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EVALUATION OF DIFFERENT TYPES OF ROOTING STIMULATORS

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Abstract

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This paper focuses on the assessment of selected stimulators, especially from Rhizopon product line, which are used for rooting and root system enhancement in various ornamental woody species. Two available methods of cuttings stimulation were selected from the available range of rooting stimulators: stimulation by long-term immersion in solutions or treatment of cuttings with powder stimulators. The experiment involved stimulators with two active components, currently the most commonly used phytohormones for this purpose – IBA and NAA – that were applied in different concentrations. The experiment took place in three propagation terms with twelve coniferous and deciduous shrub varieties. The results of the experiment show the different reactions of the individual species as well as varieties on the respective term of propagation and used form of stimulator.

propagation, cuttings, rooting stimulators, Rhizopon

Vegetative propagation is the most common method used in commercial production of many garden plants (ornamental plants, fruit and vegetable species). However, vegetative propagation of some species is more costly compared to generative propagation, but in many ornamental species it is the only way of propagating that ensures the preservation of all characteristics of the parent plant (Hartmann *et al*., 2002).

In many species, vegetative propagation depends on the regeneration ability and growing of adventitious roots on overground parts of the plants. The efficiency of vegetative propagation is also significantly influenced by the environment in the propagation house, such as temperature, quality of the used substrate, and the air humidity. Other important aspects include the care for mother plants, selection of appropriate term for taking the cuttings, and quality of storage of the plant material before the cuttings are taken (Walter, 1997; Obdržálek and Pinc, 1997; Bärtels, 1988; Hartmann *et al*., 2002). The result of the influence of adverse conditions and factors is a consequent delay or low ability to produce adventitious roots (Dirr and Heuser, 2006). Production of adventitive roots is a process induced and regulated by external and internal factors, such as temperature, light, phytohormones, content of sugars, mineral salts and other substances. Phytohormones have a direct (interacting with other hormones and molecules) influence on the regenerative ability of the plant. Auxins play an important role in controlling the growth and development of the plants; besides other things they also influence the production of primary, secondary and adventitious roots (Šebánek, 2008). They are currently the most frequently used plant hormones for rooting of cuttings in nursery practice. The most commonly used auxin is synthetic 3-indolylbutyric acid (IBA), which proves to be the most effective hormone promoting the production of adventitious roots compared to natural indolyl-3-acetic acid (IAA) (Pop *et al*., 2011). Another relatively common synthetic auxin is α-naphthylacetic acid (NAA), which is not so effective in comparison with IBA and IAA, but its main advantage is lower price on the market. All these acids are also used in the form of potassic salts, which are easily soluble in water without the necessity to use organic solvents (Pop *et al*., 2011). For successful propagation by cuttings it is also necessary to select the correct time for taking the cuttings, which closely relates to the content of natural phytohormones (Šebánek, 2008).

However, in the conditions of practical operation we often encounter lack of time for taking of cuttings in appropriate terms of propagation. In this case the propagators resort to using rooting stimulators, which increase the overall percentage of rooting, facilitate initiation of adventitious roots, and enhance the number and quality of adventitious roots (Dirr and Heuser, 2006). There are several products commercially available on our market that directly or indirectly support or positively influence the production of adventitious rots. In horticultural practice there are many plant stimulators with various phytohormone content. We often see improper use of rooting stimulators due to using too high or too low doses of the active components (Ersoy *et al*., 2010; Sulusoglu and Cavusoglu, 2010).

One of the commercially available products is Rhizopon stimulator, which is distributed to the market in multiple forms (solution, powder, …) and also in different concentrations. The active component of this stimulator is synthetic auxin IBA and NAA. The purpose of this experiment was to find out the suitability of selected stimulators in different concentrations on rooting and formation of root system in selected species of plants suggested by Pasič corporation (Dolní Životice), such as hard-to-propagate species in relevant propagation terms.

MATERIALS AND METHODS

In 2011 and 2012 the experiment focused on assessing the effect of different stimulators on selected species of ornamental woody plants. The experiment took place on two sites – in Pasič corporate nursery (Dolní Životice) and at Faculty of Horticulture MENDELU in Lednice. Three separate experiments were established with different species of ornamental plants and unequal number of studied stimulators. Experiment A took place in Pasič nursery corporation with propagation term on 7. 12. 2011. It was established in order to study the influence of stimulators No 1 to No 8 (see Tab. I). The "cold" greenhouse within the company premises was used as propagation area. Dew spraying was performed via Coolnet nozzles and was controlled by misting regulator (AMET, Velké Bílovice) with wetness sensor. Measuring of environment parameters was performed by an automatic meteorological station (AMET, Velké Bílovice) that measured air temperature and humidity, as well as the number of mist sprayings, substrate mooisture (see Figs. 1 and 2) and intensity of leaf wetness in quarter-hourly intervals, uploading this data on a website in order to allow for remote reading of the measured values and adjusting them if necessary.

Supplementary experiment B took place at the Faculty of Horticulture in Lednice with propagation term of 29. 08. 2011. The experiment was situated in experimental foil tunnel. Misting was performed via Coolnet nozzles and was controlled by misting regulator (AMET, Velké Bílovice). Measuring of environment parameters was performed with Hobo temperature and humidity registering device (AMET, Velké Bílovice). The experiment studied stimulators No. 1 to No. 11 (see Tab. I).

Supplementary experiment C took place on the same site and under the same conditions as experiment B and was performed on 19.06.2012. It studied the effect of stimulators No. 1 to No. 13 (see Tab. I).

The experiment used 3 different commercially available stimulators of Rhizopon and Stimulax brands. Selected stimulators were further used in multiple concentrations and combinations. All together there were 13 alternatives in the experiment, including control treatment alternative, which was left to establish roots without the use of any stimulators (see Tab. I). Each alternative had three 3 repeats with 140 cuttings in each repeat, i.e. 420 repeats in one alternative.

I: *Stimulators used in the experiment*

Number of treatment	Treatments	State	Concentration	Active ingredient
1	Control treatment	–	–	–
2	Rhizopon A	T	0.005%	IAA
3	Rhizopon A	T	0.01%	IAA
4	Rhizopon A	T	0.015%	IAA
5	Rhizopon A	T	0.02%	IAA
6	Rhizopon AA	P	0.50%	IBA
7	Rhizopon AA	P	1%	IBA
8	Rhizopon AA	P	2%	IBA
9	Rhizopon B	T	0.01%	NAA
10	Rhizopon B	T	0.015%	NAA
11	Rhizopon B	T	0.02%	NAA
12	Rhizopon AA + Rhizopon B	P+T	0.5% + 0.5%	IBA + NAA
13	Stimulax III + IBA + NAA	G	0.5% + 0.5%	IBA + NAA

*T – tablets, P – powder, G – gel

II: *Model plants in three terms of propagation*

Experiment A		Experiment B	Experiment C
Term of propagation 7.12.2011		**Term of propagation 29.8.2011**	**Term of propagation 19.6.2012**
Picea abies 'Nidiformis'	*Taxus baccata* 'Hicksii'	*Deutzia gracilis* 'Nikko'	*Weigela hybrida* 'Piccolo'
Picea glauca 'Conica'	*Taxus baccata* 'David'	*Pyracantha coccinea* 'Dart's Red'	*Syringa meyeri* 'Palibin'
x *Cupressocyparis leylandii* 'Gold Rider'	*Taxus baccata* 'Repandens'	*Cornus alba*	*Cornus alba* 'Spaethii'
Juniperus procumbens 'Nana'	*Buxus sempervirens* 'Winter Beauty'	*Forsythia x intermedia* 'Maluch'	
Buxus sempervirens 'Rotundifolia'	*Buxus sempervirens* 'Globosa'		

Table II below shows the model plants selected for the given terms.

In terms of listing in cuttings category, the first term of propagation used mature woody cuttings of coniferous and evergreen plant species. The second term of propagation used semi-mature cuttings, third term of propagation used herbaceous cuttings of deciduous broadleaf shrubs. The mother plants are freely grown at special stock nursery with unwowen textile between the rows. The stock is radically cut down every year in early spring to approximately 20 cm above the ground. Polycomponent fertiliser is applied at the beginning of the vegetation and followed by further fertilising steps using leaf-on Kristalon spray 3 times during the growing period. Common protection routine against fungal diseases and pests is performed. The mother stock age ranges between 3 and 6 years. The cuttings were taken in a standard way for each type of cuttings, in approximately 7–15 cm size depending on the plant species. Once taken, the cuttings were placed in nursery trays with 140 cells (1 cell of 5.4 cm^3). As rooting substrate was used Klasmann rooting subtrate; it is offen used for nursery purposes and consists of peat with added pearlite. Prior to filling with substrate the nursery trays were treated with 71 $g.m^3$ of Gliorex for improving tolerance to fungal pathogens in rooting substrate. Once the cuttings were planted the trays were placed in the nursery environment. The propagation house was constantly monitored for air temperature, humidity of air and substrate, and number of dew-drop sprayings.

After the end of the rooting period the individual experiments were evaluated on a point scale; four-point rooting scale was used for propagation terms of 7. 12. 2012 and 19. 06. 2012 (Tab. III). Three-point rooting scale was used for the propagation term of 29. 8. 2011 (Tab. IV). Evaluation of rooting was carried out after aaproximately 60 days following the establishment of the experiment for broadleaf plants and after 7 months for conifers (due to the possibilities of the production company).

III: *Four-point scale for evaluation of cutting's rooting*

Points	Evaluation of rooting
1	Not rooted
2	Callus formed
3	1–2 roots
4	3 and more roots

IV: *Three-point scale for evaluation of cutting's rooting*

Points	Evaluation of rooting
1	Not rooted + callus formed
2	1–2 roots
3	3 and more roots

RESULTS AND DISCUSSION

Four woody coniferous species and one evergreen woody plant in cultivars were selected for testing in the first term of propagation.

The best results were achieved in *Buxus sempervirens,* which scored high in all alternatives of the experiment with high percentage of rooting. Walter (1997) states that the best term for propagating the *Buxus* genus is between August and November, using mature cuttings that are stimulated either in powder stimulator of 12000 ppm IBA (1.2%) concentration or long-term immersion in aqueous solutions of 20–80 ppm IAA (0.002–0.008%) concentration, immersion time was 16 hours. Rhizopon (2012) states June to September to be the best term for taking cuttings, and recommends powder as stimulator. Dirr and Heuser (2006) recommend mid June as the best term for taking the cuttings, promoting rooting in clean sand without stimulator; with later terms of taking – from August to November, they recommend the use of powder stimulators containing IBA as active substance in various concentrations; they consider high air humidity and its maintenance in the propagation house to be the key criterion of successful rooting of this species. However, this experiment did not record a statistically significant positive influence of the used stimulator on the rooting ability of the *Buxus* genus in comparison with the control alternative used for the 'Winter Beauty' and 'Globosa' cultivars. The 'Rotundifolia' cultivar, when treated with powder stimulator Rhizopon AA (1%) showed a statistically significant effect on root formation compared to the control alternative. Rooting ranged between 57.1% and 97.9% in all the cultivars and alternatives, where cuttings received high point scores, which means that most of them formed more than three roots per cutting (see Tab. V).

The reduction of the overall rooting percentage in this genus is a result of using aqueous solution and method of long-term immersion, especially with the 'Globosa' and 'Winter Beauty' cultivars (see Tab. V).

For *Taxus baccata* species and its cultivars, authors Walter (1997) and Rhizopon (2012) recommend

V: *Experiment A – Term of propagation – 7. 12. 2011*

Evaluation percentage of rooting [%]										
Model plant	*Taxus baccata* 'Hicksii'	*Taxus baccata* 'David'	*Taxus baccata* 'Repandens'	*Buxus sempervirens* 'Winter Beauty'	*Buxus sempervirens* 'Globosa'	*Buxus sempervirens* 'Rotundifolia'	*Picea abies* 'Nidiformis'	*Picea glauca* 'Conica'	*x Cupressocyparis leylandii* 'Gold Rider'	*Juniperus procumbens* 'Nana'
Control treatment	73.2	34.6	2.9	92.9	97.9	88.9	15.0	1.8	60.4	21.1
Rhizopon A 50 mg tablets 0,005 %	81.1	52.5	5.7	68.2	57.1	92.5	6.1	2.9	83.2	11.8
Rhizopon A 50 mg tablets 0,01 %	75.4	50.4	6.4	91.4	93.2	91.1	30.0	42.9	85.4	20.0
Rhizopon A 50 mg tablets 0,015 %	78.9	58.9	21.4	85.0	60.0	91.4	37.5	33.6	84.6	16.4
Rhizopon A 50 mg tablets 0,02 %										
Rhizopon AA powder 0,5 %	88.9	40.4	10.7	87.1	91.4	94.6	6.8	3.6	73.6	25.0
Rhizopon AA powder 1 %	71.4	50.0	10.7	92.9	92.5	96.8	42.1	1.4	92.9	31.8
Rhizopon AA powder 2 %	42.9	58.2	10.7	88.6	93.6	91.1	11.4	0.4	81.4	20.0
Evaluation number of roots [point]										
Control treatment	$3,12^{a}\pm0,08$	$2,54^{c}\pm0.05$	$1,87^{b}\pm0,03$	$3,76^{a}\pm0,05$	$3,93^{a}\pm0,03$	$3,68^{a}\pm0,05$	$1,40^{b}\pm0,06$	$1,05^{a}\pm0,03$	$2,93^{d}\pm0,08$	$1,68^{abc}\pm0,06$
Rhizopon A 50 mg tablets 0,005 %	$3,42^{bcd}\pm0,06$	$2,90^{ab}\pm0,05$	$1,71^{ab}\pm0,04$	$3,03^{b}\pm0,08$	$2,67^{b}\pm0,09$	$3,81^{ab}\pm0,04$	$1,15^{a}\pm0,04$	$1,08^{a}\pm0,08$	$3,51^{ab}\pm0,06$	$1,41^{a}\pm0,07$
Rhizopon A 50 mg tablets 0,01 %	$3,32^{abc}\pm0,07$	$2,88^{ab}\pm0,06$	$1,60^{a}\pm0,04$	$3,74^{a}\pm0,05$	$3,77^{a}\pm0,05$	$3,74^{ab}\pm0,05$	$1,81^{c}\pm0,08$	$2,16^{c}\pm0,08$	$3,57^{ac}\pm0,06$	$1,60^{ab}\pm0,06$
Rhizopon A 50 mg tablets 0,015 %	$3,48^{cd}\pm0,06$	$3,04^{a}\pm0,06$	$2,12^{c}\pm0,06$	$3,53^{a}\pm0,06$	$2,77^{b}\pm0,09$	$3,75^{ab}\pm0,05$	$2,03^{c}\pm0,04$	$1,96^{c}\pm0,03$	$3,55^{ac}\pm0,06$	$1,47^{ab}\pm0,07$
Rhizopon A 50 mg tablets 0,02 %										
Rhizopon AA powder 0,5 %	$3,65^{d}\pm0,06$	$2,70^{bc}\pm0,06$	$1,72^{ab}\pm0,05$	$3,62^{a}\pm0,06$	$3,73^{a}\pm0,05$	$3,83^{ab}\pm0,04$	$1,17^{ab}\pm0,03$	$1,08^{a}\pm0,01$	$3,24^{b}\pm0,08$	$1,72^{bc}\pm0,08$
Rhizopon AA powder 1 %	$3,17^{ab}\pm0,08$	$2,89^{ab}\pm0,06$	$1,71^{ab}\pm0,05$	$3,76a\pm0,05$	$3,76^{a}\pm0,05$	$3,87^{b}\pm0,03$	$1,15^{a}\pm0,05$	$1,03^{a}\pm0,01$	$3,79^{c}\pm0,05$	$1,95^{c}\pm0,07$
Rhizopon AA powder 2 %	$2,29^{e}\pm0,08$	$3,04^{a}\pm0,06$	$1,75^{ab}\pm0,04$	$3,63^{a}\pm0,06$	$3,80^{a}\pm0,04$	$3,69^{a}\pm0,05$	$1,27^{ab}\pm0,02$	$1,01^{a}\pm0,02$	$3,44^{ab}\pm0,07$	$1,57^{ab}\pm0,03$

Evaluation of the number of roots = AM (arithmetic mean) points of evaluation of the cuttings' rooting $^{HG\ (homogenous\ groups)}$ ± SEM (standard error of the mean)

September to December as the best term for taking the cuttings. They mostly recommend using the stimulator in powder form in concentrations from 0.4 to 1.2% IBA. In this experiment, species *Taxus baccata* and its cultivars, propagated in the first term of propagation, recorded only a low percentage of rooting, especially the 'Repandens' cultivar, where it ranged from 2.9% to 21.4%. This corresponds with the conclusions of Dirr and Heuser (2006), who state that it is a hard-to-propagate cultivar for many growers. For this cultivar they recommend using stimulator with IBA auxin in 0.8% concentration plus fungicidal component. In this experiment, statistically significant increase of rooting percentage was caused only by the use of stimulator in the form of solution with 0.02% concentration. Use of powder stimulator with higher concentrations of IBA increased the percentage of rooting by 7.8%. The best results in this term were achieved by the propagation of 'Hicksii' cultivar, where rooting ranged between 42.9 and 88.9%. Developed root system was found mainly in cuttings treated with low-concentration stimulators (0.5% IBA), but especially with powder stimulator (see Tab. V). Slighly weaker results were achieved by 'David' cultivar, in which the overall rooting percentage ranged approximately around 50%. Use of higher IBA concentrations proved to be more effective in comparison with lower concentrations.

Species x *Cupressocyparis leylandii* 'Gold Rider' achieved relatively good results when treated with rooting stimulators appropriate for this species in the given term. Authors Walter (1997) and Dirr & Heuser (2006) recommend to propagate this species in summer and autumn period, with the use of powder stimulator containing IBA 0.3–0.8%. Statistically provably higher percentages of rooting with the use of stimulators were achieved in comparison to the first control alternative. The best results were achieved with powder stimulator Rhizopon AA that contained 1% IBA.

Species *Picea abies* in two cultivars and *Juniperus procumbens* 'Nana' achieved, in this term of propagation, low yield of cuttings (see Tab. V). The lowest percentage of rooting was recorded in *Picea abies* 'Conica', where most of the cuttings died during the rooting period, not having formed callus. Walter (1997), Dirr and Heuser (2006) as well as Rhizopon (2012) claim June to October to be the best period of propagating spruce by cuttings; they recommend using powder stimulators as well as other methods of stimulation with IBA, such as long-term immersion or the Quick Dip method. In general, *Picea* species achieved a positive increase of rooting with stimulators in higher concentrations (0.01 and 0.015% IBA) in the form of aqueous solutions. Although this increase was statistically significant ($\alpha = 0.05$) in comparison to the control alternative, due to very low rooting percentage it came out as not very effective. For *Juniperus procumbens* 'Nana' Dirr and Heuser (2006) state that the best term for taking the cuttings is December to February, with the necessity to use powder stimulator with IBA in 0.8% concentration as the active substance. As another important factor of success they also state that for this species it is necessary to keep the propagating substrate moist but not too wet. The use of studied stimulators, however, did not prove successful for this species in this experiment.

In the second term of propagation the model plants were four species of deciduous shrubs (see Tab. VI). Abbreviated point scale was used here to assess the root system of the cuttings (see Methods).

Species *Pyracantha coccinea* 'Dart's Red' and *Cornus alba* achieved very high values of rooting percentage in all the alternatives of the experiment. In

VI: *Experiment B – Term of propagation – 29. 8. 2011*

Evaluation percentage of rooting [%]				
Model plant	***Deutzia gracilis* 'Nikko'**	***Pyracantha coccinea* 'Dart´s Red'**	***Cornus alba***	***Forsythia x intermedia* 'Maluch'**
Control treatment	52.9	91.4	90.7	50.7
Rhizopon A 50 mg tablets 0,01 %	64.3	95.0	87.9	85.0
Rhizopon A 50 mg tablets 0,015 %	53.6	91.4	92.9	62.9
Rhizopon A 50 mg tablets 0,02 %	57.1	97.1	88.6	92.1
Rhizopon AA powder 0,5 %	70.0	92.9	91.4	45.7
Rhizopon AA powder 1 %	59.3	92.1	97.9	13.6
Rhizopon AA powder 2 %	67.1	88.6	94.3	38.6
Rhizopon B 25 mg tablets 0,01 %	47.1	85.0	92.9	65.7
Rhizopon B 25 mg tablets 0,015 %	40.0	94.3	90.0	93.6
Rhizopon B 25 mg tablets 0,02 %	47.9	95.7	91.4	88.6
Evaluation number of roots [point]				
Control treatment	$1,84^{ab} \pm 0,07$	$2,00^{abc} \pm 0,12$	$2,15^{a} \pm 0,14$	$1,71^{a} \pm 0,07$
Rhizopon A 50 mg tablets 0,01 %	$2,13^{ac} \pm 0,08$	$2,45^{bd} \pm 0,12$	$2,00^{a} \pm 0,15$	$2,48^{be} \pm 0,06$
Rhizopon A 50 mg tablets 0,015 %	$1,95^{ab} \pm 0,08$	$1,93^{abc} \pm 0,12$	$2,48^{ab} \pm 0,14$	$2,03^{d} \pm 0,07$
Rhizopon A 50 mg tablets 0,02 %	$1,95^{ab} \pm 0,08$	$2,58^{d} \pm 0,11$	$2,00^{a} \pm 0,14$	$2,71^{bc} \pm 0,05$
Rhizopon AA powder 0,5 %	$2,35^{c} \pm 0,08$	$2,03^{abc} \pm 0,11$	$2,23^{a} \pm 0,13$	$1,63^{a} \pm 0,08$
Rhizopon AA powder 1 %	$2,06^{ac} \pm 0,08$	$2,20^{abd} \pm 0,13$	$2,85^{b} \pm 0,15$	$1,65^{a} \pm 0,05$
Rhizopon AA powder 2 %	$2,34^{c} \pm 0,08$	$1,88^{ac} \pm 0,11$	$2,58^{ab} \pm 0,14$	$1,56^{a} \pm 0,06$
Rhizopon B 25 mg tablets 0,01 %	$1,84^{ab} \pm 0,08$	$1,60^{c} \pm 0,12$	$2,23^{a} \pm 0,14$	$2,20^{de} \pm 0,06$
Rhizopon B 25 mg tablets 0,015 %	$1,71^{b} \pm 0,08$	$2,30^{abd} \pm 0,13$	$2,15^{a} \pm 0,08$	$2,79^{c} \pm 0,07$
Rhizopon B 25 mg tablets 0,02 %	$1,87^{ab} \pm 0,07$	$2,25^{abd} \pm 0,13$	$2,30^{ab} \pm 0,13$	$2,63^{bc} \pm 0,07$

Evaluation of the number of roots = AM (arithmetic mean) points of evaluation of the cuttings' rooting $^{HG\ (homogenous\ groups)} \pm$ SEM (standard error of the mean)

Pyracantha species, only the alternative with aqueous solution of Rhizopon A (0.02% IAA) as stimulator achieved statistically provable higher point score for the root system compared to the control alternative, which correlates also with the higher percentage of rooting of this alternative. Just as in *Cornus alba* species and treatment with powder stimulator Rhizopon AA (1% IBA), where this treatment, compared to the control alternative, also achieved statistically provable higher point score in the root system evaluation.

Control alternative of *Deutzia gracilis* 'Nikko' achieved 52.9% rooting. Statistically provable higher percentage values, as well as better scores in the point-scale evaluation of the root system were recorded in treatments using powder stimulator, specifically concentrations of 0.5 and 2% IBA. In this species, use of stimulator with IBA as active substance proved positive compared to alternatives where NAA was the active component: these cuttings did not root or formed just a weak root system.

Use of powder stimulators Rhizopon AA (IBA) did not prove beneficial for *Forsythia intermedia* 'Maluch'. Cuttings treated by these stimulators achieved the lowest statistically provable values of rooting percentage at the end of the experiment. Other alternatives using tablet and water-soluble stimulators Rhizopon A (IAA) and Rhizopon B (NAA) achieved statistically provable higher values of rooting percentage compared to the control alternative, while statistically highly provable higher values were achieved with the use of these stimulators containing higher concentrations of active substances.

In the third term of propagation the point scale rating the root system of the cuttings was extended again and there were also more stimulators in the study. This term of propagation used herbaceous cuttings of deciduous broadleaf shrubs (see Tab. VII).

Species *Syringa meyeri* 'Palibin' achieved increased percentage of rooting compared to control alternative in only two alternatives: using powder stimulator (Rhizopon AA) in the highest concentration 2% (IBA) and combination of powder stimulator Rhizopon AA (0.5% IBA) with tablet stimulator Rhizopon B (0.5% NAA). However, this increase was not statistically provable. In general all the alternatives of the experiment achieved rooting percentage over 50% with relatively high point scores of their root systems, which means that the cuttings had one or more developed roots. Walter (1997) recommends June to be the best term for this species and suggests also using aqueous solutions of IBA in various concentrations. Dirr and Heuser (2006) state that this species belongs to hard-to-propagate ones. Positive results can be achieved through a correct term of taking the cuttings from young mother plants, and it is also necessary to

VII: *Experiment C – Term of propagation – 19. 6. 2012*

Evaluation percentage of rooting [%]			
Model plant	***Weigela hybrida*** **'Piccolo'**	***Syringa meyeri*** **'Palibin'**	***Cornus alba*** **'Spaethii'**
Control treatment	8.1	87.4	48.9
Rhizopon A 50 mg tablets 0,005 %			
Rhizopon A 50 mg tablets 0,01 %	25.2	56.3	72.6
Rhizopon A 50 mg tablets 0,015 %	48.9	80.0	63.0
Rhizopon A 50 mg tablets 0,02 %	77.0	77.8	77.8
Rhizopon AA powder 0,5 %	94.1	72.6	59.3
Rhizopon AA powder 1 %	94.1	79.3	70.4
Rhizopon AA powder 2 %	83.7	96.3	71.1
Rhizopon B 25 mg tablets 0,01 %	84.4	71.9	28.1
Rhizopon B 25 mg tablets 0,015 %	89.6	54.1	40.7
Rhizopon B 25 mg tablets 0,02 %	77.0	40.0	14.8
Rhizopon AA 0,5 % + Rh B 0,5 %	86.7	88.9	50.4
Stimulax III, 0,5 IBA + 0,5 NAA	39.3	73.3	63.0
Evaluation number of roots [point]			
Control treatment	$1,96^{c} \pm 0,05$	$3,61^{bd} \pm 0,09$	$2,47^{c} \pm 0,13$
Rhizopon A 50 mg tablets 0,005 %			
Rhizopon A 50 mg tablets 0,01 %	$2,27^{cd} \pm 0,09$	$2,62^{c} \pm 0,13$	$3,11^{ab} \pm 0,11$
Rhizopon A 50 mg tablets 0,015 %	$2,76^{e} \pm 0,10$	$3,34^{ab} \pm 0,10$	$2,85^{abc} \pm 0,12$
Rhizopon A 50 mg tablets 0,02 %	$3,39^{b} \pm 0,09$	$3,29^{ab} \pm 0,11$	$3,31^{b} \pm 0,11$
Rhizopon AA powder 0,5 %	$3,82^{a} \pm 0,09$	$3,11^{a} \pm 0,11$	$2,77^{abc} \pm 0,11$
Rhizopon AA powder 1 %	$3,84^{a} \pm 0,07$	$3,36^{ab} \pm 0,12$	$3,09^{ab} \pm 0,13$
Rhizopon AA powder 2 %	$3,50^{ab} \pm 0,11$	$3,85^{d} \pm 0,12$	$3,13^{ab} \pm 0,09$
Rhizopon B 25 mg tablets 0,01 %	$3,51^{ab} \pm 0,05$	$3,07^{ac} \pm 0,11$	$1,90^{d} \pm 0,13$
Rhizopon B 25 mg tablets 0,015 %	$3,79^{a} \pm 0,05$	$2,96^{ac} \pm 0,10$	$2,75^{ac} \pm 0,12$
Rhizopon B 25 mg tablets 0,02 %	$3,56^{ab} \pm 0,09$	$3,18^{a} \pm 0,05$	$2,96^{ab} \pm 0,12$
Rhizopon AA 0,5 % + Rh B 0,5 %	$3,64^{ab} \pm 0,07$	$3,65^{bd} \pm 0,08$	$2,50^{c} \pm 0,13$
Stimulax III, 0,5 IBA + 0,5 NAA	$2,53^{de} \pm 0,09$	$3,19^{ab} \pm 0,11$	$2,88^{abc} \pm 0,12$

Evaluation of the number of roots = AM (arithmetic mean) points of evaluation of the cuttings' rooting $^{HG\ (homogenous\ groups)} \pm$ SEM (standard error of the mean)

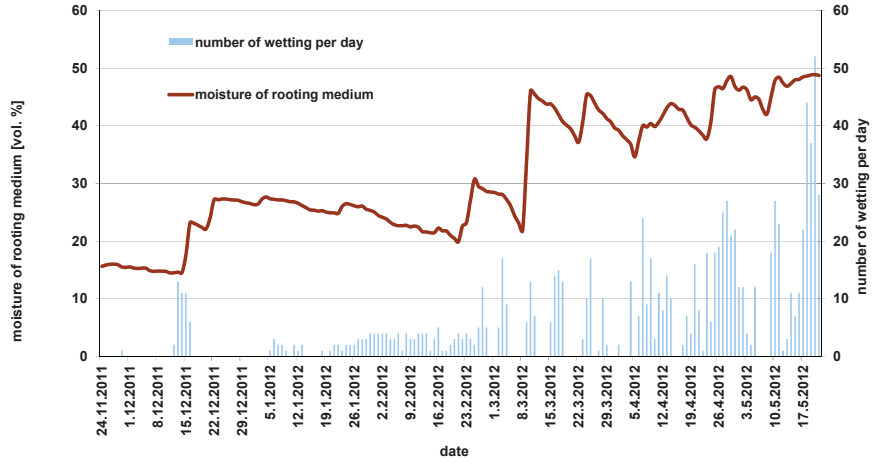
use IBA (0.3%) powder stimulator in 3000 ppm concentration.

Species *Weigela hybrida* 'Piccolo' in control alternative achieved a low percentage of cuttings' rooting, but the point score reveals that on average the cuttings had set up and formed callus. This species reacted positively to the use of all stimulators by increasing its rooting percentage. The best statistically highly significant ($\alpha = 0.01$) results were recorded in alternatives with powder stimulators and stimulators in concentrations of 0.5 and 1% IBA. Statistically highly significant ($\alpha = 0.01$) increase of the rooting percentage, as well as of the point score of the formed root system was recorded also with stimulators containing NAA as active component and combination of powder stimulator Rhizopon B (0.5% NAA) see Tab. VII. Rhizopon (2012) and Dirr & Heuser (2006) state the appropriate term for propagating this species to be June to July, with the use of powder stimulators in concentrations of 0.5–1% IBA, or use of solutions containing IBA in 0.1–0.3% concentrations.

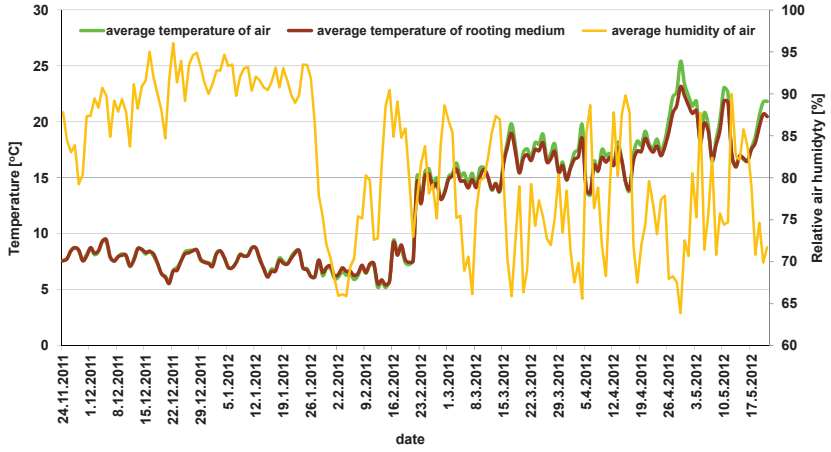
Species *Cornus alba* 'Spaethii' reacted positively to treating the cuttings prior to planting with IBA phytohormone; in all the alternatives this treatment increased the percentage of the cuttings' rooting. The highest rooting percentage, as well as the point evaluation of the root system was achieved by the alternative in which water-soluble stimulator Rhizopon A (0.02% IAA) was used, as well as powder stimulators Rhizopon AA (1 and 2% IBA) see. Tab VII. Rhizopon (2012) and Walter (1997) state that the best term for propagating this species is June to September, and recommend the use of powder stimulators in 1–2% concentration of IBA and also aqueous solutions with IBA as the active component in concentration 0.003–0.02%, for short-term immersion of the cuttings in 0.8% concentration. Dirr and Heuser (2006) recommend to propagate this species by summer cuttings with the use of stimulators containing IBA as the active component in concentrations of 0.1–0.3%.

CONCLUSIONS

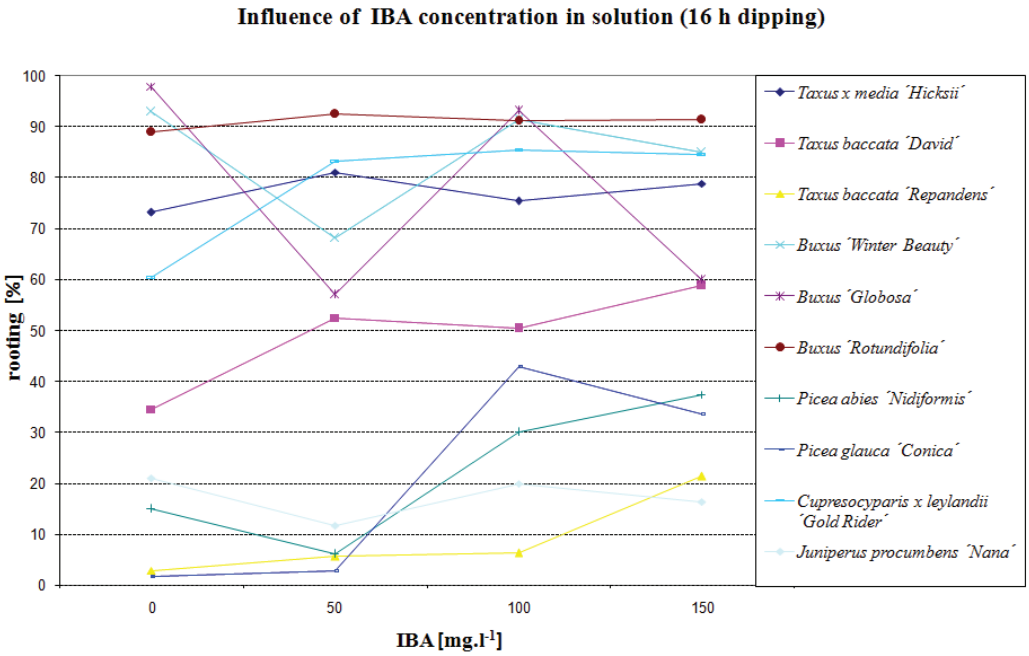
Use of rooting stimulators for the genus *Syringa*, and in the second term of propagation for *Buxus, Deutzia* and *Cornus* proved to be less effective due to



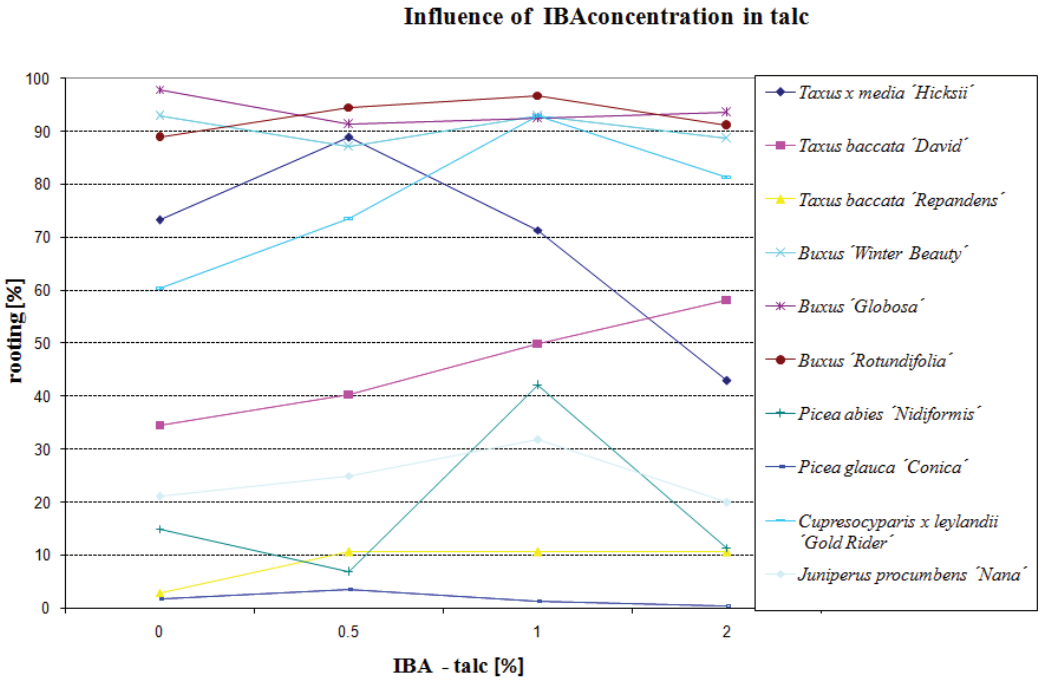
1: *Number of mist sprayings and moisture*



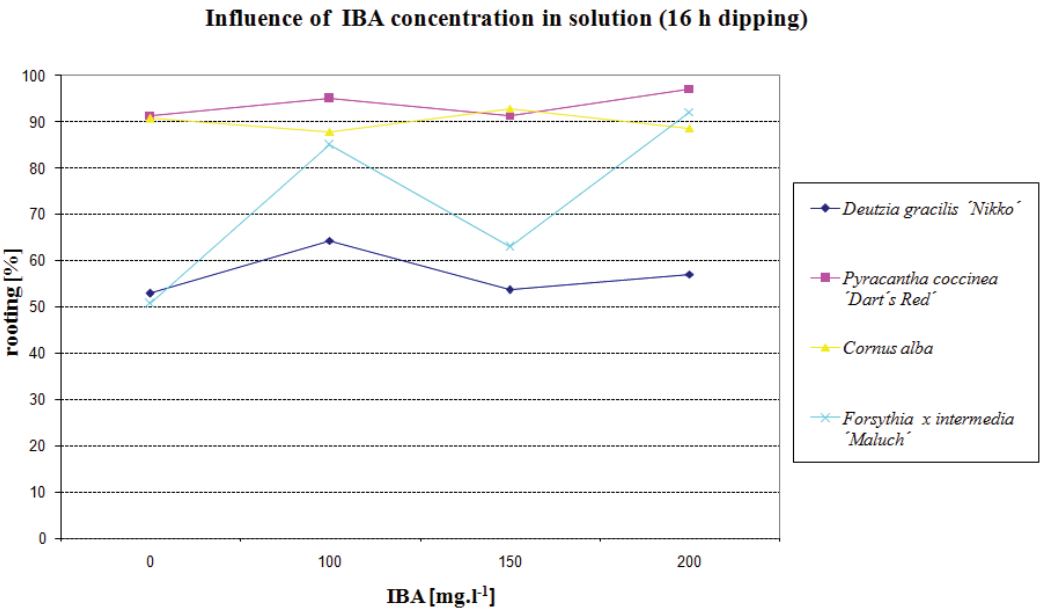
2: *Average values of temperature and humidity in experiment A*



3: *Effect of IBA concentration in liquid carrier (water solution) on cuttings' rooting (17. 12. 2011)*

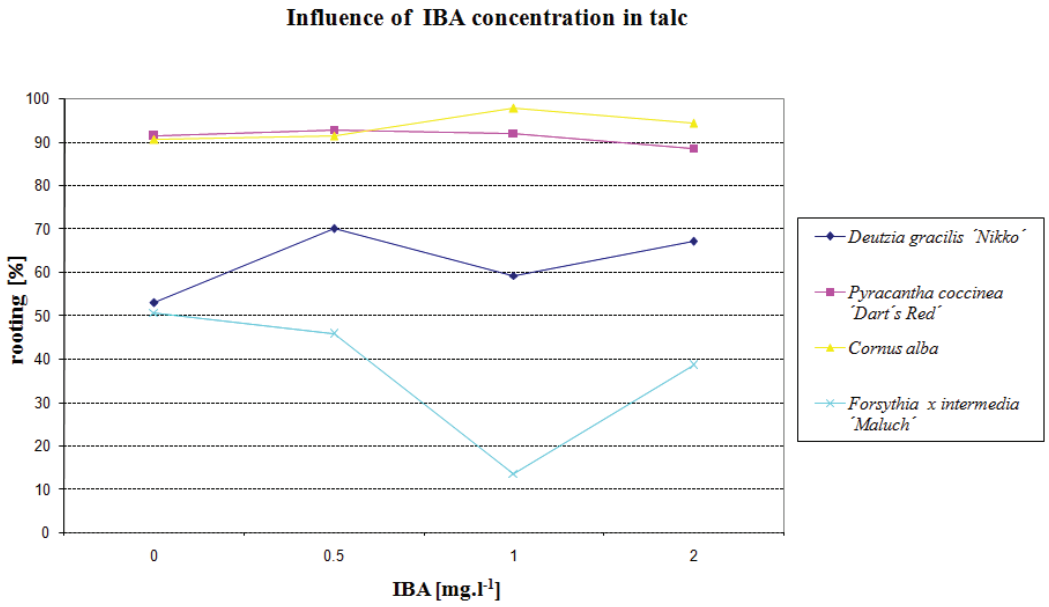


4: *Effect of IBA concentration in powder carrier (talc) on cuttings' rooting (17. 12. 2011)*

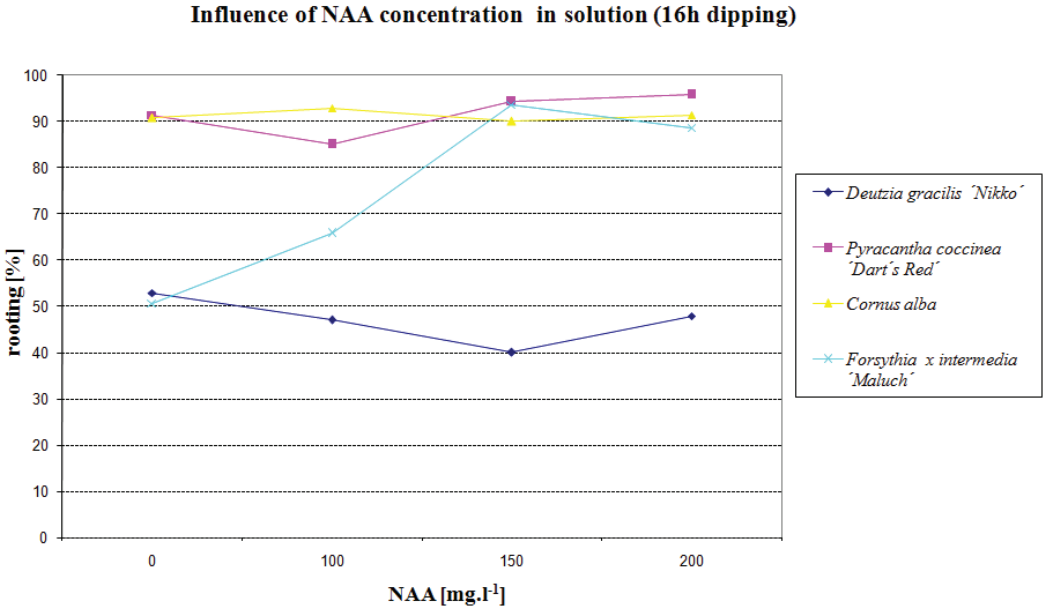


5: *Effect of IBA concentration in liquid carrier (water solution) on cuttings' rooting (29. 8. 2011)*

sufficient natural regenerative ability of the cuttings in the given term of propagation and conditions in the propagation house. It would be beneficial to test the effectiveness of using the given stimulators under adverse environmental conditions or in different terms of propagation with other types of cuttings. In *Taxus baccata* species the ability to form adventitious roots as well as rooting ability depended on the cultivar. Upon the gained results it can be said that the use of stimulators containing IBA can positively influence the formation and quantity of roots in this species, but it is necessary to reduce or increase its concentration upon the propagated cultivar. For *Picea abies* it proved best to use stimulators in higher concentrations of aqueous solutions. No stimulator proved good for genus *Juniperus* in the given terms of propagation and type of propagation house. It would be necessary to continue seeking different concentrations or other stimulating substances, or to find better terms of propagation. Genus *Cupressocyparis* reacted positively only to stimulators with IBA as active component, where it

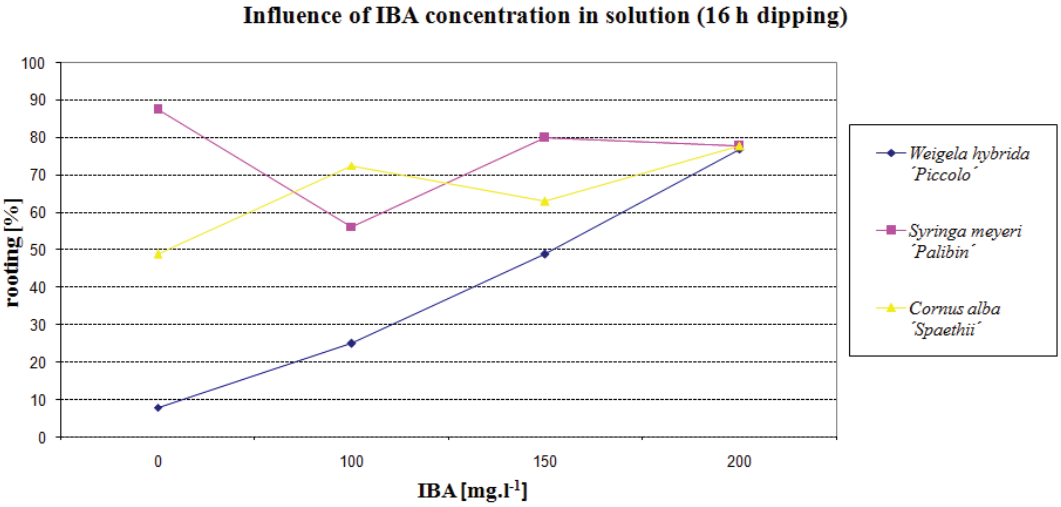


6: *Effect of IBA concentration in powder carrier (talc) on cuttings' rooting (29. 8. 2011)*

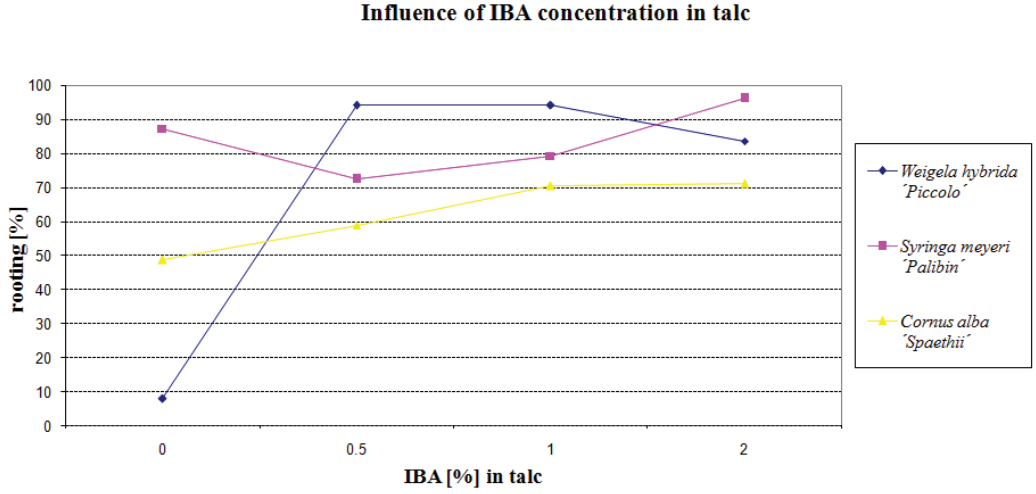


7: *Effect of NAA concentration in liquid carrier (water solution) on cuttings' rooting (29. 8. 2011)*

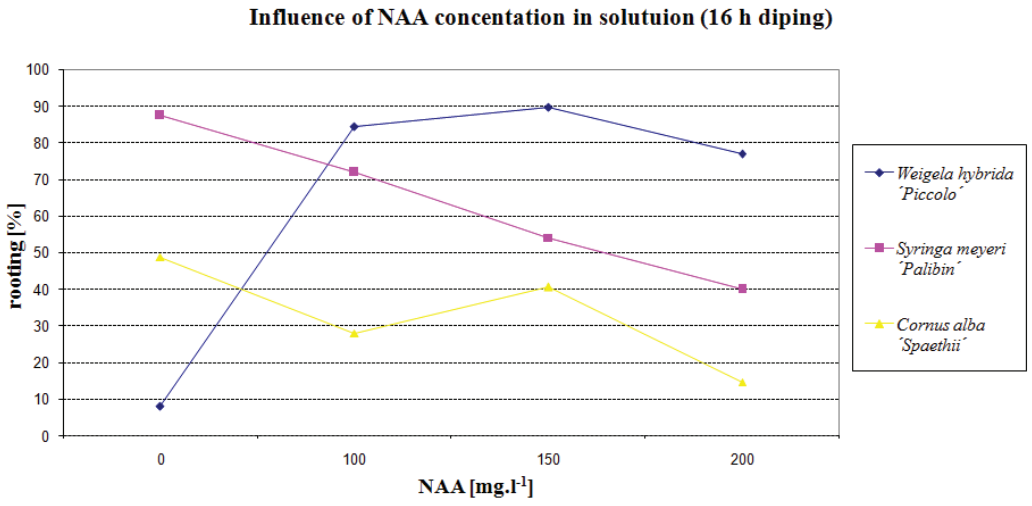
did not matter which form of stimulator was used. *Deutzia gracilis* 'Nikko' reacted positively to use of powder stimulator with IBA, but it would be good to continue working with the concentrations of the active component in this stimulator. *Forsythia intermedia* 'Maluch' reacted positively to the use of stimulators in the form of aqueous solutions and it did not matter which active component was used (IBA, NAA); however, it is necessary to study the different concentrations further. Genus *Weigela* achieved relatively good percentage results with aqueous solutions with IBA as active substance and it would be good to focus on the increasing of its concentration in the solution. *Cornus alba* 'Spaethii' positively reacted to stimulation of its cuttings with IBA as active component. Upon the results it is not possible to claim an outright recommendation for a certain group of cuttings (e.g. herbaceous cuttings) or certain plant species or cultivars. In the given terms of propagation each plant species and cultivar reacted differently to stimulation with two active substances as well as the form of stimulator used.



8: *Effect of IBA concentration in liquid carrier (water solution) on cuttings' rooting (19. 6. 2012)*



9: *Effect of IBA concentration in powder carrier (talc) on cuttings' rooting (19. 6. 2012)*



10: *Effect of NAA con*

SUMMARY

This paper deals with the assessment of selected stimulators, especially from Rhizopon product line, for the purposes of rooting and formation of root system. The experiment took place between 2011 and 2012 on two sites. Model plants were selected representatives of hard and easy-to-propagate species of ornamental coniferous and deciduous broadleaf shrubs. Different types of cuttings were taken from the model plants in three terms of propagation. These were consequently treated by rooting stimulators. The experiment involved three different stimulators from the Rhizopon and Stimulax product lines. Selected stimulators were used further in different concentrations and combinations. The selected commercially available stimulator products were used especially for two ways of stimulating the cuttings: by long-term immersion in aqueous solutions with low concentration, and treatment of the cuttings with powder stimulators. Stimulators with two active components, currently most commonly used phytohormones, were selected for the experiment: IBA and NAA. After the end of the rooting period the individual trials were evaluated upon a point scale of rooting. The results of the experiment show the different reactions of the individual species as well as cultivars on the relevant term of propagation and used form of stimulator.

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