

Morphological Differentiation of Flower Buds in Apple-Trees

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Abstract. The paper deals with the study of morphological differentiation of flower buds in 10 varieties of apple-trees in relation to the growth of summer shoots and the earliness of varieties. The data obtained indicate that in the warmer regions of Slovakia the critical season of transformation of flower buds from vegetative to generative forms takes place, on the average, between July 20 and 29, and, at the same time, the variety Yellow Transparent deviates from the average four week-earlier. According to the author we can speak neither of a positive relation between the onset of morphological differentiation and the active growth of summer shoots nor of the relation between the earliness of the variety in maturing and the onset of differentiation. The morphological differentiation may be classified into five phases: 1st phase — the formation of the growing point primordium, 2nd phase — the formation of the cup on sepal primordia, 3rd phase — the formation of petal primordium, 4th phase — the formation of carpel and stamen primordia, 5th phase — completion of the differentiation through substantial enlargement of flower organs before the onset of winter.

The fertility of apple-trees is among other factors influenced by flower bud setting. This development begins in the year preceding the harvest (Ro 1929; KOBEL 1954). Studying the morphological differentiation of flower buds, we were interested in the critical period of the change of the buds from the vegetative to their generative phases, further, in the particular phases of morphological differentiation and the relation of the first phase to the dynamics of the summer shoots growth. Ro (1929), KOBEL (1954), NESTEROV (1959) report about a positive relation between the earliness of a variety and the morphological differentiation of flower buds. HOŘAVKA (1957) supports the theory of this positive relation. The above author puts the differentiation of the flower buds into relation with the cessation of the active growth of the tree crown of a given variety. Studying the morphological differentiation many authors segregate this phenomenon into various numbers of phases, stages, or periods. Ro (1929) and NESTEROV (1959) distinguish seven phases in apple-trees: 1 — swell up of the growing point, 2 — appearance of the first flower primordia, 3 — appearance of the second

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flower primordia, 4 — clear differentiation of petal and carpel primordia, 5 — appearance of stamens in the form of primordia, 6 — clear differentiation of stamens, 7 — appearance of carpels in the form of shoots in the centre of the flower bud. KOLOMIEC (1956) distinguishes two development stages of the flower buds, the first stage from the swelling of the growing point to the formation of petal primordia, stamens and carpels, and the second stage from the formation of primordia to the completion of flower organs.

SERGEEV, SERGEEVA and MELNIKOV (1961) distinguish 6 phases: 1 — swelling up of the first flower primordium and the formation of the inflorescence axis, 2 — the formation of sepal primordia and leaves around the inflorescence, 3 — the formation of stamen primordia, 4 — the formation of carpel primordia, 5 — the final phase of differentiation, which generally takes place before the onset of the winter season, 6 — flowering. RYADNOVA (1958) distinguishes three phases of the flower bud development in trees 1. — 8 to 10 days after the formation of the leaf area or 10—20 days after the early spring growth of branches, 2. — begins at the moment of accelerated partition of the growing point and the appearance of primordium in the centre of the bud, 3. — takes place during the autumn season which means at the end of the development of carpels and stamens, the formation of stigmas and hairing of the carpel. HOŘAVKA (1961) distinguishes four phases 1 — vegetative phase, 2 — morphological differentiation of the flower primordia, 3 — the formation of the flower organs, 4 — flowering.

From the viewpoint of different agrotechnical treatments (manuring, pruning, shaping) it is important to know the period of the critical season of the bud transformation from the vegetative to its generative form, or the period of swelling up, the enlargement of the growing point. HOŘAVKA (1957) reported July 19 as the date of the first differentiation of flower buds in Central Bohemia (Yellow Transparent, Lord Lambourne, and Marbrée do Watervliett), but according to the above author the differentiation in the majority of varieties begins from the 1st to the 15th of July.

GYURÓ (1958) reports the period of differentiation from July 10th to 20th. His results are from orchards in the vicinity of Kecskemét and Budapest. According to the above author, the differentiation begins 4—5 weeks after the cessation of the summer shoot growth. Ro (1929) reported the differentiation of apple-trees at Mleev in the south of the USSR during the third July decade and the first decade of August, with the exception of the Yellow Transparent variety, in which differentiation was recorded as early as June 12th, thus exceedingly early.

The aim of this paper is to point out the date of the onset of flower bud differentiation in apple-trees, particularly the course of its phases and to show the relation of the growth of summer shoots under conditions in southern Slovakia.

Material and Methods

Between 1962 and 1966, the course of morphological differentiation at the locality of Borovce (near Piešťany) was studied on a 12—15 year old

apple-tree cultivation grafted on the root stock seedling *Malus sylvestris*, in this varietal composition: Red Delicious, Ontario, Mother, Transparent de Croncels, Yellow Bellflower, Reinette du Baumann, Reinnette du Canada, King of the Pippins, Oberländer Himbeerapfel and Yellow Transparent.

The orchard is situated on degraded chernozem soils at an altitude of 175 m above sea level, with an average precipitation of 625 mm and an average temperature of 9.2° C. Increments of the summer shoots were recorded during the May—September periods in 14 days' intervals between 1962 and 1964. The sampling of buds was done in weekly intervals during July and August, in the other months only at monthly intervals, taking 15—20 buds from one variety per sampling. The buds were fixed in a FAA solution derived in alcoholic and butanol series, they were paraffin coated and after coloration with Bismarck brown processed into lasting preparations.

Results and Discussion

Recording the summer shoot growth increments during a period of three growing seasons it was found that the growth of the summer shoots lasts, on the average, up to August 5th but the varieties Oberländer Himbeerapfel and Yellow Transparent terminate their growth a month earlier (July 5) and, on the contrary, the variety Reinette du Canada a month later (September 5). Table 1 shows that except for the variety Oberländer Himbeerapfel, the differentiation of the flower buds in all studied varieties begins 1 to 8 days earlier than the complete cessation of the summer shoot growth. In this sense, the results of the present paper do not correspond with those of HOŘAVKA (1957), where the differentiation of the flower buds begins after the cessation of the active growth of tree crown, nor with the results of GYURÓ (1958) where the differentiation begins 4 to 5 weeks after the termination of the growth of summer shoots. The termination of growth of the summer shoots varies greatly, e.g. the short, fruit-bearing shoots cease their active growth 3—5 week after bursting, on the other hand, the growth of skeleton or leading branches lasts several months, until early July and even until early September. Flower buds establish generally on the short fruit bearing shoots, which terminate their growth, as already mentioned, very early. But the active growth of the tree crown as a whole continues. The variety Jonathan establishes flower buds not only on the two years old branches but also on summer shoots. These flower buds are generally established on the last third of the whole length of the summer shoot, thus after their differentiation the summer shoot continues in its active growth. Thus, we can speak about a subdue, retardation or interruption of the growth during the critical period of differentiation.

The relation between the earliness and the differentiation was not confirmed completely, as was reported by Ro (1929), KOBEL (1954) and NESTEROV (1958). The earliness may be judged according to the period of flowering, fruit ripening and the onset of fertility, the most important feature for the trait of earliness being the period of fruit ripening. According to this,

Table 1

Flowering, formation of flower buds and the termination of growth in apple-trees between 1962 and 1964

Variety	Flowering date	Date of the 1st phase of differentiation and swelling of the growing point	Date of the active growth stop	Earliness according to the ripening of the fruits
Red Delicious 1962 1963 1964	27. 4. 2. 5. 8. 5.	7. 8. 29. 7. 20. 7.—29. 7.	5. 9. 5. 8. 5. 8.	1
Ontario	26. 4. 4. 5. 8. 5.	29. 7. 29. 7. 22. 7.	5. 9. 5. 8. 5. 8.	1
Mother	28. 4. 5. 5. 5. 5.	29. 7. 29. 7. 20. 7.	5. 9. 5. 8. 5. 8.	3
Transparent de Croncels	27. 4. 3. 5. 2. 5.	22. 7. 22. 7. 20. 7.	5. 8. 5. 8. 20. 7.	4
Yellow Bellflower	27. 4. 4. 5. 6. 5.	29. 7. 7. 8. 29. 7.	20. 8. 5. 8. 5. 7.	1
Baumann's Reinette	26. 4. 3. 5. 7. 5.	15. 7. 27. 7. 27. 7.	20. 8. 5. 8. 20. 8.	1
Reinette du Canada	27. 4. 3. 5. 6. 5.	5. 7. 5. 7. 13. 7.	5. 9. 5. 9. 5. 9.	1
King of the Pippins	27. 4. 5. 5. 7. 5.	22. 7. 22. 7. 27. 7.	20. 8. 20. 8. 20. 8.	2
Oberländer Himbeerapfel	26. 4. 2. 5. 4. 5.	5. 7. 5. 7. 13. 7.	5. 8. 5. 7. 5. 7.	1
Yellow Transparent	25. 4. 3. 5. 3. 5.	15. 6.—20. 6. 15. 6.—20. 6. 5. 7.	5. 8. 5. 7. 5. 7.	

Earliness: 1 — very late, 2 — late, 3 — fairly late, 4 — early, 5 — very early.

all summer varieties should be early and, on the other hand, all winter varieties late. Yellow Transparent is our earliest ripening variety; its onset of differentiation is also earliest; the onset of fertility is also very early, the beginning of flowering is also 2 to 3 days earlier, compared with other varieties, so that in this instance we can speak about a positive relation of the given characters. A different picture exists with other varieties. For instance, the varieties Reinette du Canada and the Oberländer Himbeerapfel differentiate their flower buds by 2 to 3 weeks earlier, compared to other varieties, and this does not in the least correspond with the ripening period of their fruits. Both are winter varieties with a late ripening of fruits. Flowering of apple-trees is in our climatic conditions only a minor characterizing trait, as the differences among the varieties are insignificant (1—3 days), which contrasts sharply with the differences in differentiation and fruit ripening. The results of this paper agree with those of HOŘAVKA (1957), denying a positive relation between the differentiation and the earliness.

In the study of the particular phases of differentiation I consider it useful to have a classification beginning with the critical period, i.e. enlargement of the growing point and its shaping. Thus, the development of the flower bud differs clearly from the morphological differentiation of the vegetative bud. The classification of the development phases of the flower bud in apple-trees in our climatic conditions is as follows:

- 1st phase — the formation of the growing point primordium;
- 2nd phase — the formation of the cup or sepal primordia;
- 3rd phase — the formation of primordia;
- 4th phase — the formation of carpel und stamen primordia;
- 5th phase — completion of the differentiation through substantial enlargement of flower organs before the onset of winter.

In this classification the vegetative and flowering phases are eliminated, which I think, is advantageous from the viewpoint of time reduction of morphological differentiation and thus also from the viewpoint of detailed study of particular phases. The results of this study do not correspond with those of SERGEEV, SERGEEVA, MELNIKOV (1961), in which, in my opinion, an independent phase — the formation of petal primordia-is missing. Further, the papers of these and other authors (Ro 1929; KOLOMIEC, 1956; NESTEROV, 1958) divide the formation of stamens and carpels into two phases, while in our study we always found contemporaneous formation of primordia of both organs (4th phase), in agreement with the study of HOŘAVKA (1961) who recorded the appearance of stamen and carpel primordia contemporaneously in one period, though his classification of particular phases was different.

The date of the critical period of bud change from its vegetative into its generative form takes place in the majority of cases between July 20th to 29th. The Variety Yellow Transparent deviates from the mean by 4 weeks, varieties Oberländer Himbeerapfel a Rainette du Canada by 2 weeks. Compared with the results of HOŘAVKA (1957), the differentiation under our conditions takes place, on the average, 1 to 3 weeks earlier (Yellow Transparent 4 weeks earlier) and compared with the results of the Hungarian

author GYURÓ (1958) the differentiation under our conditions takes place, on the average, 2 to 3 weeks later. This knowledge should reflect itself in the dates of nitrogen fertilization during vegetation and in the date of branch bending by shaping of apple-trees.

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Práca sa zaoberá štúdiom morfolologickej diferenciacie kvetných pukov u 10 sort jabloní vo vzťahu k rastu letorastov a ku skorosti sort. Výsledkom práce je poznatok, že v teplejších oblastiach Slovenska prebieha kritické obdobie premeny vegetatívnej na generatívnu formu kvetného puku priemerne 20. — 29. VII. a pritom sorta Priesvitné letné sa odchyľuje od priemeru o 4 týždne skôr. Podľa autora nemožno hovoriť o priamom vzťahu medzi začiatkom morfolologickej diferenciacie a aktívnym rastom letorastov, ani o vzťahu medzi skorosťou sorty v dozrievaní plodov a začiatkom diferenciacie. Morfologickú diferenciaciu možno rozdeliť na 5 fáz: 1. fáza — vznik rozšíreného hrbolčeka vegetačného vrcholu, 2. fáza — vznik čiašky, alebo vznik základov kališných lístkov, 3. fáza — vytvorenie základov korunných lístkov, 4. fáza — vytvorenie základov tyčíniek a pestíkov, 5. fáza — dokončenie diferencovania podstatným zväčšením kvetných orgánov pred nástupom zimy.

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DIFFERENTIATION OF FLOWER BUDS



Fig. 1. Baumann's Reinette, first flower primordium (1st phase). On July 22, 1963.

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Fig. 2. Baumann's Reinette, sepal primordium (2nd phase). On July 29, 1963.

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Fig. 3. Baumann's Reinette, petal primordium (3rd phase) On August 7, 1963

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Fig. 4. Baumann's Reinette, stamen primordium and carpel primordium (4th phase). On August 15, 1963.

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F/g. 5. Baumann's Reinette. (5th phase.) On November 15, 1963.

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Fig. 6. Baumann's Reinette. On January 15, 1964.

Б. Бенко, Институт растениеводства, Пиеšťаны: **Морфологическая дифференциация цветочных почек яблони.** — Biol. Plant. 9 : 263—269, 1967.

Изучалась морфологическая дифференциация цветочных почек яблони и ее связь со скоростью роста побегов и с раннеспелостью сортов. В более теплых областях Словакии критический период превращения почек в генеративную форму — в среднем от 20 до 29 июля. Сорт «Приесвитне летне» отклоняется от этого срока, дифференциация у него проходит на 4 недели ранее. По мнению автора, нет связи между началом морфологической дифференциации и активностью роста побегов, а также между дифференциацией и скороспелостью сорта. Автор различает в процессе морфологической дифференциации следующие 5 фаз: 1 — расширение конуса нарастания; 2 — возникновение чашечки или зачатков чашелистиков, 3 — образование зачатков лепестков венчика; 4 — образование зачатков тычинок и пестиков; 5 — окончание дифференциации, сопровождающееся значительным увеличением органов цветка перед наступлением зимы.