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Investigations on the dormancy of *Fraxinus excelsior* L. buds

II. Bud dormancy on shoots in various parts of the tree crown

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Abstract

The course of the particular phases of dormancy of terminal buds from various parts of the tree crown of 12-year-old *Fraxinus excelsior* trees was investigated. The following treatments breaking dormancy were applied: defoliation, a warm water bath and chilling. Significant differences in the depth of bud dormancy between the main and lateral shoots were noted only in the period of correlated inhibition. No differences could be found either in the course of rest and imposed dormancy or in the process of their receding.

INTRODUCTION

In most trees the terminal buds are set successively beginning with the lower shoots and ending with the main leader of the crown. This shows that the phase of correlated inhibition which precedes the phase of rest (Witkowska-Żuk and Kapuściński, 1969; Witkowska-Żuk and Kozłowska, 1973) starts at different times in the shoots variously situated in the crown.

The experiments were undertaken to establish whether there are differences in the length of dormancy phases in terminal buds of the shoots situated in various parts of the *Fraxinus* crown. This species is known for its late starting and short period of growth (Büsgen, 1961; Jefimova, 1966; Witkowska-Żuk and Kozłowska, 1973) as well as for its long rest, difficult to be broken (Molisch, 1909; Weber, 1916).

MATERIAL AND METHODS

Shoots were cut from 12-year-old *Fraxinus excelsior* trees growing on an experimental plot of the Agricultural University in Warsaw. The depth of dormancy was determined by the time necessary for the opening of buds on shoots defoliated at the

time of detachement from the tree. The shoots were placed in the laboratory in conditions favouring growth. In some cases treatment breaking dormancy was applied: a warm water bath and long-lasting chilling. In the laboratory, where the observations were performed, the mean air temperature was in July and August 24°C, in September and October 21°C and from November to March 18°C with a small amplitude between night and day temperatures.

Weather conditions during the time preceding cutting of the shoots are shown in Fig. 1 of the previous paper (Witkowska-Żuk and Kozłowska, 1973).

At 2—3-day intervals observations were performed on the opening of buds on the detached shoots (appearance of tips of leaves between the bud scales). Since only few axillary buds developed, the results are reported only for terminal buds. The development of buds of each group of the shoots was characterized by : 1. the number of shoots on which the buds started to grow, and 2. by the time required for bud opening after the shoots had been cut from the tree or after the treatment breaking dormancy had been finished. If the buds on the shoots did not burst up to March 23rd, the time of their development was assumed as infinity (∞). To facilitate comparison of the data obtained and to make possible statistical elaboration, the mean number of days from treatment to bud opening on shoots was calculated theoretically (Witkowska-Żuk and Kozłowska, 1973) according to the formula:

$$T = \frac{N}{\frac{1}{t_1} + \frac{1}{t_2} + \ldots + \frac{1}{t_n}}$$

where: N = number of shoots in one treatment and t = the period of time (in days) from the moment of cutting the shoots or from finishing the treatment breaking dormancy, up to the bud opening.

The results were subjected to analysis of variance and Duncan's test at $P = 0.05$.

EXPERIMENTAL

Every month between 21 July, 1971 and 28 February, 1972 and additionally on 14 September, 1971 the terminal segments 20—30 cm long were cut from all shoots of a group of 5 trees. The height of the trees within each group differed, but the groups were similar to one another. The shoots were taken from three zones of the crown: 1. the terminal shoot of the main leader (I order axis), 2. laterals (II order axes) from the upper and 3. from the lower part of the crown. The shoots from the upper part of the crown will be called "upper" and those from the lower part will be called "lower". The latter were least numerous since the trees were planted densely.

From 28 September, 1971 additional shoots were taken at the same intervals as before with the exception of 26 November, from a similar group of trees and subjected to a warm water bath (Molish, 1909). During previous experiments it was established that the buds burst the best and are healthy when treated with water at 35°C for 16 h.

In order to establish chilling requirements for breaking the dormancy, the shoots were cut and defoliated on 28 September (before mean diurnal air temperature had decreased below 10°C) and were placed in beakers with water to be kept at a temperature of 5 ± 2°C for 30, 45, 60 and 90 days. Afterwards, the shoots were brought to the laboratory, to observe bud opening.

RESULTS

Fig. 1 presents the time, calculated according to the above given formula, up to bud development, for the shoots from various parts of the crown. In July and August, the buds opened on shoots taken from all parts of the crown. They opened quickest and most abundantly on the main shoots cut on 21 July. The lower the shoots were situated in the tree crown the smaller number of them developed (differences statistically proved). In August less than one half of the upper buds opened and the time which elapsed to their opening was longer than in shoots cut in July. On the lower shoots cut in August only one bud opened. All shoots collected from September to November did not develop, and the lower shoots did not show any activity even to the end of December. In material collected on 27 December the buds burst earlier and were more numerous on the upper shoots than on the main shoots, however, statistical calculations demonstrated that the difference was not significant.

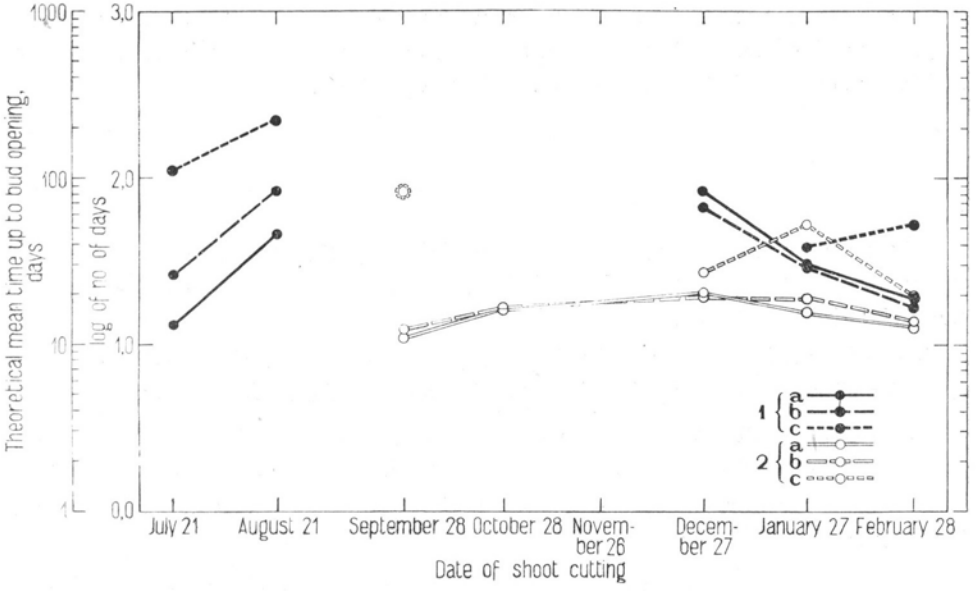

Fig. 1. Opening of terminal buds on shoots detached from various parts of the crown of 12-year-old *Fraxinus excelsior* trees in 1971/72

1 — shoots cut (and defoliated in the period 21 July—28 September); 2 — shoots cut (and defoliated on 28 September) and subjected to a warm bath

a — main shoots, *b* — upper shoots, *c* — lower shoots

Buds on the main and upper shoots cut on 27 January and 28 February burst more quickly and abundantly, owing to natural chilling in the field. Only the buds on the lower shoots developed somewhat weaker.

The warm bath caused the development of 70—100 per cent of buds on the main and upper shoots at all dates (Fig. 1). Less buds developed on the lower shoots and in the period from September to November they did not open at all or burst only on one shoot. The buds on the leaders and upper shoots developed after a warm bath similarly at all dates from September to February.

Table 1

Opening of terminal buds on shoots from various parts of the crown of 12-year-old *Fraxinus excelsior* trees, cut on 28 September and subjected to chilling at +5°C

Duration of chilling, days	Main shoot		Upper shoots	
	No. of opened buds per 5 shoots	Mean no. of days	No. of opened buds per 20 shoots	Mean no. of days
0 (control)	0	—	0	—
30	0	—	0	—
45	0	—	0	—
60	2	52.0	8	59.7
90	1	57.0	14	51.1

The buds of both the main leader and upper shoots opened only after 60—90 days of chilling (Table 1). Lower shoots did not develop after different periods of chilling, opened their buds after a warm bath on 23 March.

DISCUSSION

The buds on the lower shoots behaved differently than those on the main and upper shoots. They developed always in lower numbers and slowly, probably because their viability was lower.

The observation of bud behaviour on shoots cut from 12-year-old *Fraxinus excelsior* allowed to distinguish the following phases of bud dormancy:

1. Correlated inhibition (summer dormancy, predormancy) — when the buds burst after shoot defoliation. It gradually deepens in July and August.

2. Rest (true dormancy) — when the buds do not open at all. It lasted from September to November.

3. Imposed dormancy (post-dormancy) — when the buds gradually opened at an increasingly quicker rate. In this experiment it started in late December.

In all buds investigated correlated inhibition deepened gradually and passed into rest, as it was shown for other plant material in earlier papers (Witkowska-Żuk and Kapuściński, 1969; Witkowska-Żuk and Kozłowska, 1973).

The depth of bud dormancy during correlated inhibition was significantly different for all three groups of shoots in the tree crown. As well in July as in August, terminal buds on the lateral shoots formed earlier than those on the main shoot and exhibited deeper dormancy. The curves showing deepeining of correlated inhibition of buds on the main leaders and on shoots from the upper part of the crown have a parallel course (Fig. 1). This indicates a similarity in the occurrence of this process in the shoots investigated. It would seem on this basis that buds from both these kinds of shoots remain in the state of correlated inhibition for a similarly long period, and pass to a phase of rest at different dates.

The results of experiments in which breaking of dormancy with a warm bath or chilling was applied showed that, when the buds had already entered their rest, its length and deepness were similar for terminal buds of all shoots in the crown. This supports the hypothesis of the autonomy of resting buds — a problem repeatedly discussed (Coville, 1920; Denny and Stanton, 1928; Molisch, 1930; Takahashi, 1963; Witkowska-Żuk, 1970).

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REFERENCES

Büsgen M., 1961. Stroieniie i zhizn'nashikh lesnykh dereviev. Moskva, Goslezbumizdat.

Coville F. V., 1920, The influence of cold in stimulating the growth of plants, Jour. Agr. Res. 20:151—160.

Denny F. E., Stanton E. N., 1928, Localization of response of woody tissues to chemical treatments that break the rest period, Amer. Jour. Bot. 15:337—344.

Jefimova M. A., 1966. Vremia zalozhenia i formirovania pochek u niekotorykh drevesnych porod. Uch. Zap. Leningr. Gos. Ped. Inst. 310:224—237.

Molisch H., 1909, Das Warmbad als Mittel zum Treiben der Pflanzen. Sitzber. Kais. Akad. Wiss. Wien. Bd. CXVIII, Abt. I.

Molisch H., 1930. Pflanzenphysiologie als Theorie der Gärtnerei, Jena.

Takahashi N., 1963. Studies on the promotion of sprouting and breaking of dormancy in winter buds of *Cornus controversa*, Japan Jour. Bot. 18(2):169—197.

Weber F., 1916. Studien über die Ruheperiode der Holzgewächse, Sitzber. Kais. Akad. Wiss. Wien. Bd. CXXV, Abt. I: 311—351.

Witkowska-Żuk L., 1970. Investigations on the bud dormancy of *Populus* × *berolinensis* Dipp. V. Relation between the growth apexes on neighbouring shoots, Acta Soc. Bot. Pol. 39 (2): 285—296.

Witkowska-Żuk L., Kapuściński F., 1969, Investigations on the bud dormancy of *Populus* × *berolinensis* Dipp. III. Sequence of dormancy in trees growing in natural conditions, Acta Soc. Bot. Pol. 37(4): 615—624.

Witkowska-Żuk L., Kozłowska W., 1973 Investigations on the bud dormancy of *Fraxinus excelsior* L. I. Sequence of growth period, correlated inhibition and rest of shoot apex in the annual cycle, Acta Soc. Bot. Pol. 42(4): 627—636.

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Badanie nad spoczynkiem pączków Fraxinus excelsior L.

Streszczenie

Badano długość kolejnych faz spoczynku szczytowych pączków pędów z trzech poziomów korony 12-letnich drzew *Fraxinus excelsior*. Głębokość spoczynku pączków określano na podstawie długości czasu (w dniach) upływającego od momentu ścięcia pędu, jego defoliacji, ewentualnie ukończenia zabiegu przerywającego spoczynek (ciepłej kąpieli wodnej lub chłodzenia), do rozwoju pączków w warunkach sprzyjających wzrostowi.

W okresie spoczynku pączków wyodrębniono następujące fazy:

1. Spoczynek względny — kiedy pączki rozwijały się po defoliacji pędu. Spoczynek ten w lipcu i sierpniu stopniowo się pogłębiał.

2. Spoczynek głęboki — kiedy pączki nie podejmowały rozwoju. Występował od września do grudnia.

3. Spoczynek narzucony, kiedy pączki podejmowały wzrost stopniowo coraz szybciej, poczynając od stycznia.

Pączki na pędach z dolnej części korony rozwijały się zawsze mniej licznie i wolniej niż na pędach szczytowych i z górnej strefy korony. Podczas spoczynku względnego pączki na pędach bocznych wykazywały głębszy spoczynek niż na pędach głównych. Przebieg spoczynku głębokiego i proces jego ustępowania był podobny dla pączków na pędach głównych i bocznych w górnej części korony.