Improvement of Seabuckthorn Propagation Technology at Altai

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Introduction

Seabuckthorn is one of the most important and promising berry crop in Altai horticultural branch. Nowadays it occupied about 4500 hectares of industrial plantations increasing each year to 300-500 hectares, meaning 75-80% of total areas of horticultural crops at Altai krai. It is extremely important for further spreading of seabuckthorn plantations to produce high quality plant material in great quantities.

There different ways of seabuckthorn propagation are exist. Most of them are well known, widely tested and have their own pros and cons. Easiest way of seabuckthorn propagation – by seeds, which unfortunately do not provide the features of mother plant and mostly use for eco purposes or in selection activity. Propagation by root suckers can provide the features of mother plant, but do not widely implement because of low propagation ratio and lack of technologies. Another method - is propagation by hardwood cutting which quite reliable, comparatively easy in implementation but cannot provide requested volumes of high quality cuttings. Micropropagation of seabuckthorn nowadays is quite popular in the frames of comprehensive investigations but not widely utilized in industry. And last but not least – green cutting, which considers as most promising way of seabuckthorn propagation in Siberia. It provides both great volumes and high quality of plant material.

For the first time technology of green cutting was proposed by E. Panteleeva in 1977 [2] and has been published in her thesis. Such topics as mother plants cultivation, period of cutting, initial length of cuttings, soil medium, as well as greenhouses construction have been described at that paper. It is interesting to know that after that a number of document named as technology of green cutting were released [3, 4, 5, 6, 7], but nothing more or less significant have been changed.

Most of elements of this technology is well tested and show sufficient usability. However, mentioned approach has several bottlenecks. First of them is extremely high temperature inside of greenhouses during sunny days, which demands permanent irrigation. Even short delay provokes plants suffering, not only because of absence of water but mainly because of high temperature. The side effect of mentioned delay occur in overheating of water tubes, mounted in upper part of greenhouses, followed by burns of cuttings after water supply resumption. Second issue concerns detrimental organisms (mainly fungi and alga), which develop in warm and wet conditions significantly affecting young plants and request special treatment and permanent control. And finally – It is quite expensive constructions. For instance, mounting of 1 m^2 of conventional greenhouses estimated in range of 20-40 euro, which quite expensive for ordinary farmers of Siberia.

Summarize the above we would like to stress that the improvement of technology of green cuttings is quite necessary and should be directed to reducing of costs of constructions which should provide at the same time the better quality of plant material. One of the ways we used in our investigation is to turn to simple constructions, which easier for establish and lower in costs. This method is not completely new especially for regions with warm and moist climate, characterized by long period of rooting, but for Siberia with short summer and unpredictable weather conditions during rooting period this method have never been investigated.

The main aim of our investigation was to estimate the possibility of green cuttings growing not in conventional greenhouses (completely covered by film) but in partially covered one (only side part on 2 m high without roof).

Undoubtedly, such kind of technology request additional approaches directed to stimulation of plants growth process.

The first idea was that initial length of cuttings should pay a key role in success of growing green cuttings without conventional greenhouses. The background for that suggesting lies on well known relationship between rhizogenic ability (root generation) and quantity of buds and leaves on cutting. It was found out previously by many authors on different crops [9, 10] that decreasing of volume of leaves on cutting leads both to lower percentage of survived plants as well as reducing length and total volume of generated roots.

It is well known that proteins, auxins, carbohydrates are most important substances which closely related to root formation and lack of them followed by poor generation of root. For good rooting it is very important to has sufficient amount of mentioned substances, which accumulated in higher volumes in comparatively large cuttings. That is why the initial length of cuttings was one of most important option through several ones in our experiments.

One of the most important task, related to length of cutting – Is mother plants treatment. To obtain as maximum large cuttings (about 40 cm) as possible the specific approach should be applied. Till now only few articles are published regarding methods of mother plants preparation but most of them were directed to obtain medium size (15-20 cm) cuttings [8]. That is why estimation of mother plants productivity depending on different ways of plant pruning was also in the frames of our interest.

The rest two tasks were temperature estimation in two different cultivation constructions as well as study of rhizogenic ability and root formation of green cuttings in conditions of partially covered construction.

Materials and methods

Experiment 1 - response of mother plants on different ways of pruning.

The experiment was carried out in 2011-2012 on plants which have been planted in 2009 by one-year plant material.

Two factors have been tested:

Factor A – variety

1. Altaiskaya (moderate growth capability);

2. Elizaveta (high growth capability).

Factor B – level of pruning

1. moderate pruning (all branches grown in previous year have been half-cut)

2. extreme pruning (all branches have been cut remaining 3-4 lower buds)

3. intelligent pruning (depending on level of branches: upper braches cut remaining 8-12 buds, side and lower remaining 3-4 buds, week and small branches – cut completely.

All plants have been cut in April before buds breaking.

Records have been made at June 27 and June 25 in 2011 and 2012 respectively directly before cutting. Triple replication has been used.

Experiment 2 - Influence of greenhouse construction on green cuttings development.

Three factors have been tested:

Factor A – two different greenhouse constructions:

1. Completely covered by film (conventional technology);

2. Partially covered by film (only side part without roof on high of 2 m).

Factor B – three different varieties:

1. Avgustina (low growth capability);

2. Altaiskaya (moderate growth capability);

3. Elizaveta (high growth capability).

Factor C – three lengths of cuttings:

1. 20cm;

2. 30cm;

3. 40 cm.

Triple replication has been used.

Atmospheric and soil temperature was registered by temperature recorder “Minizamer-C” (http://www.zamer.ru/product/105). Atmospheric temperature was registered at level 5-10 cm from the ground (in the middle part of plants layer); soil temperature was registered on depth 0-15 cm (in the root layer). Temperature was registered every day, 24 hours per day, each 15 minutes from the day of planting till the end of September (totally was obtain about 35000 readings per year).

We use the same sprinkle type irrigation system in both estimated constructions. Irrigation conditions during first 30 days after planting as follow: duration – 10 sec, intervals – 5 min. Afterwards duration has been increased as well as intervals between irrigation, mostly referring to climate condition.

Soil medium is the same in both constructions: Lower level – cultivated ordinary soil, middle – organic manure 2-3 cm, upper layer – river sand 5-7 cm.

Root development was studied by the method of transparent glass [1]. Dynamic of root growing was recorded every 10-15 days. Volume of roots estimated by method of water displacement. We put roots to graduated cylinder with water and registered change of the water level.

Results

Experiment 1.

It was found out on most variants of pruning that total amount of sprouts on Altaiskaya variety is 15% higher comparing to Elizaveta both in 2011 and 2012 (table 1).

Table 1 - Total amount of sprouts, pieces per plant

Factor A - variety	***Factor B - type of pruning***							
	Year 2011				***Year 2012***			
	mode-rate	***extreme***	***intel-ligent***	***average on factor B***	***mode-rate***	***extreme***	***intel-ligent***	***average on factor B***
Elizaveta	94	49	66	70	266	78	169	171
Altaiskaya	117	63	64	81	298	120	173	197
Average on factor A	106	56	65		282	99	171	
LSD_{05}	50,9				88,2			
LSD_{05} (A)	$F_f<F_t$				$F_f<F_t$			
LSD_{05} (B)	36,0				62,3			
LSD^{05} (AB)	$F_f<F_t$				$F_f<F_t$			

Moderate pruning seems to be the most productive variant regarding total amount of sprouts and vary from 94 to 117 in 2011 and from 266 to 298 in 2012. That is quite significant volume, which can provides 500000 cuttings of different length in first year of harvesting and till 1.5 millions cuttings at second one. Lowest volumes were expectedly recorded at extreme pruning provided 2-3 times less sprouts compare to moderate pruning.

However in all obvious advantages of moderate pruning we should emphases that simple multiply of sprouts is not the main aim of our efforts. We are looking for as many as possible comparatively long cuttings. Because of that, the estimation of average length of sprouts was the next point of our research. Maximum value of average length of sprouts has been recorded on variant with extreme pruning, and in 2012 this value was significantly higher comparing to 2011. Thus, average length of sprouts on Altaiskaya variety was 21.4 and 27.4 cm in 2011 and 2012 respectively, as well as 19.8 and 27.0 on Elizaveta (table 2).

Table 2 - Average length of sprouts

Factor A – variety	***Factor B - type of pruning***							
	Year 2011				***Year 2012***			
	mode-rate	***extreme***	***intel-ligent***	***Average on factor B***	***mode-rate***	***extreme***	***intel-ligent***	***Average on factor B***
Elizaveta	14.8	19.8	18.6	17.7	17.4	27.0	21.0	21.8
Altaiskaya	15.0	21.4	17.3	17.9	15.7	27.4	21.0	21.4
Average on factor A	14.9	20.6	18.0		16.6	27.2	21.0	
LSD_{05}	4.2				2.7			
LSD_{05} (A)	$F_f<F_t$				$F_f<F_t$			
LSD_{05} (B)	3.0				1.9			
LSD_{05} (AB)	$F_f<F_t$				$F_f<F_t$			

Intelligent pruning provide average length of sprouts from 18.0 to 21.0 cm as well as moderate only from 14.9 to 16.6 cm depending on year.

Finally, the most important factor considered by us – the number of sprouts in each group ranged by the length. As regards our main idea, the most valuable group in our research is 30 cm and more. Significant difference was observed at Altaiskaya variety on extreme pruning in 2012 than 51 sprouts with length more than 30 cm were obtained (table 3). From another hand Elizaveta contrary produced significantly lower large sprouts at extreme pruning variant. Other variants produced similar numbers of long sprouts.

Table 3 - Number of sprouts ranged by the length

Type of pruning	***Range, year, number of sprouts, pcs.***											
	< 10 cm		***10-14.9 cm***		***15-19.9 cm***		***20-24.9 cm***		***25-29.9 cm***		***> 30 cm***	
	2011	***2012***	***2011***	***2012***	***2011***	***2012***	***2011***	***2012***	***2011***	***2012***	***2011***	***2012***
Elizaveta												
moderate	44	82	14	49	10	40	7	32	4	21	13	42
extreme	16	11	6	9	7	8	5	8	4	9	12	32
intelligent	25	43	8	27	7	22	6	18	5	16	15	43
average	28	45	9	28	8	23	6	19	4	15	13	39

Altaiskaya												
moderate	53	123	17	54	14	35	9	26	7	19	17	41
extreme	21	19	6	16	3	11	4	12	3	11	18	51
intelligent	26	48	8	28	7	21	4	16	4	15	14	46
average	33	63	10	33	8	22	6	18	5	15	16	46

In average the volume of sprouts longer that 30 cm was ranged from 13-16 in 2011 and 39-46 – In 2012. That amount provides until 75000 high quality cuttings at first year of harvesting and 215000 at the second year.

As a result of preliminary investigation it was found out that within first two years of mother plants treatment there is no significant difference in long cuttings productivity depending on type of pruning. From another hand the total quantity of sprouts are much higher on moderate pruning, which provide potential for the next year. Unfortunately intelligent pruning was not such effective as planned and probably will show better results in the next years.

Experiment 2.

Climate conditions pay important role in plant development. Significant part of our efforts was directed to temperature estimation in both greenhouses.

Temperatures of atmosphere and soil were as expected higher in covered greenhouse, especially at first several weeks after planting (table 4).

Table 4 - Mean daily temperature in different greenhouse constructions, °C

Period	***Soil temperature, ^{o}C***				***Atmosphere temperature, ^{o}C***			
	2011		***2012***		***2011***		***2012***	
	CG*	***PCG****	***CG***	***PCG***	***CG***	***PCG***	***CG***	***PCG***
July 1-10	22.6	17.2	23.1	20.4	21.0	15.2	21.5	18.3
July 11-20	22.3	18.7	22.8	19.3	20.9	17.3	21.2	17.9
July 21-31	20.2	16.6	22.3	21.8	17.7	14.4	20.5	20.4
July 1-31	**21.7**	**17.5**	**22.7**	**20.5**	**19.9**	**15.6**	**21.1**	**19.0**
August 1-10	19.2	18.4	20.6	20.6	16.7	16.7	18.7	18.5
August 11-20	18.1	18.7	20.6	18.4	15.7	18.1	19.3	16.2
August 21-31	15.4	14.6	16.4	16.4	13.5	13.4	14.9	14.9
August 1-31	**17.6**	**17.2**	**19.2**	**18.5**	**15.3**	**16.1**	**17.6**	**16.5**
September 1-10	13.7	13.4	15.1	15.1	13.0	12.5	14.0	14.0
September 11-20	11.1	11.0	14.0	14.0	10.3	8.7	13.1	13.1
September 1-20	**12.4**	**12.2**	**14.6**	**14.6**	**11.7**	**10.6**	**13.6**	**13.6**
Average	**17.8**	**16.1**	**19.4**	**18.3**	**16.1**	**14.5**	**17.9**	**16.7**

* CG - conventional (full covered) greenhouse, PCG - partially covered greenhouse

In 2011 difference in temperature between greenhouses reached in several periods 5.4 ^{0}C in soil and 4.8 ^{0}C in atmosphere. In 2012 that difference was 2.7 ^{0}C in soil and 3.2 ^{0}C in atmosphere. In August because of changing of irrigation procedure and beginning of temporary ventilation, value of temperature in both greenhouses became mostly the similar. Moreover, in the second ten days of August 2011 the temperature of soil and atmosphere was on 0.6 and 2.4 ^{0}C higher in partially covered greenhouse, than that in conventional one.

In 2011 accumulated temperatures of soil for 79 days of cultivation (from July 5 to September 22) was 1356 ^{0}C in conventional greenhouse, 1279 ^{0}C – In partially covered. Accumulated temperatures of atmosphere was 1214 ^{0}C and 1151 ^{0}C respectively. In 2012 accumulated temperatures of soil for 79 of cultivation (from July 3 to September 20) was 1523 ^{0}C in conventional greenhouse, 1462 ^{0}C – In partially covered. Accumulated temperatures of atmosphere was 1399 ^{0}C and 1338 ^{0}C respectively.

Root development.

It was found out that volume of roots of Altaiskaya and Elizaveta varieties in 2012 on 1.3 and 1.6 cm^3 higher compare to 2011 (table 5). At the same time in 2012 poor root development was recorder on Avgustina variety especially at partially covered construction. Most likely last variety is not quite resistant to low relative air humidity on the background of high temperature during initial period of rooting.

Table 5 – Volume of roots of seabuckthorn plants after digging out, cm^3

Factor A - type of construction	***Factor B - variety***	***Factor C - initial cutting's length***			***Average on factor B***	***Average on factor A***
		20 cm	***30 cm***	***40 cm***		
Year 2011						
PCG	Avgustina	3.3	3.0	3.7	Avgustina – 3.5	PCG – 4.5
	Altaiskaya	4.2	4.3	5.5		
	Elizaveta	4.6	5.4	6.2	Altaiskaya – 4.9	
CG	Avgustina	3.2	3.7	4.1		CG – 4.6
	Altaiskaya	4.4	5.4	5.4	Elizaveta – 5.3	
	Elizaveta	4.4	5.0	6.2		
Average on factor C		4.0	4.5	5.2		
Year 2012						
PCG	Avgustina	2.7	2.1	2.5	Avgustina – 2.9	PCG – 5.0
	Altaiskaya	6.4	5.2	6.3		
	Elizaveta	5.2	6.2	8.0	Altaiskaya – 6.2	
CG	Avgustina	3.0	3.9	3.4		CG – 5.7
	Altaiskaya	5.7	5.6	7.7	Elizaveta – 6.9	
	Elizaveta	6.1	6.3	9.5		
Average on factor C		4.9	4.9	6.2		

Both initial length of cuttings and variety influenced to volume of roots. Within two years of investigations Elizaveta referred as most promising variety providing 5.3 cm^3 of roots comparing to 3.5 and 4.9 cm^3 at Avgustina and Altaiskaya in 2011, as well as 6.9 cm^3 comparing to 2.9 and 6.2 cm^3 in 2012 respectively. Expectedly highest initial length of cuttings provided increased volume of roots. It ranged from 4.0 cm^3 at initial length of 20 cm to 5.2 cm^3 at initial length of 40 cm in 2011, as well as from 4.9 to 6.2 in 2012 respectively. Highest value was registered at Elizaveta variety at initial length of 40 cm in 2012 – 9.5 cm^3. In 2011 significant difference in volume of roots in two estimated constructions has not been recorded, but in 2012 this difference was in favor of conventional type of greenhouse and ranged from 5.0 to 5.7 cm^3. Summarized the above we would like to highlight that most significant influence on root development has variety specific, after that – initial length of cuttings and only at last – type of greenhouse.

One of the most interesting observation in our research was dynamics of root development. First observation in 2011 have been conducted at July 18 (15 days after planting). To this date root development was registered in both type of greenhouses at most variants, except several variants on Avgustina and at Altaiskaya variety with initial length of 20 cm in partially covered greenhouse. In 2012 to July 18 (13 days after planting) root development was registered at most variants except all three options on Avgustina variety at partially covered construction.

Second measuring have been done at July 29 and July 30 in 2011 and 2012 respectively. To this date in 2011 at partially covered greenhouse the growth of roots of first degree has been registered, as well as at conventional greenhouse development of secondary roots has been registered. In 2012 at both types of greenhouses growth of secondary roots have been observed.

Third observation shown beginning of darkening of first degree roots in both constructions. At forth and fifth observations darkening of secondary roots has been registered followed by complete mature of all roots till the middle of September in most variants except Avgustina variety in 2011.

To summarize the above it has to be mentioned that in average rhizogenic activity began within 10-12 days after planting. Root development occur more vigorous in conventional greenhouse, but to the middle of September most of variants produce complete mature root system. Significant difference have been found within varieties. For instance, Avgustina variety because of low rhizogenic activity do not recommended for partially covered greenhouses.

Sprout development.

In 2012 growth of sprouts was more vigorous compare to 2011. In partially covered greenhouse mentioned difference was 2.2 cm, in conventional one – 4.1 cm.

Table 6 - Length of plants after digging out, cm

Factor A - type of construction	***Factor B - variety***	***Factor C - initial cutting's length***			***Average on factor B***	***Average on factor A***
		20 cm	***30 cm***	***40 cm***		
Year 2011						
PCG	Avgustina	23.7	35.1	44.2	Avgustina - 35.6	PCG - 35.1
	Altaiskaya	24.8	36.2	45.3		
	Elizaveta	24.9	36.2	45.2	Altaiskaya - 36.4	
CG	Avgustina	26.8	35.4	48.5		CG - 37.2
	Altaiskaya	25.7	38.0	48.4	Elizaveta - 36.4	
	Elizaveta	26.6	37.6	48.1		
Среднее по фактору С		25.4	36.4	46.6		
Year 2012						
PCG	Avgustina	25.0	34.9	45.4	Avgustina - 36.2	PCG - 37.3
	Altaiskaya	26.0	36.2	48.4		
	Elizaveta	26.1	39.8	53.5	Altaiskaya - 39.0	
CG	Avgustina	25.9	36.8	49.3		CG - 41.3
	Altaiskaya	27.8	39.6	55.9	Elizaveta - 42.6	
	Elizaveta	32.0	42.3	62.1		
Average on factor C		27.1	38.3	52.4		

Most of variants shown better growth in covered greenhouse. In average this difference was 2.1 cm in 2011 and 4.0 cm in 2012. Additional length of sprouts was in direct relation with initial length of cuttings and increased from 5.4 cm, 6.4 cm to 6.6 cm at initial length of 20, 30 and 40 cm in 2011, and from 7.1, 8.3 to 12.4 cm in 2012 respectively (table 6).

Maximum length of plants was registered in 2012 in covered greenhouse on Elizaveta variety and reached 62.1 cm with additional growth of 22.1 cm, which on 14 cm higher compare to year 2011, and on 9.6 cm higher compare to partially covered greenhouse. Average length of plants of Elizaveta variety in 2012 was on 6.2 cm higher than in 2011 and consist as 42.6 and 36.4 cm respectively. Difference within Altaiskaya and Avgustina was not such significant, but also best results were obtained in conventional greenhouse in 2012 at 40 cm of initial length of cuttings.

To find out the most intensive period of sprout growth in greenhouses we estimated the length of upper part of cuttings each 10-15 days (simultaneously with estimation of root development).

Table 7 - Height of upper part of sprouts, 2011

Variant	***Date of observation***							
	05.07	***19.07***	***29.07***	***08.08***	***18.08***	***30.08***	***15.09***	***Additional length***
Partially covered greenhouse								
Avgustina, 20 см	14.8	16.9	17.1	17.9	18.5	18.5	18.5	3.7
Avgustina, 30 см	22.6	26.0	26.4	26.9	27.5	27.6	27.7	5.1
Avgustina, 40 см	33.0	35.5	35.5	36.0	36.7	36.9	37.2	4.2
Altaiskaya, 20 см	14.9	19.1	19.2	19.4	19.6	19.7	19.7	4.8
Altaiskaya, 30 см	22.1	27.0	27.5	27.9	28.2	28.3	28.3	6.2
Altaiskaya, 40 см	33.2	35.0	36.4	37.1	37.8	38.2	38.5	5.3
Elizaveta, 20 см	15.2	18.0	18.3	19.1	19.8	20.0	20.1	4.9
Elizaveta, 30 см	22.7	26.9	27.1	27.8	28.3	28.5	28.9	6.2
Elizaveta, 40 см	33.0	34.7	35.3	36.5	37.4	37.6	38.2	5.2
Conventional greenhouse								
Avgustina, 20 см	14.5	20.1	20.1	20.6	21.3	21.3	21.3	6.8
Avgustina, 30 см	24.3	28.9	28.9	29.2	29.6	29.7	29.7	5.4
Avgustina, 40 см	32.2	38.7	38.7	40.3	40.6	40.6	40.7	8.5
Altaiskaya, 20 см	14.9	19.5	19.6	20.2	20.6	20.6	20.6	5.7
Altaiskaya, 30 см	23.7	30.1	30.8	31.1	31.6	31.7	31.7	8.0
Altaiskaya, 40 см	30.4	36.7	37.4	37.8	38.3	38.6	38.8	8.4
Elizaveta, 20 см	15.4	20.3	20.6	21.8	21.9	21.9	22.0	6.6
Elizaveta, 30 см	24.1	28.7	29.5	30.7	31.5	31.5	31.7	7.6
Elizaveta, 40 см	34.7	38.2	38.5	41.6	41.8	42.6	42.8	8.1

It has been found out that growth of plants has two stage. Maximum growth of sprouts has been observed at first 10-15 days after planting in both greenhouses on most variants. At August further growth was registered but not so vigorous. At September growth of upper part of plants has not been found. We suppose that initial growth of sprouts, which are completely without roots within 10-

15 days after planting, appears due to residual plastic substances at cuttings. After that initial and secondary roots provides plants by nutrients. It is interesting that growth on residuals is more intensive compare to rooted plants.

Table 8 - Height of upper part of sprouts, 2012

Variant	***Date of observation***							
	6.07	***18.07***	***30.07***	***8.08***	***23.08***	***5.09***	***19.09***	***Additional length***
Partially covered greenhouse								
Avgustina, 20 см	17.9	19.2	19.6	19.6	19.6	19.6	19.4	1.5
Avgustina, 30 см	26.9	27.3	28.0	28.1	28.0	28.0	27.9	1.0
Avgustina, 40 см	36.0	36.3	36.8	37.3	37.5	37.7	37.9	1.9
Altaiskaya, 20 см	18.5	19.8	19.9	20.2	20.2	20.3	20.3	1.8
Altaiskaya, 30 см	27.1	28.1	28.4	28.7	28.8	28.8	28.7	1.6
Altaiskaya, 40 см	37.2	38.6	39.4	40.3	40.9	41.1	41.2	4.0
Elizaveta, 20 см	18.1	19.2	19.7	20.3	20.7	20.7	20.8	2.7
Elizaveta, 30 см	27.1	28.2	29.2	30.9	31.6	31.8	31.9	4.8
Elizaveta, 40 см	36.1	37.2	38.7	41.0	43.2	44.1	44.3	8.2
Conventional greenhouse								
Avgustina, 20 см	18.3	19.9	20.2	20.3	20.5	20.5	20.7	2.4
Avgustina, 30 см	27.7	29.4	29.6	29.8	29.8	29.9	29.9	2.2
Avgustina, 40 см	37.1	38.3	39.3	40.3	40.7	40.8	41.0	3.9
Altaiskaya, 20 см	19.8	22.3	22.5	22.6	22.8	22.8	22.8	3.0
Altaiskaya, 30 см	29.1	31.0	31.9	32.5	32.7	32.9	32.9	3.8
Altaiskaya, 40 см	38.5	40.9	43.4	45.7	47.5	48.1	47.9	9.4
Elizaveta, 20 см	20.5	22.5	23.3	24.1	25.3	25.7	26.1	5.6
Elizaveta, 30 см	29.4	31.8	33.0	34.3	35.9	36.3	36.6	7.2
Elizaveta, 40 см	38.3	40.3	42.8	45.5	49.5	51.8	52.0	13.7

Cuttings with high initial length (40 cm) provide significant growth during all period of cultivation. At the same time cuttings with low initial length have additional growth mostly during first stage (two weeks after planting).

Percentage of rooted plants has a prior importance within most of our observation. Average rooting was extremely high in both types of constructions and ranged from 91.5 to 97.7%. In conventional greenhouse rooting was a bit higher, but mostly because of low results on Avgustina in partially covered greenhouse (77.0% in 2011 with initial length of 20 cm, and 77.3% in 2012 with initial length of 40 cm). Altaiskaya and Elizaveta have comparatively equal percent of rooting in both constructions.

Table 9 - Results of rooting of green cuttings, %

Factor A -type of construction	***Factor B - variety***	***Factor C - initial cutting's length***			***Average on factor B***	***Average on factor A***
		20 cm	***30 cm***	***40 cm***		
Year 2011						
PCG	Avgustina	77.0	90.0	94.0	Avgustina - 88.6	PCG - 94.4
	Altaiskaya	99.4	98.7	99.4		
	Elizaveta	96.3	95.7	99.0	Altaiskaya - 99.1	
CG	Avgustina	83.7	89.7	97.0		CG - 95.9
	Altaiskaya	98.3	99.3	99.0	Elizaveta - 97.9	
	Elizaveta	97.0	99.7	99.7		
Average on factor C		92.0	95.5	98.0		
Year 2012						
PCG	Avgustina	81.0	81.7	77.3	Avgustina - 88.0	PCG - 91.5
	Altaiskaya	98.7	96.3	91.0		
	Elizaveta	99.0	99.0	99.3	Altaiskaya - 96.5	
CG	Avgustina	97.0	97.3	93.3		CG - 97.7
	Altaiskaya	99.7	97.0	96.3	Elizaveta - 99.4	
	Elizaveta	99.7	99.7	99.3		
Average on factor C		95.9	95.2	92.8		

Conclusions

The possibility of green cuttings growing in greenhouses without complete covering has been proved. Quality of one year plant material grew in partially covered construction is like the same as in conventional greenhouse. Variety specific has been found out regarding root development and upper part growing.

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