REGULATION OF GROWTH AND FLOWERING OF SOME *CARYOPTERIS* AND *LESPEDEZA* TAXA

Thesis of PhD Dissertation

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1. PRELIMINARIES AND AIMS OF THE STUDY

Because of high energy costs, the production of glasshouse pot plants strongly decreased in the Carpathian Basin including Hungary. At the same time the open-ground growing of flowering shrubs shows an increasing tendency in the nurseries. Some of these shrubs, with a proper technology, could be marketed not only as garden plants but also as flowering pot plants.

Some examples of traditionally grown outdoors which are sold as pot-plants as well: *Skimmia japonica* (Japanese laurel) 'Rubella' and 'Rubinetta', *Hebe* species and cultivars (Veronica shrub), *Cupressus macrocarpa* 'Goldcrest' (Cyprus), *Chamaecyparis lawsoniana* 'Ellwoodii' (Lawson's cypress 'Ellwoodii'), *Chamaecyparis pisifera* 'Boulevard', *Ch. lawsoniana* 'Columnaris', *Ch. pisifera* 'Filifera Aurea', *Thuja occidentalis* 'Sunkist' and 'Europe Gold', *Th. occidentalis* 'Smaragd'.

In our experiments *Caryopteris* and *Lespedeza* taxa were investigated, which are autumn flowering woody plants. These shrubs are mainly sold as container-grown garden plants. Smaller and more compact plants would need fewer places in the nursery, and perhaps could be marketed not only as outdoor but also as pot-grown indoor flowering plants. Such plants can be obtained by regular pruning but the use of growth retardants would be probably a more effective and cheaper (labour-saving) way.

Dwarfing and timing of the flowering of some autumn flowering woody plants can provide a new livelihoods to ornamental plant growers in the Carpathian Basin.

The aim of the experiment

The fundamental aim of my research was the selection of such dual-purpose plants following the example of two *Caryopteris* cultivars and *Lespedeza thunbergii* which have two useful expansions and by the dwarfing and timing of flowering, some small compact plants can be obtained, which are full of flowers, and which can be sold easily in the autumn sales season.

During the trials I intended to carry out tasks and find answers to the following questions:

1. How do the different propagation time influence:

- root development,
- shoot development,
- flowering time,
- overwintering?

2. Which are the best rooting stimulants in the case of the test plants?
3. How do the different rooting stimulants influence

- root development, and
- shoot development of hardwood and softwood cuttings?

4. Which are the growth regulators commonly used in Hungary?

- Which are the most suitable for the treatment in case of my test plants?
- What concentration should be used for?
- When and how many times do the growth retardants need to get out to have the desired effect?
- What effects do the chemicals used have
    - on growing,
    - on the development of vegetative parameters,
    - on flower bud initiation and on the start of flowering of test plants?

5. How do the different growth retardants influence

- stomatal conductance,
- transpiration rate,
- photosynthetic rate,
- water use efficiency?

6. Are there any the after-effects of growth retardants

- on rooting, on shoot development,
- on growth, on flower bud initiation and on the start of flowering of rooted cuttings?

To answer these questions four-year long experiment was carried out.

2. MATERIAL AND METHODS

Between 2009 and 2012, propagation, growing, chemical and instrumental experiments were carried out. The subjects of the experiments were the follows:

2.1. In the case of ***Caryopteris incana*** and ***Caryopteris* × *clandonensis* 'Grand Bleu'**:

Propagation experiments

- *2009: the effect of rooting compounds* on rooting, shoot development and flowering;
- *2009-2011: comparison of the flower bud initiation and flowering time in the case of mother plants and young plants;*
- *2010-2011: effect of the propagation time* on rooting, shoot growth, and blooming time;

Dwarfing experiments

- *2010-2012: effect of growth retardants* on vegetative and generative parameters;
- *2011-2012: effect of growth retardants* on photosynthetic activity including stomatal conductance, transpiration rate, photosynthetic rate and water use efficiency;
- *2011-2012: the after-effect of growth retardants* on rooting and on shoot growth.

2.2. In case of ***Lespedeza thunbergii***:

- *2009-2012: the effect of propagation time* on rooting, shoot development, and flowering time
- *2010: Effect of propagation time on overwintering capacity* of softwood cuttings.

Propagation experiments

The experiments were carried out in the Experimental Field (in Soroksár) where hardwood and softwood cuttings were propagated from the mother plant. The base, the middle, the upper part and the top of the shoots were propagated separately. In 2009 different rooting compounds (0.2% IBA, 0.4% NAA, Radistim 1) were given to the cuttings in powder form or diluted in 50% alcohol and put into a propagating box in a 3:1 mixture of sand and perlite. The cuttings of *Caryopteris* rooted well without rooting compounds, so in 2010-2012 years they were not applied. In the case of *Lespedeza thunbergii* just the 0.4% NAA powder was used in the following years. Minimum 15 cuttings were taken from each part of the shoots. The experiments were carried out in 4 repetitions. The cuttings were put into an unheated greenhouse or glasshouse, where the relative humidity was up to 100%. The propagating experiments were taken monthly from February to October.

The evaluation of the experiments took place one month after the propagation when the rooting percentage, root number and length, shoot number and length, and flower bud initiation were measured. The rooted cuttings were planted into 9x9 cm pots in a 3:1 mixture of sand and perlite with 2 g/l long-acting Everris Start Osmocote chemical fertilizer.

Anatomical investigations were made on *Lespedeza thunbergii* cuttings. The differences between below and above ground parts of the stems were investigated on the rooted cuttings.

Dwarfing experiments

The growth retardant treatments (Alar 85 SP, Bumper 25 EC, Cultar, Cycocel and Mirage 45 EC) were given three times during the summer as foliar sprays to the young plants of *Caryopteris incana*, *Caryopteris* × *clandonensis* 'Grand Bleu' in different concentrations. Every treatment contained 16-16 plants in 4 repetitions. At the end of the dwarfing experiment shoot length, number of nodes per shoot, branching per shoot and blossom attributes were measured. The treated and untreated plants were placed in a sunny place and irrigated depending on the weather conditions (usually every day).

Instrumental studies

The influence of growth retardants on stomatal conductance, transpiration rate, CO_2 fixation was measured by LCi portable infrared gas analyzer (IRGA) on the first, third and sixth week after the last spraying. From the above mentioned parameters the water use efficiency was calculated.

The after-effect of growth retardants

Next year after dwarfing experiments, new cuttings were taken from the formerly treated plants to measure the after-effect of the five growth retardants on rooting percentage, shoot development, and blooming time of cuttings.

Data recording and method of analysis

All the data were statistically analyzed by ANOVA using the statistical package SPSS 20 Statistics software. Data were separated by Tukey or Games-Howel-test at level p=0.05

3. RESULTS AND DISCUSSION

3.1. *Caryopteris incana* and *Caryopteris* × *clandonensis* 'Grand Bleu'

3.1.1. Effect of rooting compounds on rooting, shoot development and flowering

The results of the experiment are shown in Tables 1 and 2.

Table 1. Effect of rooting compounds on rooting and shoot development of *Caryopteris* × *clandonensis* 'Grand Bleu' softwood cuttings propagated on 29.04.2009. (one month after the propagation, on 28.05.2009., Soroksár)

Rooting compounds	Rooting percentage (%)	Average number of roots (pc)	Average length of roots (cm)	Average number of new shoots (pc)
0.4% NAA powder	89,4	4,7 (d)	3,1 (b)	2,4 (a)
0.2 % IBA powder	97,1	9,0 (b)	3,9 (a)	1,4 (c)
Radistim 1 powder	95,8	5,2 (d)	3,3 (b)	2,1 (b)
0.4% NAA solution	**99,3**	17,4 (a)	3,8 (a)	0,7 (d)
control	95,7	6,2 (c)	3,9 (a)	1,3 (c)

Table 2. Effect of rooting compounds on the length of main shoot, on the average number of nodes, and on the flowering stage of *Caryopteris* × *clandonensis* 'Grand Bleu' softwood cuttings propagated on 29.04.2009. (4 months after the rooting, on 09.09.2009., Soroksár)

Rooting compounds	Average length of the main shoots (cm)	Average number of nodes (pc)	Flowering stage
0.4% NAA powder	**41,7** (a)	12,2 (a)	3,6 (ab)
0.2 % IBA powder	40,4 (ab)	12,0 (ab)	3,7 (ab)
Radistim 1 powder	40,1 (ab)	12,0 (ab)	3,7 (a)
0.4% NAA solution	39,2 (b)	11,7 (ab)	3,4 (ab)
control	40,2 (ab)	11,7 (b)	3,4 (b)

Flowering stage: 0= no flower buds; 1= flower buds just shown; 2= flower buds have elongated; 3= color of flower buds can be seen; 4= half of flower buds blossom, 5= all flowers bloom.

To sum up of the results it can be stated that all the *Caryopteris* × *clandonensis* 'Grand Bleu' cuttings rooted well during one month. The effect of rooting compounds was minimal.

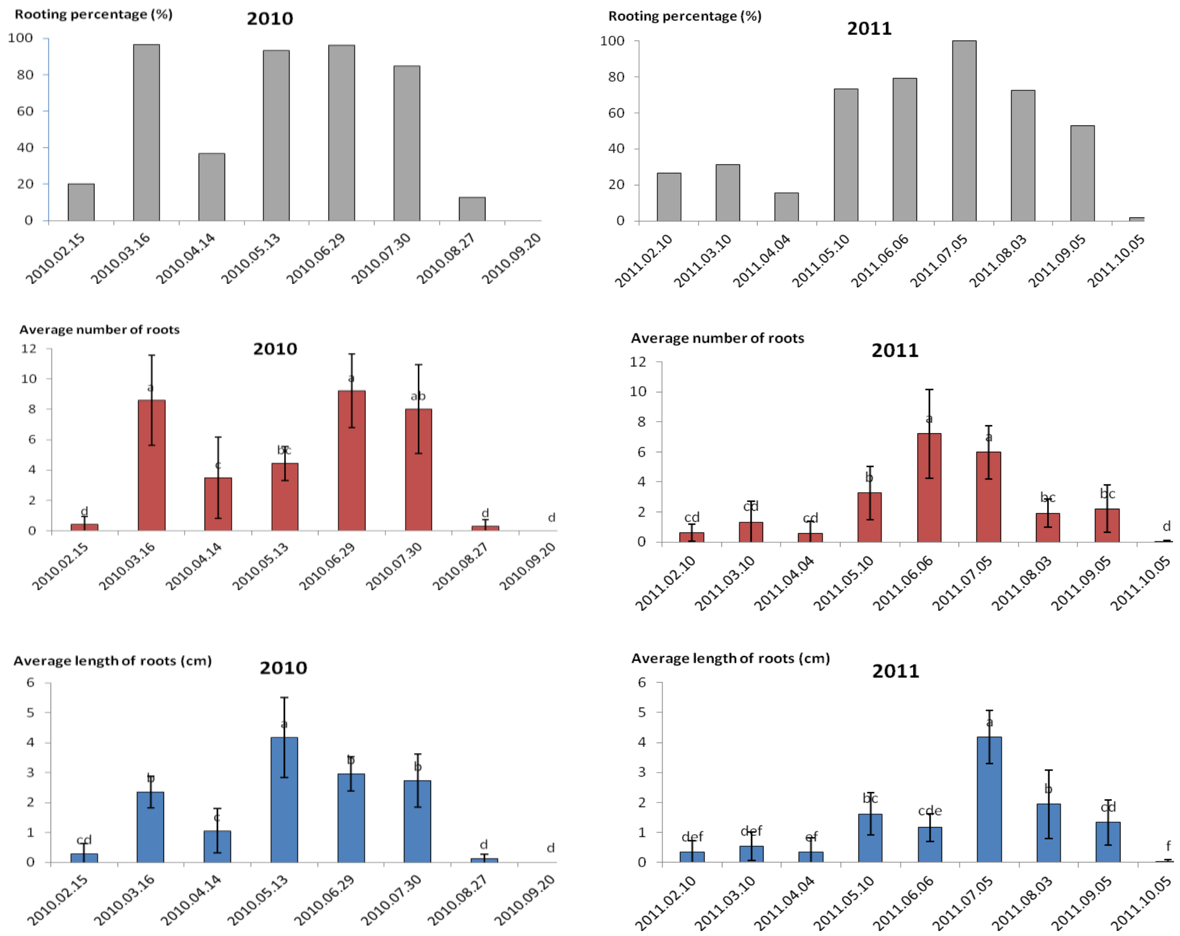
Cuttings treated with 0.4% NAA gave the best result, their rooting percentage was 99.3% while this ratio was 95.7% in the case of untreated control cuttings. However, the differences were statistically not significant.

Two months after the propagation the most numerous and the longest shoots were measured in the case of Radistim 1. This treatment may have a good effect on shoot development after rooting.

Four months after the rooting shoot number and length were similar compared different treatments, and there were no remarkable differences in the number of nodes and in the flowering stage of young plants.

3.1.2. Effect of propagation time on rooting, shoot growth, and blooming time of hardwood and softwood cuttings;

The results of *root and shoot growth* experiments are shown in Fig. 1.



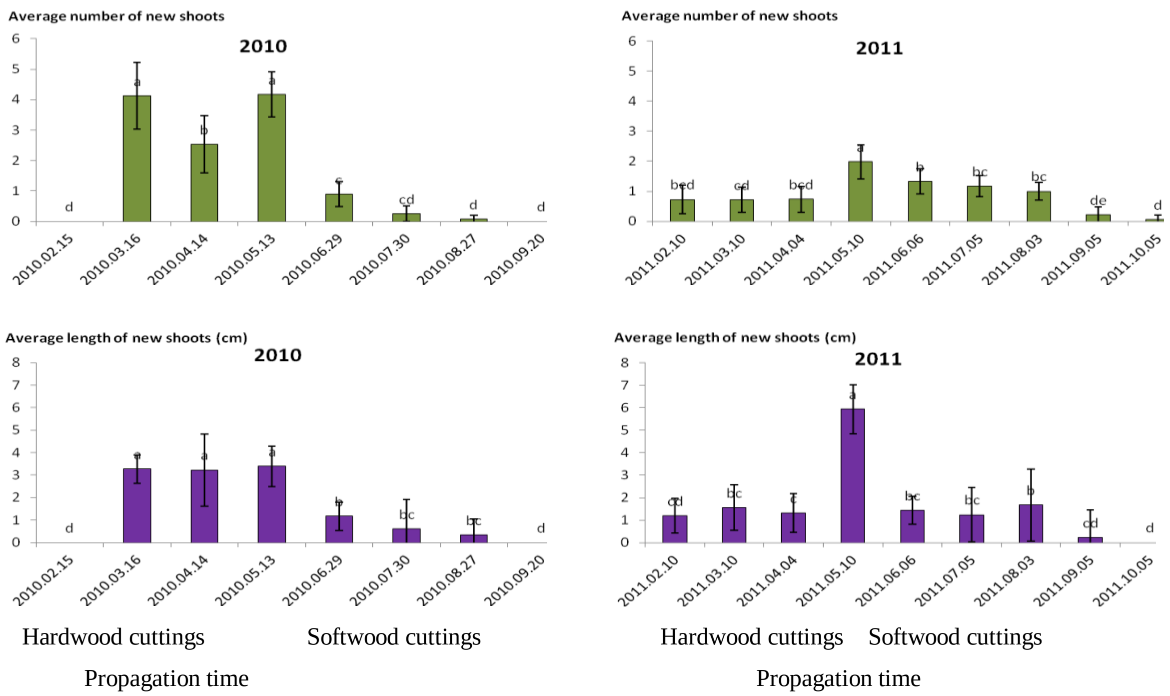


Fig. 1. Effect of propagation time on rooting and shoot development on *Caryopteris incana* cuttings in 2010 and 2011

The results of the measurements showed that the optimal propagation time of hardwood cuttings was the month of March, as in this period the hardwood cuttings had the highest rooting percentage. The number of roots and also the length of the roots were also the maximum in this period. The best propagation time of softwood cuttings was the months of June and July, when the rooting percentage was between 79.2% and 100% (Fig. 1.).

Flowering results

Mother plants needed 9-11 nodes to develop first flower-buds, but the first flowers actually opened after 12-16 nodes (Table 3). Interestingly these first developed flower buds had not opened, but remained in the flower bud stage.

The softwood cuttings propagated in June needed minimum 7-9 nodes to develop the first flower-buds, while 9-12 nodes were needed to develop the first open flowers. The reason of this could be that in the shoots from which the cuttings were taken the flower buds had already differentiated, so they could develop after fewer nodes.

In 2009, cuttings propagated in July bloomed the earliest and by September more than half of the flowers were opened. One month later the cuttings propagated in February also started to bloom. The mother plants started to bloom in the middle of October, and they were in full flowers only in November, which may be associated with drier weather conditions.

Table 3. Number of nodes needed for the first visible flower buds and for the first open flowers of *Caryopteris incana* mother plant, hardwood and softwood cuttings propagated from the mother plant in 2009-2011.

Test plants	Measuring dates														
2009	09.07.2009.			24.08.2009.			17.09.2009.			19.10.2009.			12.11.2009.		
	I.	II.	FS	I.	II.	FS	I.	II.	FS	I.	II.	FS	I.	II.	FS
Mother plant	11	12	1	11,0	15,0	1	11,0	17,0	2	11,1	18,0	4	11,2	19,3	5
hardwood cuttings propagated on 24.02.2009.	-	-	0	9,1	9,3	2	9,1	9,8	3	9,1	10,5	5	9,2	11,0	7
softwood cuttings propagated on 03.07.2009.	-	-	0	8,7	8,8	2	8,7	9,5	5	8,8	10,0	6	9,0	10,7	8
2010	21.07.2010.			27.08.2010.			21.09.2010.			08.10.2010.			10.11.2010.		
Mother plant	10	12	1	10	15	3	10	16	5	10	16	7	10	17	8
softwood cuttings propagated on 29.06.2010.	-	-	0	9	11	2	9	12	4	9	12	6	9	14	7
2011	05.07.2011.			03.08.2011.			07.09.2011.			05.10.2011.			03.11.2011.		
Mother plant	9	10	1	9	11	3	9	12	4	9	15	6	9	17	8
softwood cuttings propagated on 06.06.2011.	-	-	0	7	8	1	7	9	2	7	9	5	7	11	7

Legend: I= Number of nodes needed for the first visible flower buds; II= number of nodes needed for the first open flowers.
FS= Flowering stage: 0= no flower buds; 1= flower buds just shown; 2= flower buds have elongated; 3= color of flower buds can be seen; 4= half of flower buds blossom, 5= all flowers bloom; 6= half of flowers are overbloomed; 7= all flowers are overbloomed; 8= the plant had seeds.

In 2010-2011, the mother plants bloomed earlier than the cuttings propagated from them, which can be associated with the more humid weather in these years.

It is interesting to note that in the lowest parts of the cuttings preformed roots were clearly visible by autumn (Fig. 2).

Fig. 2. Visible preformed roots developed on *Caryopteris incana* cuttings, 26.08.2012.,Soroksár

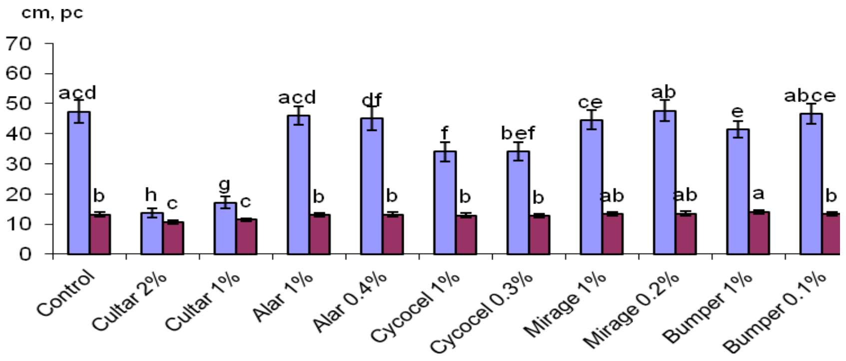
3.1.3. Effect of growth retardants

A. On vegetative and generative parameters of dwarfed plants

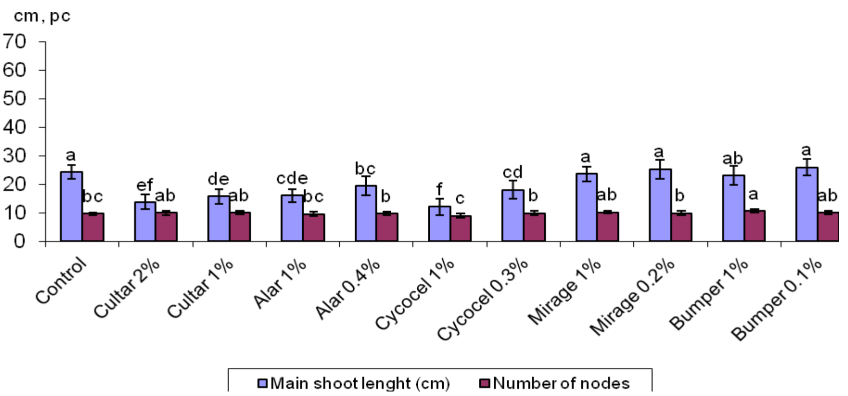
Generally it can be reported that changeable results were obtained with the chemicals used. Plants treated with Cultar 2% and 1% were the shortest compared with plants treated with Bumper and Mirage and with untreated control plants (Fig. 3.). Their shoot length was in average between 13.7 cm and 17.2 cm, while other treatments reaching up to 67.1 cm (Fig. 4.).

The growth retardants which decreased the plant height most effectively (for example Cultar 2%), had also delayed the flowering stage with approximately one week as well. Plants treated with the less effective retardants (Mirage 45 EC and Bumper 25 EC) flowered at the earliest time, parallel with Control plants (Fig. 6.).

Shoot length (cm), number of nodes



2011 (2 weeks after the last treatment)



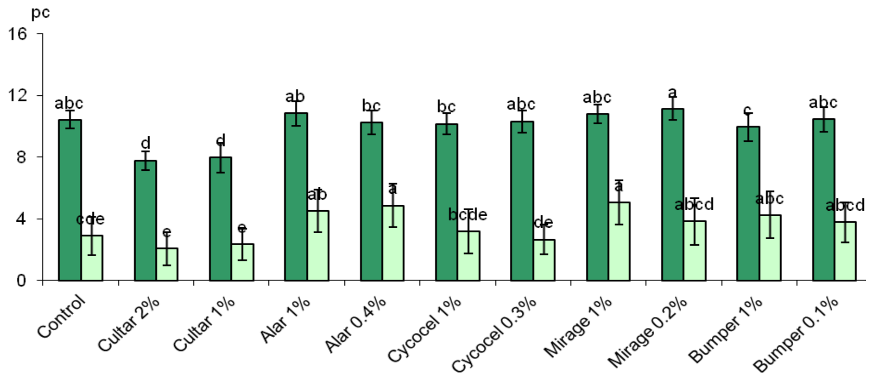
2012 (3 weeks after the last treatment)

Fig. 3. Effect of growth retardants on shoot length (cm) and the number of nodes on the main shoot of *Caryopteris incana* plants in 2011-2012

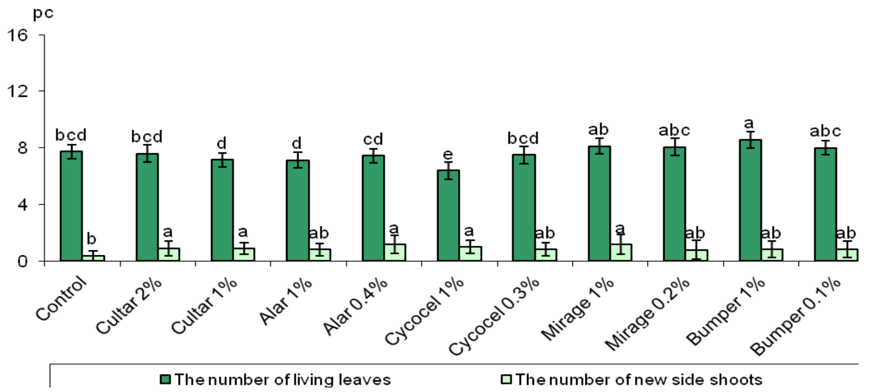
Control Mirage 1%; 0,2% Cycocel 1%, 0,3% Cultar 2%; 1% Bumper 1%; 0,1% Alar 1%; 0,4%

Fig. 4. Effect of growth retardants on *Caryopteris incana* plants (20.09.2011., Soroksár) (2 weeks after the last treatment)

Number of living leaves and the number of new side shoots



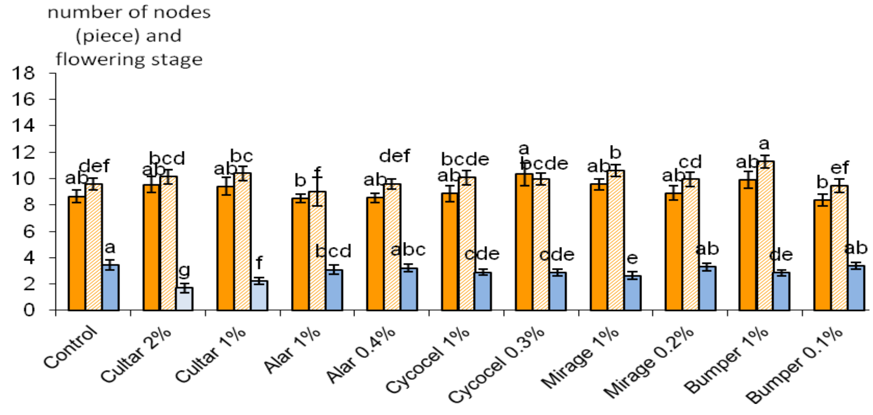
2011 (2 weeks after the last treatment)



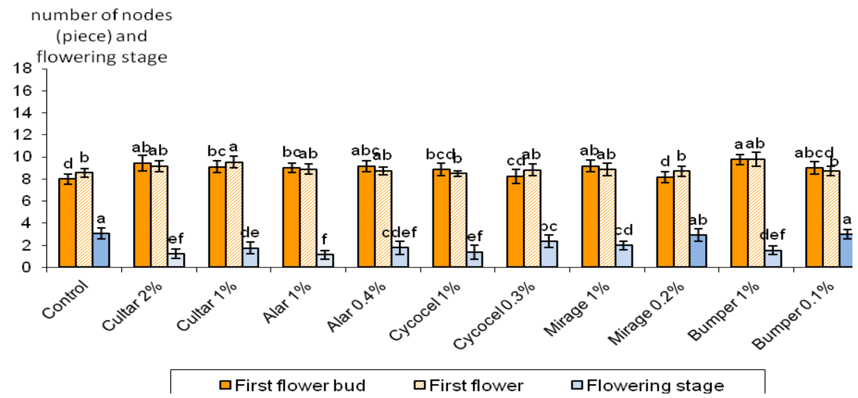
2012 (3 weeks after the last treatment)

Fig. 5. Effect of growth retardants on the number of living leaves and on the number of new side shoots of *Caryopteris incana* plants in 2011-2012

Number of nodes needed for the first flower buds and the fisrt flowers, and the flowering stage of flowers



2011 (2 weeks after the last treatment)



2012 (3 weeks after the last treatment)

Fig. 6. Effect of growth retardants on the number of nodes needed for the first flower buds and the fisrt flowers, and the flowering stage of flowers of *Caryopteris incana* plants in 2011-2012

Flowering stage: 0= no flower buds; 1= flower buds just shown; 2= flower buds have elongated; 3= color of flower buds can be seen; 4= half of flower buds blossom, 5= all flowers bloom; 6= half of flowers are overbloomed; 7= all flowers are overbloomed; 8= the plant had seeds.

Fig. 7. The flowering stage of *Caryopteris incana* young plants on 05.10.2012., Soroksár

B. On photosynthetic activity

The results of the experiment are shown in Fig. 8.

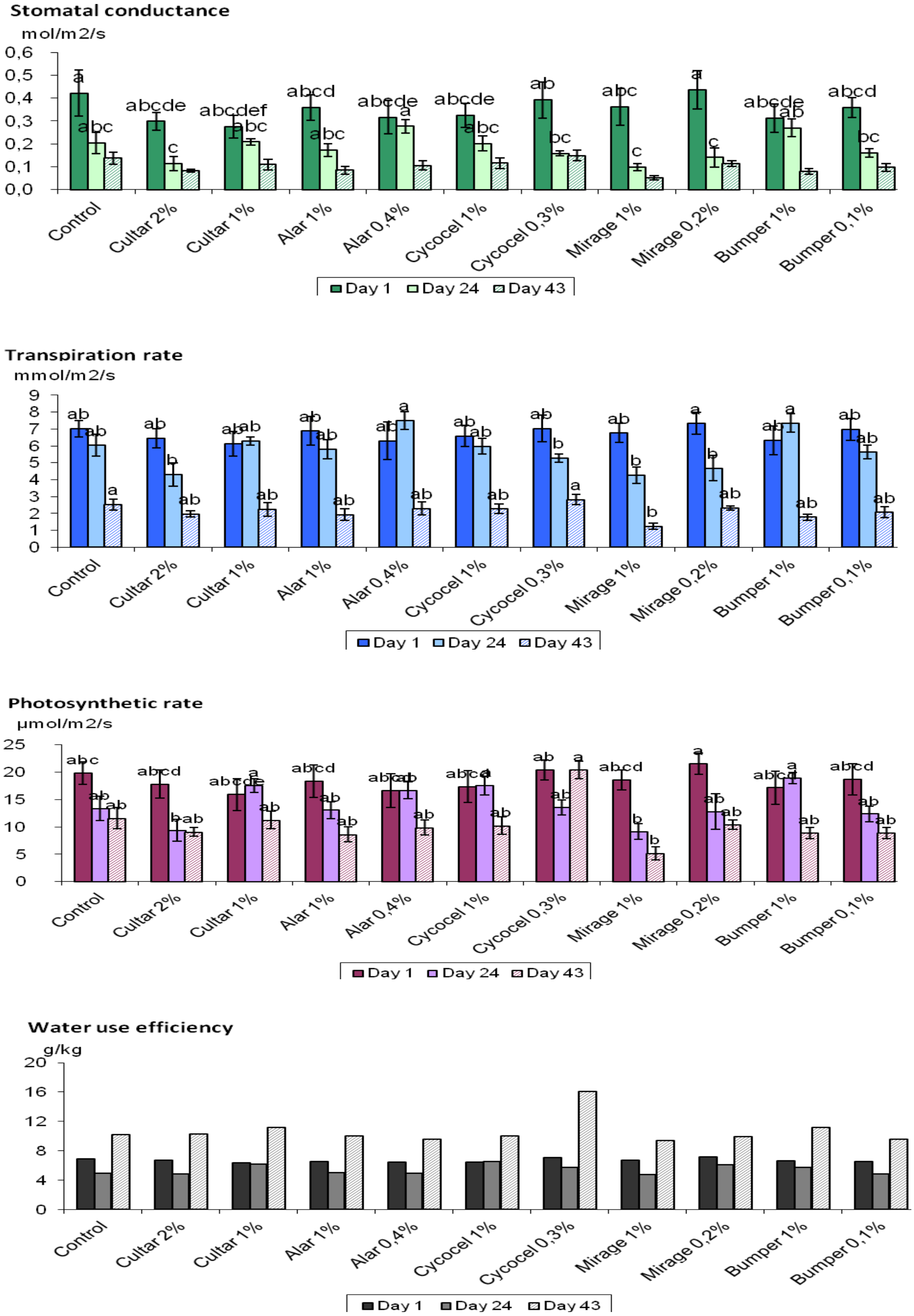


Fig. 8. Effect of growth retardants on stomatal conductance, transpiration rate, photosynthetic rate, and water use efficiency of leaves of *Caryopteris incana* plants on the 1st, 24th and 43rd day after the last spraying in 2011

We found strong correlation between the dates of the measurements and the values of stomatal conductance, transpiration rate and photosynthetic rate. Almost in all cases, the highest values were measured on the leaves at the first measurement and the lowest at the third measurement. The measured parameters showed a similar tendency at the different measurement times. As it might be expected, the highest values of water use efficiency were found on the last measurement date, because of the cooler, more humid weather conditions.

The growth retardant treatments influenced the measured parameters only minimally. Significant changes were caused by external environmental factors like temperature, solar radiation, and precipitation.

3.1.4. After-effect of growth retardants on rooting, shoot growth, and blooming time of cuttings

The results of the experiments of the year 2012 are shown in Fig. 9-14. The after-effect of Cultar 1% and 2%, Alar 1%, Cycocel 1%, Mirage 1% and Bumper 1% were measured on the formerly (in 2011) treated plants.

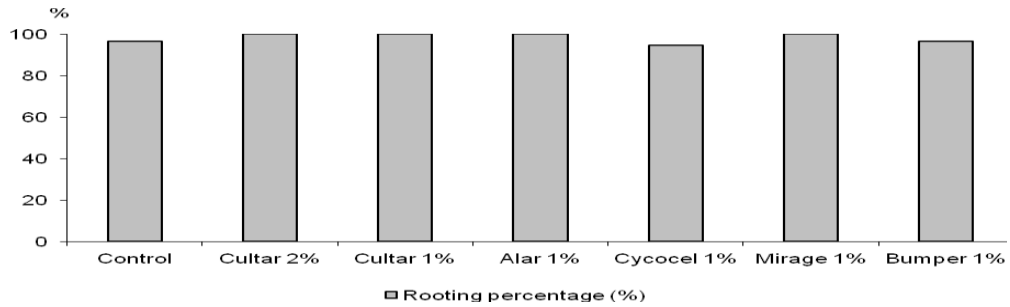


Fig. 9.: After-effect of growth retardants on rooting percentage of *Caryopteris incana* cuttings propagated on 04.06.2012. and measured on 05.07.2012., Soroksár

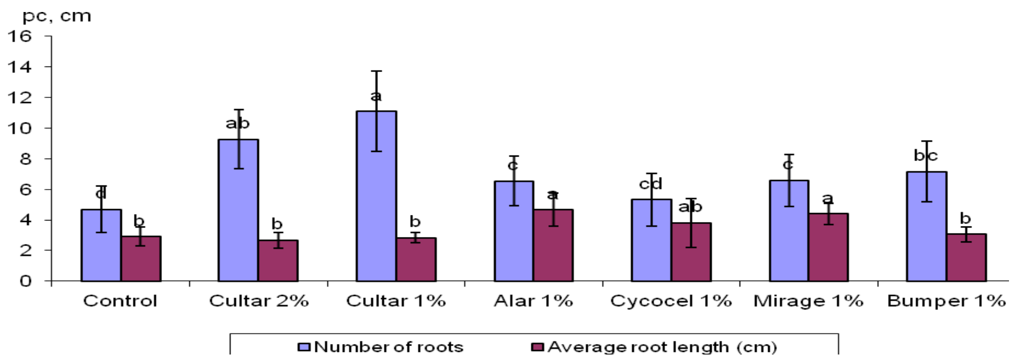


Fig. 10.: After-effect of growth retardants on root development of *Caryopteris incana* cuttings propagated on 04.06.2012. and measured on 05.07.2012., Soroksár

The most marked effect on root development was obtained int he case of cuttings taken from the plants treated formerly with Cultar 1% and Cultar 2% (100%), when the average root number was between 9.3 and 11.1. The untreated Control cuttings had the lowest rooting percentage (96,4%), with a number of root 4.7 (Fig. 10.).

From the above it can be concluded that the growth retardants did not influence the rooting development of cuttings, but they had a positive after-effect on the quality of the roots.

As for the shoot development (Fig. 11.), cuttings formerly treated with Alar 1% had the highest number (1.7), and cuttings formerly treated with Bumper 1% had the longest shoots (1.4 cm).

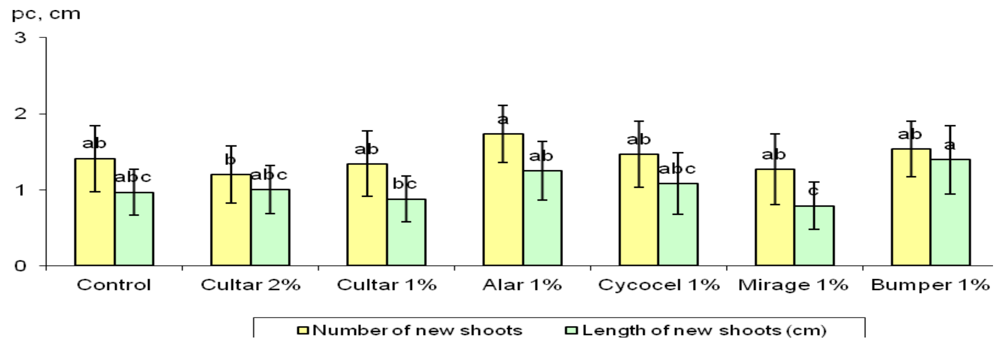


Fig. 11.: After-effect of growth retardants on shoot development of *Caryopteris incana* cuttings propagated on 04.06.2012. and measured on 05.07.2012., soroksár

In case of shoot length the differences were statistically not significant (Fig. 12). The differences between the minimum and maximum values were 3.7 cm. The number of nodes per plant was between 10 and 12.

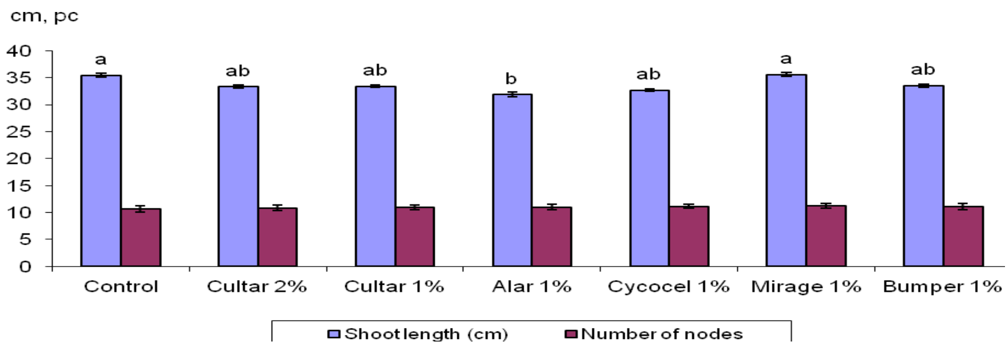


Fig 12.: After-effect of growth retardants on shoot development of *Caryopteris incana* cuttings propagated on 04.06.2012. and measured on 04.10.2012., Soroksár

The number of living leaves varied between 8 and 9 (Fig. 13). The highest number of new shoots was developed (3.7 pc) in the case of Alar 1%, the lowest number (2.7 pc) in the case of Cycocel 1% and Bumper 1%. The differences between the treatments statistically were not significant.

Fig. 13.: After-effect of growth retardants on shoot development of *Caryopteris incana* cuttings propagated on 04.06.2012. and measured on 04.10.2012., Soroksár

Untreated control plants needed the fewest nodes (7.2 pc) and plants treated with Cultar 1% needed the highest number of nodes (8.1 pc) to develop the first flower buds and first open flowers. Flowers of plants treated with Cycocel 1% and Mirage 1% overbloomed at the earliest time (Fig. 14).

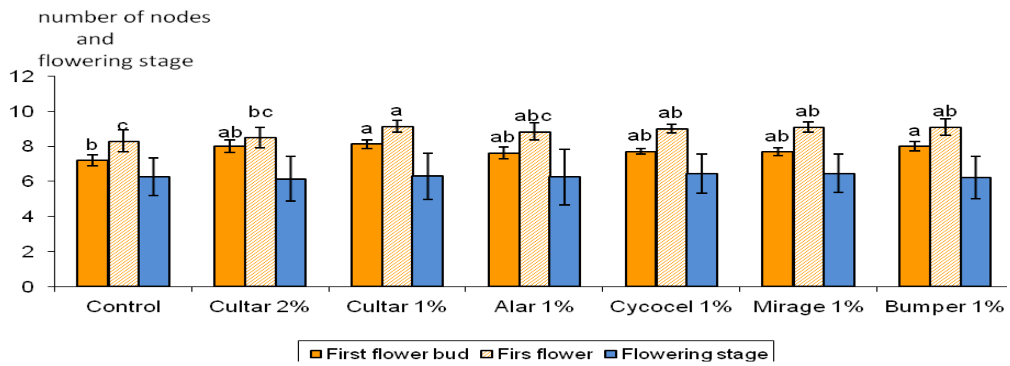


Fig. 14.: After-effect of growth retardants on flower bud development and on flowering stage of *Caryopteris incana* cuttings propagated on 04.06.2012. and measured on 04.10.2012., Soroksár
Flowering stage: 6= half of flowers are overbloomed; 7= all flowers are overbloomed; 8= the plant had seeds.

To sum up, the growth retardants had some after-effect on rooting, shoot growth, and blooming time of cuttings, but they did not affect the development of generative parts significantly.

3.2. Lespedeza thunbergii

3.2.1. Effect of propagation time on rooting, shoot development, and the sprouting of basal buds of softwood cuttings

Rooting percentage (%)

The results of the experiment of 2009-2012 are shown in Fig. 15-19.

The rooting of *Lespedeza thunbergii* cuttings was successful from mid-May till early September (Fig. 16).

In May and June cuttings rooted in one month and produced new shoots very fast. In autumn the young plants flowered with abundance and in some cases the young plants had seeds. The cuttings propagated in July rooted fast as well, produced new shoots and flowered in autumn. The cuttings propagated in August produced roots at their base and flower buds on their new shoots in September (Fig. 15.), but their overwintering was uncertain. Cuttings propagated at the end of September had a very weak root system, with some new shoots and some flower buds. In October cuttings didn't root and developed almost no new shoots. They died during the winter.

Fig. 15. Flower bud development of *Lespedeza thunbergii* cuttings propagated on 08.08.2011 (one month after the propagation)

The number and length of the new shoots

Different propagation time did not affect significantly on the number of new shoots. The lengths of the new shoots were the highest in the case of cuttings propagated from the top of the shoots, since these cuttings had already shoots which needed only to grow up. The basal cuttings have grown their new shoots from the buds located on the shoots. The shoot length of the cuttings propagated from the base, middle, over and from the top of the shoots shows alternations in different propagation times.

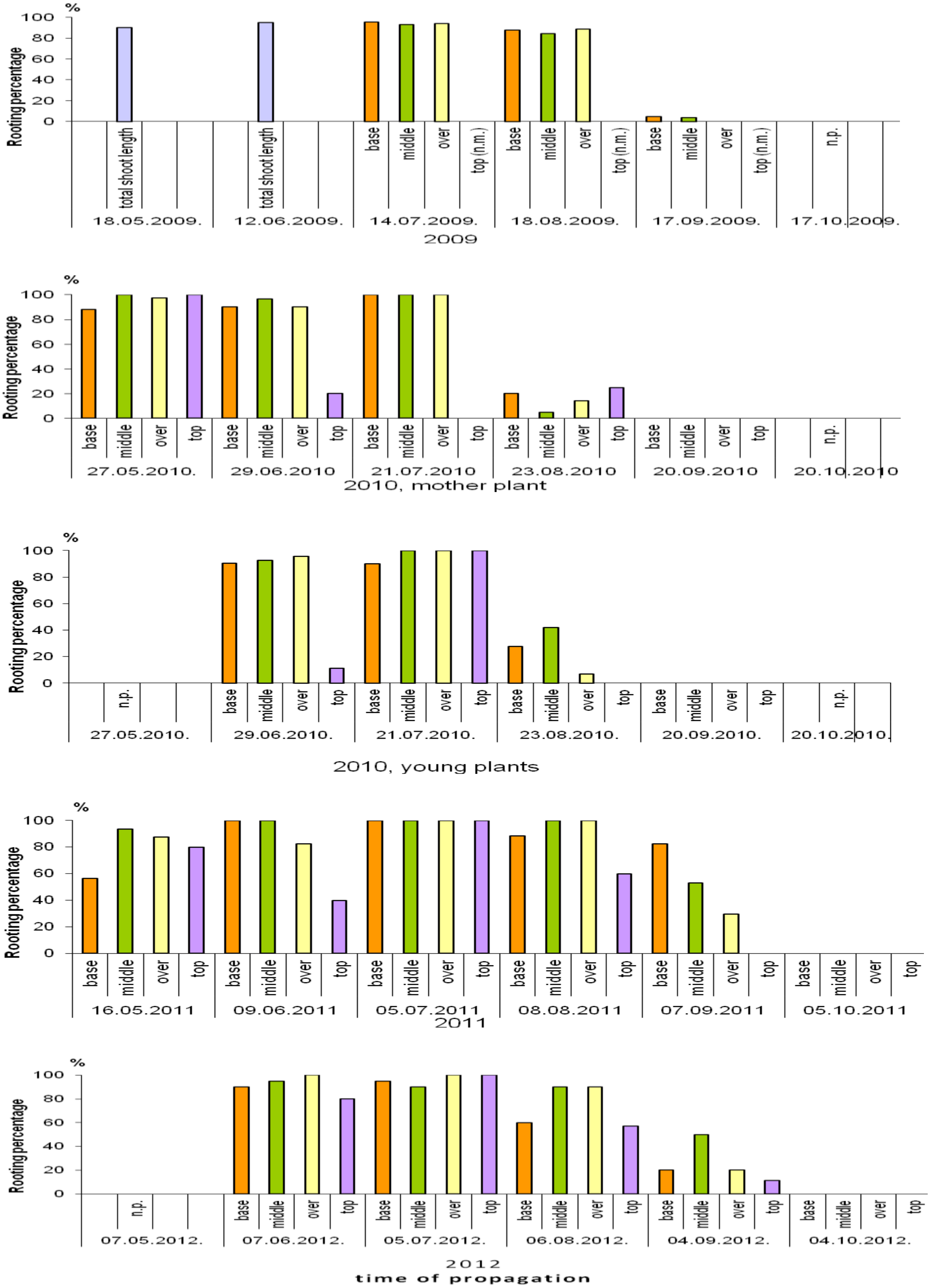


Fig. 16. Effect of propagation time on rooting percentage of *Lespedeza thunbergii* cuttings (one month after the propagation)

Legend. n.p.= no propagation, n.m.= not measured.

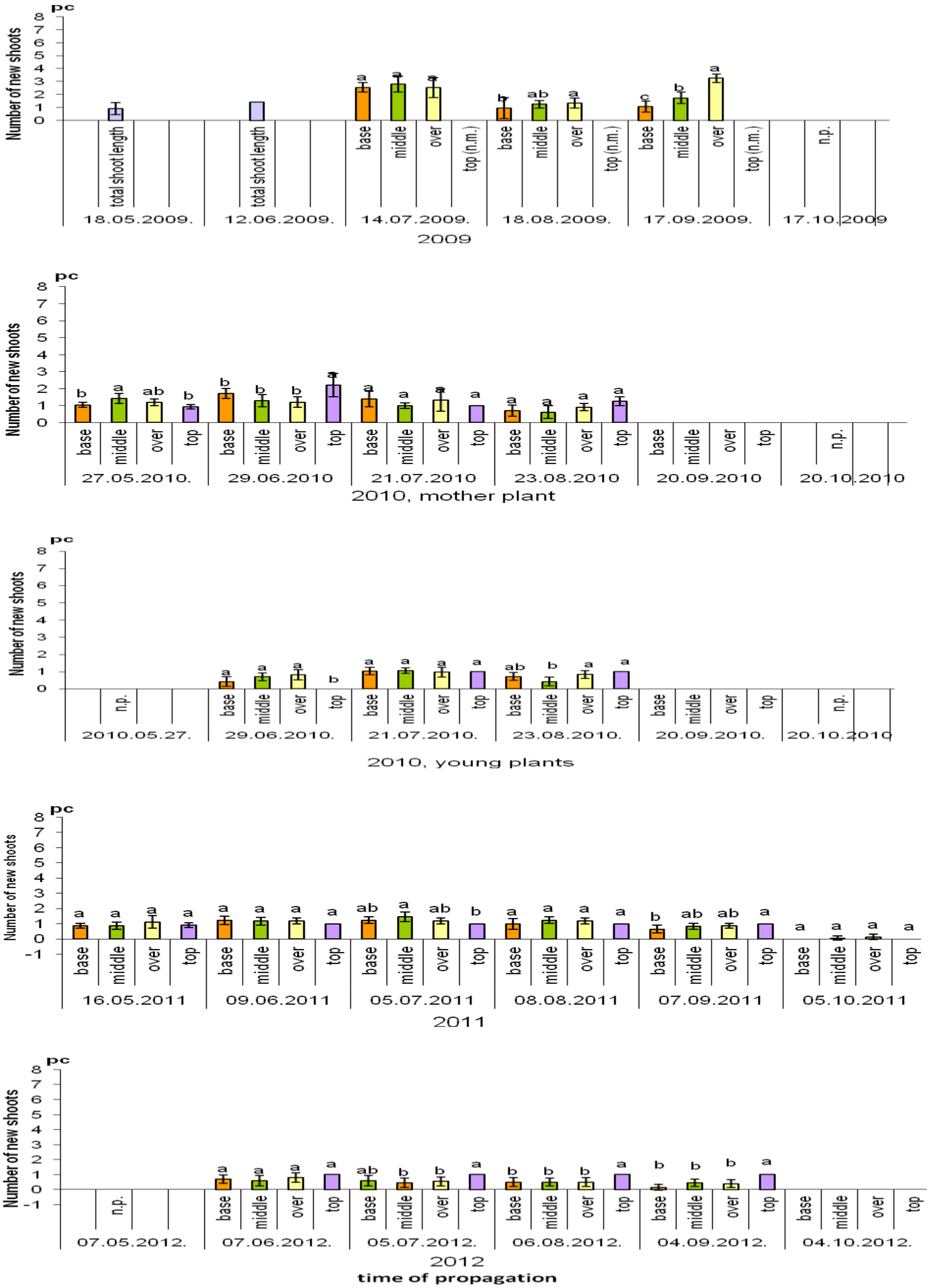


Fig. 17. Effect of propagation time on new shoot development of *Lespedeza thunbergii* cuttings (one month after the propagation)

Legend. n.p.= no propagation, n.m.= not measured.

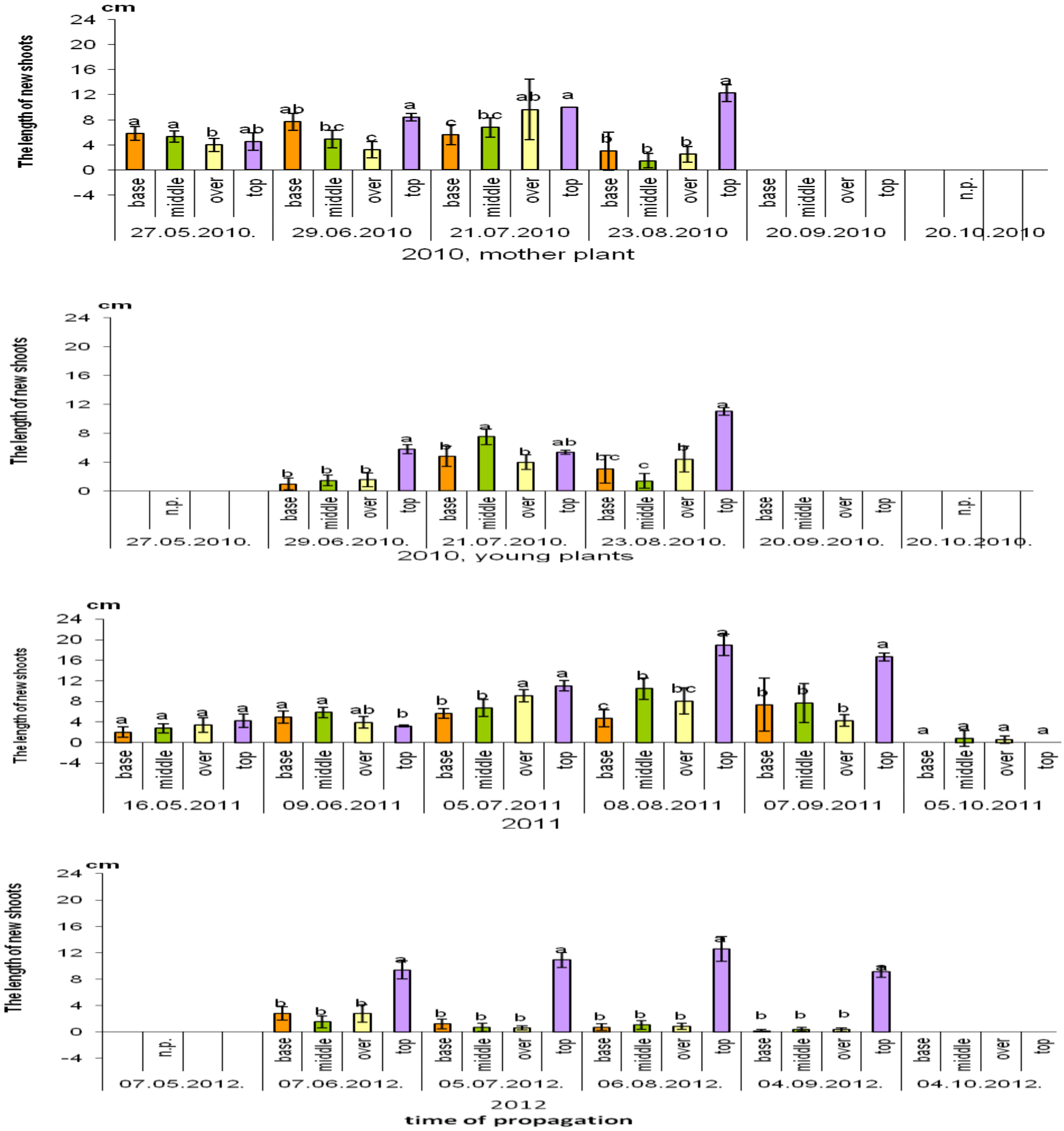


Fig. 18. Effect of propagation time on the length of new shoots of *Lespedeza thunbergii* cuttings (one month after the propagation)

Legend. n.p.= no propagation

The sprouting of underground buds

The sproutings of underground buds in 2009-2012 were the highest in the case of cuttings propagated in May, June and July. Cuttings propagated from the base and from the middle of the shoots had the most number of sprouted underground buds. On the cuttings propagated in October underground buds did not sprout (Fig. 19).

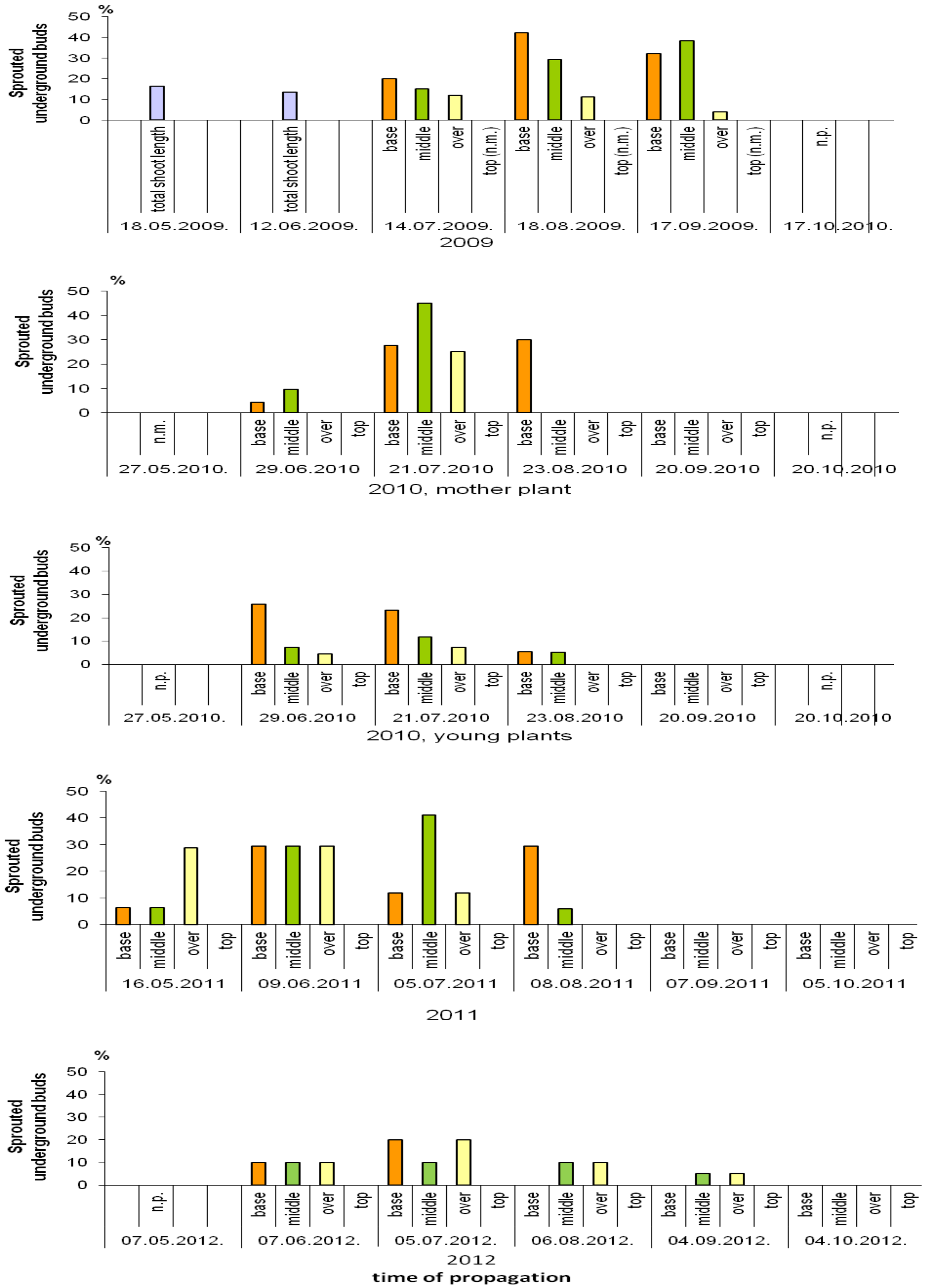


Fig. 19. Effect of propagation time on the sprouting of underground buds of *Lespedeza thunbergii* cuttings (one month after the propagation)

Legend. n.p.= no propagation, n.m.= not measured.

3.2.2. Effect of propagation time on flowering of softwood cuttings

The results of the experiment are shown in Fig. 20.

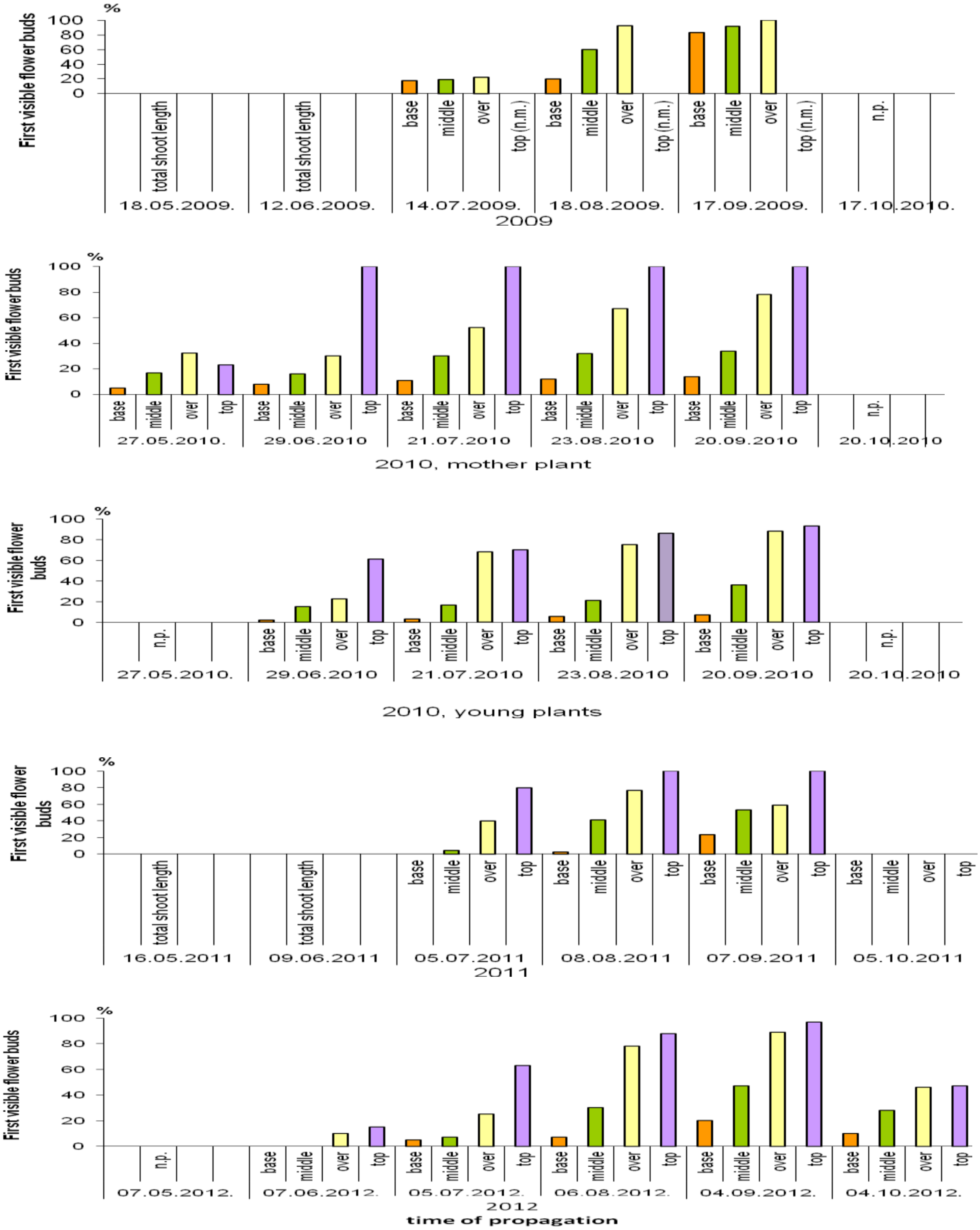


Fig. 20. Effect of propagation time on the visible flower bud development of *Lespedeza thunbergii* cuttings (one month after the propagation)

Legend. n.p.= no propagation, n.m.= not measured.

Generally, the earlier propagated cuttings produced relatively fewer inflorescences, while the late ones (taken in July-August) and especially those ones which originated from the upper part of the shoots, tended to develop inflorescence rather than a new leafy shoot immediately from their leaf axils. The reason for this phenomenon was that these cuttings already had the flower primordium (or even the small inflorescence) in their leaf axils, prior to propagation. The inflorescence above the ground bloomed, while under the ground they aborted.

It is suggested that *Lespedeza thunbergii* needs long day conditions for the flowering.

3.2.3. Effect of propagation time on overwintering capacity **of softwood cuttings**

The most viable young plants were obtained from the cuttings which were taken at the earliest dates and whose basal parts remained in vegetative stage during and after the propagation. In most cases, the underground bud sprouted out and produced a new shoot with a fleshy and somewhat rhizome-like underground base (Fig. 21). However, in some cases buds above the ground were sprouted out as well.

Fig.21: Longitudinal section: cuttings propagated in May 2009 with thick stem and with underground bud in October 2009.

According to our observation, the majority of buds developed under the ground, however, the number of new shoots just above the ground was also neither negligible. The buds above the ground (unless the first 1 cm) died completely during the winter even if the temperature in the heated glasshouse was above 10 °C. The best overwintering result was obtained by the cuttings propagated at the beginning of the summer. The cuttings taken in May and June became thick and by the autumn developed some storage roots with are as starch reserves one of the conditions overwintering.

Anatomical investigations

The results of the anatomical investigations are shown in Figs. 22-23.

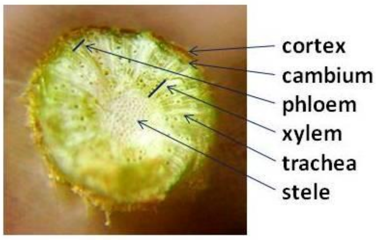


Fig. 22. Cross-section: thin stem about 10 cm above the ground

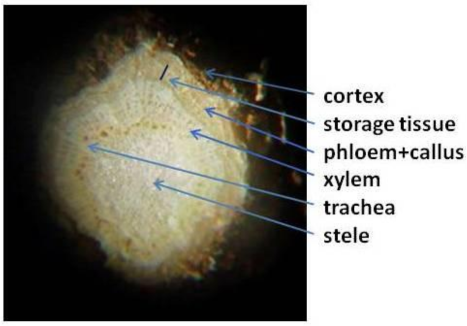


Fig. 23. Cross-section: thick stem about 1 cm under the ground

The underground stem of cuttings taken in May increased strongly in diameter, due to suberized periderm and strong primary cortex of fleshy consistence. The basal buds of these cuttings started a secondary development with more and more leaf primordia.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. *Caryopteris incana* and *Caryopteris* × *clandonensis* 'Grand Bleu'

Rooting experiments

The rooting stimulants have only minimal effect on the rooting of *Caryopteris*. The control cuttings rooted up to 100 % without the use of chemicals; therefore their use in this respect is unnecessary. This finding is in accordance with the recommendation of Bärtels (1996).

Effect of propagation time on rooting and shoot growth

Hardwood cuttings

Hardwood cuttings gave the highest rooting percentage in March (propagated in greenhouse). In this propagation time the most new shoots were developed.

Softwood cuttings

Softwood cuttings gave the best results in June and July, when the highest rooting percentage (79,2% and 100%) was obtained, so these are the optimal propagation time of the test plants. According to Krüssmann (1986) these cuttings were optimal in terms of flower bud development, because the rooted cuttings started to bloom at the beginning of autumn on their new shoots.

The study of flower initiation of mother and young plants

On the young plants (on hardwood and softwood cuttings) the first flower buds developed after 7-9 nodes on the shoot. It was very interesting that the first 1-2 whorl of flower buds did not open. In the case of mother plant the first flower buds developed after the 9-11 nodes and the first 5-6 whorls of flower buds did not open. This interesting phenomenon is not mentioned by the literature. Probably it can be associated with the different growing vigor of mother and young plants.

Effect of growth retardants on vegetative and generative parameters of cuttings

The results show that the most effective chemical was Cultar used in 2% and 1% concentration, because these treatments gave the smallest plants and had also delayed the flowering time. In 2011 the size of the plants decreased with 71.1%, in 2012 with 43.3%. The growth retardants which most effectively decreased the plant height, had also delayed the flowering stage with approximately one week compared with control plants. This suggestion is in accordance with the results of Menhenett (1984), Dakó (1987), Armitage (1994), Mohamed (1997), Basra (2000), Papageorgiou (2002), Whipker et al. (2003), Kisvarga et al. (2010) and Köbli et al. (2010). In the experiments of Rounkova (1989) Cultar decreased the shoot length of *Chrysanthemum coreanum* 'Jantar', *Phlox* and *Dahlia* plants with 50%, and delayed the flowering time with 3-5 days compared with the control plants.

The growth retardants decreased the size of the plants mainly by shortening the internodes similarly to researches of Cathey (1975), Jiao et al (1986), Kochankov et al. (1989), Mohamed, (1997), Matysiak (2002), Hanson et al. (2003), Krause et al. (2003), Kisvarga et al. (2010) and Köbli et al. (2010). The size of plants treated by Cultar decreased by 43-71%, however the number of nodes alternated between 1.6-18.7% compared with Control plants. Similar results were achieved by Rounkova (1989).

Effect of growth retardants on photosynthetic activity

The growth retardant treatments had some effect on the transpiration rate, stomatal conductance, and net CO_2 fixation of leaves, but not in the same extent in all three measurement times. These results are comparable with the researches of Deyton et al. (1991), Thetford et al. (1995) and Xu et al. (2010).

There were significant differences in net CO_2 fixation and stomatal conductance between the different treatments on the first day after last spraying. At the second measurement time (3-4 weeks after the last spraying) the differences were moderated, at the third measurement time (6 week after the last spraying) the differences were minimal.

Probably, the reason was partially the degradation of chemicals and also the decrease in their concentration (a sort of dilution) due to the increased volume of the constantly growing, larger sized plants. The photosynthetic activity of plants and water use efficiency was influenced not only by growth retardants but also by weather conditions (photosynthetically active radiation, temperature, precipitation). At the third measurement time the water use efficiency was the highest, which can be in context with the more humid and cold weather.

The after-effect of growth retardants on rooting, shoot growth, and blooming time of cuttings

The after-effect of growth retardants was minimal in the following year. The rooting of the cuttings was not influenced. There were some differences in the height of young plants (cuttings taken from the formerly treated plants), but their blooming time was similar to the untreated control. From the above it can be stated that the chemicals probably disappeared from the plant after one year, or decreased in concentration on the constantly growing, larger sized plants, so they did not influence the rooting and the blooming time of cuttings.

4.2. *Lespedeza thunbergii*

Effect of propagation time on rooting, shoot development, and the sprouting of basal buds of softwood cuttings

The best root development was observed in case of cuttings propagated in May, June, and July. These cuttings flowered in autumn, and their underground buds sprouted, so the optimal propagation time of *Lespedeza thunbergii* was throughout the spring, and early summer. These results are in accordance with the results of Dirr and Heuser (1987). Cuttings propagated in August-September rooted badly, after flowering they died, their underground buds did not develope. Cuttings propagated in October did not root. In late summer and in the autumn period, therefore, it is no longer recommended to propagate *Lespedeza thunbergii*.

Effect of propagation time on flowering and overwintering capacity of softwood cuttings

The developing of inflorescences was 95% on the shoots of the cuttings propagated in May and June. The cuttings propagated in July, August, and September have inflorescences on their new shoots in 76-100%. This number was the lowest in cuttings taken from the basal part of the shoot, and the highest in the cuttings taken from the upper part of the shoot, where new inflorescences developed directly from their leaf axils. It is supposed that by the time of taking the cuttings they had not only vegetative, but also flower buds as well.

The best overwintering result was obtained by the cuttings taken at the beginning of the summer. The cuttings taken in May and June became thick at the base and developed overwintering buds and also some storage roots with starch reserves by the autumn. However, the majority of overwintering buds developed under the ground or just above the ground.

5. NEW SCIENTIFIC RESULTS

Reproduction results

1. At the base of the cuttings propagated in May, June and July some preformed roots formed at the end of autumn.

2. On *Lespedeza* softwood cuttings, the overwintering underground organs (starch roots and stems, overwintering underground buds) developed in two months after the rooting.

Flowering results

3. However, English-language literature keeps both *Caryopteris* taxa and *Lespedeza thunbergii* as short day plants, I proved long day conditions are necessary for the flower initiation of these plants in Hungary, and they need certain number of nodes to develop flower buds.

4. On the shoots of young plants the first flower buds developed after 7-9 nodes, while on the mother plants they developed after 9-11.

5. In case of *Caryopteris* the first 1-2 whorl of flower buds did not open, flower buds opened just whorls above them. The number of remaining dormant buds depends on the age of the plants as well. In the shoots of mother plants more (up to 6 nodes) buds remain dormant, than in the shoots of the young plants propagated in the same year (1-2 nodes).

6. At the end of June *Lespedeza thunbergii* plants flowered directly on short side shoots, while from August new flowers developed directly from leaf axils.

***Overwintering* results**

7. *Lespedeza thunbergii* plants are just perennials in Hungary, because their shoots die during the winter completely, even if the temperature does not fall below +10ºC, in greenhouse conditions, and only the underground parts remained alive.

PRACTICAL RESULTS

I have found safe propagation technology for *Caryopteris incana* and *Caryopteris* × *clandonensis* 'Grand Bleu', and also for *Lespedeza thunbergii*.

With the timing of propagation, I could shorten their growing time from two years to one year.

Using growth retardants with *Caryopteris incana* and *Caryopteris* × *clandonensis* 'Grand Bleu' they can be grown not only as outdoor container plants but also as pot-grown outdoor flowering plants.

a) *Caryopteris incana* *Caryopteris* × *clandonensis* 'Grand Bleu'

b) *Caryopteris incana* *Caryopteris* × *clandonensis* 'Grand Bleu'

Fig. 24. a, b. *Caryopteris incana* and *Caryopteris* × *clandonensis* 'Grand Bleu' plants treated with Cultar 2% (left) and untreated control cuttings (right):

a) 4th day after the last sparying (on 06.09.2013.)

b) 23rd day after the last sparying (on 24.09.2013.)

Cuttings propagated in May and early summer, became well rooted plants by autumn full of flowers (Fig. 25).

Fig. 25: The growing and flowering of *Lespedeza thunbergii* cutting propagated in 07.05.2012. Photos taked on 06.09.2013. (left) and on 24.09.2013. (right).

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3. Harmath J., Schmidt G. (2010): A dugványozás hatása a *Caryopteris* × *clandonensis* 'Heavenly Blue' virágzási időpontjára, Kertgazdaság 42(2):61-65.

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5. Harmath J. (2012): Dwarfing of *Caryopteris* × *clandonensis* 'Grand Bleu': the interaction between growth retardants and the transpiration rate stomatal conductance and CO_2 fixation, Acta Universitatis Sapientiae 4:19-30.

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7. Harmath J. (2013): Retardánsok hatása két *Caryopteris* faj leveleinek vízhasznosítására, Kertgazdaság, 45(2):47-52.

8. Harmath J., Schmidt G., Forrai M., Szabó V., (2014): The influence of some growth retardants on growth, transpiration rate, stomatal conductance and CO2 fixation of *Caryopteris incana* 'Heavenly Blue', Folia Oecologica 41(1):

9. Harmath J., Schmidt G. (2014): Retardánsok alkalmazása a kékszakáll (*Caryopteris* × *clandonensis* 'Grand Bleu') törpésítésére, virágzásának befolyásolására, Kertgazdaság 46(1)

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1. Harmath J., Schmidt G. (2009): Virágkezdemények kialakulásának feltételei három nyáron virágzó díszcserjénél, Erdei Ferenc V. Tudományos Konferencia kiadványa, Kecskemét, 1189-1192.
2. Harmath J., Schmidt G. (2011): Törpítőszerek hatása két *Caryopteris* faj virágzására, Erdei Ferenc VI. Tudományos Konferencia kiadványa, Kecskemét, 324-328.

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1. Schmidt G., Harmath J. (2009): Anatomical and histological changes in the stem of *Lespedeza thunbergii* L. rooted cuttings as depending on the time of propagation, Lippay-Ormos-Vas Tudományos ülésszak, Dísznövénytermesztési és Dendrológiai szekció, Budapest, 60-61.
2. Harmath J., Schmidt G., Daczó L. (2009): Effect of different hormone products on the rooting and shootgrowth of A *Caryopteris × clandonensis* A. Simmonds ex Rehd. cuttings, Lippay-Ormos-Vas Tudományos ülésszak, Dísznövénytermesztési és Dendrológiai szekció, Budapest, 16-17.
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2. Harmath J., Schmidt G. (2010): Effect of some growth retardants on *Caryopteris clandonensis* 'Grand Bleu' young plants, Bulletin of University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Horticulture, vol.67 (1), 354-358.

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1. Harmath J., Schmidt G. (2011): Effect of some growth retardants on *Caryopteris incana* young plants, I. Transilvanian Horticulture and Landscape Studies Conference, Marosvásárhely, p. 32.
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