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EFFECT OF BIOSTIMULATORS ON ROOTING OF *PRUNUS MAHALEB* SOFTWOOD CUTTINGS

PhD thesis

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1. Introduction

Plant propagation by softwood cutting belongs to autovegetative propagation. It means that the propagated part of plants needs to regenerate after sever from stockplant. It follows that propagated part of plant, in this case a part of shoot with leaves, is essential to keep alive and functionable under rooting period. The optimal environmental condition is also essential.

Usage of natural plant growth regulators in horticulture is increasing. They can be bioregulators or biostimulators, what enhance the physiological progresses in plants to improve biomass. Usage of practice was confirmed by more and more organised congress based on this topic (Prague 2007; Warsaw 2008). These substances are frequently used in agriculture, but rarely in horticulture, such as nursery propagation management.

The interest for Hungarian mahaleb clonal rootstocks is rising. Biostimulators give new opportunities developing propagation technology by softwood cutting of these rootstocks. Three mahaleb cultviars and one candidate were tested. The main aims of our research were to improve the propagation by softwood cutting by using biostimulators on stockplants and learn more about their effects on cutting and its rooting percentage.

Substances of Kelpak® (made of brown kelp, ***Ecklonia maxima***) are auxin, cytokinin, gibberellin and natural compounds such as vitamins, amino-acids and alginates. Wuxal® Ascofol is a leaf fertilizer with seaweed (***Ascophyllum nodosum***) extract, what containing NPK, auxin, cytokinin and gibberellin. The main substance of Pentakeep®-V is 5-aminolevulic-acid (ALA) which is a precursor of chlorophyll-synthesis in plants, in low level of concentration (10mM), which then improves photosynthesis and dry mass. The main substance of Yeald Plus® leaf fertilizer is zinc ammonium acetate, recommended for improved rooting after transplanting of young plants. BA (benzyladenine), what belongs to cytokinins, spray successfully improved the sylleptic shoot formation, what can improve the number of new auxin-producing meristems in shoot tip. Indole-butryc acid (IBA) from group of synthetic auxins is the wide-spread rooting stimulating substance. However the answer of plants for IBA is not definitely general, treatment of IBA on softwood cuttings is wide-spread, so this was considered as a secondary control in theese trials.

2. The aims of researchs

The aims of researchs are collected in the following.

1. In inland trade available or before release standing products of natural plant growth regulators will be first used on mahaleb clonal rootstock cultivars to improve shoot production of stockplants, number and quality of appropriate shoots for softwood cuttings.
2. We would like to estimate rooting rate of with biostimulators preconditioned shoots, respectively from them cut softwood cuttings to learn more about effects of this way of precondition on rooting and quality of the soffwood cuttings.
3. Based on literature effects of biostimulators are appropriate for improving efficiency of propagation by softwood cutting through spraying the cuttings under rooting period.
4. Biostimulators generally improve biomass production through increasing photosynthetic activity. We investigated theese effects on mahaleb cuttings, correlated with auxin establishment in stockplants and in cuttings, the chlorophyll content in leaves and the dry mass production of cuttings.

3. Materials and methods

3.1. Location of trials

The trial series were carried out in two areas. The stockplants are planted in open-ground, at the Experimental Farm of Corvinus University of Budapest. The farm is located in Central Hungary, the yearly average temperature is 11.3 °C, sunshine hours around 2079, precipitation 550 mm in a year. The characteristics of this area are as same as in Great Hungarian Plate. The precipitation is poor in July and August, the most precipitate fall in May and July. Both precipitation and temperature are unequipartition.

The other area of trials is the farm of Jenő Müller in Helvécia, near by Kecskemét. In this area the cuttings were rooting under an automated plastic tent, what fit to force ***Anthurium*** under good conditions. The high air humidity is reached by automated intermittent mist system. In the tent there is 70-80% of air humidity with 18°C in night until 6 o'clock a.m. and 24°C up to midday, the other periods of a day the temperature is 26°C. The cuttings were covered after srapying to morning after to prevent the washing-down of sprayed solutions there of leaves. Rooting medium was pure perlite to get clean root to be measured.

3.2. The mahaleb clonal rootstock cultivars in trials and their cutting stock block

'Bogdány' is a registered cultivar from 2009. It can be propagated by softwood cutting. The cuttings' rooting potential is varying.

'Magyar' is also a registered cultivar from 2009. Its cuttings are root in variable rate (between 70-80%).

'SL 64' was registered in Hungary in 2006. It was selected at INRA research institute, in Bordeaux, France in 1954. It is an easy-to-root cultivar (more than 90% rooting rate), propagated by softwood cutting.

'SM 11/4' is a candidate to cultivar. It is a chance seedling from a cherry orchard in Szigetcsép. It can be propagated by softwood cutting efficiently. Its cuttings are rooted 80-90% mostly in three weeks.

The stockplant block was planted in 2009. The shape of stockplants is hedged trees (Hrotkó 1999). All of stockplants were pruned severely and equal in late wintertime. There was not any other shoot-sorting after that. The water uptake of plants was supplemented by overhead irrigation system in cutting stock block.

3.3. Methods of trials

Stockplant treatments and measurements

Three biostimulators were used to spray onto stockplants with referenced concentration: Kelpak (0.2%), Wuxal Ascofol (0.2%) and Pentakeep-V (0.05%). Control plants were sprayed by tap water. First treatement was spraying on first week in May, when shoot were starting to grow. Each treatment was done early in the morning, all the time until the solution wet fully the leaves. Treatments were used weekly, four times. One week after the last stockplants treatments, the cuttings were cut in uniform size (20 cm long), treated with IBA (0.2%) and fungicide.

On the day, when shoots were cut, leaves from each group were collected to measure chlorphyll content (Arnon 1949). The daily running of photosynthetic activity was measured by a portable LCi instrument, which calculates the net CO_2 assimilation rate (BioScientific ltd.). The samples were collected to estimate IAA-level in stockplant shoots also that day, when shoots were cut (Sándor et al 2008).

From each treatment 80 cuttings were cut for rooting per cultivars, together 320 pieces, in total for four cultivars 1280 cuttings were cut in each year. The table 3.1. displays all of measurements on treated stockplants and their cuttings.

Table 3.1. Summary of all measurements on pretreated stockplants and their cutting by years

Measured on	Measurements	investigational years		
		2010	2011	2012
stock-plants	trunk diameter (cm)	x	x	x
	height (cm)	x	x	x
	total shoot mass (g) and total shoot number (pcs) per a plant	x	x	x
	weight (g) and number (pcs) of appropriate (more than 3 mm basal diameter) shoots		x	x
	chlorophyll content in leaves (μg/g)	x		x
	photosynthetic activity (LCi)		x	x
both	HPLC-mesurements (stockplants and cuttings)		x	x
cuttings	starting fresh and dry weight of cuttings (g)	x	x	x
	fresh and dry weight of rooted cuttings (g)		x	x
	fresh and dry weight of root (g)		x	x
	fresh and dry weight of shoot part of rooted cuttings (g)		x	x
	fresh and dry weight increment of starting mass and rooted cutting mass (g)		x	x

Treatments of cuttings from untreated stockplants and adherent measurements

Paralel with above-mentioned trial cuttings were collected from untreated stockplants to learn more about effects of biostimulators, leaf fertilizer and bioregulators spraying directly onto cuttings. Cuttings were prepared in the same way as above-mentioned. In this trial there were 8 different groups for treatments (parenthetic concentrations were spraying):

1. Kelpak (0.2%),
2. Wuxal Ascofol (0.2%),
3. Pentakeep-V (0.05%) and 0.5 ml/l Tween 20 adhensive enhance substance,
4. Yeald Plus (0.15%),
5. early BA (0.2%) and Tween 20 in concentration of 0.5 ml/l,
6. late BA (0.2%) and Tween 20 in concentration of 0.5 ml/l,
7. IBA (0.2%)
8. control (tap water spraying).

The first treatment was started at the same time, when cuttings wete set into propagation house. Treatments were repeated four times, weekly. Early BA treatment was sprayed out at the same time with other treatments, while late BA treatments were started from the fourth week to sixth week. Except of control group, all other groups of cuttings were treated with 0.2 % IBA before setting.

80 cuttings were cut to rooting for each treatment per cultivars, together 640 pieces per cultivar, in total for four cultivars 2560 cuttings were cut in each year. The sprayings were carried out in late afternoon propagation house, in Helvécia. After spraying cuttings were covered to prevent the wash-down of solution thereof leaves. For spraying each substance was soluted in one liter water. The table 3.2. contents all of measurements on treated stockplants and their cuttings.

Table 3.2. The collected data of cutting treatments trial correlated of investigational years

Measure on	Measurements	investigational years		
		2011	2012	2014
cutting	starting fresh and dry weight of cuttings (g)	x	x	x
	fresh and dry weight of rooted cuttings (g)	x	x	x
	fresh and dry weight of root (g)	x	x	x
	fresh and dry weight of shoot part of rooted cuttings (g)	x	x	x
	fresh and dry weight increment of starting mass and rooted cutting mass (g)	x	x	x

3.4. Statistical analysis

All data, what were collected from both trial series per cultivar in all years, were set out by treatments and cultivars in Microsoft Excel tables. All data were statistically analyzed by ANOVA using the statistical package IBM SPSS Statistics 20. Means were separated by Duncan-test at level $p = 0.05$. Different letters in the same column of the tables indicate significant differences at $p = 0.05$. Where the investigational data did not give standard deviaton, Games-Howell test was used, that do not requires the standard deviation of data. In the course of data review there is not any sign for it.

4. Results

4.1. Results of stockplants precondition

Effects of biostimulator treatments on shoot and cutting production of stockplants

Total fresh mass of each cultivar was increasing over the years correlated with age of stockplants. Estimating of total fresh mass in each year, Kelpak treated stockplants gave the highest fresh mass production at ‘Bogdány (table 4.1.), ‘Magyar’ (table 4.2.) and ‘SM 11/4’ (table 4.4.). Other treatments on stockplants did not cause any significant differences in total fresh mass production. Significantly larger total fresh mass was measured on ‘Bogdány’ stockplants treated with Kelpak, Wuxal Ascofol and Pentakeep-V in average of two investigational years.

Table 4.1. Shoot production of ’Bogdány’ stockplants treated with different biostimulators. Soroksár, 2010, 2011, 2012.

BOGDÁNY	2010	2011	2012	average of years*
total fresh mass (g)				
Kelpak (0.2 %)	- -	865 b	1980 b	1423 b
Wuxal Ascofol (0.2%)	- -	755 ab	1745 ab	1250 b
Pentakeep-V (0.05%)	- -	708 ab	1552 a	1130 b
control	- -	600 a	1348 a	974 a
total shoot number per a tree (pcs)				
Kelpak (0.2 %)	- -	113 b	238 b	176 b
Wuxal Ascofol (0.2%)	- -	103 ab	240 b	172 b
Pentakeep-V (0.05%)	- -	92 ab	199 ab	146 ab
control	- -	84 a	185 a	135 a
appropriate shoot number per a tree (pcs)				
Kelpak (0.2 %)	45 a	48 ab	153 b	82 b
Wuxal Ascofol (0.2%)	43 a	34 a	140 b	72 b
Pentakeep-V (0.05%)	42 a	53 b	127 ab	74 b
control	38 a	39 ab	99 a	59 a

Note: - : no data;

*: where not any data from year 2010, there is average of two investigational years.

Means are separated by Duncan-test, different letters in the same column indicate significant differences at p = 0.05.

There were significant differences in total shoot number in investigated years and in average of years. The cultivars ’Bogdány’, ’Magyar’ and ’SM 11/4’ treated with Kelpak increased significantly their shoot number compared to control – except to cultivar ‘SL 64’ (table 4.3.), where there were not any significant differences between treatments. There were significantly more shoot on cultivar ’Magyar’ treated with Wuxal Ascofol in 2011, and on

cultivar ’Bogdány’ in 2012-ben compared to control. The difference of shoot number on stockplants ’Bogdány’ is significantly in average of investigational years.

It can be seen on number of appropriate shoots, that all of the three treatments increased it in average of investigated years. In case of stockplants ’Magyar’, all treatments show more appropriate shoots in average of tree years – compared to control.

Table 4.2. Shoot production of ’Magyar’ stockplants treated with different biostimulators. Soroksár, 2010, 2011, 2012.

MAGYAR	2010	2011	2012	average of years *
total fresh mass (g)				
Kelpak (0.2 %)	- -	887 b	1540 b	1241 b
Wuxal Ascofol (0.2%)	- -	747 ab	1400 b	1047 ab
Pentakeep-V (0.05%)	- -	645 a	1365 ab	1005 ab
control	- -	687 ab	1080 a	884 a
total shoot number per a tree (pcs)				
Kelpak (0.2 %)	- -	143 b	284 b	214 b
Wuxal Ascofol (0.2%)	- -	132 b	235 ab	184 a
Pentakeep-V (0.05%)	- -	104 a	222 a	163 a
control	- -	109 a	215 a	162 a
appropriate shoot number per a tree (pcs)				
Kelpak (0.2 %)	41 b	87 c	149 ab	92 b
Wuxal Ascofol (0.2%)	30 a	78 bc	168 b	92 b
Pentakeep-V (0.05%)	33 a	57 ab	165 b	85 b
control	45 b	38 a	125 a	69 a

Note: - : no data;

*: where not any data from year 2010, there is average of two investigational years.

Means are separated by Duncan-test, different letters in the same column indicate significant differences at p = 0.05.

Table 4.3. Shoot production of ’SL 64’ stockplants treated with different biostimulators.

Soroksár, 2010, 2011, 2012.

SL 64	2010	2011	2012	average of years *
total fresh mass (g)				
Kelpak (0.2 %)	- -	565 ab	1200 a	883 a
Wuxal Ascofol (0.2%)	- -	673 b	1240 a	957 a
Pentakeep-V (0.05%)	- -	613 b	1260 a	937 a
control	- -	513 a	1305 a	909 a
total shoot number per a tree (pcs)				
Kelpak (0.2 %)	- -	90 a	206 a	148 a
Wuxal Ascofol (0.2%)	- -	110 a	223 a	167 a
Pentakeep-V (0.05%)	- -	101 a	206 a	154 a
control	- -	74 a	189 a	132 a
appropriate shoot number per a tree (pcs)				
Kelpak (0.2 %)	50 b	54 a	102 a	69 a
Wuxal Ascofol (0.2%)	36 a	59 a	149 a	81 a
Pentakeep-V (0.05%)	34 a	56 a	139 a	76 a
control	28 a	43 a	126 a	66 a

Note: - : no data;

*: where not any data from year 2010, there is average of two investigational years.

Means are separated by Duncan-test, different letters in the same column indicate significant differences at p = 0.05.

Table 4.4. Shoot production of ’SM 11/4’ stockplants treated with different biostimulators.

Soroksár, 2010, 2011, 2012.

SM 11/4	2010	2011	2012	average of years *
total fresh mass (g)				
Kelpak (0.2 %)	- -	727 b	1307 b	1017 a
Wuxal Ascofol (0.2%)	- -	627 a	1020 a	824 a
Pentakeep-V (0.05%)	- -	680 ab	1233 b	957 a
control	- -	667 ab	1250 b	959 a
total shoot number per a tree (pcs)				
Kelpak (0.2 %)	- -	131 b	227 b	179 a
Wuxal Ascofol (0.2%)	- -	108 ab	173 a	141 a
Pentakeep-V (0.05%)	- -	104 ab	209 ab	157 a
control	- -	97 a	219 b	158 a
appropriate shoot number per a tree (pcs)				
Kelpak (0.2 %)	37 a	75 a	131 b	81 a
Wuxal Ascofol (0.2%)	34 a	62 a	102 a	66 a
Pentakeep-V (0.05%)	32 a	57 a	140 b	77 a
control	31 a	55 a	136 b	73 a

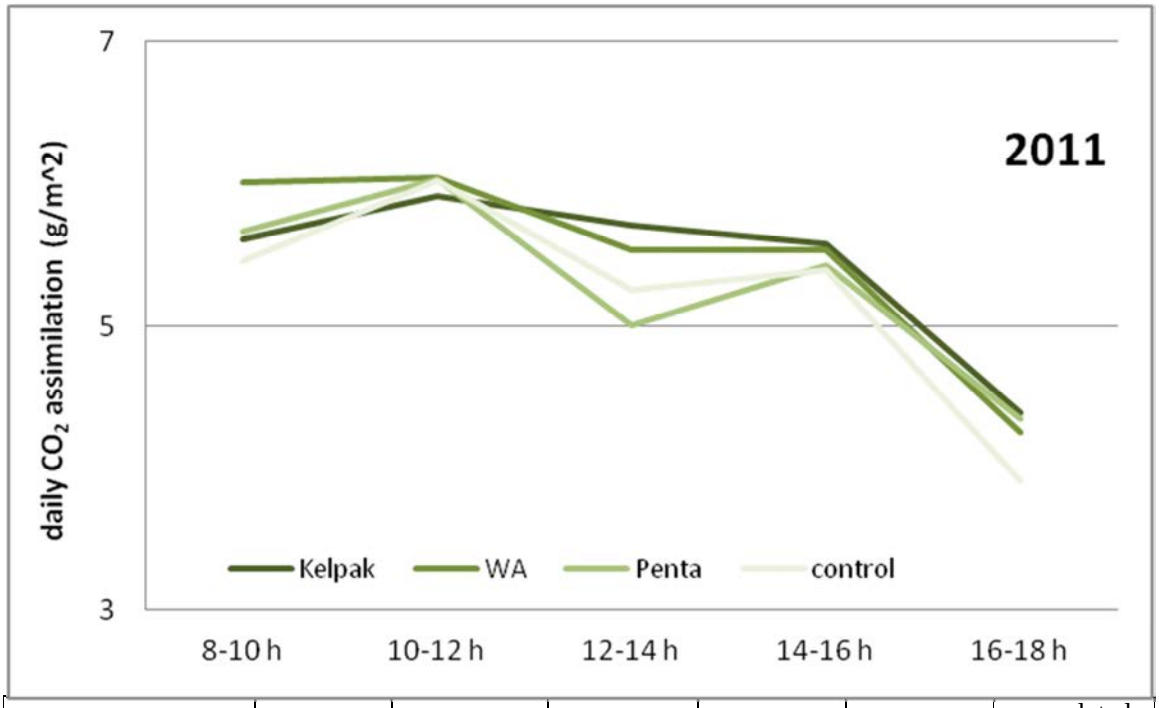
Note: - : no data;

*: where not any data from year 2010, there is average of two investigational years.

Means are separated by Duncan-test, different letters in the same column indicate significant differences at p = 0.05.

Photosynthetic activity of stockplants treated with different biostimulators

Estimated photosynthetic activity (g m^{-2}) on leaves of 'Bogdány' stockplants it can be seen, that the daily runnig of net CO_2 assimmilation was different in the two investigated years. While in 2011 the line had got two peaks (figure 4.1.), the first one reached in the morning hours (10.00-12.00), the second one in early afternoon (14.00-16.00), then in 2012 there was a longer peak in the line (10.00-14.00), it follows a a reduction in net CO2 assimilation (14.00-16.00) and in late afternoon (16.00-18.00) it rised again (figure 4.2.). The daily cumulated CO_2 assimilation in 2011 was between 26 and 27 g m^{-2}, while in 2012 it was between 19 and 21 g m^{-2}.

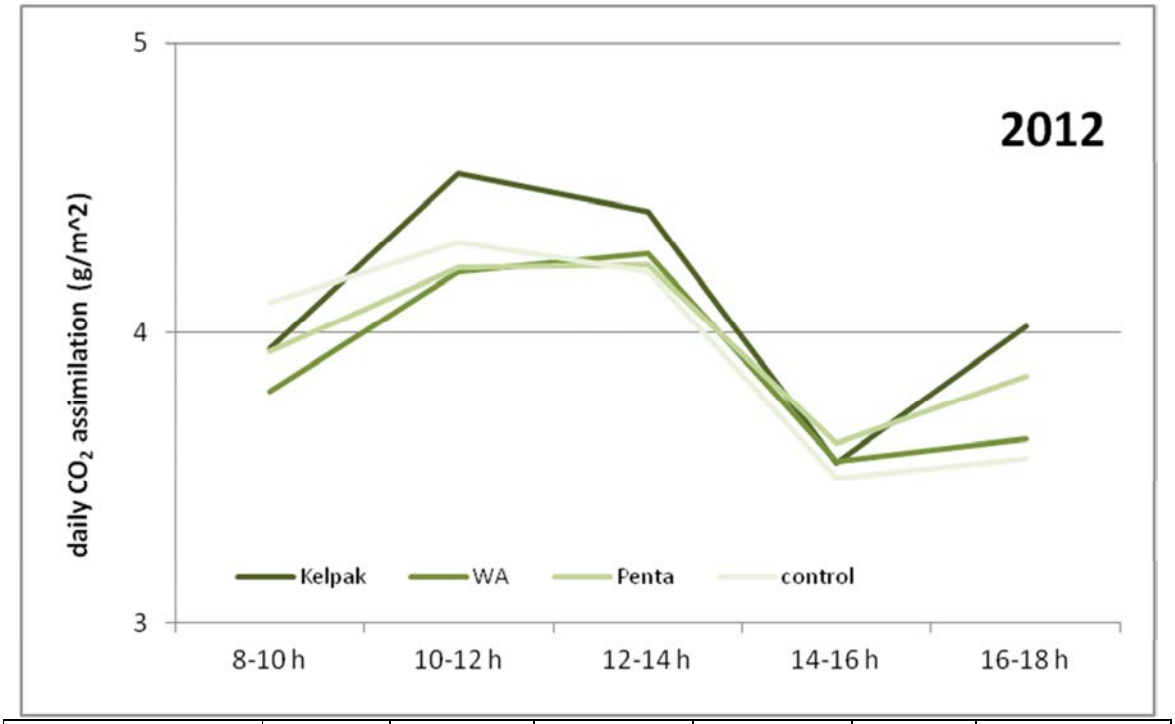


	8-10 h		10-12 h		12-14 h		14-16 h		16-18 h		cumulated daily CO_2 assimilation (g m^{-2})	
Kelpak 0.2%	5,61	a	5,91	a	5,71	c	5,58	a	4,39	b	27,19	b
Wuxal Asc. 0.2%	6,00	b	6,04	a	5,53	bc	5,53	a	4,25	b	27,35	b
Pentakeep-V 0.05%	5,66	ab	6,02	a	5,01	a	5,42	a	4,35	b	26,46	ab
control	5,45	a	6,02	a	5,25	ab	5,40	a	3,91	a	26,02	a

Figure 4.1. Effect of different biostimulátor treatments on daily net CO_2 assimilation (g m^{-2}) of stockplant 'Bogdány'.

The table contents the average of each interval and the sign of statistical analysis. Means are separated by Duncan-test, different letters in the same column indicate significant differences at p = 0.05. Soroksár, 2011.

In 2011, there were significant differences in daily cumulated CO_2 assimilation on stockplant treated with Kelpak and Wuxal Ascofol, while stockplants treated with Pentakeep-V had got these results in tendency compared to control. In 2012, the daily cumulated CO_2 assimilation on 'Bogdány' leaves treated with Kelpak shows significantly higher value than control or other treatments (figure 4.2.).



	8-10 h		10-12 h		12-14 h		14-16 h		16-18 h		cumulated daily CO_2 assimilation (g m-2)	
Kelpak 0.2%	3,95	a	4,55	a	4,42	a	3,55	a	4,02	b	20,49	b
Wuxal Asc. 0.2%	3,80	a	4,21	a	4,28	a	3,56	a	3,64	a	19,48	a
Pentakeep-V 0.05%	3,94	a	4,23	a	4,24	a	3,62	a	3,85	a	19,87	a
control	4,11	a	4,31	a	4,21	a	3,50	a	3,57	a	19,70	a

Figure 4.2. Effect of different biostimulátor treatments on daily net CO2 assimilation (g m-2) of stockplant 'Bogdány'.

The table contents the average of each interval and the sign of statistical analysis. Means are separated by Duncan-test, different letters in the same column indicate significant differences at p = 0.05. Soroksár, 2012.

Rooting rate, fresh and dry weight increment of softwood cuttings from pretreated stockplants

After precondition of stockplants, the cuttings were setting under the above-mentioned conditions in Helvécia. The rooting rate of all cultivars can be seen in figure 4.3. in average of investigational years.

The statistical analysis did not confirm any significant differences in rooting rate of each cultivar. Among the cultivars, ’Magyar’ is difficult-to-root (between 55.7% and 65.7%), while rooting rate of ’Bogdány’ was between 79.2% és 85.0%, of ’SL 64’ was between 86.9% and 95.0% and of ’SM 11/4’ canditate was between 90.0% and 95,6% in the average of investigational years.

Because of short communication form, I would like to inform only about fresh and dry weight increment of rooted cuttings (figure 4.4 and 4.5.). The other data of cuttings quality (fresh and dry weight of root and shoot part of cuttings data) are in details in PhD dissertation.

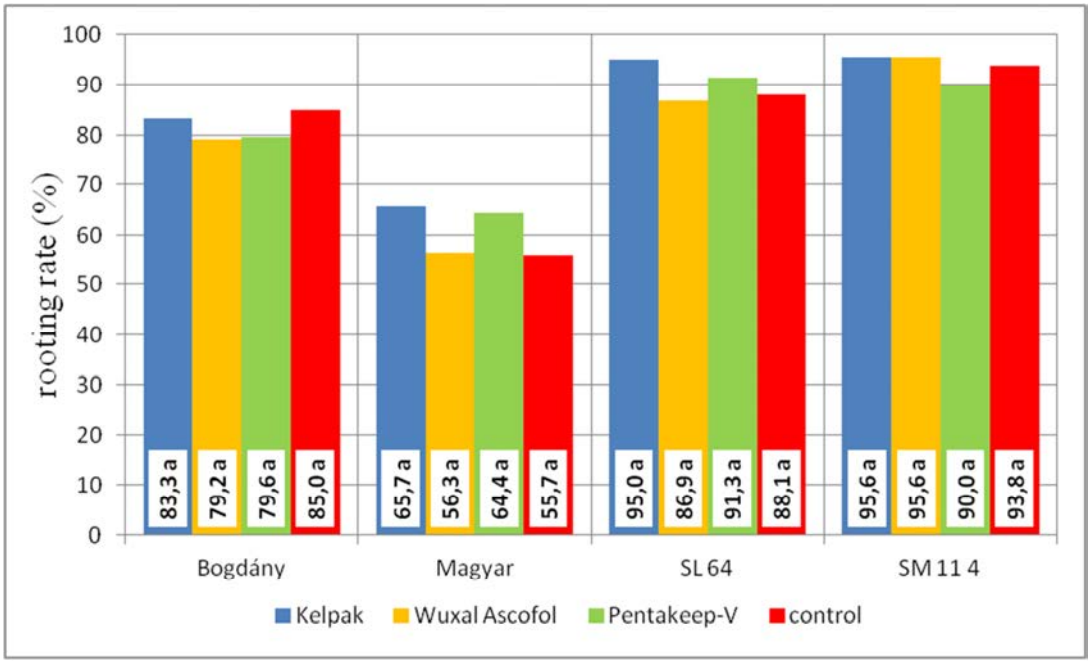


Figure 4.3. Estimated mahalebs cultivars’ rooting rate (%) in investigational years. Means are separated by Duncan-test, different letters after values in the same column indicate significant differences at p = 0.05. Statistical analysis was done separately for each cultivar.

The averaged fresh weight increment of rooted cutting (g) in case of cultivars ’Bogdány’ and ’Magyar’ was significantly increased by Kelpak treatment on stockplants compared to control (figure 4.4.). Fresh weight increment of cuttings from Pentakeep-V preconditioned ‘Bogdány’ stockplants and of cuttings from Wuxal Ascofol preconditioned ’SL 64’ stockplants were increased significantly. There were not any significant differences in fresh weight increments in case of different way preconditioned ’SM 11/4’.

Analysing of dry weight increment, it can be seen, that rooted cuttings of ’Bogdány’ pretreated with Pentakeep-V saved their significantly higher value after drying. It can be said in case of cuttings of ’Magyar’ pretreated with Kelpak (figure 4.5.). There were significant differences in dry weight increment between ‘SL 64’ cuttings from stockplants pretreated with Kelpak and with Wuxal Ascofol. Cuttings from Kelpak pretreated stockplants gave significantly lower value compared to Wuxal Ascofol treatment.

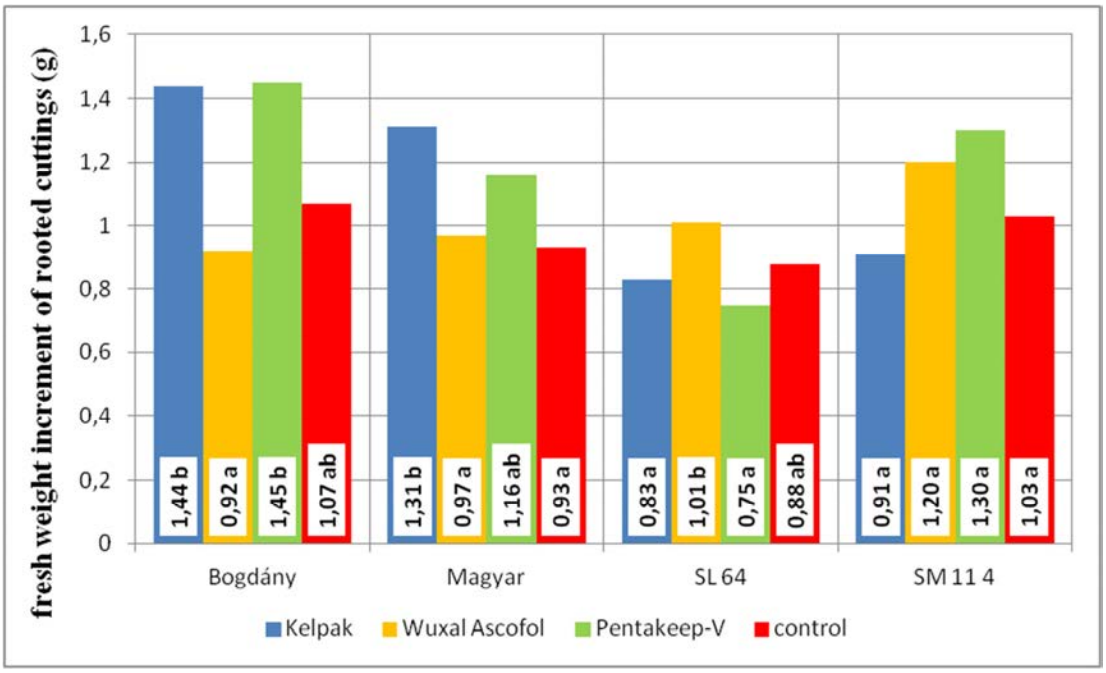


Figure 4.4. Fresh weight increment of cuttings (g) from stockplants with different biostimulator pretreatments in average of investigational years.

Means are separated by Duncan-test, different letters after values in the same column indicate significant differences at p = 0.05. Statistical analysis was done separately for each cultivar.

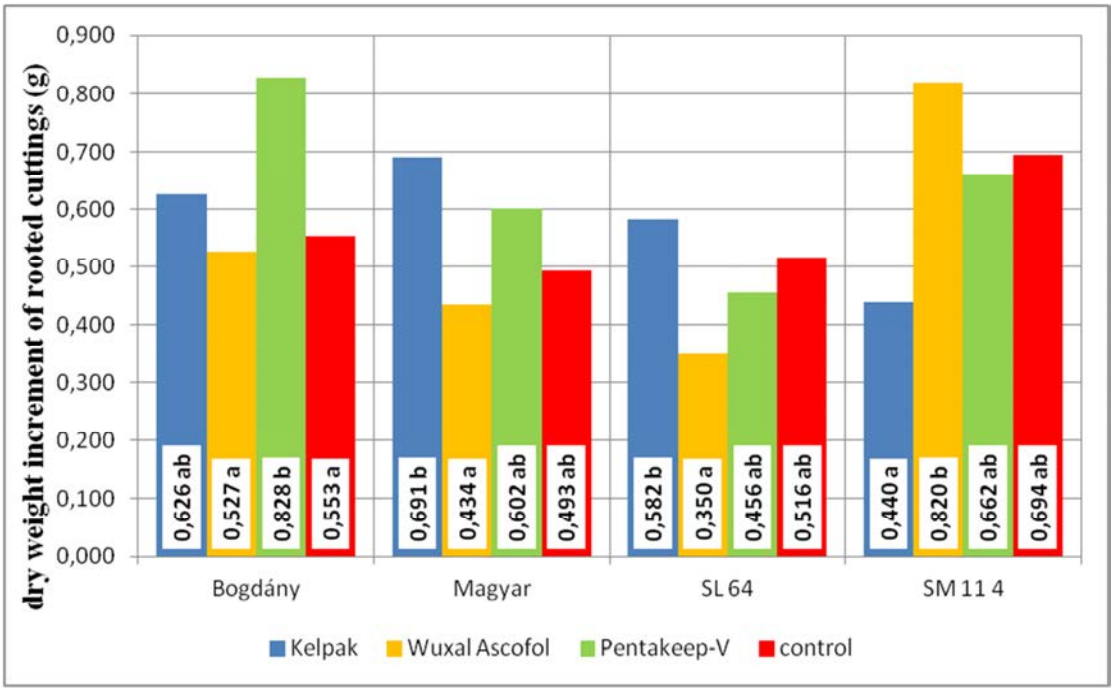


Figure 4.5. Dry weight increment of cuttings (g) from stockplants with different biostimulator pretreatments in average of investigational years.

Means are separated by Duncan-test, different letters after values in the same column indicate significant differences at p = 0.05. Statistical analysis was done separately for each cultivar.

4.2. Results of cutting treatments

Rooting rate of cuttings treated with biostimulators or bioregulators

Effect of direct treatments on rooting rate of cuttings can be seen in figure 4.6. Early BA treatments on ’Bogdány’ gave even lower rooting rate than control. Kelpak, Wuxal Ascofol, Pentakeep-V, Yeald Plus, later BA and IBA treatments on ‘Bogdány’ cuttings increased significantly rooting rate. Yeald Plus treatments on ‘Bogdány’ cuttings resulted the highest value in rooting rate (89.8%).

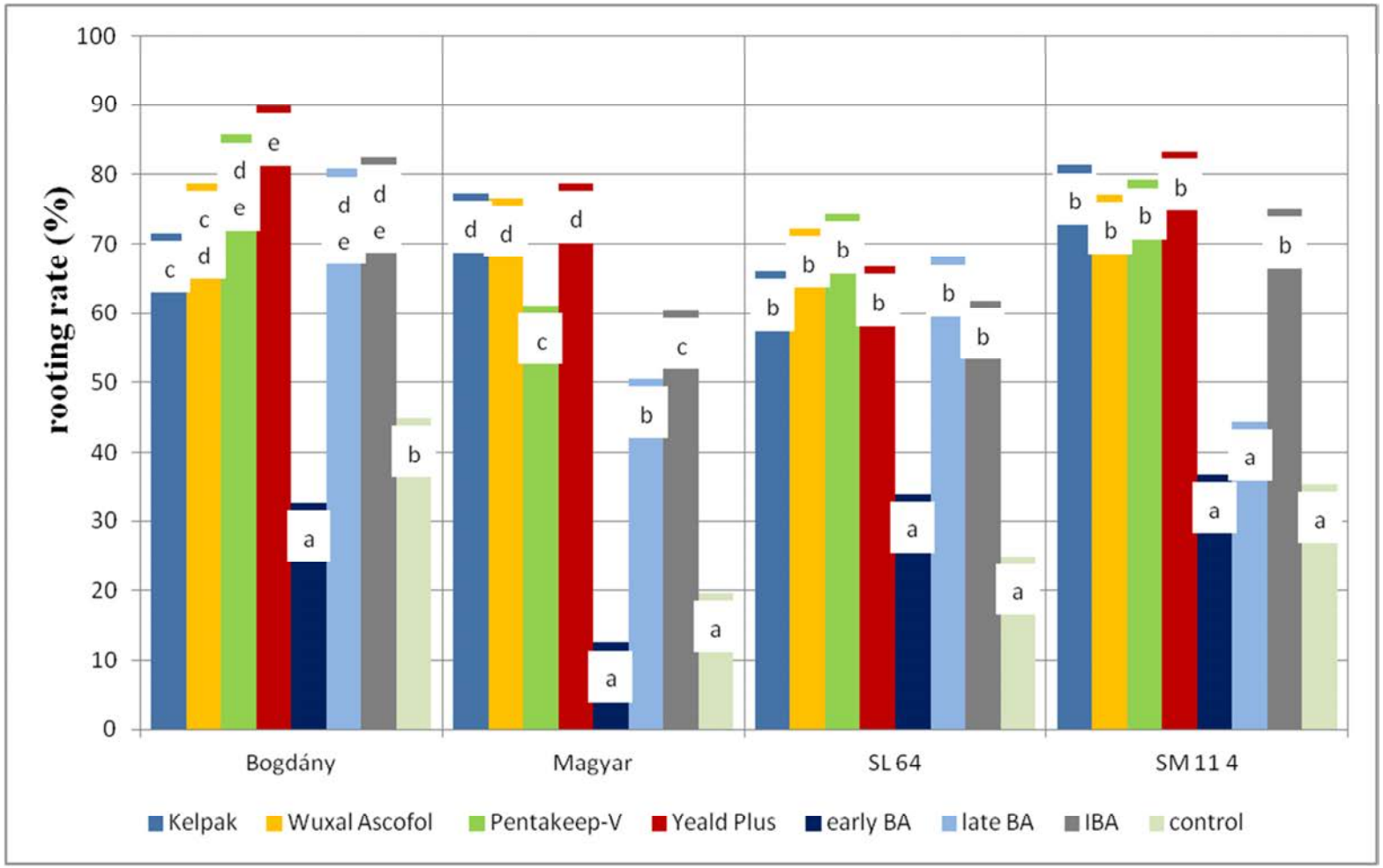


Figure 4.6. Rooting rate (%) of biostimulator or bioregulator treated, rooted cuttings in average of investigational years. Means are separated by Duncan-test, different letters after values in the same column indicate significant differences at p = 0.05. Statistical analysis was done separately for each cultivar.

The early BA treatment and control cuttings on ‘Magyar’ resulted significantly lower rooting rate. Kelpak, Wuxal Ascofol and Yeald Plus were increased rooting rate not only compared to control, but IBA and Pentakeep-V treated cuttings, too (figure 4.6.). Early BA treated and control cuttings on ‘SL 64’ showed significantly lower rooting rate than other treatments. The rooting rate of early and late BA treated and control cuttings on ‘SM 11/4’ were decreased compared to other treatments. In this case, other treatments did not shown any significantly differences (figure 4.6.).

Results of fresh and dry weight increment of different biostimulators or biosregulators treated cuttings

Fresh weight increments of rooted ‘Bogdány’ cutting treated with Kelpak and Pentakeep-V were significantly higher than control or other treatments. Early BA, IBA treatments and control ’Magyar’ cuttings had got significantly lower fresh weight increments than other treatments. Effect of Yeald Plus treatment on ‘Magyar’ cuttings fresh weight increment can be seen in figure 4.7. Kelpak treated ’SL 64’ cuttings were differed based on statistical analysis from control and other treatments in investigational years. Fresh weight increment of ‘SM 11/4’ cuttings was increased significantly by Kelpak, Wuxal Ascofol, Yeald Plus, both BA and IBA treatments.

The dry weight increment (figure 4.8.) on ‘Bogdány’ cuttings was increased significantly by Kelpak, Wuxal Ascofol, Pentakeep-V, Yeald Plus, early BA and IBA treatments compared to control. All treatments – except to IBA and control – improved dry weight increment on ’Magyar’ rooted cuttings. Yeald Plus treated rooted cuttings had got the highest value of dry weight increment. Kelpak increased significantly dry weight increment on rooted ‘SL 64’ cuttings. There were significant differences between Kelpak, Wuxal Ascofol and both BA treated cuttings and control in dry mass increment in average of investigational years.

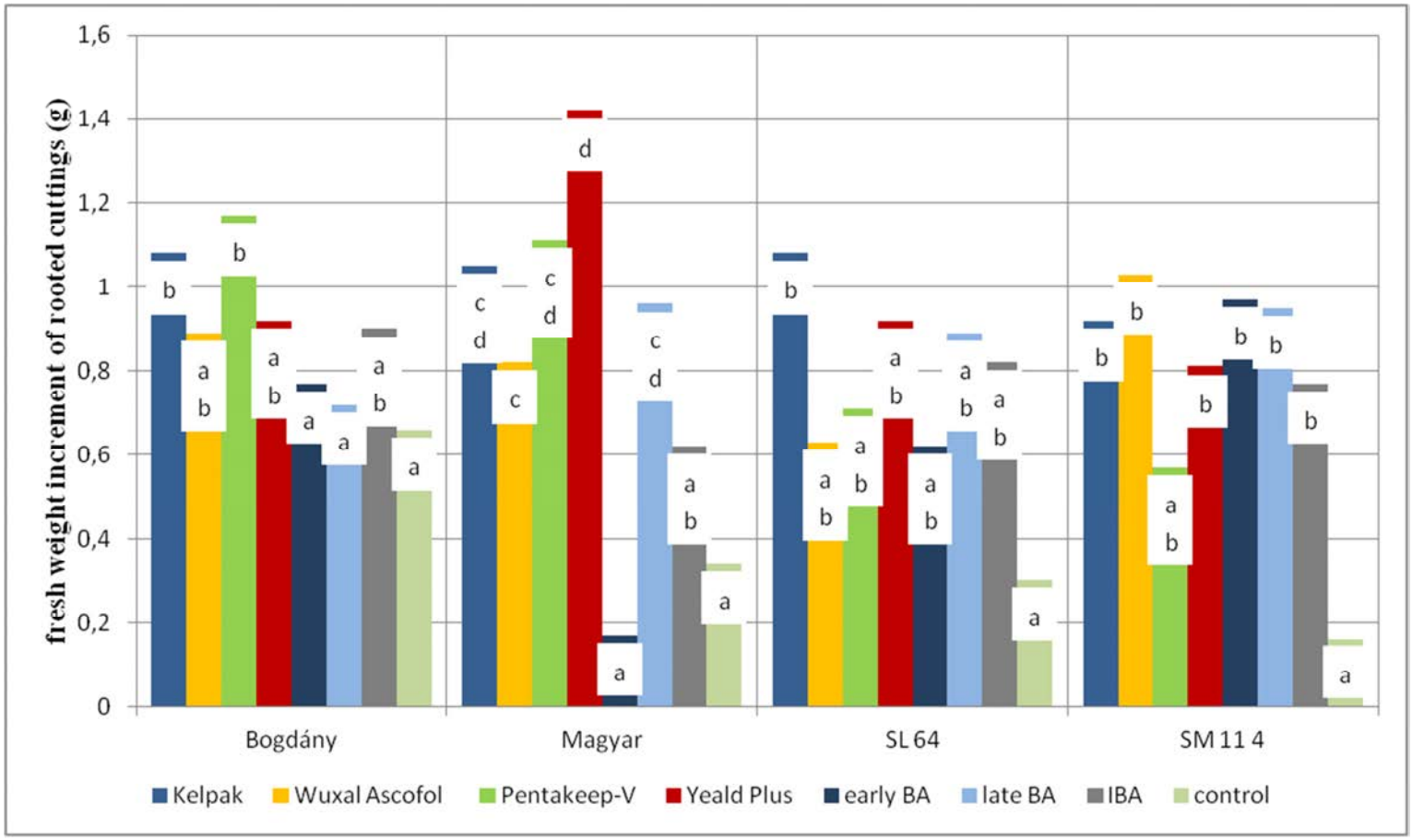


Figure 4.7. Fresh weight increments of biostimulator or bioregulator treated, rooted cuttings in average of investigational years. Means are separated by Duncan-test, different letters after values in the same column indicate significant differences at p = 0.05. Statistical analysis was done separately for each cultivar.

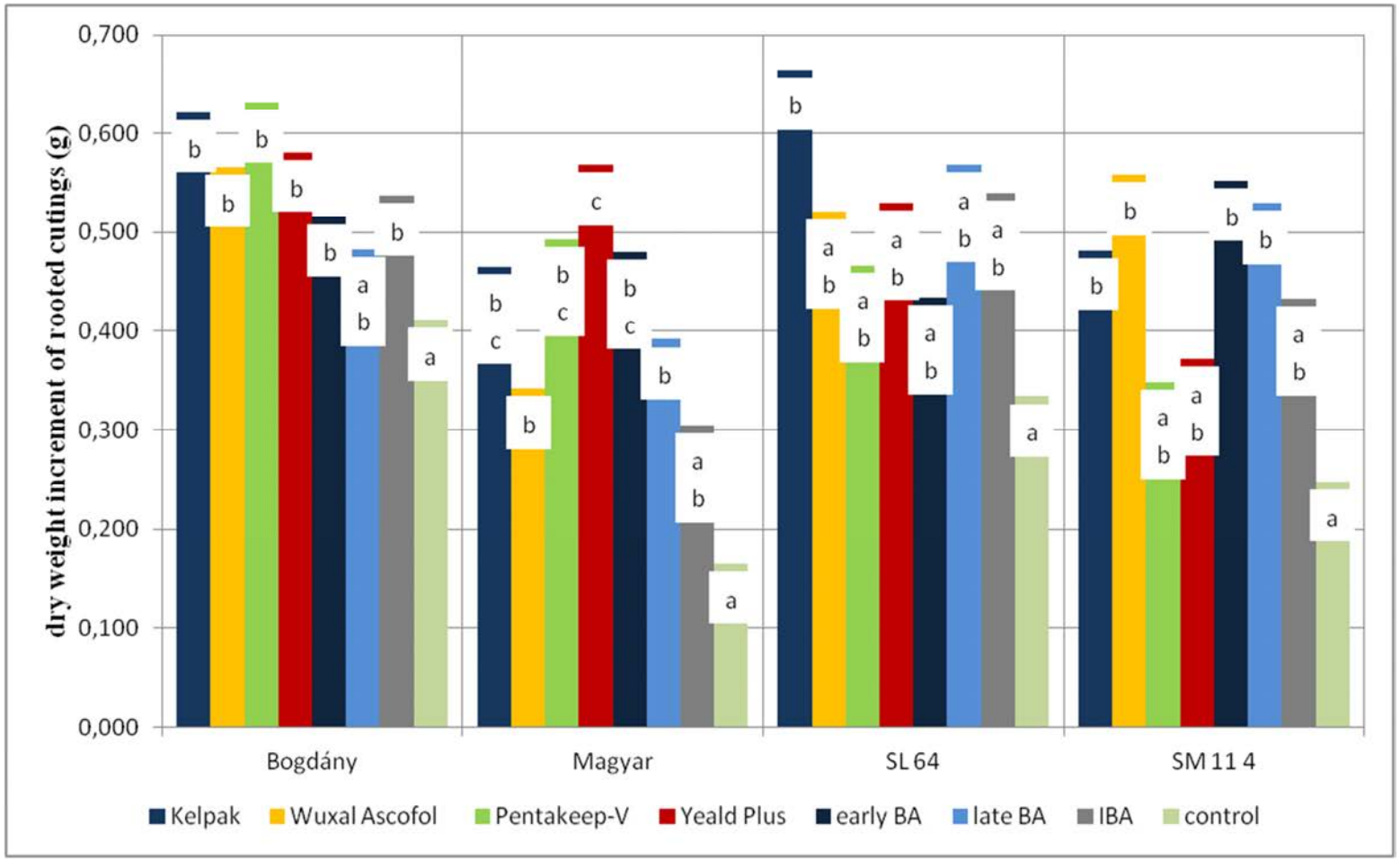


Figure 4.8. Dry weight increment of biostimulator or bioregulator treated, rooted cuttings in average of investigational years. Means are separated by Duncan-test, different letters after values in the same column indicate significant differences at p = 0.05. Statistical analysis was done separately for each cultivar.

5. Conclusions and practical applications

5.1. Stockplants treatments

Effect of treatments on shoot and cutting production of stockplants

The efficiency of rooting starts at condition of stockplants, because the cutting is made of from the stockplant severed shoot with its current water, nutrient content and hormonal level for rooting (Leakey and Storeton-West 1992, Hartmann et al. 1997, Hrotkó 1999, Leakey 2004). The physiological state of stockplants correlates with rooting potential (Mesén et al. 1997, 2001) that is why the precondition of stockplants is so important. Plant growth regulators are wide-spread used (Read and Yang 1989, Leakey 2004, Szabó et. al. 2011), but hormonal treatments on stockplants are less known (Stoutemeyr et al. 1961, Sadhu 1989, Leakey 1992).

Effecting of Kelpak treatments, ’Bogdány’ and ’Magyar’ stockplants can improve their total fresh mass, and the effect of treatments can be shown on total shoot number and appropriate shoot number per a tree, too. These results are correlated with increasing fresh mass production based on literature (Alexander 2008, Colapietra and Alexander 2006, Basak et al. 2008, Belz and Pfeiffer 2004, Csihon et al. 2013). It is a new result that stockplants treatments affect on number of appropriate shoot. Instead of it, on clonal stockplant ’SL 64’ and ’SM 11/4’ this affect missed, however the total number of shoots increased, what drove to decreasing single shoot weight on ‘SM 11/4’.

Current results of stockplants precondition confirm partly the fact of improving effect of plant growth regulators (Alexander 2008, Colapietra and Alexander 2006, Basak et al. 2008, Belz and Pfeiffer 2004, Csihon et al. 2013). On first hand, it is confirmed by higher fresh mass production on ’Bogdány’ and ’Magyar’ stockplants, what means more shoots and more appropriate shoots to cutting. These facts give right for cited results, what state that Kelpak (Jenkins and Mahmood 2003, Magyar et al. 2008, Szabó 2009) and Wuxal Ascofol (Magyar et al. 2008, Szabó 2009) have got good effect on shoot production and its quality (Belz and Pfeiffer 2004, Colapietra and Alexander 2006, Alexander 2008). We can not confirm on clonal mahaleb cutting stockplants after four weeks treatments the improving effect of Pentakeep-V on fresh mass, what based on literatures (Hotta et al. 1997; Babik and Dysko 2008). It can be occurred the realatively short (four weeks) treating period compared to agricultural crops. It needs further trials to learn more about optimal concentrate to treat clonal mahalebs stockplants.

Characteristics of photosynthetic activity on different treated 'Bogdány' stockplants

Fresh mass productivity of motherplants is determined by the consumed CO2 volume, what was definited by photosyntethic activity. Based on results of year 2011, it can confirm that Kelpak and Wuxal Ascofol have got affect on photosyntesis. The positive effect of Wuxal Ascofol treatment on net CO_2 assimilation of 'Bogdány' stockplants starts in morning hours (8.00-10.00), what remained in midday hours (12.00-14.00). Kelpak treatment improves the efficiency of net CO_2 assimilation mainly in midday hours (12.00-14.00). However effect of Pentakeep-V treatments was weak in CO_2 assimilation in midday hours (12.00-14.00), its efficiency improved in late afternoon hours (16.00-18.00). In cumulated daily CO_2 assimilation Kelpak and Wuxal Ascofol treatments were effective to raise significantly the photosynthetic activity. This effect can be seen, on the first hand, in shoot weight of Kelpak treated stockplants, and on the other hand, in the increasing shoot number of Wuxal Ascofol treated stockplants.

Summarizing Kelpak and Wuxal Ascofol treatments had positive effect on photosynthesis. In literature we had not found any results about effects of these substances on photosynthesis. The improved photosynthetical activity of Pentakeep-V, noted by Beale 1990, Hotta et al. 1997 and Mihalovits 2010, was failed in our results.

Effect of stockplants treatments on rooting rate, fresh and dry weight increment of rooted cuttings

The rooting rate of four clonal mahaleb cuttings was in line with Hrotkó (1982) results. The highest rooting percentage gave by 'SM 11/4' (90-95%), followed by 'SL 64' (85-95%), 'Bogdány' (85-88%) and 'Magyar' (55-65%).

Our results confirm that larger shoot mass and cuttings productivity did not effect on quality of cuttings. We estimate these results that by biostimulator preconditioned stockplants give more appropriate shoots for cuttings but rooting potential of their cuttings do not decrease. The propagation rate reflected to stock block area can improved by biostimulator treatments – in different rate depended on cultivars and treatments (with 20% or 30%).

Athough biostimulators treatments do not affect on rooting rate, but they have got effect on fresh and dry mass, further the dry mass production under rooting, what raise cutting quality. In this viewpoint the cultivars gave different reactions in each investigational year for the different stockplant treatments.

5.2. Cutting treatments

In the second trial, all groups of cutting were treated by IBA (0.2%), except to control, that is why the IBA treated cuttings were basic for comparison. The rooting rate of early BA treatments did not differ by the value of IBA treatment cuttings. This treatment had negatively effect on rooting rate. On the other hands, biostimulators did not affect significantly difference on rooting rate compared to IBA basic treatment – except to cultivar 'Magyar'. It comes from the relatively high rooting rate of cuttings (62-75%), and the 10-15% difference compared to this rooting rate, was not significant.

The Kelpak, Wuxal Ascofol and Yeald Plus treatments resulted 27-37% growth of rooting rate at clonal mahaleb 'Magyar' compared to weak rooting capacitiy (54.9%). We can conclude based on this results, that treatments used directly on rooting cuttings are effective only in that case, where cultivars have got low rooting affinity (Németh 2011). The leaf fertilizer, Yeald Plus with main substance of zinc, what stimulates auxin-synthesis (Kwizda Agro 2009), improved the rooting rate in all case in line with other results in nursery (Magyar et al. 2008, Szabó 2009, Hajdú 2010, Németh 2011).

Rooting rate is improved by Kelpak and Wuxal Ascofol, both contain auxin. These results confirm statements of earlier trials on young grafted trees (Dickmann et al. 2007, Magyar et al. 2008, Szabó 2009), what conclude that these biostimulators improved root quality, furthermore results of Jenkins and Mahmood (2003). Our results confirm positive effect of Pentakeep-V treatment on rooting. Németh (2011) stated, based on her results, cuttings of clonal mahaleb cultivar 'Egervár' was rooted the best by direct Kelpak treatment, what was followed by Wuxal Ascofol, Pentakeep-V and Yeald Plus treatment. Our results confirm the counted rooting rate by Németh (2011), what stated Pentakeep-V and Yeald Plus treatment are the best to root.

Based on our results, effect of IBA treatment is as good as biostimulators. However the statistical analysis do not confirm in all cases the difference in rooting rate, the above-mentioned substances give more at least 10-10% higher rooting rate in average of investigational years, of course varying in cultivars, which one is the best. Pentakeep-V and Yeald Plus for 'Bogdány', Wuxal Ascofol and Yeald Plus for 'Magyar', Wuxal Ascofol and Pentakeep-V for 'SL 64', and Kelpak and Yeald Plus for 'SM 11/4' were the most effective way to root – in average of investigational years.

The early BA treatment in all the case of each cultivar desreased clearly the rooting rate. It confirms statement by Eriksen (1974), who said cytokinin treatments can be decreased rooting. Beside of generally mobilization of nutrients (Pethő 2002), furthermore improve

nutrient uptake from progress of ***sink-source*** (Mothes et al. 1961, Mothes and Engelbrecht 1963, Werner et al. 2008), cytokinins activate that enzyme progresses, what need to uptake of nitrate, ammonium, sulphate, phosphorus and iron (Sakakibara 2006, Séguéla et al. 2008). So this explain, how decreased from the beginning sprayed BA treatment the rooting rate. These cuttings used their consumed proteins to produce enzymes instead of root initiation, what drive to fall leaves and to lose the consumed nutrients and in the end to rot the cuttings. The later started BA treatment (in this case from fourth week of cutting setting) did not improve basicly rooting, but it did not decrease, as well. It needs further trial to estimate more lately, for example BA treatment started in 6^{th} or 8^{th} week after cutting setting can improve the rooting rate.

The BA treatments also improved in more cases the fresh weight of rooted cuttings, the effect of later started BA-spraying can be explained by the added weight of new shoot. The early sprayed BA treatment has got negative effect on rootless cuttings, what confirmed through the least rooting rate in case of each cultivar and confirmed by Eriksen (1974), who stated cytokinins have got negative effect onto rooting. The weigh gowth of rooted cuttings in this case can be explained with that fact, that cytokinins activate basicly the nutrient mobilization (Pethő 2002), first of all the ***sink*** progress (Mothes et al. 1961, Mothes and Engelbrecht 1963, Werner et al. 2008). So that cuttings, what survived the waterless and nutrientless period, and grew adventitious root, had got increased fresh weight through effect of cytokinins.

The growth of rooted cutting weight depends on, firstly, the consumed nutrients in cutting shootpart, and on the other hand, weight of new roots. These changes can appear in dry mass utilization. The different treatments on cultivars had got different effects on fresh weight of cutting shoot. The Yeald Plus leaf fertilizer improved fresh weight of cutting shoots and roots at cultivar ’Magyar’, too.

Based on our results, we can recommend Kelpak treatment for improving stockplant shoot production, and Kelpak, Wuxal Ascofol and Yeald Plus for raising rooting rate. Yeald Plus is good for increasing weight of rooting cuttings.

6. New scientific results

The following new results can be stated based the issued trialserie with treated stockplants and directly treated cuttings.

1. We stated that biostimulators have got positive effect on total fresh mass, shoot and cutting productivity of ’Bogdány’, ’Magyar’ and ’SL 64’ mahalebs clonal stockplants. Their effect work specially, they affect positively on fresh mass of shoots and starting weight of from them severed cuttings. The treatments affected increasing shoot number, but decreasing cutting weight in case of ’SM 11/4’ stockplants.
2. Kelpak and Wuxal Ascofol treatments improve photosynthetic activity on ‘Bogdány’ stockplants, but it can not work each year because of openground-cultivated stockplants.
3. Although treatments on stockplants ’SM 11/4’ increased the shoot and cutting productivity, the starting weight of cuttings did not raised, furthermore effecting by Kelpak decreased strongly. Further Kelpak treatments had got negative effect on fresh and dry weight of rooted cuttings, so this substance is not recommended for this cultivar.
4. Kelpak, Wuxal Ascofol and Yeald Plus treatments improved rooting rate on difficult-to-root cultivar ’Magyar’ with 27-37%, when cuttings severed from untreated stockplants. The treatments had got any significant effect on rooting rate (10-15%) in the case of the easy-to-root ’Bogdány’, ’SL 64’ and ’SM 11/4’ with high rooting rate.
5. Yeald Plus, applied on from untreated stockplant severed ‘Magyar’ cuttings, increased the fresh and dry weight of rooted cuttings, furthermore fresh and dry weight increment under rooting period.
6. Based on our results, we recommend in practical application Kelpak to improve shoot productivity of stockplants and Kelpak, Wuxal Ascofol and Yeald Plus to raise rooting rate. Yeald Plus is good for increasing weight of rooting cuttings.

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