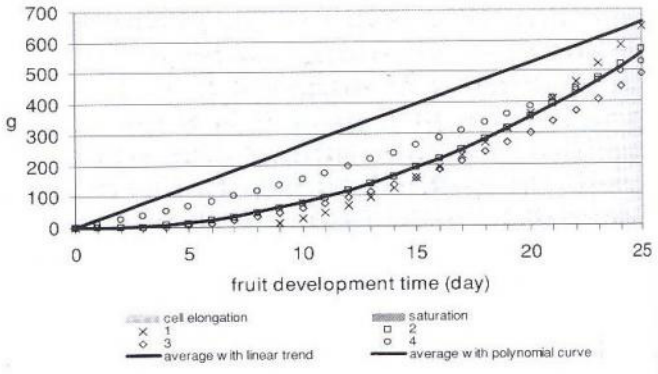

Figure 3 The curves of fruit development of the different varieties and in average. 1–4.varieties; -average value of development;

Examining the fruits developed in the same time on the plants, we pointed out that the first four fruits (on the lowest nodes) represent three-quarter of the whole weight, the next four fruits, which are placed higher, give one-quarter of fruits quantity, and any other fruit gives only 1%. This parameter mostly depends on the time of fruit development and on the precise timing of harvest *(Figure 4.)*. Our results show that, in the most important period of forcing, **the total weight of fruits** in variable phases, developed by our plants was **1.68 kg day^{-1} plant^{-1}**.

In the sake of the numerical defining the cultivars' productivity we calculated the daily growth of the total weight from the mentioned data. When we had harvested the fully developed fruits the growth of the weight increased, because more developed fruits put on weight quicker (Figure 5.). In the case of the hybrids studied, the **average daily growth of the total weight was 160 g plant^{-1}**. Figure 5 shows that the plants' productivity significantly decreases at the end of the growth season the average daily growth of the weight is only 100–150 g. In the most productive period (between the 10th of April and the 15th of May) it was 200 g day^{-1}. It practically means that a cucumber plant produces the weight of a fully developed fruit in 2–2.5 days as an average. A plant can develop only 8–11 fruits at the same time without any problem, so pruning should be performed according to this capacity.

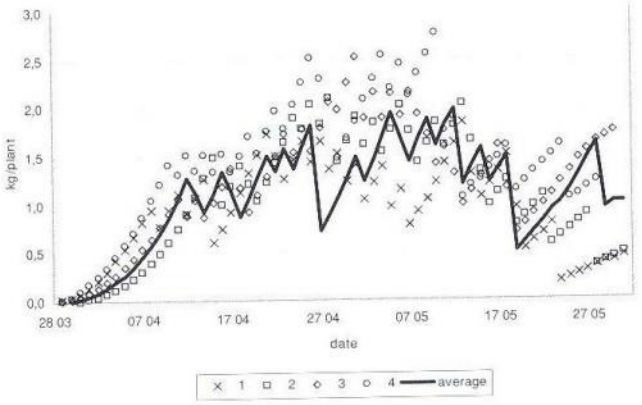

Figure 4 The total volume of fruits per plant in average at the same time. 1–4: varieties; – average value of total volume

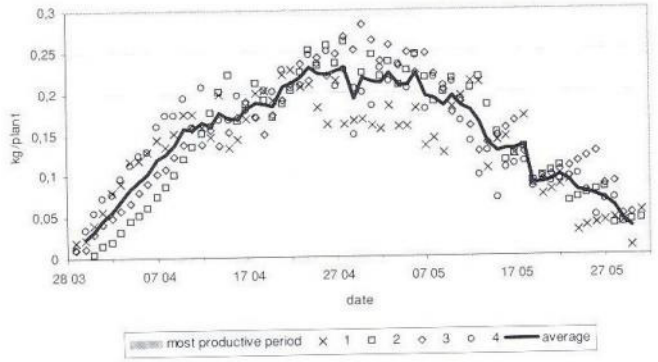

Figure 5 The total development of all fruits at the same time per plant in average 1–4: varieties; – average value of total volume

Conclusions

The spring forcing of parthenocarp cucumber is widely spread and it has a great importance. Cultivars used in cucumber forcing are productive remarkable. Their productivity is determined by the genetic potential and the effect of environmental factors. Our spring, cucumber-forcing experiment was aimed to characterize the productivity and the dynamics of fruit growth. We studied four parthenocarp hybrids. The beginning of flowering, the fruit length and diameter of fruit primordial during flowering, growth of fruits finally, the weight, the length and the diameter of marketable fruits were recorded. The parameters of fruits developed by a plant in the same time were calculated. Our results verified that fruit growth could be clearly divided into two phases: cell-elongation and saturation. The average daily growth of weight of an individual fruit and the number of the fruits developed by a plant in the same time were estimated, and the total weight of fruits on a plant was figured out day by day, and the average daily growth of the total weight composed. The last parameter indicates productivity more precisely and it's easier to explain.

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