Report of Short Term Scientific Mission (STSM)

STSM topic: Harvesting and management of different clones of short rotation coppice in Latvia.

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In the period from 7 to 18 March 2016, I attended the Short Term Scientific Mission (STSM) in Latvia (Salaspils). The Latvian State Forest Research institute "Silava" (LSFRI Silava) organized this mission in the Skrīveri, Medemciens, Kazdanga, Valmiera and Rubene regions of Latvia. The main purpose of this mission was to get more data about short rotation coppice productivity and to make contacts with those Latvian researchers who work in the field of short rotation coppice for energy targets.

The succession of the planned work was changed. A short description of the work during the STSM is presented in the Table 1.

Table 1. Short description of the work during the STSM

Work	Planned	Done
Arrival. Introduction of research activities in the Latvian State Forest Research institute "Silava".	Day 1st	Day 1st Arrival to Latvia. Introduction of research activities: presentation of research from LSFRI Silava. Brief characteristics of short rotation coppice in Latvia, amount of resources. Consideration of plans for 2 weeks. Familiarization with the instruments and their use for field work. Familiarizing with the instruments and its using for field work.
Visit of first field – commercial willow trials since 2002 at Medemciems.	Day 1st	Day 4th
Field tests: Measurements of the height and diameter of stems in experimental willow trial at Skrīveri following time studies of harvesting and fresh biomass determination.	Day 2nd – 5th	Day 2nd (Skrīveri region) Day 9th (Kazdanga region) Day 10th (Valmiera region)
Data processing. Quality checking of obtained data. Generalization.	Day 6th – 7th	Day 6th – 7th Day 3th – Economic analyses of willow in Latvia, comparison with economic aspects of willow in Lithuania and Latvia, information (that only exists in local language) exchange. Day 8th – Report draft.
Evaluation of the frost resistance of young willow plantations.	Day 8th	Day 9th (Kazdanga region) + Animals resistance
Visit and interviews with those farmers who grow willows as agriculture crop	Day 9th – 10th	Day 4th (Medemciems region)

and having willow forest stands.		Day 9th (Kazdanga region) Day 11th (Rubene region)
Determination of harvested material moisture content. Data processing.	Day 11th	Day 12th
Departure.	Day 12th	Day 12th
Hibernating of insects on willow stems & rooting in the aqua media study.	Not planned	Day 5th

In general, the work accomplished is supported by the data collected consisting of 5 main information sources:

1. Evaluation of the diameter and heights of the willow and poplar clones;
2. Harvesting time study and evaluation of willow moisture;
3. Evaluation of the frost resistance of young willow plantations;
4. Interview study
5. Hibernating of insects on willow stems & rooting in the aqua media study.

1. Evaluation of the diameter and heights of the willow and poplar clones

Method: The measurements of the height and diameter of willow and poplar stems were done in an experimental willow trial at Skrīveri (Figure 1).

Figure 1. Scheme of the willow and poplar trial at Skrīveri

Field tests were carried out in willow plantations with 3, 4 and 5 year-old shoots. All of them have 5 year old roots. However, there are differences between the ages of the shoots:

- 3 year-old shoots – were cut after the 2nd year;
- 4 year-old shoots – were cut after the 1st year;
- 5 year-old shoots – no cutting was performed.

Different "Tree shaped" and "Bush shaped" crown willow clones were researched (Table 2), however, with similar characteristics: these fields were fertilized with wood ash, waste water sludge and a control field (for each clone).

Table 2.The willow clones that were researched at Skrīveri

Crown form of willow	Clone name
"Tree shaped"	Sven; Klara; Inger; Gudrun; Lisa; Tora; Stina
"Bush shaped"	S. viminalis (local); S. smithensis; S. burjatica; S. purpurea.

The distribution of all the clone plants can be seen in Table 3. The I block was cut up during my visit, and the II experimental block was measured. The interval between the willow's rows was 0.5 x 0.7 x 1.5 m, and each clone plot was 53 m^2 (2.2 x 24 m^2). The III experimental block was not measured due to bad weather conditions: the plantations were standing in water (Figure 2).

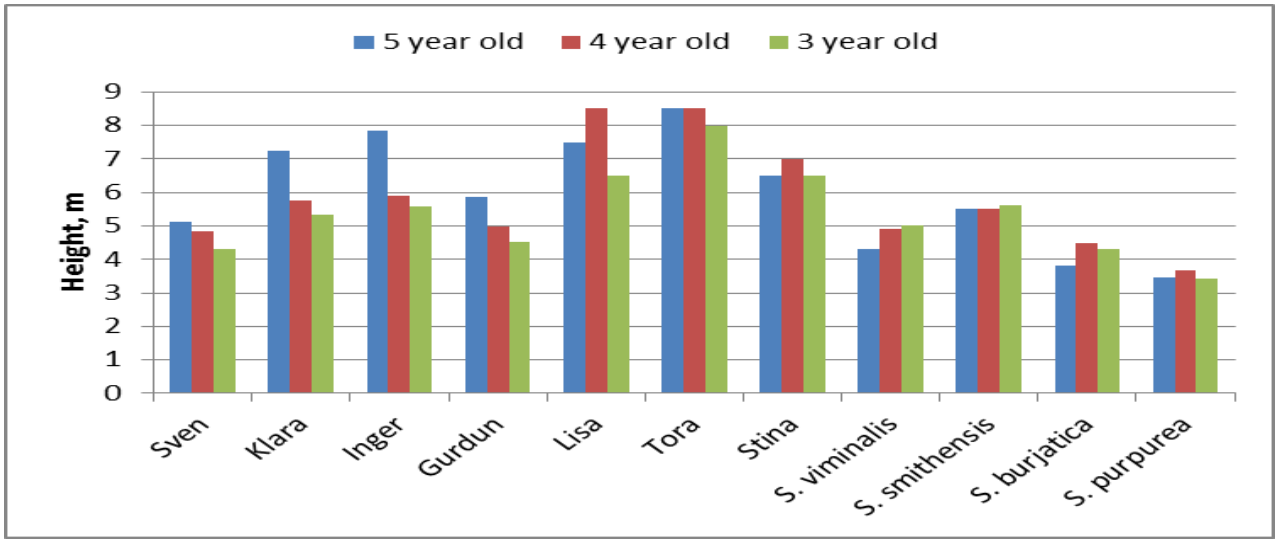
Table 3. The plantations scheme at Skrīveri (orange color in scheme means mineral fertilize)

I bloc				II bloc				III bloc			
Control	for fertilization			Control	for fertilization			Control	for fertilization		
control	***ash***	***sludge***	***conrol***	***control***	***sludge***	***control***	***ash***	***control***	***control***	***ash***	***sludge***
SVEN (S)	S	S	S	S	S	S	S	S	S	S	S
KLARA (K)	K	K	K	K	K	K	K	K	K	K	K
INGER (I)	I	I	I	I	I	I	I	I	I	I	I
GUDRUN (G)	G	G	G	G	G	G	G	G	G	G	G
LISA (L)	L	L	L	L	L	L	L	L	L	L	L
TORA (T)	T	T	T	T	T	T	T	T	T	T	T
STINA (ST)	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST
VIMINALIS (V)	V	V	V	V	V	V	V	V	V	V	V
SMITHENSIS (SM)	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM
BURJATICA (B)	B	B	B	B	B	B	B	B	B	B	B
PURPUREA (P)	P	P	P	P	P	P	P	P	P	P	P
AF 2	AF 2	AF 2	AF 2	AF 2	AF 2	AF 2	AF 2	AF 2	AF 2	AF 2	AF 2
AF 6	AF 6	AF 6	AF 6	AF 6	AF 6	AF 6	AF 8	AF 8	AF 8	AF 8	AF 8
AF 7	AF 7	AF 7	AF 7	AF 7	AF 7	AF 7	AF 7	AF 7	AF 7	AF 7	AF 7
AF 8	AF 8	AF 8	AF 8	AF 8	AF 8	AF 8	AF 8	AF 8	AF 8	AF 8	AF 8
AF 2	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8
AF8	AF7	AF7	AF7	AF7	AF7	AF7	AF7	AF7	AF7	AF8	AF8
AF7	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	TORDIS/ TORHILD	TORDIS/ TORHIL
AF8	AF7	AF7	AF7	AF7	AF7	AF7	AF7	AF7	AF7	TR	TR
AF7	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	K	K
AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	AF8	S	S

Figure 2. Work conditions at Skrīveri field

Results: The 5 year-old willow clones were the tallest in the fields fertilized with ash in the I block. The research results showed that willows in fields fertilized with waste water sludge were the tallest as compared with the control fields and fertilized with wood ash in the II block (Figure 3).

Figure 3. The maximum height of willow by age in fields fertilized with waste water sludge



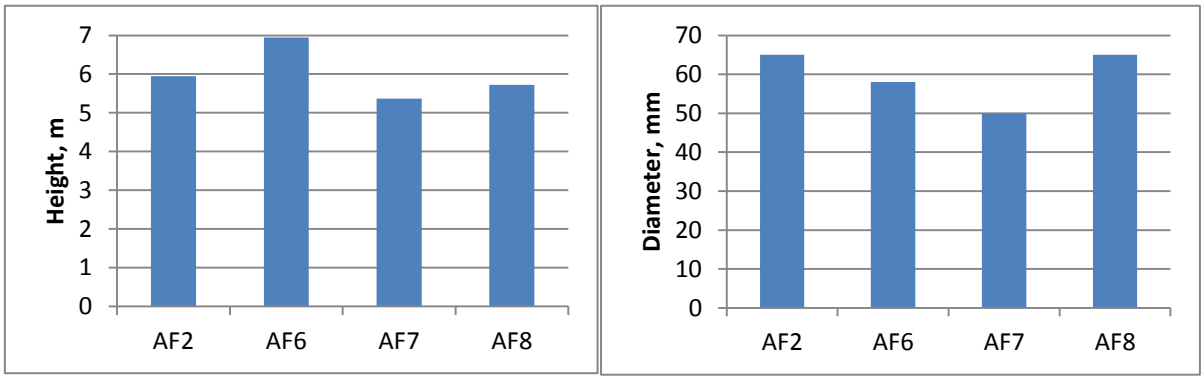
It is estimated that Tora and Lisa were the tallest clones. It is important to estimate the risk for electrical lines. Therefore, the S. burjatica and S. purpurea clones were the best suitable for such places. The minimum and average data of the heights of willow clones in fields fertilized with waste water sludge is presented in Table 4.

Table 4. The minimum and average data of the heights of willow clones in fields fertilized with waste water sludge

Age, years	Height, m	Sven	Klara	Inger	Gudrun	Lisa	Tora	Stina	S. viminalis	S. smithensis	S. burjatica	S. Purpurea
5	Minimal	3.4	5.7	5.4	4.9	5.5	5.5	2.9	3.2	3.6	2.4	2.7
	Average	4.7	6.4	6.4	5.5	7	7	5.2	4.1	4.9	3.3	3.2
4	Minimal	3.9	4.6	4.4	3.5	6.5	6.5	5.5	3.1	5	3.1	2.6
	Average	4.3	5.1	5.4	4.2	7.6	7.9	6.3	4,5	5.4	3.7	3
3	Minimal	2.8	4.4	3.3	3.2	1.8	5.5	4.4	3.2	3.9	3.2	2.8
	Average	3.7	4.8	4.5	3.9	5	7	5.7	4.4	5.2	3.8	3.2

Poplar measurements showed that the 5 year-old AF2 and AF3 clones were the tallest, but the AF2 and AF8 clones had the biggest diameter stems (Figure 4).

Figure 4. The maximum heights and diameter of different poplars clones at the control field



The minimum and average data of the heights and diameter of 5 year-old poplars clones at the control field is presented in Table 5.

Table 5. The minimum and average data of the heights and diameter of poplars

Clones name	Minimum height, cm	Average height, cm	Minimal diameters (at 1.3 m), mm	Average diameters (at 1.3 m), mm
AF2	70	406	6	30
AF6	158	492	6	34
AF7	90	402	5	27
AF8	152	378	2	25

Studies at the Kazdanga region (measured field – 1.05 ha) showed that the Wilhelm, Olof and Emma 2 year-old clones were the tallest in comparison compare with the other clones (Figure 5).

Figure 5. The maximum heights of 2 year-old willow clones

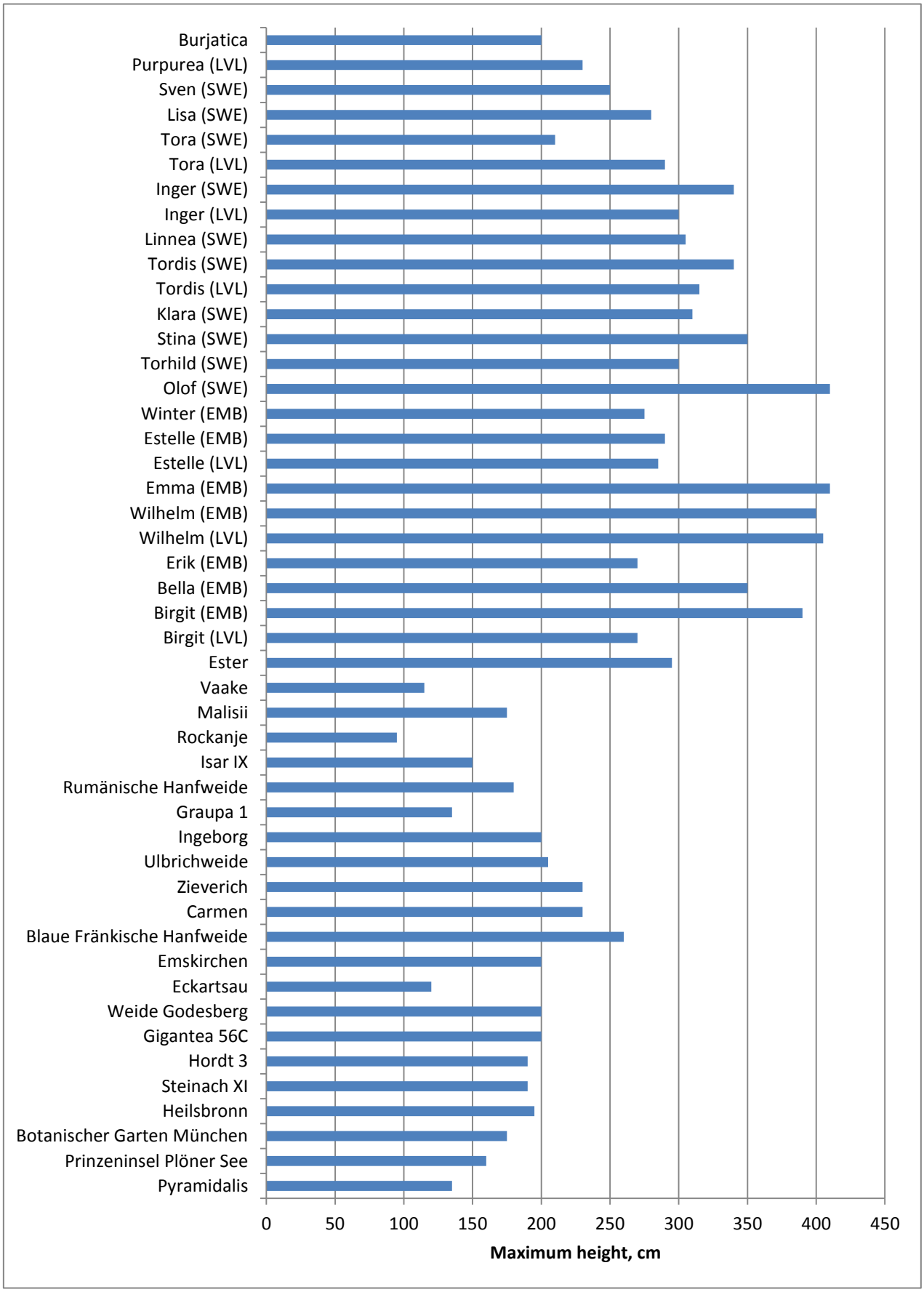


Figure 6. The measurements of the heights of willows stems at Skrīveri

2. Harvesting time study and evaluation of willow moisture

The harvesting (manually, by saw) time study was done in the experimental 5 year-old willow mix of clones. The time elements of the harvesting process included: walking, cutting, resting (re-filling of fuel) and other activities. Respectively, it was 63%, 25%, 4%. and 0% for every element of the harvesting process. The length of each row was 200 meters. Also, the quantity of stems was estimated at the field. The total measured plot was 2 ha, the distance between rows was 1.5 m, and between the plants in each row, it was 0.5 m. A total of 50 rows (by 25 rows per diagonal) were measured. The length of each row was 10 m. The study results will be used for a joint article.

The harvested weight of the willow is determined at the moment in the enterprise of the owner of this willow plantation. The Director of this company will share the information obtained, which will

be used in a further joint article about the economic analysis of the willows SRC. The available data for the average willow yield of Latvia is about 8 odt/ha (Makvovskis et al., 2012). It is based on the collection of the willow height data at Skrīverithe field, whose preliminary weight was calculated by a formula (about 7.6 odt/ha).

In order to determine the moisture of the willow, a sample of moist chips was taken (about 3 kg). It was observed that the root was released (per 1 week, Figure 7).

Figure 7. Root on chips

An evaluation of the fractions results are presented in Table 6 below. This demonstrates the integrity of the plants.

Table 6. The willow weight by fractions

No	Fraction, mm	Weight, g	%
1	63	80	2.7
2	45	63	2.1
3	16	1220	40.9
4	3:15	1360	45.6
5	< 3:15	260	8.7

The moisture content of the wet willow biomass was 53%. It is estimated, that the net calorific value was 2.06 MWh from 1 wet ton.

3. Evaluation of the frost resistance of young willow plantations

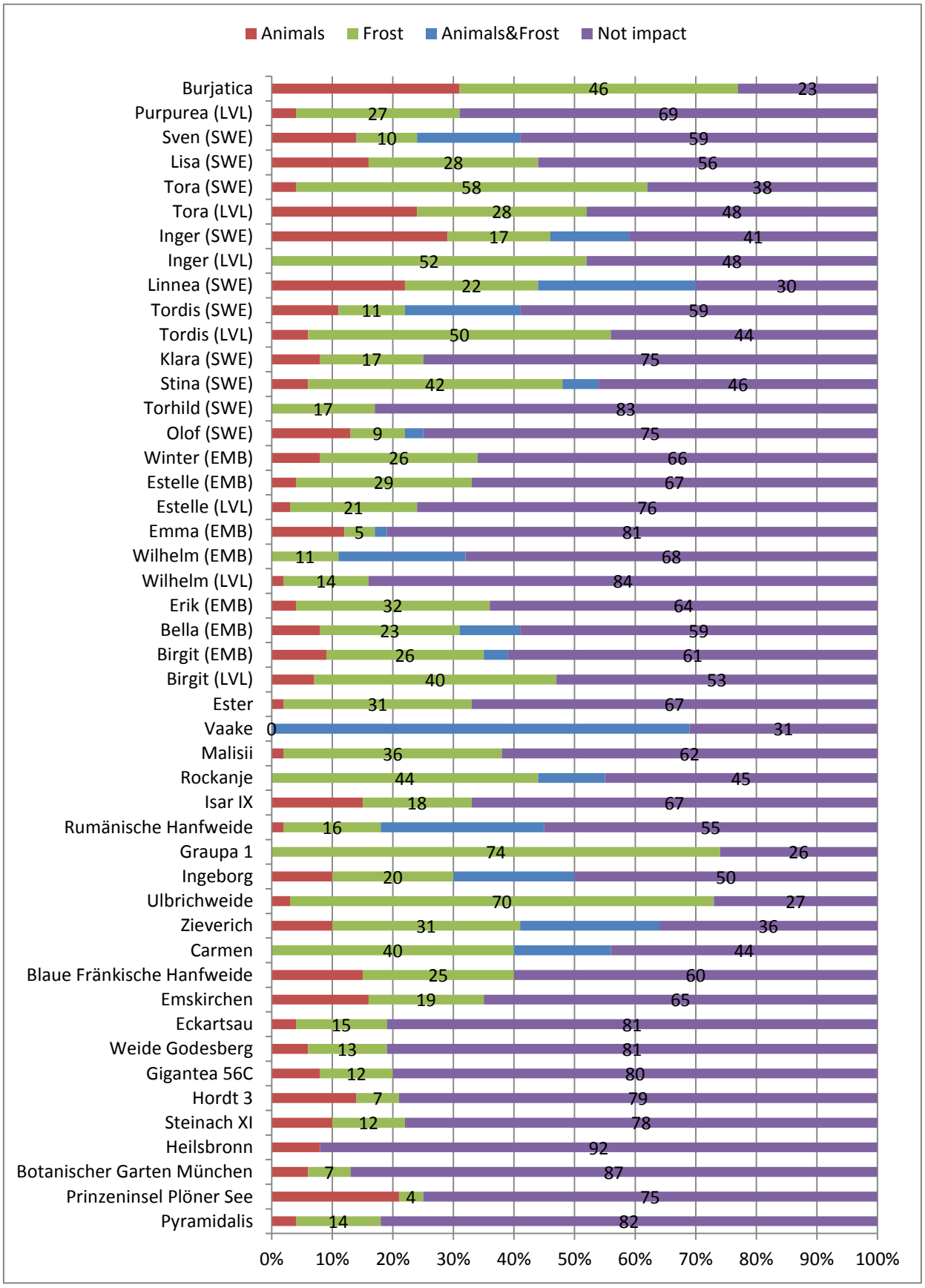
47 rows of different willow clones were measured at the Kazdanga plantations. The total measured field was 1.05 ha (103 x 100 m^2). Each 3^{th} plant in a row was measured. All the plants were 2 years-old. The characteristics from frost and the damage from animals for plants were fixed (Fig. 8 and 9).

Figure 8. The damage from animals

Figure 9. The damage from frost

The results of the evaluation of the frost resistance of young willow plantations showed which clones had the best frost and the least frost resistance (Figure 10). It can be said that the Burjatica and Inger clones are very attractive to animals.

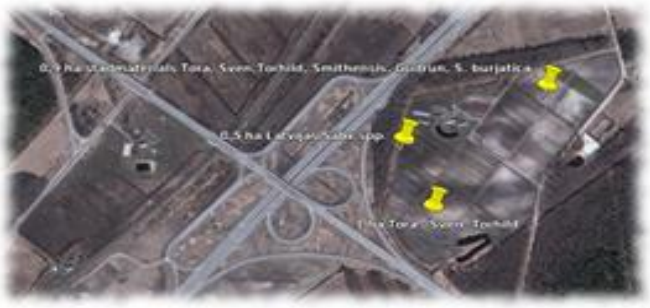
Figure 10. The frost resistance and the attractiveness to animals



4. Interview study

Interviews with the willow owners were conducted (at Medemciems (Figure 11), at Kazdanga, at Rubene).

Figure 11. The scheme of Medemciems nursery



The preliminary questions were prepared (Table 7). The summarized responses/answers are shown in Tables 7, 9 and 11.

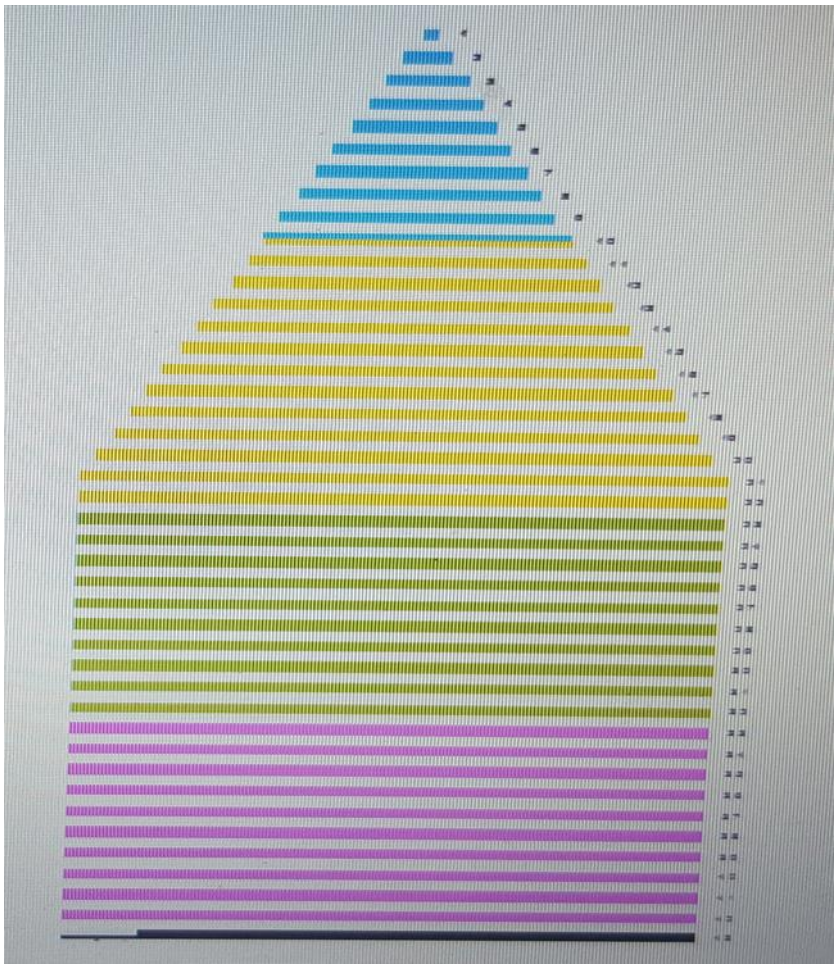
Table 7. The questions- answers (1st interview at Medemciems)

No	Questions / themes	Answers
1	Total plantations area	1.5 ha
2	Clones name	Table 8 and Figure 12
3	Establishment time	Establishment in 2002 and 2006
4	Main target	Willow stems for fences and other products (not energy production targets)
5	Reason to start this activity	Collaboration with LSFRI Silava researchers
6	Negative factors for this activity	Figure 13 and 14
7	Productivity; incomes	Irregular
8	Subsidies for this activity	None (because it is not agriculture land)
9	Do you provide services for planting?	No
10	Additional information	The Tora that was 3 years-old is very tall (It is supposedly due to the fact that this place has underground water vessels)

Table 8. The scheme of willow clones at Medemcies (planted in 2002)

Clones name	TORA			TORHILD			SVEN		
Total No rows	20			18			16		
No rows	6	8	6	6	6	6	6	4	6
Age	2	1	3	2	1	3	3	2	1

Figure 12. The clones that planted in 2006 (where different colors means following clones: blue – V. burjatica; yellow – Tora; green – Torhild; violet – Sven; blue sky – Gudrun; black – S. smithensis)



The visit showed that part of the plants was damaged by beavers (Figure 13).

Figure 13. The damage from beavers

The Monika and Visvaldis clones were bred in Latvia (Figure 14). These Latvian clones and S. viminalis (local) (Figure 15) are good planting material.

Figure 14. Monika and Visvaldis (Latvian clones)

Figure 15. S.viminalis (local)

Table 9. The questions- answers (2nd interview at Kazdanga)

No	Questions / themes	Answers
1	Total plantations area	230 ha (willow and aspen)
2	Clones name	Table 10
3	Establishment time	Establishment in 2014
4	Main target	Energetic targets
5	Reason to start this activity	New business
6	Negative factors for this activity	Partly animals; Limitations due to melioration; Small subsidies; Increasing price of agricultural lands (> 1500-2000 eur/ha depending on the state and geography); Small price of biofuel (due to warm winters); "Bush shaped" plants are a problem for the mechanized technique
7	Productivity; incomes	Doesn't have yield.
8	Subsidies for this activity	Yes
9	Do you provide services for planting?	No
10	Additional information	It is not yet known which willow clones will produce the greatest amount of biomass, because the willows are very young. But for example, Estelle grows well under poor conditions.

Table 10. The willow clones at Kazdanga

No	Name	No	Name	No	Name	No	Name
1	Pyramidalis	13	Zieverich	25	Bella (EMB)	37	Tordis (LVL)
2	Prinzeninsel Plöner See	14	Ulbrichweide	26	Erik (EMB)	38	Tordis (SWE)
3	Botanischer Garten München	15	Ingeborg	27	Wilhelm (LVL)	39	Linnea (SWE)
4	Heilsbronn	16	Graupa 1	28	Wilhelm (EMB)	40	Inger (LVL)
5	Steinach XI	17	Rumänische Hanfweide	29	Emma (EMB)	41	Inger (SWE)
6	Hordt 3	18	Isar IX	30	Estelle (LVL)	42	Tora (LVL)
7	Gigantea 56C	19	Rockanje	31	Estelle (EMB)	43	Tora (SWE)
8	Weide Godesberg	20	Malisii	32	Winter (EMB)	44	Lisa (SWE)
9	Eckartsau	21	Vaake	33	Olof (SWE)	45	Sven (SWE)
10	Emskirchen	22	Ester	34	Torhild (SWE)	46	Purpurea (LVL)
11	Blaue Fränkische Hanfweide	23	Birgit (LVL)	35	Stina (SWE)	47	Burjatica
12	Carmen	24	Birgit (EMB)	36	Klara (SWE)		

It is very important to take good care of willows for the first 2-3 years. Fertilizers during the first year are unnecessary, because while it enhances willow grow by 30%, it enhances weed grow by 100%. But, fertilization after each harvesting is an ideal solution (Dagnija Lazdina, 2016).

Table 11. The questions- answers (3th interview at Rubene)

No	Questions / themes	Short answers
1	Total plantations area	300 ha willow
2	Clones name	Tora, Inger
3	Establishment time	Establishment in 2011
4	Main target	Energy production targets
5	Reason to start this activity	Business
6	Negative factors for this activity	Limitations due to melioration; Small price of biofuel (due to warm winters); Lack of harvesting machine (manual labour); A Stemster harvesting machine is very expensive; An engineering company is being sought that can make a similar machine in Latvia.
7	Productivity; incomes	No data about product yield is available yet. The first yield will be harvested this season (the plants are 3 years old). The productivity (tons per hectare) is unknown yet.
8	Subsidies for this activity	Yes
9	Do you provide services for planting?	Yes. A maximum of 10 ha are planted per work day (8 hours).
10	Additional information	About 14 euros for MWh.

In conclusion, it could be said that willow growing as a business is very young in Latvia. The total amount of willow grown in Latvia is about 1200 ha. Owners hope for bigger subsidies. The subsidy amount is 38 EUR / ha (53 LTV / ha) per year at the moment in Latvia. This subsidy is only paid if the SRC plantations are harvested at least one time per 5 years. There are also restrictions on melioration. The farmers are also faced with a lack of technical harvesting solutions.

Supposedly (Dagnija Lazdina, 2016), the main benefit of willow coppice development in agricultural land is using this land as a resource, because the result is biologically good land due to

lower fertilizer use. Another benefit of growing willow is that the owner of an SRC plantation does not produce much of a yield, if there is no buyer (or the biofuel price is small), as compared to other agricultural crop owners.

5. Hibernating of insects on willow stems & rooting in the aqua media study

These are new studies. **Method:** A total of 198 model stems were taken: 11 clones from 3 places (ash, sludge and a control field) and 6 model stems from each clone. From 8 stems of each willow, 6 stems with the least amount of branches were selected from each clone. A 45 cm length of each model stem was truncated from top, middle and bottom.

They were placed in water, covered with a special construction (Figure 16), left in a light room and investigated for about 3–4 months. The purpose of the experiment is to learn about which insects hibernate on the willow stems and how the willow roots grow.

Figure 16.The process of hibernating of insects on willow stems & rooting in the aqua media study

All the aims of this STSM were achieved. Participation in this Scientific Mission was useful for me, because this visit provided me with the opportunity to get data for analysis about short rotation coppice productivity in Latvia. The preliminary data revealed the current situation of short rotation

coppice development in Latvia. Additionally, learning the new methods was a good experience. This work experience is good base for further studies.

The COST Action FP 1301 aims to bring together European scientists, experts and young scholars to exchange knowledge about coppice forestry. The data collected and information will be used for future common research in Latvia and Lithuania, and partly for my PhD thesis. I had the possibility to make contacts with other scientists. I hope that these contacts will provide mutual benefit for our Institutes as opportunities for close cooperation in the future.

I would also like to thank the "Silava" team for the effort and time they put into this short term scientific mission.

Future collaboration with host institution is planned (joint article).

Confirmation by the host institution of the successful execution of the STSM is attached (the file: Confirmation_Konstantinaviciene_STSM).