Wpływ usuwania pąków kwiatowych, kwiatów i zawiązków owoców na zawartość związków azotowych w krótkopędach jabłoni

The effect of removal of flower-buds, flowers and fruitlets on the content
of nitrogen compounds in the apple spurs

M. BIELIŃSKA-CZARNECKA

INTRODUCTION AND REVIEW OF LITERATURE

Results of several experimental works indicate the relation between the level of nitrogen compounds in tissues of apple trees, and the intensity of fruit bearing.

A higher content of nitrogen in the leaves of bearing trees, as compared the non-bearing or slightly bearing ones, was established by Boynton and Compton (1945), Cain and Boynton (1948), Boynton et al. (1950), Bielińska (1954, 1956, 1957), Lamb and Golden (1959), Grochowska (1963), Bielińska, Dzieciół and Dawydko (1964). Samples were taken mostly from the central parts of shoots.

While investigating the leaves from spurs of bearing and non-bearing trees, Rubin (1949) noticed that in spring the nitrogen content was lower in the leaves of bearing than in those of non-bearing spurs. Later periodical fluctuations occurred and finally, after the harvest, the amount of nitrogen in those leaves became markedly higher than in the leaves from the spurs of non-bearing trees.

A higher total nitrogen content in spurs of bearing apple trees, as compared with the non-bearing ones, was established by Hooker (1920), Potter et al. (1925), Lagasse (1926), Potter and Phillips (1930), Kolomiyets (1955), Bielińska (1956, 1957) Dzieciół and Bielińska (1962), Sahulka (1962), Włodek and Bielińska (1963), Bielińska, Dzieciół and Dawydko (1964). Potter and Phillips expressed the opinion, that bearing and non-bearing spurs could not be compared directly with each other because of differences in their morphology. Harley et al. (1942) and Sahulka (1962) represented a similar point of view, as they ascribed the differences in the nitrogen content between bearing and non-bearing spurs to the differences in their morphology. This opinion, however, was not confirmed by the ex-

periments of Włodek and Bielińska (1963), in which removing of young fruits from the spurs of bearing 'Boskoop' apple trees caused a decrease of their nitrogen content, indicating that the level of nitrogen in the spurs corresponded to the fruit-bearing in the first place. It could be concluded that fruit-bearing influences both the metabolism of nitrogen compounds and also the anatomical structure of bearing organs.

In single cases (Bielińska 1957) a higher content of total nitrogen was noted in long shoots of bearing trees as compared with the shoots of non-bearing ones.

These facts lead to the conclusion that the nitrogen compounds are mobilized during the season of bearing and consequently accumulated in young above-ground parts of the trees, mainly in the current growth of bearing spurs and also in the leaves.

The greatest differences in nitrogen content between bearing and non-bearing spurs occur at the period of blooming (Włodek and Bielińska 1963, Bielińska, Dziecioł and Dawydko 1964). This period is also characterized by the maximum content of nitrogen compounds in the current year's growths of spurs. The studies of Dziecioł and Bielińska (1962), and Bielińska, Dziecioł and Dawydko (1964) have proved that the curves of total nitrogen and soluble nitrogen content in spurs run almost parallel. This led to the conclusion that the rapid increase of nitrogen compounds observed in bearing spurs in spring depends mainly on an increase in soluble nitrogen fraction. This, in turn, stimulated a closer interest in the soluble nitrogen fraction and, particularly, its, dominating constituents: amino-acides and amides.

The amino-acides constitution of shoots and leaves and sometimes also of flower-buds and flowers of apple trees was investigated by several authors over a period of more than ten years (Bollard 1953; McKee and Urbach 1953; Urbach 1955; Hulme and Steward 1955; Oland 1954, 1956, 1959; Dziecioł and Bielińska 1962; Bielińska 1963; Bielińska et Casimir 1963; Bielińska, Dziecioł and Dawydko 1964; Sahulka 1960, 1962; Romanskaya 1963; Afrikan and Arutyunian 1964; Briner and Grismanis 1964; Tupy 1964). The following amino acids, amides and amines were found: aspartic acid, glutamic acid, asparagine, glutamine, alanine, arginine, γ -aminobutyric acid, serine, threonine, methionine, valine, proline, leucines, phenylalanine, lysine, tyrosine, ethanolamine, histidine, homoserine, 4-hydroxymethylproline and less frequently also: citruline, ornithine, pipercolic acid, tryptophan, α -amino adipic acid, trimethylamine, methylamine, ethylamine and finally several unidentified spots.

The presence of most of the compounds listed above was observed in all organs. Their amount fluctuated in dependence on the season and material tested. Some of them were detected not in all organs and only

in some periods. α -amino adipic acid and tryptophan, for instance, were found mainly in flowers, and only very minute amounts of them occurred in other organs (Bielińska and Casimir 1964). Tupy (1964) discovered a considerable amount of proline in pollen; he considered a high proportion of proline/histidine as an indicator of pollen fertility.

From among the amides found in apple shoots, asparagine, and from among amino acids, arginine were represented in greatest amounts (Oland 1954, 1956, 1959; Sahulka 1962; Bielińska, Dzieciol, Dawydko 1964). Arginine was considered by Oland the most important reserve amino acid in young apple trees. Reuter (1957), investigating the storage organs of 166 species of 48 botanical families found that arginine was the main free amino acid in the majority of *Rosaceae* and *Saxifragaceae*.

Afrikan and Arutyunian (1964) found arginine, both in free and bound form in bearing spurs. The free form, however, was not found in non-bearing spurs.

Bielińska, Dzieciol and Dawydko (1964), while investigating the distribution of various amino acids in the pool of soluble nitrogen in spurs, found a higher proportion of arginine and glutamine in the soluble nitrogen fraction of bearing spurs as compared with that in the non-bearing ones. This would indicate a close relation of these compounds to the process of bearing.

In order to trace the influence of fruit-bearing on changes in nitrogen compounds content, with special reference to amino acids, successive removing of flower-buds, flowers and fruitlets from the spurs was performed. Then the changes occurring in nitrogen metabolism of these decapitated spurs, as compared with the intact, bearing ones were investigated as well as the content of nitrogen compounds in the detached flower-buds, flowers and fruitlets.

EXPERIMENTAL

Materials and sampling

Spurs of about thirty-years-old 'Grosser Rheinischer Bohnapfel', 'Grossherzog Friedrich von Baden', and 'Fieser's Erstling' apple trees were studied in 1960—1962 in the Pomological Orchard in Skierniewice.

Preliminary experiments performed in 1960 on one tree of 'Grosser Rheinischer Bohnapfel' variety, in which samples were taken from May till July, at 10-day intervals, showed that one month was a sufficiently long period to demonstrate the effect of decapitation on the nitrogen metabolism in spurs. Therefore, in 1961—1962 sampling was limited to three

dates, i.e. 5, about 18 and about 30 days after decapitation. Each year the experiments began at the end of March or April and ended in July. Sampling involved spurs of the current and previous years' growth of both fruiting and non-fruiting trees. Flower-buds, flowers and fruitlets were removed from the bearing trees, while in control non-bearing trees leaf-buds and tops of spurs were cut off. The corresponding spur samples were taken from the non-decapitated spurs of bearing and non-bearing trees at the same intervals.

In the second year spurs of fruiting trees, which spontaneously dropped the fruitlets, were also collected and investigated.

The removed flower-buds, flowers and fruitlets, as well as the leaves of fruiting spurs, were analyzed.

Preparation of samples

The leaf samples (10—110 g) were heat-dried at 50°C, while the spurs (1.4—26 g), flower-buds (0.95—43 g), flowers (42—50 g) and fruitlets (36—246 g) were lyophilized.

Total nitrogen was determined in all samples by the Kjeldahl procedure.

Extractions. The 1 g samples of lyophilized material were pulverized and extracted with ethanol and water (according to Reuter, Przybylska 1963). The extract was used for determinations of soluble nitrogen, α -amino nitrogen and electrophoretic and chromatographic fractionation.

Soluble nitrogen was determined colorimetrically at 535 m μ by the aid of a Kovo SFMZ spectrophotometer, with Nessler reagent. For this purpose 1 ml aliquots of extract were mineralized with sulphuric acid and after dilution suitable aliquots were taken for analysis.

Insoluble nitrogen content was calculated from the difference between total and soluble nitrogen.

α -amino nitrogen was determined by the chromatographic Antoszewski and Lis* modification of the Pope-Steven method, based on the determination of soluble copper-amino acid complexes with ditionite.

Basic amino-acids, γ -aminobutyric acid, glutamic and aspartic acids (the latter two compounds before and after hydrolysis) were estimated densitometrically after low-voltage electrophoretic separation in the pyridine buffer according to Mathias (1959) and development with 1% ninhydrin in acetone.

Composition of amino-acids was estimated chromatographically after

* In press.

Matthias (1956) with Whatman No. 1 paper and butanol — acetic acid — water solvent (90 : 10 : 29). Each separation was repeated 3 times. Densitometric measurements were carried out as previously (Bielińska, Dzieciol, Dawydko 1964) after spray with 1% ninhydrin and copper nitrate.

RESULTS

I. *Total N-content in leaves* decreased during the growing season in leaves of both fruiting and non-fruiting spurs. Its level was slightly higher in the latter in early spring, but then decreased rapidly and became significantly lower than in the leaves of fruiting spurs. In July there were little, if any, differences in N-content between the two kinds of leaves. These changes are illustrated by the examples given in table 1 and by the arithmetic means for the whole experiment (table 2).

Table 1

Total nitrogen content (percent. d. m.) in leaves of bearing and non-bearing control spurs of Grosser Rheinischer Bohnapfel.

1961	Dates of sampling	25.IV	8.V	24.V	6.VI	19.VI	5.VII	16.VII
	Leaves of bearing spurs	3,42	3,50	3,16	2,59	2,68	2,39	2,41
	Leaves of non-bearing spurs	3,84	2,95	2,47	2,44	2,66	2,40	2,43

1962	Dates of sampling	9.V	23.V	6.VI	20.VI	4.VII	18.VII
	Leaves of bearing spurs	3,06	3,19	2,49	2,33	2,45	2,19
	Leaves of non-bearing spurs	3,49	2,89	2,23	2,15	2,06	2,08

II. 1. *Total N-content* in spurs generally decreased in both kinds of spurs (fruiting and non-fruiting) during the growing season. However, a slight increase of N-content was often observed after decapitation in both kinds. The removal of flower buds, flowers or fruitlets from bearing spurs resulted in a rapid decrease of N-content (particularly in their current-year's growths), much more pronounced than in untouched bearing controls. The same is true for the fruiting spurs which spontaneously dropped the fruitlets. Usually, earlier decapitations were more effective (examples given in table 3).

Table 2
Average total nitrogen content in leaves of bearing and non-bearing spurs
(percent. d. m.)*)

Kind of spurs	Varieties and years			
	Grosser Rheinischer Bohnapfel		Grossherzog Friedrich von Baden	Fieser's Erstling
	1961	1962	1961	1962
Leaves of bearing spurs	2,85	2,57	2,76	2,33
Leaves of non-bearing spurs	2,73	2,44	2,63	1,87

*) each value represents an average of 16—17 results.

Table 3

Total nitrogen contents (percent. d. m.) in current growths of bearing spurs of Grosser Rheinischer Bohnapfel.

1961	Date of sampling	25.IV	8.V	24.V	6.VI	19.VI	5.VIII	16.VII
	Controls, intact spurs	4,60	4,26	3,93	2,94	2,92	2,60	2,56
	Differences between control and decapitated spurs:							
	5 Days after decapitation	+0,09 -0,07 -0,14 -0,36						
	18—21 Days after decapitation	-0,51 +0,08 -0,12 -0,36						
1962	31—34 Days after decapitation	-0,06 -0,75 -0,09 -0,76						
	Date of sampling	25.IV	9.V	23.V	6.VI	20.VI	4.VII	18.VII
	Controls, intact spurs	4,14	4,35	4,57	3,99	3,08	3,03	2,29
	„Fruitlet-drop” spurs					2,53	2,19	1,58
	Differences between control and decapitated spurs:							
1962	5 Days after decapitation	-0,39 -0,42 +0,34						
	19—20 Days after decapitation	-1,37 -1,0 +0,09 -0,32						
	33—34 Days after decapitation	-1,08 -0,77 -0,86 -0,28						

No significant effect of decapitation on the rate of decrease of N-content was observed in non-fruitlet spurs; moreover, the initial increase after decapitation was more prolonged than in bearing spurs, particularly in the previous year's growths. In this case the effect of

decapitation was not uniform, as indicated by the results of analyses which show a considerable variance. Table 4 shows the ratio-numbers and percentage of samples with lowered N-content, one month after decapitation, in bearing and non-bearing spurs. Further analyses were performed only on current growths of bearing spurs.

Table 4
Ratio-numbers and percentage of samples of spurs with N-contents decreased one month after decapitation.

Kind of spurs	Current — year's growth	Last — year's growth
Bearing spurs	17/19 (89%)	17/27 (63%)
Non-bearing spurs	8/15 (53%)	5/22 (23%)

2. *Dry matter content in spurs.* Dry matter in decapitated current growths of fruiting spurs was slightly but significantly higher than in normally fruiting controls. Average dry matter contents in decapitated current growths of bearing spurs and in controls are given in table 5.

Table 5
Dry matter percentage in current growthsof control and decapitated bearing spurs.

Varieties and years	Controls, intact spurs	Decapitated spurs, one month after decapitation
Grosser Rheinischer Bohnapfel 1960	31,22	32,72
Grosser Rheinischer Bohnapfel 1961	29,46	31,08
Grosser Rheinischer Bohnapfel 1962	30,41	33,81
Grossherzog Friedrich von Baden 1961	31,71	33,76
Fieser's Erstling 1962	30,79	33,18

No effects of decapitation on dry matter content was observed in previous year's growths of fruiting spurs and in non-fruiting spurs. These data, therefore, were not included.

3. *The contents of insoluble, soluble and α -amino N in the current-years growths of fruiting spurs.* The rate of decrease of these forms of

(c. d. tab. 7)

1962	Dates of sampling	25.IV	9.V	23.V	6.VI	20.VI	4.VII	18.VII
	Controls, intact spurs	162,8	231,5	300,3	332,2	260,0	224,0	188,0
	„Fruitlet-drop” spurs					254,8	199,8	117,4
	5 Days after decapitation	Differences between control and decapitated spurs:						
	19—20 Days after decapitation	+36,5	+39,7					
	33—34 Days after decapitation		+104,0	-105,5	-47,3	-22,1		
				-180,2	-56,7		+3,8	

Table 8

Glutamine content in the current growths of bearing spurs of Grosser Rheinischer Bohnapfel ($\mu\text{g/lg d. m.}$)

1961	Dates of sampling	25.IV	8.V	24.V	6.VI	19.VI	5.VII	16.VII
	Controls, intact spurs	294,6	188,0	130,0	102,5	109,6	104,7	82,0
	5 Days after decapitation	Differences between control and decapitated spurs:						
	18—21 Days after decapitation		-70,7	-9,5	-12,5	+47,5		
	31—34 Days after decapitation			-26,0	-8,7	-34,9	-89,3	
					-5,5	-29,3	-46,9	-45,1
1962	Date of sampling	25.IV	9.V	23.V	6.VI	20.VI	4.VII	18.VII
	Controls, intact spurs	96,7	87,1	77,5	54,9	29,5	27,8	14,2
	„Fruitlet-drop” spurs					26,5	25,9	-8,5
	5 Days after decapitation	Differences between control and decapitated spurs:						
	19—20 Days after decapitation		-11,9	+10,9				
	33—34 Days after decapitation			-27,1	-34,7	-10,1	-5,8	
					-29,3	-3,0		-1,3

Table 9

Glutamic acid content in the current growths of bearing spurs of Grosser Rheinischer Bohnapfel ($\mu\text{g/lg d. m.}$)

	Dates of sampling	25.IV	8.V	24.V	6.VI	19.VI	5.VII	16.VII
	Controls, intact spurs	20,7	20,9	14,5	15,8	15,1	8,3	12,0
1961	Differences between control and decapitated spurs:							
	5 Days after decapitation		-6,6	-1,4	-5,7	-0,4		
	18—21 Days after decapitation			-11,6	-2,5	-3,4	-2,1	
	31—34 Days after decapitation				-11,2	-9,8	+1,9	-7,0
	Dates of sampling	25.IV	9.V	23.V	6.VI	20.VI	4.VII	18.VII
	Controls, intact spurs	14,2	16,0	17,8	8,8	7,9	5,5	3,1
	„Fruitlet-drop” spurs					8,2	5,7	1,6
1962	Differences between control and decapitated spurs:							
	5 Days after spurs		-8,0	-9,1		-2,7		
	19—20 Days after spurs			-9,8	-3,6	-1,4	-0,6	
	33—34 Days after spurs				-4,1	0		+0,3

Table 10

Asparagine content in the current growths of bearing spurs of Grosser Rheinischer Bohnapfel ($\mu\text{g/lg d. m.}$)

	Dates of sampling	25.IV	8.V	24.V	6.VI	19.VI	5.VII	16.VII
	Controls, intact spurs	439,0	485,7	374,3	266,5	232,6	263,3	295,6
1961	Differences between control and decapitated spurs:							
	5 Days after decapitation		+86,0	+49,5	-12,3	+72,1		
	18—21 Days after decapitation			-170,2	+12,1	+46,0	-45,6	
	31—34 Days after decapitation				+265,2	+249,6	-53,6	-202,1
	Dates of sampling	25.IV	9.V	23.V	6.VI	20.VI	4.VII	18.VII
	Controls, intact spurs	473,9		469,1	487,1	782,2	531,5	280,8
	„Fruitlet-drop” spurs					743,8	535,2	267,3
1962	Differences between control and decapitated spurs:							
	5 Days after decapitation		+144,7					
	19—20 Days after decapitation			-47,4	+11,2	-302,9	-165,4	
	33—34 Days after decapitation				-117,6	-299,7		-114,3

Table 11

γ -Aminobutyric acid content in the current growths of bearing spurs of Grosser Rheinischer Bohnapfel ($\mu\text{g/lg d. m.}$)

Dates of sampling		25.IV	8.V	24.V	6.VI	19.VI	5.VII	16.VII
Controls, intact spurs		38,2	49,1	21,5	19,9	14,9	11,6	9,2
1961	Differences between control and decapitated spurs:							
	5 Days after decapitation	-2,3	-0,4	+8,4	+0,9			
	18—21 Days after decapitation	-2,9	-4,2	+5,8	+1,4			
	31—34 Days after decapitation		-10,5	-5,3	+7,9	-1,3		

*) Determinations of γ -aminobutyric acid content were made only in 1961 in the spurs of Grosser Rheinischer Bohnapfel.

Table 12

Soluble nitrogen content in flower-buds, flowers and fruitlets of Grosser Rheinischer Bohnapfel 1961 (percent. d. m.)

Dates of sampling	Varieties and years			
	Grosser Rheinischer Bohnapfel		Grossherzog Friedrich von Baden 1961	Erstling Fieser's 1962
	1961	1962		
24—25.III (flower-buds)	0,26	—	0,28	—
6.IV " "	0,37	—	—	—
20—21.IV " "	0,58	1,01	0,70	0,71
2—4.V (flowers)	0,69	—	0,59	—
16—20.V (fruitlets)	1,02	0,76	0,61	0,58
1—2.VI " "	0,52	1,0	0,61	0,70
13—16.VI " "	0,48	0,45	0,32	0,38
29.VI—1.VII " "	0,47	0,37	0,20	0,27
11—14.VII " "	0,32	0,34	0,19	0,23

III. 1. *Total nitrogen content in flower-buds, flowers and fruitlets.* Although except 'Grosser Rheinischer Bohnapfel' no variety was represented by a full set of examples, there is general agreement of the data concerning all three varieties in the two experimental years. The total N-content increases rapidly in spring, reaches its maximum in buds just before blooming and remains at the same level in flowers and in very young fruitlets. Then it decrease rapidly as the size of the fruitlets increases (Fig. 1).

2. *Soluble N-content in flower-buds, flowers and fruitlets.* Data concerning soluble N-content in these organs are more variable than those for total N. Maximum content was observed from the end of April till

Fig. 1. — Contents of total N in flower-buds (A), flowers (B) and fruitlets (C), (percent. d.m.)

1 — Grosser Rheinischer Bohnapfel 1961; 2 — Grosser Rheinischer Bohnapfel 1962; 3 — Grossherzog Friedrich von Baden 1961; 4 — Erstling Fieser's 1962.

the beginning of June, depending on the variety and weather conditions. There was a rapid increase early in spring and a decrease in June, similarly as in the total N-content (table 12).

The soluble/total N-ratio was higher in fruitlets (21—57%) than in flower-buds (12—21%) and flowers (16—19%).

3. *Content of amino acids and amides in flower-buds, flowers and fruitlets.* Similarly as that of total and soluble N, the content of some quantitatively determined amino acids first increased rapidly in spring and decreased by the end of May (graph. 2). The individual amino acids did not reach their maximum contents at the same time.

The changes in the contribution of other amino acids to soluble N-content can be traced in chromatographic diagrams. There was a remarkable increase in the proline + alanine and valine + methionine

Fig. 2 — Contents of some free amino-acids and amides in flower-buds (A), flowers (B) and fruitlets (C) of Grosser Rheinischer Bohnapfel 1961 ($\mu\text{g}/1\text{g}$ d.m.)

contributions up to the blooming stage, with a sharp decrease thereafter. The contributions of γ -aminobutyric acid, phenylalanine and leucines decreased also with the growth of fruitlets (fig. 3).

DISCUSSION AND CONCLUSIONS

The lower content of total N in the leaves of fruiting spurs often observed in early spring is presumably due to their earlier development. Young tissues were always characterized by a higher content of N in dry matter. The same was observed by Rubin (1949), although in our experiments the higher N-content in leaves of fruiting spurs was observed much earlier.

An increase of dry matter content in current growths of decapitated fruiting spurs was in agreement with many previous experiments (Kraybill et al. 1925, Dziecioł and Bielińska 1962, Wło-

Fig. 3 — Allotment of different free amino-acids and amides in the pool of soluble nitrogen in flower-buds (A), flowers (B) and fruitlets (C) of Grosser Rheinischer Bohnapfel 1961.

1 — leucines, 2 — phenylalanine, 3 — valine + methionine, 4 — γ -aminobutyric acid, 5 — proline + alanine, 6 — serine + glutamic acid + threonine, 7 — glutamine + aspartic acid, 8 — asparagine, 9 — arginine.

dek and Bielińska 1963; Bielińska, Dziecioł and Dawydko 1964 and others), in which lower content of nitrogen was connected with higher dry matter content.

The data concerning N-content in spurs lead to the following conclusions:

An initial increase of N-content immediately after decapitation was often observed in both kinds of spurs. It might be due to increased metabolism after injury or to the accumulation of N-compounds which would have been used by the removed organ. It is possible that this phenomenon could be observed in all cases if more frequent samplings had been done after decapitation.

The higher rate of decrease of the content of total, soluble, insoluble and α -amino-N, some amino-acids and amides in spurs after removal of buds, flowers or fruitlets (or after spontaneous dropping) indicates a close relation between N-metabolism on the one hand, and blooming and fruiting processes on the other. Large quantities of nutrients are transported to the fruits from other tissues through the spurs. Therefore it would seem natural that N-compounds are accumulated mostly in the current growths, i. e. in the meristematic and sub-meristematic tissues. On the other hand, a higher nitrogen content in the leaves of fruiting trees, sometimes even in long shoots, indicates that the mobilizing effect of flower-buds, flowers or fruitlets on the nitrogen metabolism is not limited to the organs immediately involved in transport of N-compounds.

The results of quantitative determinations of some amino acids seem to indicate a particular role played by the basic amino acids, first of all by arginine, in storage and transport of N-compounds in apple trees in relation to generative processes. This is in agreement with the opinions previously discussed on the role of arginine as the main N-storing and transporting amino-acid in apple trees.

The content of asparagine in spurs, although high, seems to have little, if any, relation to the blooming and fruiting. A considerable variance in the quantitative determinations of this compound, presumably due to its lability, may have obscured the results.

Data concerning the contents of particular soluble N-compounds are usually more variable than those representing total or insoluble N. This may be due to their greater lability or sensitivity to environmental factors, but also to the technique of determination.

Dziecioł and Bielińska (1962) showed that the increase of total N content in fruiting spurs, particularly at the time of blooming is due to the increase of soluble N. The present results indicate that decapitation or spontaneous fruitlet — dropping change the contents of both soluble and insoluble N in fruiting spurs. However, differences in extraction techniques should be taken into account.

Data on the contents of various forms of N and of some amino acids in flower buds, flowers and fruitlets indicate that the metabolism of N in these organs is most intensive within a period beginning shortly before blooming and extending up to the stage of young fruitlets. Not only the contents but also the diversity of amino acids is the greatest at this stage. As the quantitative relations of different amino acids in flower-buds, flowers and fruitlets were investigated only in one season of 1961 in one variety of apple trees, it would be desirable to check, whether the results of this work could be confirmed in other seasons and with different varieties of apples.

Changes in the content of N-compounds in buds, flowers and fruitlets, as well as in current growths of fruiting spurs after decapitation or spontaneous fruitlet drop reveal a close relationship between the nitrogen metabolism, and blooming and fruiting processes.

SUMMARY

Experiments were carried out in 1960—1961 involving the removal of flower-buds, flowers and fruitlets on single branches of 30-years old apple trees of the varieties; 'Grosses Rheinischen Bohnapfel', 'Grossherzog Friedrich von Baden', and 'Fieser's Erstling'. It was found that the content of N-compounds in spurs decreased more rapidly after the removal of flower-buds, flowers or fruitlets, or following spontaneous fruitlet-drop. The results indicate that the basic amino acids, particularly arginine, are the main N-storing and transporting amino acids in spurs in the course of blooming and fruiting processes.

The author is grateful to professor S. A. Pieniążek, director of the Research Institute of Pomology, for providing the facilities for performing this work.

My deep thanks are due to my research fellows and to the technical staff of the Institute for their help and assistance.

*Research
Institute of Pomology
Skierniewice, Poland*

(Received: 21.02.1966)

STRESZCZENIE

W latach 1960—1962 przeprowadzono doświadczenie z usuwaniem pąków kwiatowych, kwiatów i zawiązków owoców z poszczególnych konarów dwudziesto-kilkoletnich jabłoni odmian: 'Grochówka', 'Kalwila Badeńska', 'Erstling Fieser'. Stwierdzono dużo szybszy spadek zawartości związków azotowych w krótkopędach pozbawionych sztucznie pąków kwiatowych, kwiatów i zawiązków owoców, oraz tych, które w naturalny sposób zrzuciły zawiązki (w porównaniu z kontrolnymi, normalnie owocującymi). Wyniki wskazują na rolę aminokwasów zasadowych, przede wszystkim argininy, jako głównego aminokwasu zapasowego i transportowego w krótkopędach w procesie kwitnienia i owocowania.

REFERENCES

- Afrikan B. L., Arutijunian G. S., 1964, Izučenje aminokislотново sostava kolčatок jabloni v sviazi s periodičnostiu plodonošenja i različnymi agromeroprijatijami. Biohimia plodov i ovoščej. Immunitet i pokoj kartofelia, plodov i ovoščej, Izd. Nauka, Moskva.
- Bielińska M., 1954, Zmiany chemiczne towarzyszące przemienemu owocowaniu jabłoni, *Postępy Biochemii* 2: 85—86.
- Bielińska M., 1956, Chemical investigations on biennial bearing of apple trees, *Bull. Acad. Polon. Sci. Ser. biol.* 4: 179—181.
- Bielińska M., 1957a, Studia nad zawartością azotu i węglowodanów w liściach i pędach jabłoni przemennie owocujących, *Rocz. Nauk. Roln.* 75-A-C: 433—520.
- Bielińska M., 1957b, Zawartość azotu i węglowodanów w liściach i pędach jabłoni przemennie owocujących, *prace I. S.* 2: 223—232.
- Bielińska-Czarnecka M., 1963, Ninhydrin reacting substances from apple spurs, *J. Sci. Food. Agric.* 7: 527—528.
- Bielińska-Czarnecka M., Casimir J., 1963, Composition en acides aminés des lambourdes, fleurs et feuilles de pommier. Isolement de l'acide L- α -aminoadipique, *Bull. Inst. agron. et Stat. Rech. Gembloux* 31: 261—268.
- Bielińska-Czarnecka M., Dziecioł U., Dawydko B., 1964, Comparison of spurs and leaves of annually and biennially bearing apple trees of Perkins variety in respect to their contents of nitrogen compounds, *Acta Agrobot.* 16: 133—144.
- Bollard E. G., 1953, Nitrogen metabolism of apple trees, *Nature* 171: 571—572.
- Boynton D., Compton O. C., 1945, Leaf analysis in estimating the potassium, magnesium and nitrogen needs of fruit trees, *Sci. Sci.*, 59: 339—351.
- Boynton D. et al., 1950, Responses of Mc Intosh apple orchards to varying nitrogen fertilization and weather, *Cornell Univ. Agr. Exp. Mem.* 290: 1—35.
- Briner G. P., Grasmanis V. O., 1964, Ethanolamine in fruit buds of Australian apple and peach trees, *Nature* 202: 359—360.
- Cain J. C., Boynton D., 1948, Some effects of season, fruit crop and nitrogen fertilization on the mineral composition of Mc Intosh apple leaves, *Proc. Amer. Hort. Sci.*, 51: 13—22.
- Dziecioł U., Bielińska-Czarnecka M., 1962, The content of soluble and insoluble nitrogen compounds in spurs of biennial bearing apple trees, *Acta Agrobotanica* 11: 177—195.
- Grochowska M. J., 1963, Studies on natural growth regulators in the apple in connection with biennial bearing habit of trees, *Bull. Acad. Polon. Sci. Ser. sci. biol.* 12: 585—590.
- Harley C. O. et al., 1942, Investigations on the cause and control of biennial bearing of apple trees, *U. S. Dept. Agric. Technic. Bull. Washington*, 792: 1—58.
- Hooker H. D., 1920, Seasonal changes in the chemical composition of the apple spurs, *Mc. Agr. Exp. Sta. Res. Bull.* 40: 1—54.
- Hulme A. C., Steward F. C., 1955, Infra-red spectra of the new proline derivative from the apple, *Nature*, 175: 171.
- Kołomijec I. A., 1955, Причыны періодічнасці плоданошенія яблони. Jeżegodnoje plodonošenje jabloni, 32—52, *Sielhozgis*, Moskva.
- Kraybill H. R., et al., 1925, Some Chemical constituents of fruit spurs associated with blossom bud formation in the Baldwin apple, *N. H. Agr. Exp. Sta. Techn. Bull.* 29: 1—41.
- Lamb J. G. D., Golden J. D., 1959, Chemical composition of the shoot leaves

- of the apple Laxton's Superb as affected by biennial bearing, J. Hort. Sci., 34: 193—198.
- Mc Kee H. S., Urbach G. E., 1953, The physiology of growth in apple fruits. V. Soluble nitrogen constituents, Austr. J. Biol. Sci. 6: 369—378.
- Matthias W., 1956, Über eine einfache Methode für Papierchromatographische Untersuchungen (Keilstreifenverfahren), Naturwiss. 43: 351—352.
- Matthias W., 1959, Kombinationsmethode von Papierelektrophorese und Papierchromatographie zur Bestimmung von Aminosäuren, Journ. Chrom. 2: 434—436.
- Oland K., 1954, Nitrogenous constituents of apple maidens grown under different nitrogen treatments, Physiologia Plantarum 7: 463—474.
- Oland K., 1959, Nitrogenous reserves of apple trees, Physiologia Plantarum, 12: 594—648.
- Oland K., Yemm E. W., 1956, Nitrogenous reserves of apple trees, Nature 178: 219.
- Potter G. F., Phillips T. G., 1930, Composition and fruit bud formation in non-bearing spurs of the Baldwin apple, N. H. Agr. Exp. Sta. Techn. Bull. 42: 1—41.
- Przybylska J., 1963, Homoserine in various species in the genus *Lathyrus*, Bull. Acad. Polon. Sci. Ser. sci. biol. 11: 317—319.
- Reuter G., 1957, Über den Stickstoffhaushalt der Betulaceen und anderer Laub und Nadelhölzer, Flora 144: 420—496.
- Romanskaja O. I., 1963, Aminokislrotnyj obmien w tkaniach odnoletnich pobiegov plodowych restenii w godičnom cikle ich razvítia. Fizj. Rast. 10: 692.
- Rubin S. S., 1949, Udobrenje plodovych i jagodnych kultur. Sjelhozgif, Moskva.
- Sahulka J., 1962a, Free amino acids and amides in the axial parts of apple trees and their relationship to flower-bud initiation, Biol. Plantarum 4: 3—23.
- Sahulka J., 1962b, Free amino acids and amides in the buds, and amino acids in hydrolizates of the buds of biennial fruit-bearing apple trees, Biol. Plantarum 4: 278—282.
- Sahulka J., 1962c, The content of nitrogen and free amino acids in the spurs of annually and biennial bearing apple trees and the problem of their relation to flower-bud initiation, Biol. Plantarum 4: 291—305.
- Tupy J., 1963, Free amino acids in apple pollen from the point of view of its fertility, Biol. Plantarum 5: 154—160.
- Urbach G., 1955, A new amino-acid from apples, Nature 175: 170—171.
- Włodek L., Bielińska-Czarnecka M., 1963, Wpływ nawożenia na plon oraz na zawartość suchej masy i azotu w krótkopędach owocujących i nieowocujących jabłoni, Prace I. S. 7: 15—20.